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OUR FILE NO. 367420-000002

June 23, 2011
VIA ELECTRONIC MAIL AND OVERNIGHT DELIVERY

Frank T. Melbourn, P.E.
Water Resource Control Engineer
California Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, CA 92123

**Re: In Re Tentative Cleanup and Abatement Order No. R9-2011-0001
Evidence Submissions by BAE Systems San Diego Ship Repair, Inc.**

Dear Mr. Melbourn:

Pursuant to the Third Amended Order of Proceedings in this matter, enclosed herewith is BAE Systems San Diego Ship Repair, Inc.'s supplement to the Administrative Record in the above referenced proceedings, submitted in connection with its Reply comments of June 23, 2011, consisting copies of the following documents:

1. 2009 BAE Municipal Stormwater sample analysis (Calscience)

2. 2001 BAE Municipal Stormwater sample analysis (AMEC)

3. 1974 Southern California Coastal Water Research Project study: "Marine Inputs from Polychlorinated Biphenyls and Copper from Vessel Antifouling Paints"

4. 1983 EPA "Results of the Nationwide Urban Runoff Program" (Executive Summary)

5. 1983 EPA "Results of the Nationwide Urban Runoff Program" (Volume I - Final Report)

6. Declaration of Shaun Halvax in Support of BAE's Reply to Environmental Parties' Comments Regarding TCAO/DTR No. R9-2011-0001

7. Port – SWM Agreement for Amendment of Lease - Amendment No. 2 (11/18/1997)

8. Port – SWM Agreement for Amendment of Lease - Amendment No. 3 (1/6/2004)

Also enclosed is the Certification that the electronic submittals are true and correct copies of the submitted signed originals.

As a courtesy, also enclosed is a disc containing text-searchable, electronic copies of the aforementioned documents. Please contact me if there are any questions.

Very truly yours,

DLA Piper LLP (US)

Matthew B. Dart

Admitted to practice in California

cc: All Designated Parties (letter only)

WEST\223740964.1

Calscience Environmental Laboratories, Inc.

December 21, 2009

Steve Cash
BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Subject: **Calscience Work Order No.: 09-12-0619**
Client Reference: BAE MUNI STORM WATER

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 12/7/2009 and analyzed in accordance with the attached chain-of-custody.

Unless otherwise noted, all analytical testing was accomplished in accordance with the guidelines established in our Quality Systems Manual, applicable standard operating procedures, and other related documentation. The original report of subcontracted analysis, if any, is provided herein, and follows the standard Calscience data package. The results in this analytical report are limited to the samples tested and any reproduction thereof must be made in its entirety.

If you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Virendra Patel
Project Manager

Calscience Environmental Laboratories, Inc.

Analytical Report

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: 12/07/09
Work Order No: 09-12-0619
Preparation: EPA 3005A Total / EPA 245.1 Total
Method: EPA 200.8 / EPA 245.1
Units: mg/L

Project: BAE MUNI STORM WATER

Page 1 of 1

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MS4-SD1	**09-12-0619-1-I**	**12/07/09 07:30**	**Aqueous**	**ICP/MS 03**	**12/08/09**	**12/08/09 17:42**	**091208L01T**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.
-Mercury was analyzed on 12/9/2009 11:44:27 AM with batch 091208L04A

Parameter	Result	RL	MDL	DF	Qual	Parameter	Result	RL	MDL	DF	Qual
Arsenic	0.00300	0.00100	0.000589	1		Nickel	0.0367	0.00100	0.000155	1	
Cadmium	0.000877	0.00100	0.000266	1	J	Silver	0.000305	0.00100	0.000120	1	J
Chromium	0.0117	0.00100	0.000618	1		Zinc	1.14	0.00500	0.00180	1	
Copper	0.325	0.00100	0.000105	1		Mercury	ND	0.000500	0.0000310	1	
Lead	0.0312	0.00100	0.000170	1							

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
Method Blank	**099-10-008-1,338**	**N/A**	**Aqueous**	**ICP/MS 03**	**12/08/09**	**12/08/09 14:15**	**091208L01T**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Parameter	Result	RL	MDL	DF	Qual
Arsenic	ND	0.00100	0.000589	1		Lead	ND	0.00100	0.000170	1	
Cadmium	ND	0.00100	0.000266	1		Nickel	ND	0.00100	0.000155	1	
Chromium	ND	0.00100	0.000618	1		Silver	ND	0.00100	0.000120	1	
Copper	ND	0.00100	0.000105	1		Zinc	ND	0.00500	0.00180	1	

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
Method Blank	**099-04-008-4,483**	**N/A**	**Aqueous**	**Mercury**	**12/09/09**	**12/09/09 11:42**	**091208L04A**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Parameter	Result	RL	MDL	DF	Qual
Mercury	ND	0.000500	0.0000310	1							

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

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Calscience Environmental Laboratories, Inc.

Analytical Report

BAE Systems		Date Received:	12/07/09
P.O. Box 13308		Work Order No:	09-12-0619
San Diego, CA 92170-3308		Preparation:	EPA 3510C
		Method:	EPA 8015B (M)

Project: BAE MUNI STORM WATER

Page 1 of 1

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MS4-SD1	**09-12-0619-1-O**	**12/07/09 07:30**	**Aqueous**	**GC 49**	**12/09/09**	**12/10/09 14:30**	**091209B11**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units
TPH as Motor Oil	ND	2500	2100	1		ug/L
Surrogates:	REC (%)	Control Limits			Qual	
Decachlorobiphenyl	114	68-140				

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
Method Blank	**099-12-258-107**	**N/A**	**Aqueous**	**GC 49**	**12/09/09**	**12/10/09 13:15**	**091209B11**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units
TPH as Motor Oil	ND	2500	2100	1		ug/L
Surrogates:	REC (%)	Control Limits			Qual	
Decachlorobiphenyl	99	68-140				

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

Analytical Report

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: 12/07/09
Work Order No: 09-12-0619
Preparation: EPA 3510C
Method: EPA 8015B (M)

Project: BAE MUNI STORM WATER

Page 1 of 1

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MS4-SD1	**09-12-0619-1-O**	**12/07/09 07:30**	**Aqueous**	**GC 49**	**12/09/09**	**12/10/09 14:30**	**091209B10**

Comment(s): -The sample chromatographic pattern for TPH does not match the chromatographic pattern of the specified standard. Quantitation of the unknown hydrocarbon(s) in the sample was based upon the specified standard.
-Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units
TPH as Diesel	1200	500	480	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
Decachlorobiphenyl	114	68-140	

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
Method Blank	**099-12-308-1,247**	**N/A**	**Aqueous**	**GC 49**	**12/09/09**	**12/10/09 13:15**	**091209B10**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units
TPH as Diesel	ND	500	480	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
Decachlorobiphenyl	99	68-140	

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

Analytical Report

BAE Systems		Date Received:	12/07/09
P.O. Box 13308		Work Order No:	09-12-0619
San Diego, CA 92170-3308		Preparation:	EPA 5030B
		Method:	EPA 8015B (M)

Project: BAE MUNI STORM WATER

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MS4-SD1	**09-12-0619-1-A**	**12/07/09 07:30**	**Aqueous**	**GC 42**	**12/10/09**	**12/10/09 18:06**	**091210B01**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units
TPH as Gasoline	ND	100	48	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
1,4-Bromofluorobenzene	105	38-134	

Client Sample Number	Lab Sample Number	Date/Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
Method Blank	**099-12-247-3,774**	**N/A**	**Aqueous**	**GC 42**	**12/10/09**	**12/10/09 13:14**	**091210B01**

Comment(s): -Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units
TPH as Gasoline	ND	100	48	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
1,4-Bromofluorobenzene	98	38-134	

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

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Calscience Environmental Laboratories, Inc.

Analytical Report

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: 12/07/09
Work Order No: 09-12-0619

Project: BAE MUNI STORM WATER

Page 1 of 1

Client Sample Number	Lab Sample Number	Date Collected	Matrix
MS4-SD1	**09-12-0619-1**	**12/07/09**	**Aqueous**

Comment(s): (24) Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
HEM: Oil and Grease (24)	3.2	1.0	0.85	1		mg/L	12/17/09	12/17/09	EPA 1664A
Chemical Oxygen Demand (24)	200	20	8.5	1		mg/L	12/09/09	12/09/09	EPA 410.4
Specific Conductance (24)	240	1.0	0.50	1		umhos/cm	N/A	12/07/09	SM 2510 B
Solids, Total Suspended (24)	205	1.0	0.95	1		mg/L	12/14/09	12/04/09	SM 2540 D
Solids, Settleable (24)	0.70	0.10	0.10	1		mL/L/hr	12/07/09	12/07/09	SM 2540 F
Carbon, Total Organic (24)	48	2.5	0.10	5		mg/L	N/A	12/08/09	SM 5310 D

Client Sample Number	Lab Sample Number	Date Collected	Matrix
Method Blank		**N/A**	**Aqueous**

Comment(s): (24) Results were evaluated to the MDL, concentrations >= to the MDL but < RL, if found, are qualified with a "J" flag.

Parameter	Result	RL	MDL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
HEM: Oil and Grease (24)	ND	1.0	0.85	1		mg/L	12/17/09	12/17/09	EPA 1664A
Chemical Oxygen Demand (24)	ND	20	8.5	1		mg/L	12/09/09	12/09/09	EPA 410.4
Solids, Total Suspended (24)	ND	1.0	0.95	1		mg/L	12/14/09	12/04/09	SM 2540 D
Carbon, Total Organic (24)	ND	0.50	0.021	1		mg/L	N/A	12/08/09	SM 5310 D

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received:	12/07/09
Work Order No:	09-12-0619
Preparation:	N/A
Method:	EPA 200.8

Project BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
09-12-0265-5	**Aqueous**	**ICP/MS 03**	**12/08/09**	**12/08/09**	**091208S01**

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Arsenic	88	89	80-120	1	0-20	
Cadmium	94	96	80-120	1	0-20	
Chromium	102	104	80-120	2	0-20	
Copper	106	107	80-120	2	0-20	
Lead	102	104	80-120	2	0-20	
Nickel	103	105	80-120	2	0-20	
Silver	98	96	80-120	3	0-20	
Zinc	98	119	80-120	19	0-20	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

BAE Systems		Date Received:	12/07/09
P.O. Box 13308		Work Order No:	09-12-0619
San Diego, CA 92170-3308		Preparation:	EPA 5030B
		Method:	EPA 8015B (M)

Project BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
09-12-0439-1	**Aqueous**	**GC 42**	**12/10/09**	**12/10/09**	**091210S01**

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Gasoline	97	100	68-122	3	0-18	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: 12/07/09
Work Order No: 09-12-0619
Preparation: EPA 245.1 Total
Method: EPA 245.1

Project BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
09-12-0581-1	**Aqueous**	**Mercury**	**12/08/09**	**12/08/09**	**091208S04**

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Mercury	109	108	57-141	1	0-10	

RPD - Relative Percent Difference , CL - Control Limit

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Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: N/A
Work Order No: 09-12-0619

Project: BAE MUNI STORM WATER

Matrix: Aqueous or Solid

Parameter	Method	Quality Control Sample ID	Date Analyzed	Date Extracted	MS% REC	MSD % REC	%REC CL	RPD	RPD CL	Qualifiers
Carbon, Total Organic	SM 5310 D	09-12-0617-6	12/08/09	N/A	94	94	70-130	0	0-25	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: N/A
Work Order No: 09-12-0619

Project: BAE MUNI STORM WATER

Matrix: Aqueous or Solid

Parameter	Method	QC Sample ID	Date Analyzed	Sample Conc	DUP Conc	RPD	RPD CL	Qualifiers
Specific Conductance	SM 2510 B	09-12-0562-1	12/07/09	1100	1100	0	0-25	
Chemical Oxygen Demand	EPA 410.4	09-12-0624-8	12/09/09	80	78	3	0-25	
Solids, Total Suspended	SM 2540 D	09-12-0621-2	12/04/09	169	176	4	0-20	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

BAE Systems		Date Received:	N/A
P.O. Box 13308		Work Order No:	09-12-0619
San Diego, CA 92170-3308		Preparation:	EPA 3005A Total
		Method:	EPA 200.8

Project: BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
099-10-008-1,338	**Aqueous**	**ICP/MS 03**	**12/08/09**	**12/08/09**	**091208L01T**

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Arsenic	95	96	85-115	1	0-20	
Cadmium	105	106	85-115	1	0-20	
Chromium	100	99	85-115	1	0-20	
Copper	111	109	85-115	1	0-20	
Lead	96	97	85-115	1	0-20	
Nickel	104	101	85-115	3	0-20	
Silver	103	103	85-115	0	0-20	
Zinc	101	104	85-115	3	0-20	

RPD - Relative Percent Difference , CL - Control Limit

Calscience
Environmental
Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received:	N/A
Work Order No:	09-12-0619
Preparation:	EPA 3510C
Method:	EPA 8015B (M)

Project: BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
099-12-258-107	**Aqueous**	**GC 49**	**12/09/09**	**12/10/09**	**091209B11**

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Motor Oil	93	82	75-117	12	0-13	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

BAE Systems		Date Received:	N/A
P.O. Box 13308		Work Order No:	09-12-0619
San Diego, CA 92170-3308		Preparation:	EPA 3510C
		Method:	EPA 8015B (M)

Project: BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
099-12-308-1,247	**Aqueous**	**GC 49**	**12/09/09**	**12/10/09**	**091209B10**

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Diesel	104	104	75-117	0	0-13	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received:	N/A
Work Order No:	09-12-0619
Preparation:	EPA 5030B
Method:	EPA 8015B (M)

Project: BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
099-12-247-3,774	**Aqueous**	**GC 42**	**12/10/09**	**12/10/09**	**091210B01**

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Gasoline	102	105	78-120	3	0-10	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received:	N/A
Work Order No:	09-12-0619
Preparation:	EPA 245.1 Total
Method:	EPA 245.1

Project: BAE MUNI STORM WATER

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
099-04-008-4,483	**Aqueous**	**Mercury**	**12/09/09**	**12/08/09**	**091208L04A**

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Mercury	109	109	85-121	0	0-10	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: N/A
Work Order No: 09-12-0619

Project: BAE MUNI STORM WATER

Matrix: Aqueous or Solid

Parameter	Method	Quality Control Sample ID	Date Extracted	Date Analyzed	LCS % REC	LCSD % REC	%REC CL	RPD	RPD CL	Qual
HEM: Oil and Grease	EPA 1664A	099-05-119-2,170	12/17/09	12/17/09	94	94	78-114	0	0-18	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Quality Control - Laboratory Control Sample

BAE Systems
P.O. Box 13308
San Diego, CA 92170-3308

Date Received: N/A
Work Order No: 09-12-0619

Project: BAE MUNI STORM WATER

Matrix: Aqueous or Solid

Parameter	Method	Quality Control Sample ID	Date Analyzed	Date Extracted	Conc Added	Conc Recovered	LCS %Rec	%Rec CL	Qualifiers
Carbon, Total Organic	SM 5310 D	099-05-097-3,675	12/08/09	N/A	5.00	4.84	97	80-120	

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

Glossary of Terms and Qualifiers

Work Order Number: 09-12-0619

Qualifier	Definition
*	See applicable analysis comment.
1	Surrogate compound recovery was out of control due to a required sample dilution, therefore, the sample data was reported without further clarification.
2	Surrogate compound recovery was out of control due to matrix interference. The associated method blank surrogate spike compound was in control and, therefore, the sample data was reported without further clarification.
3	Recovery of the Matrix Spike (MS) or Matrix Spike Duplicate (MSD) compound was out of control due to matrix interference. The associated LCS and/or LCSD was in control and, therefore, the sample data was reported without further clarification.
4	The MS/MSD RPD was out of control due to matrix interference. The LCS/LCSD RPD was in control and, therefore, the sample data was reported without further clarification.
5	The PDS/PDSD associated with this batch of samples was out of control due to a matrix interference effect. The associated batch LCS/LCSD was in control and, hence, the associated sample data was reported with no further corrective action required.
A	Result is the average of all dilutions, as defined by the method.
B	Analyte was present in the associated method blank.
C	Analyte presence was not confirmed on primary column.
E	Concentration exceeds the calibration range.
H	Sample received and/or analyzed past the recommended holding time.
J	Analyte was detected at a concentration below the reporting limit and above the laboratory method detection limit. Reported value is estimated.
ME	LCS Recovery Percentage is within LCS ME Control Limit range.
N	Nontarget Analyte.
ND	Parameter not detected at the indicated reporting limit.
Q	Spike recovery and RPD control limits do not apply resulting from the parameter concentration in the sample exceeding the spike concentration by a factor of four or greater.
U	Undetected at the laboratory method detection limit.
X	% Recovery and/or RPD out-of-range.
Z	Analyte presence was not confirmed by second column or GC/MS analysis.
	Solid - Unless otherwise indicated, solid sample data is reported on a wet weight basis, not corrected for % moisture.

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CEL

C science Environmental Laboratories, I

☒ SoCal Laboratory
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Concord, CA 94520-8577
(925) 689-9022

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Date 12/7/09

Page 1 of 1

LABORATORY CLIENT: BAE SYSTEMS SDSR

ADDRESS: 2205 E. BELT STREET

CITY: SAN DIEGO STATE: CA ZIP: 92113

TEL: (619) 238-1000 x2055 E-MAIL: STEVE.CASH@BAESYSTEMS.COM

CLIENT PROJECT NAME / NUMBER: BAE MUNI STORM WATER

P.O. NO.:

PROJECT CONTACT: STEVE CASH

LAB USE ONLY

SAMPLER(S): (PRINT) MIKE CHENG

COELT LOG CODE

COOLER RECEIPT TEMP= °C

TURNAROUND TIME: ☐ SAME DAY ☐ 24 HR ☐ 48 HR ☐ 72 HR ☐ 5 DAYS ☒ 10 DAYS

SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY): ☐ RWQCB REPORTING FORMS ☐ COELT EDF ☐

SPECIAL INSTRUCTIONS:
~~CHROMIUM III CALCULATE + REPORT~~
Revised COC received 12/08/09 at 10:05 - VP
Revision: Metals list is As,Cd,Cr,Cu,Pb,Ni,Ag,Zn by EPA 200.8 (TR)
Mercury by EPA 245.1

REQUESTED ANALYSES

LAB USE ONLY	SAMPLE ID	FIELD POINT NAME (FOR COELT EDF)	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT.	TPH (GAS) SM8015 B	TPH (DIESEL) SM8015 B	TPH (MOTOR OIL) SM8015 B	TSS SM2540 D	SS	COD	TBT (TBT ONLY)	TOC	OIL + GREASE SM1664 A	METALS EPA 200.8 As, Cd, Cu, Pb, Zn	MERCURY EPA 245.1	CONDUCTANCE	PCB 1668					
	MS4-SD1	MS4	12/7	7:30	L	16	X	X	X	X	X	X	X	X	X	X	X	X	X					

Relinquished by: (Signature)	Received by: (Signature/Affiliation)	Date:	Time:
[signature]	[signature] CEL	12/7/9	1540
Relinquished by: (Signature)	Received by: (Signature/Affiliation)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature/Affiliation)	Date:	Time:

DISTRIBUTION: White with final report, Green and Yellow to Client.
Please note that pages 1 and 2 of 2 of our T/Cs are printed on the reverse side of the green and Yellow copies respectively.

05/01/07 Revision

Q&Q Graphic 714-898-9702

Calscience Environmental Laboratories, Inc.

CEL

☒ SoCal Laboratory
7440 Lincoln Way
Garden Grove, CA 92841-1427
(714) 895-5494

☐ NorCal Service Center
5063 Commercial Circle, Suite H
Concord, CA 94520-8577
(925) 689-9022

CHAIN OF CUSTODY RECORD

Date 12/7/09

Page 1 of 1

LABORATORY CLIENT: BAE SYSTEMS SDSR

ADDRESS: 2205 E. BELT STREET

CITY: SAN DIEGO STATE: CA ZIP: 92113

TEL: (619) 238-1000 x2055 E-MAIL: STEVE.CASH@BAESYSTEMS.COM

TURNAROUND TIME: ☐ SAME DAY ☐ 24 HR ☐ 48 HR ☐ 72 HR ☐ 5 DAYS ☒ 10 DAYS

SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY): ☐ RWQCB REPORTING FORMS ☐ COELT EDF ☐ ____

SPECIAL INSTRUCTIONS: CHROMIUM III CALCULATE + REPORT

CLIENT PROJECT NAME / NUMBER: BAE MUNI STORM WATER

P.O. NO.:

PROJECT CONTACT: STEVE CASH

LAB USE ONLY: 12-0619

SAMPLER(S): (PRINT) MIKE CHENG

COELT LOG CODE: ☐☐☐☐

COOLER RECEIPT TEMP= °C

REQUESTED ANALYSES

LAB USE ONLY	SAMPLE ID	FIELD POINT NAME (FOR COELT EDF)	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT.	TPH (GAS) SM8015B	TPH (DIESEL) SM8015B	TPH (MOTOR OIL) SM8015B	TSS SM2540D	SS	COD	TBT (TBT ONLY)	TOC	OIL + GREASE SM1664A	METALS EPA 200.8	MERCURY EPA 245.1	CONDUCTANCE	PCB 1668
1	MS4-SD1	MS4	12/7	7:30	L	16	X	X	X	X	X	X	X	X	X	X	X	X	X

Relinquished by: (Signature)	Received by: (Signature/Affiliation)	Date:	Time:
[signature]	CEL	12/7/9	1540
[signature]	Danny le CEL	12/7/09	18:20

DISTRIBUTION: White with final report, Green and Yellow to Client.
Please note that pages 1 and 2 of 2 of our T/Cs are printed on the reverse side of the green and Yellow copies respectively.

05/01/07 Revision

Calscience Environmental Laboratories, Inc.

WORK ORDER #: 09-12-0619

SAMPLE RECEIPT FORM

Cooler 1 of 1

CLIENT: BAE

DATE: 12/7/09

TEMPERATURE: (Criteria: 0.0 °C – 6.0 °C, not frozen)

Temperature 3.7 °C - 0.8 °C (CF) = 2.9 °C ☑ Blank ☐ Sample

☐ Sample(s) outside temperature criteria (PM/APM contacted by: ________).

☐ Sample(s) outside temperature criteria but received on ice/chilled on same day of sampling.

☐ **Received at ambient temperature, placed on ice for transport by Courier.**

Ambient Temperature: ☐ Air ☐ Filter ☐ Metals Only ☐ PCBs Only Initial: [signature]

CUSTODY SEALS INTACT:

☐ Cooler ☐________ ☐ No (Not Intact) ☑ Not Present ☐ N/A Initial: [signature]

☐ Sample ☐________ ☐ No (Not Intact) ☑ Not Present Initial: WSC

SAMPLE CONDITION:	Yes	No	N/A
Chain-Of-Custody (COC) document(s) received with samples	☑	☐	☐
COC document(s) received complete	☑	☐	☐
☐ Collection date/time, matrix, and/or # of containers logged in based on sample labels.			
☐ COC not relinquished. ☐ No date relinquished. ☐ No time relinquished.			
Sampler's name indicated on COC	☑	☐	☐
Sample container label(s) consistent with COC	☑	☐	☐
Sample container(s) intact and good condition	☑	☐	☐
Correct containers and volume for analyses requested	☑	☐	☐
Analyses received within holding time	☑	☐	☐
Proper preservation noted on COC or sample container	☑	☐	☐
☐ Unpreserved vials received for Volatiles analysis			
Volatile analysis container(s) free of headspace	☑	☐	☐
Tedlar bag(s) free of condensation	☐	☐	☑

CONTAINER TYPE:

Solid: ☐4ozCGJ ☑8ozCGJ (5) ☐16ozCGJ ☐Sleeve ☐EnCores® ☐TerraCores® ☐________

Water: ☐VOA ☑VOAh (3) ☐VOAna₂ ☐125AGB ☐125AGBh ☐125AGBp ☐1AGB ☑1AGBna₂ (2) ☑1AGBs ☐500AGB ☑500AGJ (2) ☐500AGJs ☐250AGB ☐250CGB ☑250CGBs (2) ☑1PB (4) ☐500PB ☐500PBna ☐250PB ☑250PBn (2) ☐125PB ☐125PBznna ☐100PJ ☐100PJna₂ ☐______ ☐______ ☐______

Air: ☐Tedlar® ☐Summa® **Other:** ☐______ **Trip Blank Lot#:**____________ **Checked by:** WSC

Container: C: Clear A: Amber P: Plastic G: Glass J: Jar B: Bottle Z: Ziploc/Resealable Bag E: Envelop **Reviewed by:** [initials]

Preservative: h: HCL n: HNO3 na₂: $Na_2S_2O_3$ Na: NaOH p: H_3PO_4 s: H_2SO_4 znna: $ZnAc_2$+NaOH f: Field-filtered **Scanned by:** WSC

EnviroMatrix Analytical, Inc.

21 December 2009

Calscience Environmental Lab
Attn: Virendra Patel
7440 Lincoln Way
Garden Grove, California 92841

EMA Log #: 0912319

Project Name: 09-12-0619

Enclosed are the results of analyses for samples received by the laboratory on 12/09/09 12:38. Samples were analyzed pursuant to client request utilizing EPA or other ELAP approved methodologies. I certify that this data is in compliance both technically and for completeness.

Dan Verdon
Laboratory Director

CA ELAP Certification #: 2564

Client Name: Calscience Environmental Lab Project Name: 09-12-0619	EMA Log #: 0912319

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MS4-SD1	0912319-01	Water	12/07/09 10:35	12/09/09 12:38

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Client Name: Calscience Environmental Lab
Project Name: 09-12-0619

EMA Log #: 0912319

Organotin Compounds by GC - FPD

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MS4-SD1 (0912319-01) Water	**Sampled: 12/07/09 10:35**		**Received: 12/09/09 12:38**							**GC-05**
Tributyltin	ND	0.004	0.005	ug/l	1	9120928	12/09/09	12/14/09	GC - FPD	
Surrogate: Tripentyltin		*114 %*	*71-128*			"	"	"	"	
Surrogate: Tri-n-propyltin		*92 %*	*67-130*			"	"	"	"	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Client Name: Calscience Environmental Lab
Project Name: 09-12-0619

EMA Log #: 0912319

Organotin Compounds by GC - FPD - Quality Control

Analyte	Result	MDL	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 9120928											
Blank (9120928-BLK1)					Prepared: 12/09/09 Analyzed: 12/14/09						
Tributyltin	ND	0.004	0.005	ug/l							
Surrogate: Tripentyltin	*0.264*			"	*0.250*		*106*	*71-128*			
Surrogate: Tri-n-propyltin	*0.274*			"	*0.250*		*110*	*67-130*			
LCS (9120928-BS1)					Prepared: 12/09/09 Analyzed: 12/14/09						
Tributyltin	0.250	0.004	0.005	ug/l	0.250		100	65-138			
Surrogate: Tripentyltin	*0.278*			"	*0.250*		*111*	*71-128*			
Surrogate: Tri-n-propyltin	*0.278*			"	*0.250*		*111*	*67-130*			
LCS Dup (9120928-BSD1)					Prepared: 12/09/09 Analyzed: 12/14/09						
Tributyltin	0.248	0.004	0.005	ug/l	0.250		99	65-138	0.8	30	
Surrogate: Tripentyltin	*0.284*			"	*0.250*		*114*	*71-128*			
Surrogate: Tri-n-propyltin	*0.267*			"	*0.250*		*107*	*67-130*			

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Client Name: Calscience Environmental Lab
Project Name: 09-12-0619

EMA Log #: 0912319

Notes and Definitions

GC-05	Results confirmed by GCMS.
ND	Analyte NOT DETECTED at or above the reporting limit (or method detection limit when specified)
NR	Not Reported
dry	Sample results reported on a dry weight basis (if indicated in units column)
RPD	Relative Percent Difference
MDL	Method detection limit (indicated per client's request)

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Calscience Environmental Laboratories, Inc.

7440 LINCOLN WAY
GARDEN GROVE, CA 92841-1432
TEL: (714) 895-5494 . FAX: (714) 894-7501

Sub to: Enviro Matrix
4340 Viewridge Avenue, Suite A
San Diego, CA 92123

0912319

CHAIN OF CUSTODY RECORD

DATE:

PAGE: 1 OF 1

LABORATORY CLIENT	Calscience Environmental Laboratories, Inc.
ADDRESS	7440 Lincoln Way, Garden Grove, CA 92841-1427
TEL	714-895-5494
FAX	714-898-2036
E-MAIL	vpatel@calscience.com
CLIENT PROJECT NAME / NUMBER	09-12-0619
P.O. NO.:	
PROJECT CONTACT	Virendra Patel
SAMPLER(S) (SIGNATURE)	
COELT LOG CODE	
LAB USE ONLY	
COOLER RECEIPT	Temp = °C

TURNAROUND TIME

☐ SAME DAY ☐ 24 HR ☐ 48HR ☐ 72 HR ☐ 5 DAYS ☒ Standard

SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY)

☐ LOCUS EIM53 EDD ☐ COELT EDF ☐

SPECIAL INSTRUCTIONS

Report with "J" flags

REQUESTED ANALYSIS

DEC 9'09 12:55

LAB USE ONLY	SAMPLE ID	Field Point Name	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT	Tributyltin only (Krone et. Al)	CONTAINER TYPE
	MS4-SD1		12/07/09	10:35	W	1	X	

Relinquished by: (Signature) [signature] CEL	Received by: (Signature) [signature] 12/9/09 1238	Date: 12/9/9	Time: 1238
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:

2°C on ice

Maxxam Analytics

Driven by Service and Science

Your Project #: 09-12-0619
Your C.O.C. #: na

Attention: Virendra Patel
CALSCIENCE ENVIRONMENTAL LABORATORIES INC
7440 LINCOLN WAY
GARDEN GROVE, CA
USA 92841-1427

Report Date: 2009/12/18

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9G6555
Received: 2009/12/09, 12:27

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
PCB Congeners in Water (1668A)	1	2009/12/16	2009/12/16	BRL SOP-00408	EPA 1668A mod.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

ANCY SEBASTIAN, C.Tech., Senior Project Manager, Air Toxics
Email: Ancy.Sebastian@MaxxamAnalytics.com
Phone# (905) 817-5831

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Maxxam Analytics — Driven by Service and Science

Maxxam Job #: A9G6555
Report Date: 2009/12/18

CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
2-MonoCB-(1)	ng/L	0.0127	0.0013	N/A	N/A	N/A	2037456
3-MonoCB-(2)	ng/L	0.0124	0.0013	N/A	N/A	N/A	2037456
4-MonoCB-(3)	ng/L	0.0138	0.0013	N/A	N/A	N/A	2037456
22'-DiCB-(4)	ng/L	<0.022	0.022	N/A	N/A	N/A	2037456
2,3-DiCB-(5)	ng/L	<0.0071	0.0071	N/A	N/A	N/A	2037456
2,3'-DiCB-(6)	ng/L	<0.013	0.013	N/A	N/A	N/A	2037456
2,4-DiCB-(7)	ng/L	<0.0062	0.0062	N/A	N/A	N/A	2037456
2,4'-DiCB-(8)	ng/L	0.0436	0.0053	N/A	N/A	N/A	2037456
2,5-DiCB-(9)	ng/L	<0.0060	0.0060	N/A	N/A	N/A	2037456
2,6-DiCB-(10)	ng/L	<0.0066	0.0066	N/A	N/A	N/A	2037456
3,3'-DiCB-(11)	ng/L	1.07	0.0061	N/A	N/A	N/A	2037456
DiCB-(12)+(13)	ng/L	<0.0062	0.0062	N/A	N/A	N/A	2037456
3,5-DiCB-(14)	ng/L	<0.0060	0.0060	N/A	N/A	N/A	2037456
4,4'-DiCB-(15)	ng/L	0.0438	0.0086	N/A	N/A	N/A	2037456
22'3-TriCB-(16)	ng/L	0.0483	0.0042	N/A	N/A	N/A	2037456
22'4-TriCB-(17)	ng/L	0.0377	0.0029	N/A	N/A	N/A	2037456
TriCB-(18)+(30)	ng/L	0.0728	0.0025	N/A	N/A	N/A	2037456
22'6-TriCB-(19)	ng/L	0.0117	0.0025	N/A	N/A	N/A	2037456
TriCB-(20) + (28)	ng/L	0.145	0.0015	N/A	N/A	N/A	2037456
TriCB-(21)+(33)	ng/L	0.0704	0.0014	N/A	N/A	N/A	2037456
234'-TriCB-(22)	ng/L	0.0575	0.0015	N/A	N/A	N/A	2037456
235-TriCB-(23)	ng/L	<0.0015	0.0015	N/A	N/A	N/A	2037456
236-TriCB-(24)	ng/L	<0.0020	0.0020	N/A	N/A	N/A	2037456
23'4-TriCB-(25)	ng/L	0.0118	0.0013	N/A	N/A	N/A	2037456
TriCB-(26)+(29)	ng/L	0.0232	0.0014	N/A	N/A	N/A	2037456
23'6-TriCB-(27)	ng/L	0.0086	0.0021	N/A	N/A	N/A	2037456
24'5-TriCB-(31)	ng/L	0.119	0.0014	N/A	N/A	N/A	2037456
24'6-TriCB-(32)	ng/L	0.0353	0.0020	N/A	N/A	N/A	2037456
23'5'-TriCB-(34)	ng/L	<0.0015	0.0015	N/A	N/A	N/A	2037456

N/A = Not Applicable
EDL = Estimated Detection Limit
QC Batch = Quality Control Batch
TEF = Toxic Equivalency Factor, TEQ = Toxic Equivalency Quotient,
The Total Toxic Equivalency (TEQ) value reported is the sum of Toxic Equivalent Quotients for the congeners tested.
EDL = Estimated Detection Limit
WHO(2005): The 2005 World Health Organization, Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds

Maxxam Analytics

Driven by Service and Science

Maxxam Job #: A9G6555
Report Date: 2009/12/18

CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
33'4-TriCB-(35)	ng/L	0.0799	0.0014	N/A	N/A	N/A	2037456
33'5-TriCB-(36)	ng/L	0.0050	0.0013	N/A	N/A	N/A	2037456
344'-TriCB-(37)	ng/L	0.0772	0.0019	N/A	N/A	N/A	2037456
345-TriCB-(38)	ng/L	<0.0015	0.0015	N/A	N/A	N/A	2037456
34'5-TriCB-(39)	ng/L	<0.0014	0.0014	N/A	N/A	N/A	2037456
TetraCB-(40)+(41)+(71)	ng/L	0.150	0.0024	N/A	N/A	N/A	2037456
22'34'-TetraCB-(42)	ng/L	0.0667	0.0026	N/A	N/A	N/A	2037456
22'35-TetraCB-(43)	ng/L	<0.0030	0.0030	N/A	N/A	N/A	2037456
TetraCB-(44)+(47)+(65)	ng/L	0.402	0.0022	N/A	N/A	N/A	2037456
TetraCB-(45)+(51)	ng/L	0.143	0.0024	N/A	N/A	N/A	2037456
22'36'-TetraCB-(46)	ng/L	0.0206	0.0027	N/A	N/A	N/A	2037456
22'45-TetraCB-(48)	ng/L	0.0393	0.0024	N/A	N/A	N/A	2037456
TetraCB-(49)+TetraCB-(69)	ng/L	0.188	0.0020	N/A	N/A	N/A	2037456
TetraCB-(50)+(53)	ng/L	0.0893	0.0023	N/A	N/A	N/A	2037456
22'55'-TetraCB-(52)	ng/L	0.553	0.0022	N/A	N/A	N/A	2037456
22'66'-TetraCB-(54)	ng/L	0.0128	0.0013	N/A	N/A	N/A	2037456
233'4-TetraCB-(55)	ng/L	<0.0030	0.0030	N/A	N/A	N/A	2037456
233'4'-Tetra CB(56)	ng/L	0.131	0.0030	N/A	N/A	N/A	2037456
233'5-TetraCB-(57)	ng/L	<0.0029	0.0029	N/A	N/A	N/A	2037456
233'5'-TetraCB-(58)	ng/L	<0.0029	0.0029	N/A	N/A	N/A	2037456
TetraCB-(59)+(62)+(75)	ng/L	0.0255	0.0018	N/A	N/A	N/A	2037456
2344'-TetraCB -(60)	ng/L	0.0631	0.0029	N/A	N/A	N/A	2037456
TetraCB-(61)+(70)+(74)+(76)	ng/L	0.603	0.0028	N/A	N/A	N/A	2037456
234'5-TetraCB-(63)	ng/L	0.0077	0.0027	N/A	N/A	N/A	2037456
234'6-TetraCB-(64)	ng/L	0.128	0.0018	N/A	N/A	N/A	2037456
23'44'-TetraCB-(66)	ng/L	0.242	0.0027	N/A	N/A	N/A	2037456
23'45-TetraCB-(67)	ng/L	0.0080	0.0026	N/A	N/A	N/A	2037456
23'45'-TetraCB-(68)	ng/L	0.0054	0.0027	N/A	N/A	N/A	2037456
23'55'-TetraCB-(72)	ng/L	<0.0027	0.0027	N/A	N/A	N/A	2037456

N/A = Not Applicable
EDL = Estimated Detection Limit
QC Batch = Quality Control Batch
TEF = Toxic Equivalency Factor, TEQ = Toxic Equivalency Quotient,
The Total Toxic Equivalency (TEQ) value reported is the sum of Toxic Equivalent Quotients for the congeners tested.
EDL = Estimated Detection Limit
WHO(2005): The 2005 World Health Organization, Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds

Maxxam Analytics

Driven by Service and Science

Maxxam Job #: A9G6555
Report Date: 2009/12/18

CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
23'5'6-TetraCB-(73)	ng/L	<0.0023	0.0023	N/A	N/A	N/A	2037456
33'44'-TetraCB-(77)	ng/L	0.105	0.0034	0.000100	0.0000105	N/A	2037456
33'45-TetraCB-(78)	ng/L	<0.0028	0.0028	N/A	N/A	N/A	2037456
33'45'-TetraCB(79)	ng/L	0.0114	0.0025	N/A	N/A	N/A	2037456
33'55'-TetraCB-(80)	ng/L	<0.0026	0.0026	N/A	N/A	N/A	2037456
344'5-TetraCB-(81)	ng/L	<0.0034	0.0034	0.000300	0.00000102	N/A	2037456
22'33'4-PentaCB-(82)	ng/L	0.188	0.0014	N/A	N/A	N/A	2037456
PentaCB-(83)+(99)	ng/L	0.822	0.0013	N/A	N/A	N/A	2037456
22'33'6-PentaCB-(84)	ng/L	0.469	0.0014	N/A	N/A	N/A	2037456
PentaCB-(85)+(116)+(117)	ng/L	0.190	0.0010	N/A	N/A	N/A	2037456
PentaCB-(86)(87)(97)(109)(119)(125)	ng/L	1.61	0.0011	N/A	N/A	N/A	2037456
PentaCB-(88)+(91)	ng/L	0.202	0.0013	N/A	N/A	N/A	2037456
22'346'-PentaCB-(89)	ng/L	0.0127	0.0013	N/A	N/A	N/A	2037456
PentaCB-(90)+(101)+(113)	ng/L	1.66	0.0011	N/A	N/A	N/A	2037456
22'355'-PentaCB-(92)	ng/L	0.299	0.0013	N/A	N/A	N/A	2037456
PentaCB-(93)+(98)+(100)+(102)	ng/L	0.140	0.0013	N/A	N/A	N/A	2037456
22'356'-PentaCB-(94)	ng/L	0.0277	0.0014	N/A	N/A	N/A	2037456
22'35'6-PentaCB-(95)	ng/L	1.35	0.0012	N/A	N/A	N/A	2037456
22'366'-PentaCB-(96)	ng/L	0.0127	0.0018	N/A	N/A	N/A	2037456
22'45'6-PentaCB-(103)	ng/L	0.0270	0.0011	N/A	N/A	N/A	2037456
22'466'-PentaCB-(104)	ng/L	<0.0053	0.0053	N/A	N/A	N/A	2037456
233'44'-PentaCB-(105)	ng/L	0.610	0.0030	0.0000300	0.0000183	N/A	2037456
233'45-PentaCB-(106)	ng/L	<0.0028	0.0028	N/A	N/A	N/A	2037456
233'4'5-PentaCB-(107)	ng/L	0.0983	0.0026	N/A	N/A	N/A	2037456
PentaCB-(108)+(124)	ng/L	<0.053	0.053	N/A	N/A	N/A	2037456
PentaCB-(110)+(115)	ng/L	2.57	0.0010	N/A	N/A	N/A	2037456
233'55'-PentaCB-(111)	ng/L	<0.00095	0.00095	N/A	N/A	N/A	2037456
233'56-PentaCB-(112)	ng/L	<0.00097	0.00097	N/A	N/A	N/A	2037456
2344'5-PentaCB-(114)	ng/L	0.0252	0.0029	0.0000300	0.000000756	N/A	2037456

N/A = Not Applicable
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CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

Maxxam Job #: A9G6555
Report Date: 2009/12/18

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
23'44'5-PentaCB-(118)	ng/L	1.38	0.0029	0.0000300	0.0000414	N/A	2037456
23'455'-PentaCB-(120)	ng/L	0.00527	0.00089	N/A	N/A	N/A	2037456
23'45'6-PentaCB-(121)	ng/L	<0.00096	0.00096	N/A	N/A	N/A	2037456
233'4'5'-PentaCB-(122)	ng/L	<0.014	0.014	N/A	N/A	N/A	2037456
23'44'5'-PentaCB-(123)	ng/L	<0.016	0.016	0.0000300	0.000000480	N/A	2037456
33'44'5-PentaCB-(126)	ng/L	0.0429	0.0029	0.100	0.00429	N/A	2037456
33'455'-PentaCB-(127)	ng/L	<0.0029	0.0029	N/A	N/A	N/A	2037456
HexaCB-(128)+(166)	ng/L	<0.41	0.41	N/A	N/A	N/A	2037456
HexaCB-(129)+(138)+(163)	ng/L	3.62	0.0047	N/A	N/A	N/A	2037456
22'33'45'-HexaCB-(130)	ng/L	0.210	0.0055	N/A	N/A	N/A	2037456
22'33'46-HexaCB-(131)	ng/L	0.0450	0.0056	N/A	N/A	N/A	2037456
22'33'46'-HexaCB-(132)	ng/L	1.16	0.0057	N/A	N/A	N/A	2037456
22'33'55'-HexaCB-(133)	ng/L	0.0476	0.0052	N/A	N/A	N/A	2037456
HexaCB-(134)+(143)	ng/L	0.139	0.0061	N/A	N/A	N/A	2037456
HexaCB-(135)+(151)	ng/L	1.04	0.0015	N/A	N/A	N/A	2037456
22'33'66'-HexaCB-(136)	ng/L	0.368	0.0011	N/A	N/A	N/A	2037456
22'344'5-HexaCB-(137)	ng/L	0.131	0.0050	N/A	N/A	N/A	2037456
HexaCB-(139)+(140)	ng/L	0.0534	0.0050	N/A	N/A	N/A	2037456
22'3455'-HexaCB-(141)	ng/L	0.605	0.0052	N/A	N/A	N/A	2037456
22'3456-HexaCB-(142)	ng/L	<0.0056	0.0056	N/A	N/A	N/A	2037456
22'345'6-HexaCB-(144)	ng/L	0.147	0.0014	N/A	N/A	N/A	2037456
22'3466'-HexaCB-(145)	ng/L	<0.0012	0.0012	N/A	N/A	N/A	2037456
22'34'55'-HexaCB-(146)	ng/L	0.454	0.0046	N/A	N/A	N/A	2037456
HexaCB-(147)+(149)	ng/L	2.71	0.0057	N/A	N/A	N/A	2037456
22'34'56'-HexaCB-(148)	ng/L	0.0100	0.0015	N/A	N/A	N/A	2037456
22'34'66'-HexaCB-(150)	ng/L	0.0106	0.0011	N/A	N/A	N/A	2037456
22'3566'-HexaCB-(152)	ng/L	<0.0086	0.0086	N/A	N/A	N/A	2037456
HexaCB-(153)+(168)	ng/L	2.61	0.0040	N/A	N/A	N/A	2037456
22'44'56'-HexaCB-(154)	ng/L	0.0686	0.0013	N/A	N/A	N/A	2037456

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Maxxam Analytics

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Maxxam Job #: A9G6555
Report Date: 2009/12/18

CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
22'44'66'-HexaCB-(155)	ng/L	0.0014	0.0010	N/A	N/A	N/A	2037456
HexaCB-(156)+(157)	ng/L	0.360	0.0044	0.0000300	0.0000108	N/A	2037456
233'44'6-HexaCB-(158)	ng/L	0.339	0.0036	N/A	N/A	N/A	2037456
233'455'-HexaCB-(159)	ng/L	0.0236	0.0040	N/A	N/A	N/A	2037456
233'456-HexaCB-(160)	ng/L	<0.0040	0.0040	N/A	N/A	N/A	2037456
233'45'6-HexaCB-(161)	ng/L	<0.0039	0.0039	N/A	N/A	N/A	2037456
233'4'55'-HexaCB-(162)	ng/L	<0.0091	0.0091	N/A	N/A	N/A	2037456
233'4'5'6-HexaCB-(164)	ng/L	0.256	0.0040	N/A	N/A	N/A	2037456
233'55'6-HexaCB-(165)	ng/L	<0.0043	0.0043	N/A	N/A	N/A	2037456
23'44'55'-HexaCB-(167)	ng/L	0.133	0.0043	0.0000300	0.00000399	N/A	2037456
33'44'55'-HexaCB-(169)	ng/L	<0.0044	0.0044	0.0300	0.000132	N/A	2037456
22'33'44'5-HeptaCB-(170)	ng/L	1.05	0.0042	N/A	N/A	N/A	2037456
HeptaCB-(171)+(173)	ng/L	0.246	0.0045	N/A	N/A	N/A	2037456
22'33'455'-HeptaCB-(172)	ng/L	0.163	0.0046	N/A	N/A	N/A	2037456
22'33'456'-HeptaCB-(174)	ng/L	0.797	0.0041	N/A	N/A	N/A	2037456
22'33'45'6-HeptaCB-(175)	ng/L	0.0439	0.00094	N/A	N/A	N/A	2037456
22'33'466'-HeptaCB-(176)	ng/L	0.115	0.00074	N/A	N/A	N/A	2037456
22'33'45'6'-HeptaCB-(177)	ng/L	0.478	0.0044	N/A	N/A	N/A	2037456
22'33'55'6-HeptaCB-(178)	ng/L	0.192	0.00099	N/A	N/A	N/A	2037456
22'33'566'-HeptaCB-(179)	ng/L	0.330	0.00073	N/A	N/A	N/A	2037456
HeptaCB-(180)+(193)	ng/L	2.05	0.0036	N/A	N/A	N/A	2037456
22'344'56-HeptaCB-(181)	ng/L	<0.0042	0.0042	N/A	N/A	N/A	2037456
22'344'56'-HeptaCB-(182)	ng/L	0.00898	0.00093	N/A	N/A	N/A	2037456
22'344'5'6-HeptaCB-(183)	ng/L	0.557	0.0041	N/A	N/A	N/A	2037456
22'344'66'-HeptaCB-(184)	ng/L	0.00389	0.00072	N/A	N/A	N/A	2037456
22'3455'6-HeptaCB-(185)	ng/L	<0.0042	0.0042	N/A	N/A	N/A	2037456
22'34566'-HeptaCB-(186)	ng/L	<0.00077	0.00077	N/A	N/A	N/A	2037456
22'34'55'6-HeptaCB-(187)	ng/L	1.14	0.00090	N/A	N/A	N/A	2037456
22'34'566'-HeptaCB-(188)	ng/L	0.00546	0.00085	N/A	N/A	N/A	2037456

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Maxxam Job #: A9G6555
Report Date: 2009/12/18

CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
233'44'55'-HeptaCB-(189)	ng/L	0.0385	0.0052	0.0000300	0.00000116	N/A	2037456
233'44'56-HeptaCB-(190)	ng/L	0.170	0.0036	N/A	N/A	N/A	2037456
233'44'5'6-HeptaCB-(191)	ng/L	0.0349	0.0035	N/A	N/A	N/A	2037456
233'455'6-HeptaCB-(192)	ng/L	<0.0038	0.0038	N/A	N/A	N/A	2037456
22'33'44'55'-OctaCB-(194)	ng/L	0.474	0.0031	N/A	N/A	N/A	2037456
22'33'44'56-OctaCB-(195)	ng/L	0.165	0.0033	N/A	N/A	N/A	2037456
22'33'44'56'-OctaCB-(196)	ng/L	0.277	0.0012	N/A	N/A	N/A	2037456
22'33'44'66'OctaCB-(197)	ng/L	<0.013	0.013	N/A	N/A	N/A	2037456
OctaCB-(198)+(199)	ng/L	0.650	0.0012	N/A	N/A	N/A	2037456
22'33'4566'-OctaCB-(200)	ng/L	0.0659	0.00092	N/A	N/A	N/A	2037456
22'33'45'66'-OctaCB-(201)	ng/L	0.0782	0.00084	N/A	N/A	N/A	2037456
22'33'55'66'-OctaCB-(202)	ng/L	0.122	0.0010	N/A	N/A	N/A	2037456
22'344'55'6-OctaCB-(203)	ng/L	0.399	0.0011	N/A	N/A	N/A	2037456
22'344'566'-OctaCB-(204)	ng/L	<0.00087	0.00087	N/A	N/A	N/A	2037456
233'44'55'6-OctaCB-(205)	ng/L	<0.022	0.022	N/A	N/A	N/A	2037456
22'33'44'55'6-NonaCB-(206)	ng/L	0.336	0.0027	N/A	N/A	N/A	2037456
22'33'44'566'-NonaCB-(207)	ng/L	<0.040	0.040	N/A	N/A	N/A	2037456
22'33'455'66'-NonaCB-(208)	ng/L	0.113	0.0028	N/A	N/A	N/A	2037456
DecaCB-(209)	ng/L	0.109	0.0027	N/A	N/A	N/A	2037456
Monochlorobiphenyl	ng/L	0.0389	0.0013	N/A	N/A	N/A	2037456
Dichlorobiphenyl	ng/L	1.16	0.0086	N/A	N/A	N/A	2037456
Trichlorobiphenyl	ng/L	0.804	0.0042	N/A	N/A	N/A	2037456
Tetrachlorobiphenyl	ng/L	2.99	0.0034	N/A	N/A	N/A	2037456
Pentachlorobiphenyl	ng/L	11.8	0.0030	N/A	N/A	N/A	2037456
Hexachlorobiphenyl	ng/L	14.5	0.0061	N/A	N/A	N/A	2037456
Heptachlorobiphenyl	ng/L	7.43	0.0052	N/A	N/A	N/A	2037456
Octachlorobiphenyl	ng/L	2.23	0.0033	N/A	N/A	N/A	2037456
Nonachlorobiphenyl	ng/L	0.449	0.0028	N/A	N/A	N/A	2037456
Decachlorobiphenyl	ng/L	0.109	0.0028	N/A	N/A	N/A	2037456

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Maxxam Job #: A9G6555
Report Date: 2009/12/18

CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
Total PCB	ng/L	41.5	N/A	N/A	N/A	N/A	2037456
TOTAL TOXIC EQUIVALENCY	ng/L	N/A	N/A	N/A	0.00451	N/A	N/A
Surrogate Recovery (%)							
C13-2,44'-TriCB-(28)	%	123	N/A	N/A	N/A	N/A	2037456
C13-22'33'44'55'6-NonaCB-(206)	%	100	N/A	N/A	N/A	N/A	2037456
C13-22'33'44'5-HeptaCB-(170)	%	113	N/A	N/A	N/A	N/A	2037456
C13-22'33'455'66'-NonaCB-(208)	%	100	N/A	N/A	N/A	N/A	2037456
C13-22'33'55'66'-OctaCB-(202)	%	116	N/A	N/A	N/A	N/A	2037456
C13-22'33'55'6-HeptaCB-(178)	%	114	N/A	N/A	N/A	N/A	2037456
C13-22'344'55'-HeptaCB-(180)	%	116	N/A	N/A	N/A	N/A	2037456
C13-22'34'566'-HeptaCB-(188)	%	105	N/A	N/A	N/A	N/A	2037456
C13-22'44'66'-HexaCB-(155)	%	117	N/A	N/A	N/A	N/A	2037456
C13-22'466'-PentaCB-(104)	%	106	N/A	N/A	N/A	N/A	2037456
C13-22'66'-TetraCB-(54)	%	92	N/A	N/A	N/A	N/A	2037456
C13-22'6-TriCB-(19)	%	85	N/A	N/A	N/A	N/A	2037456
C13-22'-DiCB-(4)	%	77	N/A	N/A	N/A	N/A	2037456
C13-233'44'55'6-OctaCB-(205)	%	97	N/A	N/A	N/A	N/A	2037456
C13-233'44'55'-HeptaCB-(189)	%	113	N/A	N/A	N/A	N/A	2037456
C13-233'44'-PentaCB-(105)	%	99	N/A	N/A	N/A	N/A	2037456
C13-233'55'-PentaCB-(111)	%	109	N/A	N/A	N/A	N/A	2037456
C13-23'44'55'-HexaCB-(167)	%	109	N/A	N/A	N/A	N/A	2037456
C13-2344'5-PentaCB-(114)	%	103	N/A	N/A	N/A	N/A	2037456
C13-23'44'5-PentaCB-(118)	%	102	N/A	N/A	N/A	N/A	2037456
C13-2'344'5-PentaCB-(123)	%	104	N/A	N/A	N/A	N/A	2037456
C13-2-MonoCB-(1)	%	78	N/A	N/A	N/A	N/A	2037456
C13-33'44'55'-HexaCB-(169)	%	86	N/A	N/A	N/A	N/A	2037456
C13-33'44'5-PentaCB-(126)	%	93	N/A	N/A	N/A	N/A	2037456
C13-33'44'-TetraCB-(77)	%	99	N/A	N/A	N/A	N/A	2037456
C13-344'5-TetraCB-(81)	%	105	N/A	N/A	N/A	N/A	2037456

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CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

SEMI-VOLATILE ORGANICS BY HRMS (WATER)

Maxxam ID		EP2747					
Sampling Date		2009/12/07 10:35					
COC Number		na		TOXIC EQUIVALENCY		# of	
	Units	MS4-SD1	EDL	TEF (2005 WHO)	TEQ(DL)	Isomers	QC Batch
C13-344'-TriCB-(37)	%	112	N/A	N/A	N/A	N/A	2037456
C13-44'-DiCB-(15)	%	91	N/A	N/A	N/A	N/A	2037456
C13-4-MonoCB-(3)	%	85	N/A	N/A	N/A	N/A	2037456
C13-DecaCB-(209)	%	95	N/A	N/A	N/A	N/A	2037456
C13-HexaCB-(156)+(157)	%	102	N/A	N/A	N/A	N/A	2037456

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CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Client Project #: 09-12-0619

Test Summary

Maxxam ID	EP2747	**Collected**	2009/12/07
Sample ID	MS4-SD1	**Shipped**	
Matrix	Water	**Received**	2009/12/09

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
PCB Congeners in Water (1668A)	HRMS/MS	2037456	2009/12/16	2009/12/16	BY

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Package 1	2.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Results relate only to the items tested.

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Maxxam Analytics

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CALSCIENCE ENVIRONMENTAL LABORATORIES INC
Attention: Virendra Patel
Client Project #: 09-12-0619
P.O. #:
Project name:

Quality Assurance Report

Maxxam Job Number: GA9G6555

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
2037456 BY	Spiked Blank	C13-2,44'-TriCB-(28)	2009/12/16		106	%	40 - 125
		C13-22'33'44'55'6-NonaCB-(206)	2009/12/16		101	%	30 - 140
		C13-22'33'44'5-HeptaCB-(170)	2009/12/16		103	%	30 - 140
		C13-22'33'455'66'-NonaCB-(208)	2009/12/16		101	%	30 - 140
		C13-22'33'55'66'-OctaCB-(202)	2009/12/16		94	%	30 - 140
		C13-22'33'55'6-HeptaCB-(178)	2009/12/16		116	%	40 - 125
		C13-22'344'55'-HeptaCB-(180)	2009/12/16		104	%	30 - 140
		C13-22'34'566'-HeptaCB-(188)	2009/12/16		102	%	30 - 140
		C13-22'44'66'-HexaCB-(155)	2009/12/16		95	%	30 - 140
		C13-22'466'-PentaCB-(104)	2009/12/16		94	%	30 - 140
		C13-22'66'-TetraCB-(54)	2009/12/16		81	%	30 - 140
		C13-22'6-TriCB-(19)	2009/12/16		82	%	30 - 140
		C13-22'-DiCB-(4)	2009/12/16		74	%	30 - 140
		C13-233'44'55'6-OctaCB-(205)	2009/12/16		111	%	30 - 140
		C13-233'44'55'-HeptaCB-(189)	2009/12/16		113	%	30 - 140
		C13-233'44'-PentaCB-(105)	2009/12/16		124	%	30 - 140
		C13-233'55'-PentaCB-(111)	2009/12/16		119	%	40 - 125
		C13-23'44'55'-HexaCB-(167)	2009/12/16		121	%	30 - 140
		C13-2344'5-PentaCB-(114)	2009/12/16		117	%	30 - 140
		C13-23'44'5-PentaCB-(118)	2009/12/16		120	%	30 - 140
		C13-2'344'5-PentaCB-(123)	2009/12/16		122	%	30 - 140
		C13-2-MonoCB-(1)	2009/12/16		72	%	15 - 140
		C13-33'44'55'-HexaCB-(169)	2009/12/16		121	%	30 - 140
		C13-33'44'5-PentaCB-(126)	2009/12/16		127	%	30 - 140
		C13-33'44'-TetraCB-(77)	2009/12/16		120	%	30 - 140
		C13-344'5-TetraCB-(81)	2009/12/16		120	%	30 - 140
		C13-344'-TriCB-(37)	2009/12/16		108	%	30 - 140
		C13-44'-DiCB-(15)	2009/12/16		91	%	30 - 140
		C13-4-MonoCB-(3)	2009/12/16		77	%	15 - 140
		C13-DecaCB-(209)	2009/12/16		95	%	30 - 140
		C13-HexaCB-(156)+(157)	2009/12/16		123	%	30 - 140
		2-MonoCB-(1)	2009/12/16		106	%	50 - 150
		4-MonoCB-(3)	2009/12/16		105	%	50 - 150
		22'-DiCB-(4)	2009/12/16		100	%	50 - 150
		4,4'-DiCB-(15)	2009/12/16		106	%	50 - 150
		22'6-TriCB-(19)	2009/12/16		95	%	50 - 150
		235-TriCB-(23)	2009/12/16		95	%	50 - 150
		23'5'-TriCB-(34)	2009/12/16		92	%	50 - 150
		344'-TriCB-(37)	2009/12/16		107	%	50 - 150
		22'66'-TetraCB-(54)	2009/12/16		106	%	50 - 150
		33'44'-TetraCB-(77)	2009/12/16		107	%	50 - 150
		344'5-TetraCB-(81)	2009/12/16		107	%	50 - 150
		22'466'-PentaCB-(104)	2009/12/16		103	%	50 - 150
		233'44'-PentaCB-(105)	2009/12/16		105	%	50 - 150
		2344'5-PentaCB-(114)	2009/12/16		108	%	50 - 150
		23'44'5-PentaCB-(118)	2009/12/16		108	%	50 - 150
		23'44'5'-PentaCB-(123)	2009/12/16		104	%	50 - 150
		33'44'5-PentaCB-(126)	2009/12/16		106	%	50 - 150
		22'44'66'-HexaCB-(155)	2009/12/16		108	%	50 - 150
		HexaCB-(156)+(157)	2009/12/16		105	%	50 - 150
		23'44'55'-HexaCB-(167)	2009/12/16		104	%	50 - 150
		33'44'55'-HexaCB-(169)	2009/12/16		105	%	50 - 150
		22'33'44'5-HeptaCB-(170)	2009/12/16		106	%	50 - 150
		HeptaCB-(180)+(193)	2009/12/16		93	%	50 - 150
		22'344'56'-HeptaCB-(182)	2009/12/16		101	%	50 - 150

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2037456 BY	Spiked Blank	22'34'55'6-HeptaCB-(187)	2009/12/16		102	%	50 - 150
		22'34'566'-HeptaCB-(188)	2009/12/16		106	%	50 - 150
		233'44'55'-HeptaCB-(189)	2009/12/16		105	%	50 - 150
		22'33'55'66'-OctaCB-(202)	2009/12/16		107	%	50 - 150
		233'44'55'6-OctaCB-(205)	2009/12/16		106	%	50 - 150
		22'33'44'55'6-NonaCB-(206)	2009/12/16		107	%	50 - 150
		22'33'455'66'-NonaCB-(208)	2009/12/16		107	%	50 - 150
		DecaCB-(209)	2009/12/16		104	%	50 - 150
	Method Blank	C13-2,44'-TriCB-(28)	2009/12/16		90	%	40 - 125
		C13-22'33'44'55'6-NonaCB-(206)	2009/12/16		80	%	30 - 140
		C13-22'33'44'5-HeptaCB-(170)	2009/12/16		85	%	30 - 140
		C13-22'33'455'66'-NonaCB-(208)	2009/12/16		81	%	30 - 140
		C13-22'33'55'66'-OctaCB-(202)	2009/12/16		75	%	30 - 140
		C13-22'33'55'6-HeptaCB-(178)	2009/12/16		93	%	40 - 125
		C13-22'344'55'-HeptaCB-(180)	2009/12/16		84	%	30 - 140
		C13-22'34'566'-HeptaCB-(188)	2009/12/16		80	%	30 - 140
		C13-22'44'66'-HexaCB-(155)	2009/12/16		77	%	30 - 140
		C13-22'466'-PentaCB-(104)	2009/12/16		80	%	30 - 140
		C13-22'66'-TetraCB-(54)	2009/12/16		68	%	30 - 140
		C13-22'6-TriCB-(19)	2009/12/16		70	%	30 - 140
		C13-22'-DiCB-(4)	2009/12/16		63	%	30 - 140
		C13-233'44'55'6-OctaCB-(205)	2009/12/16		87	%	30 - 140
		C13-233'44'55'-HeptaCB-(189)	2009/12/16		97	%	30 - 140
		C13-233'44'-PentaCB-(105)	2009/12/16		98	%	30 - 140
		C13-233'55'-PentaCB-(111)	2009/12/16		98	%	40 - 125
		C13-23'44'55'-HexaCB-(167)	2009/12/16		94	%	30 - 140
		C13-2344'5-PentaCB-(114)	2009/12/16		94	%	30 - 140
		C13-23'44'5-PentaCB-(118)	2009/12/16		96	%	30 - 140
		C13-2'344'5-PentaCB-(123)	2009/12/16		96	%	30 - 140
		C13-2-MonoCB-(1)	2009/12/16		63	%	15 - 140
		C13-33'44'55'-HexaCB-(169)	2009/12/16		79	%	30 - 140
		C13-33'44'5-PentaCB-(126)	2009/12/16		98	%	30 - 140
		C13-33'44'-TetraCB-(77)	2009/12/16		92	%	30 - 140
		C13-344'5-TetraCB-(81)	2009/12/16		96	%	30 - 140
		C13-344'-TriCB-(37)	2009/12/16		87	%	30 - 140
		C13-44'-DiCB-(15)	2009/12/16		79	%	30 - 140
		C13-4-MonoCB-(3)	2009/12/16		67	%	15 - 140
		C13-DecaCB-(209)	2009/12/16		75	%	30 - 140
		C13-HexaCB-(156)+(157)	2009/12/16		95	%	30 - 140
		2-MonoCB-(1)	2009/12/16	<0.0013		ng/L	
		3-MonoCB-(2)	2009/12/16	<0.0013		ng/L	
		4-MonoCB-(3)	2009/12/16	<0.0028		ng/L	
		22'-DiCB-(4)	2009/12/16	<0.0051		ng/L	
		2,3-DiCB-(5)	2009/12/16	<0.0076		ng/L	
		2,3'-DiCB-(6)	2009/12/16	<0.0066		ng/L	
		2,4-DiCB-(7)	2009/12/16	<0.0066		ng/L	
		2,4'-DiCB-(8)	2009/12/16	<0.0084		ng/L	
		2,5-DiCB-(9)	2009/12/16	<0.0064		ng/L	
		2,6-DiCB-(10)	2009/12/16	<0.0053		ng/L	
		3,3'-DiCB-(11)	2009/12/16	<0.033		ng/L	
		DiCB-(12)+(13)	2009/12/16	<0.0066		ng/L	
		3,5-DiCB-(14)	2009/12/16	<0.0064		ng/L	
		4,4'-DiCB-(15)	2009/12/16	<0.0092		ng/L	
		22'3-TriCB-(16)	2009/12/16	0.0051, EDL=0.0027		ng/L	
		22'4-TriCB-(17)	2009/12/16	<0.0032		ng/L	

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2037456 BY	Method Blank	TriCB-(18)+(30)	2009/12/16	0.0096, EDL=0.0016		ng/L	
		22'6-TriCB-(19)	2009/12/16	<0.0016		ng/L	
		TriCB-(20) + (28)	2009/12/16	0.0139, EDL=0.00088		ng/L	
		TriCB-(21)+(33)	2009/12/16	0.00647, EDL=0.00084		ng/L	
		234'-TriCB-(22)	2009/12/16	<0.0039		ng/L	
		235-TriCB-(23)	2009/12/16	<0.00092		ng/L	
		236-TriCB-(24)	2009/12/16	<0.0013		ng/L	
		23'4-TriCB-(25)	2009/12/16	0.00110, EDL=0.00080		ng/L	
		TriCB-(26)+(29)	2009/12/16	0.00185, EDL=0.00085		ng/L	
		23'6-TriCB-(27)	2009/12/16	<0.0014		ng/L	
		24'5-TriCB-(31)	2009/12/16	0.0119, EDL=0.00081		ng/L	
		24'6-TriCB-(32)	2009/12/16	<0.0027		ng/L	
		23'5'-TriCB-(34)	2009/12/16	<0.00088		ng/L	
		33'4-TriCB-(35)	2009/12/16	<0.00085		ng/L	
		33'5-TriCB-(36)	2009/12/16	<0.00076		ng/L	
		344'-TriCB-(37)	2009/12/16	<0.0036		ng/L	
		345-TriCB-(38)	2009/12/16	<0.00087		ng/L	
		34'5-TriCB-(39)	2009/12/16	<0.00083		ng/L	
		TetraCB-(40)+(41)+(71)	2009/12/16	<0.0031		ng/L	
		22'34'-TetraCB-(42)	2009/12/16	<0.0024		ng/L	
		22'35-TetraCB-(43)	2009/12/16	<0.0019		ng/L	
		TetraCB-(44)+(47)+(65)	2009/12/16	0.0143, EDL=0.0014		ng/L	
		TetraCB-(45)+(51)	2009/12/16	<0.0024		ng/L	
		22'36'-TetraCB-(46)	2009/12/16	<0.0018		ng/L	
		22'45-TetraCB-(48)	2009/12/16	<0.0013		ng/L	
		TetraCB-(49)+TetraCB-(69)	2009/12/16	0.0065, EDL=0.0013		ng/L	
		TetraCB-(50)+(53)	2009/12/16	<0.0015		ng/L	
		22'55'-TetraCB-(52)	2009/12/16	0.0263, EDL=0.0014		ng/L	
		22'66'-TetraCB-(54)	2009/12/16	<0.0010		ng/L	
		233'4-TetraCB-(55)	2009/12/16	<0.0012		ng/L	
		233'4'-Tetra CB(56)	2009/12/16	<0.0025		ng/L	
		233'5-TetraCB-(57)	2009/12/16	<0.0011		ng/L	
		233'5'-TetraCB-(58)	2009/12/16	<0.0011		ng/L	
		TetraCB-(59)+(62)+(75)	2009/12/16	<0.0012		ng/L	
		2344'-TetraCB -(60)	2009/12/16	<0.0017		ng/L	
		TetraCB-(61)+(70)+(74)+(76)	2009/12/16	0.0167, EDL=0.0011		ng/L	
		234'5-TetraCB-(63)	2009/12/16	<0.0011		ng/L	
		234'6-TetraCB-(64)	2009/12/16	<0.0027		ng/L	
		23'44'-TetraCB-(66)	2009/12/16	0.0071, EDL=0.0011		ng/L	
		23'45-TetraCB-(67)	2009/12/16	<0.0010		ng/L	
		23'45'-TetraCB-(68)	2009/12/16	<0.0010		ng/L	
		23'55'-TetraCB-(72)	2009/12/16	<0.0011		ng/L	
		23'5'6-TetraCB-(73)	2009/12/16	<0.0012		ng/L	
		33'44'-TetraCB-(77)	2009/12/16	0.0015, EDL=0.0013		ng/L	
		33'45-TetraCB-(78)	2009/12/16	<0.0011		ng/L	
		33'45'-TetraCB(79)	2009/12/16	<0.00097		ng/L	
		33'55'-TetraCB-(80)	2009/12/16	<0.0010		ng/L	
		344'5-TetraCB-(81)	2009/12/16	<0.0013		ng/L	
		22'33'4-PentaCB-(82)	2009/12/16	<0.00052		ng/L	
		PentaCB-(83)+(99)	2009/12/16	0.00853, EDL=0.00047		ng/L	
		22'33'6-PentaCB-(84)	2009/12/16	<0.0056		ng/L	
		PentaCB-(85)+(116)+(117)	2009/12/16	<0.00040		ng/L	
		PentaCB-(86)(87)(97)(109)(119)(125)	2009/12/16	0.0256, EDL=0.00041		ng/L	
		PentaCB-(88)+(91)	2009/12/16	<0.00081		ng/L	
		22'346'-PentaCB-(89)	2009/12/16	<0.00049		ng/L	

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2037456 BY	Method Blank	PentaCB-(90)+(101)+(113)	2009/12/16	0.0930, EDL=0.00042		ng/L	
		22'355'-PentaCB-(92)	2009/12/16	0.0137, EDL=0.00047		ng/L	
		PentaCB-(93)+(98)+(100)+(102)	2009/12/16	<0.00047		ng/L	
		22'356'-PentaCB-(94)	2009/12/16	<0.00051		ng/L	
		22'35'6-PentaCB-(95)	2009/12/16	0.0687, EDL=0.00045		ng/L	
		22'366'-PentaCB-(96)	2009/12/16	<0.00061		ng/L	
		22'45'6-PentaCB-(103)	2009/12/16	<0.00043		ng/L	
		22'466'-PentaCB-(104)	2009/12/16	<0.00051		ng/L	
		233'44'-PentaCB-(105)	2009/12/16	<0.0049		ng/L	
		233'45-PentaCB-(106)	2009/12/16	<0.0014		ng/L	
		233'4'5-PentaCB-(107)	2009/12/16	<0.0013		ng/L	
		PentaCB-(108)+(124)	2009/12/16	<0.0014		ng/L	
		PentaCB-(110)+(115)	2009/12/16	0.0630, EDL=0.00039		ng/L	
		233'55'-PentaCB-(111)	2009/12/16	<0.00035		ng/L	
		233'56-PentaCB-(112)	2009/12/16	<0.00036		ng/L	
		2344'5-PentaCB-(114)	2009/12/16	<0.0015		ng/L	
		23'44'5-PentaCB-(118)	2009/12/16	0.0402, EDL=0.0015		ng/L	
		23'455'-PentaCB-(120)	2009/12/16	<0.00033		ng/L	
		23'45'6-PentaCB-(121)	2009/12/16	<0.00036		ng/L	
		233'4'5'-PentaCB-(122)	2009/12/16	<0.0015		ng/L	
		23'44'5'-PentaCB-(123)	2009/12/16	<0.0015		ng/L	
		33'44'5-PentaCB-(126)	2009/12/16	<0.0015		ng/L	
		33'455'-PentaCB-(127)	2009/12/16	<0.0013		ng/L	
		HexaCB-(128)+(166)	2009/12/16	<0.0082		ng/L	
		HexaCB-(129)+(138)+(163)	2009/12/16	0.128, EDL=0.0033		ng/L	
		22'33'45'-HexaCB-(130)	2009/12/16	0.0069, EDL=0.0039		ng/L	
		22'33'46-HexaCB-(131)	2009/12/16	<0.0039		ng/L	
		22'33'46'-HexaCB-(132)	2009/12/16	0.0444, EDL=0.0040		ng/L	
		22'33'55'-HexaCB-(133)	2009/12/16	<0.0037		ng/L	
		HexaCB-(134)+(143)	2009/12/16	<0.0052		ng/L	
		HexaCB-(135)+(151)	2009/12/16	0.0495, EDL=0.00073		ng/L	
		22'33'66'-HexaCB-(136)	2009/12/16	0.0188, EDL=0.00054		ng/L	
		22'344'5-HexaCB-(137)	2009/12/16	<0.0035		ng/L	
		HexaCB-(139)+(140)	2009/12/16	<0.0035		ng/L	
		22'3455'-HexaCB-(141)	2009/12/16	0.0296, EDL=0.0037		ng/L	
		22'3456-HexaCB-(142)	2009/12/16	<0.0039		ng/L	
		22'345'6-HexaCB-(144)	2009/12/16	<0.0083		ng/L	
		22'3466'-HexaCB-(145)	2009/12/16	<0.00057		ng/L	
		22'34'55'-HexaCB-(146)	2009/12/16	0.0175, EDL=0.0032		ng/L	
		HexaCB-(147)+(149)	2009/12/16	0.105, EDL=0.0040		ng/L	
		22'34'56'-HexaCB-(148)	2009/12/16	<0.00072		ng/L	
		22'34'66'-HexaCB-(150)	2009/12/16	<0.00056		ng/L	
		22'3566'-HexaCB-(152)	2009/12/16	<0.00053		ng/L	
		HexaCB-(153)+(168)	2009/12/16	0.107, EDL=0.0028		ng/L	
		22'44'56'-HexaCB-(154)	2009/12/16	<0.00063		ng/L	
		22'44'66'-HexaCB-(155)	2009/12/16	<0.00049		ng/L	
		HexaCB-(156)+(157)	2009/12/16	<0.011		ng/L	
		233'44'6-HexaCB-(158)	2009/12/16	0.0135, EDL=0.0025		ng/L	
		233'455'-HexaCB-(159)	2009/12/16	<0.00039		ng/L	
		233'456-HexaCB-(160)	2009/12/16	<0.0028		ng/L	
		233'45'6-HexaCB-(161)	2009/12/16	<0.0027		ng/L	
		233'4'55'-HexaCB-(162)	2009/12/16	<0.00040		ng/L	
		233'4'5'6-HexaCB-(164)	2009/12/16	0.0124, EDL=0.0028		ng/L	
		233'55'6-HexaCB-(165)	2009/12/16	<0.0030		ng/L	
		23'44'55'-HexaCB-(167)	2009/12/16	0.00512, EDL=0.00042		ng/L	

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2037456 BY	Method Blank	33'44'55'-HexaCB-(169)	2009/12/16	<0.00043		ng/L	
		22'33'44'5-HeptaCB-(170)	2009/12/16	0.0309, EDL=0.0010		ng/L	
		HeptaCB-(171)+(173)	2009/12/16	0.0100, EDL=0.0011		ng/L	
		22'33'455'-HeptaCB-(172)	2009/12/16	0.0049, EDL=0.0011		ng/L	
		22'33'456'-HeptaCB-(174)	2009/12/16	0.0201, EDL=0.00097		ng/L	
		22'33'45'6-HeptaCB-(175)	2009/12/16	<0.00089		ng/L	
		22'33'466'-HeptaCB-(176)	2009/12/16	<0.0039		ng/L	
		22'33'45'6'-HeptaCB-(177)	2009/12/16	0.0125, EDL=0.0011		ng/L	
		22'33'55'6-HeptaCB-(178)	2009/12/16	<0.0044		ng/L	
		22'33'566'-HeptaCB-(179)	2009/12/16	0.0101, EDL=0.00035		ng/L	
		HeptaCB-(180)+(193)	2009/12/16	0.0522, EDL=0.00087		ng/L	
		22'344'56-HeptaCB-(181)	2009/12/16	<0.0010		ng/L	
		22'344'56'-HeptaCB-(182)	2009/12/16	<0.00044		ng/L	
		22'344'5'6-HeptaCB-(183)	2009/12/16	0.0125, EDL=0.00099		ng/L	
		22'344'66'-HeptaCB-(184)	2009/12/16	<0.00034		ng/L	
		22'3455'6-HeptaCB-(185)	2009/12/16	<0.0010		ng/L	
		22'34566'-HeptaCB-(186)	2009/12/16	<0.00037		ng/L	
		22'34'55'6-HeptaCB-(187)	2009/12/16	0.0252, EDL=0.00043		ng/L	
		22'34'566'-HeptaCB-(188)	2009/12/16	<0.00040		ng/L	
		233'44'55'-HeptaCB-(189)	2009/12/16	0.00191, EDL=0.00088		ng/L	
		233'44'56-HeptaCB-(190)	2009/12/16	0.00504, EDL=0.00086		ng/L	
		233'44'5'6-HeptaCB-(191)	2009/12/16	<0.00083		ng/L	
		233'455'6-HeptaCB-(192)	2009/12/16	<0.00091		ng/L	
		22'33'44'55'-OctaCB-(194)	2009/12/16	0.0073, EDL=0.0016		ng/L	
		22'33'44'56-OctaCB-(195)	2009/12/16	0.0035, EDL=0.0017		ng/L	
		22'33'44'56'-OctaCB-(196)	2009/12/16	0.00448, EDL=0.00088		ng/L	
		22'33'44'66'OctaCB-(197)	2009/12/16	<0.0014		ng/L	
		OctaCB-(198)+(199)	2009/12/16	<0.0051		ng/L	
		22'33'4566'-OctaCB-(200)	2009/12/16	<0.00068		ng/L	
		22'33'45'66'-OctaCB-(201)	2009/12/16	0.00108, EDL=0.00063		ng/L	
		22'33'55'66'-OctaCB-(202)	2009/12/16	<0.0013		ng/L	
		22'344'55'6-OctaCB-(203)	2009/12/16	0.00508, EDL=0.00085		ng/L	
		22'344'566'-OctaCB-(204)	2009/12/16	<0.00065		ng/L	
		233'44'55'6-OctaCB-(205)	2009/12/16	<0.0013		ng/L	
		22'33'44'55'6-NonaCB-(206)	2009/12/16	<0.00089		ng/L	
		22'33'44'566'-NonaCB-(207)	2009/12/16	<0.00077		ng/L	
		22'33'455'66'-NonaCB-(208)	2009/12/16	<0.00093		ng/L	
		DecaCB-(209)	2009/12/16	<0.0011		ng/L	
		Monochlorobiphenyl	2009/12/16	<0.0014		ng/L	
		Dichlorobiphenyl	2009/12/16	<0.0092		ng/L	
		Trichlorobiphenyl	2009/12/16	0.0499, EDL=0.0027		ng/L	
		Tetrachlorobiphenyl	2009/12/16	0.0724, EDL=0.0019		ng/L	
		Pentachlorobiphenyl	2009/12/16	0.313, EDL=0.0015		ng/L	
		Hexachlorobiphenyl	2009/12/16	0.537, EDL=0.0043		ng/L	
		Heptachlorobiphenyl	2009/12/16	0.185, EDL=0.0011		ng/L	
		Octachlorobiphenyl	2009/12/16	0.0214, EDL=0.0017		ng/L	
		Nonachlorobiphenyl	2009/12/16	<0.00093		ng/L	
		Decachlorobiphenyl	2009/12/16	<0.0011		ng/L	
		Total PCB	2009/12/16	1.18, EDL=0		ng/L	

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

Validation Signature Page

Maxxam Job #: A9G6555

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

EDMOND MCNEIL, B.Sc.(Hons), C.Chem., Senior Scientific Specialist, HRMS Services

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Calscience Environmental Laboratories, Inc.
7440 LINCOLN WAY
GARDEN GROVE, CA 92841-1432
TEL: (714) 895-5494 . FAX: (714) 894-7501

Sub to Maxxam Laboratories

CHAIN OF CUSTODY RECORD

DATE:

PAGE: 1 OF 1

LABORATORY CLIENT: Calscience Environmental Laboratories, Inc.

ADDRESS: 7440 Lincoln Way
Garden Grove, CA 92841-1427

TEL: 714-895-5494 FAX: 714-898-2036 E-MAIL: vpatel@calscience.com

CLIENT PROJECT NAME / NUMBER: 09-12-0619

P.O. NO.:

PROJECT CONTACT: Virendra Patel

LAB USE ONLY:

SAMPLER(S) (SIGNATURE):

COELT LOG CODE:

COOLER RECEIPT: Temp = °C

TURNAROUND TIME: SAME DAY ☐ 24 HR ☐ 48HR ☐ 72 HR ☐ 5 DAYS ☒ Standard

SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY): ☐ LOCUS EIM53 EDD ☐ COELT EDF ☐

SPECIAL INSTRUCTIONS:

Report with "J" flags

REQUESTED ANALYSIS

9-Dec-09 12:27
ANCY SEBASTIAN
A9G6555
J L ENV-880

LAB USE ONLY	SAMPLE ID	Field Point Name	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT.	PCB Congeners (1668)	CONTAINER TYPE
	MS4-SD1		12/07/09	10:35	W	1	X	

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Wcbatm CEL	FedEx 958734003511	12/8/09	1215
	[illegible] ASPD BARRAU	2009/12/09	12:27

1.8/2.3/2.8°C

AMEC Earth and Environmental
San Diego Bioassay Laboratory
AMEC Test Log Numbers: 0111-126, -127; -128
Prepared: 8 January 2002

SUMMARY REPORT

Client: Southwest Marine
Sample ID: 011-070 Municipal Stormwater

Sample Information

Sample Date:	11/29/01
Sample Time:	1200
Sample Receipt Date at Laboratory:	11/29/01
Test Material Matrix:	Liquid
Sampling Method:	Grab
Sample Container Size:	4-liter poly cubitainers; amber glass as appropriate for analyses

Toxicity Testing Specifications

Test Series Initiation Date:	11/30/01
Test Series Termination Date:	12/7/01
Test Organism:	*Mysidopsis bahia*
Test Organism Source:	Aquatic Biosystems
Acute Organism Age:	5 days
Chronic Organism Age:	7 days
Dilution Water:	Natural Seawater (Source: Scripps Aquarium Intake)
Test Concentrations:	100% test material, laboratory and salt controls
Protocol Used:	EPA 1991 (Acute); EPA 1987 (Chronic)
Statistical Analysis Software:	TOXCALC, version 5.0

Mysid Toxicity Testing Results Summary

Test Exposure	Acute 96-hr Percent Survival	Acute TU Value	Chronic 7-day Percent Survival	Chronic TU Value	Chronic 7-day Weight Results
Lab Control	100		100		0.13 mg
Salt Control	95		92.5		0.14 mg
100% Test Material	0*	>1.0	12.5*	>1.0	0.18 mg[1]

*stat. diff. from control (Acute)   *stat. diff. from control (Chronic)   [1]no statistical difference

Summary Results of Chemical Analyses

Analyte	Sample Result	Reporting Limit	Units
Specific Conductance	20000	100	umhos/cm
pH	7.34	0.01	pH units
Total Organic Carbon	43	5	mg/L (ppm)
Oil & Grease	1.6	1.0	mg/L (ppm)
Total Suspended Solids	2200	10.0	mg/L (ppm)
Settleable Solids	43	1.0	mL/L/hr
Chemical Oxygen Demand	230	25	mg/L (ppm)
Arsenic	ND	0.0100	mg/L (ppm)
Cadmium	ND	0.0100	mg/L (ppm)
Chromium	ND	0.0100	mg/L (ppm)
Copper	0.103	0.010	mg/L (ppm)
Lead	0.0237	0.0100	mg/L (ppm)
Nickel	0.0171	0.0100	mg/L (ppm)
Silver	ND	0.0100	mg/L (ppm)
Zinc	0.306	0.050	mg/L (ppm)
Mercury	ND	0.00050	mg/L (ppm)
TPH - diesel	2100	1000	ug/L (ppb)
TPH - gas	ND	100	ug/L (ppb)
Tributyltin	16.2	1	ng/L (ppt)
Dibutyltin	17.7	1	ng/L (ppt)
Monobutyltin	ND	1	ng/L (ppt)

Results Verification/Date: SC 1/15/02

Appendix A

Toxicity Bench Sheets

Acute Mysid Test-96 Hr Survival

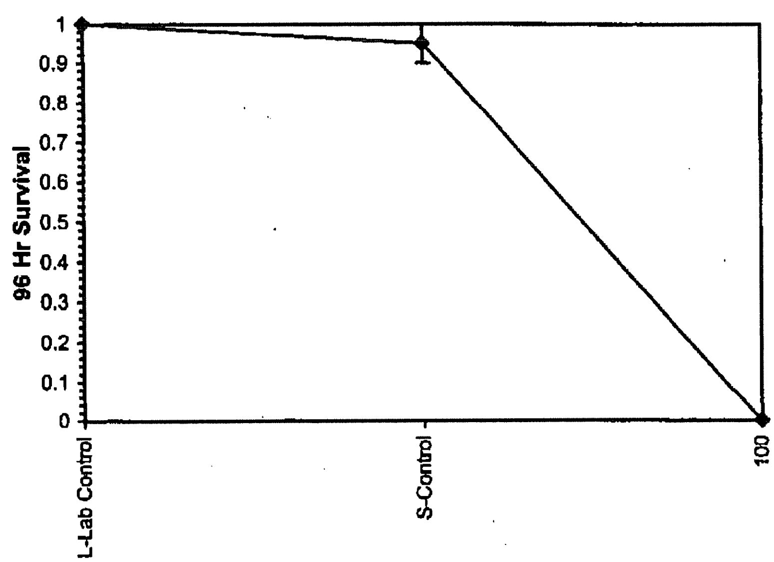
Start Date:	11/30/2001	Test ID:	0111-126	Sample ID:	SWM-South West Marine
End Date:	12/04/2001	Lab ID:	AEESD-AMEC Bioassay SD	Sample Type:	STW-Stormwater
Sample Date:	11/29/2001	Protocol:	EPAA 91-EPA Acute	Test Species:	MY-Mysidopsis bahia
Comments:					

Conc-%	1	2
L-Lab Control	1.0000	1.0000
S-Control	1.0000	0.9000
100	0.0000	0.0000

			Transform: Arcsin Square Root				
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N
L-Lab Control	1.0000	1.0526	1.4120	1.4120	1.4120	0.000	2
S-Control	0.9500	1.0000	1.3305	1.2490	1.4120	8.661	2
100	0.0000	0.0000	0.1588	0.1588	0.1588	0.000	2

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Normality of the data set cannot be confirmed				
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.42)	1	4.30266		

Dose-Response Plot



ToxCalc v5.0

Reviewed by: *[signature]* 1/15/02

Saltwater Acute

96 Hour Toxicity Test Data Sheet - Amec Bioassay Laboratory

Client: South West Marine
Facility ID: SWM
Contact: Sandor Halvax
Test #: 0111-126

Start Date & Time: 11-30-01 1615
End Date & Time: 12-4-01 1330
Test Organism: M. bahia
Test Protocol: EPA 91

Concentration or Percent	Rep	Number of Live Organisms					Dissolved Oxygen (mg/L)						pH (units)						Salinity (ppt)				Temperature (°C)						Percent Surv.
		0	24	48	72	96	0	24	48i	48f	72	96	0	24	48i	48f	72	96	0	48i	48f	96	0	24	48i	48f	72	96	
LAB CONT.	A	10	10	10	10	10	6.9	5.5	7.85	6.5	6.6	5.9	7.80	7.74	7.71	8.10	7.98	7.91	30	30	31	33	24.0	24.9	24.6	24.7	24.7	24.4	100
	B	10	10	10	10	10																							100
Salt cont.	A	10	10	10	10	10	7.1	4.9	7.80	6.4	6.6	6.1	7.97	7.85	6.8	7.15	8.16	8.04	30	30	32	34	24.1	25.3	24.2	24.6	24.8	24.3	100
	B	10	9	9	9	9																							90
100%.	A	10	0 (4)	0 (4)	(4)	0	7.9	2.1	8.0	6.3	6.0	6.0	7.97	7.37	7.88	8.13	7.91	8.05	30	29	32	34	25.1	25.5	25.3	24.6	24.7	24.1	0
	B	10	2 (4)	0 (4)	(4)	0																							0
	A																												
	B																												
	A																												
	B																												
	A																												
	B																												
	A																												
	B																												
Technician Initials		TM	ER	BR	BR	JW																							

Conc.	Alkalinity* (mg/L as $CaCO_3$) LAB	Salt	Chlorine Resid. (mg/L)	
Control	95	106	ND	ND
Highest conc.	—	93	ml	—

Sample Description: Dark brown, cloudy, heavy debris

Comments:
0 hrs: fed @ 1450
24 hrs. fed @ 0840, 1350 @ low visibility (could be more
48 hrs. fed @ 1020, 1350
72 hrs. fed @ 930, 1625
96 hrs. Fed 0950

Amec Earth and Environmental
5550 Morehouse Dr., Suite B
San Diego, CA 92121
(858) 458-9044

Reviewed: [signature] 1/14/02

QC check: JW 12-12-01

Mysid Survival, Growth and Fecundity Test-7 Day Survival

Start Date:	11/30/2001	Test ID:	0111-127	Sample ID:	SWM-South West Marine
End Date:	12/07/2001	Lab ID:	AEESD-AMEC Bioassay SD	Sample Type:	STW-Stormwater
Sample Date:	11/29/2001	Protocol:	EPAM 87-EPA Marine	Test Species:	MY-Mysidopsis bahia

Comments:

Conc-%	1	2	3	4	5	6	7	8
L-Lab Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
S-Control	1.0000	0.8000	1.0000	1.0000	1.0000	0.8000	0.8000	1.0000
100	0.0000	0.0000	0.0000	0.4000	0.2000	0.0000	0.2000	0.2000

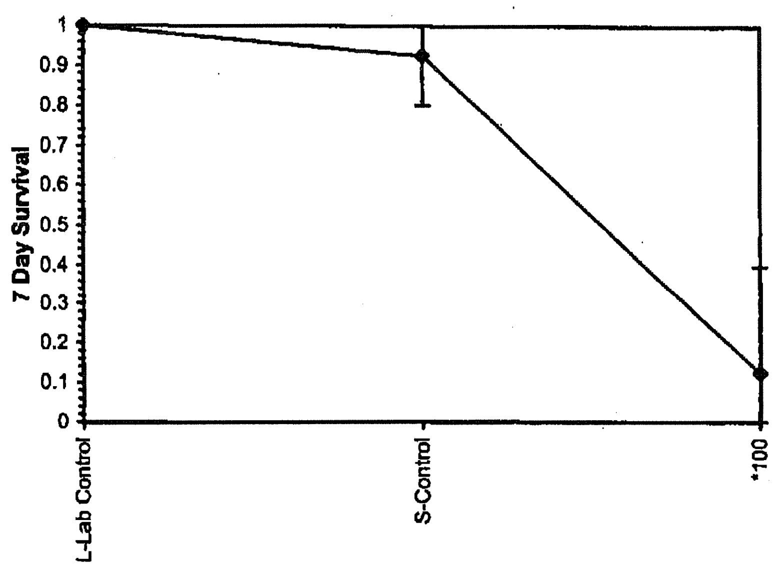
			Transform: Arcsin Square Root					Rank	1-Tailed
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical
L-Lab Control	1.0000	1.0811	1.3453	1.3453	1.3453	0.000	8		
S-Control	0.9250	1.0000	1.2560	1.1071	1.3453	9.813	8		
*100	0.1250	0.1351	0.3722	0.2255	0.6847	46.403	8	36.00	51.00

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.01)	0.76468	0.844	0.34659	-0.6866
F-Test indicates equal variances (p = 0.39)	1.96397	8.88531		
The control means are not significantly different (p = 0.06)	2.04939	2.14479		

Hypothesis Test (1-tail, 0.05)

Wilcoxon Two-Sample Test indicates significant differences

Dose-Response Plot



 ToxCalc v5.0 Reviewed by: [signature] 1/15/02

Mysid Survival, Growth and Fecundity Test-Growth-Weight

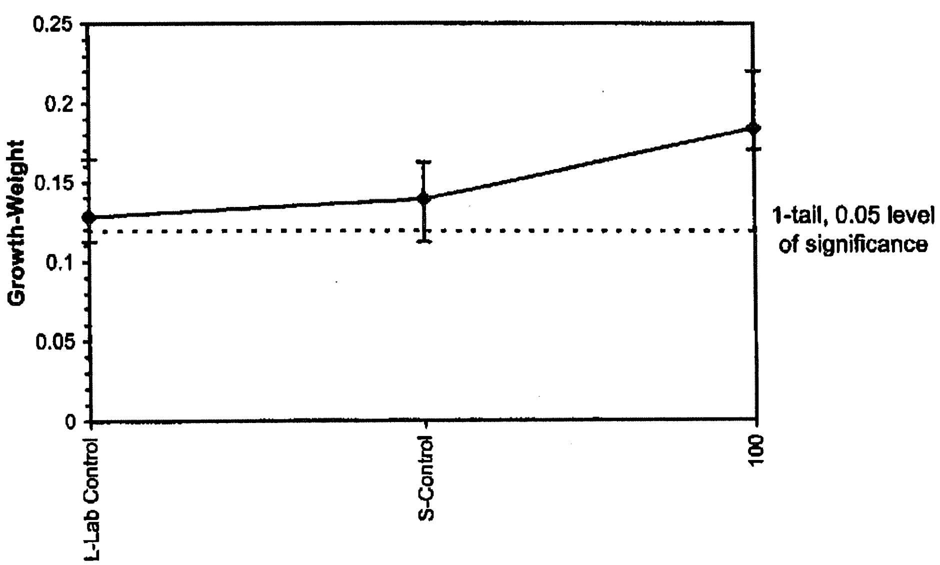
Start Date:	11/30/2001	Test ID:	0111-127	Sample ID:	SWM-South West Marine
End Date:	12/07/2001	Lab ID:	AEESD-AMEC Bioassay SD	Sample Type:	STW-Stormwater
Sample Date:	11/29/2001	Protocol:	EPAM 87-EPA Marine	Test Species:	MY-Mysidopsis bahia
Comments:					

Conc-%	1	2	3	4	5	6	7	8
L-Lab Control	0.1440	0.1200	0.1160	0.1140	0.1200	0.1300	0.1640	0.1120
S-Control	0.1380	0.1450	0.1300	0.1460	0.1120	0.1350	0.1625	0.1420
100	0.1750	0.1700	0.2200	0.1700				

			Transform: Untransformed						1-Tailed	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
L-Lab Control	0.1275	0.9185	0.1275	0.1120	0.1640	14.149	8			
S-Control	0.1388	1.0000	0.1388	0.1120	0.1625	10.450	8			
100	0.1837	1.3237	0.1837	0.1700	0.2200	13.214	4	-4.076	1.812	0.0200

Auxiliary Tests	Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.9488		0.805		0.7694	0.76793
F-Test indicates equal variances (p = 0.24)	2.80188		10.8826			
The control means are not significantly different (p = 0.19)	1.38223		2.14479			
Hypothesis Test (1-tail, 0.05)	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Homoscedastic t Test indicates no significant differences	0.01998	0.14396	0.00539	0.00032	0.00223	1, 10

Dose-Response Plot



ToxCalc v5.0

Reviewed by: [signature] 1/15/02

AMEC Earth & Environmental
Bioassay Laboratory
5550 Morehouse Dr. Suite B
San Diego, CA 92121

Raw Data Sheet
Initial and Final Chemistries
Seven Day Chronic Bioassay
Test Species: M. bahia

Client: ~~NES~~ Southwest Marine

Test Date: 11/30/01

Sample ID. SWM Stormwater

Test No: 0111-127

Concentration: Lab control	Day 0 Ⓐ init.	Day 0 final	Ⓐ Day 1 init.	Day 1 final	Day 2 init.	Day 2 final	Ⓐ Day 3 init.	Day 3 final	Ⓡ Day 4 init.	Day 4 final	Ⓡ Day 5 init.	Day 5 final	Ⓡ Day 6 init.	Day 6 final
pH	7.81	↓	↓	8.12	7.78	8.06								7.96
DO (mg/L)	7.2	↓	↓	6.4	7.4	6.6								6.5
Salinity (ppt)	30	↓	↓	32	30	32								46
Temperature (°C)	24.0	↓ 25.1	↓	24.4	25.3	24.5		25.0		25.3		25.0		25.2

Concentration: Salt control	Day 0 Ⓐ init.	Day 0 final	Ⓐ Day 1 init.	Day 1 final	Day 2 init.	Day 2 final	Ⓐ Day 3 init.	Day 3 final	Ⓡ Day 4 init.	Day 4 final	Ⓡ Day 5 init.	Day 5 final	Ⓡ Day 6 init.	Day 6 final
pH	7.93	↓	↓	8.16	7.97	8.19								8.05
DO (mg/L)	7.3	↓	↓	6.4	6.6	6.5								6.2
Salinity (ppt)	30	↓	↓	32	30	33								45
Temperature (°C)	24.5	↓ 25.1	↓	24.5	25.0	~~25.3~~ 24.5		25.0		25.3		25.0		25.2

Concentration: 100%	Day 0 Ⓐ init.	Day 0 final	Ⓐ Day 1 init.	Day 1 final	Day 2 init.	Day 2 final	Ⓐ Day 3 init.	Day 3 final	Ⓡ Day 4 init.	Day 4 final	Ⓡ Day 5 init.	Day 5 final	Ⓡ Day 6 init.	Day 6 final
pH	7.95	↓	↓	8.05	7.87	7.96								8.10
DO (mg/L)	8.1	↓	↓	6.0	8.0	6.1								6.2
Salinity (ppt)	29	↓	↓	31	29	32								47
Temperature (°C)	25.0	↓ 25.1	↓	24.5	24.0	24.3		25.0		25.3		25.0		25.2

	Lab Cont	Salt Cont	Rec Cont	a	b	c
Alkalinity*	95	106		93		
Initial Chlorine†	ND	ND		matrix interf.		
STS added (g)	–	–		–		
Final Chlorine †	–	–		–		

* mg/L as CaCO3; † mg/L; ND: no chlorine detected

Sample Description: brown, opaque, no odor, heavy debris/particulates

Animal Source: ABS

Date Received: 11/20/01

Comments: 4 days old @ initiation
Ⓐ no renewal

Analysts: [initials]

Reviewed: [initials] 1/5/02

AMEC Earth & Environmental
Bioassay Laboratory
5550 Morehouse Dr., Suite B
San Diego, CA 92121

Raw Data Sheet
Larval Survival and Growth Test

Test Species: M. bahia

Client Name: Southwest Marine

Test Date: 11/30/01

Sample ID: SWM Stormwater

Test No.: 0111-127

Conc.	Rep.	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Percent Survival	Average Survival
lab control	a	5	5 0 Ⓐ	5	5	5	5	5	5		
	b	5	5 1	5	5	5	5	5	5		
	c	5	5 1	5	5	5	5	5	5		
	d	5	5 4 1	5	5	5	5	5	5		
	e	5	5 1	5	5	5	5	5	5		
	f	5	5	5	5	5	5	5	5		
	g	5	5 1	5	5	5	5	5	5		
	h	5	5 2	5	5	5	5	5	5		
salt control	a	5	5	5	5	5	5	5	5		
	b	5	4	4	4	4	4	4	4		
	c	5	5	5	5	5	5	5	5		
	d	5	5	5	5	5	5	5	5		
	e	5	5	5	5	5	5	5	5		
	f	5	5	5	4	4	4	4	4		
	g	5	4	4	4	4	4	4	4		
	h	5	5	5	5	5	5	5	5		
100%	a	5	0 Ⓐ	0 Ⓐ	Ⓐ	Ⓐ	Ⓐ	Ⓐ	0		
	b	5	1	0					0		
	c	5	1	1					0		
	d	5	[illegible]	2					2		
	e	5	1	1					1		
	f	5		0					0		
	g	5	1	1					1		
	h	5	2	[illegible]					1		
	a										
	b										
	c										
	d										
	e										
	f										
	g										
	h										
Tech. Initials		TM	ER	BR	GB	AM	HC	HC	ER		

Feeding Times: 0 1450 1 0840 1350 2 1020 1350 3 930 1625 4 ~~1620~~ ER 0850 1620 5 0945 1610 6 0940 1635

Comments: Ⓐ unable to do accurate counts due to low visibility

QA Review Date: [illegible] 1/15/02
Final Review Date: [illegible]

AMEC Earth & Environmental
Bioassay Laboratory
5550 Morehouse Dr., Suite B
San Diego, CA 92121

Raw Data Sheet
Mysid Weights
Seven Day Chronic Bioassay

Client: Southwest Marine

Test Species: M. bahia

Sample ID: SWM Stormwater

Test Date: 11/30/01

Test Number: 0111-127

Conc.	rep.	pan wt. (gm)	pan + mysid (gm)	mysid wt. (mg)	# mysid	avg. per mysi (mg)	avg. per conc. (mg)
lab cont.	a	0.02986	0.03058				
	b	0.02923	0.02983				
	c	0.02793	0.02851				
	d	0.02822	0.02879				
	e	0.02929	0.02989				
	f	0.02895	0.02960				
	g	0.02821	0.02903				
	h	0.02956	0.03012				
Salt cont.	a	0.02942	0.03011				
	b	0.03051	0.03109				
	c	0.02973	0.03038				
	d	0.02941	0.03014				
	e	0.02961	0.03017				
	f	0.02821	0.02875				
	g	0.02702	0.02767				
	h	0.02799	0.02870				
100%	a	0.02938	—				
	b	0.03085	—				
	c	0.02944	—				
	d	0.02962	0.02997				
	e	0.03079	0.03096				
	f	0.03052	—				
	g	0.02994	0.03016				
	h	0.02816	0.02833				
	a						
	b						
	c						
	d						
	e						
	f						
	g						
	h						

Date/Time in: 12-7-01/1520
Date/Time out: 12-10-01/0930
Oven temp. (°C): 62

Tech Initials: DG
Weigh Date: 12-10-01
QA Review Date: [initials] 1/15/02
Final Review Date: [signature]

Appendix B

Original Chemistry Reports

Calscience
Environmental
Laboratories, Inc.

December 11, 2001

Marilyn Schwartz
AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Subject: **Calscience Work Order No.: 01-11-1643**
Client Reference: SWM 11-29-01

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 11/30/01 and analyzed in accordance with the attached chain-of-custody.

Unless otherwise noted, all analytical testing was accomplished in accordance with the guidelines established in our Quality Assurance Program Manual, applicable standard operating procedures, and other related documentation. The results in this analytical report are limited to the samples tested and any reproduction thereof must be made in its entirety.

If you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Robert Stearns
Project Manager

Michael J. Crisostomo
Quality Assurance Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	EPA 5030B
Method:	EPA 8015M

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/06/01	01120502sa

Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	ND	100	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
1,4-Bromofluorobenzene	71	49-157	

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
Method Blank	098-03-006-2,083	Aqueous	N/A	N/A	12/06/01	01120502sa

Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	ND	100	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
1,4-Bromofluorobenzene	67	49-157	

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

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ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: Ext. + D/I
Method: EPA 8015M

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	12/04/01	12/05/01	01120401sa

Comment(s): -The sample chromatographic pattern for TPH does not match the chromatographic pattern of the specified standard. Quantitation of the unknown hydrocarbon(s) in the sample was based upon the specified standard.

Parameter	Result	RL	DF	Qual	Units
TPH as Diesel	2100	1000	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
Decachlorobiphenyl	120	53-141	

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
Method Blank	098-03-003-825	Aqueous	N/A	12/04/01	12/04/01	01120401sa

Parameter	Result	RL	DF	Qual	Units
TPH as Diesel	ND	1000	1		ug/L

Surrogates:	REC (%)	Control Limits	Qual
Decachlorobiphenyl	129	53-141	

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience
Environmental
Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: N/A
Method: EPA 120.1

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/01/01	1201SCDUP1

Comment(s): -Sample analyzed outside recommended holding time.

Parameter	Result	RL	DF	Qual	Units
Specific Conductance	20000	100	1		umhos/cm

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

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ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
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Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	N/A
Method:	EPA 150.1

Project: SWM 11-29-01

Client Sample Number	Lab Sample Number	Matrix	Date Collected	Date Prepared	Date Analyzed	QC Batch ID
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/01/01	1201PHDUP1

Comment(s): -Sample analyzed outside recommended holding time.

Parameter	Result	RL	DF	Qual	Units
pH	7.34	0.01	1		pH unit

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	N/A
Method:	EPA 415.1

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/06/01	1206TOCMB1

Parameter	Result	RL	DF	Qual	Units
Total Organic Carbon	43	5	10	D	mg/L

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
Method Blank	099-05-097-1,088	Aqueous	N/A	N/A	12/06/01	1206TOCMB1

Parameter	Result	RL	DF	Qual	Units
Total Organic Carbon	ND	0.50	1		mg/L

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	N/A
Method:	EPA 410.4

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/06/01	1206ODMB2

Parameter	Result	RL	DF	Qual	Units
Chemical Oxygen Demand	230	25	5	D	mg/L

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
Method Blank	099-05-062-1,121	Aqueous	N/A	N/A	12/06/01	1206ODMB2

Parameter	Result	RL	DF	Qual	Units
Chemical Oxygen Demand	ND	5.0	1		mg/L

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental	Date Sampled: 11/29/01
5510 Morehouse Drive, Suite 300	Date Received: 11/30/01
San Diego, CA 92121-3723	Date Analyzed: 12/06/01
	Work Order No.: 01-11-1643
Attn: Marilyn Schwartz	Method: EPA 413.1
RE: SWM 11-29-01	Page 1 of 1

All concentrations are reported in mg/L (ppm).

Sample Number	Oil and Grease Concentration	Reporting Limit
SW Marine	1.6	1.0
Method Blank	ND	1.0

Note: Sample volume was insufficient for duplicate analysis.

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	N/A
Method:	EPA 160.5

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/01/01	1201SSDUP1

Parameter	Result	RL	DF	Qual	Units
Solids, Settleable	43	1.0	1		mL/L/hr

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: N/A
Method: EPA 160.2

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	N/A	12/01/01	1201TSSDP4

Parameter	Result	RL	DF	Qual	Units
Solids, Total Suspended	2200	10	1		mg/L

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	Total Digestion
Method:	EPA 6020

Project: SWM 11-29-01

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SW Marine	01-11-1643-1	11/29/01	Aqueous	12/03/01	12/04/01	011203lcs1

Parameter	Result	RL	DF	Qual	Units	Parameter	Result	RL	DF	Qual	Units
Arsenic	ND	0.0100	10		mg/L	Lead	0.0237	0.0100	10		mg/L
Cadmium	ND	0.0100	10		mg/L	Nickel	0.0171	0.0100	10		mg/L
Chromium (Total)	ND	0.0100	10		mg/L	Silver	ND	0.0100	10		mg/L
Copper	0.103	0.010	10		mg/L	Zinc	0.306	0.050	10		mg/L

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
Method Blank	096-06-003-385	N/A	Aqueous	12/03/01	12/04/01	011203lcs1

Parameter	Result	RL	DF	Qual	Units	Parameter	Result	RL	DF	Qual	Units
Arsenic	ND	0.00100	1		mg/L	Lead	ND	0.00100	1		mg/L
Cadmium	ND	0.00100	1		mg/L	Nickel	ND	0.00100	1		mg/L
Chromium (Total)	ND	0.00100	1		mg/L	Silver	ND	0.00100	1		mg/L
Copper	ND	0.00100	1		mg/L	Zinc	ND	0.00500	1		mg/L

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

AMEC Earth and Environmental
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Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	Total Digestion
Method:	EPA 7470A

Project: SWM 11-29-01

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
SW Marine	01-11-1643-1	Aqueous	11/29/01	12/03/01	12/04/01	011203lcs1

Parameter	Result	RL	DF	Qual	Units
Mercury	ND	0.00050	1		mg/L

Client Sample Number:	Lab Sample Number:	Matrix:	Date Collected:	Date Prepared:	Date Analyzed:	QC Batch ID:
Method Blank	099-04-008-706	Aqueous	N/A	12/03/01	12/03/01	011203lcs1

Parameter	Result	RL	DF	Qual	Units
Mercury	ND	0.00050	1		mg/L

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	EPA 5030B
Method:	EPA 8015M

Spiked Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
01-11-1644-1	Aqueous	GC 29	N/A	12/05/01	01120502ms

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Gasoline	82	78	72-120	5	0-21	

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: EPA 5030B
Method: EPA 8015M

LCS Sample Number	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
098-03-006-2,083	Aqueous	GC 29	N/A	12/06/01	01120502sa

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Gasoline	87	90	81-123	4	0-17	

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: Ext. + D/I
Method: EPA 8015M

LCS Sample Number	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
098-03-003-825	Aqueous	GC 6	12/04/01	12/04/01	01120401sa

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
TPH as Diesel	117	112	67-128	5	0-21	

Calscience Environmental Laboratories, Inc.

Quality Control - Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	N/A
Method:	EPA 120.1

Spiked Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	Duplicate Batch Number
01-11-1642-10	Aqueous	SC 1	N/A	12/01/01	1201SCDUP1

Parameter	Sample Conc	DUP Conc	RPD	RPD CL	Qualifier
Specific Conductance	104	104	0	0-25	

Calscience Environmental Laboratories, Inc.

Quality Control - Duplicate

AMEC Earth and Environmental
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San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: N/A
Method: EPA 150.1

Spiked Sample ID	Matrix	Instrument	Date Prepared:	Date Analyzed:	Duplicate Batch Number
01-11-1405-1	Aqueous	PH 1	N/A	12/01/01	1201PHDUP1

Parameter	Sample Conc	DUP Conc	RPD	RPD CL	Qualifiers
pH	8.56	8.57	0	0-25	

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

AMEC Earth and Environmental
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San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received:	11/30/01
Work Order No.:	01-11-1643
Preparation:	N/A
Method:	EPA 415.1

Spiked Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
01-12-0198-5	Aqueous	TOC 1	N/A	12/06/01	1206TOCMS1

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifier
Total Organic Carbon	91	89	70-130	2	0-25	

Calscience Environmental Laboratories, Inc.

Quality Control - Laboratory Control Sample

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received:	11/30/01
Work Order No.:	01-11-1643
Preparation:	N/A
Method:	EPA 415.1

LCS Sample Number	Matrix	Instrument	Date Analyzed	Lab File ID	LCS Batch Number
099-05-097-1,088	Aqueous	TOC 1	12/06/01	NONE	1206TOCMB1

Parameter	Conc Added	Conc Recovered	%Rec	%Rec CL	Qualifier
Total Organic Carbon	10.0	9.8	98	80-120	

Calscience Environmental Laboratories, Inc.

Quality Control - Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received:	11/30/01
Work Order No:	01-11-1643
Preparation:	N/A
Method:	EPA 410.4

Spiked Sample ID	Matrix	Instrument	Date Prepared:	Date Analyzed:	Duplicate Batch Number
01-12-0230-1	Aqueous	UV 3	N/A	12/06/01	1206ODDUP2

Parameter	Sample Conc	DUP Conc	RPD	RPD CL	Qualifiers
Chemical Oxygen Demand	1300	1400	1	0-25	

Calscience Environmental Laboratories, Inc.

Quality Control - Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: N/A
Method: EPA 160.5

Spiked Sample ID	Matrix	Instrument	Date Prepared:	Date Analyzed:	Duplicate Batch Number
SW Marine	Aqueous	NA	N/A	12/01/01	1201SSDUP1

Parameter	Sample Conc	DUP Conc	RPD	RPD CL	Qualifiers
Solids, Settleable	43	42	2	0-25	

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Quality Control - Duplicate

AMEC Earth and Environmental		Date Received:	11/30/01
5510 Morehouse Drive, Suite 300		Work Order No:	01-11-1643
San Diego, CA 92121-3723		Preparation:	N/A
		Method:	EPA 160.2
Project:	SWM 11-29-01		

Spiked Sample ID	Matrix	Instrument	Date Prepared:	Date Analyzed:	Duplicate Batch Number
01-11-1650-1	Aqueous	NA	N/A	12/01/01	1201TSSDP4

Parameter	Sample Conc	DUP Conc	RPD	RPD CL	Qualifiers
Solids, Total Suspended	70	71	1	0-25	

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: Total Digestion
Method: EPA 6020

Spiked Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
01-11-1487-4	Aqueous	ICP/MS A	12/03/01	12/04/01	120301msa

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Arsenic	93	94	80-120	1	0-20	
Cadmium	90	92	80-120	2	0-20	
Chromium (Total)	89	89	80-120	0	0-20	
Copper	86	86	80-120	0	0-20	
Lead	98	99	80-120	1	0-20	
Nickel	81	82	80-120	0	0-20	
Silver	86	89	80-120	4	0-20	
Zinc	80	116	80-120	27	0-20	4

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: Total Digestion
Method: EPA 6020

LCS Sample Number	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
096-06-003-385	Aqueous	ICP/MS A	12/03/01	12/04/01	011203lcs1

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Arsenic	89	95	80-120	7	0-20	
Cadmium	98	103	80-120	5	0-20	
Chromium (Total)	96	100	80-120	4	0-20	
Copper	98	105	80-120	6	0-20	
Lead	97	99	80-120	2	0-20	
Nickel	94	100	80-120	6	0-20	
Silver	105	117	80-120	10	0-20	
Zinc	96	104	80-120	8	0-20	

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

AMEC Earth and Environmental
5510 Morehouse Drive, Suite 300
San Diego, CA 92121-3723

Project: SWM 11-29-01

Date Received: 11/30/01
Work Order No: 01-11-1643
Preparation: Total Digestion
Method: EPA 7470A

Spiked Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
01-11-1599-1	Aqueous	Mercury	12/03/01	12/03/01	120301ms1

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Mercury	106	112	71-134	6	0-14	

Calscience Environmental Laboratories, Inc.

Quality Control - Laboratory Control Sample

AMEC Earth and Environmental		Date Received:	11/30/01
5510 Morehouse Drive, Suite 300		Work Order No:	01-11-1643
San Diego, CA 92121-3723		Preparation:	Total Digestion
		Method:	EPA 7470A
Project:	SWM 11-29-01		

LCS Sample Number	Matrix	Instrument	Date Analyzed	Lab File ID	LCS Batch Number
099-04-008-706	Aqueous	Mercury	12/03/01	011203 l	011203lcs1

Parameter	Conc Added	Conc Recovered	%Rec	%Rec CL	Qualifiers
Mercury	0.0100	0.0110	110	90-122	

Calscience Environmental Laboratories, Inc.

GLOSSARY OF TERMS AND QUALIFIERS

Work Order Number: 01-11-1643

Qualifier	Definition
4	The MS/MSD RPD was out of control due to matrix interference. The LCS/LCSD RPD was in control and, therefore, the sample data was reported without further clarification.
D	The sample data was reported from a diluted analysis.
ND	Not detected at indicated reporting limit.

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LABORATORIES, INC.
7440 LINCOLN WAY
GARDEN GROVE, CA 92841-1432
TEL: (714) 895-5494 • FAX: (714) 894-7501

CHAIN OF CUSTODY RECORD

Date 11-30-01

Page 1 of 1

LABORATORY CLIENT: AMEC Earth + Environmental

ADDRESS: 5510 Morehouse Drive

CITY San Diego STATE CA ZIP 92121

TEL: 858-458-9044 FAX: E-MAIL:

CLIENT PROJECT NAME / NUMBER: SWM 11-29-01

P.O. NO.:

PROJECT CONTACT: Marilyn Schwartz

LAB USE ONLY 01-1643

SAMPLER(S): (SIGNATURE) Steve Carlson

COOLER RECEIPT TEMP = ____ °C

TURNAROUND TIME
☐ SAME DAY ☐ 24 HR ☐ 48 HR ☐ 72 HR ☒ 5 DAYS ☐ 10 DAYS

SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY)
☐ RWQCB REPORTING ☐ ARCHIVE SAMPLES UNTIL ___ / ___ / ___.

SPECIAL INSTRUCTIONS

REQUESTED ANALYSES

LAB USE ONLY	SAMPLE ID	LOCATION/DESCRIPTION	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT.	TPH (G)	TPH (D) or ___	BTEX / MTBE (8021B)	HALOCARBONS (8021B)	VOCs (8260B)	VOCs (5035 / 8260B) EnCore	SVOCs (8270C)	PEST (8081A)	PCBs (8082)	EOB / DBCP (504.1) or (8011)	CAC, T22 METALS (6010B)	PNAs (8310)	VOCs (TO-14A) or (TO-15)	CH4 / TGNMO (25.1)	FIXED GASES (25.1) or (D1946)	Specific Conductance	pH, TOC, COD, O&G	Settleable Solids, TSS	EPA 7470A Mercury	As, Cd, Cr, Cu, Pb, Ni, Ag, Zn (EPA 6020 ICP/MS)
	S.W. Marine	Municipal Storm H2O	11-29-01	1200	Liq	1	X	X														X	X	X	X	X

Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Steve Carlson	[signature]	11.30.01	15:47
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature) [signature]	Received for Laboratory by: (Signature) [signature]	11.30.01	20:00

DISTRIBUTION: White with final report, Green to File, Yellow and Pink to Client.
Please note that pages 1 and 2 of 2 of our T/Cs are printed on the reverse side of the Yellow and Pink copies respectively.

10/01/00 Revision

CRG Marine Laboratories, Inc.

2020 Del Amo Boulevard, Suite 200
Torrance, California 90503
(310) 533-5190 FAX (310) 533-5003 EMAIL crglabs@sbcglobal.net

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December 18, 2001

AMEC Earth & Environmental
5510 Morehouse Dr.
San Diego, CA 92121

ATTN: Ms. Marilyn Schwartz

CRG Marine Laboratories is pleased to provide you with the enclosed analytical data report for your project 1164 UNITS. According to the chain-of-custody, 1 water sample was collected on November 29, 2001 and received intact and cool at CRG on December 3, 2001. Per your instructions, the sample was analyzed for Organic Tins. Please don't hesitate to call if you have any questions and thank you very much for using our laboratory for your analytical needs.

Sincerely,
Rich Gossett

Reviewed and Approved ____________________

CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

ORGANOTINs By Rice et al.
HP6890/5972 GC/MS

CRG ID#: 5726 **Replicate #:** R1 **Project ID:** 21104 **Batch ID:** 21104-5013 **Matrix:** Water

Client Sample ID: 1164UNITS **Sample Description:** SWM-Municipal
Client Name: AMEC Marilyn Schwartz

Date Sampled: 29-Nov-01 **Date Processed:** 04-Dec-01
Date Received: 03-Dec-01 **Date Analyzed:** 17-Dec-01

CONSTITUENT	RESULT	UNITS	MDL	DILUTION FACTOR
(Tripentyltin)	82	% Recovery		1
Dibutyltin	17.7	ng/L	1	1
Monobutyltin	ND	ng/L	1	1
Tetrabutyltin	ND	ng/L	1	1
Tributyltin	16.2	ng/L	1	1

MDL= Method Detection Limit; ND= Not Detected

California ELAP Certificate # 2261

CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

ORGANOTINs By Rice et al.
HP6890/5972 GC/MS

CRG ID#: 5727 **Replicate #:** B1 **Project ID:** 21104 **Batch ID:** 21104-5013 **Matrix:** DI Water

Client Sample ID: QAQC
Client Name: AMEC Marilyn Schwartz
Sample Description: Procedural Blank

Date Sampled:
Date Received:
Date Processed: 04-Dec-01
Date Analyzed: 17-Dec-01

CONSTITUENT	RESULT	UNITS	MDL	DILUTION FACTOR
(Tripentyltin)	85	% Recovery		1
Dibutyltin	ND	ng/L	1	1
Monobutyltin	ND	ng/L	1	1
Tetrabutyltin	ND	ng/L	1	1
Tributyltin	ND	ng/L	1	1

CRG Marine Laboratories, Inc. 820 S. Seaside Avenue, Terminal Island, CA 90731, (310) 519-4007, FAX (310) 519-3587

CHAIN-OF-CUSTODY RECORD

DATE: 30 Nov 2001 Lab ID: SWM 11/30/01

Client:	AMEC Earth & Environmental
Address:	5510 Morehouse Drive San Diego, CA 92121
Sampled By:	
Phone:	858-458-9044 x300
FAX:	858-587-3961
Project Manager:	Marilyn Schwartz
Project Number:	1164UNITS

REQUESTED ANALYSIS

	Client Sample ID	Sample Date	Sample Time	Sample Matrix	Container #	Container Type	TBT										
1	SWM - Municipal	11/29/2001	1200	liquid	1	1-Gal glass	X										
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Correct Containers:	Yes	No	
Sample Temperature:	Ambient	Cold	Warm
Sample Preservative:	Yes	No	
Turnaround Time:	Normal	Specify:	

Comments:

Mono, di, and tributyl tin

RELINQUISHED BY		RECEIVED BY	
Signature:	[signature]	Signature:	[signature]
Print:	Steve Carlson	Print:	B. KRISTIANTI
Company:	AMEC	Company:	CALSCIENCELAB
Date:	11-30-01 Time: 1545	Date:	11.30.01 Time: 1547
Signature:	[signature]	Signature:	[signature]
Print:	B. KRISTIANTO	Print:	D.E BACK
Company:	CEL	Company:	CALSCIENCE
Date:	11 30 01 Time: 2000	Date:	12/3/01 Time: 1000
Signature:	[signature]	Signature:	[signature]
Print:	D. E. BACK	Print:	S.PATRICK HERSHELMAN
Company:	CALSCIENCE	Company:	CRG
Date:	12/30/01 Time: 2:00 pm	Date:	DEC 3, 01 Time: 2:00 pm

Appendix C

Chain-of-Custody Forms

amec Earth & Environmental

AMEC San Diego Bioassay Laboratory
5550 Morehouse Drive, Suite B
San Diego, CA 92121
858-458-9044

Chain of Custody

Date 11/~~28~~ 29/01 Page 1 of 1

COMPANY SOUTHWEST MARINE, INC
ADDRESS FOOT OF SAMPSON ST.
CITY SD STATE CA ZIP 92113
PHONE NO. 619 238-1000

SANDOR HALVAX
PROJECT MANAGER
[signature]
SAMPLERS (SIGNATURE)
619-238-1000 X2060
PHONE NUMBER

ANALYSIS REQUIRED

SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	TOXICITY	Specific Conductance	pH, TOC, O&G	Settleable solids	COD	As, Cd, Cr, Cu	Pb, Ni, Ag	Zn, Hg	TPH D, G	TBT				CONCENTRATIONS/COMMENTS	NUMBER OF CONTAINERS
~~[illegible]~~	~~11/28/01~~	~~1200~~	~~LIQ~~	~~P/G~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~				~~[illegible]~~	~~3~~
011-070 Municipal	11/29/01	1200	LIQ	P/G	X	X	X	X	X	X	X	X	X	X				Use ICP/MS Limits	3
	11/29/01																	~~Use ICP/MS [illegible]~~	

PROJECT INFORMATION	
CLIENT	
P.O. NO.	
SHIPPED VIA:	Allstate

SAMPLE RECEIPT	
TOTAL NO. OF CONTAINERS	3
CHAIN OF CUSTODY SEALS	
REC'D. GOOD CONDITION/COLD	
CONFORMS TO RECORD	

SPECIAL INSTRUCTIONS/COMMENTS:
Use ICP/MS Det. Lim.

RELINQUISHED BY		RELINQUISHED BY	
(Signature) [signature]	(Time)	(Signature)	(Time)
(Printed Name) Sonia Singh	(Date)	(Printed Name)	(Date)
(Company) SWM		(Company)	

RECEIVED BY		RECEIVED BY (LABORATORY)	
(Signature)	(Time)	(Signature) [signature]	(Time) 1600
(Printed Name)	(Date)	(Printed Name) Steve Carlson	(Date) 11/29/01
(Company)		AMEC Bioassay Lab Log-In No.	

Additional disposal charges may apply.

DISTRIBUTION: WHITE, CANARY - AMEC Bioassay Lab, PINK - Originator

C-034

TM 212
MAY 1974

MARINE INPUTS OF POLYCHLORINATED BIPHENYLS AND COPPER FROM VESSEL ANTIFOULING PAINTS

David R. Young
Theadore C. Heesen
Deirdre J. McDermott
Paul E. Smokler

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
1500 East Imperial Highway, El Segundo, California 90245

TM 212
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Preliminary results of a project financed in part with Federal funds from the Environmental Protection Agency under grant number R-801152. The contents do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

Southern California Coastal Water Research Project
1500 East Imperial Highway
El Segundo, California 90245
(213) 322-3080

INTRODUCTION

Vessel antifouling paints constitute a potentially signficant source of certain trace contaminants to coastal marine waters. For example, copper, mercury, and lead have been used extensively in bottom paints or primers, and relatively high concentrations of polychlorinated biphenyls (PCB) also have been found in such materials (Barry 1972; Young et al. 1973; McClure, personal communication*). Because of the extensive use of recreational, commercial, and naval vessels off southern California, the Coastal Water Project conducted a study of the application of antifouling paints to boats in marinas and harbors along this coast. Samples of the principal brands of paints used were obtained and analyzed for PCB. In addition, when possible, copper content was obtained from the paint can labels. The results of this survey have been incorporated into estimates of annual mass emission rates (or their upper limits) for these potential pollutants, and the values have been compared to past estimates for two other sources.

PROCEDURES AND RESULTS

Field Surveys

The southern California coastline has 14 major recreational marinas between Santa Barbara and the U.S./Mexico border (Figure 1); in addition, there are major harbors at Los Angeles and San Diego that contain almost all of the commercial and naval drydock facilities in the region. During 1971, the number of small craft then maintained in each marina was obtained from the appropriate harbor master (Table 1). This inventory was followed by a preliminary investigation into the usage of antifouling paints and other vessel-related materials in Marina del Rey, the second largest marina in southern California (Southern California Coastal Water Research Project 1973). During 1973, we conducted detailed investigations into antifouling paint usage at four marinas--Ventura Harbor and Oxnard-Channel Islands Harbor (Ventura County), Marina del Rey (Los Angeles County), and Newport Bay (Orange County). These anchorages accommodate more than half of the marine recreational craft moored in southern California.

---

* Dr. Vance McClure, National Marine Fisheries Service, Tiburon, Ca.

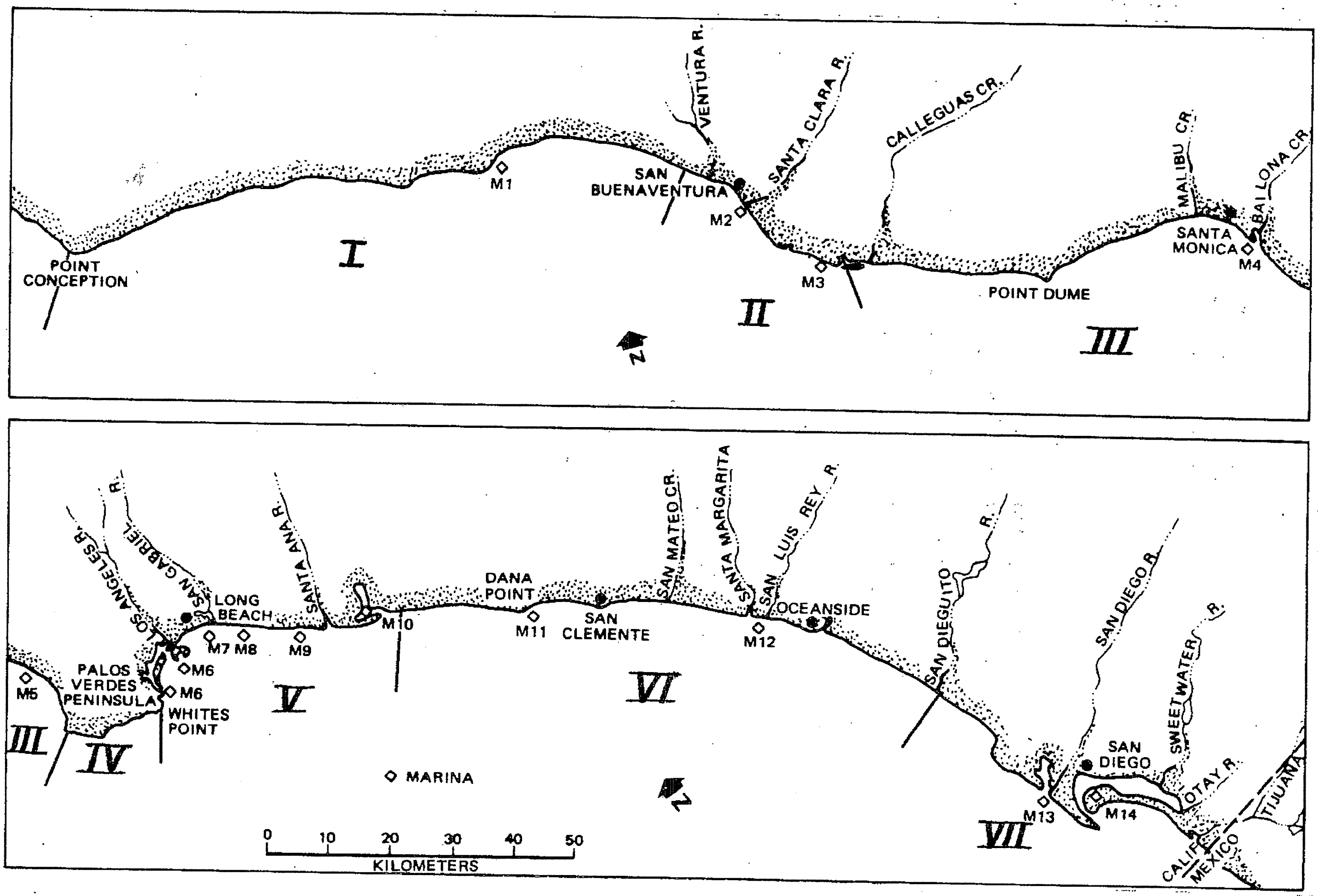

Figure 1. Southern California Marinas

Table 1

Number of Boats Harbored in Southern California Marinas, 1971.

Ref. No.[a]	Marina	No. of Boats[b]
M1	Santa Barbara Harbor	750
M2	Ventura Harbor	930
M3	Oxnard-Channel Islands Harbor	930[c]
M4	Los Angeles-Marina del Rey	5,500[d]
M5	Redondo Beach-King Harbor Marina	1,400
M6	San Pedro Bay-Los Angeles Harbor	3,400
M7	San Pedro Bay-Long Beach Harbor	2,530
M8	San Pedro Bay-Long Beach Marina	2,300
M9	Huntington Beach-Huntington Harbor	3,200
M10	Newport Bay-Newport Beach Harbor	8,000[e]
M11	Dana Point Harbor	550
M12	Oceanside Harbor	550
M13	San Diego-Mission Bay	1,500
M14	San Diego Bay	3,320
	TOTAL	34,860

a. Key to location on Figure #1
b. Includes only 16- to 65-ft boats corresponding to U.S. Coast Guard Classes 1, 2, and 3. Boats smaller than 16 ft, which are U.S. Coast Guard Class A, are not included in this inventory.
c. 1973 estimate: 980 boats.
d. 1973 estimate: 6,000 boats.
e. 1973 estimate: 8,600 boats.

Information on boat size and type was generally not available; however, we located relatively detailed data on one recreational craft anchorage--Newport Bay.* This bay, which is located in approximately the middle of the Project's coastal study region, harbors almost 25 percent of the total number of small craft anchored in southern California; thus, we felt it would be reasonably representative of the other marinas of interest. Table 2 gives the results of an inventory of the numbers of power, sail, and hand-powered craft in several length classes moored in the Bay during winter 1971. Table 3 presents information on annual counts of craft of a number of different types anchored there between 1962 and 1971.

We used two methods to obtain estimates of the amounts of antifouling paint used. The first was to quantify directly the number of gallons of all major brands applied or sold annually in a marina area. The second was to obtain estimates of the average number of gallons of antifouling paint applied per boat and the number of boats painted annually in the area. In addition, data on the percentage use of each of the major brands was sought. Such information was obtained by visiting all of the boat "haul-out" yards in the marina under study and all of the retail paint and hardware stores in the vicinity of the marina. We obtained samples of paints currently in use and also collected paint scrapings at several of the yards.

During 1973, our detailed survey efforts were first directed to Marina del Rey. Only two haul-out yards and four retail suppliers of antifouling paints were located in the vicinity. Information obtained on principal brands used and estimated application rates is summarized in Table 4.

Following the collection of the information summarized in Table 4, we attempted to evaluate the completeness of the survey of antifouling paint usage on Marina del Rey craft. Paint retailers' estimates of the number of gallons applied per boat (averaging approximately 30 ft (10 m) in length) ranged from 0.5 to 1.5.** Taking an average figure of 1 gal. per boat, and assuming that sales by Retail Store No. 4 (Table 4) were similar to those of the other three local retailers (averaging about 100 gal./yr), the painting of approximately 400 boats is accounted for by retail paint sales. This compares to approximately 4,100 boats painted annually by the two boat yards. In addition, another 300 boats that did not require antifouling paint were inventoried in dry storage. As the

* Larry Miller, Newport Beach Chamber of Commerce, personal communication.

** Estimates from the haul-out yards were somewhat higher, averaging about 1.5 gal./boat.

Table 2

Estimated Numbers of Power, Sail, and Hand-powered Boats in Five Length Classes - Newport Bay, Winter 1971.

Length	Power	Sail	Hand-Powered	Total
Under 20 ft	2,000	2,060	1,040	5,100
20-29 ft	1,200	980	-	2,180
30-39 ft	730	430	-	1,160
40-49 ft	360	120	-	48480
Over 50 ft	150	70	-	220
TOTAL	4,440	3,660AL	1,040	9,140

average reported interval between paintings was 12 months, approximately 4,800 (or 80 percent) of the estimated 6,000 craft maintained at Marina del Rey were accounted for in the survey. We do not presently know how much of the remainder is due to unattended craft, to craft painted elsewhere or at a reduced frequency, or to inaccuracies in the usage estimates. However, it does appear that most of the paint applied to small craft anchored in Marina del Rey was accounted for in this survey.

A corresponding approach at the other marinas studied was not possible because our surveys revealed that some of the haul-out yards obtained their paints from local retail stores. However, in light of the fact that about 90 percent of the (accountable) antifouling paint used on Marina del Rey craft was applied by local boat yards, we have assumed that this is the predominant source of antifouling paints utilized on small craft in the marinas. Results on bottom paint usage for Newport Bay and Ventura and Oxnard Harbors are presented in Tables 5 and 6.

To obtain estimates of antifouling paints used in southern California on commercial and naval vessels, we visited most of the major drydock facilities in Los Angeles-Long Beach Harbor and San Diego Harbor. Estimates of the quantities and types of major paints applied annually at these drydocks was obtained (Tables 7 and 8). Samples of these paints also were collected and analyzed for PCB.

Laboratory Technique

Wet Paint Extraction Methods. Most samples were extracted using a separatory funnel. A measured volume of the wet paint sample was pipetted into a 500-ml separatory funnel containing 100 ml of 15 percent diethyl ether in hexane (by volume). If the paint

Table 3

Annual Inventory of Recreational Craft in Newport Bay 1960-71.

	1971	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
Cabin Cruisers	2,036	2,0181	2,076	2,029	1,966							
Motor Boats, Z-drives	790	771	642	746	682	2,743	2,462	2,462	2,7051	2,522		
Sailboats boats	3,703	3,562	3,308	3,129	3,129	3,055	2,585	2,266	2,208	2,119		
Out-boards	1,455	1,461	1,276	1,400	1,254	1,141	1,207	1,098	1,005	1,005		
Rowboats	964	804	738	903		969	895	825	864	1,047		
Canoes, Paddle Boards, Outriggers	58	54	38	47	27	20	34	20	21			
Kayaks, Pedaloes	41	82										
Dredges, Barges, Tugs	24	27	27	8	1	2			1			
House-boats	4	4	2				2					
Steam-boats	2	2	5	5								
Rafts, Floats	7	2	4									
Hull		2	1	1								
Rescue, Fire	6											
TOTAL	9,090	8,789	8,117	8,268	7,059	7,930	7,185	6,671	6,804	6,693	6,242	6,136

Table 4

Estimated Use of Antifouling Paints at Marina del Rey, 1973.

Supplier	Boats/ Year	Average Gal./Boat	Gal./ Year	Brand	Est. % of Total
Boatyard No. 1	3,000 x	1.5 =	4,500	Brolite Z-Spar Woolsey	50 50
Boatyard No. 2	1,100 x	1.5 =	1,650	Brolite Z-Spar Woolsey	50 50
Paint Retailer No. 1	100*	1	100	Brolite Z-Spar Woolsey	- -
Paint Retailer No. 2	50*	1	50	Brolite Z-Spar Mariner's	95 5
Paint Retailer No. 3	150*	1	150	Brolite Z-Spar International	75 25
Paint Retailer No. 4	100*	-	100**	Brolite Z-Spar Woolsey	- -
TOTAL	4,500		6,550		

*Boats per year equals gallons per year divided by average gallons per boat.
**No quantitative information released; value assumed from data for Retailers 1 through 3.

seemed to disperse easily when dropped into the ether-hexane mixture, the separatory funnel method of extraction was employed. On the other hand, if the wet paint sample formed a seemingly nonpermeable drop or plastic-like string, the separatory funnel method was not used, and the samples were extracted using the Soxhlet method.

Separatory Funnel Method. The separatory funnel was shaken for a period of 2 minutes with the ether-hexane mixture and the sample. The sample was allowed to settle to the bottom of the separatory funnel, and the extract was carefully decanted into a round-bottomed flask. Next, 100 ml of 6 percent diethyl ether in hexane was added to the 500-ml separatory funnel containing the sample and shaken for a period of 2 minutes. Again the extract was carefully decanted into the round-bottomed flask. The paint was shaken again with 100 ml of hexane, and the extract was again added to the round-bottomed flask. The sample was reduced in a Rotovapor to a volume suitable for a Florisil cleanup.

Table 5.

Estimated Use of Antifouling Paints
at Newport Bay, 1973.

Supplier	Boats per Year		Avg. Gal./ Boat		Gal./ Year	Brand	Est. % of Total
Boatyard							
1	550	x	1	=	550	Brolite Z-Spar	880
2	600		0.5		300	Pettit	20
2	600		0.5		300	Pettit	100
3	1,040		1		1,040	Brolite Z-Spar	44
						Woolsey	20
						International	36
4	500		1		500	Brolite Z-Spar	60
						International	20
						Woolsey	15
						Pettit	5
5	600		1		600	International	40
						Woolsey	55
						Brolite Z-Spar	55
6	110		1.25		140	International	65
						Brolite Z-Spar	35
7	180		2		360	International	98
						Brolite Z-Spar	1
						Pettit	1
8	500		1.5		750	Brolite Z-Spar	50
						International	50
9	790		1		790	Brolite Z-Spar	45
						Mariners	35
						Bettit	45
						Woolsey	10
						International	5
10	560		0.5		280	Brolite Z-Spar	45
						Woolsey	45
						Pettit	10
11	100		3		300	Brolite Z-Spar	100
12	100		0.75		75	Pettit	100
TOTAL	5,630				5,680		
Paint Retailer							
1	–		–		300	Mariners	50
						Woolsey	50
2	–		1		3	Kuhls	100
3	–		0.75		600	Pettit	100
4	–		–		10	Brolite Z-Spar	–
						International	–
5	–		2		700	International	60
						Brolite Z-Spar	40

Table 5b (Continued)

Supplier	Boats per Year	Avg. Gal./ Boat	Gal./ Year	Brand	Est. % of Total
Paint Retailer (Cont.)					
6	–	–	1	Pettit	100
7	–	1	–*	International	–
				Brolite Z-Spar	–
8	–	–	900	Brolite Z-Spar	75
				International	25
9	–	1	300	Pettit	45
				Mariners	35
				Woolsey	10
				Brolite Z-Spar	5
				International	5
10	–	–	1	Brolite Z-Spar	100

*No estimate available.

Table 6.

Estimated Use of Antifouling Paints for Ventura and Oxnard Marinas, 1973.

Supplier	Boats per Year	Avg. Gal./ Boat	Gal./ Year	Brand	Est. % of Total
VENTURA HARBOR					
Boatyard	330	1	330	–	–
Paint Retailer	–	–	50	Brolite Z-Spar	100
OXNARD/CHANNEL ISLANDS HARBOR					
Boatyard	480*	3.25	1,560	–	–

*Boatyard recently changed ownership; therefore, this estimate is believed to significantly underestimate past and future usage.

Table 7.

Estimated Annual Use of Antifouling Paints on Commercial and Naval Vessels in Los Angeles-Long Beach Harbor.

Shipyard*	Ships/Year Commer-cial	Ships/Year Naval	Avg. Gal./Ship	Gallons/Year Commer-cial	Gallons/Year Naval	Gallons/Year Total	Brand	Est. % of Total
1	38	2	-	2,605**	355**	2,960	International	40
							Devoe-Reynolds	60
2	0	24	-	0	4,650**	4,650	International	-
							Devoe-Reynolds	-
							Proline	-
3	300	0	20	6,000	0	6,000	International 1609	40
							Devoe-Reynolds	30
							Proline 1080	30
4	52	0	44	2,290	0	2,290	International	10
							Devoe-Reynolds	90
5	-	-	-	-	-	3,980†	-	-
6	-	-	-	-	-	3,980†	-	-
7	0	25	270	0	6,750	6,750	Devoe-Reynolds 121/63	90
							Devoe-Reynolds 129/63	10
TOTAL						30,600		

*All are commercial shipyards, except for Shipyard 7 (U.S. Navy).
**Obtained directly from company records.
†Assuming average value for Shipyards 1-4.

Table 8.

Estimated Annual Use of Antifouling Paints on on Commercial and Naval Vessels at Two of the Largest Shipyards in San Diego Harbor, 1972

	Commercial			Naval		
	Yard 1	Yard 2	Total	Yard 1	Yard 2	Total
Ships per Year	24	3		2	4	
Average Gallons per Ship	40	3,000		300	500	
Gallons per Year	960	9,000	9,960	600	2,000	2,600

Soxhlet Extraction Method. This method was used only when the separatory funnel method would not be used. The wet paint sample was spread out on aluminum foil and allowed to dry. After drying, the sample was extracted using the same method as that used on dry paint samples.

Dry Paint Extraction Method. Dry paint samples were Soxhlet extracted with hexane. The thimbles and hexane were added to the Soxhlet extraction apparatus, and the hexane was refluxed for a period of 2 hours to clean the apparatus. The rinse hexane was removed and replaced with clean hexane, and the samples were weighed into the cleaned thimbles. The Soxhlets were then refluxed for an 18-hour period. The extracts were concentrated in a Roto-vapor to a volume suitable for the Florisil clean-up column.

Florisil Cleanup. Activation of the Florisil was carried out using a pottery kiln. The temperature was set at a dial reading of 1300°F (705°C); this temperature setting on the kiln melts aluminum foil (which has a melting point of 659°C) and appears to be a satisfactory setting for the activation of Florisil. The Florisil was placed in 250-ml covered cricibles in the kiln and was baked for 4 hours after the kiln reached equilibrium temperature. The activated Florisil was stored under hexane until use.

Three inches of the slurried-activated Florisil were added to the cleanup chromatographic columns,* and 1/2 inch of anhydrous sodium sulfate was added over the Florisil. Samples were concentrated to a volume of approximately 50 ml and added to the Florisil column. The column was eluted with 45 ml of 6 percent diethyl ether in hexane.

Extraction Efficiency. One paint chip sample (Code P17, Table 10) with a high PCB concentration (about 15 percent on a dry weight basis) was extracted and re-extracted with a Soxhlet extraction apparatus. The PCB value for the second extraction was 0.01 percent of the total value of the first extraction. If all dried

* 25 mm o.d., 22 mm i.d., 400 mm length with sealed-in coarse porosity fritted disc, Kontes Glass Co., Vineland, N.J.

paint samples are assumed to have the same permeability, then the procedure for dry paint extraction may be assumed to be highly satisfactory. Because none of the wet paint samples analyzed showed any appreciable concentration of PCB, it was not possible to quantify extraction efficiency for such samples. However, double extractions were conducted on a number of wet paint samples. Based on the relative signals obtained in the double extractions, and the very high recovery observed for the dry paint sample, we concluded that the PCB concentrations (usually upper limit values) listed in Table 9 are representative.

RESULTS

Sample descriptions, measured PCB concentrations, measured densities, weight percentages of copper compounds listed on paint can labels, and estimated metallic copper content are presented in Table 9. Table 10 lists PCB concentrations measured in weathered antifouling paint samples obtained at boat haul-out yards.

Because no DDT compounds were ever identified in the paint samples, upper limit concentrations were not calculated. Such values could be estimated to be approximately one-tenth of the maximum PCB 1254 values.

DISCUSSION

Antifouling Paint Usage

As seen from the data presented in Table 1, the 1971 inventory of small craft harbored at marinas throughout the Bight generally was confirmed by the 1973 inventories conducted at Oxnard Harbor, Marina del Rey, and Newport Bay. The percentage increases in numbers were 5, 9, and 7 percent, respectively. Assuming that the median value of 7 percent for percentage increase over the 2-year period is representative, approximately 37,000 recreational boats* were harbored in southern California marinas during 1973. The intensive surveys conducted at Marina del Rey and Newport Bay, which together account for about 40 percent of this total, yielded remarkably similar results. For example, the 4,100 small craft painted in the two boatyards at Marina del Rey during 1973 constituted 68 percent of the total number of boats (6,000) harbored there. In comparison, the 5,630 small craft painted at the 12 boatyards at Newport Bay constituted 66 percent of the total number (8,600) harbored at the Bay during 1973. Similarly, the median values for estimated gallons of antifouling paint applied per boat at both anchorages and for both haulout yards and paint retailers were 1 gal./boat.

As discussed in the previous section, at Marina del Rey, the boatyards apparently accounted for about 90 percent of the antifouling paint used at the marina, and retail sales to individuals for pri-

* Generally between 16 and 65 ft (5 to 22 m) in length.

Table 9.

Measured Polychlorinated Biphenyl Concentrations and Estimated Copper Concentrations in Antifouling Paints Used in Southern California.

Code	Brand and Type	Extraction Method*	PCB (mg/l) 1242	PCB (mg/l) 1254	Cu_2O (%)	ρ (kg/l)	Cu (g/l)
Recreational							
	Brolite Z-Spar						
P23	2000	A	<0.06	<0.16	32.6	1.73	500
P48	Multitox	A	<0.05	1.6	35.7	1.70**	540
P34	Colortox	B	-	0.29	0	-	0
P50	Supertox	-			59.4	1.70**	900
P53	Killer (B-90)	A	<0.3	<0.6	69.0	1.70**	1,040
P40	Racing Bronze	-			26.7†	1.13	300
P27	Vinyl Cop	-			-	-	-
P37	A-1316 (1969)	-	<0.4	<1.2	-	-	-
	Woolsey						
P24	Vinelast (Blue)	A	<0.3	<1.0	42.0	1.63	610
P39	Vinelast (Red)	A	<0.1	<0.3	42.0	2.08	780
P1	OTT	-			0	-	0
P44	Tradewinds	-			24.0††	1.50	390
P46	Racing Finish	-			42.0	1.47	550
-	Super-Vinelast	-			48.0§	1.70**	730
P33	Neptune	-			68.0	2.68	1,620
-	Foul-Ban	-			40.0	1.70**	600
	International						
P28	Interlux 62	B	<0.2	<0.6	31.5	1.70**	480
P26	Bottomkote 69	A	<0.4	<1.1	43.5	1.92	740
P20	Vinyl-lux	A	<0.03	<0.07	45.0	2.24	900
P19	Tri-lux	B	<0.3	<1.0	0	1.70**	0
P18	Copper-lux	A	<0.06	<0.15	67.5	2.83	1,700
-	Inter-club	-			31.5	1.70**	480

*A = separatory funnel method; B = Soxhlet method.
**Median density assumed.

†Percent metallic copper.
††Plus 9% CuOH.
§Plus 3% CuOH.

Table 9 (Continued)

Code	Brand and Type	Extraction Method*	PCB (mg/l) 1242	PCB (mg/l) 1254	Cu_2O (%)	ρ (kg/l)	Cu (g/l)
	Pettit						
P25	Unepoxy	B	<0.01	<0.03	60.7	2.30	1,240
P51	Trinidad 75 (Red)	A	<0.09	<0.2	75.8	1.79	1,210
P31	Pacific Special	A	1.7	1.2	35.0	1.66	520
P41	Old Salem	-			55.2	1.10	540
	Vinylcide red						
P36	Starline	-			0	-	0
	Antifouling Bronze						
	Mariner's						
P2	1034 Lido	A	<0.3	<0.6	68.1	1.76	1,060
	Singapore						
P32	696 Blue	A	<0.4	<1.2	34.0	1.54	470
	Devoe-Reynolds						
P30	Navicote	A	<84	<220	47.8	2.20	940
P63	Triple C	A	12.0	28.0	24.6	1.51	330
Commercial							
	Devoe-Reynolds						
P54	Super Tropical	A	18	23	24.6	1.88	410
P58	3407	A	<0.005	<0.023	38.5	2.58	880
P59	213	A	<0.92	<0.29	36.2	1.70**	550
P60	121	A			70.3	1.74	1,100
P64	Hot Plastic	B	1.30	3.00	32.5	1.20	350
P55	Cold Plastic 105	B	<1.6	<4.0	40.3	1.34	480
-	3402	-			10.0	1.70**	150
	Amarcoat						
P62	Emeron 67	A	1.20	2.80	15.0	1.51	200
	Proline						
P57	1080	A	<0.17	<0.72	51.0	1.70**	770
Navy							
	Devoe-Reynolds						
P60	121/63	A	<0.1	<0.4	70.3	1.74	1,090
P61	129/63	A	<0.1	<0.4	63.2	1.24	690

*A = separatory funnel method; B = Soxhlet method. **Median density assumed.

Table 10.

Concentrations of Polychlorinated Biphenyls Measured in Bottom Paints Removed from Boats in Southern California Drydocks.

Boatyard	Code	Origin	Method	PCB (mg/dry kg) 1242	PCB (mg/dry kg) 1254
Marina del Rey					
No. 1	P9	Fiberglass Hull	Sandblast	<0.1	3.0
	P10	Trashcan	Scrape	1.3	1.4
	P11	Trashcan	Scrape	9.5	3.5
	P12	Drain 1	-	<28	3,300
	P13	Drain 2	-	7.5	8.3
	P14	Drain 2	-	110	160
	P15	Wood Hull	Scrape	-	19
	P16	Wood Hull	Scrape	3,000	5530000
	P17	Wood Hull	Scrape	-	150,000
	P21	Yard	Scrape	<2.8	<0.3
	P22	Wood Hull	Scrape	<0.9	20
No. 2	P4	Wood Hull	Sandblast	<1.1	<1.1
	P8	Fiberglass Hull	Sandblast	<1.0	<4.2
Long Beach Harbor					
No. 5	P65	Wood Hull	Scrape	0.5	0.8
	P66	Wood Hull	Scrape	3.7	1.9

vate use accounted for the other 10 percent. Applying this factor to the boatyard statistics presented above, it is estimated that approximately 75 percent of the boats inventoried in the marinas of the Bight are painted annually, using on the average about 1 gal. of antifouling paint per boat. This implies that the application rate of antifouling paints to recreation craft along the southern California coast during 1973 was approximately:

$$37{,}000 \text{ boats inventoried} \times 0.75 \ \frac{\text{boats painted per year}}{\text{boats inventoried}}$$

$$\times \ 1 \ \frac{\text{gallon paint}}{\text{boats painted}}$$

$$= 28{,}000 \text{ gal./yr*}$$

Regarding the annual use of antifouling paint for commercial and naval vessels, as seen in Table 7, the estimated total for Los Angeles-Long Beach Harbor (San Pedro Bay) is 30,600 gal./yr. Table 8 presents data obtained for 1972 from records of the two largest shipyards in San Diego Bay; approximately 12,600 gal. of antifouling paint were used at these yards during that year. These results are in excellent agreement with those reported by Barry (1972) for the previous year; during 1971, a total of approximately 13,000 gal. of antifouling paint were applied to commercial and naval vessels in these two yards. As Barry's data imply that the total value for such vessels (excluding recreational craft) painted during 1971 in the Bay was approximately 19,400 gal., the estimated total annual use of antifouling paint on commercial and naval vessels at shipyards in the two bays is:

San Pedro Bay	=	30,600 gal./yr
San Diego Bay	=	19,400 gal./yr
Total	=	50,000 gal./yr

These two harbors contain the major shipyards located along the southern California coast.

PCB and Copper Inputs

As seen from Table 9, PCB 1242 or 1254 were detected in only 7 of the 28 wet paint samples analyzed. With the exception of Samples P54 and P63, whose total PCB concentrations each were approximately 40 mg/l, levels generally were the order of 1 mg/l or below. (Neglecting inequality signatures in Table 9, median values for PCB 1242 and 1254 were 0.3 mg/l and 0.7 mg/l, respectively.) When we combine these median values with the estimated quantities of antifouling paint applied annually to recreational, commercial, and naval vessels in marinas or harbors of the Bight, we obtain the estimated upper limits for PCB annual usage at each of the southern California anchorages shown in Table 11.

* One gallon equals 3.78 liters.

A corresponding calculation may be made for estimated copper usage. From the data presented in Table 9, the following summary of copper concentrations in antifouling paints is obtained:

Class	No. of Values	Cu (g/l)
Recreational	29	Median = 550 Range = 0-1,700 Mean = 660 $S_{\bar{x}}$ = 82
Commercial	9	Median = 480 Range = 150-1,100 Mean = 540 $S_{\bar{x}}$ = 110
Navy	2	Median = 890 Range = 690-1,090 Mean = 890 $S_{\bar{x}}$ = 200
Combined	40	Median = 550 Range = 0-1,700 Mean = 650 $S_{\bar{x}}$ = 655

These results are in reasonable agreement with those of Barry (1972); from his data, median concentrations for the above four categories are 610 (n = 21), 670 (n = 6), 1240 (n = 2), and 640 (n = 29). Although the naval vessel paints apparently contain somewhat more copper than do most paints used on the other types of craft, the results are generally quite similar. Until better data on usage of individual paints become available, it appears adequate to apply an average value for the copper content of antifouling paints used in the Bight. Combination of the results from Barry's study (overall median = 550 g/l) and from our study (overall median = 640 g/l) results in an estimated typical copper level of about 600 g/l. Using this figure, the estimated annual application rates of copper to vessel bottoms in each anchorage of the Bight have been calculated and are also listed in Table 11.

In Table 12, potential input rates of PCB and copper to the Bight through vessel paints are compared to those estimated for municipal wastewater (1971 data) and surface runoff (Water Year 1971-72) entering our coastal waters (Southern California Coastal Water Research Project 1973).

Table 11.

Estimated Annual Application Rates of PCB 1242, PCB 1254, and Copper to Recreational, Commercial, and Naval Vessels via Antifouling Paints at the Major Marinas and Harbors of the Bight, 1973.

Area	Anchorage	Paints* (gal./yr)	PCB (g/yr)** 1242	PCB (g/yr)** 1254	PCB (g/yr)** Total	Copper† (metric tons/yr)
I	Santa Barbara Harbor	600	0.7	1.6	2.3	1.4
II	Ventura Harbor	750	0.8	2.0	2.8	1.7
	Oxnard Harbor	750	0.8	2.0	2.8	1.7
III	Marina del Rey	4,410	5.0	12	17	10
	Redondo-King Harbor	1,120	1.3	3.0	4.3	2.5
V	Huntington	2,560	2.9	6.8	9.7	5.8
	San Pedro Bay	37,200	42	98	140	84
	Newport Bay	6,410	7.3	17	24.3	15
VI	Dana Point Harbor	440	0.5	1.2	1.7	1.0
	Oceanside Harbor	440	0.5	1.2	1.7	1.0
VII	Mission Bay	1,200	1.4	3.2	4.6	2.7
	San Diego Bay	22,100	25	58	83	50
	TOTAL	77,980			<294	177

*Assuming (1) a 7% increase in the 1971 inventory values for recreational craft listed in Table 1; (2) 75% of the recreational craft are painted annually, using an average of 1 gal. of antifouling paint per boat. The values for San Pedro Bay and San Diego Bay (30,600 and 19,400 gal./yr, respectively) include estimates for commercial and naval vessels. One gallon is equivalent to 3.78 liters.

**Upper limit figures, based on median values not exceeding 0.3 and 0.7 mg/l for PCB 1242 and PCB 1254, respectively.

†Assuming that, on the average, the concentration of copper in antifouling paint is about 600 g/l.

Table 12. Estimated recent annual input rates of PCB and copper to seven coastal areas of the Bight via municipal wastewaters and surface runoff, and estimated application rates of vessel antifouling paints.

Area	Total PCB (kg/yr)			Copper (m tons/yr)		
	Waste-waters*	Runoff**	Paints	Waste-waters*	Runoff**	Paints
I	-	1	0.01	--	0066	1144
II	3	10	0.01	1	88	3344
III	570	18	0.02	190	33	12.5
IV	6,000	-	-	290	-	-
V	3,000	214	0.17	66	6	105
VI	-	3	0.01	-	0.9	2.0
VII	110	-	0.09	20	-	52.7
TOTAL	9,700	250	0.3	570	19	180

* 1971 data.
** Data from Water Year 1971-72.

CONCLUSIONS

Because 1971-72 was an unusually dry year, the estimated inputs for surface runoff (Table 12) are thought to be lower by about a factor of two than those that would have occurred under normal rainfall conditions. Also, source control efforts by the municipal wastewater managers apparently have now reduced the 1971 total PCB annual inputs by about a factor of two or three. Nevertheless, it is apparent that surface runoff probably is not an important source of either PCB or copper relative to municipal wastewater inputs.

While use of antifouling paints obviously now contributes a trivial amount of PCB to the harbors of the Bight (Table 12), the potential input (application rate) of copper via antifouling paint is seen to be quite significant. Overall, this potential input is about one-third the total estimate for municipal wastewater, and in Area V (San Pedro Basin) and Area VII (San Diego), it exceeds the wastewater value. Although we cannot yet estimate with any reliability what fraction of the copper contained in antifouling paint actually is released to the marine environment, the fact that this toxicant is deliberately added to the paint (in a matrix designed to gradually release the toxicant) to prevent fouling by marine invertebrates suggests that an important fraction of the copper applied is indeed released to the marine environment before repainting. In addition, during repainting, a significant fraction of bottom scrapings may be blown or washed into the harbor water.

There is some indication that copper concentrations in digestive glands of the intertidal mussel and in the liver tissue of Dover sole collected from the vicinities of the major harbors in the Bight are somewhat higher than estimated baseline concentrations (Figures 8-19 and 7-14, Southern California Coastal Water Research Project 1973). This hypothesis is now being further investigated.

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United States
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Agency

Water Planning Division
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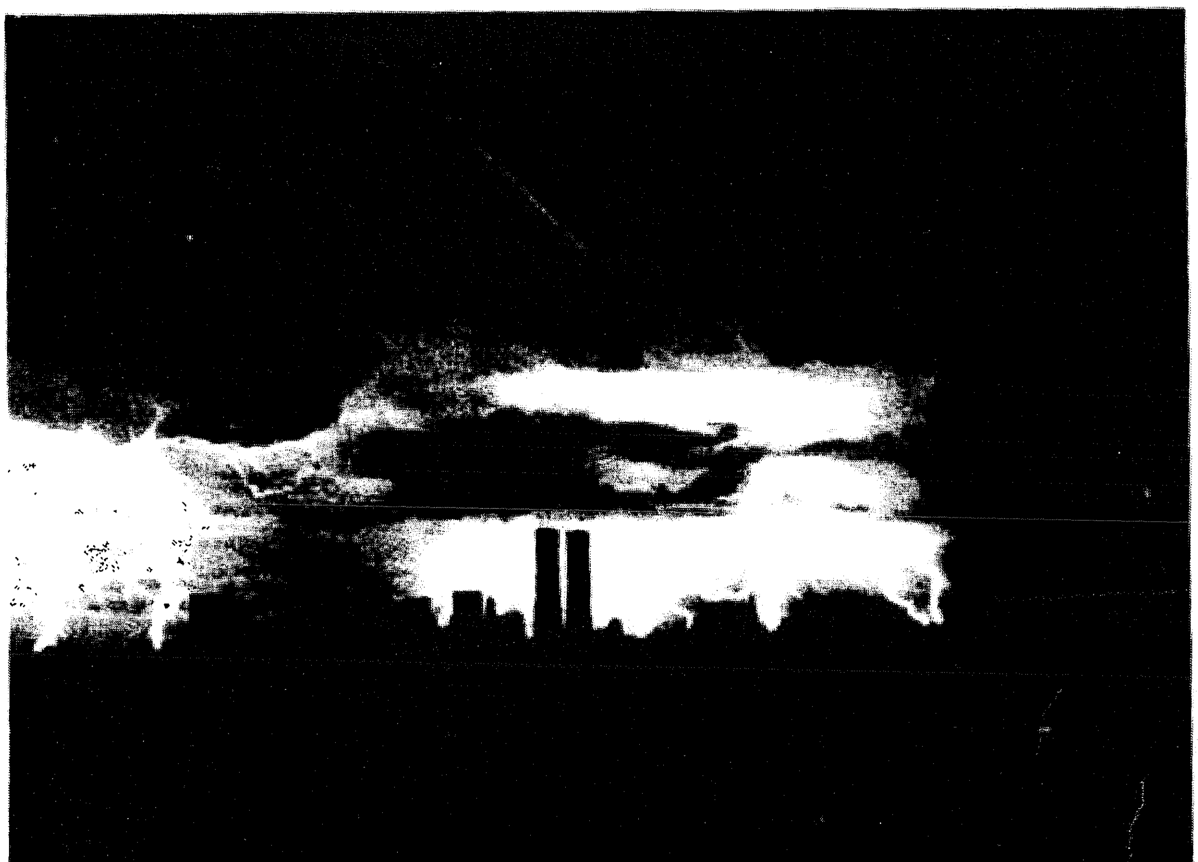
December 1983

Water

EPA

Results of the Nationwide Urban Runoff Program

Executive Summary



RESULTS

OF THE

NATIONWIDE URBAN RUNOFF PROGRAM

December, 1983

EXECUTIVE SUMMARY

Water Planning Division

U.S. Environmental Protection Agency

Washington, D.C. 20460

National Technical Information Service (NTIS)
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DISCLAIMER

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The Nationwide Urban Runoff Program was unusual in its large scale, covering a broad spectrum of technical and planning issues at many geographic locations. Because the program placed such emphasis on tailoring the results to support the planning process, it involved many participants - some from EPA, some from other federal agencies, and many from state, regional, and local planning agencies and other consultants.

The program was developed, implemented, and managed by the Water Planning Division, Office of Water, at EPA Headquarters, Washington, D.C. Principal contributors were: Dennis N. Athayde, Program Manager; and Patrice M. Bubar, Norman A. Whalen, Stuart S. Tuller, and Phillip H. Graham, all of whom served as Project Officers. Additional contributions from EPA personnel came from Rod E. Frederick and Richard P. Healy (Monitoring and Data Support Division), Richard Field (Storm and Combined Sewer Section, EPA Office of Research and Development), and many project staff in the various EPA Regional Offices.

As described elsewhere, much of the field work, water quality analysis, and data analysis was performed by the U.S. Geological Survey (USGS), under a Memorandum of Agreement with EPA. Both District Offices and National Headquarters participated actively. The contributions of Messrs. Ernest Cobb and David Lystrom are especially acknowledged.

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The principal writers of this report were Dennis N. Athayde (EPA), Philip E. Shelley (EG&G Washington Analytical Services Center, Inc.), Eugene D. Driscoll (E. D. Driscoll & Associates), and David Gaboury and Gail B. Boyd (Woodward-Clyde Consultants).

EXECUTIVE SUMMARY

BACKGROUND

The water quality effects of stormwater pollution received little attention prior to 1960. Stormwater concerns were primarily related to drainage problems. As stormwater pollution began to be investigated, the work, reported by EPA and published in professional journals, tended to focus on determining (a) the type and amount of pollutants involved and/or (b) methods to reduce the loads. However, such reports and articles gave limited consideration to either the level of improvement attainable or the need to improve quality of the receiving water body associated with the study. A conclusion common to all such reports was that not enough was known about stormwater, and recommendations for further study and more data were the norm. A tangible result of the uncertain attitude in this area is the fact that stormwater controls for water quality have been implemented in so few places throughout the nation. Thus, there has been a critical need to objectively examine the situation. This need led to the development of the Nationwide Urban Runoff Program (NURP).

The overall goal of NURP was to develop information that would help provide local decision makers, States, EPA, and other interested parties with a rational basis for determining whether or not urban runoff is causing water quality problems and, in the event that it is, for postulating realistic control options and developing water quality management plans, consistent with local needs, that would lead to implementation of least cost solutions. It is also hoped that this information base will be used to help make the best possible policy decision on Federal, State, and local involvement in urban stormwater runoff and its control. Among the many objectives of NURP was the assembly of an appropriate data base and the development of analytical methodologies that would allow us to examine such issues as:

- The quality characteristics of urban runoff, and similarities or differences at different urban locations;

- The extent to which urban runoff is a significant contributor to water quality problems across the nation; and

- The performance characteristics and the overall effectiveness and utility of management practices for the control of pollutant loads from urban runoff.

Water quantity problems are relatively easy to identify and describe. Water quality problems, on the other hand, tend to be more elusive because their definition often involves some subjective considerations, including experiential aspects and expectations of the populace. They are not immediately obvious and are usually less dramatic than, for example, floods. They also tend to vary markedly with locality and geographic regions within the country. Thus, a methodological approach to the determination of water quality problems is essential if one is to consider the relative role of urban runoff as a contributor. An important finding of the work conducted during NURP was to learn to avoid the following simplistic logic train: (a) water quality problems are caused by pollutants, (b) there are pollutants in urban runoff, therefore, (c) urban runoff causes "problems". The unspoken implication is that a "problem" by definition requires action, and any type of "problem" warrants equally vigorous action. It becomes clear that a more fundamental and more precise definition of a water quality "problem" from urban runoff is necessary. For this purpose, NURP adopted the following three-level definition:

- Impairment or denial of beneficial uses;
- Water quality criterion violation; and
- Local public perception.

The foregoing levels of problem definition provide an essential framework within which to discuss water quality problems associated with urban runoff. However, it is important to understand that when one is dealing at a local level all three elements are typically present. Thus, it is up to the local decision makers, influenced by other levels of support and concern, to carefully weigh each, prior to making a final decision about the existence and extent of a problem and how it is to be defined.

The NURP studies have greatly increased our knowledge of the characteristics of urban runoff, its effects upon designated uses, and of the performance efficiencies of selected control measures. They have also confirmed earlier impressions that some States and local communities have actually begun to develop and implement stormwater management programs incorporating water quality objectives. However, such management initiatives are, at present, scattered and localized. The experience gained from such efforts is both needed and sought after by many other States and localities. Documentation, evaluation, refinement and transfer of management and financing mechanisms/ arrangements, of simple and reliable problem assessment methodologies, and of implementation guidance which can be used by planners and officials at the State and local level are urgently needed as is a forum for the sharing of experiences by those already involved, both among themselves and with those who are about to address nonpoint source issues.

CONCLUSIONS

The following summarizes NURP's conclusion relating to its major objectives and is based on the results presented in Chapters 6, 7, and 8 of the report. Conclusions reached by the individual NURP projects are also presented to further support the results of the national level analysis.

URBAN RUNOFF CHARACTERISTICS

General

Field monitoring was conducted to characterize urban runoff flows and pollutant concentrations. This was done for a variety of pollutants at a substantial number of sites distributed throughout the country. The resultant data represent a cross-section of regional climatology, land use types, slopes, and soil conditions and thereby provide a basis for identifying patterns of similarities or differences and testing their significance.

Urban runoff flows and concentrations of contaminants are quite variable. Experience shows that substantial variations occur within a particular event and from one event to the next at a particular site. Due to the high variability of urban runoff, a large number of sites and storm events were monitored, and a statistical approach was used to analyze the data. Procedures are available for characterizing variable data without requiring knowledge of or existence of any underlying probability distribution (nonparametric statistical procedures). However, where a specific type of probability distribution is known to exist, the information content and efficiency of statistical analysis is enhanced. Standard statistical procedures allowed probability distributions or frequency of occurrence to be examined and tested. Since the underlying distributions were determined to be adequately represented by the lognormal distribution, the log (base e) transforms of all urban runoff data were used in developing the statistical characterizations.

The event mean concentration (EMC), defined as the total constituent mass discharge divided by the total runoff volume, was chosen as the primary water quality statistic. Event mean concentrations were based on flow weighted composite samples for each event at each site in the accessible data base. EMCs were chosen as the primary water quality characteristic subjected to detailed analysis, even though it is recognized that mass loading characteristics of urban runoff (e.g., pounds/acre for a specified time interval) is ultimately the relevant factor in many situations. The reason is that, unlike EMCs, mass loadings are very strongly influenced by the amount of precipitation and runoff, and estimates of typical annual mass loads will be biased by the size of monitored storm events. The most reliable basis for characterizing annual or seasonal mass loads is on the basis of EMC and site-specific rainfall/runoff characteristics.

Establishing the fundamental distribution as lognormal and the availability of a sufficiently large population of EMCs to provide reliability to the statistics derived has yielded a number of benefits, including the ability to provide:

- Concise summaries of highly variable data

- Meaningful comparisons of results from different sites, events, etc.

- Statements concerning frequency of occurrence. One can express how often values will be expected to exceed various magnitudes of interest.

- A more useful method of reporting data than the use of ranges; one which is less subject to misinterpretation

- A framework for examining "transferability" of data in a quantitative manner

Conclusions

1. Heavy metals (especially copper, lead and zinc) are by far the most prevalent priority pollutant constituents found in urban runoff. End-of-pipe concentrations exceed EPA ambient water quality criteria and drinking water standards in many instances. Some of the metals are present often enough and in high enough concentrations to be potential threats to beneficial uses.

   All 13 metals on EPA's priority pollutant list were detected in urban runoff samples, and all but three at frequencies of detection greater than 10 percent. Most often detected among the metals were copper, lead, and zinc, all of which were found in at least 91 percent of the samples.

   Metal concentrations in end-of-pipe urban runoff samples (i.e., before dilution by receiving water) exceeded EPA's water quality criteria and drinking water standards numerous times. For example, freshwater acute criteria were exceeded by copper concentrations in 47 percent of the samples and by lead in 23 percent. Freshwater chronic exceedances were common for lead (94 percent), copper (82 percent), zinc (77 percent), and cadmium (48 percent). Regarding human toxicity, the most significant pollutants were lead and nickel, and for human carcinogenesis, arsenic and beryllium. Lead concentrations violated drinking water criteria in 73 percent of the samples.

   It should be stressed that the exceedances noted above do not necessarily imply that an actual violation of standards will exist in the receiving water body in question. Rather, the enumeration of exceedances serves a screening function to identify those heavy metals whose presence in urban runoff warrants high priority for further evaluation.

   Based upon the much more extensive NURP data set for total copper, lead, and zinc, the site median EMC values for the median urban site are: Cu = 34 μg/l, Pb = 144 μg/l, and Zn = 160 μg/l. For the 90th percentile urban site the values are: Cu = 93 μg/l, Pb = 350 μg/l, and Zn = 500 μg/l. These values are suggested to be appropriate for planning level screening analyses where data are not available.

   Some individual NURP project sites (e.g., at DC1, MD1, NH1) found unusually high concentrations of certain heavy metals (especially copper and zinc) in urban runoff. This was attributed by the projects to the effect of acid rain on materials used for gutters, culverts, etc.

2. <u>The organic priority pollutants were detected less frequently and at lower concentrations than the heavy metals.</u>

Sixty-three of a possible 106 organics were detected in urban runoff samples. The most commonly found organic was the plasticizer bis (2-ethylhexl) phthalate (22 percent), followed by the pesticide α-hexachlorocyclohexane (α-BHC) (20 percent). An additional 11 organic pollutants were reported at frequencies between 10 and 20 percent; 3 pesticides, 3 phenols, 4 polycyclic aromatics, and a single halogenated aliphatic.

Criteria exceedances were less frequently observed among the organics than the heavy metals. One unusually high pentachlorophenol concentration of 115 μg/l resulted in exceedances of the freshwater acute and organoleptic criteria. This observation and one for chlordane also exceeded the freshwater acute criteria. Freshwater chronic criteria exceedances were observed for pentachlorophenol, bis (2-ethylhexyl) phthalate, gamma-BHC, chlordane, and alpha-endosulfan. All other organic exceedances were in the human carcinogen category and were most serious for alpha-hexachlorocyclohexane (alpha-BHC), gamma-hexachlorocyclohexane (gamma-BHC or Lindane), chlordane, phenanthrene, pyrene, and chrysene.

The fact that the NURP priority pollutant monitoring effort was limited to two samples at each site leaves us unable to make many generalizations about those organic pollutants which occurred only rarely. We can speculate that their occurrences tend to be very site specific as opposed to being a generally widespread phenomena, but much more data would be required to conclusively prove this point.

3. <u>Coliform bacteria are present at high levels in urban runoff and can be expected to exceed EPA water quality criteria during and immediately after storm events in many surface waters, even those providing high degrees of dilution.</u>

Fecal coliform counts in urban runoff are typically in the tens to hundreds of thousand per 100 ml during warm weather conditions, with the median for all sites being around 21,000/100 ml. During cold weather, fecal coliform counts are more typically in the 1,000/100 ml range, which is the median for all sites. Thus, violations of fecal coliform standards were reported by a number of NURP projects. High fecal coliform counts may not cause actual use impairments, in some instances, due to the location of the urban runoff discharges relative to swimming areas or shellfish beds and the degree of dilution/dispersal and rate of die off. The same is true of total coliform counts, which were found to exceed EPA water quality criteria in undiluted urban runoff at virtually every site every time it rained.

The substantial seasonal differences noted above do not correspond with comparable variations in urban activities. The NURP analyses as well as current literature suggest that fecal coliform may not be the most appropriate indicator organism for identifying potential health risks when the source is stormwater runoff.

4. Nutrients are generally present in urban runoff, but with a few individual site exceptions, concentrations do not appear to be high in comparison with other possible discharges to receiving water bodies.

NURP data for total phosphorus, soluble phosphorus, total kjeldahl nitrogen, and nitrate plus nitrite as nitrogen were carefully examined. Median site EMC median concentrations in urban runoff were TP = 0.33 mg/l, SP = 0.12 mg/l, TKN = 1.5 mg/l, and NO2+3 - N = 0.68 mg/l. On an annual load basis, comparison with typical monitoring data, literature values, and design objectives for discharges from a well run secondary treatment plant suggests that mean annual nutrient loads from urban runoff are around an order of magnitude less than those from a POTW.

5. Oxygen demanding substances are present in urban runoff at concentrations approximating those in secondary treatment plant discharges. If dissolved oxygen problems are present in receiving waters of interest, consideration of urban runoff controls as well as advanced waste treatment appears to be warranted.

Urban runoff median site EMC median concentrations of 9 mg/l BOD5 and 65 mg/l COD are reflected in the NURP data, with 90th percentile site EMC median values being 15 mg/l BOD5 and 140 mg/l COD. These concentrations suggest that, on an annual load basis, urban runoff is comparable in magnitude to secondary treatment plant discharges.

It can be argued that urban runoff is typically well oxygenated and provides increased stream flow and, hence, in view of relatively long travel times to the critical point, that dissolved oxygen problems attributable solely to urban runoff should not be widespread occurrences. No NURP project specifically identified a low DO condition resulting from urban runoff. Nonetheless, there will be some situations where consideration of urban runoff controls for oxygen demanding substances in an overall water quality management strategy would seem appropriate.

6. Total suspended solids concentrations in urban runoff are fairly high in comparison with treatment plant discharges. Urban runoff control is strongly indicated where water quality problems associated with TSS, including build-up of contaminated sediments, exist.

There are no formal water quality criteria for TSS relating to either human health or aquatic life. The nature of the suspended solids in urban runoff is different from those in treatment plant discharges, being higher in mineral and man-made products (e.g., tire and street surface wear particles) and somewhat lower in organic particulates. Also, the solids in urban runoff are more likely to have other contaminants adsorbed onto them. Thus, they cannot be simply considered as benign, nor do they only pose an aesthetic issue. NURP did not examine the problem of contaminated sediment build-up due to urban runoff, but it undeniably exists, at least at some locations.

The suspended solids in urban runoff can also exert deleterious physical effects by sedimenting over egg deposition sites, smothering juveniles, and altering benthic communities.

On an annual load basis, suspended solids contributions from urban runoff are around an order of magnitude or more greater than those from secondary treatment plants. Control of urban runoff, as opposed to advanced waste treatment, should be considered where TSS-associated water quality problems exist.

7. A summary characterization of urban runoff has been developed and is believed to be appropriate for use in estimating urban runoff pollutant discharges from sites where monitoring data are scant or lacking, at least for planning level purposes.

   As a result of extensive examination, it was concluded that geographic location, land use category (residential, commercial, industrial park, or mixed), or other factors (e.g., slope, population density, precipitation characteristics) appear to be of little utility in consistently explaining overall site-to-site variability in urban runoff EMCs or predicting the characteristics of urban runoff discharges from unmonitored sites. Uncertainty in site urban runoff characteristics caused by high event-to-event variability at most sites eclipsed any site-to-site variability that might have been present. The finding that EMC values are essentially not correlated with storm runoff volumes facilitates the transfer of urban runoff characteristics to unmonitored sites. Although there tend to be exceptions to any generalization, the suggested summary urban runoff characteristics given in Table 6-17 of the report are recommended for planning level purposes as the best estimates, lacking local information to the contrary.

RECEIVING WATER EFFECTS

General

The effects of urban runoff on receiving water quality are highly site-specific. They depend on the type, size, and hydrology of the water body; the urban runoff quantity and quality characteristics; the designated beneficial use; and the concentration levels of the specific pollutants that affect that use.

The conclusions which follow are based on screening analyses performed by NURP, observations and conclusions drawn by ~~individual NURP~~ projects that examined receiving water effects in differing levels of detail and rigor, and NURP's three levels of problem definition. Conclusions are organized on the basis of water body type: rivers and streams, lakes, estuaries and embayments, and groundwater aquifers. Site-specific exceptions should be expected, but the statements presented are believed to provide an accurate perspective on the general tendency of urban runoff to contribute significantly to water quality problems.

Rivers and Streams

1. Frequent exceedances of heavy metals ambient water quality criteria for freshwater aquatic life are produced by urban runoff.

   The Denver NURP project found that in-stream concentrations of copper, lead, zinc, and cadmium exceeded State ambient water quality standards for the South Platte River during essentially all storm events.

NURP screening analyses suggest that frequent exceedances of both EPA 24-hour and maximum water quality criteria for heavy metals should be expected on a relatively general basis.

2. Although a significant number of problem situations could result from heavy metals in urban runoff, levels of freshwater aquatic life use impairment suggested by the magnitude and frequency of ambient criteria exceedances were not observed.

Based upon the magnitude and frequency of freshwater aquatic life ambient criteria exceedances, one would expect to observe impairment of this beneficial use in most streams that receive urban runoff discharges. However, those NURP project studies which examined this issue did not report significant use impairment problems associated with urban runoff.

The Bellevue, Washington NURP project concluded that toxic effects of urban runoff pollutants did not appear to be a significant factor.

The Tampa, Florida NURP project conducted biological studies of the impact of stormwater runoff upon the biological community of the Hillsborough River. They conducted animal bioassay experiments on five sensitive species in two samples of urban runoff from the Arctic Street drainage basin. Thirty-two bioassay experiments were completed including 22 acute tests and 10 chronic tests. Neither sample of stormwater was acutely toxic to test organisms. Long-term chronic experiments were undertaken with two species and resulted in no significant effects attributable to stormwater exposure.

NURP screening analyses suggest that the potential of urban runoff to seriously impair this beneficial use will be strongly influenced by local conditions and the frequency of occurrence of concentration levels which produce toxic effects under the intermittent, short duration exposures typically produced by urban runoff.

While the application of the screening analysis to the Bellevue and Tampa situations supports the absence of a problem situation in these cases, it also suggests that a significant number of problem situations should be expected. Therefore, although not the general, ubiquitous problem situation that criteria exceedances would suggest, there are site-specific situations in which urban runoff could be expected to cause significant impairment of freshwater aquatic life uses.

Because of the inconsistency between criteria exceedances and observed use impairments due to urban runoff, adaptation of current ambient quality criteria to better reflect use impacts where pollutant exposures are intermittent and of short duration appears to be a useful area for further investigation.

3. Copper, lead and zinc appear to pose a significant threat to aquatic life uses in some areas of the country. Copper is suggested to be the most significant of the three.

Regional differences in surface water hardness, which has a strong influence on toxicity, in conjunction with regional variations in stream flow and rainfall result in significant differences in susceptibility to adverse impacts around the nation.

The southern and southeastern regions of the country are the most susceptible to aquatic life effects due to heavy metals, with the northeast also a sensitive area, although somewhat less so.

Copper is the major toxic metal in urban runoff, with lead and zinc also prevalent but a problem in more restricted cases. Copper discharges in urban runoff are, in all but the most favorable cases, a significant threat to aquatic life uses in the southeast and southern regions of the country. In the northeast, problems would be expected only in rather unfavorable conditions (large urban area contribution and high site concentrations). In the remainder of the country (and for the other metals) problems would only be expected under quite unfavorable site conditions. These statements are based on total metal concentrations.

4. Organic priority pollutants in urban runoff do not appear to pose a general threat to freshwater aquatic life.

   This conclusion is based on limited data on the frequency with which organics are found in urban runoff discharges and measured end-of-pipe concentrations relative to published toxic criteria. One unusually high pentachlorophenol concentration of 115 µg/l resulted in the only exceedance of the organoleptic criteria. This observation and one for chlordane exceeded the freshwater acute criteria. Freshwater chronic criteria exceedances were observed for pentochlorophenol, bis (2-ethylhexyl) phlhalate, γ-hexachlorocyclohexane (lindane), α-endosulfan, and chlordane.

5. The physical aspects of urban runoff, e.g., erosion and scour, can be a significant cause of habitat disruption and can affect the type of fishery present. However, this area was studied only incidentally by several of the projects under the NURP program and more concentrated study is necessary.

   The Metropolitan Washington Council of Governments (MWCOG) NURP project did an analysis of fish diversity in the Seneca Creek Watershed, 20 miles northwest of Washington, D.C. In this study, specific changes in fishery diversity were identified due to urbanization in some of the subwatersheds. Specifically, the number of fish species present are reduced and the types of species present changed dramatically, e.g., environmentally sensitive species were replaced with more tolerant species. For example, the Blacknose Dace replaced the Mottled Sculpin. MWCOG concluded that the changes in fish diversity were due to habitat deterioration caused by the physical aspects of urban runoff.

   The Bellevue, Washington NURP project concluded that habitat changes (streambed scour and sedimentation) had a more significant effect than pollutant concentrations, for the changes produced by urbanization.

6. Several projects identified possible problems in the sediments because of the build-up of priority pollutants contributed wholly or in part by urban runoff. However, the NURP studies in this area were few in number

and limited in scope, and the findings must be considered only indicative of the need for further study, particularly as to long-term impacts.

The Denver NURP project found significant quantities of copper, lead, zinc, and cadmium in river sediments. The Denver Regional Council of Governments is concerned that during periods of continuous low flow, lead may reach levels capable of adversely affecting fish.

The Milwaukee NURP project reported the observation of elevated levels of heavy metals, particularly lead, in the sediments of a river receiving urban runoff.

7. Coliform bacteria are present at high levels in urban runoff and can be expected to exceed EPA water quality criteria during and immediately after storm events in most rivers and streams.

   Violations of the fecal coliform standard were reported by a number of NURP projects. In some instances, high fecal coliform counts may not cause actual use impairments due to the location of the urban runoff discharge relative to swimming areas and the degree of dilution or dispersal and rate of die off.

   Coliform bacteria are generally accepted to be a useful indicator of the possible presence of human pathogens when the source of contamination is sanitary sewage. However, no such relationship has been demonstrated for urban runoff. Therefore, the use of coliforms as an indicator of human health risk when the sole source of contamination is urban runoff, warrants further investigation.

8. Domestic water supply systems with intakes located on streams in close proximity to urban runoff discharges are encouraged to check for priority pollutants which have been detected in urban runoff, particularly those in the organic category.

   Sixty-three of a possible 106 organics were detected in urban runoff samples. The most commonly found organic was the plasticizer bis (2-ethylhexl) phthalate (22 percent), followed by the pesticide α-hexachlorocyclohexane (α-BHC) (20 percent). An additional 11 organic pollutants were reported at frequencies between 10 and 20 percent; 3 pesticides, 3 phenols, 4 polycyclic aromatics, and a single halogenated aliphatic.

Lakes

1. Nutrients in urban runoff may accelerate eutrophication problems and severely limit recreational uses, especially in lakes. However, NURP's lake projects indicate that the degree of beneficial use impairment varies widely, as does the significance of the urban runoff component.

   The Lake Quinsigamond NURP project in Massachusetts identified eutrophication as a major problem in the lake, with urban runoff being a prime contributor of the critical nutrient phosphorus. Point source discharges to the lake have been eliminated almost entirely. However, in spite of the abatement of point sources, survey data indicate that the lake has shown little improvement over the abatement period. In particular, the trophic status of the lake has shown no change, i.e., it is still classified as late mesotrophic-early eutrophic. Substantial growth is projected in the basin, and there is concern that Lake Quinsigamond will become more eutrophic. A proposed water quality management plan for the lake includes the objective of reducing urban runoff pollutant loads.

The Lake George NURP project in New York State also identified increasing eutrophication as a potential problem if current development trends continue. Lake George is not classified as eutrophic, but from 1974 to 1978 algae production in the lake increased logarithmically. Lake George is a very long lake, and the limnological differences between the north and south basins provide evidence of human impact. The more developed, southern portion of the lake exhibits lower transparencies, lower hypolimnetic dissolved oxygen concentrations, higher phosphorus and chlorophyll a concentrations, and a trend toward seasonal blooms of blue-green algae. These differences in water quality indicators are associated with higher levels of cultural activities (e.g., increased sources of phosphorus) in the southern portion of the lake's watershed, and continued development will tend to accentuate the differences.

The Lake George NURP project estimated that urban runoff from developed areas currently accounts for only 13.6 percent of the annual phosphorus loadings to Lake George as a whole. In contrast, developed areas contribute 28.9 percent of the annual phosphorus load to the NURP study areas at the south end of the Lake. Since there are no point source discharges, this phosphorus loading is due solely to urban runoff. These data illustrate the significant impact of urbanization on phosphorus loads.

The NURP screening analysis suggests that lakes for which the contributions of urban runoff are significant in relation to other nonpoint sources (even in the absence of point source discharges) are indicated to be highly susceptible to eutrophication and that urban runoff control may be warranted in such situations.

2. Coliform bacteria discharges in urban runoff have a significant negative impact on the recreational uses of lakes.

As was the case with rivers and streams, coliform bacteria in urban runoff can cause violations of criteria for the recreational use of lakes. When unusually high fecal coliform counts are observed, they may be partially attributable to sanitary sewage contamination, in which case significant health risks may be involved.

The Lake Quinsigamond NURP project in Massachusetts found that bacterial pollution was widespread throughout the drainage basin. In all cases where samples were taken, fecal coliforms were in excess of 10,000 counts per 100 ml, with conditions worse in the Belmont street storm drains. This project concluded that the very high fecal coliform counts in their stormwater are at least partially due to sewage contamination apparently entering the stormwater system throughout the local catchment.

The sources of sewage contamination are leaking septic tanks, infiltration from sanitary sewers into storm sewers, and leakage at manholes. In the northern basin, the high fecal coliform counts are attributed to known sewage contamination sources on Poor Farm Brook. The data from the project suggest that it would be unwise to permit body contact recreation in the northern basin of the lake during or immediately following significant storm events. The project concluded that disinfection at selected storm drains should be considered in the future, especially if the sewage contamination cannot be eliminated.

The Mystic River NURP project in Massachusetts found various areas where fecal coliform counts were extremely high in urban stormwater. Fecal coliform levels of up to one million with an average of 178,000/100 ml were recorded in Sweetwater Brook, a tributary to Mystic River, during wet weather. These high fecal coliform levels were specifically attributed to surcharging in their sanitary sewers, which caused sanitary sewage to overflow into their storm drains via the combined manholes present in this cathcment. Fecal coliform levels above the class B fecal coliform standard of 200 per 100 ml were found in approximately one-third of the samples tested in the upper and lower forebays of the Upper Mystic Lake and occasionally near the lake's outlet. In addition, Sandy Beach, a public swimming area on Upper Mystic Lake, exceeded the State fecal coliform criteria in July of 1982, and warnings that swimming may be hazardous to public health were posted for several days. It is important to note that sewage contamination of surface waters is a major problem in the watershed. The project concluded that urban runoff contributes to the bacteria load during wet weather but, comparatively, is much less significant than the sanitary sources.

Estuaries and Embayments

X 1. Adverse effects of urban runoff in marine waters will be a highly specific local situation. Though estuaries and embayments were studied to a very limited extent in NURP, they are not believed to be generally threatened by urban runoff, though specific instances where use is impaired or denied can be of significant local and even regional importance. Coliform bacteria present in urban runoff is the primary pollutant of concern, causing direct impacts on shellfish harvesting and beach closures.

The significant impact of urban runoff on shellfish harvesting has been well documented by the Long Island, New York NURP project. In this project, stormwater runoff was identified as the major source of bacterial loading to marine waters and, thus, the indirect cause of the denial of certification by the New York State Department of Conservation for about one-fourth of the shellfishing area. Much of this area is along the south shore, where the annual commercial shellfish harvest is valued at approximately $17.5 million.

The Myrtle Beach, South Carolina NURP project found that stormwater discharges from the City of Myrtle Beach directly onto the beach showed high bacterial counts for short durations immediately after storm events. In many instances these counts violated EPA water quality criteria for aquatic life and contact recreation. The high bacteria counts, however, were associated with standing pools formed at the end of collectors for brief periods following the cessation of rainfall and before the runoff percolated into the sand. Consequently, the threat to public health was not considered great enough to warrant closure of the beach.

Groundwater Aquifers

1. Groundwater aquifers that receive deliberate recharge of urban runoff do not appear to be imminently threatened by this practice at the two locations where it was investigated.

   Two NURP projects (Long Island and Fresno) are situated over sole source acquifers. They have been practicing recharge with urban runoff for two decades or more at some sites, and extensively investigated the impact of this practice on the quality of their groundwater. They both found that soil processes are efficient in retaining urban runoff pollutants quite close to the land surface, and concluded that no change in the use of recharge basins is warranted.

   Despite the fact that some of these basins have been in service for relatively long periods of time and pollutant breakthrough of the upper soil layers has not occurred, the ability of the soil to continue to retain pollutants is unknown. Further attention to this issue is recommended.

CONTROL EFFECTIVENESS

General

A limited number of techniques for the control of urban runoff quality were evaluated by the NURP program. The set is considerably smaller than previously published lists of potential management practices. Since the control approaches that were investigated were selected at the local level, the choices may be taken as an initial indication of local perceptions regarding practicality and feasibility from the standpoint of implementation.

Conclusions

1. There is a strong preference for detention devices, street sweeping, and recharge devices as reflected by the control measures selected at the local level for detailed investigation. Interest was also shown in grass swales and wetlands.

   Six NURP projects monitored the performance of a total of 14 detention devices. Five separate projects conducted in-depth studies of the effectiveness of street sweeping on the control of urban runoff quality. A total of 17 separate study catchments were involved in this effort. Three NURP projects examined either the potential of recharge devices to reduce discharges of urban runoff to surface waters or the potential of the practice to contaminate groundwaters. A total of 12 separate sites were covered by this effort.

Grass swales were studied by two NURP projects. Two swales in existing residential areas, and one experimental swale constructed to serve a commercial parking lot were studied.

A number of NURP projects indicated interest in wetlands for improving urban runoff quality at early stages of the program. Only one allocated monitoring activity to this control measure, however.

Various other management practices were identified as having local interest by individual NURP projects, but none of them was allocated the necessary resources to be pursued to a point which allowed an evaluation of their ability to control pollution from urban runoff. Management practices in this category included urban housekeeping (e.g., litter programs, catch basin cleaning, pet ordinances) and public information programs.

2. Detention basins are capable of providing very effective removal of pollutants in urban runoff. Both the design concept and the size of the basin in relation to the urban area served have a critical influence on performance capability.

Wet basins (designs which maintain a permanent water pool) have the greatest performance capabilities. Observed pollutant reductions varied from excellent to very poor in the basins which were monitored. However, when basins are adequately sized, particulate removals in excess of 90 percent (TSS, lead) can be obtained. Pollutants with significant soluble fractions in urban runoff show lower reductions; on the order of 65 percent for total P and approximately 50 percent for BOD, COD, TKN, Copper, and Zinc. Results indicate that biological processes which are operative in the permanent pool produce significant reductions (50 percent or more) in soluble nutrients, nitrate and soluble phosphorus. These performance characteristics are indicated by both the NURP analysis results and conclusions reached by individual projects.

Dry basins, (conventional stormwater management basins), which are designed to attenuate peak runoff rates and hence only very briefly detain portions of flow from the larger storms, are indicated by NURP data to be essentially ineffective for reducing pollutant loads.

Dual-purpose basins (conventional dry basins with modified outlet structures which significantly extend detention time) are suggested by limited NURP data to provide effective reductions in urban runoff loads. Performance may approach that of wet ponds; however, the additional processes which reduce soluble nutrient forms do not appear to be operative in these basins. This design concept is particularly promising because it represents a cost effective approach to combining flood control and runoff quality control and because of the potential for converting existing conventional stormwater management ponds.

Approximate costs of wet pond designs are estimated to be in the order of $500 to $1500 per acre of urban area served, for on-site applications serving relatively small urban areas, and about $100 to $250 per acre of urban area for off-site applications serving relatively large urban areas. The costs reflect present value amounts which include both capital and operating costs. The difference is due to an economy of scale associated with large basin volumes. The range reflects differences in size required to produce particulate removals in the order of 50 percent or 90 percent. Annual costs per acre of urban area served are estimated at $60 to $175, and $10 to $25 respectively.

3. Recharge Devices are capable of providing very effective control of urban runoff pollutant discharges to surface waters. Although continued attention is warranted, present evidence does not indicate that significant groundwater contamination will result from this practice.

   Both individual project results and NURP screening analyses indicate that adequately sized recharge devices are capable of providing high levels of reduction in direct discharges of urban runoff to surface waters. The level of performance will depend on both the size of the unit and the soil permeability.

   Application will be restricted to areas where conditions are favorable. Soil type, depth to groundwater, land slopes, and proximity of water supply wells will all influence the appropriateness of this control technique.

   Surface accumulations which result from the high efficiency of soils to retain pollutants, suggest further attention in applications where dual purpose recharge areas also serve as recreational fields or playground areas.

4. Street sweeping is generally ineffective as a technique for improving the quality of urban runoff.

   Five NURP projects evaluated street sweeping as a management practice to control pollutants in urban runoff. Four of these projects concluded that street sweeping was not effective for this purpose. The fifth, which had pronounced wet and dry seasons, believed that sweeping just prior to the rainy season could produce some benefit in terms of reduced pollution in urban runoff.

   A large data base on the quality of urban runoff from street sweeping test sites was obtained. At 10 study sites selected for detailed analysis, a total of 381 storm events were monitored under control conditions, and an additional 277 events during periods when street sweeping operations were in effect. Analysis of these data indicated that no significant reductions in pollutant concentrations in urban runoff were produced by street sweeping.

   There may be special cases in which street cleaning applied at restricted locations or times of year could provide improvements in urban runoff quality. Some examples that have been suggested, though not demonstrated by the NURP program, include periods following snow melt or leaf fall, or urban neighborhoods where the general level of cleanliness could be significantly improved.

5. Grass swales can provide moderate improvements in urban runoff quality. Design conditions are important. Additional study could significantly enhance the performance capabilities of swales.

   Concentration reductions of about 50 percent for heavy metals, and 25 percent for COD, nitrate, and ammonia were observed in one of the swales studied. However the swale was ineffective in reducing concentrations of organic nitrogen, phosphorus, or bacterial species. Two other swales studied failed to demonstrate any quality improvements in the urban runoff passing through them.

   Evaluations by the NURP projects involved concluded, however, that this was an attractive control technique whose performance could be improved substantially by application of appropriate design considerations. Additional study to develop such information was recommended.

   Design considerations cited included slope, vegetation type and maintenance, control of flow velocity and residence time, and enhancement of infiltration. The latter factor could produce load reductions greater than those inferred from concentration changes and effect reductions in those pollutant species which are not attenuated by flow through the swale.

6. Wetlands are considered to be a promising technique for control of urban runoff quality. However, neither performance characteristics nor design characteristics in relation to performance were developed by NURP.

   Although a number of projects indicated interest, only one assigned NURP monitoring activity to a wetland. This was a natural wetland, and flows passing though it were uncontrolled. Results suggest its potential to improve quality, but the investigation was not adequate to associate necessary design factors to performance capability. Additional attention to this control technique would be useful, and should include factors such as the need for maintenance harvesting to prevent constituent recycling.

ISSUES

A number of issues with respect to managing and controlling urban runoff emerge from the conclusions summarized above. In some instances they represent the need for additional data/information or for further study. In others they point to the need for follow-up activity by EPA, State, or local officials to assemble and disseminate what is already known regarding water quality problems caused by urban runoff and solutions.

Sediments

The nature and scope of the potential long-term threat posed by nutrient and toxic pollutant accumulation in the sediments of urban lakes and streams requires further study. A related issue is the safe and environmentally sound disposal of sediments collected in detention basins used to control urban runoff.

Priority Pollutants

NURP clearly demonstrated that many priority pollutants can be found in urban runoff and noted that a serious human health risk could exist when water supply intakes are in close proximity to urban stormwater discharges. However, questions related to the sources, fate, and transport mechanisms of priority pollutants borne by urban runoff and their frequencies of occurrence will require further study.

Rainfall pH Effects

The relationship between pH and heavy metal values in urban runoff has not been established and needs further study. Several NURP projects (mostly in the northeastern states) attributed high heavy metals concentrations in urban runoff to the effects of acid rain. Although it is quite plausible that acid rain increases the level of pollutants in urban runoff and may transform them to more toxic and more easily assimilated forms, further study is required to support this speculation.

Industrial Runoff

No truly industrial sites (as opposed to industrial parks) were included in any of the NURP projects. A very limited body of data suggests, however, that runoff from industrial sites may have significantly higher contaminant levels than runoff from other urban land use sites, and this issue should be investigated further.

Central Business Districts

Data on the characteristics of urban runoff from central business districts are quite limited as opposed to other land use categories investigated by NURP. The data do suggest, however, that some sites may produce pollutant concentrations in runoff that are significantly higher than those from other sites in a given urban area. When combined with their typically high degrees of imperviousness, the pollutant loads from central business districts can be quite high indeed. The opportunities for control in central business districts are quite limited, however.

Physical Effects

Several projects concluded that the physical impacts of urban runoff upon receiving waters have received too little attention and, in some cases, are more important determinants of beneficial use attainment than chemical pollutants. This contention requires much more detailed documentation.

Synergy

NURP did not evaluate the synergistic effects that might result from pollutant concentrations experienced in stormwater runoff, in association with pH and temperature ranges that occur in the receiving waters. This type of investigation might reveal that control of a specific parameter, such as pH, would adequately reduce an adverse synergistic effect caused by the presence of other pollutants in combination and be the most cost effective solution. Further investigations should include this issue.

Opportunities for Control

Based upon the results of NURP's evaluation of the performance of urban runoff controls, opportunities for significant control of urban runoff quality are much greater for newly developing areas. Institutional considerations and availability of space are the key factors. Guidance on this issue in a form useful to States and urban planning authorities should be prepared and issued.

Wet Weather Water Quality Standards

The NURP experience suggests that EPA should evaluate the possible need to develop "wet weather" standards, criteria, or modifications to ambient criteria to reflect differences in impact due to the intermittent, short duration exposures characteristic of urban runoff and other nonpoint source discharges.

Coliform Bacteria

The appropriateness of using coliform bacteria as indicator organisms for human health risk where the source is exclusively urban runoff warrants further investigation.

Wetlands

The use of wetlands as a control measure is of great interest in many areas, but the necessary information on design performance relationships required before cost effective applications can be considered has not been adequately documented. The environmental impacts of such use upon wetlands is a critical issue which, at present, has been addressed marginally, if at all.

Swales

The use of grass swales was suggested by two NURP projects to represent a very promising control opportunity. However, their performance is very dependent upon design features about which information is lacking. Further work to address this deficiency and appropriate maintenance practices appears warranted.

Illicit Connections

A number of the NURP projects identified what appeared to be illicit connections of sanitary discharges to stormwater sewer systems, resulting in high bacterial counts and dangers to public health. The costs and complications of locating and eliminating such connections may pose a substantial problem in urban areas, but the opportunities for dramatic improvement in the quality of urban stormwater discharges certainly exist where this can be accomplished. Although not emphasized in the NURP effort, other than to assure that the selected monitoring sites were free from sanitary sewage contamination, this BMP is clearly a desirable one to pursue.

Erosion Controls

NURP did not consider conventional erosion control measures because the information base concerning them was considered to be adequate. They are effective, and their use should be encouraged.

Combined Sewer Overflows

In order to address urban runoff from separate storm sewers, NURP avoided any sites where combined sewers existed. However, in view of their relative levels of contamination, priority should be given to control of combined sewer overflows.

Implementation Guidance

The NURP studies have greatly increased our knowledge of the characteristics of urban runoff, its effects upon designated uses, and of the performance efficiencies of selected control measures. They have also confirmed earlier impressions that some States and local communities have actually begun to develop and implement stormwater management programs incorporating water quality objectives. However, such management initiatives are, at present, scattered and localized. The experience gained from such efforts is both needed and sought after by many other States and localities. Documentation, evaluation, refinement and transfer of management and financing mechanisms/ arrangements, of simple and reliable problem assessment methodologies, and of implementation guidance which can be used by planners and officials at the State and local level are urgently needed as is a forum for the sharing of experiences by those already involved, both among themselves and with those who are about to address nonpoint source issues.

APPENDIX
THE NATIONWIDE URBAN RUNOFF PROGRAM

Program Design

NURP was not intended to be a research program, per se, and was not designed as such. Rather, the program was intended to be a support function which would provide information and methodologies for water quality planning efforts. Therefore, wherever possible, the projects selected were ones where the work undertaken would complete the urban runoff elements of formal water quality management plans and the results were likely to be incorporated in future plan updates and lead to implementation of management recommendations. Conduct of the program provided direction and assistance to 28 separate and distinct planning projects, whose locations are shown in Figure 1 and listed in Table 1, but the results will be of value to many other planning efforts. NURP also acted as a clearinghouse and, in that capacity, provided a common communication link to and among the 28 projects.

The NURP effort began with a careful review of what was known about urban runoff mechanisms, problems, and controls, and then built upon this base. The twin objectives of the program were to provide credible information on which Federal, State, and local decision makers could base future urban runoff management decisions and to support both planning and implementation efforts at the 28 project locations.

An early step in implementing the NURP program involved identifying a limited number of locations where intensive data gathering and study could be done. Candidate locations were assessed relative to three basic selection criteria:

- Meeting program objectives;
- Developing implementation plans for those areas; and
- Demonstrating transferability, so that solutions and knowledge gained in the study area could be applied in other areas, without need for intensive, duplicative data gathering efforts.

The program design used for NURP included providing a full range of technical and management assistance to each project as the needs arose. Several forums for the communication of experience and sharing of data were provided through semi-annual meetings involving participants from all projects. The roles and responsibilities of the various State, local, and regional agencies and participating Federal agencies were clearly defined and communicated at the outset. These were reviewed and revised where warranted as the projects progressed.

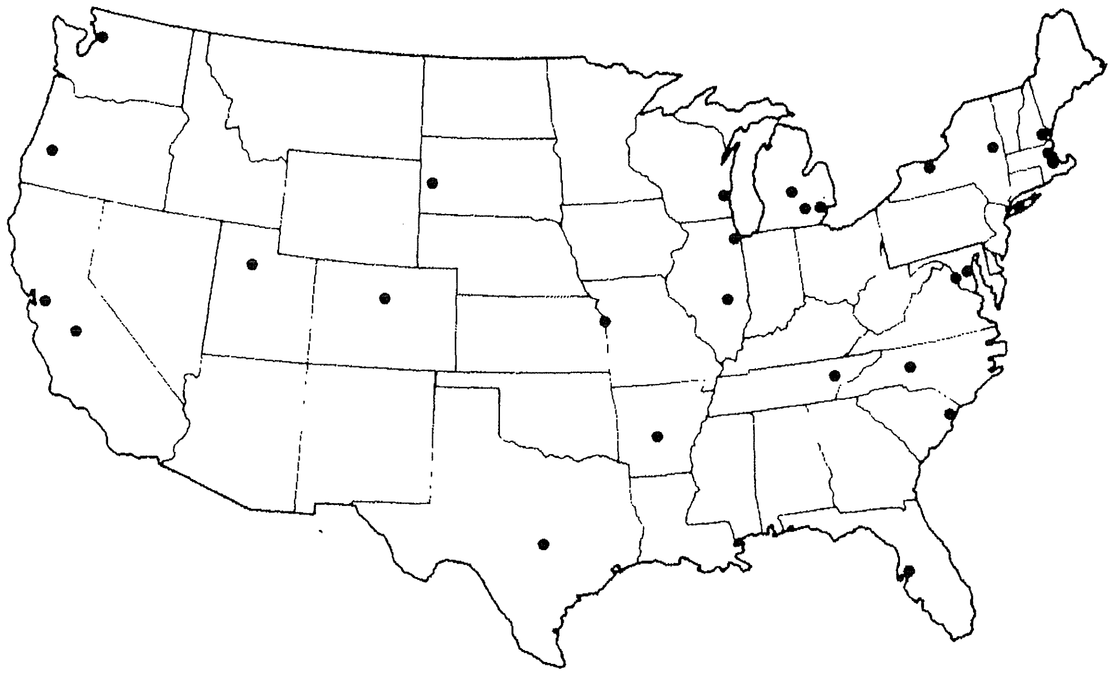

Figure 1. Locations of the 28 NURP Projects

TABLE 1. NURP PROJECT LOCATIONS

EPA Region	NURP Code	Project Name/Location	EPA Region	NURP Code	Project Name/Location
I	MA1	Lake Quinsigamond (Boston Area)	V	IL1	Champaign-Urbana, Illinois
				IL2	Lake Ellyn (Chicago Area)
	MA2	Upper Mystic (Boston Area)		MI1	Lansing, Michigan
	NH1	Durham, New Hampshire		MI2	SEMCOG (Detroit Area)
II	NYI	Long Island (Nassau and Suffolk Counties)		MI3	Ann Arbor, Michigan
				WII	Milwaukee, Wisconsin
	NY2	Lake George	VI	AR1	Little Rock, Arkansas
	NY3	Irondequoit Bay (Pochester Area)		TX1	Austin, Texas
			VII	KS1	Kansas City
III	DC1	WASHCOG (Washington, D.C. Metropolitan Area)	VIII	CD1	Denver, Colorado
				SD1	Rapid City, South Dakota
	MD1	Baltimore, Maryland		UT1	Salt Lake City, Utah
IV	FL1	Tampa, Florida	IX	CA1	Coyote Creek (San Francisco Area)
	NC1	Winston-Salem, North Carolina			
	SC1	Myrtle Beach, South Carolina		CA2	Fresno, California
	TN1	Knoxville, Tennessee	X	DR1	Springfield-Eugene, Dregon
				WA1	Bellevue (Seattle Area)

The 28 NURP projects were managed by designated State, county, city, or regional governmental associations. The U.S. Geological Survey (USGS) was involved with EPA as a cooperator, through an inter-agency agreement, on 11 of the NURP projects. The Tennessee Valley Authority was also involved in one project.

Project Selection

Projects were selected from among the 93 Areawide Agencies that had identified urban runoff as one of their significant problems. The intention was to build upon what these agencies had already accomplished in their earlier programs. Also, projects that would be a part of this program were screened to be sure that they represented a broad range of certain characteristics (e.g., hydrologic regimes, land uses, populations, drainage system types). Actual selection of projects was a joint effort among the States, local governments, and Regional EPA offices. The five major criteria used to screen candidate projects were as follows:

1. Problem Identified. Had a problem relative to urban runoff actually been identified? Could that problem be directly related to separate storm sewer discharges? What pollutant or pollutants were thought to be causing the problem? Using the NURP problem identification categories, what was the "problem" (i.e., denying a beneficial use, violating a State water quality standard, or public concern)?

2. Type of Receiving Water. The effects of stormwater runoff on receiving water quality were the NURP program's ultimate concern. Because flowing streams, tidal rivers, estuaries, oceans, impoundments, and lakes all have different hydrologic and water quality responses, the types of receiving waters associated with each candidate project had to be examined to ensure that an appropriately representative mix was included in the overall NURP program.

3. Hydrologic Characteristics. The pattern of rainfall in the study area is perhaps the single most important factor in studying urban runoff phenomena, because it provides the means of conveyance of pollutants from their source to the receiving water. For this reason, projects in locations having different hydrologic regimes were chosen for the program.

4. Urban Characteristics. Characteristics such as population density, age of community, and land use were considered as possible indicators of the waste loads and ultimately the rainfall-runoff water quality relationship. The type of sewerage system was another factor considered (e.g., whether it is combined, separate, or mixed; how severe the infiltration and inflow problems may be). Such factors have different effects on the quantity and quality of storm runoff, and were balanced as well as possible in selecting projects.

5. Beneficial Use of Receiving Water. Because this factor greatly affects the type of control measure that would be appropriate, attempts were made to include a wide range in selecting projects.

Although these were the primary criteria used to identify potential projects, other factors also had to be considered (e.g., the applicant agencies' willingness to participate, the State's acceptance of the project, the experience of the proposed project teams). Because the NURP program used planning grants (not research funds) a major consideration was the anticipated working relationships with local public agencies and the applicants' ability to raise local matching funds.

Program Assistance

Technical expertise and resources available for urban runoff planning varied among the various projects participating in NURP. Therefore, the program strategy called for providing a broad spectrum of technical assistance to each project as needed and for intercommunication of experiences and sharing of data in a timely manner.

Assistance was also provided to the applicants in developing their final work plans. This was done to ensure that there would be consistency among methods, especially in the collection of data. If there were to be differences in data from city to city, they must be due to the characteristics of each city and not a result of how the data were obtained.

Assistance with instrumentation was provided during the program in the form of information on available equipment, installation, calibration, etc. Because one of the more important elements of a data collection program is the "goodness" or quality of the data themselves, questionable data would be of little use. Accordingly, a quality assurance and quality control element was required in the plans for each project.

Periodic visits were made to each project site to ensure that the participants were provided opportunities to discuss any problems, technical or administrative. The visiting team typically included an EPA Regional Office representative, an EPA Headquarters representative, and one or two experienced consultants. All interested parties, including representatives from State or local governments, were requested to attend those visits.

As the projects moved farther into their planned activities and the time for data analysis approached, each project was required to describe how they were going to analyze their data. No single method was recommended for each project, because it was believed that a broad diversity of available methods would be suitable, if used properly. Guidance on proper use was provided as a part of technical assistance through project visits and special workshops for this purpose.

Communication

It was intended that the entire group of NURP participants function as a single team. Accordingly, a communication program was developed. National meetings were conducted semi-annually so that key personnel from the individual projects would have an opportunity to discuss their experiences and findings.

Reports were required of each project quarterly. EPA Headquarters also provided composite quarterly reports summarizing the status of each project and discussing problems encountered and solutions found.

OUTPUTS TRANSFERABLE TO STATE AND LOCAL GOVERNMENTS

The program has yielded a great deal of information which will be useful for a broad spectrum of planning activities for many years. Furthermore, it has fostered valuable cooperative relationships among planning and regulatory agencies. The most tangible products of the program are this report, the reports of various grantees (available under separate cover), and several technical reports which focus on specialized aspects of the program, its techniques, and its findings. In addition, a considerable number of individual articles drawing on information developed under the NURP program have already appeared in the technical literature and address specific technical or planning aspects of urban runoff.

At the time of publication of this Final Report, the main technical effort of the NURP program is complete; the field studies and the analysis of most of the resultant data are complete enough that the findings reported herein can be taken with confidence. However, there is still some work in progress to make certain details of the program available for future use. The products of this on-going work include:

- A detailed database which has been compiled to make technical information from the 28 projects available for review and use (DECEMBER 1985);

- A technical report which focuses on the program's studies and findings relative to detention and recharge devices (MAY 1984);

- A technical report on urban runoff effects on the water quality of rivers and streams (MARCH 1984); and

- A technical report on the effectiveness of street sweeping as a potential "best management practice" for water pollution control (MAY 1984).

This report supersedes the earlier NURP publication, "Preliminary Results of the Nationwide Urban Runoff Program," March 1982. Information presented there has been expanded, updated, and in some cases revised.

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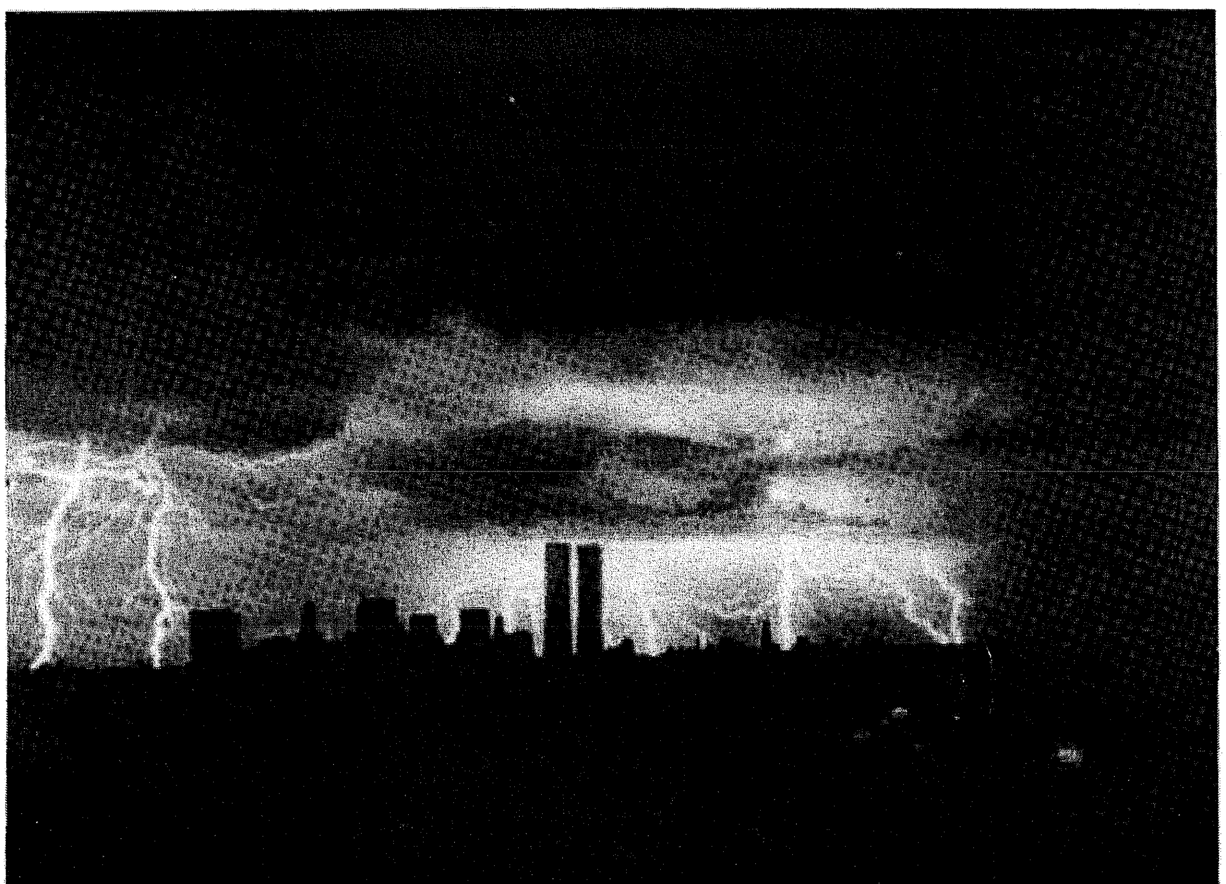
Results of the Nationwide Urban Runoff Program

Volume I - Final Report



RESULTS

OF THE

NATIONWIDE URBAN RUNOFF PROGRAM

December, 1983

VOLUME I - FINAL REPORT

Water Planning Division

U.S. Environmental Protection Agency

Washington, D.C. 20460

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DISCLAIMER

FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about environmental quality. The complexity of our environment and the interplay among its components require concentrated and integrated approaches to pollution problems.

The possible deleterious water quality effects of nonpoint sources in general, and urban runoff in particular, were recognized by the Water Pollution Control Act Amendments of 1972. Because of uncertainties about the true significance of urban runoff as a contributor to receiving water quality problems, Congress made treatment of separate stormwater discharges ineligible for Federal funding when it enacted the Clean Water Act in 1977. To obtain information that would help resolve these uncertainties, the Agency established the Nationwide Urban Runoff Program (NURP) in 1978. This five-year program was designed to examine such issues as:

- The quality characteristics of urban runoff, and similarities or differences at different urban locations;

- The extent to which urban runoff is a significant contributor to water quality problems across the nation; and

- The performance characteristics and the overall effectiveness and utility of management practices for the control of pollutant loads from urban runoff.

The interim NURP report, published in March 1982, presented preliminary findings of the program. This document is the final report covering the overall NURP program. Several specialized technical reports are published under separate cover.

PREFACE

The Nationwide Urban Runoff Program (NURP) was conducted by the EPA and many cooperating federal, state, regional, and local agencies, distributed widely across the United States. The individual project studies, which were conducted over the past five years, were designed and overseen using a common technical team from EPA headquarters. This approach was taken to assure a desired level of commonality and consistency in the overall program, while allowing each individual project to specially tailor its effort to focus on local concerns.

The program has yielded a great deal of information which will be useful for a broad spectrum of planning activities for many years. Furthermore, it has fostered valuable cooperative relationships among planning and regulatory agencies. The most tangible products of the program are this report, the reports of various grantees (available under separate cover), and several technical reports which focus on specialized aspects of the program, its techniques, and its findings. In addition, a considerable number of individual articles drawing on information developed under the NURP program have already appeared in the technical literature and address specific technical or planning aspects of urban runoff.

At the time of publication of this Final Report, the main technical effort of the NURP program is complete; the field studies and the analysis of most of the resultant data are complete enough that the findings reported herein can be taken with confidence. However, there is still some work in progress to make certain details of the program available for future use. The products of this on-going work include:

- A summary database which is being compiled to make all technical information from the 28 projects available for review and use (DECEMBER 1985);

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- A technical report on the effectiveness of street sweeping as a potential "best management practice" for water pollution control (MAY 1984).

This report and the supplementary technical documents identified above, supersedes the earlier NURP publication, "Preliminary Results of the Nationwide Urban Runoff Program," March 1982. Information presented there has been expanded, updated, and in some cases revised.

ACKNOWLEDGEMENTS

The Nationwide Urban Runoff Program was unusual in its large scale, covering a broad spectrum of technical and planning issues at many geographic locations. Because the program placed such emphasis on tailoring the results to support the planning process, it involved many participants - some from EPA, some from other federal agencies, and many from state, regional, and local planning agencies and other consultants.

The program was developed, implemented, and managed by the Water Planning Division, Office of Water, at EPA Headquarters, Washington, D.C. Principal contributors were: Dennis N. Athayde, Program Manager; and Patrice M. Bubar, Norman A. Whalen, Stuart S. Tuller, and Phillip H. Graham, all of whom served as Project Officers. Additional contributions from EPA personnel came from Rod E. Frederick and Richard P. Healy (Monitoring and Data Support Division), Richard Field (Storm and Combined Sewer Section, EPA Office of Research and Development), and many project staff in the various EPA Regional Offices.

As described elsewhere, much of the field work, water quality analysis, and data analysis was performed by the U.S. Geological Survey (USGS), under a Memorandum of Agreement with EPA. Both District Offices and National Headquarters participated actively. The contributions of Messrs. Ernest Cobb and David Lystrom are especially acknowledged.

Members of the project team which provided essential strategic, technical, and management assistance to the EPA Water Planning Division through a contract with Woodward-Clyde Consultants were: Gail B. Boyd, David Gaboury, Peter Mangarella, and James D. Sartor (Woodward-Clyde Consultants); Eugene D. Driscoll (E. D. Driscoll and Associates); Philip E. Shelley (EG&G Washington Analytical Services Center, Inc.); John L. Mancini (Mancini and DiToro Consultants); Robert E. Pitt (private consultant); Alan Plummer (Alan Plummer and Associates); and James P. Heaney and Wayne C. Huber (University of Florida).

The principal writers of this report were Dennis N. Athayde (EPA), Philip E. Shelley (EG&G Washington Analytical Services Center, Inc.), Eugene D. Driscoll (E. D. Driscoll & Associates), and David Gaboury and Gail B. Boyd (Woodward-Clyde Consultants).

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CHAPTER 1
INTRODUCTION

Rain falling on an urban area results in both benefits and problems. The benefits range from watering vegetation to area cleansing. Many of the problems are associated with urban runoff, that portion of rainfall which drains from the urban surfaces and flows via natural or man-made drainage systems into receiving waters.

The historical concern with urban runoff has been focused primarily on flooding. Urban development has the general effect of reducing pervious land surface area and increasing the impervious area (such as roof tops, streets, and sidewalks) where water cannot infiltrate. In comparison with an undeveloped area (for a given storm event), an urban area will yield more runoff, and it will occur more quickly. Such increases in the rate of flow and total volume often have a decided effect on erosion rates and flooding. It is not surprising, therefore, that at the local level the quantity aspect continues to be a principal concern.

In recent years, however, concern with urban runoff as a contributor to receiving water quality problems has been expressed. Section 62 of the Water Quality Act of 1965 (P.L. 89-234) authorized the Federal government to make grants for the purpose of "assisting in the development of any project which will demonstrate a new or improved method of controlling the discharge into any water of untreated or inadequately treated sewage or other waste from sewerage which carry storm water or both storm water and sewage or other waste ..." The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) signaled a heightened national awareness of the degraded state of the nation's surface waters and a Congressional intent that national water quality goals be pursued. The scarcely two-year old Environmental Protection Agency built upon its predecessors' activities by taking up the challenge and implementing this far reaching legislation.

As a result of Section 208 of The Act, State and local water quality management agencies were designated to integrate water quality activities. As point source discharges were increasingly brought under control and funds for the construction and upgrading of municipal sewage treatment plants were granted, the awareness of nonpoint sources (including urban runoff) as potential contributors to water quality degradation was heightened. Uncertainties associated with the local nature and extent of urban runoff water quality problems, the effectiveness of possible management and control measures, and their affordability in terms of benefits to be derived mounted as water quality management plans were developed. The unknowns were so great and certain control cost estimates were so high that the Clean Water Act of 1977 (P.L. 95-217) deleted Federal funding for the treatment of separate stormwater discharges. The Congress stated that there was simply not enough known about urban runoff loads, impacts, and controls to warrant making major investments in physical control systems.

In 1978, EPA Headquarters reviewed the results of work on urban runoff by the technical community and t various 208 Areawide Agencies and determined that additional, consistent data were needed. The NURP program was implemented to build upon pertinent prior work and to provide practical information and insights to guide the planning process, including policy and program development and implementation. The NURP program included 28 projects, conducted separately at the local level, but centrally reviewed, coordinated, and guided. While these projects were separate and distinct, most share certain commonalities. All were involved with one or more of the following elements: characterizing pollutant types, loads, and effects on receiving water quality; determining the need for control; and evaluating various alternatives for the control of stormwater pollution. Their emphasis was on answering the basic questions underlying the NURP program and providing practical information needed for planning.

CHAPTER 2
BACKGROUND

EARLY PERCEPTIONS

As noted earlier, drainage is perhaps the single most important factor of the urban hydrologic cycle. Nuisance flooding, more than anything else, gives Public Works directors concern, as complaints are received from unhappy motorists, residents, and business. Drainage has typically been considered a local responsibility, usually that of the City or County Public Works Department. Rarely does this responsibility go to the State or Federal level, except in cases of catastrophic flooding involving risk to human life and extensive property damage.

By 1964, the U.S. Public Health Service had begun to be concerned about identified pollutants in urban runoff and concluded that there may be significant water quality problems associated with stormwater runoff. In 1969, the Urban Water Resources Research Committee of the American Society of Civil Engineers (directed by M. B. McPherson and sponsored by the U.S. Geological Survey) recognized the potential threat of pollution from urban runoff and described a research program intended to obtain needed information to characterize urban stormwater quality.

In the late 1960's, the Federal Water Quality Administration (FWQA) conducted a study in an area of Tulsa, Oklahoma which was served by separate storm sewers. This first attempt at using regression analysis on urban runoff indicated that there was only a very poor correlation between stormwater runoff quantity and water quality constituents (except for suspended solids). Comparing the concentrations of various pollutants examined by this study (separate storm sewers) with previous data on combined sewer overflows indicated that storm runoff from areas having separate sewers had much lower values for BOD, fecal coliform, and most other pollutant concentrations. The study concluded that the largest portion of pollutants resulted from (1) washoff of material from impervious surfaces and (2) the erosion of drainage channels (caused by high volumes of runoff from the impervious surfaces). Control of urban runoff was recommended to reduce both runoff volume and rates.

Atlanta, Georgia is an example of a city that has both a combined sewer system and a separate system. In 1971, EPA conducted a study which compared the contribution of various sources of pollutants. It was concluded that, on an annual basis, 64 percent of the BOD load came from separate storm sewers, and 19 percent came from combined sewers, the balance coming from treatment plants.

In 1971, EPA also conducted a study in Oakland and Berkeley, California, to assess the infiltration of stormwater into sanitary sewers. While only four percent of the study area had combined sewerage and the remaining 96 percent separate, the study made it clear that infiltration can cause a separate system to function as though it were combined.

Studies in Sacramento, California, which has both combined and separate storm sewers, indicated that the stormwater was comparable to the average strength of domestic wastewater. However, the concentrations for BOD were found to be so unrealistically high, that contamination of the runoff by raw sanitary sewage was considered to be a distinct possibility.

In 1973, the Council on Environmental Quality published a report titled, "Total Urban Pollutant Loads: Sources and Abatement Strategies." The primary conclusion was that much pollution was coming from urban runoff and that, unless it was taken care of, the goals of the Act would not be met.

CONCLUSIONS FROM SECTION 208 EFFORTS

EPA guidance for conducting the early 208 planning efforts designated 17 topic areas (including urban runoff) that were to be addressed by all Water Quality Management agencies in developing their 208-funded plans. Although all topic areas were to be covered, the degree of emphasis to place on each was left to the individual agencies to decide. As a result, the amount of the 208 efforts spent in the area of urban runoff varied greatly (but was rarely a major portion).

Many of the 208 agencies began their studies with the assumption that urban runoff was an important cause of water quality problems. Although the studies developed much information on runoff and receiving waters, not enough basic information was known to assess urban runoff's role as a major cause of problems. This was partly because of interferences by other sources and complex relationships within the receiving waters. It was also due to the difficulties in deciding what constitutes a "problem." In some cases, "problems" were synonymous with criteria violations; in others, "problems" were synonymous with an impairment or denial of beneficial uses. In many cases, "problems" were concluded to exist, simply on the basis of the possible presence of certain contaminants in urban runoff, based solely on values taken from literature regarding studies conducted elsewhere. The practical implication of these differences (which were differences in viewpoints rather than differences in physical conditions, in many cases) was that local agencies were very reluctant to commit to implementing urban runoff controls in the absence of a clear problem definition.

Furthermore, in the early years of the 208 program, EPA's guidance on how to address urban runoff was vague. As a result, local agencies took a wait-and-see attitude on the stormwater portion of their plans. They simply did not know what EPA would eventually do on the issue of stormwater control.

Another major obstacle to implementation resulted from the uncertainties regarding the effectiveness of controls. Many of the measures proposed for controlling urban runoff are either new or special applications of conventional practices developed for other purposes. Little was known about how well they would work in urban runoff applications. Engineers, planners, public works personnel, and other decision makers have been understandably reluctant to invest large amounts of time and money in controls which may not perform as hoped.

Another obstacle to implementation of controls was a lack of basic data on sources, transport mechanisms, and receiving water characteristics (hydrologic and water quality aspects). Some of the more important topic areas where knowledge was lacking are summarized below:

- Sources - Not enough was known about where pollutants originate. Major sources certainly include vehicles, vegetation, erosion, fertilizer and pesticide application, litter, animals, and air pollution. However, a better understanding of source contributions could enhance control opportunities.

- Washoff/transport mechanisms - Not enough was known about how pollutants get from the sources to the receiving waters. Models could be better used for simulating runoff in problem definition and control evaluation, if they more accurately reflected washoff and transport mechanisms.

- Impacts - It was difficult to go beyond speculation in assigning urban runoff its proper share of responsibility for problems in cases where several pollutant sources contribute. In cases where other sources create obvious problems, it was difficult to determine the appropriate degree to which urban runoff should be controlled.

- Relative benefits - Planners had difficulty deciding whether the various benefits of controlling urban runoff quality justify the costs involved. There was considerable controversy over the present dry weather standards' relationship to beneficial uses, given the time and space scales of storm events and their intermittent nature. Many plans failed to be implemented because of uncertainties regarding: How much control is enough? Who benefits? Who should pay? Who should decide?

- Controls - Both cost and effectiveness data on full-scale control programs were lacking. Some of the control measures cited for typical 208 plans were plausible candidates, but their application for the purpose of urban runoff pollution control had not been studied quantitatively.

EPA'S ORD EFFORT

During the past 15 years, EPA's Office of Research and Development (ORD) has conducted over 250 studies on the characterization and control of stormwater discharges and combined sewer overflows, with particular emphasis on the latter due to their greater pollution potential. Consistent with overall Agency policies, ORD has deemphasized studies on receiving water impacts and effects (although it has done some such work). Rather, ORD has focussed principally on multi-purpose analyses and controls, because it is nearly impossible to segregate benefits and strategies of urban stormwater runoff pollution control from drainage, flood, and erosion control. Many significant results have been obtained by ORD's effort, which has dramatically increased the technical literature in the area.

Data from ORD studies indicate the high variability of pollutant concentrations in urban runoff. Based on loading projections, it is safe to conclude that urban stormwater can contribute significant pollutant loads to receiving waters, in many cases having pollutant concentrations on the order of secondary treatment plant effluent for some constituents. Nonetheless, in its efforts to find direct urban runoff generated receiving water impacts (using the conventional dissolved oxygen parameter as the indicator) ORD has been only partly successful. However, this was only one study and was not intended to be the final word. Nonetheless, based on the size of the load coming from urban runoff, a significant pollution potential is there for at least some types of receiving waters. For example, a small urban lake could receive nutrient loads sufficient to increase algal productivity and accelerate the eutrophication process. The existence of heavy metals and certain organics (mostly of petroleum origin) in urban runoff have also been documented by the ORD program.

In addition to studying urban runoff loads, the ORD program has investigated a number of management and control approaches. This effort has been very successful, and many innovative techniques have been proposed and tested. The results of such research, development, and demonstrations have been presented in reports which document many of these potential controls, thereby allowing the technology to be utilized in other programs and at other locations. Included have been such control measures as on-site (upstream) storage; porous pavement; the swirl concentrator, helical bend, tube settler, and fine mesh screens for grit and settleable solids removal; street sweeping; disinfection; and high rate filtration, dissolved air flotation, and microscreening for suspended solids and BOD removal. Most of these controls were developed principally to deal with combined sewer overflow problems. However, some may also have application in urban runoff control, once their effectiveness has been conclusively demonstrated and initial and operating cost data are available to allow the necessary trade-off studies to be made.

The ORD program's reports constitute an invaluable source of data and information that was used to design and guide the development of the emerging NURP program. Also, three of the NURP projects were joint efforts with ORD (i.e., West Roxbury, Massachusetts, Bellevue, Washington, and Lansing, Michigan).

OTHER PRIOR/ONGOING EFFORTS

The Clean Water Act requires EPA to provide Congress with a needs assessment every two years in the six categories of the construction grant funds program. In 1974, the Needs Survey for Separate Storm Sewer Discharges (Category VI) was done by each state. Using the goals of the Act as the criteria to be met, they identified a cost of about $235 billion (June 1973 dollars). One state alone identified $80 billion in needs to control separate storm sewer discharges. In 1976, the Needs Survey was conducted by the Agency, and it was found that Category VI would require $66 billion to meet the goals of the Act. This survey broke the goals into three categories or levels of pollution abatement; (1) aesthetics, (2) fish and wildlife, and (3) recreation. Costs to meet each category were determined.

As noted previously, the ASCE defined a program in 1969 to identify the causes and effects of urban stormwater pollution. The recommendations were not followed, so in 1974 at the Rindge, New Hampshire, Engineering Foundation Conference (jointly sponsored with ASCE's Urban Water Resources Research Council), a similar program was again recommended. A similar scenario occurred at the Easton, Maryland, conference of 1976 sponsored by the same group.

DISCUSSION

In the past (ca 1890), dilution was considered to be the appropriate way to control combined sewer overflows, since the primary concern was odor and related nuisances. Between 1890 and 1960 little concern was shown for stormwater pollution. Stormwater concerns were primarily related to drainage problems. As time progressed, water quality began to be considered, and workers began to characterize problems in terms of concentrations of certain pollutants and loads of these pollutants. In the 1970's, problems were being defined in terms of pounds of pollutants needing to be removed from overflows, in the interest of preventing pollution.

Past work, reported by EPA and published in professional journals, tended to focus on determining (a) the type and amount of pollutants involved and/or (b) methods to reduce the loads. However, such reports and articles did not consider either the level of improvement attainable or the need to improve quality of the receiving water body associated with the study. A conclusion common to all such reports was that not enough was known about stormwater to adequately understand cause and effect relationships. Also common to such reports were recommendations for further study and more data. A tangible result of the lack of belief and uncertain attitude in this area is the fact that stormwater controls for water quality have been implemented in so few places throughout the nation. Thus, there has been a critical need to objectively examine the situation.

Many factors led to the development of NURP, one being a legally-mandated necessity. As implementation of P.L. 92-500 moved into full swing, the lack of progress in the area of urban runoff was becoming apparent. In 1974 EPA lost a court case, which led to the decision that EPA should issue permits for separate storm sewer discharges. In 1976 EPA requested that the Areawide Waste Management Planning Program focus on the three or four most important of the 17 items required by the regulations. Many of the 208 Areawide Agencies cited urban runoff as an important item.

Two years later, EPA reviewed ninety-three 208 Areawide Agencies' work plans to assess their basis for having identified urban runoff as an element upon which they would focus. Review of these projects' methods and findings did not provide much to further our understanding of the pollution aspects of urban runoff. If one reason can be identified, it was the lack of site-specific data to define the local conditions.

As mentioned earlier, the Rindge Conference recommended a candidate program for obtaining the data necessary to provide a good understanding of stormwater pollution (EFC/ASCE, 1974). It is not coincidental that the NURP program is quite similar in design to those recommendations.

THE NATIONWIDE URBAN RUNOFF PROGRAM

Program Design

NURP was not intended to be a research program, per se, and was not designed as such. Rather, the program was intended to be a support function which would provide information and methodologies for water quality planning efforts. Therefore, wherever possible, the projects selected were ones where the work undertaken would complete the urban runoff elements of formal water quality management plans and the results were likely to be incorporated in future plan updates and lead to implementation of management recommendations. Conduct of the program provided direction and assistance to 28 separate and distinct planning projects, whose locations are shown in Figure 2-1 and listed in Table 2-1, but the results will be of value to many other planning efforts. NURP also acted as a clearinghouse and, in that capacity, provided a common communication link to and among the 28 projects.

The NURP effort began with a careful review of what was known about urban runoff mechanisms, problems, and controls, and then built upon this base. The twin objectives of the program were to provide credible information on which Federal, State, and local decision makers could base future urban runoff management decisions and to support both planning and implementation efforts at the 28 project locations.

An early step in implementing the NURP program involved identifying a limited number of locations where intensive data gathering and study could be done. Candidate locations were assessed relative to three basic selection criteria:

- Meeting program objectives;
- Developing implementation plans for those areas; and
- Demonstrating transferability, so that solutions and knowledge gained in the study area could be applied in other areas, without need for intensive, duplicative data gathering efforts.

The program design used for NURP included providing a full range of technical and management assistance to each project as the needs arose. Several forums for the communication of experience and sharing of data were provided through semi-annual meetings involving participants from all projects. The roles and responsibilities of the various State, local, and regional agencies and participating Federal agencies were clearly defined and communicated at the outset. These were reviewed and revised where warranted as the projects progressed.

Figure 2-1. Locations of the 28 NURP Projects

TABLE 2-1. NURP PROJECT LOCATIONS

EPA Region	NURP Code	Project Name/Location	EPA Region	NURP Code	Project Name/Location
I	MA1	Lake Quinsigamond (Boston Area)	V	IL1	Champaign-Urbana, Illinois
	MA2	Upper Mystic (Boston Area)		IL2	Lake Ellyn (Chicago Area)
	NH1	Durham, New Hampshire		MI1	Lansing, Michigan
II	NY1	Long Island (Nassau and Suffolk Counties)		MI2	SEMCOG (Detroit Area)
	NY2	Lake George		MI3	Ann Arbor, Michigan
	NY3	Irondequoit Bay (Rochester Area)		WI1	Milwaukee, Wisconsin
III	DC1	WASHCOG (Washington, D.C. Metropolitan Area)	VI	AR1	Little Rock, Arkansas
	MD1	Baltimore, Maryland		TX1	Austin, Texas
IV	FL1	Tampa, Florida	VII	KS1	Kansas City
	NC1	Winston-Salem, North Carolina	VIII	CO1	Denver, Colorado
	SC1	Myrtle Beach, South Carolina		SD1	Rapid City, South Dakota
	TN1	Knoxville, Tennessee		UT1	Salt Lake City, Utah
			IX	CA1	Coyote Creek (San Francisco Area)
				CA2	Fresno, California
			X	OR1	Springfield-Eugene, Oregon
				WA1	Bellevue (Seattle Area)

The 28 NURP projects were managed by designated State, county, city, or regional governmental associations. The U.S. Geological Survey (USGS) was involved with EPA as a cooperator, through an inter-agency agreement, on 1: of the NURP projects. The Tennessee Valley Authority was also involved in one project.

A major objective of the program was the acquisition of data. Because these data will be used for several years to characterize problems, evaluate receiving water impacts from urban runoff, and evaluate management practices, consistent methods of data collection had to be developed and rigorously employed.

Project Selection

Projects were selected from among the 93 Areawide Agencies that had identified urban runoff as one of their significant problems. The intention was to build upon what these agencies had already accomplished in their earlier programs. Also, projects that would be a part of this program were screened to be sure that they represented a broad range of certain characteristics (e.g., hydrologic regimes, land uses, populations, drainage system types). Actual selection of projects was a joint effort among the States, local governments, and Regional EPA offices. The five major criteria used to screen candidate projects were as follows:

1. Problem Identified. Had a problem relative to urban runoff actually been identified? Could that problem be directly related to separate storm sewer discharges? What pollutant or pollutants were thought to be causing the problem? Using the NURP problem identification categories, what was the "problem" (i.e., denying a beneficial use, violating a State water quality standard, or public concern)?

2. Type of Receiving Water. The effects of stormwater runoff on receiving water quality were the NURP program's ultimate concern. Because flowing streams, tidal rivers, estuaries, oceans, impoundments, and lakes all have different hydrologic and water quality responses, the types of receiving waters associated with each candidate project had to be examined to ensure that an appropriately representative mix was included in the overall NURP program.

3. Hydrologic Characteristics. The pattern of rainfall in the study area is perhaps the single most important factor in studying urban runoff phenomena, because it provides the means of conveyance of pollutants from their source to the receiving water. For this reason, projects in locations having in different hydrologic regimes were chosen for the program.

4. Urban Characteristics. Characteristics such as population density, age of community, and land use were considered as

possible indicators of the waste loads and ultimately the rainfall-runoff water quality relationship. The type of sewerage system was another factor considered (e.g., whether it is combined, separate, or mixed; how severe the infiltration and inflow problems may be). Such factors have different effects on the quantity and quality of storm runoff, and were balanced as well as possible in selecting projects.

5. Beneficial Use of Receiving Water. Because this factor greatly affects the type of control measure that would be appropriate, attempts were made to include a wide range in selecting projects.

Although these were the primary criteria used to identify potential projects, other factors also had to be considered (e.g., the applicant agencies' willingness to participate, the State's acceptance of the project, the experience of the proposed project teams). Because the NURP program used planning grants (not research funds) a major consideration was the anticipated working relationships with local public agencies and the applicants' ability to raise local matching funds.

Program Assistance

Technical expertise and resources available for urban runoff planning varied among the various projects participating in NURP. Therefore, the program strategy called for providing a broad spectrum of technical assistance to each project as needed and for intercommunication of experiences and sharing of data in a timely manner.

Assistance was also provided to the applicants in developing their final work plans. This was done to ensure that there would be consistency among methods, especially in the collection of data. If there were to be differences in data from city to city, they must be due to the characteristics of each city and not a result of how the data were obtained.

Assistance with instrumentation was provided during the program in the form of information on available equipment, installation, calibration, etc. Because one of the more important elements of a data collection program is the "goodness" or quality of the data themselves, questionable data would be of little use. Accordingly, a quality assurance and quality control element was required in the plans for each project.

Periodic visits were made to each project site to ensure that the participants were provided opportunities to discuss any problems, technical or administrative. The visiting team typically included an EPA Regional Office representative, an EPA Headquarters representative, and one or two experienced consultants. All interested parties, including representatives from State or local governments, were requested to attend those visits.

As the projects moved farther into their planned activities and the time for data analysis approached, each project was required to describe how they were going to analyze their data. No single method was recommended for each project, because it was believed that a broad diversity of available methods would be suitable, if used properly. Guidance on proper use was provided as a part of technical assistance through project visits and special workshops for this purpose.

Communication

It was intended that the entire group of NURP participants function as a single team. Accordingly, a communication program was developed. National meetings were conducted semi-annually so that key personnel from the individual projects would have an opportunity to discuss their experiences and findings.

Reports were required of each project quarterly. EPA Headquarters also provided composite quarterly reports summarizing the status of each project and discussing problems encountered and solutions found.

CHAPTER 3
URBAN RUNOFF PERSPECTIVES

In evaluating the impacts of urban runoff, one's perspective may be influenced by one's concerns and priorities - and what one defines to be a "problem". Recognizing this, the following discussion covers several such perspectives, including concerns over runoff quantity, water quality, and control possibilities.

RUNOFF QUANTITY

The following discussion covers a major cause and two major effects of runoff problems related to "quantity" (i.e., increased urbanization as a cause; flooding and erosion/sedimentation as effects).

Flooding Problems

As noted earlier, drainage has historically been the principal local-level concern regarding urban runoff. Concerns over quantity can be divided into two basic categories: nuisance flooding and major flooding. Nuisance flooding (e.g., temporary ponding of water on streets, road closings, minor basement flooding), although hardly tolerable to those immediately affected, rarely affects an entire urban populance. Nonetheless, the concerns of the (often vocal) minority of affected citizens commonly reach the point where local action is taken to minimize the recurrence of such events. Such mitigation activities are usually locally determined, funded, and implemented because both the affected public and government decision makers perceive and concur that such flooding constitutes a "problem".

Catastrophic flood events, on the other hand, have to be thought about differently for several reasons:

- They typically affect the majority of the urban populace.
- Mitigation measures often involve engineering improvements extending well beyond local jurisdictions.
- Mitigation measures often cost more than the local community could afford. Historically, the Federal government has become involved, in major flood control efforts through a number of related programs. In such cases, water quantity problems are relatively easy to define because the extent of flooding is readily observable, the degree of damage is easily determined, and the benefits of proposed flood control projects can be estimated. Thus, decision makers face a relatively low risk in prescribing courses of action and justifying the associated

costs in light of benefits. As will be discussed later, decision making in the case of water quality concerns is less straightforward.

Erosion and Sedimentation Problems

Erosion results from rainfall and runoff when soil and other particles are removed from the land surface and transported into conveyance systems and water bodies. Since land surface erosion is the principle source of stream sediment, the type of soil, land cover, and hydrologic conditions are major factors in determining the severity and extent of sedimentation problems. Although erosion is a natural process, it is frequently exacerbated by the activities of man, in both urban and rural environments.

When addressing the broad spectrum of receiving water problems which result from sedimentation, it is convenient to divide cases into two categories; (1) those that respond to control measures directed at nuisance flood prevention, and (2) those that are not controlled by such measures. When natural loads are discharged into receiving waters, the effects are primarily physical and only secondarily chemical (because the mineral constituents which make up the primary sediment load are relatively benign in most cases). Among the physical problems imposed upon the receiving waters are:

- Excess turbidity reduces light penetration, thereby interfering with sight feeding and photosynthesis;

- Particulate matter clogs gills and filter systems in aquatic organisms, resulting, for example, in retarded growth, systemic disfunction, or asphyxiation in extreme cases; and

- Benthal deposition can bury bottom dwelling organisms, reduce habitat for juveniles, and interfere with egg deposition and hatching.

Although sedimentation is storm-event related, its resultant problems are not exclusively either "quantity" problems or water "quality" problems. Being hybrid problems, sedimentation control has received a mixed approach. The organizations involved range widely, from Federal agencies (e.g., the Army Corps of Engineers, the Soil Conservation Service) to local drainage and sedimentation control officials, frequently with involvement from State and county governmental agencies.

Urbanization as a Cause of Problems

Urbanization accelerates erosion through alteration of the land surface. Disturbing the land cover, altering natural drainage patterns, and increasing impervious area all increase the quantity and rate of runoff, thereby increasing both erosion and flooding potential. Also, the sedimentation products which result from urban activities are generally not as benign as the natural mineral sediments which result from soil erosion. Atmospheric deposition (associated with industrial, energy, and agricultural production activities) and added surface particulates (resulting from tire wear, auto exhaust, and road surface decomposition) fall in this latter category. Their effects on receiving waters tend to be more "chemical" than "physical". They may contain toxic substances and/or other compounds which can have adverse impacts upon receiving water quality and the associated ecological communities.

WATER QUALITY CONCERNS

The notion that urban runoff can be a significant contributor to the impairment or degradation of the quality of receiving waters has formed only recently and is not universally shared. It is the totality of receiving water characteristics (e.g., flow rate, size or volume, and physical and chemical characteristics) that determines its use, although some characteristics are more important than others (e.g., there must be present an appropriate rate of flow and/or volume in the receiving water to support the desired use).

In addressing the water quality needed to support a designated use, one must consider specific requisite characteristics. For example, in the case of swimming, total dissolved solids and dissolved oxygen levels are far less important than pathogenic organisms. For irrigation, the biochemical oxygen demand of the water is of little concern to the farmer, whereas the total dissolved solids level is of immense concern (to minimize salt buildup). Although high nutrient levels may be detrimental to the quality of impounded waters (by hastening eutrophication processes), a farmer may welcome nutrients in irrigation water.

It is also important to note that it is the concentration, rather than the mere presence of a water quality constituent, that affects use. The relationship between pollutant concentration and resultant impacts on receiving water use are quite non-linear, with plateau effects not uncommon. For example, consider dissolved oxygen and its effect upon fin fish. Down to a certain level below saturation, there are virtually no important effects (upon a given species). As dissolved oxygen levels fall below this threshold, the more sensitive members of the species begin to be affected. As levels continue to fall, the affected percentage of the population will increase until a level is reached at which the entire population can no longer survive. Obviously, any further reduction of dissolved oxygen level would have no further effect upon the community, since it no longer exists. It is important to keep this plateau effect in mind when considering the practical impacts of increased pollution and the practical value of remedial measures to restore beneficial uses, since limited removal of a polluting substance may do nothing to alleviate the problem. In the example given above, if one were to somehow reduce the input of oxygen demanding substances to the receiving water, the result might be that the dissolved oxygen level of the receiving water would rise from 1.0 mg/l to 3 mg/l. If the species of concern were trout, they still could not survive. Even though polluting substances were removed and money was spent, the desired benefit would not be achieved.

WATER QUANTITY AND QUALITY CONTROL

There is no question that excessive urban runoff causes problems. Remedial costs may be high, but the benefits are obvious. Currently, there is a growing national awareness that, if steps are taken during the planning phase of development, excessive stormwater discharges can be prevented, at least from typical events (large infrequent storms will always present a greater threat).

Past And Current Work

During the past two decades attention has been focused on reducing runoff rates and volumes and reducing flood damage. During the early 1970's, a manual of practices was prepared under grants from the Office of Water Research and Technology sponsored by the American Public Works Association stressing detention (Poertner, 1974). The University of Delaware also issued a manual of practices on methods to control rates and volumes of urban runoff (Toubier and Westmacott, 1974).

Work done by the ASCE Urban Water Resources Research Council during the sixties stressed the concept of natural easements for drainage, observing that there were two drainage ways; major routes for large events and minor routes for smaller more frequent events (Jones, 1968). It was claimed that money could be saved by using natural channels, swales, etc., thus reducing the need for more expensive concrete conveyances.

The idea of intentionally using natural runoff courses, green belts, and the like was new to engineers who had long been trying to control runoff through more artificial conveyances. In 1970, EPA's Office of Research and Development initiated work on a development known as the Woodlands project in Texas near Houston. Studies were conducted to determine how storm flows could be managed and water quality could be protected or improved by the use of natural drainage ways, detention facilities, porous pavements, increased infiltration rates, and a decrease in runoff rates (Characklis, 1979).

Federal Involvement

As part of its national effort to control erosion from agricultural lands, the Soil Conservation Service (SCS) (Department of Agriculture) provides technical assistance in developing erosion control plans. During the past decade or so, the methods they have developed have been applied much more widely than just to agricultural situations. SCS has become increasingly involved in erosion control in urban areas and has produced a useful document for assessing urban hydrology in small watersheds (SCS, 1975).

Other Federal agencies that have an interest in urban runoff and its control include the U.S. Geological Survey, the Federal Highway Administration, the ~~Federal Housing Administration, the Tennessee Valley Authority,~~ and others too numerous to mention.

State And Local Involvement

Although some 27 states have adopted floodplain management legislation to protect property, the control of urban drainage has traditionally been a local matter. Some states have some form of erosion control laws in force; however few states have runoff rate/quantity legislation. This situation has begun to change over the last decade, and Maryland is one example where the statewide legislation for stormwater management is implemented at the county level.

The methods used tend to be preventive, wherein erosion is controlled by prescribing certain proven design practices and conventions. Many local agencies are developing control plans along these lines, so this report will not cover this aspect of control.

PROBLEM DEFINITION

As pointed out earlier, water quantity problems are relatively easy to identify and describe. Water quality problems, on the other hand, tend to be more elusive because their definition often involves some subjective considerations, including experiential aspects and expectations of the populace. They are not immediately obvious and are usually less dramatic than, for example, floods. They also tend to vary markedly with locality and geographic regions within the country. For example, a northwestern resident may want to upgrade stream quality to support some highly-prized species of game fish, while a northeastern resident contemplating the river flowing by the local factory might be grateful to see any game fish at all. Thus, a methodological approach to the determination of water quality problems is essential if one is to consider the relative role of urban runoff as a contributor. An important finding of the work conducted during this NURP program has been to learn to avoid the following simplistic logic train: (a) water quality problems are caused by pollutants, (b) there are pollutants in urban runoff, therefore, (c) urban runoff causes "problems". The unspoken implication is that a "problem" by definition requires action, and any type of "problem" warrants equally vigorous action. It becomes clear that a more fundamental and more precise definition of a water quality "problem" from urban runoff is necessary. For this purpose, the NURP has adopted the following three-level definition:

- Impairment or denial of beneficial uses;
- Water quality criterion violation; and
- Local public perception.

The first of these levels refers to cases of impairment or denial of a designated use. An example would be a case where a determination has been made that some specific beneficial use should be attained; however, present water quality characteristics are such that attainment of the use cannot be fully realized.

The second level of problem definition refers to violations of a designated water quality criterion. An example would be a case where some measure or measures of water quality characteristics have been found to violate recommended or mandatory levels for the receiving water classification. Some of the subtle distinctions between this and the preceding problem definition arise in the fact that receiving water classification may not be appropriate, the beneficial use may not be impaired or denied, and the water quality criteria associated with that classification may or may not be overly conservative or directly related to the desired use.

The third level of problem definition involves public perception. This may be expressed in a number of ways, such as telephone calls to public officials complaining about receiving water color, odor, or general aesthetic appearance. Public perception of receiving water body problems is highly variable also. Some people enjoy fishing for carp or gar, children will play in almost any creek, and so on. This level of problem definition can also include one concept of anti-degradation. Here the thought is that no polluting substances of any kind in any quantity should be discharged into the receiving water regardless of its natural assimilative capacity. This concern has its ultimate expression in the "zero discharge" concept. EPA's concept of anti-degradation, on the other hand, refers to degradation of use; a subtle but essential difference.

The foregoing levels of problem definition provide an essential framework within which to discuss water quality problems associated with urban runoff. However, it is important to understand that when one is dealing at a local level all three elements are typically present. Thus, it is up to the local decision makers, influenced by other levels of support and concern, to carefully weigh each, prior to making a final decision about the existence and extent of a problem and how it is to be defined. It follows that, if this step of problem definition is done carelessly, it will be difficult, if not impossible, to plan an effective control strategy and establish a means for assessing its effectiveness.

CHAPTER 4
STORMWATER MANAGEMENT

INTRODUCTION

This chapter is included for those who wish to know more about how to plan and implement stormwater management programs. Most of the information contained herein was developed through several related programs that were proceeding in parallel with the NURP program.

- The Southeast Michigan Council of Governments (SEMCOG), a NURP grantee, was developing stormwater management procedures.

- The Midwest Research Institute (MRI) was collecting cost information on control practices from selected NURP projects.

- A related EPA Water Planning Division program, the Financial Management Assistance Program (FMAP), was developing financial and institutional planning procedures designed to be helpful in the implementation of stormwater management plans.

STORMWATER MANAGEMENT PLANNING[1]

Stormwater management planning develops policies, regulations, and programs for the control of runoff from the land. Stormwater management planning is normally directed toward either or both of two primary goals: the reduction of local flooding and/or the protection of water quality. However, stormwater management planning is also generally used to insure that stormwater programs and regulations provide multiple benefits to the affected communities and do so in a way that does not create additional problems.

Stormwater management planning need not involve expensive technical studies. Available data and maps, the experience of other communities, and advice from experts can be used to develop an effective planning program. Detailed technical studies can then be targeted toward specific issues and problems. Effective local planning can alleviate the need for costly remedial public works projects.

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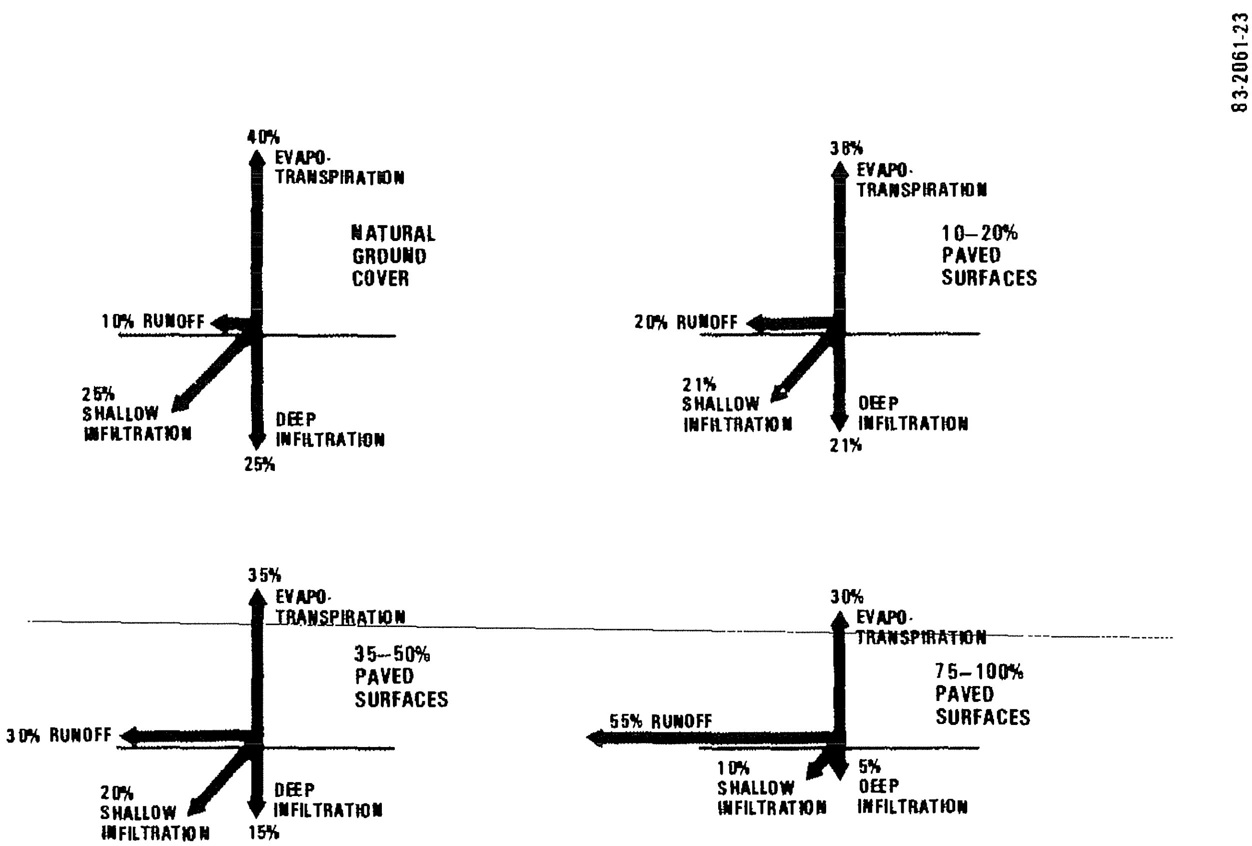
[1] The material in this section of the chapter is largely from Technical Bulletin No. 1: Stormwater Management Planning: Cost-Saving Methods for Program Development, the first of a seven-part bulletin series on water quality management prepared by the Southeast Michigan Council of Governments and available from Information Service, SEMCOG, 8th Floor, Book Building, Detroit, Michigan 48226.

The Need

Stormwater runoff cannot be ignored in developing communities. As urban development occurs, the volume of stormwater and its rate of discharge increase. These increases are caused when pavement and structures cover soils and destroy vegetation which otherwise would slow and absorb runoff. Pollutants, washed from the land surface and carried by runoff into lakes and streams, may add to existing water quality problems.

Figure 4-1 illustrates the effects of paved surfaces on stormwater runoff volumes. When natural ground cover is present over the entire site, normally less than 10 percent of the stormwater runs off the land into nearby creeks, rivers, and lakes. When paved surfaces cover 10 to 30 percent of the site area, approximately 20 percent of the stormwater can be expected to run off. As paved surfaces increase, both the volume and the rate of runoff increase. Furthermore, paved surfaces prevent natural infiltration of stormwater into the ground, and increased runoff volumes and rates increase soil erosion and pollutant runoff. Stormwater management planning can be used to develop programs to reduce adverse affects and even to provide community benefits.



Source: J.T. Tourbier and R. Westmacott, ***Water Resources Protection Technology: A Handbook of Measures to Protect Water Resources in Land Development***, p. 3.

Figure 4-1. Typical Changes in Runoff Flows Resulting from Paved Surfaces

Stormwater management can and should be directed toward two goals: the control of runoff flows (i.e., volumes and rates) and the control of pollutants in stormwater. Control measures which emphasize the storage of runoff rather than the immediate conveyance from the site and from the community often provide benefits which meet both goals. Stormwater storage and conveyance measures, however, affect the community in a variety of ways. Through stormwater management planning the effects of alternative policies, programs, control measures, and financing schemes can be evaluated.

Stormwater management planning is directed toward basic policy questions, such as:

- What should be done with runoff from the land?

- Is the temporary (detention) or permanent (retention) storage of stormwater runoff desirable?

- Under the circumstances, should retention basins, detention basins, natural infiltration areas, or dished parking lots be used to store runoff?

- What requirements should be placed on new developments?

- Do stormwater runoff problems in developed areas warrant special attention?

- Should communal retention or detention facilities be provided by the local jurisdiction? If so, how can such areas be financed?

- Who should pay for retention and detention facilities on private property?

- Are the local jurisdictions already carrying out programs (such as parkland acquisition programs or wetlands regulation) which affect stormwater runoff? Can programs and/or regulations be coordinated to achieve multiple purposes?

- Should enclosed drains or natural channels be used to convey stormwater to and from storage areas?

- Can routing and storage be provided for major storms (e.g., 100-year frequency) as well as minor storms (e.g., 10-year frequency)?

- Who should be responsible for facility maintenance?

The specific questions to be addressed in a local government planning program will vary among local jurisdictions, reflecting varying problems and community objectives. The answers to these questions may take the form of policy statements, changes in regulations or engineering design standards, technical assistance materials for landowners or consulting engineers, revisions to existing programs, or a written plan document.

Because stormwater management planning for quantity and quality control is relatively new, and because community stormwater concerns differ, there are no easy formulas for preparing stormwater management plans.

Stormwater Runoff as a Community Resource

Although, stormwater management programs are typically undertaken to avoid problems (e.g., flooding, pollution, lawsuits), effective planning can also be used to pursue potential community benefits. When effectively managed, stormwater can provide benefits such as:

- Recharge of groundwater supplies;

- Water quality enhancement;

- Recreational opportunities (e.g., use of large retention areas for boating, fishing, or nature study);

- Replenishment of wetlands which serve as wildlife habitats, absorb peak floods, and naturally break down certain pollutants;

- Maintenance of summertime lake levels and stream flows; and

- Enhancement of community appearance and image when facilities are attractively designed.

The Role of Local Governments

In some cases, the institutional systems for stormwater management may need to be complex, largely because State, county, and local agencies' policies, regulations, and procedures may all affect stormwater control within a particular development. For example, in Michigan, the following roles apply:

- County drain commissioners construct and manage county drains and also review subdivision plans to assure adequate drainage.

- County highway departments affect drainage in new developments by regulating connections to roadside drains and ditches.

- The State Department of Natural Resources regulates wetlands, dam construction, and floodplain alterations.

- The State Water Resource Commission issues permits for certain stormwater discharges when known water quality problems can be linked with a particular activity, (e.g., certain storm drains, animal feeding operations, industrial parking lots).

- Both the State Department of Public Health and county drain commissioners regulate drainage in proposed mobile home parks.

- County agencies and certain local governments issue erosion and sediment control permits for certain development sites.

Furthermore, there has been increasing emphasis upon the consideration of environmental factors in land use decisions. Recent amendments to the City or Village Zoning Act and the Township Rural Zoning Act have clarified the legal authority of local governments to complete site plan reviews for environmental management purposes. Standards for the review of land uses must be included in local ordinances and take natural resource preservation into account. The Michigan Environmental Protection Act (MEPA) (Act 127, P.A. of 1970) places a duty on all government agencies to prevent or minimize water pollution and other environmental problems while carrying on regular activities. Section 5(2) of MEPA addresses the actions of local officials in the following terms:

> In any ... administrative, licensing or other proceedings, and in any judicial review thereof, any alleged pollution impairment or destruction of the air, water or other natural resources or the public trust therein, shall be determined, and no conduct shall be authorized or approved which does, or is likely to have such effect so long as there is a feasible and prudent alternative consistent with the reasonable requirements of the public health, safety and welfare.

Environmental aspects of stormwater runoff may be addressed by local officials in response to MEPA.

None of the above laws specifically require local governments to undertake stormwater management programs. Instead, local governments have a wide range of possible roles available to them. Stormwater management planning programs can be directed toward the review of existing State and county programs affecting stormwater runoff and toward the evaluation of alternative roles for the local government.

Possible roles for local governments in stormwater management include the following:

- Planning - The term "stormwater management planning" refers to the process of developing policies, programs, regulations, and other recommendations to chart the future course of the community in terms of stormwater management. Such planning can address existing problems or help to avoid future problems and community expenses.

- Regulations - Stormwater runoff control for each site plan and subdivision plan can be reviewed and approved by the local government.

- Design and Construction - Storm drainage facilities (e.g., pipes, basins, areas for retention) can be designed and constructed by the local government. Purchase of lands to serve as community stormwater retention areas may also be undertaken.

- Inspection and Maintenance - Requirements for regular inspection and maintenance of stormwater facilities, including drains and retention or detention basins, may be enforced by local governments. Requirements for easements are usually part of maintenance programs. Local governments may choose to undertake maintenance as a community service (such as a utility) or may require maintenance through contractual agreements with property owners.

The types of programs developed and the role assumed by a local government should, of course, reflect available financing options as well as program needs and management gaps.

FINANCIAL AND INSTITUTIONAL CONSIDERATIONS[2]

The traditional planning approach would ideally culminate in the successful implementation of a detailed design. In many cases, however, this objective is not accomplished due to financial and institutional constraints. Often a study team will fail to adequately consider such institutional and financial issues as who will manage the system and how will it be financed, thus creating a gap between technical planning and implementation. This omission is illustrated in Figure 4-2.

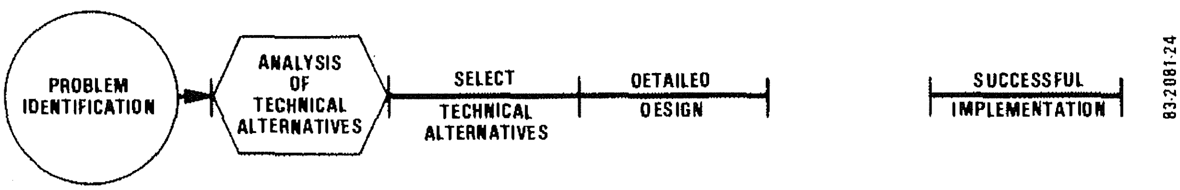


Figure 4-2. Incomplete Water Quality Planning

The implementation gap that results from the traditional planning approach has occurred all too often in attempts to control urban runoff.

As an illustration of the need to integrate financial and technical planning, consider the traditional process for developing a program to control construction runoff. A typical outcome of the process is a new ordinance. To reach this outcome, some of the issues that are normally considered from the technical perspective include:

- What are the technical construction requirements to be set out in the ordinance?

- What control measures will be required?

- How will compliance be monitored?

2 This material is largely from the draft document, Planning for Urban Runoff Control: Financial and Institutional Issues, December 1981, prepared for FMAP by the Government Finance Research Center of the Municipal Finance Officers Association, Washington, D.C.

To balance the planning process, this technical analysis should be expanded to include financial and institutional issues such as:

- Does the city have legal authority to implement each requirement in an ordinance?

- How much will each cost, and who will pay for implementation of the control measures?

- Who will conduct compliance review, and who will pay for the reviews?

Numerous additional factors increase the need for financial and institutional analysis in all water quality management planning. Examples might include:

- Implementation of control programs occurs at the local level, and local budgets are being tightened as water quality expenditures compete with other local demands.

- Benefits from water quality projects are difficult to quantify and often accrue to people living downstream.

- It is becoming more difficult to obtain municipal funds through the bond market because of high interest rates.

- The cost of pollution controls is often sizable and difficult to allocate to specific polluters or beneficiaries.

These problems affect most areas of water quality management, but they are especially important in identifying and implementing solutions to urban runoff pollution.

Integrated Approach

An integrated planning approach helps water quality planners make the best control decisions in light of many complex issues. This approach takes the traditional planning process and adds to it financial and institutional elements at each step along the way. This integration is shown in Figure 4-3, with the traditional approach illustrated along the upper track and the financial and institutional elements added along the lower track.

During the early planning stages, financial and institutional issues are reviewed on a preliminary basis. This information becomes more detailed and refined as planning proceeds. Ultimately, the information forms the basis for a financial and institutional plan that supports the detailed design of a control alternative.

When very complex problems are being evaluated, it may be advisable to use a preliminary matrix early in the evaluation process for screening-out unacceptable alternatives. This approach permits a more detailed evaluation of issues surrounding the two or three best alternatives before a final selection is made. An example of a preliminary matrix is given in Figure 4-4.

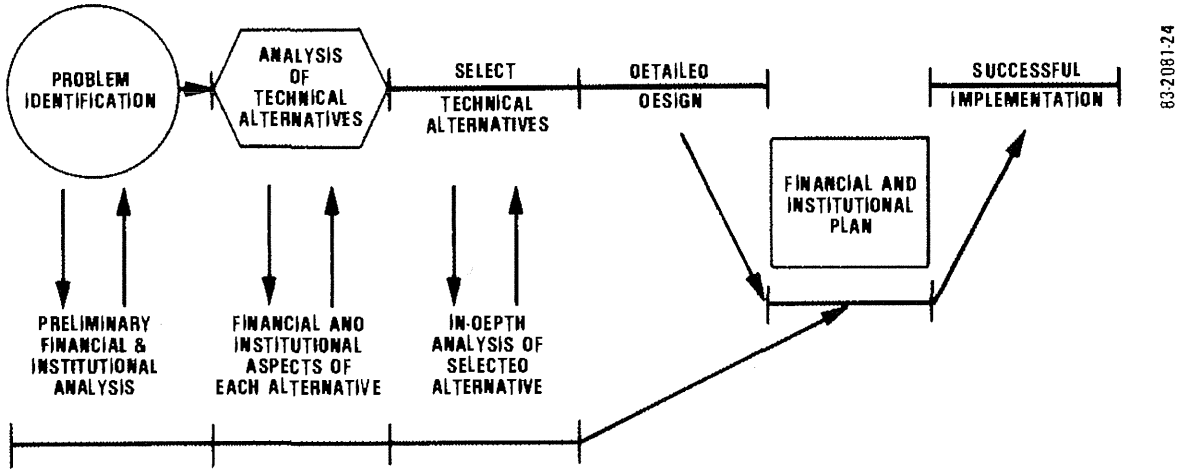


Figure 4-3. Integrated Water Quality Planning

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CONTROL APPROACH	TECHNICAL DESCRIPTION	EFFECTIVENESS IN CONTROLLING POLLUTION	FINANCIAL ISSUES		INSTITUTIONAL ISSUES
			NET PRESENT VALUE	ABILITY TO PAY	
• SEPARATE SEWERS	CONSTRUCT NEW STORM SEWERS IN COMBINED AREAS	100% EFFECTIVE IN ELIMINATING CSOs	$1 BILLION	EXCEEDS CITY'S BONDING CAPACITY	EXISTING INSTITUTIONS COULD HANDLE THE PROJECT
• SELECTIVE EXPANSION OF UNDERSIZED TRUNK SEWERS	REMOVE BOTTLENECKS, REDUCE NUMBER OF OVERFLOW EVENTS	50% EFFECTIVE	$200 MILLION	IF STAGED OVER 10 YEARS, COULD BE FINANCED BUT WOULD RESTRICT OTHER PROGRAMS	EXISTING INSTITUTIONS COULD HANDLE THE PROJECT
• CONSTRUCTION OF DETENTION BASINS	CONSTRUCT 10 DETENTION BASINS SIZED TO HOLD THE FIRST FLUSH FROM A STORM	30% EFFECTIVE	$50 MILLION	IF STAGED OVER 5 YEARS, COULD BE FINANCED; COULD RESTRICT OTHER PROGRAMS	NEW ORGANIZATION MIGHT BE NEEDED TO MAINTAIN AND AND OPERATE BASINS

Figure 4-4. Preliminary Matrix for Selection of a Control Approach (Combined Sewer Overflows)

Once a control approach is selected, a detailed design and a financial and institutional plan can be prepared. Figure 4-5 illustrates the major features of a financial and institutional plan. Key features of the detailed analysis required to prepare this plan are discussed in the following section.

INSTITUTIONAL SECTION

- RESPONSIBLE AGENCY
  - OPERATING PLAN
  - STAFFING NEEOS
  - ORGANIZATIONAL STRUCTURE
- LEGISLATIVE NEEOS
  - LEGAL ANALYSIS
  - ORAFT OROINANCES
  - ASSISTANCE NEEOEO

FINANCIAL SECTION

- PROGRAM COST
  - OPERATING BUOGET
  - CAPITAL REQUIREMENTS
- PROGRAM REVENUE
  - FUNOING SOURCES
  - FLOW OF FUNOS
  - PROGRAM CASH FLOW
  - COST ALLOCATION FORMULA
- OTHER FACTORS
  - FINANCIAL BUROEN ON PARTIES PAYING FOR THE PROGRAM
  - SENSITIVITY OF COST ANO REVENUE ESTIMATES TO CHANGES IN FINANCIAL ASSUMPTIONS
  - INOIRECT IMPACTS

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Figure 4-5. Major Components of a Financial and Institutional Plan

Key Financial and Institutional Elements

There are six essential elements[3] of financial and institutional analysis which provide a structure for the integrated planning process;

- institutional assessment,
- cost analysis,
- revenue analysis,
- ability-to-pay analysis,
- sensitivity analysis, and
- indirect impact analysis.

[3] These elements were first defined in Planning for Clean Water Programs: The Role of Financial Analysis, U.S. EPA's Financial Management Assistance Program by the Government Finance Research Center of the Municipal Finance Officers Association, September 1981.

Each of these elements threads through the planning process and becomes more definitive as the process proceeds. The following discussion defines each element and identifies its major features.

Institutional Assessment

The institutional assessment identifies the organizations or participating agencies that would be affected or involved in implementing a particular control program. The role of each entity in a program is evaluated with respect to its interest in solving the problem and its planning, management, operating, and regulatory capabilities. If the study team identifies an urban runoff problem, a preliminary institutional analysis can provide insight into capabilities of agencies that may be asked to play a role in the implementation and can, in some cases, aid in determining the types of technical alternatives that are analyzed.

The key factors to consider in evaluating an agency's capabilities are its statutory authority and organizational ability. In order to control urban runoff, an agency must have or be able to obtain the authority to implement a control measure. The authority of an agency can be assessed by thoroughly reviewing applicable federal, state, and local legislation. This review helps to determine which agency can best manage a given problem and highlights areas where additional legislation or local ordinances are needed.

Cost Analysis[4]

A cost analysis is performed to identify the additional capital, operational, maintenance, and administrative costs of each activity that is part of a control program. These costs are estimated for each agency responsible for an activity. Cost estimates are prepared in uninflated dollars (using today's cost for all projections into the future) and brought back to their present value (or present worth) for comparison among alternatives. The interest rate to be used in the present value analysis is the agency's current interest rate for borrowing funds minus the expected rate of inflation.[5]

Cost analysis of control alternatives is included in increasing detail in each step of the planning process. It begins with "ball park" estimates in early stages which are refined as the process progresses and finalized in the detailed financial plan.

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[4] A substantial part of this material is from a report, Collection of Economic Data from Nationwide Urban Runoff Program Projects, prepared for EPA by the Midwest Research Institute, 425 Volker Boulevard, Kansas City, MO 64110.

[5] For a further discussion of present value analysis, see pp 36 to 42 of Facilities Planning 1981, U.S. Environmental Protection Agency, FRD-20, 1981.

Cost estimates cannot be static. They are prepared on a preliminary basis when an alternative is first considered and detail is added as an alternative becomes more feasible. As the planning process progresses, estimates are updated on a regular basis to account for changing costs.

To update and improve available data on the costs of specific urban runoff BMPs, EPA conducted a program to guide, assist, and coordinate the efforts of selected NURP projects in gathering cost data on the BMPs and BMP systems which they were evaluating as part of the NURP national workplan. A report[6] was prepared to summarize the preliminary economic data submitted by the NURP projects. Economic data were submitted for street sweeping, detention basins, catch basin cleaning, ocean discharge control systems, and a public education/information program by nine projects. The data must be considered preliminary and subject to change, particularly annual operating cost data. Most of the capital cost data are well documented and represent the actual cost of the BMP control and will not change. The annual operating cost data, however, range from detailed analyses to estimates, and some of the data reported are incomplete. Since most of the projects were still in progress, incomplete operating cost data were to be expected.

The capital costs of street sweepers varied from $21,988 (in 1975) to $40,000 in 1981. The annual operating costs of street sweeping programs varied from $53,445 to $1,138,097. The unit cost varied from $16.80 to $45.45 per hour of operation, and from $5.95 to $23.36 per curb-mile swept. This wide range indicates that many variables affect the actual cost of operating a street sweeper.

The installed capital costs of recharge basins in Fresno, California, ranged from $933,750 to $5,587,000. BMP modifications to three detention basins in Oakland County, Michigan, cost $2,345 to $8,442. The installed capital cost of the modifications to the wet pond in the Lansing, Michigan project was $50,149. Construction of the wet pond in the Salt Lake County, Utah project cost $41,138; modifications to the dry pond included placing aluminum plates in an existing underdrain and installing a redwood outlet skimmer at a nominal cost of $371.

The annual operating costs of the Fresno, California, basins range from $1,625 to $7,975. The annual cost for the basin in Lansing, Michigan is incomplete and includes only the interest cost on a 7 percent, $38,500 bond used to help finance the project. The annual operating costs for the ponds in the Salt Lake County, Utah project were estimated at $560 for the wet pond and $200 for the dry pond.

The costs of the structural control alternatives to control discharge to the ocean in Myrtle Beach, South Carolina, were presented in detail and are valid estimates of the costs that will be incurred if one of them is constructed.

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[6] Collection of Economic Data From Nationwide Urban Runoff Program Projects - Final Report, April 7, 1982, EPA Contract No. 68-01-5052. Detailed cost data provided by the projects are included in the appendices of this Report to show how the various projects prepared the data for submission.

The 1980 construction cost estimates ranged from $32,849,200 to $50,973,500, and the annual operating cost estimates ranged from $3,735,400 to $5,301,900. The cost of the public education program at Salt Lake County, Utah, was estimated at $1,550. The project will report the actual cost of the program upon its completion.

Revenue Analysis

The revenue analysis identifies the funding sources needed to match the estimated cost for control activities by participating agencies. This analysis is important because it ensures adequate funding to implement the technical solution to an urban runoff problem.

There are three categories of funding that are typically used to pay for runoff control: Federal and State funds, local public funds, and private funds. These sources include a variety of different financing mechanisms, each with advantages and disadvantages. The use of any or a combination of these sources requires consideration regarding:

- Revenue adequacy - Will funds be available in the long- and short-term?

- Equity - Are the beneficiaries of the control program paying their full share?

- Economic efficiency - Is the charge that is assessed equal to the social cost of the program?

- Administrative simplicity - Can the funds be managed and directed to the control program without significant administrative problems?

Ability-to-Pay Analysis

The ability-to-pay analysis evaluates the implementing agencies' and the individual user's ability to pay for the proposed program by determining how reasonable a proposed revenue program is in terms of its overall impact on the community as a whole as well as on individual residents.

For a given revenue source, the additional burden of the program is expressed as a percentage of the base costs. For example, if the proposed program is to be financed by property taxes and it adds $.50 to a $1,000 tax bill, the additional tax burden is .05 percent. In this instance, it would appear that the homeowner's ability to pay is quite high.

An important factor to remember is that programs to control urban runoff are not the only programs that are placing a burden on the people or institutions who must support them. Hence, the cost of a control program may not be excessive but cannot be imposed because ability to pay has already been exceeded due to other projects.

Sensitivity Analysis

The sensitivity analysis identifies the extent to which local ability to pay varies with changes in the assumptions used to estimate costs and revenues. Major assumptions that influence costs and revenues are: phasing of capital improvement, anticipated local funding requirements, rate of inflation, growth rate, and local fee policies.

The first step in this analysis is to determine a range of values for key cost and revenue assumptions that could occur during the program. (For example, inflation may vary between 5 percent and 15 percent.) The ability-to-pay analysis is then repeated using the high and low values for these assumptions. The final step is to evaluate the changes in burden with "best-" and "worst-" case situations in comparison with burden under the "most likely" assumption.

The purpose of this analysis is to identify control programs that are least vulnerable to changing conditions. It also helps to make the planner aware of best- and worst-case scenarios so that contingency plans can be developed to cope with such events.

Indirect Impact Analysis

The indirect impact analysis is an assessment of the costs and benefits that are not directly attributable to a proposed program. These costs and benefits can be economic, social, and/or environmental. Quantifying the indirect impacts of a program is usually quite difficult, so the planner generally resorts to qualitative measurement.

An Example: Planning an Educational Program

To illustrate further the process of identifying and resolving the financial and institutional issues connected with implementation of an urban runoff control program, the following spells out the steps involved in evaluating one control approach applicable in already developed areas. The example chosen is an educational program to inform citizens, industry, and public agencies of the problems caused by runoff-borne lawn and garden chemicals, oil and chemical residuals from industrial yards, and pesticides, herbicides, and fertilizer from parks and golf courses.

In this example, the activities would include: development of an informational brochure, including printing and distribution, and maintenance of an information center. In Figure 4-6, the institutional characteristics needed to accomplish these activities are compared with the capabilities of existing agencies. The matrix shows that the County Department of Pollution Control could provide the technical input to the Public Information Center to write the brochure. The Council of Governments might coordinate the effort and assume overall responsibilities for getting the job done.

INSTITUTIONAL CHARACTERISTICS NEEDED	AGENCIES					
	STATE	COUNCIL OF GOVERNMENTS	DEPARTMENT OF POLLUTION CONTROL	DEPARTMENT OF PLANNING	PUBLIC INFORMATION CENTER	CHAMBER OF COMMERCE
• COMMITMENT TO PROGRAM GOALS	*	*	*	*	*	*
• WORKING KNOWLEDGE OF EACH WASTE CONTRIBUTION TO THE RUNOFF PROBLEM	*	*	*	*		
• ABILITY TO WRITE CLEAR AND CONCISE INFORMATION FOR THE PUBLIC					*	
• ABILITY TO PRINT AND AND DISTRIBUTE BROCHURE				*		* DISTRIBUTE TO INDUSTRY
• STAFF TO RECEIVE FOLLOWUP CALLS		*				
• ABILITY TO ACCEPT FUNDS FROM SEVERAL AGENCIES TO PAY FOR THE PROGRAM		*				

83-2061-44

Figure 4-6. Institutional Assessment for Educational Program to Control Chemical Substances

Cost Analysis. Cost analysis determines the additional funds needed to implement a control alternative, including capital improvements and operation and maintenance. Additional administrative costs are less significant because most of these projects are undertaken by a public agency that is already performing the function to some extent.

Capital cost estimates are best prepared by the water quality planner with the assistance of the municipal engineer and in some cases his/her outside engineering advisor. These estimates identify all costs related to the purchase of a new facility or piece of equipment for a project and may require some research into vendor prices and bids on similar projects around the country. For programs which require changes to existing practices (street sweeping, etc.), the cost attributable to the water quality program is the incremental cost of the program.

Ultimately, the cost analysis is used to identify the least-cost method(s) for reducing pollution problems. It is important to remember that all costs associated with a given program must be considered. It is incorrect to assume that educational efforts, for example, are provided at no additional cost.

As an example of a cost analysis, a possible budget sheet for the educational program for the current year is presented in Figure 4-7.

ACTIVITIES	AGENCIES					
	STATE	COUNCIL OF GOVERNMENTS	DEPARTMENT OF POLLUTION CONTROL	DEPARTMENT OF PLANNING	PUBLIC INFORMATION CENTER	TOTAL
1. DEVELOP BROCHURE					$13,000	$13,000
2. PRINT BROCHURE				$1,500		$ 1,500
3 DISTRIBUTE BROCHURE				$ 800		$ 800
4. CONDUCT INFORMATIONAL MEETINGS	$2,000	$ 5,500	$2,000			$ 9,500
5. STAFF FOLLOWUP FOR PROGRAM		$24,000				$24,000
TOTAL	$2,000	$29,500	$2,000	$2,300	$13,000	$48,800

83-2061-45

Figure 4-7. Cost Analysis for Educational Program to Control Chemical, Herbicide, Fertilizer and Pesticide Runoff

Revenue Analysis. After the program cost estimate is prepared, the potential sources of revenue are analyzed. There are several critical factors in analyzing revenue for urban runoff programs including:

- Cost/Revenue Balance - Will the revenues be sufficient to cover the costs on an annual basis?

- Equitable Allocation of Costs to Different Groups - Do those who contribute to the problem pay their fair share? Do those who benefit from the program pay their fair share?

- Revenue Agreement - Do groups understand their participation in a program and its revenue formula? Have written agreements which define the cost allocation procedure been prepared ?

Revenue analysis will vary with the type of control approach selected. The critical factor in the revenue analysis is the identification of each entity that will provide revenues and the development of an understanding by that entity of the problem, the control approach, and its share of the cost.

Ability-to-Pay Analysis. Most of the costs to control runoff from developed areas are imposed on the general public or the benefiting population as a new and additional governmental expense. The ability-to-pay analysis evaluates this increased burden on the local community as a percentage of property taxes, average income, property evaluation, or other appropriate measures.

Figure 4-8 illustrates an ability-to-pay analysis for the educational program example. The key parameters to determine homeowners' ability to pay in this case are the cost of the program per household, cost as a percentage of average annual household income, and cost as a percentage of property taxes.

83-2061-46

A. TOTAL PROGRAM COST (ONE-YEAR PROGRAM)	$48,000	
B. NUMBER OF HOUSEHOLOS AFFECTEO	19,000	
C. COST PER HOUSEHOLO (A OIVIOEO BY B)		$2.57
0. MEOIAN HOUSEHOLO INCOME	$14,700	
E. COST AS A % OF MEOIAN HOUSEHOLO INCOME (C OIVIOEO BY 0 TIMES 100)		.02%
F. AVERAGE ANNUAL PROPERTY TAXES	$ 1,200	
G. COST AS A % OF PROPERTY TAXES (C OIVIOEO BY F TIMES 100)		.21%

CONCLUSION: PROGRAM APPEARS TO NOT PLACE EXCESSIVE BUROEN ON LOCAL HOMEOWNERS

Figure 4-8. Ability to Pay Analysis for Educational Program to Control Chemical, Herbicide, Fertilizer and Pesticide Runoff

Sensitivity Analysis. The sensitivity analysis will vary depending upon the revenue mechanism and program selected for implementing a proposed program. The most common revenue mechanisms for programs controlling runoff from developed areas are general funds and fees. Analyzing the sensitivity of general revenues requires a review of past collections relative to key parameters--inflation, housing starts, collection rates, capital improvements, and so on. Collections are then projected for worst and best case scenarios.

An additional consideration in the sensitivity analysis is revenue requirements. This relates to phasing a program, either handling capital improvements or starting a program on a limited basis with expansion to come in later years. For any one program, numerous options exist for staggering cash flows, and different scenarios should be developed to assess their impact on the program as part of the sensitivity analysis.

Indirect Impact. The indirect impact of a runoff control program for developed areas are extremely difficult to quantify. Educational programs will raise community awareness regarding the impacts of local activities on water pollution. Other indirect impacts from control programs may relate to recreational benefits, local improvements in quality of life, and increased tourism.

RELATIONSHIP BETWEEN NURP AND WQM PLANS

Of the locations selected for projects under the NURP effort, some 80 percent had state-approved (i.e., certified by the Governor) water quality management (WQM) plans with elements which addressed urban runoff. For 5 of these locations, the NURP project constituted the urban runoff element of the plan. For the other locations, however, the original 208 effort was unable to develop the necessary information on either water quality effects or performance of best management practices (BMPs) to justify structuring formal implementation plans for urban runoff control. Consequently, the typical WQM plan elements dealing with urban runoff identified the need for further study, usually specifying problem assessment and BMP performance evaluation. These elements became the focal points of the activities funded by NURP.

The WQM plans for the remaining 20 percent of the locations which participated in the NURP program did not contain a specific urban runoff element. Presumably this was due to time and resource constraints in relation to other issues which were assigned higher priorities in planning efforts. In these cases, the NURP projects provided the opportunity to address a water quality issue not adequately addressed in the original 208 planning studies.

Over two-thirds of the NURP project locations reported that NURP findings and recommendations have or will be incorporated in the next annual update of their formal WQM plans. The remainder generally indicate that they expect the planning issues to be addressed at the local level or that NURP results will support planning and implementation activities, even though they do not anticipate formal incorporation in WQM plans at this time.

Over half of the NURP project locations report either active or planned implementation efforts based on the results of NURP. Thirty percent indicated that no implementation is being planned because the need for or value of urban runoff control was not demonstrated. The balance (20 percent) of the NURP locations suggest that while implementation activities are not currently planned, they expect NURP results to influence future deliberations on this issue.

CHAPTER 5
METHODS OF ANALYSIS

INTRODUCTION

This chapter identifies and briefly discusses the methods adopted to assemble and analyze the large data base developed by the NURP projects and also provides the methods employed to develop and interpret results. The chapter is structured according to the three prime areas of program emphasis; (1) characteristics of pollutants in urban runoff, (2) water quality effects of urban runoff discharges including water quality criteria/standards violations and impairment or denial of beneficial uses of receiving water bodies, and (3) the effectiveness of control measures to reduce pollutant loads.

The procedures employed in this assessment were designed to provide generalized results and findings about urban runoff issues of interest for nationwide use. This national perspective, and the need to consider the fundamental variability of urban runoff processes, has prompted some significant advancements in the application of statistical methods and models. The basic methods used were, however, largely developed under different EPA efforts, many under the sponsorship of the Office of Research and Development, or other programs. In some cases, similar or equivalent procedures were applied in individual NURP projects; in other cases, methods adopted by individual projects in response to local needs and interests were different. Where possible, comparisons have been made between either detailed results, or conclusions drawn from such results, as derived from both local and national perspectives.

The descriptions provided in this chapter are brief and intended to communicate the technical framework upon which the results and conclusions are based. More detailed information on the methods and techniques are contained in other documents developed by NURP. Pertinent NURP reports cover, in separate volumes, probabilistic methods for analyzing water quality effects, detention and recharge basins for control of urban stormwater quality, and street sweeping for control of urban stormwater quality. The Data Management Procedures Manual, another of the project documents, is an additional source of information on details of the analysis methods utilized.

Because field measurements and sampling formed one of the most important information sources, it was essential that the monitoring and analysis programs produce consistent and sound data. Accordingly, NURP required that all projects adopt Quality Assurance/Quality Control elements as integral parts of their work plans. Key components of these plans include the following:

- Program Coordination. Projects were required to designate a QA/QC coordinator, responsible for the entire QA/QC effort.

- Field Quality Assurance. Guidance was provided to the projects for all key aspects of the data collection process.

- Laboratory Quality Assurance. A manual prepared by EPA's Environmental Monitoring and Support Laboratory was provided to all projects and contained analytical quality control information.

- Data Management. A manual entitled "Data Management Procedures" was provided to all projects and covered such topics as data formatting, data reduction, and some analysis.

- Data Analysis. To encourage innovative approaches and responsiveness to local conditions, uniform methods of data analysis were not stressed. Technical guidance and mandatory review of analytical procedures were provided.

| RUNOFF POLLUTANT CHARACTERISTICS

al

stantial component of the individual NURP projects was the acquisition subsequent analysis) of a data base for a number of storm events, conng of precipitation and the resulting quantity and quality of runoff a number of local urban catchments. One of the principal EPA objectives e analysis of these data has been to develop a concise summary of the cteristics of urban runoff. There are a number of questions concerning runoff characteristics which need to be addressed for water quality ing purposes, including what are the appropriate measures of the statischaracteristics of urban runoff (e.g., population distribution, central ncy, variability, etc.)? Do distinct subpopulations exist and what are characteristics? Are there significant differences in data sets ed according to locations around the county (geographic zones), land season, rainfall amount, etc.? How may these variations be recognized? s the most appropriate manner in which to extrapolate the existing data to locations for which there are no or limited measurements? Though questions cannot be fully answered given the current state of knowledge ning urban runoff, these are the types of issues addressed by the is described in this chapter and the results presented in Chapter 6.

rincipal thrust of the individual NURP projects, and thus this nationassessment report, was the characterization of what has been adopted as lard Pollutants" of primary concern in urban runoff. These include , oxygen consuming constituents, nutrients, and a number of the more ly encountered heavy metals. The methods used to characterize these rd pollutants are described under a separate heading below.

roximately two-thirds of the NURP projects the occurrence of compounds s list of "Priority Pollutants" was investigated. This program element so described under a separate heading below. A number of additional have also been addressed in the program. These are briefly discussed below because they relate closely to the general issue of pollutant characteristics. These include the following:

- Soluble vs Particulate Pollutant Forms. The distribution of soluble and particulate forms of a pollutant in urban runoff (particularly metals and nutrients) was examined in both the standard conventional pollutant and priority pollutant aspects of the study because certain beneficial use effects depend strongly on the form in which the contaminant is present. The priority pollutant program additionally determined "Total Recoverable" fractions, corresponding to contaminant forms used in EPA's published toxic criteria guidelines.

- Coliform Bacteria. Fecal coliform bacteria counts (and in some cases total coliform and fecal streptococcus as well) in urban runoff were monitored during a significant number of storms by seven of the NURP projects. Though the data base for bacteria is restricted, useful results are provided in Chapter 6.

- Wetfall/Dryfall. As part of program elements designed to examine sources of pollutants in urban runoff, a number of projects operated atmospheric monitoring stations for characterizing pollutant contributions from precipitation (wetfall) and from dry weather deposition (dryfall). Results of this work are reported in individual project reports and not included herein.

Standard Pollutants

The following constituents were adopted as standard pollutants characterizing urban runoff:

TSS - Total Suspended Solids
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
TP - Total Phosphorus (as P)
SP - Soluble Phosphorus (as P)
TKN - Total Kjeldahl Nitrogen (as N)
NO_{2+3}-N - Nitrite + Nitrate (as N)
Cu - Total Copper
Pb - Total Lead
Zn - Total Zinc

The list includes pollutants of general interest which are usually examined in both point and nonpoint source studies and includes representatives of important categories of pollutants--namely solids, oxygen consuming constituents, nutrients, and heavy metals.

The pollutant concentrations found in urban runoff vary considerably, both during a storm event, as well as from event to event at a given site and from site to site within a given city and across the country. This variability is the natural result of high variations in rainfall intensity and occurrence,