NEW YORK HARBOR

New York Harbor lies at the bottom of Hudson, Passaic, and Hackensack Rivers. The surrounding counties have a combined population of 13.5 million. New York City and the adjacent communities in New Jersey and New York operate 31 sewage treatment plants having a total design capacity of 2,400 million gallons per day (mgd). These plants generate about 15,000 tons of dry sewage sludge a month. One hundred and 85 square kilometers (20% of the surface area of NYC) is composed of landfill. Almost all of the landfills were built on wetlands adjacent to the estuary. Rainwater percolating through these sites results in 41 mgd of Coca Cola ® colored leachate. New York City's 394 combined sewer outfalls are estimated to discharge
135 mgd of untreated sewage.

Major Tributaries

Yearly average discharges of five major rivers (at head of tide) are:

Tributary Rivers:	cubic feet per second, CFS
Hudson at Waterford above confluence with Mohawk R.	5,300
Mohawk River at Cohoes	3,700
Wallkill at Gardiner, New York	690
Passaic River at Little Falls, NJ	740
Raritan River and Bound Brook, NJ	770

There is an enormous degree of daily and even hourly variability in these river discharges. The estuary responds to freshwater flows, to tides, and to other forces such as wind velocity and barometric pressure.

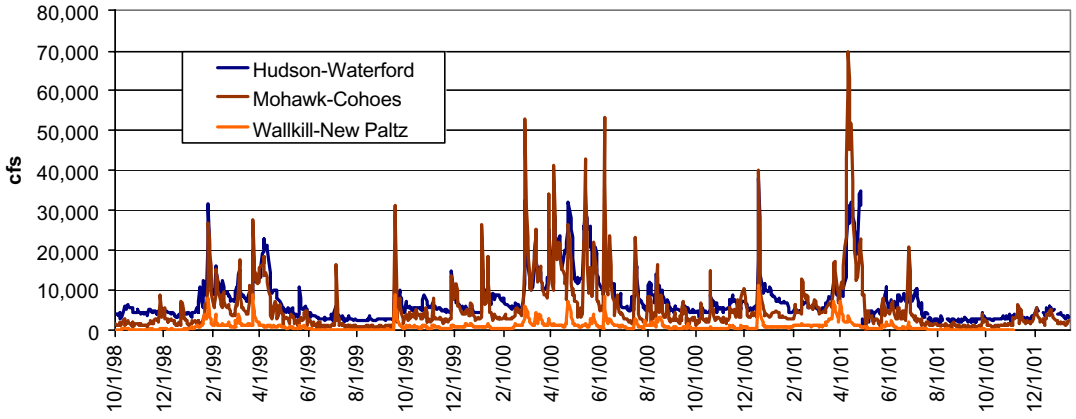

Figure 1. Comparison of discharges of the three largest freshwater sources to the Hudson Estuary over the life of CARP.

One can safely assume that a parcel of water entering the estuary will eventually reach the sea; it's much harder to know when. It is very much more difficult to predict when a

particle entering the estuary will reach the sea or the harbor. It may spend a significant amount of time buried in a deposition area and in regions nearer the ocean large amounts of sediments are brought into the harbor from the continental shelf.

USGS researchers working within the CARP studied the loading of particles particularly during high flow events. Generally, about half a river's discharge occurs in about 10% of the year in a small number of events. The loading of solids and more particularly, organic carbon may occur over shorter spans. A separately funded investigation by Gary Wall of the USGS and Rocky Geyer of Woods Hole, instigated by CARP observations, is investigating some of the fine-grain detail of particle movement in the mid-Hudson near Poughkeepsie, New York. This work will yield insights that will assist in predicting the movement of particles through the tidal portion of the Hudson.

Minor Tributaries

The CARP design called for investigating the contributions of some of the minor tributaries. The extent of urbanization in New York City is such that there are few surface streams. CARP selected three; the Bronx River in the Bronx, Saw Mill River in Westchester, and the Gowanus Canal in Brooklyn. The Gowanus Canal and Saw Mill River are obviously affected by street run-off, CSOs, and probably contaminated groundwater. The Bronx River is, particularly as it makes its way through the New York Botanical Garden, surprisingly lovely but still chemically affected by its passage through Westchester County and the Bronx.

While neither the Saw Mill River nor the Bronx River are gauged, discharges may be estimated by assuming proportionality to that of nearby streams that are monitored.

The Gowanus Canal is an odd choice as a tributary. It was at one time a real tidal creek but is no longer. It had been canalized and served as part of the terminus of the Erie Canal. Raw sewage had rendered the Gowanus obnoxious and, in 1911, the City of New York installed a pumping system to flush it out with East River or Upper Bay water. The flushing system was rebuilt in 1999 and uses East River water. The present system has an average pump rate of 200 mgd and a maximum rate of 300 mgd. The pump rate varies with the tidal elevation so as not to mobilize contaminated bottom sediments. In this case, discharge is East River water that may have some entrained bottom sediments.

There is a concern that the flushing activities would mobilize contaminated sediments and we decided to sample the Gowanus as a potential contaminant source via transport of resuspended solids.

Sewage Treatment Plants

There are 14 sewage treatment plants in New York City alone. They are on Staten Island (Port Richmond in the north and Oakwood Beach in the south), two in Manhattan (North River in the northwest and Wards Island in the northeast – actually in the East River), one in the Bronx (Hunts Point), three in Queens (Bowery Bay in Steinway near Rikers Island,

Tallman Island in College Point near the Whitestone Bridge, and Jamaica near Kennedy Airport), and six in Brooklyn (Newtown Creek in Greenpoint, Red Hook next to the Brooklyn Navy Yard, Owls Head in Bay Ridge, Coney Island in Sheepshead Bay, 26th Ward in Spring Creek, and Rockaway).

Besides the 14 NYC plants, the CARP also sampled plants in Rensselaer (near Albany), Poughkeepsie, Rockland, and Yonkers. NYSDEC sampled two plants in New Jersey, Passaic Valley Sewerage Commissioners (PVSC) and Edgewater.

Table 1. Harbor area WPCFs.

WPCFs	MGD
Newtown Creek (NC)	286
Passaic Valley (PVSC)	*283*
Wards Island (WI)	258
North River (NR)	161
Hunts Point (HP)	148
Bowery Bay (BB)	126
Owls Head (OH)	124
Coney Island (CI)	115
Yonkers (Westchester Co.) (YO)	92
Jamaica (JA)	81
26th Ward (26)	68
Tallman Island (TI)	55
Red Hook (RH)	41
Port Richmond (PR)	35
Oakwood Beach (OB)	27
Rockaway (RO)	27
Rockland County (RK)	26
Rensselaer (RE)	24
Poughkeepsie (City) (PO)	14
Orangetown SD2,	13
Tri-City	12
Newburgh	9
Haverstraw	8
Kingston	7
Beacon	6
Poughkeepsie (Town)	4
Wallkill (Town)	4
Edgewater	*3*
Ulster (Town)	1.6
Yorktown Heights	1.5

Each of the targeted WPCFs was sampled at least three times with the exception of Red Hook where there were field problems and one sample set was rejected. Some plants

(Newtown Creek, Port Richmond, Hunts Point, and 26th Ward) were sampled more intensively. Two facilities in New Jersey (PVSC and Edgewater) were visited once each as part of an investigation in sampling technique.

Sewage treatment plants generally do four things. They remove stuff that sinks ("grit") and stuff that floats ("scum"). They grow and harvest bacteria that degrade and metabolize dissolved organic material. And they disinfect the final water with chlorine. Solids, called sludge or biosolids, are dewatered, palletized, and used as fertilizer. Not all the WPCFs in New York City have dewatering facilities necessitating the transport of watery sludges by ship to plants with drying capabilities from those without. The eight plants that have dewatering capabilities and their estimated monthly output of sludge are listed below:

Table 2. Biosolids production at NYSDEP WPCFs.

WPCF	Tons/month, dry weight
Wards Island	3000
Hunts Point	2500
26th Ward	1200
Bowery Bay	1000
Oakwood Beach	820
Jamaica	690
Tallman Island	450
Red Hook	230

Municipal treatment plants are not designed to remove toxic chemicals and on occasion, toxic chemicals discharged to sewers may disrupt treatment plants by harming the bacteria and protozoa essential to the process. Therefore, sewage treatment plant operators run programs, called "pretreatment", to regulate what is discharged into sewers by manufacturers or certain commercial establishments. The following table shows the kinds and numbers of facilities in the New York City pretreatment program by wastewater treatment catchment area[1].

[1] Data kindly supplied by Leslie Lipton, NYCDEP, 7/17/2003.

Table 3. Type and number of NYC industries discharging to city WPCFs. The key to the abbreviations is in Table 1.

	Totals	177 NR	110 NC	68 BB	28 OH	26 WI	23 HP	19 JA	13 26	10 TI	9 RH	8 CI	6 PR	1 OB	1 RK
new source metal finishing	248	141	53	32	6	1	3	4	5	2	1				
radiator shop	31		2	3	4	6	6	4	2	1		2	1		
industrial launderer	26		9	3	2	3	1	3	1		1	1	1	1	
metal finishing/non-cat	24	6	8	4	2	1		2	1						
miscellaneous	23	3	5	4			3	3	1	1	2	1			
paint/ink formulator	21	2	4	2	3	3	3		1		1	2			
metal finishing	17	10	1	1	1	1				1	1		1		
textile dyer	14	2	6	1		1	1			2		1			
soap & other detergents	9		2	1	3	1		1	1						
steam electric generation	9		1	2	1	2					1		1		1
centralized waste treatment	8	1	2	1	1	1				1	1				
electroplating-> 10k gpd	7		1	5						1					
electroplating- < 10k gpd	7		3	1	1		1					1			
organic chemicals/non-cat	7			3	1	1	1			1					
pharmaceutical manfg.	6		1	1		3		1							
metals molding & casting	4		1	1	1						1				
nonferrous metals form & powders.	4	1			1	1		1							
organic chemical/categorical	4		1				2						1		
photoengraver	4	3	1												
steel drum reconditioner	4		4												
fur dresser & dyer	3	1	2												
pesticide chemicals	3			1		1	1								
heat treater	2		1				1								
metals molding & casting/non-cat	2	1							1						
nonferrous metals manfg.	2	2													
NS metal molding & casting	2	1		1											
photofinishing	2	2													
copper forming	1				1										
inorganic chemicals/non-cat	1		1												
instruments & related products	1		1												
new source metal finishing	1	1													
NS metal molding & casting/MF	1			1											
pulp & paper products	1												1		

CSOs and SWOs

Sewage gets to sewage treatment plants by means of sewers. Sewers and sewage treatment plants have designed capacities. Too much water cannot be properly treated and may, if unchecked, harm the process by washing out the bacteria being farmed at the sewage treatment plants. The collection system can divert excess water and the sewage treatment plant operators also watch their intake and can divert excess water. In some cases, at 26th Ward in Brooklyn for example, diverted water is held in vast underground tanks and processed at the treatment plant during dry weather but in most instances,

diverted water goes directly into surface water. When the diverted sewage is a mixture of rain water and what is politely called "sanitary" waste, its called combined sewer overflow (CSO); when it's only run off from the streets or roofs, it's called storm water overflow (SWO). In newer areas, cities build separate collection systems for storm water and sanitary water. In a separated system, the discharge of excess water during a storm is less contaminated and the treatment plants are less exposed to excessive flows. Most of New York City has combined sewers but there are some separate sewers in parts of Queens and in southern Staten Island. We thought that the CSOs might turn out to be important sources for loading of chemicals into the harbor.

The capacities, number of CSOs, and estimated average CSO discharges are shown below for 13 New York City WPCFs (Oakwood Beach omitted).

Table 4. NYC CSOs. See Table 1 for the key to the abbreviations.

WPCF	Max Cap. (mgd)	# CSO	Est. Avg. CSO Disch. (mgd)
NC	602	66	14
WI	457	76	11
BB	300	47	13
NR	298	46	5
HP	272	30	15
OH	234	8	9
CI	181	3	10
JA	160	14	31
26	125	4	12
TI	114	16	10
PR	109	33	1.0
RH	92	29	3.7
RO	37	22	0.47

CSOs (combined sewer overflows) should occur only when the amount of water entering a treatment plant exceeds twice its design capacity. When influent flows are greater than design capacity but below twice design capacity, some primary treatment (removal of solids) is possible but higher flow rates may damage the facility. Treatment plant operators throttle down the intakes and the water exits the system through diversions. The system's design permits some overflow to escape under minimal rains so that CSOs actually occur during times when twice design capacity has not been reached. Modeling studies estimate that the city's 394 CSOs release about 140 mgd of untreated wastewater.

During CARP, CSOs were assessed indirectly by taking samples at the influent to wastewater treatment plants during wet weather. Sampling persisted over the time that influent flows exceeded the plant's design capacity. Water at inlets is a mixture of the entire system and it avoids the parochialism of a particular sampling point. Furthermore, access to the wastewater treatment plant is simpler than to actual CSOs. Simpler is not necessarily simple. Wastewater treatment plants recycle water from various operations back into the influent often at a place upstream of the most convenient sampling point.

We do not want to sample these mixed streams. Also, some plants receive water in more than a single trunk. These were sampled separately. The amount of water required (about 100 L) and the length of time over which samples were collected (4 hours) limited the field crew to a single sample per storm event.

Landfills

About 20% of the surface area of New York City is landfill. Much of the 46,000 acres of landfill were created to hold ash generated in heating and cooking. Only a small proportion, some 2000 acres, are modern landfill. These acres are in the Bronx (Pelham Bay, 100 acres), Brooklyn (Pennsylvania Ave., 100 acres; Fountain Ave., 300 acres; Edgemere, 120 acres), and Staten Island (Fresh Kill, 1200 acres, and Brookfield, 180 acres). Assuming a yearly rainfall of 1.1 meters and infiltration rate (proportion of rainfall that becomes part of the groundwater) [2], the estimated leachate production is 2.6 mgd. Furthermore, an appreciable amount, perhaps 1 mgd of this total, is treated, at Fresh Kills Leachate Treatment Plant for the Fresh Kills and at Hunts Point WPCF for Pelham Bay Landfill. Experience at the Fresh Kill Landfill Treatment Plant suggests that this estimate may be high but the discharge may suffice for modeling.[3]

Some of the leachate from the New Jersey Meadowlands Commission sites is treated at the Passaic Valley Sewerage Commissioners (PVSC) WPCF in Newark, NJ but some leachate flows directly into the Passaic River. Assuming a similar size of landfills in New Jersey, a rough estimate of 4.2 mgd of untreated leachate may be entering the harbor area surface waters from both states.

Leachate is colored, high pH, and strong smelling. It is the product of the breakdown of mounded garbage flushed out by ground water or rainwater. Toxic chemicals, particularly metals, occur in leachates. Illegally dumped waste oils and other substances also have gotten into either the wastestream or have been directly placed in landfills.

Leachate was taken from two New York City facilities, Pelham Bay in the Bronx and Fresh Kills in Staten Island. Pelham Bay has a leachate collection system that delivers leachate to the Hunts Point WPCF. Our samples came from holding tanks at Pelham Bay. The Fresh Kills site consists of numbered mounds. Leachate from the mounds is gathered by a system of trenches and pumps. Most of the leachate production comes from mounds 1 and 9. Mounds 6 and 7 are also important producers. As they enter the Fresh Kills treatment plant they are combined into 1/9 and 6/7. There are several sampling points around the mounds, a few of which have been sampled in CARP. These include 1/9 B and 1/9 F. Three mounds, 1A, 1D, and 1E, were sampled in New Jersey at the New Jersey Meadowlands Commission (formerly called the Hackensack Meadowlands Development Commission).

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[2] Walsh, D.C., 1996. Geochemistry of solid waste landfills. Ph.D. Thesis submitted to Rensselaer Polytechic Institute, Troy, NY.

[3] Personal conversation, Philip Gleason, NYS Department of Sanitation, June 1, 2001.

SAMPLING HISTORY AND METHODS

Despite an enormous effort to monitor trace contaminants, Bob Thomann and Kevin Farley had virtually no data for their model. Why? In most places the concentrations of these chemicals are very low relative to the capabilities of conventional analytical methods. They are not, however, low relative to the risk-based water quality standards required for protection of human health. For example, the canonical technique for measuring PCBs (US EPA Method 608 – based on gas chromatography, electron capture detection, and pattern recognition of PCB congeners or domains characteristic of Monsanto's Aroclor mixtures) in wastewater has a method detection limit of 65 parts per trillion (ppt) but a practical detection level, taking variability and interferences into account, of often more than 300 ppt. The old New York ambient water quality standard for PCB (to protect humans eating wildlife) was 1 ppt. A three hundred-fold difference is a little larger than the difference between the speed of the space shuttle (17,500 mph) and New York's highway speed limit (65 mph). This situation is somewhat analogous to equipping speed cops with radar guns incapable to telling whether the space shuttle is moving or staying still. The current New York State (NYS) water quality standard for PCBs is three orders of magnitude lower (0.001 ppt or 1 part per quadrillion).

Persistent bioaccumulative chemicals like PCBs occur in all surface waters and in all wastewaters but the methods most often used are incapable of measuring toxicologically significant concentrations. Even when they are detected, sampling and laboratory errors introduce so much variability that the value of the data to modeling becomes suspect. This problem was compounded by the magnitude of the project. Sampling would be performed by many teams in two states using six different labs for organic chemical analysis and two for metals. The field methods themselves were novel and under development. The laboratory methods were also far from routine.

TOPS

One of the fundamental goals of the CARP is consistent detection of all target chemicals from all media. This has been a new idea. As noted before, the field and lab methods commonly used in regulatory programs are often incapable of detecting PCBs in surface or waste waters and always incapable of measuring dioxins and furans in water. This is caused by insufficient mass of analyte, interferences, and sometimes in the case of PCBs, unexpected patterns of congeners.

Taking these issues in reverse order, the occurrence of non-Aroclor congeners will not be seen by pattern-recognition where Aroclors are expected. The question of interferences becomes large in places where a lot is going on, like New York Harbor. Consider the task of weighing yourself. Step on a bathroom scale in the privacy of your bathroom and the reading you get from the instrument will only reflect your own weight. But if you set the scale up on a crowded sidewalk other people might be stepping on the scale at the same time you are trying to weigh yourself. Much of what the analytical chemist does with the sample is to reduce these interferences and techniques have gotten quite good – but still not perfect. And, investigation into interferences has played an important part in

environmental science. It was Søren Jensen's studies of interferences in DDT analysis that initially revealed the wide-spread existence of PCB in 1963. Later researchers saw unexplained chromatographic peaks while looking for PCBs and discovered the flame retardant and insecticide Mirex. Interfering chemicals may be mistaken for the target chemical or they may be recognized and eliminated but in the clean-up process, target analyte is also lost. More commonly, interferences increase the signal noise and consequently result in degradation of the signal.

The bathroom scale analogy is relevant to the question of accuracy. Consistent data produced by a single system are useful for making decisions even if not highly accurate. However, data collected by multiple systems are useful only if they be related back to a standard. The difficulty in doing this increases with the complexity of the data collection system. There are differences in extraction efficiencies between different environmental matrices (sewage versus landfill leachate versus surface water), between sampling systems (TOPS, PISCES, grab samples), between labs, between sets of field personnel, and so on.

The analyte mass issue can also be analogized by trying to weigh something that's very small, say a feather on our bathroom scale. The scale is too insensitive to register such a light object. However, if we collected enough feathers, we would be able to use the scale to measure them. But then, we'd need to be able to put the resulting mass into the correct units. Perhaps we might count the feathers and divide the total mass by the count to get a mean mass per feather. Similarly, in doing trace organics sampling, processing large water volumes can result in significantly lower detection limits – and we have to be able to measure accurately the volumes of water processed.

When I started working for DEC in 1979 we sampled for PCBs by collecting water into a quart Mason jar. Since the early 1980s researchers in Canada and the United States have been experimenting with ways to field concentrate larger and larger volumes. Early work on the Niagara River, by Peter Goulden and others at Environment Canada's Canada Centre for Inland Waters in Burlington, Ontario, resulted in a series of devices to mix sample water with the solvent dichloromethane chloride (DCM) and then to remove the DCM for analysis. The result of their work was a complicated piece of glassware called the Large Sample Extractor and, after Peter's unexpected death, renamed the Goulden Large Sample Extractor or GLSE. The GLSE is used by Environment Canada on the Niagara River and elsewhere, and the USEPA has operated it on board their Great Lakes Research Vessel *Lake Guardian*. To use the GLSE water is first clarified by filtration or by centrifugation. Particles collected on the filter or from the centrifuge can be sent to a lab for extraction and analysis. Some of the clarified water is fed into the GLSE where its heated and then stirred up in a mixing vessel with DCM. The rest of the GLSE separates the DCM from the water. The water is wasted and the DCM is recirculated back to the mixing vessel. Since DCM dissolves rather well into warm water, a separate pump makes up for the DCM losses. Dissolved PCBs are captured by the bulk phase DCM so the DCM that is lost through dissolving into the water does not carry with it much of the PCB. The retained DCM then contains the dissolved phase of the PCB.

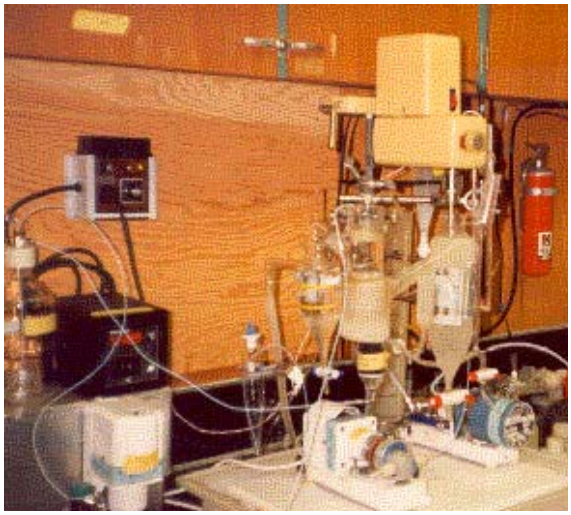

Figure 2. Goulden Large Sample Extractor set up in Environment Canada's monitoring station in Fort, Erie, Ontario.

In 1992 over a 32 hour period, we tested duplicate GLSEs, one set up, with the assistance of Dave DeVault then at EPA, on a bridge over the Oswego River in upstate New York at Minetto and another set up on the *Lake Guardian* moored a few miles away in the City of Oswego. Both processed Oswego River water collected at the same time through the same plumbing.

At the same time we were performing that experiment, Tony Ethier of Seastar, a Canadian oceanographic equipment manufacturer in Sidney, British Columbia, had set up a commercial sampling device called Infiltrex also from the Minetto Bridge. Tony sat in his car reading a book while I was rushing around tending to the GLSE.

The results of the experiment on the Oswego River Bridge showed that minute differences in glassware or operation produced order of magnitude differences between samples processed on the bridge and on the ship. This finding dashed the hope that we could have sufficiently sensitive and comparable field technique deployed in open lake waters from the *Guardian* and also from truck mounted sampling on the tributaries.
A few years later, in 1995, the EPA gave NYSDEC a grant to determine if dioxins, PCBs, and chlorinated pesticides occurred in final effluents from sewage treatment plants discharging to Lake Ontario. EPA suggested that we consider using a device that captures a "cubic meter" of water. This device turned out to be the same one that Tony Either had deployed on the Minetto Bridge.

Infiltrex is a self-contained submersible unit powered by a stack of lantern batteries. It pumps water through a glass fiber filter and then through a Teflon ® column holding a synthetic resin called XAD-2. After a set volume, or time, or if the filter is plugged, Infiltrex shuts off. The filter and the XAD are extracted and the extract may be analyzed. While the GLSE processed 50 to 100 L, Infiltrex dealt with 200 to 300 L of water. EPA was suggesting that we process 1000 L. After speaking with a number of Infiltrex users we decided to build our own version using AC power and many of the pumps left over from the ill-fated GLSE experiment. Infiltrex could be used with either a flat Whatman GFF grade glass fiber filter (0.7 micron nominal porosity) or a 4-inch wound glass cartridge filter (1.0 micron nominal porosity). We selected the cartridge filter as it had a

much greater capacity than the flat filter and would make the unit less likely to suffer plugging and then to pre-maturely shut-down. Everything needs a name and one of our engineers, Cynthia Leece, suggested calling it "TOPS" for Trace Organics Platform Sampler.

TOPS was designed with our GLSE experience in mind. It was, unlike GLSE, entirely self-contained so no part of the sample was exposed to the air. There had been problems with GLSE picking up PCBs from the air. TOPS was also intended to be physically rugged in contrast to all the breakable glassware in GLSE. Unlike Infiltrex, TOPS was capable of filtering more water than it passed through the XAD. Most synthetic chemicals of interest are poorly soluble in water and tend to adhere to suspended particles. We had seen in the Niagara many cases where we were detecting substances only from the particulate phase. TOPS was intended to filter very large volumes of water, particularly in low turbidity situations. And finally, TOPS was to be very easy to run in the field. The last wish was achieved initially but has been has steadily receding.

Using TOPS in 1996, we were able to determine the presence of the target analytes in all the treatment plant effluents. In 1997, we used TOPS to investigate dioxin and PCB levels in tributaries to Lake Ontario. In the later summer I brought it to Burlington, Ontario where Melanie Nielson and her staff and colleagues at the Canada Centre for Inland Waters criticized the design. We followed up on the many excellent suggestions and were able to re-engineer a better instrument. An improved TOPS permitted measuring open lake PCBs from the *Lake Guardian* in October of 1997 during a four day cruise.

For that work we had to figure out a way to get water from the lake while the ship was in motion. Ships are dirty and clean sampling requires avoiding smoke and ship-generated effluents. The ship's crew and captain, David Moser, helped rig a 45 pound bomb-shaped device, called "DL-76" (made to be lowered from a bridge into a flowing river to collect a sample of water for measuring suspended sediments) from an A-frame on the starboard rear. On contact with the flowing stream the DL-76 swings around to point into the current. NYSDEC Engineering Technician John Donlon attached a TOPS intake to the top surface of the DL-76. A test run out of the Port of Rochester showed the set up to be stable up to about 5 knots but at higher speeds the tow-fish had a tendency to dolphin, particularly in choppy water.

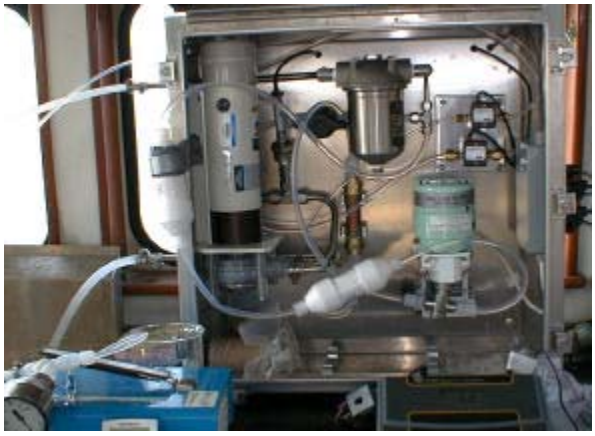

Figure 3. TOPS on the EPA' s New York Harbor Survey Vessel *Clean Waters*. The "U" shaped device near the top holds a cartridge filter and the two white double-ended cartridges hold XAD. The two small boxes in the upper right side are flow meters.

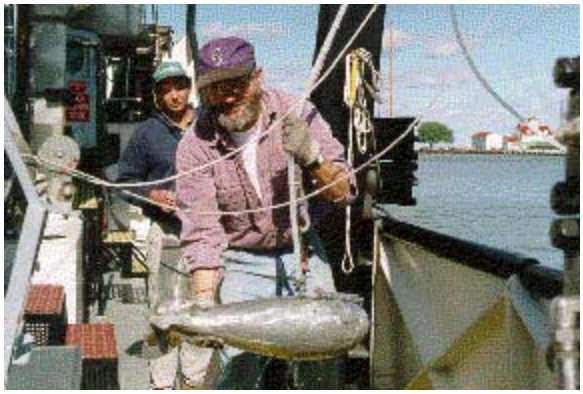

Figure 4. The DL-76 tow fish on board the R/V *Lake Guardian* moored at the mouth of the Genessee River, Rochester, New York.

As CARP was getting going in 1997 and 1998 we were gaining experience in obtaining very large volume samples from ships and at wastewater treatment plants. We knew we could detect all the target analytes. XAD was still new to us and somewhat mysterious. We knew that it was being used in large lake studies in Green Bay, Wisconsin and in the Lake Michigan Mass Balance Study. It had had some 20 years of use in the environmental field and we had seen that it appeared to behave similarly to the GLSE set up on the Niagara River. While initially we didn't have a way to evaluate it, we believed that if we followed the literature and used the same procedure everywhere, we would have a consistent data set.

Over the next few years we followed suggestions from Brian Fowler, at the Axys Group in British Columbia, to add more and more quality control tests. These were:

1) to set XAD columns in series and to analyze each individually as a way to measure break-through,
2) to spot the columns with chemical surrogates to test for wash-out and recovery,
3) to pump water through the XAD at different rates (pump speeds), and finally
4) to meter into the water stream chemical surrogates that would mimic trapping dissolved chemicals by the XAD.

The last, at least for the analytes most similar to the surrogates, is a more realistic test of XAD trapping efficiency, but one not without flaws. Naturally occurring macro-

molecules like humic and fulvic acids appear to bind synthetic hydrophobic chemicals and reduce their availability for extraction by hexane. Research by Mark Driscoll at the SUNY Environmental and Forestry College in Syracuse, New York, suggests that the length of time needed for PCBs to reach a binding equilibrium with these dissolved materials is days or even weeks. This effect is not being captured in the metered surrogate delivery used with TOPS. Dr. Driscoll had some success with simultaneous hot chromic acid digestion and extraction for PCBs but this harsh treatment would have destroyed some target pesticides.

The specific details of operating the TOPS during CARP are set out in an attached document, TOPS- Standard Operating Procedure. Dr. Gary Wall of the USGS devised some critical modifications for long duration TOPS operation in streams with very high suspended sediment concentrations. These are discussed in an attached paper, Use of a Large Volume Sampler in River Settings.

Many samples were taken during the course of CARP to help evaluate the efficiency of both XAD and the filter. At the outset of CARP a large sediment sample was taken, thoroughly mixed, subdivided, frozen, and periodically sent in for analysis to help understand inter and intralab variability. Results of these studies are reported and discussed in an appended paper (The Performance of An XAD/ One-Micron Cartridge Filter Trace Organic Platform Sampling System (TOPS)**.**

PISCES

In the mid-1980's we were looking for a cheap way to capture PCBs. The only really useable tools then available were to collect natural concentrators like sediments or biota. Those media were spotty and inconsistent. In many instances, a sample collection could be very time consuming. John Hassett at the State University of New York College of Environmental Science and Forestry in Syracuse, New York, had been thinking about passive samplers as surrogates for fish. Passive samplers use a membrane separating water from a solvent. PCBs, as well as pesticides and some PAHs (in theory dioxins and furans too) will migrate through a solvent saturated membrane and become trapped in a non-polar medium. The rate of movement is a function of the analyte/solvent interaction, the porosity of the membrane, and temperature. Dr. Hassett was working on a passive sampler that used hexane as the solvent and one mil polyethylene as the membrane. He called it PISCES for **P**assive **I**n-**S**itu **C**hemical **E**xtraction **S**ampler.

In 1988 we had success in identifying a PCB source to the Black River at Carthage, New York using PISCES and, in 1992, we found a PCB source to the Arthur Kill in New York Harbor with the device. The NYSDEC Fish and Wildlife program uses them as well as the USGS in Massachusetts, the New Jersey Harbor Dischargers Group at Linden Roselle, and a private contractor working on Alaska's North Slope uses PISCES to locate PCBs on the Colville River.

Different teams use slightly different versions of the same idea. Basically, PISCES consists of a container holding about 200 mL of hexane. We use a schedule 80 4-inch

brass nipple sealed at the top with a Teflon ® disk and at the bottom with the polyethylene. I place them in rivers, streams, or sewers with the membrane side down and leave them in the water for about two weeks. Derivation of a sampling rate requires knowing the water temperature. By knowing the rate, membrane area, and time of exposure, we can roughly estimate the volume of water sampled through the use of an empirically derived equation that John determined. PISCES are cheap (our model costs about $20 each) enough to permit placement in risky locations where losses are possible and rugged enough to withstand severe buffeting in storm charged sewers or streams.

Figure 5. Preparing PISCES in the field. PISCES are usually deployed in pairs in case one fails. The bottles in the truck hold hexane.

Data Management

The data produced by CARP are voluminous. Battelle Ocean Sciences of Duxbury, MA, maintains an official data base.

SAMPLES

Sampling for organic chemicals was accomplished using TOPS. The sampling routine was similar everywhere but not identical. For sampling the three minor tributaries and the 20 ambient stations, a 100 mesh Nytex plankton net was used to strain out larger zooplankton. In some cases, the plankton net removed a considerable amount of material. This required deploying a submersible pump and use of a stainless steel can as a receptacle for the strained water.

Landfill samples were taken from leachate collection systems. The purpose of the sampling was to obtain a quality estimate for leachate escaping the various treatment systems. Since the escaped leachate was entering the surface waters through diffusion, there was no way to estimate the particle bound phase of the transport. Therefore, only glass fiber filtered water was processed in CARP. There is no reason to collect POC or TSS data from leachate samples.

Two of the three major tributary monitoring stations (Hudson and Mohawk) were essentially identical. Water from a submerged intake ran into a shed holding a TOPS and ISCO samplers for the metals, whole water PAHs, and DOC/POC, and suspended sediment samples. The set up on the Wallkill was a little different. Very high event related suspended sediment concentrations resulted in the rapid plugging of the glass fiber filters. To overcome this problem, Dr. Gary Wall of the US Geological Survey (USGS) devised a settling tank made from a modified stainless steel milk can. The can was on an electronic scale. As the can filled and as it's weight increased, a datalogger triggered the TOPS to pull partially clarified water from the can. At the end of the event, the heavy material that settled out in the can was scraped out and incorporated with the filter as the particulate sample.

The success of sampling the tributaries can be seen in graphs displaying the hydrograph of the study period and the hydrograph of the period sampled.

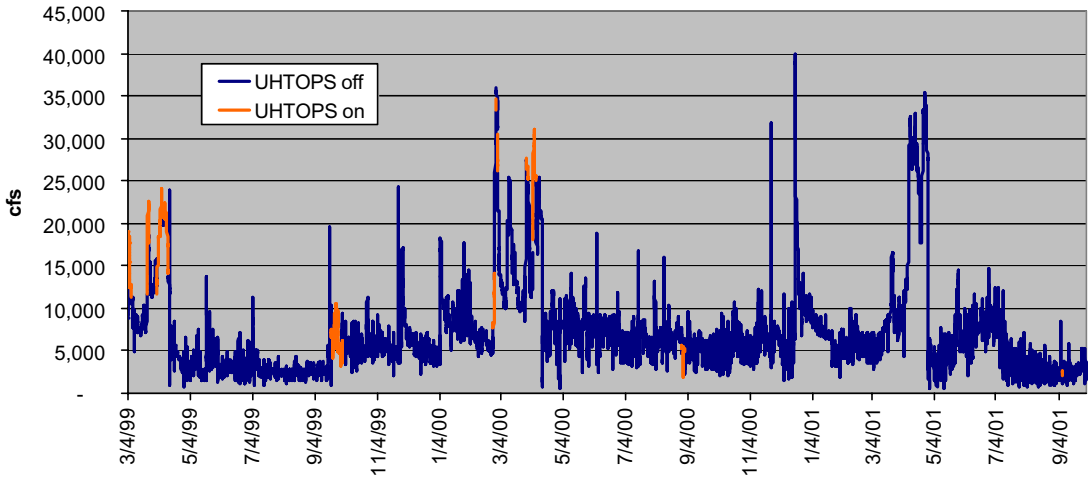

Figure 6. Over the period of study, TOPS was pumping while 7% of the Hudson's flow was passing.

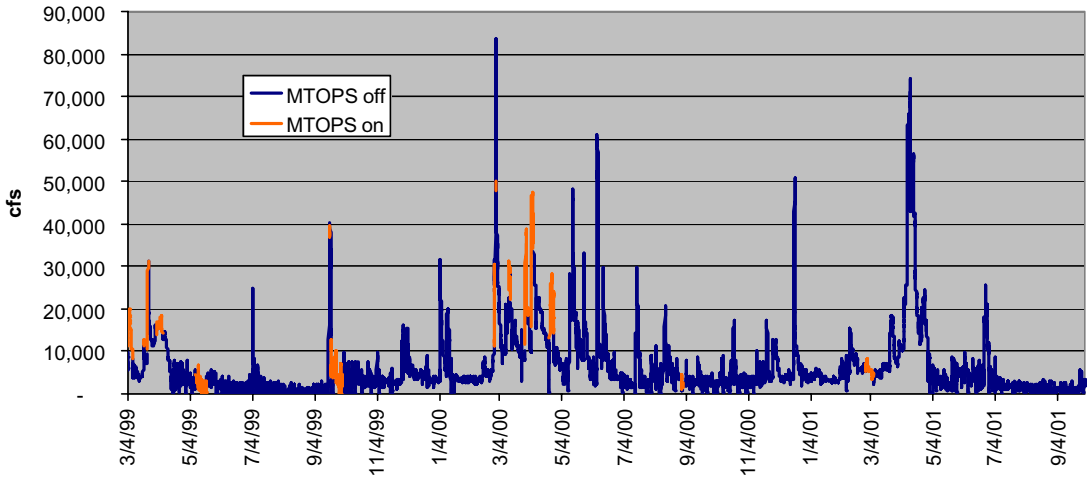

Figure 7. Over the study period, TOPS was pumping while 11% of the Mohawk's flow passed.

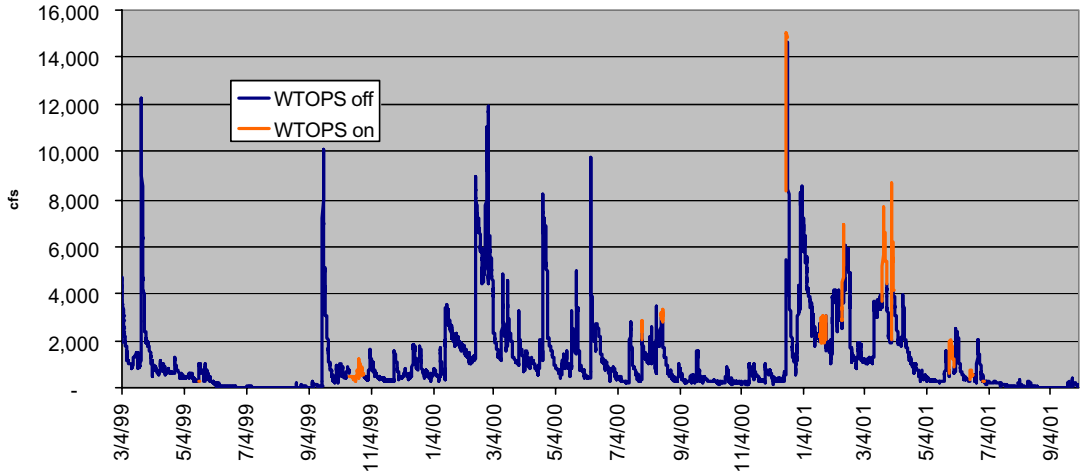

Figure 8. During the period of record, TOPS was pumping while 10% of the Wallkill flow was passing.

Most of the samples taken under CARP were done so through the use of conventionally set up TOPS and allowed the sample volume, the number of liters passed through the filter or the XAD columns, to be adjusted in the field. The average volumes of water (in L) processed using conventional TOPS are shown below:

Table 5. Average volume of water passed through TOPS media, by sample type.

Sample Type	XAD	GLASS FIBER CARTRIDGE
AMB-clean	680	3100
AMB-Hudson	210	890
AMB-Kills	170	760
AMB-Non Kills	190	720
Industrial effluents	190	1000
Landfill leachate	90	
Major Tribs	260	850
Minor Tribs	190	740
WPCF	140	380

Figure 9. TOPS running on the Passaic River. Notice the stainless steel can on the left where large zooplankton are removed by filteration. A syringe pump delivering metered surrogates is seen on the table to the right of the TOPS. The plastic carboys on the deck collected water during timed intervals as an independent check of pumping rates. Note the lack of simplicity.

We had wanted to use metered surrogates at an early date in the project but experienced a variety of problems executing it. The "gas-tight" glass syringes turned out to be temperature sensitive and the fittings leaked. These problems were eventually solved by the decision to move the process into the lab. The lab-based set-up was called "TOPS-Next Generation". Beginning in February of 2001, 35 samples were processed using TOPS-Next Generation. This modification was made to permit much slower XAD processing rates (from about 600 mL/min to about 16 mL/min) and it allowed for much better control of the metered surrogates. The disadvantage of the process was that it limited the total sample size to a little less than 100 L and there were more opportunities for sample contamination.

Cosine Tide

The average duration of sampling in tidal ambient sites (in areas other than Long Island Sound and the New York Bight) was 5.6 hours. This is a portion of a tidal cycle and results may be affected by the direction of the tide. To obtain a quantitative value expressing the tides over the duration of sampling we considered the tide to be a sine wave where each point of the tidal cycle can be mapped as an angle. If we take the cosine of the wave, high tide has a cosine of 1 (cos 0 = 1), low tide has an angle of 180 (cos 180 = -1), and points half way between (90 and 270 degrees) have cosines of 0. The

difference between the end of the run and the beginning can have a maximum value of 2 if sampling starts at high tide and ends at low tide; a value of –2 if it starts at low tide and ends at high tide, and 0 if it starts at the mid-ebb and ends at the mid-flood.

High and low tides were obtained from NOAA gauges at the Battery, the Narrows, Kill van Kull, and Kings Point on the eastern end of the East River.

Ambient Sampling Stations

Twenty ambient sampling stations are shown in Figure 10. There were two Long Island Sound sites (LISE and LISJ), and two New York Bight stations.

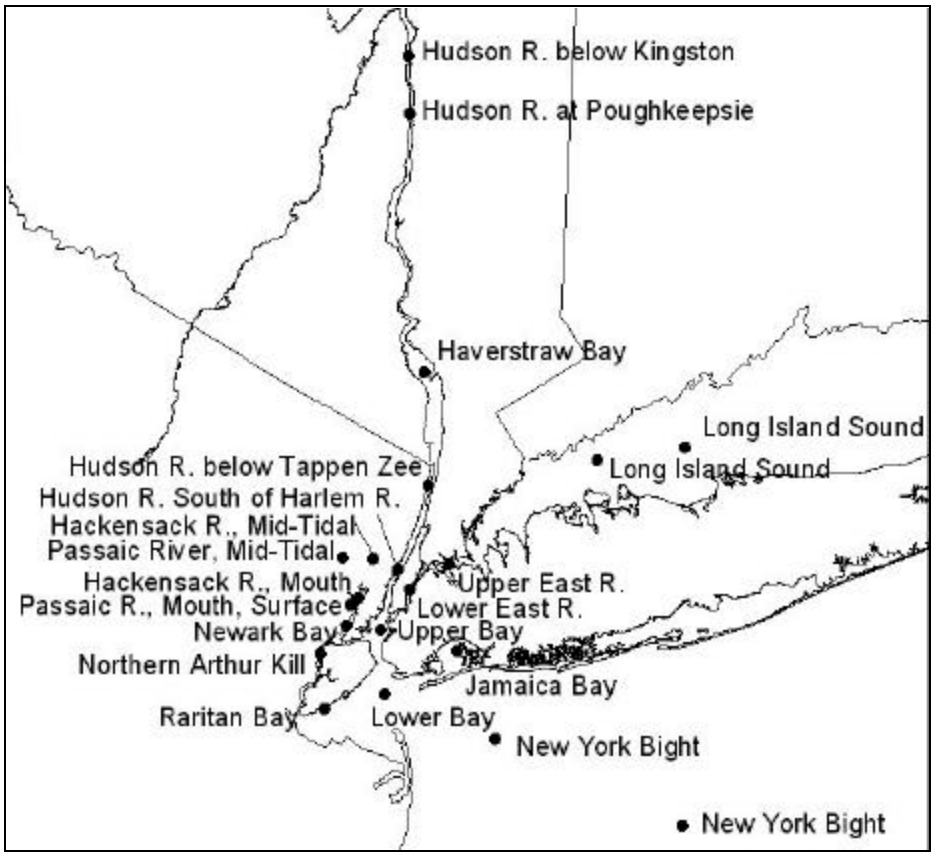

Figure 10. Centroids of ambient sampling stations.

Table 6 shows the ambient samples, the date sampling began, cosine tide, and mean sample values for DOC, POC, and SS. Some of the samples were performed over more than one tidal cycle and hence, no cosine tide value was calculated.

Table. 6. Ambient samples.

Site type and name	Date	Cosine tide	DOC, mg/L	POC, mg/L	SS, mg/L
Ambient-Non_Kills: Lower East R.	9/18/98	-0.41		1.23	5.33
Ambient-Non_Kills: Lower East R.	3/11/99	-1.52	3.79	1.18	19.00
Ambient-Non_Kills: Lower East R.	7/27/99	0.86	2.74	0.67	57.20
Ambient-Non_Kills: Lower East R.	6/2/00	1.78	3.35	0.37	18.60
Ambient-Hudson: Haverstraw Bay	11/24/98	-1.50	4.38	0.20	
Ambient-Hudson: Haverstraw Bay	2/10/99	-1.04	4.86	0.18	19.60
Ambient-Hudson: Haverstraw Bay	7/11/99	1.93	3.63	1.04	316.00
Ambient-Hudson: Haverstraw Bay	4/4/00			0.55	30.60
Ambient-Hudson: Hudson R. South of Harlem R.	12/17/98	0.47		0.33	10.60
Ambient-Hudson: Hudson R. South of Harlem R.	3/16/99	-1.11	4.29	0.97	47.50
Ambient-Hudson: Hudson R. South of Harlem R.	8/12/99	1.92	2.65	0.44	19.70
Ambient-Hudson: Hudson R. South of Harlem R.	12/14/99	1.88	3.88	0.42	11.88
Ambient-Hudson: Hudson R. South of Harlem R.	6/14/00	1.11	6.59	0.33	9.74
Ambient-Hudson: Hudson R. below Kingston	5/25/99	-1.64	3.53	0.27	
Ambient-Hudson: Hudson R. below Kingston	10/8/99		6.05	0.72	25.70
Ambient-Hudson: Hudson R. below Kingston	6/28/00		4.86	0.49	16.50
Ambient-Kills: Hackensack R., Mouth	11/12/98		6.97	0.62	5.90
Ambient-Kills: Hackensack R., Mouth	2/8/99	-1.67	5.81	0.39	3.20
Ambient-Kills: Hackensack R., Mouth	7/7/99	-1.88	5.48	0.46	24.40
Ambient-Kills: Hackensack R., Mouth	4/11/00	-1.98	9.28	2.09	12.70
Ambient-Kills: Hackensack R., Mid-Tidal	3/17/99	0.31	13.94	2.77	43.50
Ambient-Kills: Hackensack R., Mid-Tidal	9/2/99	-1.06	8.36	0.30	35.30
Ambient-Kills: Hackensack R., Mid-Tidal	10/12/99	-0.71	7.46	1.25	37.00
Ambient-Kills: Hackensack R., Mid-Tidal	11/2/99				
Ambient-Kills: Hackensack R., Mid-Tidal	5/10/00	-0.72	9.15	1.56	46.10
Ambient-Hudson: Hudson R. at Poughkeepsie	3/1/99		1.49	3.31	53.5
Ambient-Hudson: Hudson R. at Poughkeepsie	3/28/99		2.21	3.34	61.54
Ambient-Hudson: Hudson R. at Poughkeepsie	4/16/99		2.61	3.1	93.16
Ambient-Hudson: Hudson R. at Poughkeepsie	4/17/99		2.15	3.06	96.32
Ambient-Hudson: Hudson R. at Poughkeepsie	10/23/99		2.23	4.58	90.82
Ambient-Hudson: Hudson R. at Poughkeepsie	3/18/00		4.07	3.59	146.1
Ambient-Hudson: Hudson R. at Poughkeepsie	5/17/00		2.79	4.17	85.71
Ambient-Hudson: Hudson R. at Poughkeepsie	6/15/00		2.28	4.45	94.49
Ambient-Hudson: Hudson R. below Tappen Zee	12/1/98		10.52	0.64	
Ambient-Hudson: Hudson R. below Tappen Zee	2/19/99		4.73	0.61	38.20
Ambient-Hudson: Hudson R. below Tappen Zee	7/10/99	1.03	3.76	0.92	14.40
Ambient-Hudson: Hudson R. below Tappen Zee	4/4/00		10.70	0.58	41.10
Ambient-Non_Kills: Jamaica Bay	10/14/98	-1.98	2.45	0.65	7.50
Ambient-Non_Kills: Jamaica Bay	2/23/99	-1.80	3.71	1.07	19.90
Ambient-Non_Kills: Jamaica Bay	7/9/99	0.21	4.55	1.40	33.50
Ambient-Non_Kills: Jamaica Bay	5/4/00	1.23	5.03	0.96	6.09
Ambient-Non_Kills: Lower Bay	12/3/98	0.04	2.60	0.19	2.80
Ambient-Non_Kills: Lower Bay	3/2/99	1.45	4.26	2.00	22.40
Ambient-Non_Kills: Lower Bay	7/28/99	1.13	2.58	1.04	13.80

Table 6 continued.

Site type and name	Date	Cosine tide	DOC, mg/L	POC, mg/L	SS, mg/L
Ambient-Non_Kills: Lower Bay	6/1/00	0.43	3.54	1.09	
Ambient-clean: Long Island Sound	11/19/98		3.17	0.17	
Ambient-clean: Long Island Sound	3/2/99		2.74	0.13	5.27
Ambient-clean: Long Island Sound	5/27/99		2.46	0.23	
Ambient-clean: Long Island Sound	10/19/99		4.58		4.69
Ambient-Kills: Northern Arthur Kill	11/17/98	1.67	3.75	0.61	
Ambient-Kills: Northern Arthur Kill	2/17/99	1.56	18.18	0.67	4.9
Ambient-Kills: Northern Arthur Kill	7/8/99	-1.29		0.71	21.9
Ambient-Kills: Northern Arthur Kill	4/18/00	0	8.43	0.99	9.95
Ambient-Kills: Newark Bay	11/25/98	-1.07	3.52	0.28	
Ambient-Kills: Newark Bay	1/27/99	-1.94	4.89	0.5	3.8
Ambient-Kills: Newark Bay	8/11/99	1.52	3.36	0.46	44.2
Ambient-Kills: Newark Bay	12/15/99	-1.51	3.82	0.38	6.14
Ambient-Kills: Newark Bay	4/12/00	-1.22	6.04	0.75	11.3
Ambient-clean: New York Bight	12/9/98		1.5	0.11	
Ambient-clean: New York Bight	1/29/99		1.73	0.07	7.8
Ambient-clean: New York Bight	1/30/99		1.76		7.85
Ambient-clean: New York Bight	1/31/99		3.82	0.1	2.87
Ambient-clean: New York Bight	4/27/99			0.09	1.78
Ambient-clean: New York Bight	3/14/00		19.03	0.13	
Ambient-Kills: Passaic R. , Mouth, Bottom	2/5/99	-0.24	7.07	0.26	
Ambient-Kills: Passaic R., Mouth, Bottom	7/21/99	-1.25	4.4	1.64	30.1
Ambient-Kills: Passaic R., Mouth, Bottom	5/2/00	1.45	8.91	0.89	60.7
Ambient-Kills: Passaic R., Mouth, Bottom	6/26/00	-1.61	7.22	1.24	16.2
Ambient-Kills: Passaic R., Mouth, Surface	11/13/98	-1.81	6.07		4.8
Ambient-Kills: Passaic R., Mouth, Surface	2/3/99	1.7	7.61	0.15	5.92
Ambient-Kills: Passaic R., Mouth, Surface	6/17/99	0.07	4.54	0.08	23.9
Ambient-Kills: Passaic R., Mouth, Surface	6/27/00	-1.95	6.8	1.51	15.8
Ambient-Kills: Passaic River, Mid-Tidal	3/16/99	0.07	4.62	0.21	11.4
Ambient-Kills: Passaic River, Mid-Tidal	8/25/99	0.75	6.27	2.93	56.5
Ambient-Kills: Passaic River, Mid-Tidal	5/9/00	-1.78		1.49	10.3
Ambient-Kills: Passaic River, Mid-Tidal	10/18/00	-1.01	6.78	1.49	44.5
Ambient-Non_Kills: Raritan Bay	11/16/98	0.25	2.36	0.22	1.2
Ambient-Non_Kills: Raritan Bay	2/24/99	-1.83	3.15	1.35	10.9
Ambient-Non_Kills: Raritan Bay	7/12/99	1.85	4.04	0.64	10.3
Ambient-Non_Kills: Raritan Bay	5/3/00	1.78	3.56	1.56	10.3
Ambient-Non_Kills: Upper Bay	12/15/98	-1.19	8.87	0.29	3.7
Ambient-Non_Kills: Upper Bay	3/18/99	1.99	3.31	0.73	15.6
Ambient-Non_Kills: Upper Bay	8/11/99	1.1	2.97		13.3
Ambient-Non_Kills: Upper Bay	6/15/00		5.69	0.21	6.62

Table 6 continued.

Site type and name	Date	Cosine tide	DOC, mg/L	POC, mg/L	SS, mg/L
Ambient-Non_Kills: Upper East R.	36139	-0.97	3.31	0.21	
Ambient-Non_Kills: Upper East R.	36222	-1.05	6.1	0.94	24.9
Ambient-Non_Kills: Upper East R.	36382	0.63	2.58	0.18	2.58
Ambient-Non_Kills: Upper East R.	36592	-0.65	17.31	0.63	9.35

Tributaries

The locations of sampling points on the three major and three minor tributaries are shown on Figure 11. The site on the Mohawk at Cohoes was always in the same position. Changes were made in the TOPS intake locations on the Hudson at Pleasantdale and on the Wallkill at New Paltz. On the minor tributaries, the sampling locations on the Saw Mill River and the Gownus Canal remained constant but two stations were used on the Bronx River.

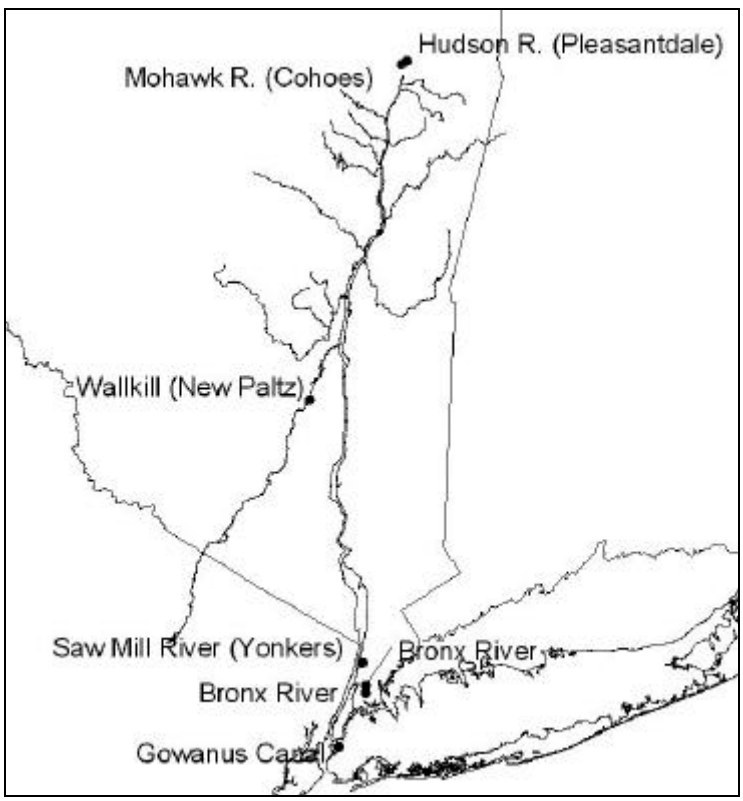

Figure 11. Locations of sampling points on major and minor tributaries.

Table 7 shows the samples taken from tributaries, their dates, discharges (in cubic feet per second), and average concentrations of POC, DOC, and suspended sediment.

Table 7. Major and minor tributary samples.

Sample	CFS	Date_Start	Date_End	POC mg/L	DOC mg/L	SS mg/L
Major tributary: Hudson R. (Pleasantdale)	18650	3/4/99	3/6/99			
Major tributary: Hudson R. (Pleasantdale)	18603	3/22/99	3/23/99	2.07	3.65	95.82
Major tributary: Hudson R. (Pleasantdale)	18887	4/1/99	4/7/99	1.23	3.22	18.04
Major tributary: Hudson R. (Pleasantdale)	18953	4/8/99	4/12/99	0.79	3.45	9.16
Major tributary: Hudson R. (Pleasantdale)	6467	9/20/99	9/30/99	0.47	4.59	10.63
Major tributary: Hudson R. (Pleasantdale)	13136	2/25/00	2/27/00	2.09	4.58	75.33
Major tributary: Hudson R. (Pleasantdale)	33634	2/28/00	2/28/00	5.77	4.05	293.46
Major tributary: Hudson R. (Pleasantdale)	28555	2/29/00	3/1/00	2.97	3.91	85.95
Major tributary: Hudson R. (Pleasantdale)	26562	3/29/00	3/30/00	3.30	3.39	53.61
Major tributary: Hudson R. (Pleasantdale)	27725	4/4/00	4/7/00	2.86	3.94	92.71
Major tributary: Hudson R. (Pleasantdale)	4967	8/29/00	8/31/00	0.29	4.89	2.36
Major tributary: Hudson R. (Pleasantdale)	2040	9/7/01	9/7/01			
Major tributary: Mohawk R. (Cohoes)	17040	3/4/99	3/23/99	1.94	3.64	1.94
Major tributary: Mohawk R. (Cohoes)	16515	4/1/99	4/7/99	1.05	2.97	23.15
Major tributary: Mohawk R. (Cohoes)	2339	5/10/99	5/20/99	0.43	3.67	8.56
Major tributary: Mohawk R. (Cohoes)	37790	9/17/99	9/17/99	5.05	3.92	158.49
Major tributary: Mohawk R. (Cohoes)	18396	2/26/00	2/27/00	2.86	3.52	92.66
Major tributary: Mohawk R. (Cohoes)	48240	2/28/00	2/28/00	10.76	3.84	478.05
Major tributary: Mohawk R. (Cohoes)	23650	3/12/00	3/13/00	2.81	4.27	130.54
Major tributary: Mohawk R. (Cohoes)	25950	3/28/00	3/31/00	3.75	3.80	143.93
Major tributary: Mohawk R. (Cohoes)	38240	4/4/00	4/5/00	4.78	3.92	194.46
Major tributary: Mohawk R. (Cohoes)	19790	4/21/00	4/26/00	1.12	4.13	33.05
Major tributary: Mohawk R. (Cohoes)	2600	8/29/00	8/31/00	0.46	4.54	5.09
Major tributary: Mohawk R. (Cohoes)	6060	2/26/01	3/5/01			
Major tributary: Wallkill (New Paltz)	279	5/17/99	5/18/99	0.70	5.90	10.00
Major tributary: Wallkill (New Paltz)	1350	9/17/99	9/19/99			
Major tributary: Wallkill (New Paltz)	608	10/13/99	10/27/99	0.70	7.40	9.00
Major tributary: Wallkill (New Paltz)	6346	2/15/00	2/16/00			
Major tributary: Wallkill (New Paltz)	2150	2/25/00	2/26/00			
Major tributary: Wallkill (New Paltz)	2551	7/27/00	7/28/00	2.20	6.80	108.00
Major tributary: Wallkill (New Paltz)	3202	8/15/00	8/17/00	7.40	9.30	114.00
Major tributary: Wallkill (New Paltz)	12134	12/17/00	12/18/00	19.70	4.50	580.00
Major tributary: Wallkill (New Paltz)	589	1/19/01	1/23/01	1.33	3.87	3.20
Major tributary: Wallkill (New Paltz)	1463	2/10/01	2/12/01	2.56	4.52	34.42
Major tributary: Wallkill (New Paltz)	6270	3/21/01	3/25/01	5.90	4.90	87.00
Major tributary: Wallkill (New Paltz)	6137	3/30/01	4/2/01	6.40	4.90	101.00
Major tributary: Wallkill (New Paltz)	1474	5/26/01	6/1/01	4.80	8.20	72.00
Major tributary: Wallkill (New Paltz)	589	6/17/01	6/19/01	1.30	5.30	39.00
Major tributary: Wallkill (New Paltz)	344	6/29/01	6/30/01	2.20	9.00	61.00
Minor tributary: Bronx River	16	10/29/98	10/29/98	0.23	7.09	3.60
Minor tributary: Bronx River	221	3/8/99	3/8/99	0.05	7.63	5.62
Minor tributary: Bronx River	6	7/27/99	7/27/99	0.76		4.83
Minor tributary: Bronx River	8	10/26/99	10/26/99	0.34	4.95	3.22
Minor tributary: Gowanus Canal		3/17/99	3/17/99	1.26	3.98	25.60
Minor tributary: Gowanus Canal		8/24/99	8/24/99	0.41		17.60

Table 7 continued.

Sample	CFS	Date_Start	Date_End	POC mg/L	DOC mg/L	SS mg/L
Minor tributary: Gowanus Canal		3/21/00	3/21/00	1.32	6.47	6.07
Minor tributary: Gowanus Canal		9/28/00	9/28/00	0.29	2.97	4.83
Minor tributary: Saw Mill River (Yonkers)	125	11/10/98	11/10/98	0.61	11.28	21.7
Minor tributary: Saw Mill River (Yonkers)	76	3/10/99	3/10/99	0.27	13.25	1.76
Minor tributary: Saw Mill River (Yonkers)	24	5/5/99	5/5/99	1.09	8.68	5
Minor tributary: Saw Mill River (Yonkers)	2	8/20/99	8/20/99	0.53		2.13

Water Pollution Control Facilities (WPCFs).

The locations of the upstate WPCFs sampled by CARP are shown in Figure 12.

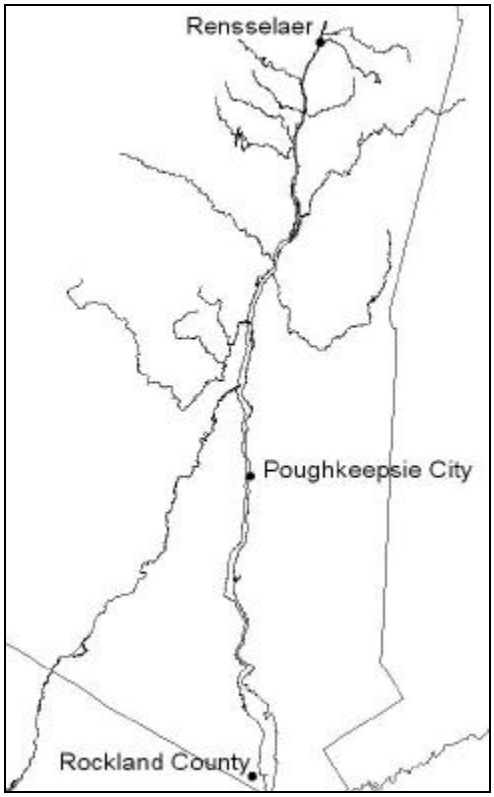

Figure 12. Upstate WPCFs samples by CARP.

Figure 13 shows the locations of New York City area WPCFs. All NYCDEP plants were sampled by CARP.

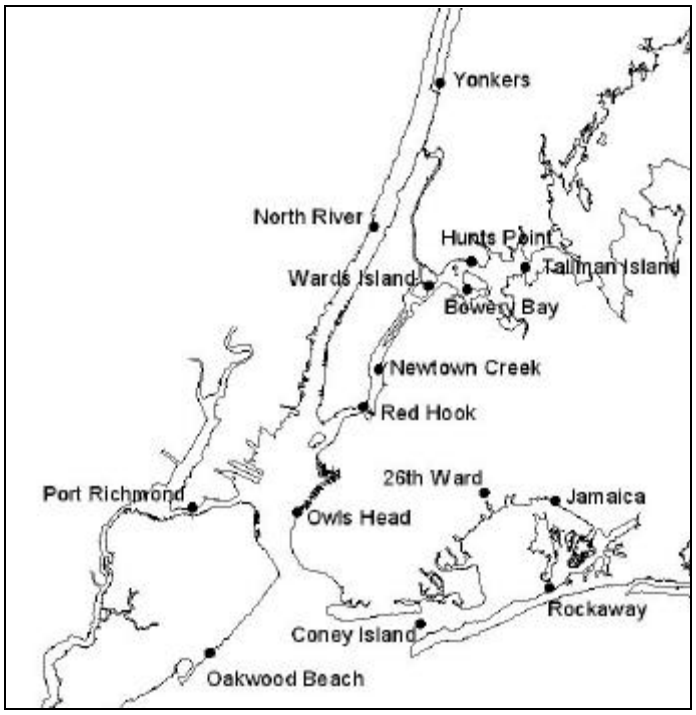

Figure 13. Locations of Yonkers and NYCDEP WPCF discharge points.

Table 8 shows summary sample data from the WPCF (sewage treatment plant) samples. WPCF discharges are conventionally shown in mgd.

Table 8. WPCF samples.

WPCF	Date Start	MGD	POC mg/L	DOC mg/L	SS mg/L
26th Ward	1/27/99	53	2.39	10.41	12.8
26th Ward	5/5/99	60	2.4	8.97	8.38
26th Ward	9/20/00	83	0.61	7.06	4.95
26th Ward	6/11/01	64			
26th Ward	6/18/01	68			
Bowery Bay	11/5/98	101	0.59	9.88	4.35
Bowery Bay	4/21/99	138	5.14	10.8	17
Bowery Bay	9/22/99	103	0	7.44	2.98
Coney Island	3/17/99	105	2.99	8.81	10.3
Coney Island	7/28/99	103	0.76	7.89	2.7
Coney Island	10/4/00	87	0.98	7.7	3.84
Edgewater	5/21/01	3			
Hunts Point	4/18/01	125			
Hunts Point	2/19/99	149	3.41	9.05	5.85
Hunts Point	4/30/99	133	0.35	9.66	48.1
Hunts Point	2/1/01	142	0.68		10.2
Hunts Point	3/19/01	120			
Hunts Point	3/28/01	181			
Hunts Point	4/11/01	146			

Table 8 continued.

WPCF	Date Start	MGD	POC mg/L	DOC mg/L	SS mg/L
Jamaica	2/5/99	84	6.68	10.58	14.5
Jamaica	6/30/99	90	1.62		6.7
Jamaica	2/15/01	88	0.7		11.6
Newtown Creek	4/8/01	248			
Newtown Creek	4/30/01	240			
Newtown Creek	5/21/01	416			
Newtown Creek	3/11/99	257	2.69	20.54	44.4
Newtown Creek	6/22/99	260		28.27	33.5
Newtown Creek	9/28/99	275	10.37	24.57	25.8
Newtown Creek	1/5/00	249	13.1		
Newtown Creek	1/5/00	249	13.1		
Newtown Creek	3/28/01	335			
North River	3/24/99	153	1.56	11.62	4.08
North River	9/1/99	167	1.28	9.91	4.28
North River	1/25/01	152	0.32		7.67
Oakwood Beach	2/11/99	25	0.97	10.99	6.33
Oakwood Beach	8/18/99	25	1.2	9.37	2.28
Oakwood Beach	10/13/99	36		9.27	3.98
Owls Head	9/15/98	113	4.88		26.7
Owls Head	7/7/99	119	1.44		7.01
Owls Head	8/23/00	115	1.88	8.98	6.41
Port Richmond	2/24/99	31	6.52	19.1	15.6
Port Richmond	8/25/99	35	1.38	13.04	2.58
Port Richmond	10/20/99	78	4.13	17.67	10.4
Port Richmond	4/11/01	49			
Port Richmond	4/30/01	29			
Poughkeepsie City	4/1/99	7	5.51	11.17	15.1
Poughkeepsie City	8/19/99	5	38.63	28.97	85.7
Poughkeepsie City	12/5/00	4	3.54		9.44
PVSC	5/22/01	318			
Red Hook	2/3/99	40	2.43	837.12	7.04
Red Hook	4/14/99	30	1.92	12.64	7.71
Rensselaer	1/12/99	16	4.43	25.48	15.6
Rensselaer	3/30/99	23	0.91	19.44	6.63
Rensselaer	8/11/99	14	1.71		6.04
Rockaway	4/1/99	21	0.33	8.17	3.59
Rockaway	8/11/99	22		9.03	18.3
Rockaway	11/3/99	19	0.45	7.28	6.38
Rockland County	4/20/99	20	3.02	16.18	16.6
Rockland County	8/19/99	17	1.37	18.61	2.94
Rockland County	3/8/00	22	8.94	29.21	

Table 8 continued.

WPCF	Date Start	MGD	POC mg/L	DOC mg/L	SS mg/L
Tallman Island	2/12/99	56	2.32		
Tallman Island	7/20/99	59	0.89	8.66	4.1
Tallman Island	9/6/00	41	1.2	8.3	3.73
Wards Island	1/20/99	221	1.57	7.81	4.83
Wards Island	4/28/99	179	0.09	7.33	2.48
Wards Island	8/10/00	220	0.88	5.73	2.51
Yonkers	4/22/99	89	1.73	10.3	6.8
Yonkers	8/18/99	85	1.16	10.62	13.5
Yonkers	3/22/00	95	10.12	19.15	26.4

Industrial Effluents and Landfill Leachates

Figure 14 shows the locations of industrial effluents and leachates sampled by CARP.

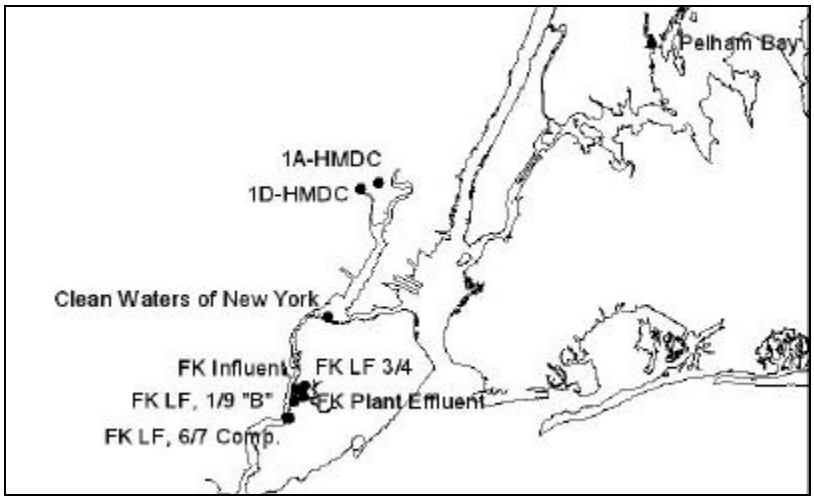

Figure 14. Locations of industrial effluents and landfill leachates sampled by CARP.

Table 9 lists the samples taken for Industrial effluents and Landfill leachates. Names, dates, DOC, POC, and TSS are also given.

Table 9. Industrial effluent and landfill leachate samples.

Sample	Date	DOC mg/L	POC mg/L	SS mg/L
Industrial effluent: Clean Waters of New York	4/29/99	6.02	0.19	
Industrial effluent: Clean Waters of New York	9/20/99	6.79	0.25	24.9
Industrial effluent: FK Plant Effluent	10/25/00	176		4.63
Industrial effluent: FK Plant Effluent	3/20/01			
Industrial effluent: FK Plant Effluent	4/19/01		0.31	30.7
Industrial effluent: FK Plant Effluent	7/25/01		0.45	8.49
Landfill leachate: 1A-HMDC	6/22/00			
Landfill leachate: 1D-HMDC	6/22/00	235		
Landfill leachate: 1D-HMDC	9/14/01			
Landfill leachate: 1E-HMDC	6/22/00	430		
Landfill leachate: 1E-HMDC	9/14/01			
Landfill leachate: FK Influent	4/5/99			
Landfill leachate: FK Influent	6/3/99			
Landfill leachate: FK LF 3/4	5/11/00	120		
Landfill leachate: FK LF, 1/9 "B"	5/11/00	490		
Landfill leachate: FK LF, 1/9 "F"	5/11/00	34.9		
Landfill leachate: FK LF, 1/9 Comp.	5/11/00	365		
Landfill leachate: FK LF, 1/9 Comp.	10/25/00	1680		
Landfill leachate: FK LF, 1/9 Comp.	3/20/01			
Landfill leachate: FK LF, 1/9 Comp.	4/19/01			
Landfill leachate: FK LF, 6/7 Comp.	5/11/00	161		
Landfill leachate: FK LF, 6/7 Comp.	10/25/00	821		
Landfill leachate: FK LF, 6/7 Comp.	7/25/01			
Landfill leachate: FK LF, 6/7 Comp.	8/9/01			26.1
Landfill leachate: Pelham Bay	11/6/98	143	1.42	4.80
Landfill leachate: Pelham Bay	1/29/01			

CSOs and SWOs

Locations of the CSO and SWO samples are indicated on Figure 15.

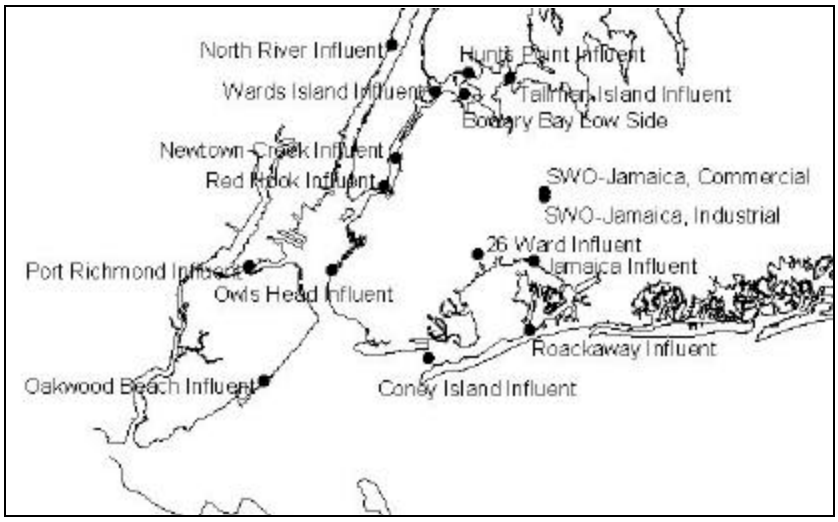

Figure 15. CSO and SWO sampling sites.

Table 10. CSOs and SWOs, names, dates, DOC, POC, and SS.

Short_Name	MGD	Date	DOC mg/L	POC mg/L	SS mg/L
26th Ward, High Side	12	6/2/01			
26th Ward, Low Side	12	5/21/01			
Bowery Bay High Side	13	3/21/01			
Bowery Bay Low Side	13	2/25/01			
Coney Island Influent	10	11/26/00		65.7	180
Hunts Point Influent	15	7/8/01			
Jamaica Influent	31	9/20/01			
Manhattan Grit Chamber	11	9/24/01			92
Manhattan Pump Station	14	2/5/01		0.667	
Newtown Creek Influent	14	1/30/01			
North River Influent	5.0	6/23/01			
Owls Head Influent	9.3	11/9/00			169
Port Richmond Influent	1.0	12/16/00	342		298
Red Hook Influent	3.7	8/27/01			404
SWO-Jamaica, Commercial		6/22/00	260	28	
SWO-Jamaica, Industrial		10/16/00		0.390	158