FRESH KILLS

CONTRACT No. 901,- 9260

Leachate Mitigation System Project IT PROJECT No. 529363

Responses to General Comments Related to the Draft Leachate Mitigation Evaluation for Sections 2/8 & 3/4 - and Related Reports

Date: May, 1994

Submitted to:

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Responses to General Comments Related to the Draft Leachate Mitigation Evaluation for Sections 2/8 and 3/4 - and Related Reports

I. Comments on the "Draft Leachate Mitigation Evaluation for Sections 2/8 and 3/4" (Report), January 1994.

A. General Comments:

1. Based upon the information provided in Table 5.6-2, it is estimated that by the year 2000, the Alternate 1 will reduce the uncontrolled:

- **horizontal leachate flow by 72% and 64% for Sections 2/8 and 3/4, respectively.**
- **vertical leachate flow by 45% and 27% for Sections 2/8 and 3/4, respectively.**

The above indicated information have been used to evaluate the in-stream ammonia concentration in the Arthur Kill, Fresh Kills, Richmond Creek and Main Stream. The NYCDOS has not provided any information regarding the mass load reduction and the in-stream concentration for the toxic pollutants, especially the heavy metals (i.e., copper, lead, nickel and zinc).

Based upon the above indicated reductions for ammonia, the average of the horizontal leachate flow of 68% has been applied to the observed ambient metals data. We have assumed that the reduction in the ambient concentration of the heavy metals is directly proportional to reduction in the leachate flow. The results show exceedance of the water quality standards for copper, lead and nickel even in the year 2000. Obviously, there will also be water quality exceedances between now and the year 2000, and also beyond the year 2000.

Response: The computed leachate reduction in Table 5.6-2 doesn't reflect the major leachate reduction associated with implementing leachate mitigation measures at Sections 6/7 & 1/9. By implementing Alternative 1, uncontrolled horizontal leachate reduction will be 90 percent. By the year 2015, it will exceed 97 percent. This reduction will have significant impact on improving surface water quality of the streams as presented in the report. However, it must be noted that the composition of Fresh Kills water presently is as follows:

Exfiltration from groundwater including leachate	1.3 mgd;
Freshwater	8.7 mgd;
Arthur Kill flood flows	800 mgd

Comparison of these flow volumes shows that the water quality of the Arthur Kill limits the extent to which water quality in the creeks can be improved. In a recent presentation, USEPA Region 2 characterized the water quality of the entire NY/NJ Harbor, including the Arthur Kill, as impaired. Attachment II.A contains USEPA's characterization table summarizing constituents for which water quality standards are exceeded. These include copper, lead, nickel, and zinc.

Clearly water quality in the Arthur Kill limits the extent to which water quality in the creeks can be improved (see Attachment II.A). This is consistent with our prediction of limited benefits attributable to the leachate mitigation system - local measurable reduction in ammonia concentrations.

Current leachate loads to the Fresh Kills Creek system for the leachate indicator parameters are shown in Table 9-15 of the Final Surface Water and Sediment Report (FSWSR). This table is included in Attachment I.A for your reference. In summary loads for the noted toxic parameters and ammonia are shown below:

	Current Load	Leachate Contribution	Standard	Fresh Kills Ambient
Ammonia	1910 kg/day	0.6 mg/l	1.0 mg/l	0.6 mg/l
Copper	0.147 kg/day	$4.0x10^{-5}$ mg/l	$2.9x10^{-3}$	$2x10^{-2}$
Lead	0.243 kg/day	$5.0x10^{-5}$ mg/l	$8.6x10^{-3}$	$1x10^{-2}$
Nickel	0.159 kg/day	$4.0x10^{-5}$ mg/l	$7.1x10^{-3}$	$4x10^{-3}$
Zinc	1.296 kg/day	$2.0x10^{-4}$ mg/l	$5.8x10^{-2}$	$5x10^{-2}$

Contribution of leachate to ambient concentrations are shown above for these parameters as are the water quality standards or guidance values. Mean concentration of these constituents at the Fresh Kills Stations at low tide are also shown. With the exception of ammonia, the leachate contributed ambient concentration is two orders of magnitude less than the standard or guidance value. In other words, if all leachate were removed from the system, changes in ambient concentrations of copper, lead, nickel, and zinc would not be measurable. Further any improvement would be insufficient to bring these constituents within water quality standards. Clearly as the comments suggests, there will be water quality exceedance between now and the year 2000 and beyond even if all leachate is removed from the system. The contribution of ammonia from leachate will be reduced to 0.2 mg/l as a result of this project as shown in Attachment II.B.1. This is below harbor wide ambient levels.

Water quality improvement is dependent upon not only the leachate mitigation project, but also implementation of abatement measures for other sources. We have contacted the Interstate Sanitation Commissioner, the City of New York, the State of New Jersey and professionals responsible for studying other area-wide sources of pollution in order to develop a cumulative abatement schedule. Such information is not available.

2. **This feasibility study assesses effectiveness and impacts of five alternatives to control leachate release to groundwater and surface waters. However, in DEC comments on the Surface Water and Sediment Report (see below), it is stated that the most significant impacts to surface waters from leachate appear to be to the benthic community, with ammonia in sediments as the most likely major cause of the depauperate communities found. In order to appropriately assess effects/benefits to surface waters of leachate control alternatives it will be necessary to predict concentrations in sediments resulting from each alternative. Furthermore, the array of alternatives assessed in this report were selected because it was believed that leachate discharge primarily affected only upstream waters. What leachate controls would be necessary to reduce ammonia in interstitial water of sediments of the Arthur Kill adjacent to the landfill and Fresh Kills and its tributaries to below EPA water quality criteria for ammonia in saltwater? Would additional alternatives need to be assessed for achieving this objective?**

Response: The objectives of the Leachate Mitigation Evaluation for Sections 2/8 and 3/4 were:

1. To develop and evaluate mitigation alternatives for controlling leachate flow at Landfill Sections 2/8 and 3/4, assuming the alternative for leachate containment, collection, and treatment at Landfill Sections 1/9 and 6/7 as required by the Consent Order and as recommended in the Final Leachate Mitigation Report [FLMR] (IT, 1993) is implemented.

2. To define the impact of any leachate flow from Landfill Sections 2/8 and 3/4 not controlled under each of the developed alternatives, in the context of the recommended site-wide alternative for Landfill Sections 1/9 and 6/7 presented in the FLMR.

The basis for developing alternatives for Sections 2/8 and 3/4 is described in Section 5.1 of the Feasibility Study. Alternatives were selected to achieve the objective of leachate control throughout the area, not just in the upstream areas.

In response to your questions regarding impact to benthic communities and sediment quality controls, we find that:

1. The USEPA criteria for ammonia in saltwater is not an appropriate sediment quality criterion;

2. Sediment quality cannot be mitigated by leachate controls; and

3. The benthic community is affected by pollutant loads that are not of leachate origin.

These conclusions are based on the discussions in Response to Comment II.D. and in Response to Comment II.C. Furthermore, the feasibility and appropriateness of predicting changes in sediment concentration due to each alternative are also discussed also in Response to Comment II.C.

3. There are reasons to question the selected alternative. Some comments on this follow:

a. Alternative 3 is included with alternatives 2, 4 and 5 as having "potential for negative public sentiment" as compared to alternative 1. As presented in this report, alternative 3 only adds wells for pump and treat of leachate, and leachate treatment would be at facilities required for sites 1/9 and 6/7. Therefore, what impacts from alternative 3 would cause more public reaction than alternative 1?

Response: As expressed at various public meetings including the annual public meetings mandated by the Consent Order and community board meetings, the public sentiment regarding the Fresh Kills landfill is (1) that operations should be discontinued as soon as possible, (2) that leachate controls be implemented expeditiously, (3) that the closed landfill sections be developed for proper end use (preferably recreational areas and natural habitats), and (4) that a strong commitment be made to never reopen the closed landfill sections.

Alternatives like Alternative 3 that include leachate controls on the closed Sections 2/8 and 3/4 that are equivalent to those on the active Sections 1/9 and 6/7 create a concern on the part of the public that DOS may consider reactivating those closed areas. In addition, structural components (leachate wells, pumping stations, headers, etc.) of the alternatives would break up habitats and limit or conflict with the development of the desired end use.

Implementation of any alternatives other than Alternative 1 will require additional extensive investigations, analyses and design. Based on the procedures laid out in the Consent Order that require multiple reviews by the NYSDEC of work plans, preliminary, draft final and final designs, and other administrative requirements (including appropriation of funds, procurement of services, permitting, etc.), the implementation of an alternative will not be complete until at least the year 2000; and of even more concern, due to the interconnected nature of the leachate mitigation systems, the commencement of the leachate mitigation systems at Landfill Sections 1/9 and 6/7 as well as ongoing closure operations at Landfill Sections 2/8 and 3/4 would also be delayed. Such delays are contrary to the public sentiment for immediate closure and the implementation of controls rather than pursuit of additional studies.

b. It is not clear why alternative 3 would not be completed until 2000. It would appear wells could be put in much sooner.

Response: In response to NYSDEC comments on the Final Hydrogeological Report, NYCDOS has initiated performance of a well installation and pump testing program within the landfill refuse mounds. The purpose of this program is to estimate the bulk hydraulic conductivity of the refuse and allow for the further evaluation of the effectiveness of refuse pumping as a corrective action measure. The areas for these tests were identified as the margins of the landfills (refuse elevation < 100 ft), in an attempt to avoid low hydraulic conductivity materials believed to exist in saturated refuse under thicker mound areas (the results of a series of in-situ hydraulic conductivity tests in basal refuse deposits indicated a geometric mean hydraulic conductivity of about 2×10^{-5} cm/sec.). Following completion of well installation at Section 1/9 in April 1994, yield from the pump test well was observed to be very low (<2 gpm), and hydraulic conductivity of the saturated refuse deposits was estimated (through in-situ instantaneous discharge tests) as approximately 1×10^{-3} cm/sec. Due to the low yield obtained from the pump test well, NYCDOS has suggested that, rather than continuing with the installation of similar wells at Sections 2/8 and 3/4, a revised strategy be identified for the remaining pump test activity. Such a strategy could more thoroughly evaluate the efficacy of the recovery well option at Landfill Sections 2/8 and 3/4, as described in Alternative # 3 of the Feasibility Study.

The planning, performance, and evaluation of such additional testing (including numerical flow analysis for preliminary design purposes) will require an execution period of at least one year. The need for such field testing is underscored by the results of pump test well installation at Section 1/9. As indicated on the Implementation Schedule for Sections 2/8 and 3/4 Leachate Mitigation Measures (Figure 5.3-1, contained herein as Attachment IA3b), the funding, procurement, permitting, specification, and construction phases of Alternative implementation (coupled with the field investigation phase noted above) would not allow for plan implementation much prior to the year 2000. The variable distribution of refuse hydraulic conductivity and saturated thickness, and the likely inability to pump a significant volume of leachate from many areas within the landfill precludes implementation of a simple well installation plan. However, as stated in the report and in the response to comment I.A.3.d below, Alternative 3 is not a cost-effective alternative.

c. **Alternatives 1 and 3 together appear to result in the maximum amount of NH_3 load reduction.**

Response: As shown on page ES-20 of the report, Alternative 3 includes all components of Alternative 1, with the addition of pumping wells. Therefore, one should not combine Alternatives 1 and 3 together, and the amount of NH_3 load reduction should be viewed separately for each alternative.

d. **The report concludes that the additional NH_3 load reduction from alternatives 2 through 5 are not worth the cost. Looking at alternative 3, the report states that the increment in NH_3 reduction over alternative 1 is about 5%, and the increased cost is about 10% (based on the cost of wells compared to total cost of controls at all landfill sites - this is reasonable since the NH_3 load reduction of alternative 1 includes reductions from all site controls). One could argue that there is little true difference between a 10% cost increase and a 5% load reduction, therefore the cost is justified. The case for justifying additional controls will be greater with only slight actual load reductions or reduced fraction of cost. However, cost vs. load reduction ratios cannot be the only determinant. A prime objective should be to reduce sediment ammonia levels below water quality criteria.**

Response: Review of the cost and leachate flow data revealed that in the year 2000, Alternative 1 (with a capital cost of 235.3 million dollars) will have achieved an effectiveness of 90% reduction in uncontrolled horizontal leachate flow, whereas Alternative 3 (with an additional capital cost of 25.6 million dollars or 11% cost increase) will only increase the effectiveness by 3.5% (to 93.5%). Therefore, the marginal benefit per unit cost associated with the implementation of Alternative 3 over Alternative 1 (about 0.14% per million dollar) is only about one third of the benefit per unit cost associated with the implementation of Alternative 1 (about 0.38% per million dollar). This indicates that Alternative 3 is a much less efficient use of the resources.

As discussed in our response to Comment II.C.4, it is not appropriate to apply water quality criteria for ammonia to sediment. Further application of this surrogate criterion to available data show that it is exceeded throughout the region. Therefore leachate controls at Fresh Kills cannot in themselves produce the proposed sediment quality. On the other hand, we can predict substantial improvement in ambient surface water ammonia concentrations. As shown in Attachment II.B.1, implementation of Alternative 1 reduces the ambient concentration attributable to leachate to 0.2 mg/l which is equal to the lowest levels reports in the Harbor in the NYCDEP Water Quality Survey. Implementation of Alternative 3 reduces the contribution to ambient to 0.15 mg/l (see Attachment II.B.1) which is lower than the concentration generally observed. Therefore, under Alternative 3 there would be no improvement in water quality since background (i.e. Arthur Kill) water quality would dominate. Alternative 3 does not provide any incremental environmental benefit over Alternative 1.

e. **This report only addresses NH_3 reductions. Presumably other contaminant loads to aquatic sediments and surface water will also be reduced. Can predictions be made of sediment concentrations of other contaminants, some of which are currently high, after leachate controls are added?**

Response: With the exception of those parameters identified as leachate indicators including ammonia, zinc, and alkalinity in sediment, the data show no significant differences in constituent concentration in sediment in the Fresh Kills Creek system as compared to harbor-wide data (see Comment II C). The sediment transport model (FSWSR, Chapter 9) shows that the Arthur Kill serves as a source of sediment to the Fresh Kills Creek System. Therefore, based on leachate control alone we do not predict an increase in sediment quality. Fresh Kill sediments will only improve if Arthur Kill sediment quality is improved. As indicated in our response to Comment I A, we know of no plans to clean up these source sediments. Please refer to our response to Comment II C for further detail.

4. **If NH_3 in sediments attains water quality criteria, benefits to natural resources would be substantial, assuming there is significant reduction in other contaminants also. Elimination of toxic, inhibitory effects can expect to result in the flourishing of diverse, productive, benthic assemblages in Fresh Kills and its tributaries which will also enhance the value of these habitats to other fish and wildlife and likely result in increased use by them.**

Response: The data in the FSWSR show that even in the absence of high ammonia concentrations in sediment, the water/sediment environment in the Arthur Kill and tributaries does not support a flourishing community as described in the comment. Therefore, we have not predicted that implementation of leachate controls would result in this benefit. The findings of Cristini in her harbor-wide review of benthic data conducted as part of the Harbor Estuary Program as described in

Chapter 7 of the FSWSR are consistent with these findings. The response to comment II C and II D provides further information in this regard.

B. Specific Technical Comments:

1. The Draft Report employs a geometric mean for calculating the permeability used in the model for leachate/groundwater at the site. An arithmetic mean appears more appropriate since flow will "give more weight to the more permeable values" just as the arithmetic mean will (flow predictions are consistent when an arithmetic mean is employed). The Department recommends the use of actual field data in the model (repeated as necessary), if possible, or the use of the arithmetic mean if the model cannot incorporate the actual data.

Response: The three dimensional numerical flow model developed for this investigation as part of the Final Hydrogeological Report and applied to the evaluation of correction action alternatives, uses the areal distribution of actual field data to describe the hydraulic conductivity of the various geologic units. The only instance where geometric mean data are used is for the case of low permeability silt/clay units, where the measured hydraulic conductivity distribution is very low and the range of data is narrow (Units 2, 4, 7, and 9 on Figure 6.2; Attachment I.B.1), and the effect of variation in hydraulic conductivity on the flow system is negligible. It should be realized that with the placement of final cover on Landfill Sections 2/8 and 3/4, variations in the hydraulic conductivity distribution of underlying silt/clay units does not affect the total volume of vertical flux or contaminant loading from the landfills; changes in these distributions would primarily affect only the time phasing of leachate mound dissipation and flux.

As noted by Fetter (1988), the geometric mean (mean of the natural logs of the data) is often a more representative description of the average hydraulic conductivity of a geologic unit. This is because hydraulic conductivity values frequently vary by more than two orders of magnitude within the same unit, and an arithmetic mean of such a sample will erroneously skew the central tendency of the data distribution to the more permeable values. Relative to this investigation, the utility of the geometric mean is evident from a comparative review of Tables 6.4 and 6.4A (Attachment I.B.1), which respectively provide a series of distribution statistics for the arithmetic and logarithmicly transformed populations of hydraulic conductivity data derived in the field and laboratory.

The coefficient of variation (standard deviation divided by the mean) indicates the amount of variation in a population. Where this value exceeds 1.0, a normal distribution is generally not assumed. Skewness is a measure of the distribution of sample data relative to the mean. Where many very large or small numbers are present in a data set, the distribution of the "bell shaped" (normal) curve will be skewed, indicating a non-normal population distribution. For the sample sizes indicated in Tables 6.4 and 6.4A, a skewness much in excess of about 1.0 indicates statistically significant deviation from a normal distribution (Snedecor and Cochoran, 1976). Kurtosis is a measure of the "peakedness" or flatness of the distribution curve relative to the normal curve. Kurtosis values much greater or smaller than about 3.0 indicate statistically significant deviation from a normal distribution (Snedecor and Cochoran, 1976). The statistics provided on Table 6.4 (Attachment I.B.1) indicate that, with the exception of several clay units where the variability in K is low, the arithmetic sample data is poorly suited to a normal distribution. The statistics compiled on Table 6.4A (Attachment I.B.1) indicate that average K is better represented by the geometric mean derived from a log normal distribution of the sample data.

2. **Current and future leachate contaminant loading estimates to surface waters in the Report are based on current leachate discharges as estimated from the chemistry of perimeter shallow wells. Leachate strength can reasonably be expected to increase in the future, given the large volume of new solid waste placed during the last few years (up to 120 feed of solid waste placed at Section 3/4 and Section 2/8 during the last 12 years). Loading estimates in the Report may be low for future conditions as a result of increased leachate strength and other factors. Increased leachate strength may act to substantially offset the reduction in loading that is achieved by cover of the landfill, as modelled in the Report.**

Response: Variability in leachate composition is a function of both spatial and temporal considerations, the former represented by the horizontal and vertical distribution of waste placement and content, and the latter represented by the continuum of chemical processes that occur within the landfill environment over time.

The chemical composition of leachate is controlled by the same set of processes that occur in organic-rich marine sediments (Baedecker and Back, 1979a,b). These processes result in the development of an anaerobic zone beneath a landfill (Figure 7.504). The processes, in order of occurrence with decreasing Eh (oxidation-reduction potential), are defined by Stumm and Morgan (1981) as:

- Aerobic reduction of organic matter
- Denitrification
- Manganese reduction
- Nitrate reduction/ammonification
- Iron reduction
- Anaerobic reduction of organic matter
- Sulfate reduction
- Methane fermentation
- Nitrogen fixation

These processes can be grouped together into an idealized five-phase waste-degradation sequence that applies specifically to sanitary landfills (Christensen and Kjeldsen, 1989). Phase I, which lasts only a few days, consists of the aerobic reduction of organic matter. Phase II, which is the first intermediate anaerobic phase, consists of denitrification, manganese reduction, ammonification, and further degradation of organic matter into volatile fatty acids. In this phase, the leachate contains high concentrations of calcium, iron, heavy metals, ammonium, and increasing bicarbonate concentrations. Phase III, the second intermediate anaerobic phase, consists of sulfate reduction and initial methane fermentation. In this phase, volatile fatty acids and sulfate concentrations decrease, and pH and alkalinity increase. The increase in pH reduces the solubility of metals. Iron and manganese likely precipitate as sulfide minerals. Ammonia concentrations continue to increase with the degradation of volatile fatty acids. Phase IV consists of methane fermentation, and correspondingly rapid production of methane. During Phase V, only refractory organic matter remains, and methane production decreases to very low levels. This sequence of waste degradation is idealized for a homogeneous landfill. The Fresh Kills landfill, which consists of four landfills of variable age and composition, likely exhibits the full spectrum of the waste degradation sequence.

The time frame for waste degradation is variable depending on abiotic parameters, such as the concentrations of oxygen, hydrogen, sulfate, nutrients, inhibitors, and water content, in addition to pH (Christensen and Kjeldsen, 1989). As noted above, the initial aerobic phase is very short, lasting only a few days (Christensen and Kjeldsen, 1989; Fetter, 1993). The time frame for each of the successive stages ranges from months to decades, dependent on the above parameters (Christensen and Kjeldsen, 1989). Also, the processes, although listed in order, have overlapping ranges (Stumm and Morgan, 1981). As a result, several anaerobic processes may be ongoing in a landfill at the same time. In an experimental study of leachate quality, Ehrig (1989) showed that pH, BOD, COD, sulfate, calcium, magnesium, iron, manganese, zinc, and strontium concentrations evolve until methane fermentation is complete. Conversely, chloride, sodium, potassium, alkalinity, ammonium, organic nitrogen, nitrate, phosphorous, phenols, and heavy metals reach maximum concentrations relatively early during the evolution of the leachate, and methane fermentation does not affect their concentrations. Thus, leachate composition could evolve for decades after a landfill is closed, but the rate of evolution, and thus the actual composition of the leachate, is dependent on several parameters that can vary.

Current leachate chemistry within Landfill Sections 1/9 and 6/7 can be compared to grossly illustrate the differences between an active filling (1/9) and a stable (6/7) landfill environment. Attachment I.B.2 contains this comparison for the general chemistry and inorganic (metals) parameters, and indicates a lower concentration at Section 6/7 relative to Section 1/9 for virtually all chemical constituents.

Given the preceding discussions, it can be generally stated that leachate strength at Fresh Kills should be expected to decrease over time in the areas where active filling has been discontinued (i.e., Sections 2/8 and 3/4), and should be expected to maintain its current characteristics or increase in strength over time in the areas where active filling is scheduled to continue (i.e., Sections 1/9 and 6/7). This condition is believed to be reasonably represented in the calculation of contaminant loading to area streams through the use of the mean (mean of the individual well means) leachate concentrations observed currently at each of the landfill sections.

3. **There are several fresh and tidal tributaries to Main and Richmond Creeks that are present around the base of landfill Sections 3/4 and 2/8. These streams receive direct discharge of leachate and have much lower natural dilution than the larger tidal creeks into which they flow. Leachate impact in these waters is therefore the greatest observed in surface waters on site. The impact of leachate discharge and the resultant standard violations in these waters are not considered in the Report.**

Response: Estimates of groundwater and leachate discharge into these small tributaries, as well as estimated contaminant (ammonia) loadings were included in Appendix M of the Draft Leachate Mitigation Report, and are evaluation for Sections 2/8 and 3/4 contained here in Attachment I.B.3. It should be noted that these tributaries drain land areas other than the landfill; consequently, water quality in them is also affected by other sources of contamination, such as non-point source runoff (e.g., runoff from the Staten Island Mall parking lot, Arthur Kill Road, etc.).

4. **The Report does not adequately evaluate the hydrologic performance of the final cover that will be installed at the two landfill sections. The values that are provided in the reports to date represent an extraordinarily high efficiency (i.e. 99.3% efficient: 99.3% of all precipitation does not penetrate the cap). The correct* figures reported by NYCDOS are equivalent to 20 gallons per acre per day which is the goal for a double composite liner. A more reasonable estimate of 95% efficiency for the cap will result in the generation of approximately 25,000 gallons of leachate per day after the cap is complete.**

* The word correct should be deleted from this comment.

Response: The 20 gallon/acre/day figure (corresponding to an efficiency of 99.3%) used to estimate leakage through the landfill final cover was based on the Final Cover Design Report (Consent Order Appendix A-3, Milestone 6) prepared by SCS Engineers in 1991 for Fresh Kills Landfill which was accepted by the NYSDEC. It is believed to be appropriate, given controlling hydraulic factors such as landfill sideslope, runoff control features, permeability of final cover substrate, and vegetative cover.

5. **The Draft Report does not contain a bibliography, so it is difficult to check some of the references provided throughout the text.**

Response: The reference section is attached; please insert it in your copy behind Section 6.0 as listed on the Table of Contents.

II. Comments on the "Final Fresh Kills Landfill Surface Water and Sediment Report" August 28, 1993. These comments apply to Chapters 2, 3 and 4 of this Report.

A. The reference sites on the Rahway River and Marshes Creek were inadequate for comparing the study sites with an unimpaired reference site. The selected reference sites were seriously degraded themselves. Apparently, this shortcoming was acknowledged by the report's author because on P. 47 of the 15 Oct 93 Addendum, it is stated that for future monitoring Environmental Monitoring and Assessment Protocols (EMAP) protocols be followed, thereby allowing use of EMAP reference sites. That's a good suggestion, but for the purpose of reviewing this report, the lack of a true reference site makes it difficult to understand the magnitude of impairments at the Fresh Kills sites, especially for those readers unfamiliar with marine and estuarine ecology.

Response: This comment is inconsistent with the objectives and scope of this study, the nature of the Arthur Kill environment, and consequently, of the role of the reference sites in the study.

As clarification, we refer to the Surface Water and Sediment Investigation Plan (SWSIP) dated July 26, 1991, a consent order deliverable which was approved by DEC and serves as the plan for the investigation. An objective of the study as set out in that document is:

"Assess the impacts of the landfill leachate on the local environment (P. 1-2)." The SWSIP further provides a summary of available information characterizing the study area including the statement,

"It is important to note that the water quality in Fresh Kills has been recognized as being impacted since the 1930's, with an acceleration is decline between 1937 and 1955 (Interstate Sanitation Commission, 1956) SWSIP, P. 4-2."

Fresh Kills landfill was opened in 1948. Not only is Fresh Kills impaired by sources other than the landfill, but the entire New York Harbor Region is impaired. The Literature Review Report published in April 1991 in accordance with the Consent Order requirements and approved by the DEC provided further description of the water quality, sediment quality and biota of the region clearly documenting that the region is impaired.

In order to meet the objective of assessing the impacts of landfill leachate, comparison of landfill affected areas to similar areas not affected by the landfill (reference areas) is an appropriate method of evaluation. Appendix E of the approved SWSIP describes in more detail the consideration given to identifying points of comparison. Attachment II. A. contains this description.

Comparison with an "unimpaired reference" or in fact a "control" site was not included in the approved SWSIP because such comparison is not relevant to achieving the study objective as defined above.

By recommending use of EMAP reference sites in the future, the authors are not acknowledging a shortcoming of the SWSIP and the studies based on it. EMAP reference sites were included in the Long Term Monitoring Plan. Use of EMAP reference sites anticipates that other causes of impairment of harbor resources may also be mitigated in the future.

Readers unfamiliar with marine and estuarine ecology are referred to the literature review report which was published in April 1991 and included in Appendix J of the FSWSR. Excerpts from the above cited documents are included in Attachment II.A for your convenience.

In order to determine whether in the years during which the study was conducted conditions might have changed such that an unimpaired control site is actually available, we consulted with Mr. Thomas Brosnan of NYCDEP (personal communication with Christine Danis, IT, May 3, 1994). Mr. Bosnan is responsible for the NYCDEP Water Quality Survey. He informed us that there is no suitable control site for the Arthur Kill/Fresh Kills area in the harbor.

Not only is a control site irrelevant to filling the objectives of the SWSIP, one does not exist.

B. Chapter 5, Surface Water Quality:

1. **The justification for comparing ambient ammonia water levels with acute criteria only is inadequate. In its 1989 water quality criterion document for ammonia in saltwater EPA states that the chronic criterion as a 4-day average should not be exceeded more than once every three years. This study found the chronic criterion exceeded over on 12 hour tidal cycle. Samples were not taken for two days before or two days after. One cannot conclude simply because there was no data collected that the 4-day criterion was not exceeded! It is clear that ammonia is one of the most important constituents of the leachate and to make a definite determination of the landfills impacts on water quality would require more long-term data, e.g., a series of 4-7 day sampling events. Without such data it should be presumed, based on data collected to date, that the chronic criterion is sometimes exceeded at some locations. This has implications for compliance with water quality standards.**

   In addition, quick review of the data would lead one to question whether there was in face only once exceedance of the chronic criterion. The appropriate criterion to apply on any sample is pH and temperature

dependent, and rather detailed analysis is necessary to determine compliance with criteria at all stations at all times. However, if one applies a summer criterion of about 1.5-2 mg/l total ammonia for waters at 20-25 degrees Celsius, pH about 7.5, then there appears to be a number of stations at several times that exceed this level. More analysis is warranted on this matter.

Finally, the conclusion that "ammonia was not significantly greater in Fresh Kills Creek than in the reference of farfield Arthur Kills Stations" (P.5-36) bears more scrutiny. It is clear from the data in Appendix B that ammonia in tributaries of Fresh Kills is much greater than the Arthur Kill (probably significant), and ammonia in Fresh Kills itself appears to be consistently higher than the Arthur Kill. There is reason to believe that there is measurable impact of leachate on Fresh Kills, contrary to the conclusion on P.5-36.

Response: The surface water sampling program was performed in accordance with the specifications in the consent order that stations be sampled at low tide and once a year samples would be taken at low, high and mid-tides. With DEC's approval, during the second year sampling during rising and falling tides was deleted. Clearly, it is not an objective of the study to determine compliance of ambient waters with a four day criterion. The ammonia data were compared to the acute criterion because it is the only comparison one can make. We further observe that in all but one instance, the furthest upstream station on Richmond Creek, incoming flood waters reduced ambient ammonia concentrations to below the USEPA chronic criteria.

The suggested series of 4-7 day sampling events might assist NYSDEC in determining whether the chronic criteria were exceeded in any of those events. Such sampling, would not add to our understanding of the impact of leachate on water quality which is the objective of this study.

The USEPA criteria were used as water quality benchmarks because NYSDEC does not have a water quality standard for ammonia. Please clarify the statement "This has implications for compliance with water quality standards".

We have provided the results of our data point by data point comparison with the criteria for the reviewer's use in Attachment II.B.1. This information is part of the ammonia parameter profile in the FSWS report. Please note that our discussion was based on this "rather detailed" analysis and not on a quick review of the data.

The conclusion that "ammonia was not significantly greater in Fresh Kills Creek than in the reference or farfield Arthur Kill Stations" is based on the results of statistical analysis presented in Table 5-7 and Appendix B-3. The table is included in Attachment II.B. for your convenience.

The impact of leachate on ambient ammonia levels in Fresh Kills Creek was further evaluated by application of the hydrodynamic/water quality model in Chapter 9 of the FSWSR. Figure 9-109 shows the contribution predicted by the model at Node 18 in Fresh Kills to vary between 0.25 mg/l at high tide and 0.6 mg/l at low tide. The evaluation of the incremental improvement in water quality that can be expected with various leachate mitigation alternatives employed this model. As can be seen in the figures presented in Attachment II.B., the concentration of 0.25 mg/l which is controlled by conditions in the Arthur Kill is achieved by capping and closure of Sections 2/8 and 3/4.

2. **The New York State guidance value for mercury of 0.00001 mg/l that is used in this report is not based on current data and current analytical techniques. The more recently developed USEPA bioaccumulation criterion of 0.025 ug/l should be used for assessing ambient mercury concentrations.**

Were collections and analyses done by the ultra clean methods now known to be necessary for Hg? Given the regular disposal of batteries, and other Hg products in landfills and the extreme toxicity and bioaccumulation of Hg, we should be particularly careful about identifying and controlling releases from landfills.

Response: The SWSIP specifies the following objective of this study:

"Assess the impacts of landfill leachate on the environment in terms of compliance with water quality standards by determining the ambient concentrations of specific chemicals in the surface waters and sediments;" (P. 1-2).

The water quality standards applicable to the area surface waters were presented in the approved SWSIP on Table 2-28. In the absence of standards, NYSDEC published guidance values were applied as benchmarks. In the absence of specific New York State issued values, USEPA criteria are referenced in the development of Data Quality Objective (DQO). The approved Data Quality Objectives are contained in Appendix H of the SWSIP. The DEC approved revisions to the DQO's are contained in the July 29, 1992 Addenda to the Quality Assurance Project Plan (QAPjP). This document is contained in Attachment II.B.2. for your convenience. Further note that the method detection limit of the approved QAPjP is 0.2 ug/l. The USEPA criterion of 0.25 mg/l is not part of the approved project plans.

NYCDOS is aware of the ongoing USEPA evaluation of "clean" and "ultra clean" techniques for assessing metals in waterbodies. The "clean" techniques refer to the sample collection and handling necessary to produce reliable analytical data in the part per billion (ppb) range and draft protocols were proposed to be available for review in late calendar year 1993. (USEPA, Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria, USEPA Memorandum dated October 1, 1993 from M.G. Prothro to Water Management Division Directors). "Ultra clean" techniques refer to those requirements necessary to produce reliable analytical data in the part per trillion (ppt) range and draft protocols are proposed to be available in 1995 (see above reference).

The sampling and analysis for mercury was performed in accordance with the approved QAPjP for the Fresh Kills Project. The New York State groundwater standard for mercury is 2 ug/l. This standard was never exceeded in the shallow wells of the landfill. In fact as shown on the parameter profile of Appendix B of the Final Surface Water and Sediment Report (FSWSR) the median concentration of mercury in shallow and refuse wells in each section was 0.1 ug/l with 90% of all samples undetected. Mercury is not a constituent of Fresh Kills leachate.

C. Chapter 6, Sediment Quality

Response: Before addressing the specific comments below it is important to remember the following basic considerations in this study.

- The objective of the study is to identify the impact of leachate on the aqueous and subaqueous environment.

- The NY/NJ Harbor and particularly the Arthur Kill has been demonstrated to have contaminated sediments. A table taken from a recent presentation by USEPA Region 2 is included in Attachment II.C. as illustration of the condition of sediments in the Harbor. The compilation of sediment data prepared by Squibb for the NY Harbor estuary program was presented in Appendix A of the FSWS Report.

- The Arthur Kill sediments are a <u>source</u> of sediment to the Fresh Kills Creek system. The sediment transport model presented in Chapter 9 of FSWS Report clearly demonstrates this phenomenon. The graphic outputs of this model are included in Attachment II.C. for your convenience.

The quality of sediment in the Arthur Kill is the limiting factor for sediment quality in Fresh Kills for all but a few indicator parameters, principally ammonia.

1. **For several organochlorines (BHC, DDT and metabolites, PCB and endrin) the Human Health and/or Wildlife based sediment criteria should have been used in the report, which are lower (i.e. protective of more uses) than those used in the report. Most organochlorine concentrations exceed the Sediment Quality Criteria (SQC) which would likely cause unacceptable residues in biota for human and wildlife consumers.**

Response: The constituents mentioned are not landfill related as shown by review of leachate data in the Final Hydrogeological Report. Thus, comparisons with any criteria would be to characterize current quality but not to determine measurable landfill impacts from leachate which is the objective of the FSWSR. The table included in Attachment II.C. shows the extent to which these compounds are a harbor wide problem.

The quality criteria for sediment were presented in the approved SWSIP and subsequently approved updates. Attachment II.C. presents criteria from the July 1992 QAPjP.

The water bodies of the study area are New York State designated SC and SD classes. Thus, they should be suitable for fishing and fish survival. In addition, SC class must be suitable for fish propagation. SD classes cannot meet the requirements of secondary contact recreation. SC classes should be suitable for such contact, though other factors may limit its use. Such a factor is the restricted landfill access. Human Health criteria are based on ingestion of specific amounts of water and/or sediment over extended periods of time. This is not a potential exposure scenario and should not be considered. Human Health consumption of wildlife (e.g., fish) criteria are likewise inappropriate based on use of the waterways. Therefore, it is concluded that organochlorine compounds are not leachate related and that human health or wildlife SQC are not appropriate benchmarks for this study.

2. **The sum of PAHs may be in the tens of ppm, probably explaining the 100's of ppm of total petroleum hydrocarbons (TPH). The levels of PAH and TPH are probably toxic to benthic animals.**

Response: Total petroleum hydrocarbons in sediment are a well recognized problem in the Arthur Kill. Table 4-6 presents the USCG record of oil spills in the Arthur Kill from 1980-1989. Fresh Kills leachate is not a source of TPH. A recent Hudson River Foundation seminar presented by the NYC Department of Parks and Recreation cited a high of 55,000 ppm of TPH in Arthur Kill sediments; they even found 1,000 ppm in the control area Lemon Creek on the southeast side of Staten Island. In this context 100's ppm of TPH are not remarkable. PAH's are associated with petroleum. Landfill leachate is not a source of these compounds as presented in the accepted Final Hydrogeological Report. As shown in Attachment II.C., Table 2 and the unpublished figure by Long et. al. 1993, harbor wide levels of PAHs are at toxic levels. This toxicity cannot be attributed to the landfill. This should be remembered when considering the benthic ecology of the region as discussed below.

3. **In general, many SQC and guidelines are exceeded. According to the report the contributions from the landfill are not known or it is unclear. It is likely that most contaminants in the freshwater sediments have a landfill origin. This issue may require more analysis. At least for several metals some organochlorines and some PAH the Fresh Kills sediments appear to often have some of the highest levels found. Nevertheless, the level of toxics in the sediments are probably toxic (even aside from ammonia toxicity) and cause elevated residues in biota. It would be useful to conduct toxicity and bioaccumulation tests of Fresh Kills sediments.**

Response: Measured exceedances of Sediment Quality Criteria have been found in Main and Richmond Creeks. Most of these are comparable to those concentrations reported for other areas of the Arthur Kill in our study and the historical literature as reported in Chapter 6 of the FSWSR. No evidence to determine a leachate-based origin was found.

The relationship between proximity of sediments to landfill is not clearly defined. Section 9.7 of the FSWSR presents the results of a sediment transport model. In short, there is a clear potential for Arthur Kill sediments to be transported into the Fresh Kills system.

Analysis of the benthic communities of Main and Richmond Creek have found these communities to be no further degraded than those in our reference area or other areas of the Arthur Kill as presented in the historical literature. The sediment transport model and quality of the sediment suggest that removal of leachate as a source would not alter sediment quality characteristics of the study area for other than ammonia.

Attachment II.C. contains two figures and a table presented by the USEPA showing that sediment toxicity is distributed throughout the NY/NJ Harbor. Considering that sediment are transported into Fresh Kills and that compounds cited in these comments are not of landfill origin, sediment toxicity tests will not be useful to identify the impacts of landfill leachate.

4. **The report states that there are no SQC for ammonia. It is not necessary to have separate SQC for ammonia. It is a highly soluble chemical and the water quality criteria can be used to assess risk of ammonia in sediments. Doing this it is apparent that there are widespread, over time exceedances of both acute and chronic ammonia criteria in the sediments. It is likely that ammonia is causing toxicity to Fresh Kills benthos. Ammonia in the sediments of Fresh Kills is typically higher than the Arthur Kill and reference sediments. As the report states in the case of ammonia it is "the cleanest indicator of leachate impact on surface water".**

Response: There are no Sediment Quality Criteria for ammonia in the approved SWSIP. Furthermore, we know of no sediment quality criteria for ammonia. However, we have taken the commenter's suggestions and compared the sediment data in this study to water quality criteria. Attachment II.C. contains the results of that comparison and demonstrates that study area locations exceed that surrogate criterion. NYCDEP analyzed sediment pore water for ammonia at selected harbor sampling stations and presented the results in the 1991-1992 annual report. As presented in Attachment II.C., these measurements show high ammonia concentrations distributed throughout the harbor. Therefore, we conclude that this surrogate criteria is not appropriate for evaluation of sediment quality. As previously stated sediment quality is highly affected by the Arthur Kill. Further as discussed in the response to Comment D, the benthos is affected by other parameters besides ammonia.

D. Chapter 7, Benthic Ecology

1. **The report's basic conclusion of "did not detect any evidence of detrimental impact on the benthic invertebrate communities" was only because the reference station is severely impacted. Page 2-13 of the report cites Cristini who found that Jamaica Bay and sections of Raritan Bay contain 1,000-20,000 amphipods/m^2. Amphipods are regarded as a key estuary indicator. The <u>total</u> number of all amphipods at <u>all</u> stations studies in this report at <u>all</u> times was less than 1,000. In other words, the benthic invertebrate communities of Fresh Kills and its tributaries are severely impacted. While attributing the cause for this to the landfill may be difficult for most water or sediment quality parameters (possibly an arguable point), the concentration of**

ammonia on its own in the sediment is probably sufficient to be the cause of the depauperate benthos.

Response: The Surface Water and Sediment Investigation began with a thorough Literature Review as required by the Consent Order and approved by DEC. The review is contained in Appendix J of the FSWSR, and summarized in Chapter 2 of the FSWSR. Findings with regard to the benthos are summarized in Chapter 7 of the FSWSR. The literature clearly shows that the benthic ecology of the Arthur Kill and its tributaries is impaired. The SWS Investigation was not designed to confirm that knowledge but rather to focus on the role of leachate in creating that impairment and conversely to predict expected benefits of removal of leachate from the system. The reference station was selected to reflect regional conditions without the specific loadings that originate in leachate. Our findings are that the reference station, which does not have high ammonia loads but is otherwise similar, has a benthic community similar to that in Fresh Kills. Therefore, we have concluded that the ammonia alone is not the cause of the impaired benthic community. Attachment II.D. contains a comparison of sediment characteristics at the reference and study sites. It is not appropriate to compare the Fresh Kills area to Jamaica Bay and Raritan Bay since the latter two bodies of water are not affected by Arthur Kill waters and are flushed by cleaner ocean waters.

2. **The Executive Summary and Chapter 7 both note that the only difference in the benthos was a higher productivity in Fresh Kills and its tributaries than the reference station. The higher productivity was virtually all in biomass of polychaetes and oligochaetes, known pollution tolerant organisms. In particular, oligochaetes are indicators of nutrient enrichment.**

Response: We agree with this comment; in fact the report provides this same information.

E. Chapter 8, Leachate Bioassay Study and Chapter 9, Hydrodynamic and Water Quality Model

1. **Sheepshead minnow and mysid shrimp are not very sensitive to toxics. These tests are still used, but often in conjunction with more sensitive organisms.**

Response: The leachate bioassay study program is described in the approved SWSIP (July 26, 1991). The SWSIP is Appendix I of the FSWSR and an excerpt is included in Attachment II.E. for your convenience. The program included acute toxicity testing using sheepshead minnow and mysid shrimp. It further provided for more sensitive chronic testing if acute toxicity was not observed. However, LC_{50} were less than 50% leachate showing that the leachate is toxic to the less sensitive species. As specified in the approved plan, chronic testing was not necessary.

The test species employed in toxicity testing were used because they are recommended by USEPA due to ease in culturing, sensitivity to a variety of pollutants, and general availability throughout the year (Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, USEPA, 1990). There are more sensitive species, rarely do these have standardized testing procedures or widespread usage. When interpreting toxicity tests, protection of more sensitive species is usually addressed through the application of protection factors. This is routinely applied to the derivation of SPDES permit limits for toxicity.

2. **The Executive Summary and Chapter 8 found that the leachate was quite toxic, largely attributable to ammonia. However, the report concludes, based on the hydrodynamic water quality model, that after dilution there would be no toxicity in the water column. There are reasons to question or be concerned with this conclusion.**

   a. **Did the model use leachate specific to each landfill section modelled. The Department is concerned that leachate strength varies from mound to mound and the model must address this.**

      Response: Yes, input to the model was landfill section specific. Attachment I.B.2. contains a table showing the leachate characteristics for each section.

   b. **The model is useful only for assessing water column affects, where there is considerable dilution. However, the leachate probably runs into shallows from upland or percolates up through the sediments, where in either case there is little or no dilution, and benthic animals are exposed to concentrated leachate, i.e. acutely toxic doses.**

      Response: There is no need to speculate as to the concentrations of ammonia in the sediments since the sites were sampled and analyzed as part of this study. The conclusions are based on actual samples in Fresh Kill. (Reported in FSWSR, December 23, 1993; page 6-16) Also, the effects on the benthic communities were reported and concluded that there were no significant differences between benthic communities near the landfill and at the reference station (FSWSR, P. 7-30). The objective of the study was to isolate the effects of the landfill on the benthic communities.

Comparison to the commenter's suggested surrogate criteria, shows that the Fresh Creek systems ammonia levels exceed those numbers as do all except one of the sediment samples obtained in this study. In fact, the pore water data obtained by NYCDEP exceed the water quality criteria.

We must reemphasize the points raised in the introduction to Comment II.C.

- The Arthur Kill sediments are a significant source to the Fresh Kills Creek system; and
- Leachate contributed constituents are not a limiting factor in benthic quality.

In the absence of larger improvements throughout the harbor, one cannot predict that improvement in benthic ecology will occur when the proposed leachate containment system is implemented.

c. **The report assesses/models only potential for acute toxicity in the receiving waters. Since leachate introduction will be continuous what should be modelled for water column effects is potential for water column <u>chronic</u> toxicity. Either new chronic toxicity tests should be conducted measuring appropriate chronic endpoints or use the existing acute data with a <u>more appropriate application factor</u>. The factor used in this report was 0.3. That is only used to estimate an acute LC_{50}. To estimate an appropriate chronic endpoint from acute data, a factor of 0.01, or at the most 0.05, should be applied to the LC_{50} data. This should be done to determine whether this would result in a prediction of chronically toxic levels of leachate in the water column.**

Response: The FSWSR reports an application factor which has been used in development of permit limitations for protection from acute toxicity by regulatory agencies like NYSDEC. The factor was reported in USEPA's Technical Guidance Document for Water Quality Based Toxic Control (1991). Application factors for protection from chronic toxicity must be lower. Application factors of 0.01 or 0.05 are reasonable for this. However, the highest predicted level of TU in ambient water attributable to leachate was $7x10^{-6}$. If

0.01 TU is used as an indicator of chronic toxicity, the leachate contribution of $7x10^{-6}$ TU does not represent chronic toxicity attributable to the leachate. Therefore using a chronic toxicity benchmark does not alter the conclusion of the FSWSR.

d. **The model assumes no background toxicity (P.9-37). In fact, there may be background toxicity in the Arthur Kill at or above 1 Toxic Unit (TU). The landfill leachate could be exacerbating the situation and be contributing to a 1 TU chronic exceedance. The NY-NJ Harbor Estuary Program found some ambient water toxicity in the Arthur Kill. That is being investigated further in that program. Any modelling of toxicity in ambient waters caused by landfill leachate should include appropriate background toxicity, and assess the landfill's share of total toxicity.**

Response: It is agreed that there may be background toxicity in the Arthur Kill. Attachment II.C. shows the distribution of toxicity through the harbor including the Arthur Kill. The objective of this study was to determine the landfill's contribution to toxicity or the incremental increase. We have predicted that $7x10^{-6}$ TU's are contributed by the landfill to the toxicity of ambient waters. As previously stated, this finding demonstrates that the ultimate benefits to be obtained by implementing the proposed leachate controls will be severely limited by background water quality.

References

Addendums to QAPP and QAPjP (July 29, 1992). In letter from T.R. Nabavi (NYCDOS) to N.H. Nosenchuck and G. Burns (NYSDEC).

Baedecker, M.J. and W. Back, 1979a, "Hydrogeological Processes and Chemical Reactions at a Landfill", ***Groundwater***, Vol. 17, No. 5, pp 429-437.

Baedecker, M.J. and W. Back, 1979b, "Modern Marine Sediments as a Natural Analog to the Chemically Stressed Environment of a Landfill", ***Journal of Hydrology***, Vol. 43, pp 393-414.

Brosnan, T., 1994. Personal communication with Christine Danis, IT Corporation (May 3, 1994).

Christensen and Kjeldsen (1989)

Ehrig (1989)

Fetter, C.W., 1988, ***Applied Hydrogeology***, Macmillian Publ. Co., New York, 592 pp.

Fetter, C.W., 1993, ***Contaminant Hydrogeology***, Macmillian Publ. Co., New York, N.Y., 458 pp.

Interstate Sanitation Commission, 1956. Study of Pollution in the Arthur Kill. Technical Report 56-3.

IT Corporation, 1990a, ***"Surface Water and Sediment Investigation Plan,"*** Document No. 529363-00196 Revision 1, dated July 26, 1991. Prepared for: City of New York, Department of Sanitation.

IT Corporation, 1991, ***"Surface Water and Sediment Literature Review Report,"*** Prepared for: City of New York, Department of Sanitation, New York, New York (April 1, 1991).

IT Corporation, 1993d, ***"Final Hydrogeological Report,"*** Prepared for: City of New York, Department of Sanitation, New York, New York (November 26, 1993).

IT Corporation, 1993e, ***"Final Surface Water and Sediment Investigation Report,"*** Prepared for: City of New York, Department of Sanitation, New York, New York (December 23, 1993).

IT Corporation, 1993f, ***"Final Leachate Mitigation Report,"*** Prepared for: City of New York, Department of Sanitation, New York, New York (October 12, 1993).

IT Corporation, 1994, ***"Draft Leachate Mitigation Evaluation for Section 2/8 and 3/4,"*** Prepared for: City of New York, Department of Sanitation, New York, New York (January 12, 1994).

Long et. al. 1993, unpublished, from Stern, Eric A., A. Lechick, D. Pabst, and Seth Ausubel. Assessment and Management of Dioxin Contaminated Sediments in the New York/New Jersey Estuary, presented to the Hudson River Foundation, March 1, 1994.

NYCDEP (New York City Department of Environmental Protection). 1993. New York Harbor Water Quality Survey Data, 1991-1992.

SCS Engineers, 1991, ***"Final Cover Design Report, Appendix A-3, Milestone 6, Order on Consent, Fresh Kills Landfill,"*** Prepared for: City of New York, Department of Sanitation, New York, New York.

Snedecor, G.W. and W.G. Cochran, 1976, ***Statistical Methods***, Iowa State University Press, Ames, Iowa, 593 p.

Stumm, W. and J.M. Morgan, 1981, ***Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters***, John Wiley and Sons, New York, New York.

USEPA, 1990, Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms.

USEPA, 1991, Technical Guidance Document for Water Quality Based Toxic Control.

USEPA, 1993, Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. Memorandum dated October 1, 1993 from M.G. Prothro (Office of Water) to Water Management Division Directors.

ATTACHMENTS

The following attachments contain supporting tables, figures and text referenced in the responses to the comments. The materials are arranged in groups according to the response (and associated comment) in which they are referenced. The attachment number corresponds to the pertinent comment number. Contents of each attachment are identified on the first page of the attachment.

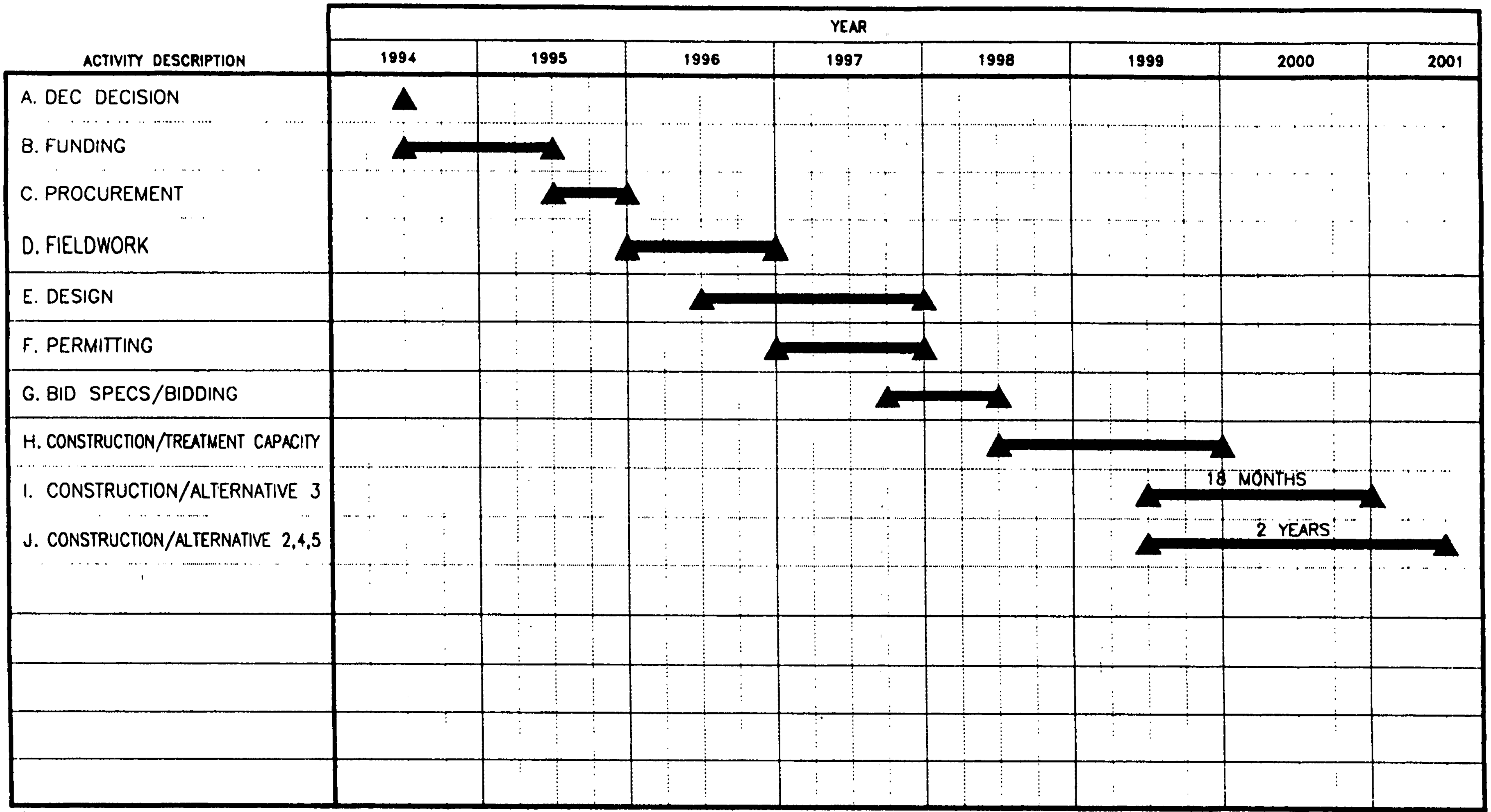
List of Attachments

ATTACHMENT I.A
FSWSR Table 9-15 Leachate Loading to Surface Waters

	FLUX TO RIVERS		LOAD TO RIVERS		
CONSTITUENT	ft ^ 3/day	gal/day	kg/day	lb/day	DATA FILE
Arsenic	174,470	1,305,036	0.088	0.194	SWGWFHR1
Barium	174,470	1,305,036	6.086	13.420	SWGWFHR2
Boron	174,470	1,305,036	17.905	39.481	SWGWFHR3
Cadmium	174,470	1,305,036	0.020	0.043	SWGWFHR4
Chromium	174,470	1,305,036	0.214	0.471	SWGWFHR5
Copper	174,470	1,305,036	0.147	0.324	SWGWFHR6
Iron	174,470	1,305,036	114.880	253.311	SWGWFHR7
Lead	174,470	1,305,036	0.243	0.536	SWGWFHR8
Manganese	174,470	1,305,036	5.112	11.271	SWGWFHR9
Nickel	174,470	1,305,036	0.159	0.350	SWGWFH10
Tin	174,470	1,305,036	0.420	0.926	SWGWFH11
Vanadium	174,470	1,305,036	0.154	0.339	SWGWFH12
Zinc	174,470	1,305,036	1.296	2.857	SWGWFH13
Ammonia	174,470	1,305,036	1910.239	4212.077	SWGWFH14
BOD	174,470	1,305,036	232.781	513.282	SWGWFH15
COD	174,470	1,305,036	2835.569	6252.429	SWGWFH16
Cyanide	174,470	1,305,036	0.117	0.258	SWGWFH17
TKN	174,470	1,305,036	3045.700	6715.768	SWGWFH18
Phenols	174,470	1,305,036	4.310	9.504	SWGWFH19

23-Nov-93

ATTACHMENT I.A.3b
Implementation Schedule for Sections 2/8 and 3/4
Leachate Mitigation Measures



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				ENGINEER:		
				APPROVED BY:		

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NEW YORK CITY DEPARTMENT OF SANITATION
FRESH KILLS LANDFILL
STATEN ISLAND, RICHMOND COUNTY, NEW YORK

SHEET TITLE:
FIGURE 5.3-1
IMPLEMENTATION SCHEDULE FOR SECTIONS 2/8 AND 3/4 LEACHATE MITIGATION MEASURES

JOB No. 529383
DATE 1/11/94
SHEET . OF .
DRAWING No. 529383-A893

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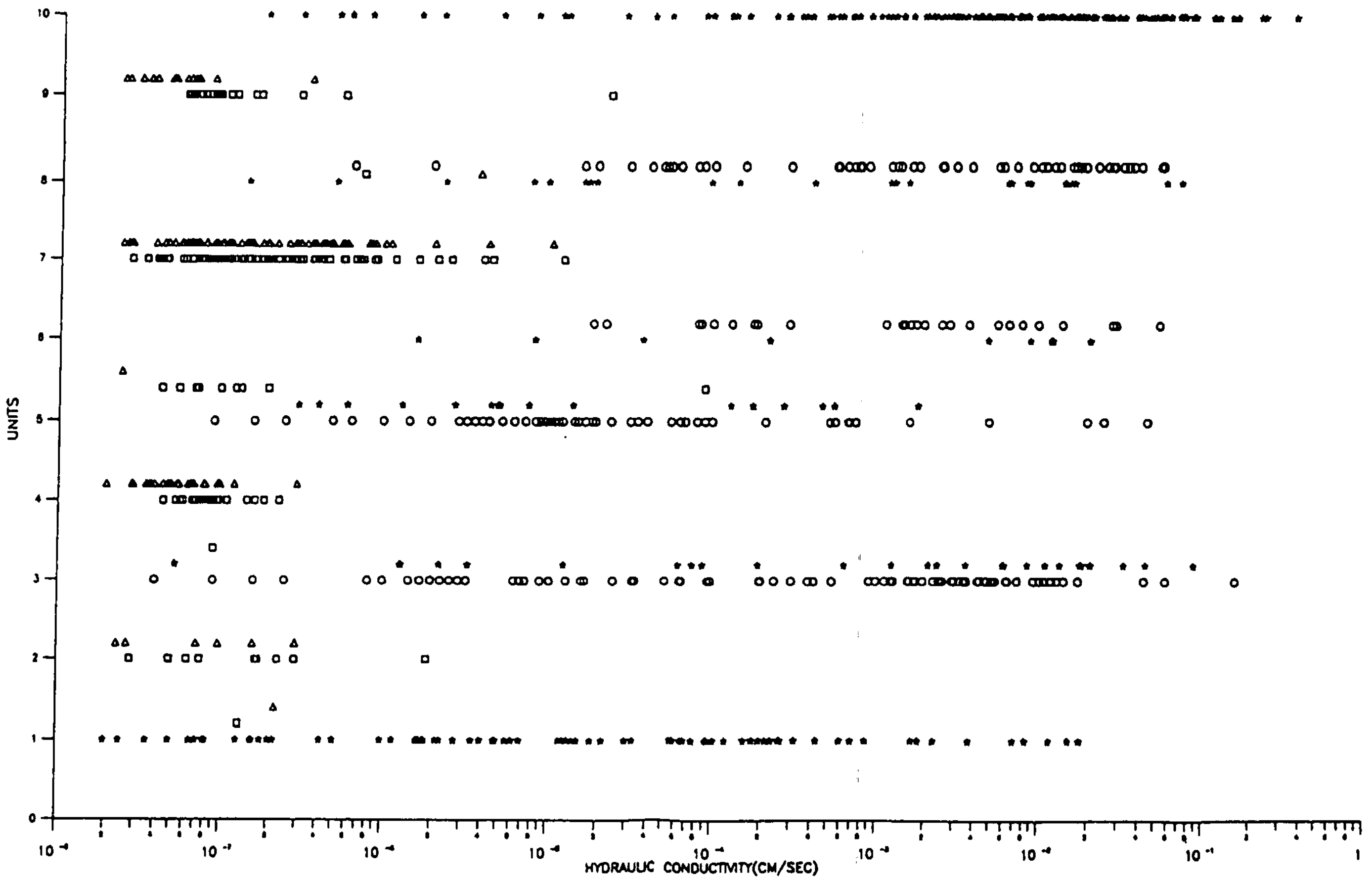
ATTACHMENT I.B.1
Hydraulic Conductivity Range Data and Distribution Statistics

STRATIGRAPHIC UNIT VS PERMEABILITY: 1/9,6/7,2/8,3/4,BF & AK INCLUSIVE

1 = BEDROCK
2 = RESIDUAL CLAY
3 = CRETACEOUS SAND
4 = CRETACEOUS CLAY
5 = GLACIAL TILL
6 = GLACIAL SAND
7 = GLACIAL CLAY
8 = RECENT SAND
9 = RECENT SILT & CLAY
10 = FILL

ooooo HAZEN PERMEABILITY
••••• IN-SITU PERMEABILITY
□□□□□ LABORATORY PERMEABILITY (Kv)
△△△△△ LABORATORY PERMEABILITY (Kh)



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CHECKED BY:	LC	2/93
ENGINEER:		
APPROVED BY:	RM	2/93

SCALE

AS SHOWN

INTERNATIONAL TECHNOLOGY CORPORATION

Wehran EnviroTech
Wehran-New York, Inc.

NEW YORK CITY DEPARTMENT OF SANITATION
FRESH KILLS LANDFILL
STATEN ISLAND, RICHMOND COUNTY, NEW YORK

FIGURE 6.2

DISTRIBUTION OF HYDRAULIC CONDUCTIVITY BY STRATIGRAPHIC UNITS FOR THE REGIONAL PROJECT AREA

JOB No. 528363
DATE 2/26/93
SHEET . OF .
DRAWING No.

TABLE 6.4A
SUMMARY OF LOGARITHMIC DISTRIBUTION STATISTICS
FOR HYDRAULIC CONDUCTIVITY DATA
FRESH KILLS LANDFILL LEACHATE MITIGATION SYSTEM PROJECT

Lithologic Unit	Test Method	Sample Size	Coefficient of		
			Variation	Skewness	Kurtosis
Refuse/Fill	In situ	166	0.494	-1.443	2.273
Recent Silt and Clay	Lab Kv	21	0.085	2.829	8.084
Recent Silt and Clay	Lab Kh	18	0.037	1.472	2.480
Recent Sand	In situ	24	0.470	-0.374	-0.947
Glacial Clay	Lab Kv	104	0.072	1.266	1.786
Glacial Clay	Lab Kh	83	0.074	0.849	0.945
Glacial Sand	In situ	10	0.468	-0.248	-1.346
Glacial Till	In situ	21	0.339	0.104	-1.118
Glacial Till	Hazen	64	0.263	0.686	0.561
Cretaceous Clay	Lab Kv	31	0.023	1.079	0.948
Cretaceous Clay	Lab Kh	27	0.033	0.826	1.370
Cretaceous Sand	In situ	30	0.538	-1.105	0.146
Cretaceous Sand	Hazen	107	0.428	-0.552	-0.781
Residual Clay	Lab Kv	9	0.078	0.805	0.188
Residual Clay	Lab Kh	7	0.064	-0.215	-1.389
Weathered Bedrock	In situ	49	0.333	0.058	-0.871
Bedrock	In situ	22	0.356	-0.175	-1.055

TABLE 6.4
SUMMARY OF ARITHMETIC DISTRIBUTION STATISTICS
FOR HYDRAULIC CONDUCTIVITY DATA
FRESH KILLS LANDFILL LEACHATE MITIGATION SYSTEM PROJECT

Lithologic Unit	Test Method	Sample Size	Coefficient of Variation	Coefficient of Skewness	Coefficient of Kurtosis
Refuse/Fill	In situ	166	2.052	4.447	24.627
Recent Silt and Clay	Lab Kv	21	4.051	4.243	16.020
Recent Silt and Clay	Lab Kh	18	1.058	3.202	9.547
Recent Sand	In situ	24	2.079	2.679	6.094
Glacial Clay	Lab Kv	104	2.923	6.983	55.228
Glacial Clay	Lab Kh	83	2.857	6.896	51.172
Glacial Sand	In situ	10	1.566	1.568	1.345
Glacial Till	In situ	21	2.622	2.840	6.734
Glacial Till	Hazen	64	4.329	5.140	27.177
Cretaceous Clay	Lab Kv	31	0.462	2.007	3.743
Cretaceous Clay	Lab Kh	27	0.780	3.226	11.678
Cretaceous Sand	In situ	30	1.667	2.930	9.439
Cretaceous Sand	Hazen	107	3.482	7.731	65.925
Residual Clay	Lab Kv	9	1.788	2.367	3.814
Residual Clay	Lab Kh	7	0.839	0.502	-1.355
Weathered Bedrock	In situ	49	3.121	3.397	10.377
Bedrock	In situ	22	1.694	1.764	2.254

ATTACHMENT I.B.2
Comparison of Leachate Chemistry Active (Section 1/9) Versus Stable (Section 6/7) Landfill Environments

SECTION 1/9 SHALLOW/REFUSE WELLS	ALKALINITY ug/L	AMMONIA ug/L	BOD5 ug/L	TOC ug/L	CHLORIDE ug/L	COD ug/L	CYANIDE ug/L	HARDNESS ug/L	CHROMIUM+6 ug/L	NITRATE ug/L	TKN ug/L	PHENOLS ug/L	TDS ug/L	SALINITY ug/L
N	160.0	156.0	143.0	156.0	156.0	159.0	142.0	155.0	160.0	140.0	157.0	79.0	160.0	145.0
MEAN	3,689,262.5	608,939.7	98,004.9	464,377.6	1,743,801.3	1,274,287.4	48.6	625,683.9	102.2	59.9	976,352.8	2,291.8	5,277,406.3	5.7
STANDARD DEV.	2,436,820.5	655,314.7	140,361.9	414,684.8	1,731,461.0	1,301,947.1	58.8	465,369.3	110.7	99.6	1,571,277.4	19,111.4	3,878,656.0	3.9
MEDIAN	3,505,000.0	530,500.0	51,000.0	398,500.0	1,355,000.0	1,000,000.0	25.6	490,000.0	50.0	26.0	714,000.0	87.0	4,510,000.0	5.0
GEO. MEAN	2,763,353.7	287,906.5	51,058.3	318,939.0	1,227,525.0	793,421.4	17.0	536,206.2	59.5	36.4	480,316.9	113.8	4,285,507.7	ERR
MAXIMUM	12,300,000.0	4,960,000.0	1,200,000.0	2,650,000.0	9,130,000.0	7,110,000.0	230.0	3,180,000.0	500.0	829.0	17,200,000.0	170,000.0	23,300,000.0	23.0
MINIMUM	70,000.0	20.0	2,000.0	13,500.0	129,000.0	20,000.0	1.0	164,000.0	7.0	20.0	486.0	50.0	760,000.0	0.0
70th PERCENTILE	4,605,000.0	676,500.0	109,200.0	555,500.0	1,710,000.0	1,468,000.0	52.4	584,000.0	100.0	42.3	922,200.0	123.0	5,692,000.0	6.9
80th PERCENTILE	5,252,000.0	785,000.0	142,800.0	679,000.0	2,110,000.0	1,710,000.0	94.1	740,000.0	200.0	53.8	1,128,000.0	161.2	6,608,000.0	7.8
90th PERCENTILE	6,100,000.0	1,045,000.0	207,200.0	787,500.0	3,260,000.0	2,390,000.0	143.6	969,000.0	250.0	139.8	1,634,000.0	265.4	8,572,000.0	9.0

SECTION 6/7 SHALLOW/REFUSE WELLS	ALKALINITY ug/L	AMMONIA ug/L	BOD5 ug/L	TOC ug/L	CHLORIDE ug/L	COD ug/L	CYANIDE ug/L	HARDNESS ug/L	CHROMIUM+6 ug/L	NITRATE ug/L	TKN ug/L	PHENOLS ug/L	TDS ug/L	SALINITY ug/L
N	167.0	166.0	152.0	167.0	165.0	166.0	138.0	163.0	167.0	137.0	163.0	17.0	167.0	154.0
MEAN	1,834,401.2	236,094.2	30,217.6	201,870.6	1,029,387.9	409,073.5	19.2	626,490.8	58.1	42.4	380,977.9	107.5	2,778,083.8	3.0
STANDARD DEV.	844,440.4	157,951.3	47,980.5	143,452.7	905,549.2	455,385.0	23.3	443,393.6	195.2	53.5	292,897.6	77.6	1,906,800.4	2.2
MEDIAN	1,740,000.0	204,500.0	17,900.0	172,000.0	740,000.0	251,500.0	10.2	530,000.0	25.0	20.0	310,000.0	75.0	2,140,000.0	2.5
GEO. MEAN	1,623,656.8	170,014.8	19,726.8	145,063.9	716,118.8	274,973.1	12.0	563,157.2	35.7	30.0	270,076.4	89.4	2,267,228.7	ERR
MAXIMUM	4,480,000.0	1,060,000.0	420,000.0	761,000.0	4,830,000.0	3,140,000.0	163.0	3,900,000.0	2,500.0	300.0	1,860,000.0	303.0	10,400,000.0	17.0
MINIMUM	204,000.0	326.0	2,000.0	189.0	52,000.0	20,800.0	1.0	300,000.0	7.0	20.0	1,060.0	50.0	340,000.0	0.0
70th PERCENTILE	2,186,000.0	304,000.0	27,560.0	253,400.0	1,196,000.0	417,000.0	20.5	610,000.0	50.0	31.0	478,000.0	86.2	3,280,000.0	3.8
80th PERCENTILE	2,626,000.0	351,000.0	34,800.0	308,800.0	1,642,000.0	533,000.0	27.9	668,000.0	50.0	35.0	567,600.0	177.4	3,784,000.0	4.1
90th PERCENTILE	2,920,000.0	427,000.0	49,350.0	405,800.0	2,112,000.0	876,000.0	40.1	738,000.0	50.0	72.4	683,600.0	222.8	5,208,000.0	5.0

SECTION 1/9 SHALLOW/REFUSE WELLS	SULFATE ug/L	SULFIDE ug/L	ALUMINUM ug/L	ANTIMONY ug/L	ARSENIC ug/L	BARIUM ug/L	BERYLLIUM ug/L	BORON ug/L	CADMIUM ug/L	CALCIUM ug/L	CHROMIUM ug/L	COBALT ug/L	COPPER ug/L	IRON ug/L	LEAD ug/L
N	150.0		125.0	141.0	157.0	159.0	160.0	159.0	156.0	160.0	158.0	150.0	125.0	157.0	141.0
MEAN	52,888.9	3,771.9	1,268.9	40.8	39.1	1,133.8	1.5	4,831.0	5.5	70,097.5	104.9	26.2	38.6	22,826.7	69.0
STANDARD DEV.	135,883.8	5,622.4	2,614.8	72.4	115.9	876.5	1.2	2,707.5	9.5	70,193.4	117.6	21.1	87.2	40,688.7	207.2
MEDIAN	17,200.0	2,300.0	344.0	23.0	7.2	936.0	1.0	4,460.0	2.0	48,100.0	79.8	21.1	10.8	9,990.0	13.6
GEO. MEAN	19,262.6	1,069.5	413.4	23.3	8.6	856.8	1.3	3,771.2	3.0	50,836.5	49.1	19.1	14.7	12,140.9	14.7
MAXIMUM	1,080,000.0	46,400.0	16,700.0	300.0	500.0	5,090.0	5.9	10,700.0	40.0	395,000.0	573.0	112.0	860.0	277,000.0	2,090.0
MINIMUM	1,000.0	40.0	18.0	8.0	1.0	56.6	1.0	21.0	1.0	10,200.0	2.0	2.0	2.0	330.0	1.0
70th PERCENTILE	25,030.0	4,256.0	637.0	23.0	11.4	1,326.0	1.0	5,796.0	3.3	66,040.0	130.0	29.8	29.2	16,040.0	33.5
80th PERCENTILE	36,060.0	5,952.0	1,136.0	30.0	20.1	1,638.0	1.0	7,362.0	4.1	89,140.0	151.6	37.3	60.0	22,600.0	61.1
90th PERCENTILE	82,150.0	8,224.0	2,904.0	30.0	28.2	2,092.0	3.0	9,280.0	10.0	144,300.0	185.8	56.3	95.0	38,920.0	118.0

SECTION 6/7 SHALLOW/REFUSE WELLS	SULFATE ug/L	SULFIDE ug/L	ALUMINUM ug/L	ANTIMONY ug/L	ARSENIC ug/L	BARIUM ug/L	BERYLLIUM ug/L	BORON ug/L	CADMIUM ug/L	CALCIUM ug/L	CHROMIUM ug/L	COBALT ug/L	COPPER ug/L	IRON ug/L	LEAD ug/L
N	150.0	158.0	118.0	146.0	163.0	166.0	165.0	166.0	151.0	167.0	151.0	158.0	147.0	162.0	155.0
MEAN	17,547.5	1,432.7	3,224.6	43.0	35.5	1,327.4	1.5	3,227.0	7.4	97,264.7	37.5	15.6	80.4	29,589.8	100.4
STANDARD DEV.	56,769.8	1,441.7	7,270.3	74.6	119.4	679.8	1.1	1,483.6	13.6	100,841.4	66.8	24.6	205.0	47,694.2	250.0
MEDIAN	3,925.0	1,060.0	211.5	23.0	2.5	1,170.0	1.0	3,055.0	2.0	74,100.0	12.3	5.5	5.5	14,150.0	5.6
GEO. MEAN	5,042.7	691.8	378.2	24.5	3.8	1,163.0	1.2	2,735.7	3.2	78,414.0	13.9	8.2	10.8	17,574.3	10.2
MAXIMUM	412,000.0	7,840.0	45,500.0	300.0	500.0	3,440.0	5.0	7,400.0	72.3	750,000.0	570.0	215.0	1,230.0	329,000.0	1,440.0
MINIMUM	1,000.0	40.0	12.0	8.0	1.0	156.0	1.0	2.0	1.0	26,900.0	2.0	3.0	1.0	1,840.0	1.0
70th PERCENTILE	5,645.0	1,840.0	1,671.0	23.0	4.1	1,470.0	1.0	3,880.0	2.8	87,520.0	28.9	10.3	17.1	19,950.0	27.7
80th PERCENTILE	8,424.0	2,400.0	3,500.0	30.0	6.7	1,810.0	1.0	4,570.0	3.0	109,800.0	70.0	19.6	68.8	28,980.0	72.8
90th PERCENTILE	31,100.0	3,280.0	9,524.0	34.3	23.8	2,240.0	3.0	5,280.0	21.9	134,200.0	101.0	43.4	243.6	72,900.0	352.0

SECTION 1/9 SHALLOW/REFUSE WELLS	MAGNESIUM ug/L	MANGANESE ug/L	MERCURY ug/L	NICKEL ug/L	POTASSIUM ug/L	SELENIUM ug/L	SILVER ug/L	SODIUM ug/L	THALLIUM ug/L	TIN ug/L	VANADIUM ug/L	ZINC ug/L
N	160.0	151.0	160.0	152.0	160.0	157.0	160.0	160.0	160.0	144.0	149.0	112.0
MEAN	66,072.5	1,982.5	0.3	67.6	295,410.0	50.0	6.8	1,580,758.1	26.6	176.8	52.9	246.6
STANDARD DEV.	61,474.5	7,547.9	0.3	59.0	204,123.6	183.2	16.4	1,447,543.0	96.7	168.1	52.5	400.7
MEDIAN	52,050.0	93.0	0.2	48.5	302,000.0	1.2	2.0	1,300,000.0	1.0	138.5	32.6	105.0
GEO. MEAN	54,938.5	139.7	0.2	43.6	211,596.8	2.5	3.0	1,149,228.9	2.0	101.0	31.1	120.7
MAXIMUM	402,000.0	52,400.0	2.0	285.0	1,220,000.0	750.0	70.0	11,100,000.0	400.0	699.0	285.0	2,510.0
MINIMUM	18,200.0	9.8	0.2	4.0	3,590.0	1.0	2.0	48,200.0	1.0	10.0	3.0	3.0
70th PERCENTILE	65,360.0	150.0	0.2	91.1	360,600.0	2.0	3.0	1,723,000.0	2.0	250.0	71.6	194.2
80th PERCENTILE	69,600.0	245.0	0.2	106.8	392,200.0	5.0	3.0	2,002,000.0	2.0	272.6	95.9	318.4
90th PERCENTILE	84,200.0	964.0	0.3	140.7	481,100.0	6.2	3.6	2,775,000.0	5.0	390.2	128.4	531.7

SECTION 6/7 SHALLOW/REFUSE WELLS	MAGNESIUM ug/L	MANGANESE ug/L	MERCURY ug/L	NICKEL ug/L	POTASSIUM ug/L	SELENIUM ug/L	SILVER ug/L	SODIUM ug/L	THALLIUM ug/L	TIN ug/L	VANADIUM ug/L	ZINC ug/L
N	167.0	162.0	167.0	155.0	166.0	167.0	153.0	167.0	167.0	152.0	138.0	109.0
MEAN	74,576.0	231.5	0.3	32.0	133,400.0	46.3	7.2	676,866.5	28.9	74.5	36.0	504.9
STANDARD DEV.	33,346.0	374.4	0.3	52.4	84,449.6	178.1	16.2	496,237.7	106.1	106.4	48.7	1,074.1
MEDIAN	69,100.0	105.0	0.2	11.3	110,000.0	1.0	3.0	516,000.0	2.0	32.0	18.8	63.3
GEO. MEAN	69,758.8	121.4	0.2	14.9	107,197.2	1.8	3.3	517,110.5	2.5	36.8	20.1	101.0
MAXIMUM	267,000.0	2,670.0	2.1	421.0	421,000.0	750.0	70.0	2,420,000.0	750.0	601.0	330.0	6,150.0
MINIMUM	17,700.0	18.5	0.2	3.0	13,400.0	1.0	2.0	56,300.0	1.0	10.0	3.0	3.0
70th PERCENTILE	75,700.0	173.5	0.2	25.3	162,500.0	1.2	3.0	872,400.0	2.0	49.0	30.7	189.2
80th PERCENTILE	82,980.0	249.2	0.2	43.0	204,000.0	2.0	3.0	1,020,000.0	4.4	101.0	62.7	480.0
90th PERCENTILE	94,420.0	547.2	0.2	90.8	253,500.0	5.0	5.4	1,284,000.0	20.0	250.0	80.0	1,810.0

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ATTACHMENT I.B.3
Summary of Groundwater Flux and Ammonia Load to Discrete Surface Water Channels

SUMMARY OF GROUNDWATER FLUX AND AMMONIA LOAD TO DISCRETE SURFACE WATER CHANNELS
LANDFILL SECTION 2/8 AND 3/4 FEASIBILITY STUDY: REVISED YEAR 2000 IMPLEMENTATION DATE

Stream Reach and Associated Tributary Streams	FLUX TO SURFACE WATERS (ft^3/day)																								
	Alternative #1					Alternative #2					Alternative #3					Alternative #4					Alternative #5				
	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045
ARTHUR KILL	17,808	2,644	1,060	790	671	17,808	2,644	1,060	790	671	17,808	2,644	1,060	789	672	17,808	2,644	1,060	790	672	17,808	2,644	1,060	790	671
Sleight Creek	14,474	12,020	10,793	10,250	9,910	14,474	12,020	10,793	10,250	9,910	14,474	12,020	10,793	10,250	9,910	14,474	12,020	10,793	10,250	9,910	14,474	12,020	10,793	10,250	9,910
Total	32,282	14,664	11,853	11,040	10,581	32,282	14,664	11,853	11,040	10,581	32,282	14,664	11,853	11,039	10,582	32,282	14,664	11,853	11,040	10,582	32,282	14,664	11,853	11,040	10,581
FRESH KILLS	39,527	23,400	14,532	9,748	8,507	39,527	23,400	11,760	8,682	7,656	39,527	23,400	14,095	8,037	7,250	39,527	23,400	12,132	8,385	7,420	39,527	23,400	12,289	8,818	7,850
Unnamed Tributary	8,094	7,208	5,675	4,062	3,642	8,094	7,208	4,199	3,595	3,509	8,094	7,208	5,545	3,739	3,575	8,094	7,208	4,199	3,595	3,508	8,094	7,208	4,199	3,595	3,509
Total	47,621	30,608	20,207	13,810	12,149	47,621	30,608	15,959	12,277	11,165	47,621	30,608	19,640	11,776	10,825	47,621	30,608	16,331	11,980	10,928	47,621	30,608	16,488	12,413	11,359
RICHMOND CREEK	23,260	10,848	6,710	4,514	4,054	23,260	10,848	3,734	2,569	2,339	23,260	10,848	5,502	2,415	2,174	23,260	10,848	3,959	2,586	2,347	23,260	10,848	4,121	2,848	2,609
Tributary # 1	22,747	16,966	8,543	4,593	4,240	22,747	16,966	5,891	3,356	3,088	22,747	16,966	7,855	3,239	2,990	22,747	16,966	6,679	3,157	2,881	22,747	16,966	7,050	3,887	3,591
Tributary # 2	2,022	1,864	1,644	1,510	1,481	2,022	1,864	1,463	1,375	1,360	2,022	1,864	1,563	1,324	1,295	2,022	1,864	1,463	1,375	1,360	2,022	1,864	1,463	1,375	1,360
South Richmond Ave. Ck.	11,547	6,166	3,581	3,032	3,017	11,547	6,166	3,582	3,032	3,016	11,547	6,166	3,581	3,031	3,017	11,547	6,166	3,582	3,032	3,016	11,547	6,166	3,582	3,032	3,016
Total	59,576	35,844	20,478	13,649	12,792	59,576	35,844	14,670	10,332	9,803	59,576	35,844	18,501	10,008	9,475	59,576	35,844	15,682	10,149	9,604	59,576	35,844	16,216	11,142	10,577
MAIN CREEK	29,497	15,300	9,115	6,204	5,570	29,497	15,300	6,603	5,145	4,853	29,497	15,300	8,571	5,461	5,065	29,497	15,300	6,601	5,145	4,845	29,497	15,300	6,604	5,146	4,858
Travis Creek	1,889	1,607	1,296	1,215	1,209	1,889	1,607	1,293	1,213	1,208	1,889	1,607	1,296	1,212	1,209	1,889	1,607	1,293	1,213	1,208	1,889	1,607	1,293	1,213	1,204
North Richmond Ave. Ck.	3,605	2,206	1,600	1,475	1,474	3,605	2,206	1,600	1,475	1,474	3,605	2,206	1,600	1,475	1,474	3,605	2,206	1,600	1,475	1,474	3,605	2,206	1,600	1,475	1,474
Total	34,991	19,113	12,011	8,894	8,253	34,991	19,113	9,496	7,833	7,535	34,991	19,113	11,467	8,148	7,748	34,991	19,113	9,494	7,833	7,527	34,991	19,113	9,497	7,834	7,536
TOTAL	174,470	100,229	64,550	47,393	43,775	174,470	100,229	51,979	41,482	39,084	174,470	100,229	61,461	40,971	38,630	174,470	100,229	53,360	41,002	38,641	174,470	100,229	54,054	42,428	40,052

Stream Reach and Associated Tributary Streams	AMMONIA LOAD TO SURFACE WATERS (kg/day)																								
	Alternative #1					Alternative #2					Alternative #3					Alternative #4					Alternative #5				
	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045	1993	1997	2000	2015	2045
ARTHUR KILL	306	11	4	3	3	306	11	4	3	3	306	11	4	3	3	306	11	4	3	3	306	11	4	3	3
Sleight Creek	169	51	46	43	42	169	51	46	43	42	169	51	46	43	42	169	51	46	43	42	169	51	46	43	42
Total	475	62	50	47	45	475	62	50	47	45	475	62	50	47	45	475	62	50	47	45	475	62	50	47	45
FRESH KILLS	577	176	111	69	60	577	176	50	37	32	577	176	87	34	31	577	176	53	36	31	577	176	58	41	36
Unnamed Tributary	62	31	24	17	15	62	31	18	15	15	62	31	23	16	15	62	31	18	15	15	62	31	18	15	15
Total	639	207	135	87	76	639	207	68	52	47	639	207	111	50	46	639	207	70	51	46	639	207	76	56	51
RICHMOND CREEK	178	76	47	30	27	178	76	16	11	10	178	76	36	10	9	178	76	17	11	10	178	76	17	11	10
Tributary # 1	177	131	66	35	32	177	131	25	14	13	177	131	33	14	13	177	131	28	13	12	177	131	38	21	19
Tributary # 2	14	14	12	11	11	14	14	6	6	6	14	14	7	6	5	14	14	6	6	6	14	14	6	6	6
South Richmond Ave. Ck.	65	26	15	13	13	65	26	15	13	13	65	26	15	13	13	65	26	15	13	13	65	26	15	13	13
Total	433	247	140	90	83	433	247	62	44	42	433	247	91	42	40	433	247	66	43	41	433	247	77	51	48
MAIN CREEK	316	174	109	71	61	316	174	28	22	21	316	174	91	23	21	316	174	28	22	21	316	174	28	22	21
Travis Creek	24	21	17	15	15	24	21	5	5	5	24	21	5	5	5	24	21	5	5	5	24	21	5	5	5
North Richmond Ave. Ck.	22	9	7	6	6	22	9	7	6	6	22	9	7	6	6	22	9	7	6	6	22	9	7	6	6
Total	363	204	132	92	83	363	204	40	33	32	363	204	103	34	33	363	204	40	33	32	363	204	40	33	32
TOTAL	1,910	720	458	315	286	1,910	720	220	176	165	1,910	720	355	173	164	1,910	720	227	174	164	1,910	720	243	187	176

ATTACHMENT II.A
Surface Water and Sediment Investigation Plan
July 26, 1991 Excerpts

Literature Review April 1991 Excerpts

NEW YORK CITY
DEPARTMENT OF SANITATION
CONTRACT NO. 901-9260

FRESH KILLS LEACHATE MITIGATION SYSTEM PROJECT

SURFACE WATER AND SEDIMENT INVESTIGATION PLAN

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IT PROJECT NO. 529363
DOCUMENT NO. 529363-00196

REVISION 1
JULY 26, 1991

Surface Water and Sediment Investigation

Addendum to the Work Plan dated December 31, 1991

Revised July 26, 1991

Document Number 529363-00196 Revision 1

NYSDEC Case No. D2-9001-89-03, Appendix A-7

1.0 INTRODUCTION

1.1 OBJECTIVES

The Surface Water and Sediment Investigation Plan (SWSIP) is prepared to respond, in part, to the requirements set forth in the New York State Department of Environmental Conservation (NYSDEC) Order of Consent (CO) Case Number D2-9001-89-03 relative to the Environmental Conservation Law Articles 27, 17, and 25 and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York Parts 360, 751 and 661. Specifically, this investigation plan addresses that section of the CO Compliance Schedule Appendix A-7 Surface Water and Sediment Investigation, as well as the requirements of 6 NYCRR Part 360-2.11(a), (b) and (c) which are referred to in A-7.

The SWSIP defines the objectives of the Surface Water and Sediment Investigation; the scope of all tasks to be performed as required in A-7 in order to meet the objectives, the methods and procedures to be used for data collection and analysis following the requirements of 6 NYCRR Part 360-2.11 and the deliverables for each task. Some of the surface water and sediment data collected during the course of this investigation will be used along with the Hydrogeologic Investigation groundwater data in the design of the leachate mitigation system for the landfill.

The schedule and data collection and analysis program presented herein has been developed using a multi-phased approach where biological evaluations are combined with chemical evaluations to determine the overall impact to the environment and the biological communities. Surface water data collection will be evaluated after three quarters and benthic data will be evaluated after two quarters through the use of statistical, graphical and numerical analyses and compared to the defined data objectives. This phased data analysis approach will maximize the information obtained from the sampling locations and allow for a high level of regulatory agency, city, and consultant involvement in the ongoing review and design of the field investigation program. Milestones for field activities and reports are summarized in Table 1-1.

It is the overall purpose of the SWSIP to supply surface water and sediment data and analysis to support the reporting requirements of the Final Surface Water and Sediment Investigation Report of the Fresh Kills Landfill as defined in 6 NYCRR Part 360-2.11 and CO Appendix A-7. The following general objectives have been defined in support of these requirements:

- Compliance with Appendix A-7 of the Consent Order;
- Consistency with information required to support Part 360 permit application and other associated permits (i.e., SPDES);
- Assess the impacts of the landfill leachate on the local environment;
- Provide information on influent characteristics and effluent quality criteria that can be applied to treatment process design; and
- Provide a basis for design of a long term monitoring program.

In addition to the general objectives described above, specific objectives have been defined to provide information for the evaluations required. These objectives are:

- Assess the impacts of landfill leachate on the environment in terms of compliance with water quality standards by determining the ambient concentrations of specific chemicals in the surface waters and sediments;
- Determine whether leachate release has an adverse effect on the benthic community of the Fresh Kill/Arthur Kill system;
- Determine the relative toxicity of the Landfill leachate on two marine organisms;
- Ascertain the extent to which ammonia is the constituent responsible for observed toxicity;
- Estimate the dispersion and fate of conservative constituents of leachate in the Arthur Kill system;

- Determine the oxygen dynamics and the capacity of the Arthur Kill/Fresh Kills system to assimilate oxygen demanding constituents;
- Provide a basis for determining allowable effluent characteristics in support of the SPDES permitting process; and
- Establish a baseline for a long term monitoring program if a need is indicated.

The assessment of the extent to which the Fresh Kills landfill and associated leachate may be affecting the aqueous and subaqueous environment is being conducted from two approaches. The first approach, which includes the surface water and sediment investigation, benthic ecology, and leachate bioassays is an attempt to discern significant conditions attributable to the landfill from direct environmental measurement. The second approach, which includes the mass transport and wasteload allocation models is a means of estimating the relative contribution of Fresh Kills leachate to ambient conditions even though an effect may not be detected by direct measurement. In the latter case leachate quantity, quality and rate of release as estimated by the hydrogeologic and leachate mitigation studies will be modeled as a source. The contribution of both conservative and biochemically active constituents to ambient conditions will then be estimated using the models.

1.2 SWS INVESTIGATION PLAN ORGANIZATION

The organization of the SWSIP is divided into chapters which describe various data collection, analysis, and reporting activities required to meet the plan objectives, the tasks described in the CO Appendix A-7, and the requirements of 6 NYCRR Part 360-2.11. A brief description of the contents of each SWSIP chapter follows.

Chapter 2.0 provides background information on project site location and history, describes previous investigations in the Fresh Kills and Arthur Kill waterways and presents a summary of environmental characteristics of the Kills system.

4.0 SURFACE WATER AND SEDIMENT SAMPLING AND CHEMICAL ANALYSIS

4.1 OBJECTIVES

Appendix A-7 of the CO provides very specific direction as to contents of the Surface Water and Sediment Investigation. In summary the study should consist of:

Station Location - Fifteen stations are to be located on the Fresh Kill Waterway, and a minimum of two stations on the Arthur Kill.

Sampling Schedule - Surface water samples are to be collected quarterly for two years; sediment samples are to be collected during the first quarter of each year (Rounds 1 and 5). During Rounds 1 and 5 water samples are to be taken four times during a tidal cycle.

Analytical Parameters - The water and sediment samples are to be analyzed for parameters defined in 6NYCRR 360-2.11(c) (6) and as specified in Appendix A-7. Grain size analyses are to be performed on sediment samples.

A primary objective of this phase of the investigation is compliance with this specific objective. However, additional objectives have been defined to assure that the study is useful in assessing impact of the landfill to surface waters and in establishing a baseline for long term monitoring. These objectives are:

- Establish sampling stations that allow for comparison to historical data.
- Provide reference data.
- Analyze for parameters that are useful in segregating leachate impacts from general anthropogenic inputs in the system.

Previous studies were reviewed (Section 4.2) and information applied to the design of this investigation as described in Section 4.3.

4.2 BACKGROUND INFORMATION

Increased urbanization of the New York/New Jersey area during the 20th century transformed the Arthur Kill and its associated tributaries into an important center for industries and municipalities. Discharges into the waterway also increased appreciably, introducing an abundance of pollutants from both point and non-point sources and resulting in an overall decline in environmental quality (EA, 1989). Because of the biological significance of the estuary, recent efforts have been made to categorize the various components of the ecosystem and to determine the magnitude of anthropogenic impact.

During the past decade, it has been determined that conditions in the Kill have generally improved, as measured by increasing dissolved oxygen (DO) concentrations (Brosnan et al, 1987). The general longitudinal DO pattern from north to south demonstrates highest values near the southern end of the Arthur Kill, decreasing northward; the lowest values were recorded in the central reaches near Fresh Kills with a slight increase toward the northern end (EA, 1989). It is important to note that the water quality in Fresh Kills has been recognized as being impacted since the 1930's, with an acceleration in decline between 1937 and 1955 (ISC, 1956).

Another parameter which is used as an indicator of relative water quality is ammonia. The NYCDEP (1979) reported that although ammonia concentrations decreased in the New York City harbor by two-thirds since 1974, ammonia levels have remained stable in the Arthur Kill. One possible source for ammonia may be the Fresh Kills landfill. Landfill leachate has been shown to contain high concentrations of nitrogenous compounds, particularly ammonia (Johansen and Carlson, 1976; Zhou and Fillos, 1989). Ahmed and Khanbilvardi (1989) estimated that as much as 2 million gallons of leachate may be released daily by Fresh Kills. Other materials entering the waterway that have been attributed to the leachate include lead (Wehran Engineering, 1983) and phenolic compounds (USDOI, 1967). However, a 1983 mathematical modeling study (Wehran Engineering) concluded that if the influx of pollutants from the landfill were removed, there would only be a marginal improvement in the water quality of the Fresh Kills stream system. This is due to the tidal exchange with the highly compromised Arthur Kill, which receives pollutant inputs from both industrial and municipal discharges far in excess of the loads generated by the landfill (Wehran Engineering, 1983).

A water quality survey of Fresh Kills conducted during spring and summer of 1982 was reported by NYCDOS in 1985. We have evaluated these data as described below.

The sampling data showed no violation of dissolved oxygen standards for both water quality classifications of SD and SC during either high or low tidal periods. However, violations were related to heavy metals, such as lead, zinc and copper; and cyanide. The BOD_5 to COD ratio was low indicating that non-biodegradable constituents were prevalent over biodegradable constituents.

For comparison between the Fresh Kill system and the Arthur Kill, all the sampling data were classified into two groups. The data from Station 2 to 8 were assembled together as Fresh Kills sampling data. The others from Station 1 and 9 to 15 represented the Arthur Kill area data.

In order to consider the worst case, the summer data, which were expected to represent the worst condition when the least dilution of water quality parameters would occur, were compared to the spring data. The comparison was made with the concentration range and the average value for each parameter taken at all sampling stations (Table 4-1). In general, summer water quality was worse than spring water quality for both high water slack and low water slack, especially as Sulfate, Total solids, Total dissolved solids, Total suspended solids and Volatile suspended solids.

Water quality parameters that showed no appreciable difference in concentration values between the Fresh Kill system and the Arthur Kill were eliminated from further analysis, as were parameters whose measured values were as low as to be too close to or below the analytical levels of detection, or which showed an extreme level of variability.

The arithmetic mean was calculated for an array of water quality parameters for high water slack and low water slack for both the Fresh Kill system streams and the Arthur Kill. Statistical analyses were not performed here due to the limited data for each parameter, therefore, only simplified analytical tools were employed.

In general, mean values for the following parameters showed little, if any, difference in both high water slack and low water slack period: temperature, pH, zinc and odor. For parameters exhibiting significant variation, results were nearly equally divided with half indicating better water quality (e.g. Sulfate, Total solids, Total dissolved solids, Lead, and Total chromium) in the Fresh Kill system (Stations 2-8) and half indicating better water quality (e.g. Alkalinity, Iron, Total suspended solids and Volatile suspended solids) in the Arthur Kill. Based on the sampling data, it is concluded that summer data analyses did not reveal any significant difference between the Fresh Kill and the Arthur Kill.

For high tidal and low tidal water quality analysis, the sampling data showed no regularity indicating the pollutant concentration in high tidal period is better or worse than that in low tidal period.

4.3 SURFACE WATER STUDY DESIGN

This study was designed to determine the ambient concentrations of specific chemical parameters in the surface waters of Fresh Kills and adjacent waterways; and to discern those conditions attributable to the leachate discharges.

Null hypotheses have been established as described below.

4.3.1 Null Hypotheses

- The Fresh Kills Landfill leachate has no effect on the water quality of the Fresh Kills and Arthur Kill waterways.

- There is no temporal variation in impact on the Kills.

4.3.2 Field Sampling

Rationale - The purpose of the sampling program is to provide information on the quality of the aqueous environment in the Fresh Kills Landfill vicinity. By developing an extensive chemical profile of the surface waters near the

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1.0 BENTHIC ECOLOGY

1.1 INTRODUCTION

The Benthic Ecology Work Plan outlined herein has been developed in conjuction with the Surface Water and Sediment (SWS) Investigation of the Fresh Kills Leachate Mitigation System Project. The SWSI was prepared to respond, in part, to the requirements set forth in the New York State Department of Environmental Conservation (NYSDEC) Order of Consent (CO) Case Number D2-9001-89-03. Specifically, the SWS Investigation Plan addresses Appendix A-7 of the CO, as well as the requirements of 6 NYCRR Part 360-2.11(a), (b) and (c), which are referenced in A-7. The current Benthic Ecology Work Plan shall serve as an addendum to the SWS Investigation Plan and completes the relevant requirements of Appendix A-7.

The structure of the benthic ecology component of a waterway is usually indicative of the overall viability of an ecosystem. Bottom sediments represent not only a "sink" for the deposition of waterborne contaminants but also a complex interface between solid and liquid phases. The benthic invertebrate segment of the ecosystem is appropriately identified in the Consent Order as the indicator of potential effects. This system is the most stationary and therefore will most directly indicate spatial variation as leachate disperses from the landfill source.

In general, benthic macroinvertebrate evaluations in soft bottoms consist of collecting sediment samples by benthic grabs, sorting to remove the invertebrate populations, and identifying the organisms to the lowest possible taxon, preferably to the species level. Community metrics such as organism abundance, dominance, species diversity, evenness and richness are then used to define the relative health of the system. Further statistical evaluations using multivariate similarity indices are also commonly employed. It is generally accepted that relatively undisturbed environments support communities having large numbers of species with no individual species present in overwhelming abundance.

1.1.1 Background Information

The literature concerning the benthic ecology of the Fresh Kills and Arthur Kill system have been reviewed and presented in the Final Surface Water and Sediment Investigation Plan (December 31, 1990) and the Final Surface Water and Sediment Literature Review Report (April 1, 1991). A synopsis of this information is included here, along with additional information, to facilitate the review of the benthic ecology work plan.

The benthic ecology of Fresh Kills and the Arthur Kill has been strongly influenced by anthropogenic processes such as dams, bulkheading and the filling of marshlands. Additional sources of contaminants include industrial and municipal sewage treatment plant discharges and combined sewer outfalls (EA, 1989a&b). Assemblages of benthic species and their linkage due to trophic relationships are structured by biotic interactions and shared tolerances and requirements for the physical environment (Franz and Harris, 1988). The physical environment of the Arthur Kill and Fresh Kills substrates are soft bottom silted mud, resulting from the absence of an extensive littoral zone and causing a reduction of a detrital food base (Beck, 1989).

The available data on benthic assemblages of the Fresh Kills waterways are limited. The most extensive study to date regarding ecological impact of the Fresh Kills Landfill is the Draft Environmental Impact Statement (DEIS) prepared by Parsons-Brinckerhoff in 1985 (PB, 1985a). The DEIS represents the only major substantiated source of benthic, aquatic and terrestrial flora and fauna for the Fresh Kills waterways and terrestrial environs. A study conducted by the US Army Corps of Engineers (1981, referred to as the PASNY study) also included some stations within Fresh Kills. In addition, a preliminary draft report prepared by SCS Engineers and EcolSciences in 1990 presents some information on the benthic assemblages collected at three locations within the Fresh Kills system.

The results of these studies indicate that the sediments of Fresh Kills maintain a relatively low diversity of benthic macroinvertebrates. The PASNY study identified the polychaete, Streblospio benedicti, as the vastly dominant species during the fall sampling and the oligochaete, Paranais litoralis, as dominant in the spring. Capitella capitata was the dominant species in the Parsons-Brinckerhoff study. Such a great abundance of one species, in an area where the total number of species is low, is usually characteristic of the presence of pollutants. This is in line with evidence that the entire Arthur Kill and associated systems are specifically subject to the diverse stresses of anthropogenic inputs (Mayer, 1982; EA, 1989a&b).

Benthic information in the Arthur Kill is somewhat more available, with several EIS efforts being conducted in the 1970's and 1980's. These studies were carried out for Public Service Electric and Gas Co. (IA, 1974a&b; EA, 1989a,b&c), Consolidated Edison (LMS, 1975), United Engineers (Raytheon, 1972), and Exxon Co. (Howells et al., 1976; Danila et al., 1980; Milstein, 1982-1984; Beck, 1989). The most recent source of benthic ecology data in the Arthur Kill in the vicinity of Fresh Kills is the Natural Resource Damage Assessment (NRDA) conducted in 1990 for Exxon Co., USA-Bayway Refinery. However, as of this writing, these data, as well as similar data collected by the Trustees for the States of New York and New Jersey, had not been released for public evaluation so were not available for this investigation plan. For a further discussion of the results of the benthic ecology studies performed in the Arthur Kill, refer to the SWS Investigation Plan and Literature Review Report identified above.

1.1.2 Objectives

Appendix A-7 of the Consent Order (CO) requires that Benthic Ecology Analyses be performed as part of the Surface Water and Sediment Investigation. The overall requirement of Appendix A-7 is that a comprehensive investigation be conducted to determine the impact of the Landfill and related landfill leachate discharge on the quality of aqueous and subaqueous environments. The investigation plan and this addendum are being prepared in fulfillment of the requirements of 6 NYCRR Part 360-2.11(a). The study is designed to assess impact which will be reported in accordance with Part 360-2.11(b). Therefore, the benthic ecology investigation is designed to fill two technical objectives as follows:

- Determine whether there is a discernable impact on the ecology that can be associated with the landfill and leachate releases.

- Develop a data base that will provide an effective baseline for a long term monitoring program if one is indicated.

The benthic ecology program consists of a series of collections and identifications of benthic macroinvertebrates from sites proximal to the landfill influence (near-field) and distant from its influence (reference).

1.2 STUDY DESIGN

The objective of this study is to assess the effects of Fresh Kills Landfill leachate on the benthic macroinvertebrate community within the Fresh Kills waterways.

1.2.1 Null Hypothesis

The null hypothesis to be tested is:

- the benthic diversity and community structure at near-field stations are not significantly different from that of reference stations.

1.2.2 Sampling Method

Rationale - The benthic ecology investigation is designed to relate distance (or impact) from the source to community composition. In selecting sampling stations, other significant variables have been considered for their influence to the community structure:

- Effect of grain size as a significant variable must be eliminated.

- Conditions other than proximity to leachate releases must be similar (e.g., salinity, temperature, DO, currents).

- Effects of other significant inputs such as thermal or effluent discharge and oil spills must be avoided.

Substrate type is a key variable in determining the species composition of the benthic community (Steimle and Caracciolo-Ward, 1989). Substrate varies from uniform solid surfaces to sediments of sand, silt and mud. In the Fresh Kills area, hard surfaces supporting invertebrate communities are limited. Therefore, a program to sample epibenthos associated with hard substrates would be of limited value. Mud and sand substrate are widely distributed and the macroinvertebrate fauna of these areas have been most frequently studied (IT, 1986a; LA, 1974a&b; LMS, 1975; Raytheon, 1972; EA, 1989 a & b). The current study will focus on the potential effects of the landfill leachate on the soft substrate component.

FRESH KILLS LEACHATE MITIGATION SYSTEM PROJECT

SURFACE WATER AND SEDIMENT LITERATURE REVIEW REPORT

DATE: APRIL 1, 1991
DOCUMENT NO. 529363-00348
004-06-001

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1.0 INTRODUCTION/OBJECTIVES

The purpose of the Surface Water and Sediment Literature Review Report is to assemble, organize and review all previous pertinent information regarding the scope of the Surface Water and Sediment Investigation. This includes aspects of surface water and sediment quality, benthic ecology, landfill leachate toxicity, and hydrodynamic and wasteload allocation modeling with special emphasis on those studies conducted in the Fresh Kills waterways. Additional information on the Arthur Kill will be utilized as it pertains to the current study.

The objective of this review is to provide information to help characterize the present conditions and to determine the appropriate sampling locations for surface water, sediment and benthic ecology analyses. In addition, any gaps in the historic database will be identified.

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FRESH KILLS SURFACE WATER STUDY
PARAMETER PROFILES

PARAMETER	PROFILE
TOTAL AMMONIA:	USEPA SALTWATER CRITERIA : ALL DATA WERE COMPARED TO THE CRITERIA FOR CONTINUOUS AND MAXIMUM TOTAL AMMONIA (mg/l) BASED UPON THE BEST FIT RELATIONSHIP OF pH, TEMP. AND SALINITY ASSOCIATED WITH THAT CRITERIA VALUE. WHEN THE COMPARISION OF pH, TEMP. AND SALINITY WAS NOT EXACT OR EASILY DISCERNABLE, THE MORE STRINGENT CRITERIA VALUE WAS CHOOSEN FOR COMPARISON WITH THE DATA.

NOV. 1990: A/R LANDFILL ALL STNS EXCEPT FKAP-1 & FKAP-2 WERE DETECTED ABOVE THE CRIT.
FKAP-3 = 5.6 mg/l (CRIT. = 1.5 mg/l)
UT-1 = 68 mg/l (CRIT. = 3.4 mg/l; MAX. = 23 mg/l)
UT-2 = 49 mg/l (CRIT. = 3.4 mg/l; MAX. = 23 mg/l)
UT-3= 22 mg/l (CRIT. = 5.3 mg/l)

JAN. 1991: SW ALL STATIONS WERE BELOW THE CONTINUOUS AND THEREFORE MAX. CONC. CRITERIA EXCEPT WC-4 & WC-5
WC-4= 1.2 mg/l (CRIT. = 0.34 mg/l); pH = 9.8
WC-5= 1.6 mg/l (CRIT. = 0.78 mg/l); pH = 8.5

FEB. 1991: A/R LANDFILL STATIONS FKAP-1, FKAP-2 AND FKAP-3 WERE DETECTED BELOW THE CRITERIA AND UT-1, UT-2 AND UT-3 WERE DETECTED ABOVE THE CONTINUOUS CRITERIA, BUT BELOW THE MAX. CRITERIA; NOTE LOW SALINITY RANGE 1.4 - 4.8 PPT
UT-1= 67 mg/l (CRIT. = 29 mg/l)
UT-2= 52 mg/l (CRIT. = 29 mg/l)
UT-3= 38 mg/l (CRIT. = 29 mg/l)

FRESH KILLS SURFACE WATER STUDY
PARAMETER PROFILES

PARAMETER — **TOTAL AMMONIA:**

PROFILE

AUG. 1991: A/R LANDFILL ALL STNS EXCEPT UT-1 AND UT-2 WERE DETECTED BELOW CRITERIA
UT-1 = 72.7 mg/l (CRIT. = 9.4 mg/l; MAX. = 62 mg/l)
UT-2 = 67.2 mg/l (CRIT. = 3.7 mg/l; MAX. = 25 mg/l)
SW THE FOLLOWING WERE DETECTED ABOVE THE CONTINUOUS CRITERIA ONLY:
WC-6(LOW) = 4.0 mg/l (CRIT. = 1.7 mg/l)
WC-7(LOW) = 1.6 mg/l (CRIT. = 1.2 mg/l)
WC-8(LOW) = 1.96 mg/l (CRIT. = 1.8 mg/l)
WC-9(LOW) = 2.55 mg/l (CRIT. = 1.2 mg/l)
WC-10(LOW) = 2.81 mg/l (CRIT. = 0.75 mg/l)
WC-11(EBB) = 2.26 mg/l (CRIT. = 1.7 mg/l)
WC-11(LOW) = 3.88 mg/l (CRIT. = 0.75 mg/l)
WC-12(RISE) = 2.43 mg/l (CRIT. = 1.7 mg/l)
WC-12(HIGH) = 1.59 mg/l (CRIT. = 1.2 mg/l)
WC-12(EBB) = 2.52 mg/l (CRIT. = 1.2 mg/l)
WC-12(LOW) = 4.0 mg/l (CRIT. = 0.75 mg/l)
WC-14(LOW) = 2.6 mg/l (CRIT. = 1.9 mg/l)
WC-15(LOW) = 5.2 mg/l (CRIT. = 1.8 mg/l)
WC-16(LOW) = 6.44 mg/l (CRIT. = 3.0 mg/l)

OCT. 1991: SW ALL STATIONS DETECTED BELOW CRITERIA

MAR. 1992: SURFACE WATER, UNFILTERED
WC-7 = 1.47 mg/l; CHRONIC CRITERIA = 1.2 mg/l

MAY 1992: SURFACE WATER, UNFILTERED
WC-16 = 2.42 mg/l; CHRONIC CRITERIA = 2.4 mg/l

OCT. 1992: SURFACE WATER, UNFILTERED
WC-9-LUB = 0.922 mg/l; CHRONIC CRITERIA = 0.59 mg/l
WC-10-LUB = 0.958 mg/l; CHRONIC CRITERIA = 0.41 mg/l
WC-11-LUB = 1.36 mg/l; CHRONIC CRITERIA = 0.37 mg/l
WC-12-LUB = 1.79 mg/l; CHRONIC CRITERIA = 0.56 mg/l
WC-13-LUB = 0.579 mg/l; CHRONIC CRITERIA = 0.41 mg/l
WC-14-LUB = 0.553 mg/l; CHRONIC CRITERIA = 0.41 mg/l
WC-15-LUB = 0.705 mg/l; CHRONIC CRITERIA = 0.41 mg/l

FRESH KILLS SURFACE WATER STUDY
PARAMETER PROFILES

PARAMETER	PROFILE	
TOTAL AMMONIA:		
	OCT. 1992:	SURFACE WATER, UNFILTERED
		WC-9-LUB = 1.05 mg/l; CHRONIC CRITERIA = 0.59 mg/l
		WC-10-LUB = 0.756 mg/l; CHRONIC CRITERIA = 0.41 mg/l
		WC-11-LUB = 1.06 mg/l; CHRONIC CRITERIA = 0.37 mg/l
		WC-12-LUB = 1.46 mg/l; CHRONIC CRITERIA = 0.56 mg/l
		WC-13-LUB = 0.457 mg/l; CHRONIC CRITERIA = 0.41 mg/l
		WC-14-LUB = 0.836 mg/l; CHRONIC CRITERIA = 0.41 mg/l
	JAN. 1993:	SURFACE WATER, UNFILTERED
		WC-1 = 0.383 mg/l; CHRONIC CRITERIA = 0.31 mg/l
		WC-28 = 0.285 mg/l; CHRONIC CRITERIA = 0.23 mg/l

Note: NA = Not Applicable
ND = Not Detected
NL = Not Listed
NS = No Standard

ST. = Station
A/R = Ash Residue Landfill
CRIT. = Criteria

Table 3-5

Acute Water Quality Criteria for Protection of Saltwater Aquatic Life Based on Total Ammonia Criteria Concentrations[1]

	Temperature(°C)							
	0	5	10	15	20	25	30	35
	Salinity = 10 g/kg							
pH								
7.0	270	191	131	92	62	44	29	21
7.2	175	121	83	58	40	27	19	13
7.4	110	77	52	35	25	17	12	8.3
7.6	69	48	33	23	16	11	7.7	5.6
7.8	44	31	21	15	10	7.1	5.0	3.5
8.0	27	19	13	9.4	6.4	4.6	3.1	2.3
8.2	18	12	8.5	5.8	4.2	2.9	2.1	1.5
8.4	11	7.9	5.4	3.7	2.7	1.9	1.4	1.0
8.6	7.3	5.0	3.5	2.5	1.8	1.3	0.96	0.75
8.8	4.6	3.3	2.3	1.7	1.2	0.92	0.71	0.56
9.0	2.9	2.1	1.5	1.1	0.85	0.67	0.52	0.44
	Salinity = 20 g/kg							
pH								
7.0	291	200	137	96	64	44	31	21
7.2	183	125	87	60	42	29	20	14
7.4	116	79	54	37	27	18	12	8.7
7.6	73	50	35	23	17	11	7.9	5.6
7.8	46	31	23	15	11	7.5	5.2	3.5
8.0	29	20	14	9.8	6.7	4.8	3.3	2.3
8.2	19	13	8.9	6.2	4.4	3.1	2.1	1.6
8.4	12	8.1	5.6	4.0	2.9	2.0	1.5	1.1
8.6	7.5	5.2	3.7	2.7	1.9	1.4	1.0	0.77
8.8	4.8	3.3	2.5	1.7	1.3	0.94	0.73	0.56
9.0	3.1	2.3	1.6	1.2	0.87	0.69	0.54	0.44
	Salinity = 30 g/kg							
pH								
7.0	312	208	148	102	71	48	33	23
7.2	196	135	94	64	44	31	21	15
7.4	125	85	58	40	27	19	13	9.4
7.6	79	54	37	25	21	12	8.5	6.0
7.8	50	33	23	16	11	7.9	5.4	3.7
8.0	31	21	15	10	7.3	5.0	3.5	2.5
8.2	20	14	9.6	6.7	4.6	3.3	2.3	1.7
8.4	12.7	8.7	6.0	4.2	2.9	2.1	1.6	1.1
8.6	8.1	5.6	4.0	2.7	2.0	1.4	1.1	0.81
8.8	5.2	3.5	2.5	1.8	1.3	1.0	0.75	0.58
9.0	3.3	2.3	1.7	1.2	0.94	0.71	0.56	0.46

[1] *Source: Federal Register Vol. 54 No. 85, May 4, 1989, 19227.*

Table 3–5

Chronic Water Quality Criteria for Protection of Saltwater Aquatic Life Based on Total Ammonia Criteria Concentrations[1]

	Temperature(°C)							
	0	5	10	15	20	25	30	35
Salinity = 10 g/kg								
pH								
7.0	41	29	20	14	9.4	5.6	4.4	3.1
7.2	26	18	12	8.7	5.9	4.1	2.8	2.0
7.4	17	12	7.8	5.3	3.7	2.6	1.8	1.2
7.6	10	7.2	5.0	3.4	2.4	1.7	1.2	0.84
7.8	6.6	4.7	3.1	2.2	1.5	1.1	0.8	0.53
8.0	4.1	2.9	2.0	1.40	0.97	0.69	0.47	0.34
8.2	2.7	1.8	1.3	0.87	0.62	0.44	0.31	0.23
8.4	1.7	1.2	0.81	0.56	0.41	0.29	0.21	0.16
8.6	1.1	0.75	0.53	0.37	0.27	0.20	0.15	0.11
8.8	0.69	0.50	0.34	0.25	0.18	0.14	0.11	0.06
9.0	0.44	0.31	0.23	0.17	0.13	0.10	0.06	0.07
Salinity = 20 g/kg								
pH								
7.0	44	30	21	14	9.7	6.6	4.7	3.1
7.2	27	19	13	8.0	6.2	4.4	3.0	2.1
7.4	18	12	8.1	5.6	4.1	2.7	1.9	1.3
7.6	11	7.5	5.3	3.4	2.5	1.7	1.2	0.84
7.8	6.9	4.7	3.4	2.3	1.6	1.1	0.78	0.53
8.0	4.4	3.0	2.1	1.5	1.0	0.72	0.50	0.34
8.2	2.8	1.9	1.3	0.94	0.66	0.47	0.31	0.24
8.4	1.8	1.2	0.84	0.59	0.44	0.30	0.22	0.16
8.6	1.1	0.78	0.56	0.41	0.28	0.20	0.15	0.12
8.8	0.72	0.50	0.37	0.26	0.19	0.14	0.11	0.06
9.0	0.47	0.34	0.24	0.18	0.13	0.10	0.08	0.07
Salinity = 30 g/kg								
pH								
7.0	47	31	22	15	11	7.2	5.0	3.4
7.2	29	20	14	9.7	6.6	4.7	3.1	2.2
7.4	19	13	8.7	5.9	4.1	2.9	2.0	1.4
7.6	12	8.1	5.6	3.7	3.1	1.6	1.3	0.90
7.8	7.5	5.0	3.4	2.4	1.7	1.2	0.81	0.56
8.0	4.7	3.1	2.2	1.6	1.1	0.75	0.53	0.37
8.2	3.0	2.1	1.4	1.0	0.69	0.50	0.34	0.25
8.4	1.9	1.3	0.90	0.62	0.44	0.31	0.23	0.17
8.6	1.2	0.84	0.6	0.41	0.30	0.22	0.16	0.12
8.8	0.78	0.53	0.37	0.27	0.20	0.15	0.11	0.09
9.0	0.50	0.34	0.26	0.19	0.14	0.11	0.08	0.07

[1] *Source: Federal Register Vol. 54 No. 85, May 4, 1989, 19227.*

Table 5–7
Statistical Comparisons of Leachate Indicators in Surface Water

Student's t–Test Comparisons																
		Reference Compared to Other Areas					Farfield Compared to Other Areas				Nearfield Compared to Other Areas			Freshwater Compared to Main & Richmond Creeks	
Parameter		Arthur Kill Nearfield 1,2	Arthur Kill Farfield 20,32	Fresh Kills Creek 3,4,5,6,7,8	Richmond Creek 9,10,11,12	Main Creek 13,14,15,16 26	Arthur Kill Nearfield 1,2	Fresh Kills Creek 3,4,5,6,7,8	Richmond Creek 9,10,11,12	Main Creek 13,14,15,16 26	Fresh Kills Creek 3,4,5,6,7,8	Richmond Creek 9,10,11,12	Main Creek 13,14,15,16 26	Richmond Creek 9,10,11,12	Main Creek 13,14,15,16 26
Alkalinity	6/92–1/93	–	–	H	H	H	–	H	H	H	H	H	H	NA	NA
	8/92	H	H	H	H	H	–	H	–	H	H	–	H	–	H
	10/92	–	–	–	–	H	–	H	H	H	–	–	H	NA	NA
	1/93	H	H	H	H	H	–	–	–	–	–	H	–	NA	NA
	5/92	NA	NA	–	H	–	NA	NA	NA	NA	–	H	H	NA	NA
Aluminum	6/92–1/93	–	–	–	–	–	–	–	H	H	–	–	H	NA	NA
	8/92	–	–	–	–	–	L	–	–	–	H	–	–	–	–
	10/92	–	–	–	–	–	–	–	–	–	–	–	–	NA	NA
	1/93	–	–	–	–	–	–	–	–	H	–	–	H	NA	NA
	5/92	–	NA	–	–	–	NA	NA	NA	NA	–	–	–	NA	NA
Ammonia	6/92–1/93	–	–	–	H	–	–	–	H	–	–	H	–	NA	NA
	8/92	NA	NA	NA	NA	NA	–	–	H	H	–	–	–	–	H
	10/92	–	–	–	H	–	H	–	H	H	–	–	–	NA	NA
	1/93	–	–	–	H	–	H	–	H	–	–	H	–	NA	NA
	5/92	–	NA	–	H	–	NA	NA	NA	NA	–	H	–	NA	NA
	3/92	–	NA	–	H	–	NA	NA	NA	NA	–	H	–	NA	NA
	10/91	–	NA	–	H	H	NA	NA	NA	NA	–	H	H	NA	NA
	6/91	–	NA	–	H	H	NA	NA	NA	NA	–	H	H	NA	NA
	1/91	–	NA	H	H	–	NA	NA	NA	NA	H	H	–	NA	NA
Antimony	6/92–1/93	–	–	–	–	–	–	–	–	–	–	–	–	NA	NA
	8/92	–	–	–	–	–	–	–	–	–	–	–	–	NA	NA
	10/92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	–	–
	1/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	5/92	–	NA	–	–	–	NA	NA	NA	NA	–	–	–	NA	NA
Arsenic	6/92–1/93	–	–	–	–	–	–	–	–	H	H	H	H	NA	NA
	8/92	–	–	–	–	–	–	H	H	H	H	H	H	H	H
	10/92	NA	NA	L	–	L	NA	L	–	–	NA	NA	NA	NA	NA
	1/93	NA	–	–	–	–	NA	NA	NA	NA	–	–	–	NA	NA
	5/92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	6/92–1/93	L	L	–	–	H	H	H	H	H	H	H	H	NA	NA
	8/92	L	–	–	H	H	H	H	H	H	H	H	H	–	–
	10/92	–	–	–	–	H	–	H	–	H	–	–	H	NA	NA
	1/93	L	–	–	–	–	–	–	H	H	–	H	H	NA	NA
	5/92	L	NA	–	H	–	NA	NA	NA	NA	–	H	–	NA	NA
Beryllium	6/92–1/93	–	H	–	–	–	–	–	L	L	–	L	L	NA	NA
	8/92	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	10/92	NA	NA	NA	NA	NA	–	–	–	–	–	–	–	NA	NA
	1/93	–	H	–	L	L	–	–	L	L	–	L	L	NA	NA
	5/92	–	NA	–	–	–	NA	NA	NA	NA	–	–	–	NA	NA
BOD5	6/92–1/93	–	–	H	H	H	–	H	H	H	H	H	H	NA	NA
	8/92	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	10/92	–	–	–	H	H	–	–	H	H	–	H	H	NA	NA
	1/93	–	–	H	H	H	–	H	H	H	H	H	H	NA	NA
	5/92	NA	NA	–	–	H	NA	NA	NA	NA	–	H	H	NA	NA
Boron	6/92–1/93	H	H	–	–	–	–	–	L	L	–	L	L	NA	NA
	8/92	–	–	–	–	–	–	L	–	L	L	–	L	–	H
	10/92	–	–	H	–	–	–	–	–	–	–	–	–	NA	NA
	1/93	–	–	–	–	–	–	–	L	L	–	L	L	NA	NA
	5/92	H	NA	–	–	–	NA	NA	NA	NA	–	L	L	NA	NA
Cadmium	6/92–1/93	–	–	–	–	–	–	–	H	–	–	–	–	NA	NA
	8/92	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	10/92	–	–	L	L	L	–	L	–	L	–	–	–	NA	NA
	1/93	–	–	–	–	–	–	–	–	–	–	–	–	NA	NA
	5/92	–	NA	–	–	–	NA	NA	NA	NA	–	–	.	NA	NA

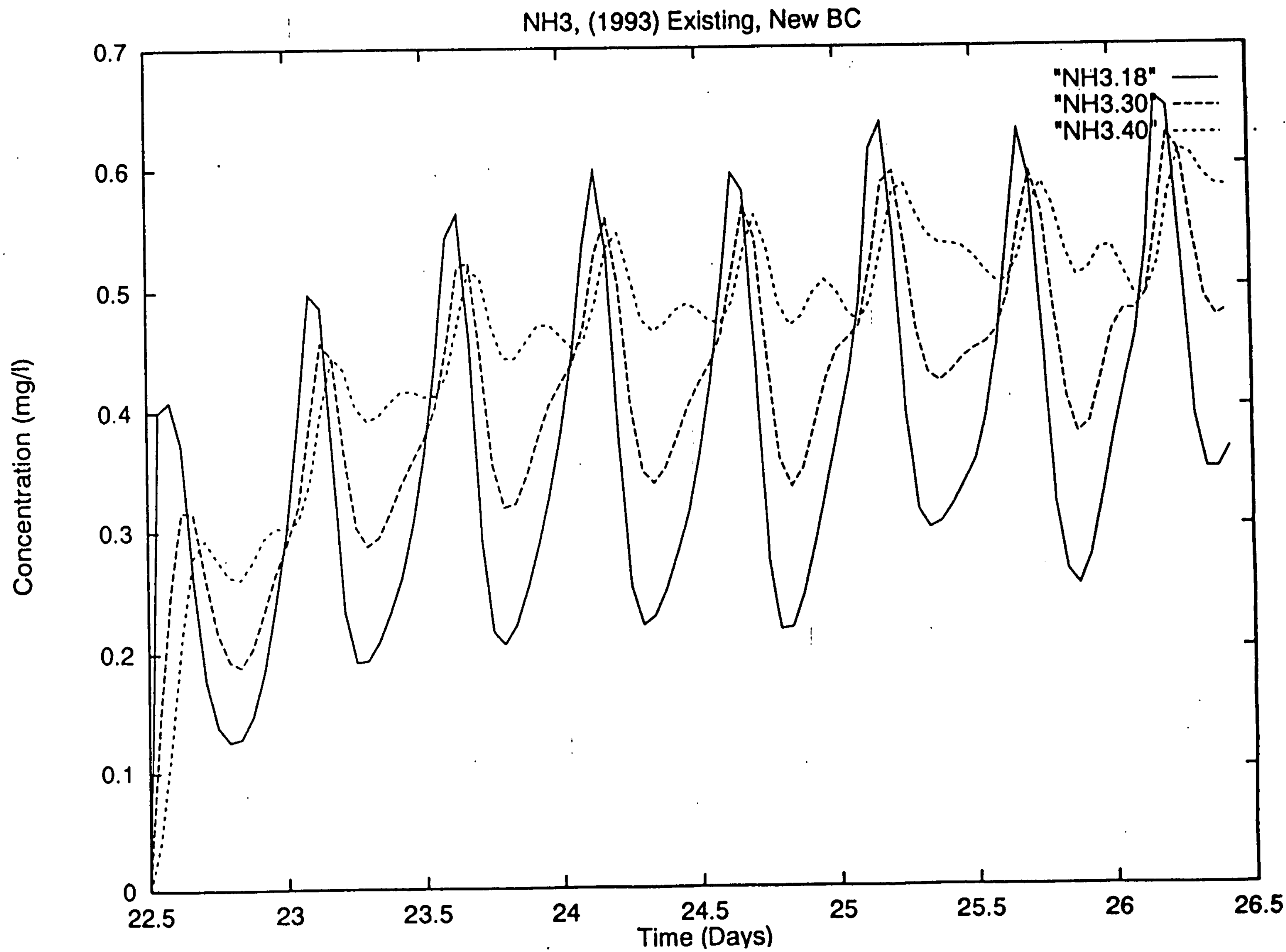

Figure 9-109 Refined Prediction of Leachate Contribution to Ammonia Concentration in Fresh

000043

DEP CITY OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL PROTECTION

NEW YORK HARBOR
WATER QUALITY SURVEY

1991-1992

Marine Sciences Section
Division of Scientific Services
Bureau of Clean Water
Wards Island, New York 10035

Albert F. Appleton
Commissioner

Edward O. Wagner, P.E.
Deputy Commissioner
Director, Bureau of Clean Water

July 29, 1993

000044

NUTRIENTS IN SURFACE WATERS
Summer Averages and Coefficient of Variations, 1992

UNITS: MG/L

BY SITE; CV = COEFFICIENT OF VARIATION AS %; NO32 = DISSOLVED NITRATE + NITRITE;

NH4 = DISSOLVED AMMONIUM; TP = TOTAL PHOSPHORUS; PO4 = DISSOLVED ORTHOPHOSPHATE;

TDIN = TOTAL DISSOLVED INORGANIC NITROGEN (NH4 + NO32)

SITE	NH4	NH4CV	NO32	NO32CV	TDIN	TDINCV	TP	TPCV	PO4	PO4CV
E1	0.409	13.9	0.359	30.7	0.768	20.3	0.136	28.3	0.110	23.7
E2	0.464	14.9	0.379	28.5	0.843	18.4	0.144	21.1	0.117	23.9
E2A	0.444	13.3	0.349	27.5	0.793	17.4	0.154	29.5	0.114	23.9
E3	0.478	14.7	0.384	27.9	0.862	17.6	0.149	24.7	0.125	30.1
E4	0.519	13.5	0.411	31.4	0.930	17.0	0.155	30.1	0.131	17.7
E5	0.549	9.5	0.390	33.4	0.939	15.7	0.160	25.4	0.126	17.0
E6	0.533	15.4	0.304	32.3	0.836	13.8	0.148	30.4	0.117	19.3
E7	0.448	14.9	0.283	42.5	0.731	19.0	0.145	27.4	0.112	27.3
E8	0.361	19.9	0.226	56.3	0.587	26.4	0.131	30.7	0.099	29.7
E11	0.341	31.5	0.227	69.1	0.568	41.1	0.127	34.2	0.103	44.0
E12	0.184	105.3	0.073	134.9	0.257	99.7	0.144	27.2	0.059	76.5
E13	0.498	17.0	0.330	44.5	0.828	23.5	0.143	28.8	0.110	28.3
E14	0.428	24.8	0.296	39.4	0.723	23.7	0.143	35.0	0.109	46.2
E15	0.603	25.0	0.268	52.6	0.871	21.6	0.206	34.3	0.118	52.4
E9	0.220	50.3	0.162	79.4	0.381	51.7	0.116	35.2	0.081	39.9
E10	0.172	65.5	0.135	87.8	0.307	63.2	0.112	39.0	0.067	51.8
H1	0.238	29.2	0.468	22.5	0.705	19.9	0.131	41.9	0.094	34.4
H2	0.278	17.8	0.469	20.5	0.747	17.3	0.129	32.5	0.104	33.4
H3	0.330	24.9	0.443	22.4	0.773	18.0	0.140	23.9	0.104	33.7
H4	0.411	29.2	0.449	21.5	0.860	21.5	0.143	32.4	0.115	28.4
H5	0.453	28.3	0.433	25.0	0.887	22.1	0.146	34.8	0.117	25.8
N1	0.161	66.8	0.463	21.1	0.625	23.0	0.104	42.4	0.074	20.1
N2	0.181	65.1	0.463	20.8	0.645	23.1	0.114	49.6	0.075	19.7
N3	0.209	61.7	0.450	20.7	0.659	23.1	0.107	43.4	0.077	23.6
N3A	0.231	47.6	0.432	21.8	0.663	21.6	0.109	42.8	0.087	16.7
N3B	0.217	50.3	0.442	21.0	0.659	20.4	0.110	39.9	0.080	18.9
N4	0.249	41.2	0.426	21.7	0.675	21.6	0.113	42.9	0.090	18.5
N5	0.298	31.0	0.383	25.3	0.681	18.4	0.116	37.1	0.091	15.8
N6	0.338	24.6	0.339	28.8	0.677	19.9	0.114	36.2	0.103	13.7
N7	0.337	21.6	0.329	26.2	0.666	19.0	0.111	36.2	0.102	21.2
G1	0.365	19.7	0.321	28.4	0.686	20.8	0.117	31.3	0.107	13.4
G2	0.329	20.9	0.343	27.6	0.672	21.7	0.123	47.8	0.103	21.1
K1	0.433	22.0	0.495	20.9	0.928	20.7	0.173	28.9	0.128	38.1
K2	0.488	32.7	0.571	23.4	1.059	23.3	0.171	36.0	0.155	29.7
K3	0.698	25.1	0.610	21.6	1.308	17.4	0.222	32.8	0.207	21.0
K4	0.826	13.1	0.564	30.8	1.390	17.1	0.243	36.4	0.210	17.1
K5	0.505	37.6	0.398	46.6	0.903	36.1	0.174	34.0	0.155	22.8
K5A	0.374	41.9	0.373	47.3	0.747	39.6	0.161	37.3	0.138	31.0
K6	0.139	91.7	0.181	75.2	0.320	78.0	0.104	45.9	0.075	44.6
N8	0.349	18.6	0.323	30.8	0.672	18.9	0.119	35.3	0.111	18.9
N9	0.135	60.7	0.111	59.8	0.246	55.2	0.071	52.4	0.053	32.8
N16	0.041	119.4	0.031	135.4	0.072	121.3	0.048	61.1	0.026	42.6
J1	0.187	49.7	0.141	60.1	0.329	37.3	0.102	47.1	0.081	47.9
J10	0.416	54.8	0.170	57.1	0.585	48.0	0.160	47.4	0.107	64.5
J11	0.092	115.4	0.150	46.4	0.242	46.5	0.088	52.0	0.050	70.3
J2	0.316	48.7	0.171	57.8	0.487	44.1	0.149	56.0	0.094	65.3
J3	0.630	76.9	0.185	58.7	0.815	68.4	0.164	49.6	0.117	54.9
J5	0.300	63.9	0.194	50.0	0.494	48.8	0.162	43.3	0.117	57.2
J7	1.256	43.4	0.191	48.0	1.447	37.9	0.275	40.9	0.191	52.8
J8	0.837	50.5	0.215	41.4	1.052	46.9	0.214	46.4	0.136	44.1
J9A	0.774	63.4	0.210	43.9	0.984	55.2	0.182	46.6	0.118	52.9
N9A	0.090	68.9	0.062	52.4	0.152	58.2	0.061	47.0	0.049	43.9

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TABLE 5.6-2
SURFACE AND GROUND WATER IMPACT OF IMPLEMENTATION OF SITEWIDE ALTERNATIVE 1
CONTAINMENT / COLLECTION / TREATMENT OF LEACHATE AT LANDFILL SECTIONS 1/9 AND 6/7
CAPPING AND CLOSURE AT LANDFILL SECTIONS 2/8 AND 3/4
FRESH KILLS LANDFILL LEACHATE MITIGATION SYSTEM PROJECT

	LANDFILL SECTION 2/8						LANDFILL SECTION 3/4					
	1993	1997	2000	2015	2030	2045	1993	1997	2000	2015	2030	2045
Leachate Generation												
Horizontal and Downward Vertical Flux From Refuse Mound (gal/day) [a]	176,917	107,099	51,530	11,983	6,956	3,523	200,172	136,622	79,310	27,429	16,299	5,790
Upward Vertical Flux (gal/day) [a]	367	396	381	329	329	344	157	224	329	546	628	696
Total (gal/day) [a]	177,283	107,495	51,911	12,312	7,286	3,867	200,329	136,847	79,640	27,975	16,927	6,485
Distribution of Leachate Flux												
Horizontal (gal/day) [b]	170,432	101,571	47,932	10,128	5,281	1,907	181,038	118,049	65,398	20,331	11,310	1,810
Downward Vertical to Recent Sand Unit 1 and Glacial Sands, Model Layer 3 (gal/day)	6,485	5,528	3,598	1,855	1,676	1,616	19,134	18,573	13,913	7,089	4,989	3,979
Downward Vertical to Cretaceous Sand Unit 1, Model Layer 6 (gal/day)	6,642	6,493	6,410	6,298	6,306	6,231	--	--	--	--	--	--
Downward Vertical to Bedrock, Model Layer 7 (gal/day) [c]	2,371	2,274	2,237	2,274	2,304	2,311	703	561	329	75	30	15
Mass Loading of Ammonia to Surface Waters (lb/day) [d,f]												
Arthur Kill	--	--	--	--	--	--	--	--	--	--	--	--
Fresh Kills	65	47	--	15	--	14	241	197	--	73	--	63
Main Creek	--	--	--	--	--	--	499	374	--	169	--	148
Richmond Creek	623	451	--	153	--	139	--	--	--	--	--	--
In-Stream Ammonia Concentration Attributed to Leachate (mg/L) [e]												
Fresh Kills	0.62	--	0.28	0.12	--	--	0.62	--	0.28	0.12	--	--
Main Creek	0.35	--	0.17	0.07	--	--	0.35	--	0.17	0.07	--	--
Richmond Creek	0.46	--	0.23	0.10	--	--	0.46	--	0.23	0.10	--	--
Vertical Mass Loading of Ammonia to Groundwater (lb/day) [f]												
Total to Recent/Glacial Sands	17	14	9	5	4	4	91	89	66	34	24	19
To Cretaceous Sands	0.08	0.08	0.08	0.08	0.08	0.08	--	--	--	--	--	--
To Bedrock [c]	0.001	0.001	0.001	0.001	0.001	0.001	0.352	0.281	0.165	0.037	0.015	0.007

Note: Fluxes do not balance within any time period due to transient nature of simulations, which accomodate changes into and out of storage in the refuse mound over time

alt12834.wk3 1/12/94

-- Not applicable

[a] Leachate generation is based on the toe-of-slope model boundaries and reflects progressive capping of landfill sections over time

[b] Uncontrolled horizontal flux

[c] Net vertical flux from bedrock is upward to overlying unconsolidated overburden sediments (Recent/glacial/Cretaceous sands) at Sections 1/9, 2/8, and 6/7

[d] Mass loadings include base loads from land areas lying between landfill perimeter containment/collection facilities and river boundaries, as well as tributary streams within/adjacent to NYCDOS property boundaries

[e] Maximum calculated in-stream ammonia concentrations at low tide

[f] Mean of individual well mean ammonia concentration (ug/L) used in mass loading calculations:
(January 1991 – January 1993 sample quarter data)

	1/9	6/7	2/8	3/4
Refuse/Fill	627,248	245,743	312,125	571,995
Recent/Glacial Sands [g]	5,769	397	1,493	60,047
Cretaceous Sands [h]	3,467	92	38	--

[g] Monitoring wells: Section 1/9 = 00911, 01011, 01111, 01112, 01211, 01611, 04511, 0171
Section 6/7 = 1561, 1581, 1621, 1631, 1651, 16611, 1671
Section 2/8 = 30811, 30812, 31111
Section 3/4 = 4041, 40511, 40512, 4061, 4341, AK138, AK131

[h] Monitoring wells: Section 1/9 = 0011, 0041, 00511, 00512, 00513, 0061, 0071, 0081, 00912, 01012, 01113, 01212, 0131, 0151, 0161, 04411, 04412, 04313, 04512
Section 6/7 = 1571, 16612
Section 2/8 = 3051, 30611, 30612, 3071, 3091, 31011, 31012, 31112

TABLE 5.6-8
SURFACE AND GROUNDWATER IMPACT OF IMPLEMENTATION OF SITEWIDE ALTERNATIVE 3
CONTAINMENT / COLLECTION / TREATMENT OF LEACHATE AT LANDFILL SECTIONS 1/9 AND 6/7
PUMPING WELLS AT SECTIONS 2/8 AND 3/4
FRESH KILLS LANDFILL LEACHATE MITIGATION SYSTEM PROJECT

	LANDFILL SECTION 2/8						LANDFILL SECTION 3/4					
	1993	1997	2000	2015	2030	2045	1993	1997	2000	2015	2030	2045
Leachate Generation												
Horizontal and Downward Vertical Flux From Refuse Mound (gal/day) [a]	176,917	107,099	82,280	70,978	70,290	72,474	200,172	136,622	104,166	26,262	29,284	23,637
Upward Vertical Flux (gal/day) [a]	367	396	696	987	1,017	770	157	224	479	1,586	1,870	1,556
Total (gal/day) [a]	177,283	--	82,976	71,965	71,307	73,244	200,329	--	104,645	27,848	31,154	25,193
Distribution of Leachate Flux												
Horizontal (gal/day) [b]	170,432	101,571	22,103	(28,641)	(31,491)	(33,368)	181,038	118,049	50,557	(1,242)	(5,700)	(5,266)
Pumping Wells (gal/day) [c]	--	--	56,826	40,938	37,565	37,565	--	--	40,908	19,470	19,470	14,661
Downward Vertical to Recent Sand Unit 1 and Glacial Sands, Model Layer 3 (gal/day)	6,485	5,528	3,351	1,399	1,234	1,541	19,134	18,573	12,701	5,530	4,114	3,719
Downward Vertical to Cretaceous Sand Unit 1, Model Layer 6 (gal/day)	6,642	6,493	6,313	6,178	6,193	6,216	--	--	--	--	--	--
Downward Vertical to Bedrock, Model Layer 7 (gal/day) [c]	2,371	2,274	2,177	2,147	2,169	2,199	703	561	299	7	0	0
Mass Loading of Ammonia to Surface Waters (lb/day) [e,g]												
Arthur Kill	--	--		--	--	--	--	--	--	--	--	--
Fresh Kills	65	--	22	6	--	5	241	--	51	16	--	14
Main Creek	--	--	--	--	--	--	499	--	102	44	--	40
Richmond Creek	623	--	235	68	--	61	--	--	--	--	--	--
In-Stream Ammonia Concentration Attributed to Leachate (mg/L) [f]												
Fresh Kills	0.62	--	0.15	0.14	--	--	0.62	--	0.15	0.14	--	--
Main Creek	0.35	--	0.10	0.05	--	--	0.35	--	0.10	0.05	--	--
Richmond Creek	0.46	--	0.10	0.05	--	--	0.46	--	0.10	0.05	--	--
Vertical Mass Loading of Ammonia to Groundwater (lb/day) [g]												
Total to Recent/Glacial Sands	17	14	9	4	3	4	91	89	61	26	20	18
To Cretaceous Sands	0.08	0.08	0.08	0.08	0.08	0.08	--	--	--	--	--	--
To Bedrock [c]	0.001	0.001	0.001	0.001	0.001	0.001	0.352	0.281	0.150	0.004	<0.001	<0.001

Note: Fluxes do not balance within any time period due to transient nature of simulations, which accomodate changes into and out of storage in the refuse mound over time

sk32834.wk3 12/16/93 .

-- Not applicable

[a] Leachate generation reflects progressive capping of landfill sections over time

[b] Uncontrolled horizontal flux; ( ) represents horizontal flow into a layer

[c] Leachate captured by pumping wells installed in the refuse mound

[d] Net vertical flux from bedrock is upward to overlying unconsolidated overburden sediments (Recent/glacial/Cretaceous sands) at Sections 1/9, 2/8, and 6/7

[e] Mass loadings include base loads from land areas lying between landfill perimeter containment/collection facilities and river boundaries, as well as tributary streams within/adjacent to NYCDOS property boundaries

[f] Maximum calculated in-stream ammonia concentrations at low tide

[g] Mean of individual well mean ammonia concentration (ug/L) used in mass loading calculations: (January 1991 - January 1993 sample quarter data)

	1/9	6/7	2/8	3/4
Refuse/Fill	627,248	245,743	312,125	571,995
Recent/Glacial Sands [h]	5,769	397	1,493	60,047
Cretaceous Sands [i]	3,467	92	38	--

[h] Monitoring wells: Section 1/9 = 00911, 01011, 01111, 01112, 01211, 01611, 04511, 0171
Section 6/7 = 1561, 1581, 1621, 1631, 1651, 16611, 1671
Section 2/8 = 30811, 30812, 31111
Section 3/4 = 4041, 40511, 40512, 4061, 4341, AK13S, AK13I

[i] Monitoring wells: Section 1/9 = 0011, 0041, 00511, 00512, 00513, 0061, 0071, 0081, 00912, 01012, 01113, 01[illegible],
0131, 0151, 01612, 04411, 04412, 04413, 04512
Section 6/7 = 1571, 16612
Section 2/8 = 3051, 30611, 30612, 3071, 3091, 31011, 31012, 31112

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ATTACHMENT II.B.2
SWSIP Table 2-28 Water Quality Standards

Addenda to the QAPjP July 29, 1992

Mercury Parameter Profile FSWSR Appendix B

CONTRACT No. 901 - 9260
IT PROJECT No. 529363

FRESH KILLS
Leachate Mitigation System Project

Surface Water and Sediment Investigation Plan

Date: *July 26, 1991*
Document No. *529363 - 00196 Revision 1*

Submitted to:

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In Compliance With the Order on Consent:
NYSDEC Case No. D2-9001-89-03, Appendix A-7

Prepared for:

CITY OF NEW YORK
DEPARTMENT OF SANITATION

NEW YORK, NEW YORK

Prepared by:

IT INTERNATIONAL TECHNOLOGY CORPORATION

Regional Office • 165 Fieldcrest Avenue • P. O. Box 7809 • Edison, New Jersey 08818 - 7809 • 908-225-2000

000649

FK-C-040 (D-31)

TABLE 2-8

NEW YORK STATE WATER QUALITY STANDARDS
FOR THE ARTHUR KILL AND ASSOCIATED TRIBUTARIES

Parameter	SD	SC	I
Dissolved oxygen (mg/L)	3.0	5.0	4.0
Fecal Coliform (per 100 ml)	NS	200[a]	2000[a]
pH Units	Normal ± 0.1	Normal ± 0.1	Normal ± 0.1
Temperature (°F)	Must insure the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife		NS No Standard
Turbidity	No unnatural increase	No unnatural increase	No unnatural increase
Oil and floating substances	No residue due to wastes and no visible oil film or globules of grease	No residue due to wastes and no visible oil film or globules of grease	No residue due to wastes and no visible oil film or globules of grease
Suspended, colloidal and settleable solids	No deposition from wastes nor deleterious effects on best usage.	No deposition from wastes nor deleterious effects on best usage.	No deposition from wastes nor deleterious effects on best usage.
Toxic wastes and deleterious subtances (ug/l)	None in sufficient amounts to impair survival of fish life or any other best usage	None in amounts that will injure culture, propagation or condition of edible fish or shellfish; no interference with secondary contact recreation or any other best usage	None in amounts that will injure culture, propagation of condtion of edible fish or shellfish; no interference with secondary contact recreation or any other best usage
Aldrin and Dieldrin	0.001	0.001	NS
Arsenic	120	63	NS
Azinphosmethyl	NS	0.01	NS

TABLE ¿ ծ (Cont'd.)

Parameter	SD	SC	I
Boron (Acid-soluble)	NS	1,000	NS
Chromium (VI) (Acid-soluble)	1,200	54	NS
Copper	3.2	2.0	NS
Cyanide	1.0	1.0	NS
DDT, DDD and DDE	0.001	0.001	NS
Demeton	NS	0.1	NS
Endosulfan	0.034	0.001	NS
Endrin	0.002	0.002	NS
Heptachlor and Heptachlor Epoxide	0.001	0.001	NS
Hexachlorobutadiene	3.0	0.3	NS
Hexachlorocyclohexane	0.16	0.004	NS
Hexachloropentadiene	0.7	0.07	NS
Hydrogen sulfide	NS	2.0	NS
Lead	220	8.6	NS
Malathion	NS	0.1	NS
Methoxychlor	NS	0.03	NS
Mirex	NS	0.001	NS

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ENV/KP146-tb13//

TABLE 2-6 (Cont'd.)

Parameter	SD	SC	I
Nickel (Acid-soluble)	140	7.1	NS
Polychlorinated Biphenyl (PCB)	0.001	0.001	NS
Silver	2.3	NS	NS
Toxaphene	NS	0.005	NS
Trichlorobenzenes	50	5	NS
Zinc	170	58	NS

(a) Monthly geometric mean value from a minimum of five examinations.

(b) Turbidity specified in Jackson Turbidity Units (JTU) as 30-day average.

NS = No Standard, NQS - No Quantitative Standard

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THE CITY OF NEW YORK Department of Sanitation

ROBERT P. LEMIEUX
Deputy Commissioner

Waste Management and
Facilities Development
44 Beaver Street
New York, NY 10004
Telephone (212) 837-8001

July 29, 1992

Mr. Norman H. Nosenchuck, P.E.
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, NY 12233

Mr. Gilbert Burns, P.E.
New York State Department of
Environmental Conservation
Region II
47-40 21st Street
Long Island City, NY 11101

RE: **Fresh Kills Landfill Consent Order,**
DEC Case Number D2-9001-89-03
Addendums to QAPP and QAPjP (July 29, 1992)

Dear Mr. Nosenchuck and Mr. Burns:

As a result of discussions with Mr. William Wurster of the New York State Department of Environmental Conservation (DEC) held on July 16, 1992, the New York City Department of Sanitation (The Department) is submitting revised tabulations listing project practical quantitation limits (PQLs), method detection limits (MDLs) and data quality objectives (DQOs) for each of the matrices monitored as part of the Fresh Kills Leachate Mitigation System Project (see Attachments 1, 2 and 3).

Tables listing PQLs, MDLs, and DQOs were submitted as attachments to the July 15, 1992 letter presenting "Addendums to QAPP and QAPjP (July 15, 1992)". However, values of DQOs and MDLs were not available for each parameter analyzed. At the request of Mr. Wurster, the gaps in the DQO tables for which updated water quality and sediment criteria do not exist were to be supplemented with numerical values. Previously, in certain cases, PQL values had been designated as the DQO where water quality standards did not exist at that time. In situations where DQO values had not been assigned for the project, PQL values have now been inserted into the tables to complete the listing, as appropriate for a particular parameter. In cases of certain leachate characteristics, it is not appropriate to list PQLs as the DQO limit because levels of these

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parameters are commonly detected in unpolluted groundwaters and surface waters at levels above the PQL. For example, PQL values are not listed as DQOs for parameters such as alkalinity, BOD, COD, carbon, color, etc.

With this submittal, the DOS is presenting these values of DQOs, MDLs and PQLs as project guidelines for reporting and evaluating monitoring data from the Fresh Kills project. An MDL study is currently being performed for metals and the new metals' MDLs will be updated when they become available.

Therefore, the Department requests DEC to review and authorize the use of these proposed values for the Fresh Kills Leachate Mitigation System Project.

If you have any questions, please do not hesitate to contact me at (212)837-8458.

Very truly yours,

Ted R. Nabavi

Ted R. Nabavi, CHMM, REP
Senior Environmental Manager

TN:mb
fk01349(pc)
529363-01349

c: (w/o attachment)
D/C R. Lemieux
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S. Bayat, DOS
D. Walsh, Regional DEC
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J. Koppen, IT
S. Posten, IT
C. Papageorgis, IT
J. Giga, IT

ATTACHMENT 2

DQO, MDL AND PQL VALUES
FOR SURFACE WATER SAMPLES

Revised July 29, 1992

I.T. CORPORATION
EDISON, NJ 08837
(908)-225-2000

FRESH KILLS LEACHATE MITIGATION SYSTEM PROJECT ANALYTICAL DATA

Reported on 07/29/92

TEST PANEL:		
LAB ID: DQO-SW LOCATION: DQO-SW COLLECTED: 07/29/92 MATRIX: Surface Water	LAB ID: MDL-SW LOCATION: MDL-SW COLLECTED: 07/29/92 MATRIX: Surface Water	LAB ID: PQL-SW LOCATION: PQL-SW COLLECTED: 07/29/92 MATRIX: Surface Water
LAB ID: LOCATION: COLLECTED: MATRIX:	LAB ID: LOCATION: COLLECTED: MATRIX:	

METHOD	ANALYTE	UNITS	RESULT	Q	EXTRACTED or ANALYZED	RESULT	Q	EXTRACTED or ANALYZED	RESULT	Q	EXTRACTED or ANALYZED	RESULT	Q	EXTRACTED or ANALYZED	RESULT	Q	EXTRACTED or ANALYZED
ASP	COPPER	ug/L	2.9			10			25								
ASP	IRON	ug/L				100			100								
ASP	LEAD	ug/L	8.6			3.0			3								
ASP	MAGNESIUM	ug/L				100			5000								
ASP	MANGANESE	ug/L				5			15								
ASP	MERCURY	ug/L	0.1			0.2			0.2								
ASP	NICKEL	ug/L	7.1			10			40								
ASP	POTASSIUM	ug/L				2500			5000								
ASP	SELENIUM	ug/L	54			5.0			5								
ASP	SILVER	ug/L	2.3			5.0			10								
ASP	SODIUM	ug/L				250			5000								
ASP	THALLIUM	ug/L	2130			10.0			10								
ASP	VANADIUM	ug/L				10			50								
ASP	TIN	ug/L				100			250								
ASP	ZINC	ug/L	58			10			20								
ASP	ALDRIN	ug/L	0.001			0.0036			0.05								
ASP	alpha-BHC	ug/L	50			0.0031			0.05								
ASP	beta-BHC	ug/L	50			0.0036			0.05								
ASP	delta-BHC	ug/L	50			0.0026			0.05								
ASP	gamma-BHC (LINDANE)	ug/L	0.004			0.0051			0.05								
ASP	alpha-CHLORDANE	ug/L	0.002			0.0054			0.05								
ASP	gamma-CHLORDANE	ug/L	0.002			0.0034			0.05								
ASP	4,4'-DDD	ug/L	0.001			0.0062			0.1								
ASP	4,4'-DDE	ug/L	0.001			0.014			0.1								
ASP	4,4'-DDT	ug/L	0.001			0.0060			0.1								
ASP	DIELDRIN	ug/L	0.001			0.0084			0.1								
ASP	ENDOSULFAN I	ug/L	0.001			0.0054			0.05								
ASP	ENDOSULFAN II	ug/L	0.001			0.0043			0.1								
ASP	ENDOSULFAN SULFATE	ug/L	50			0.67			0.1								
ASP	ENDRIN	ug/L	0.002			0.0056			0.1								

FRESH KILLS SURFACE WATER STUDY
PARAMETER PROFILES

PARAMETER		PROFILE
MERCURY:		
	CRITERIA-	CRDL= 0.2 ug/l or 0.0002 mg/l DQO= 0.1 ug/l OR 0.0001 mg/l (NYSDEC AMB. WAT. QUAL. GUID. VALUE 11/15/91) MDL = 0.2 ug/l PQL = 0.2 ug/l NYSDEC. Amb. Wat. Qual. Std. & G. V. (11/15/91) = SD= NS; SC= NS; I= 0.001 (G); B= NS
	LITERATURE FINDINGS-	NATURALLY DETECTED IN SEAWATER AT 0.03 ug/l OR 0.00003 mg/l AS HgCl(4)-2 (HORNE, 1969) INTERSTATE SANITATION COMMISSION (ISC.1988) SAMPLED AND ANALYZED FOR TOTAL METALS AT 8 SAMPLING STATIONS ALONG THE ARTHUR KILL ON 1/15/88 AT HIGH & LOW TIDE RANGE -HIGH TIDE= 0.5 - 1.2 ug/l; RANGE -LOW TIDE= 0.3 - 0.5 ug/l
	LEACHATE-	LEACHATE SEC. 1/9 SHALLOW AND REFUSE WELLS MEDIAN: 0.10 ug/l; 139 OF 160 ND LEACHATE SEC. 2/8 SHALLOW AND REFUSE WELLS MEDIAN: 0.10 ug/l; 42 OF 45 ND LEACHATE SEC. 3/4 SHALLOW AND REFUSE WELLS MEDIAN: 0.10 ug/l; 66 OF 74 ND LEACHATE SEC. 6/7 SHALLOW AND REFUSE WELLS MEIDAN: 0.10 ug/l; 150 OF 167 ND (GROUNDWATER QUALITY DATA 1/91,7/91,1/92,4/92, AND 7/92 AS PART OF THE CONSENT ORDER APPENDIX A - 6 HYDROLOGICAL INVESTIGATION)
	SW SUMMARY DATA-	NOV. 1990: A/R LANDFILL ALL STATIONS DETECTED ABOVE DQO AND NYSDEC STD.; CRDL WAS MET JAN. 1991: SW MERCURY DETECTED ABOVE DQO AND NYSDEC STD. RANGE ND (WC-1,3,5-7,11,-14,18)- 0.5 ug/l OR ND - 0.0005 mg/l FEB. 1991: A/R LANDFILL ALL STATIONS WERE ND EXCEPT FOR TWO; CRDL WAS MET; DETECTED ABOVE DQO AND NYSDEC GUIDANCE VALUE FKAP-3= 0.2 ug/l OR 0.0002 mg/l AND FKAP-1= 0.5 ug/l OR 0.0005 mg/l AUG. 1991: A/R LANDFILL ALL STATIONS WERE ND EXCEPT ONE; CRDL WAS MET; DETECTED ABOVE DQO AND NYSDEC GUIDANCE VALUE UT-2= 0.32 ug/l OR 0.00032 mg/l

FRESH KILLS SURFACE WATER STUDY
PARAMETER PROFILES

PARAMETER		PROFILE
MERCURY:		
		SW DETECTED ABOVE DQO AND NYSDEC STD.; CRDL WAS MET MORE STATIONS HAD DETECTION WITH LOW TIDE SAMPLING RANGE ND – 0.73 ug/l OR ND – 0.00073 mg/l
	OCT. 1991:	SW ALL STATIONS WERE ND
	MAR 1992:	ND (WC–1–4,6,8–13,15,16,18) TO 0.0003 mg/l (WC–14) SW MEAN VALUE = 0.0002 mg/l; STD. DEV. = 0.00004 mg/l
	MAY 1992:	ALL DATA ND EXCEPT STATION WC–16; 0.00078 mg/l (WC–16) SW MEAN VALUE = 0.0002 mg/l; STD. DEV. = 0.00014 mg/l
	AUG. 1992:	RANGE OF LOW TIDE, UNFILTERED VALUES = ND (WC–1,2,4–6,9,10,13–16,18,25,28,29,30–32) TO 0.0007 mg/l (WC–12) SW MEAN VALUE = 0.0002 mg/l; STD. DEV. = 0.00010 mg/l RANGE OF LOW TIDE, FILTERED VALUES = ND (WC–1,2,4–6,8–16,18,25,28,29,30,31) TO 0.0002 mg/l (WC–32) SW MEAN VALUE = 0.0002 mg/l; STD. DEV. = 0.000007 mg/l RANGE OF HIGH TIDE, UNFILTERED VALUES = ND (WC–1,2,4–6,9,12–14,16,18,25,28,29,32) TO 0.0004 mg/l (WC–11) SW MEAN VALUE = 0.0004 mg/l; STD. DEV. = 0.00066 mg/l
	OCT. 1992:	RANGE OF LOW TIDE, UNFILTERED VALUES = ND (ALL SITES EXCEPT WC–28) TO 0.0004 mg/l (WC–28) SW MEAN VALUE = 0.0002 mg/l; STD. DEV. = 0.00003 mg/l
	JAN. 1993:	ND (ALL WC STATIONS EXCEPT FOR WC–11) TO 0.0004 mg/l (WC–11) SW MEAN VALUE = 0.0002 mg/l; STD. DEV.= 0.00006 mg/l

Note : NA = Not Applicable
ND = Not Detected
NL = Not Listed
NS = No Standard

ST. = Station
A/R = Ash Residue Landfill
CRIT. = Criteria

ATTACHMENT II.C
USEPA Region 2 Presentation March 1, 1994

- List of Chemicals of Concern in the NY/NJ Harbor Estuary
- Table 2- Preliminary NY/NJ Harbor Toxics Categorization
- Long et. al. 1993 Incidence of Toxicity

FSWSR

- Figures 9-68 through 9-80 Sediment Exchange Analyses
- Table 4-6 USCG Record of Oil Spills

July 29, 1992 Addendum to QAPP and QAPjP

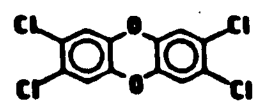
- DQO's for Sediment Samples
- Project Specific Critical Parameters

Comparison of Sediment Ammonia to Surrogate SQC

ASSESSMENT AND MANAGEMENT OF DIOXIN CONTAMINATED SEDIMENTS IN THE NEW YORK / NEW JERSEY HARBOR ESTUARY

HUDSON RIVER FOUNDATION
MARCH 1, 1994

ERIC A. STERN, ALEX LECHICH, DOUG PABST and SETH AUSUBEL



$C_{12}H_4Cl_4O_2$, TCDD

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER MANAGEMENT DIVISION
REGION 2

DRAFT

LIST OF CHEMICALS OF CONCERN IN THE NY-NJ HARBOR ESTUARY

CHEMICAL NAME	MEDIUM: WATER	BIOTA	SEDIMENTS
Metals:			
arsenic		o	
cadmium		o	
copper	•		
mercury	•		o
nickel	•		
lead	•		
PCBs	o	•	o
Dioxin		•	o
PAHs	•	o	o
Pesticides:			
DDT & metabolites		o	o
chlordane		•	o
dieldrin		•	
heptachlor		o	
heptachlor epoxide		o	
hexachlorobenzene		o	
gamma-BHC		o	
Volatile organic compounds:			
tetrachloroethylene	o		

o = Exceedances of unenforceable criteria

• = Exceedances of enforceable standard

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TABLE 2
PRELIMINARY NEW YORK/NEW JERSEY HARBOR TOXICS CATEGORIZATION
SUMMARY TABLE

TOXIC	F.T.	W.Q.	Sed.	Overall
CATEGORY IA				
Industrial Chemicals				
PCBs (T)	I.A.	I.A.	ER-M	I.A.
Dioxin (2,3,7,8-TCDD)	I.A.			I.A.
Hexachlorobutadiene		I.A.		I.A.
Trichloroethylene		I.A.		I.A.
Pesticides				
Chlordane	I.A.		ER-M	I.A.
DDT + DDD, DDE	I.B.	I.A.	ER-M	I.A.
Dieldrin	I.A.	I.A.	ER-M	I.A.
Aldrin		I.A.		I.A.
Endosulphan		I.A.		I.A.
Heptachlor + Hept. Epoxide	I.B.	I.A.		I.A.
Hexachlorocyclohexane (BHC)				
a-alpha		I.A.		I.A.
r-gamma (Lindane)	I.B.	I.A.		I.A.
Metals				
Arsenic(T)	I.B.	I.A.		I.A.
Cadmium(T)		I.A.	ER-M	I.A.
Copper		I.A.	ER-M	I.A.
Lead		I.A.	ER-M	I.A.
Mercury	I.A.	I.B.	ER-M	I.A.
Nickel(T)		I.A.	ER-M	I.A.
Silver(T)		I.A.	ER-M	I.A.
Zinc(T)		I.A.	ER-M	I.A.
CATEGORY IB				
Industrial Chemicals				
Tetrachlorodibenzofurans	I.B.			I.B.
Benzene		I.B.		I.B.
Bis (2-ethylhexyl) phthalate		I.B.		I.B.
Carbon Tetrachloride		I.B.		I.B.
Chlorobenzene		I.B.		I.B.
1,4 Dichlorobenzene		I.B.		I.B.
Ethylbenzene		I.B.		I.B.
Hexachlorobenzene	I.B.			I.B.
Methylene Chloride		I.B.		I.B.
N-Nitrosodi-N-propylamine		I.B.		I.B.
1,1,2,2-Tetrachloroethane		I.B.		I.B.
Tetrachloroethylene		I.B.		I.B.
1,1,2-Trichloroethane		I.B.		I.B.

TOXIC	F.T.	W.Q.	Sed.	Overall
CATEGORY IB				
Industrial Chemicals (cont.)				
PAHs				
LMW: Acenaphthylene	I.B.			I.B.
Anthracene	I.B.		ER-M	I.B.
Naphthalene		I.B.	ER-L	I.B.
Phenanthrene	I.B.	I.B.	ER-M	I.B.
HMW: Benzo(a)anthracene	I.B.		ER-M	I.B.
Benzo(k)fluoranthene	I.B.			I.B.
Benzo(a)pyrene	I.B.		ER-L	I.B.
Benzo(e)pyrene	I.B.			I.B.
Chrysene	I.B.		ER-L	I.B.
Dibenz(a,h)anthracene	I.B.		ER-L	I.B.
Fluorene	I.B.		ER-L	I.B.
Fluoranthene	I.B.			I.B.
Pyrene	I.B.	I.B.	ER-M	I.B.
Metals				
Beryllium(T)		I.B.		I.B.
NO OFFICIAL CATEGORY - SEDIMENT EFFECTS LEVELS ONLY				
Industrial Chemicals				
PAHs (T)				
LMW: Acenaphtene			ER-L	
2-Methylnaphthalene			ER-M	
Metals				
Chromium			ER-M	

F.T. = Fish Tissue Categorization
W.Q. = Water Quality Categorization
Sed. = NOAA Sediments Effects Values, based on concentrations in sediment observed or predicted by the (1) equilibrium partitioning approach, (2) spiked-sediment bioassay approach or (3) by different methods of evaluating synoptically collected biological or chemical field data.
(T) = Total concentration of chemical (dissolved + particulate)
Category I.A. = Ambient Data Exceed Enforceable Standard
Category I.B. = Ambient Data Exceed More Stringent But Unenforceable Criteria
LMW = Low Molecular Weight Polycyclic Aromatic Hydrocarbon (PAH)
HMW = High Molecular Weight PAH
ER-L = at or above the Low Effects Range - The lowest 10 percentile in the data associated with biological effects.
ER-M = at of above the Median Effects Range - The median range associated with biological effects.

Incidence of Toxicity

with Solid-Phase Amphipod Tests

Region	Toxic/Total	(%)	Species
Newark Bay	48/57	(84.2%)	A. abdita
Long Island Sound Bays	50/60	(83.3%)	A. abdita
San Pedro Bay	61/105	(58.1%)	R. abronius
San Francisco Bay	56/111	(50.4%)	R. abronius
Hudson-Raritan Estuary	54/117	(46.2%)	A. abdita
Tampa Bay	10/165	(6.1%)	A. abdita
Pensacola Bay	0/40	(0.0%)	A. abdita

(Long et al., 1993)
unpublished

000064

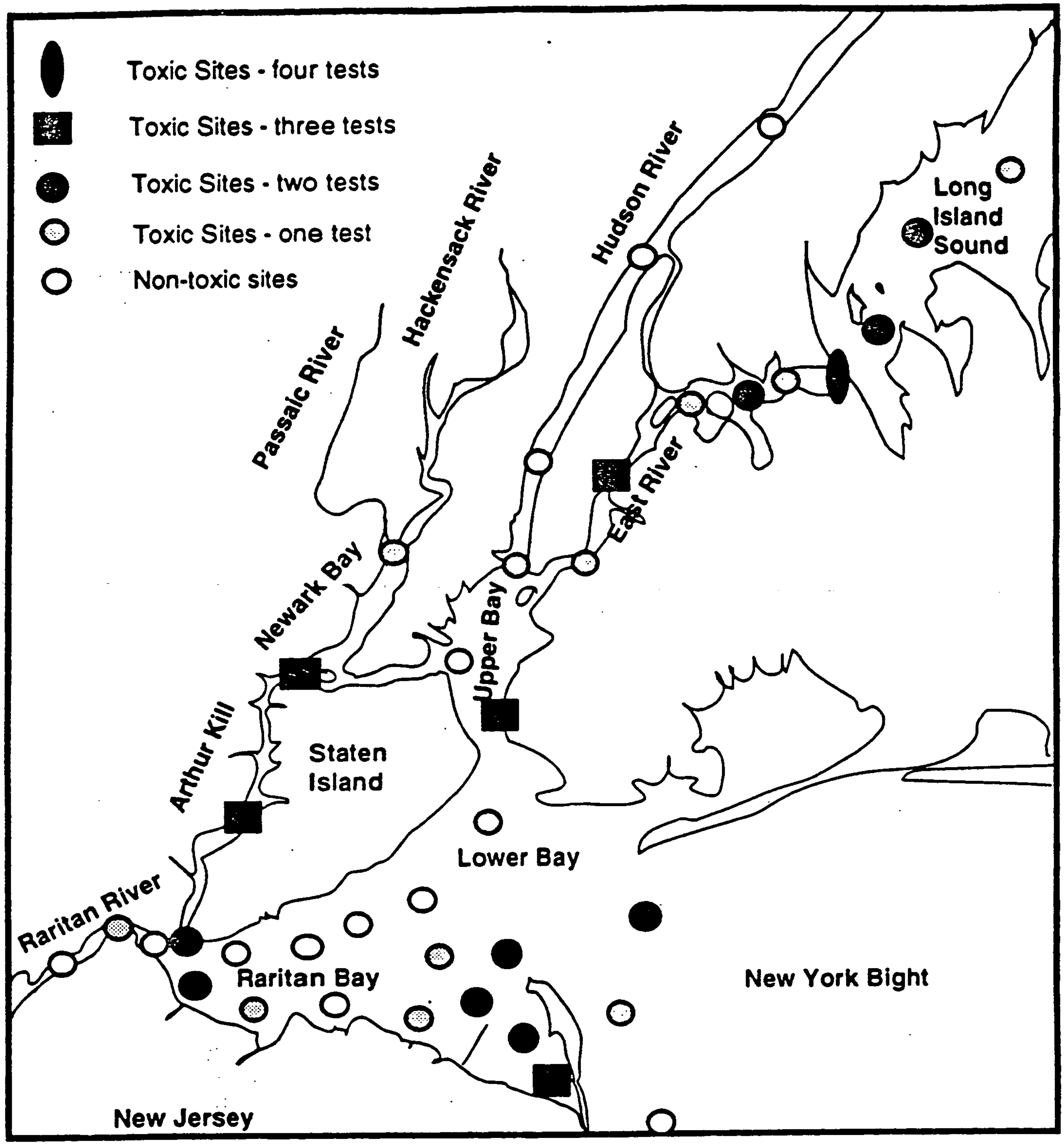
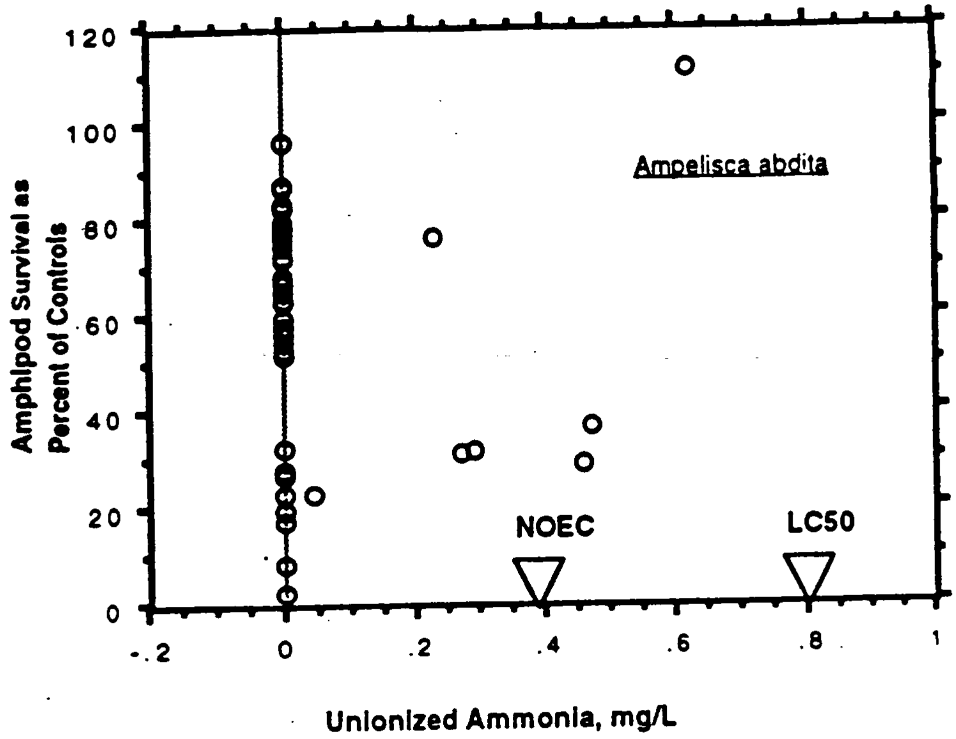


Figure 1. Sampling sites in the Hudson-Raritan estuary in which sediments were determined to be not toxic in any test, or significantly toxic in one, two, three or four of the tests.

(Long et al., 1993)
unpublished

000065

Amphipod Survival vs. Ammonia in Newark Bay



Long et al, 1993
unpublished

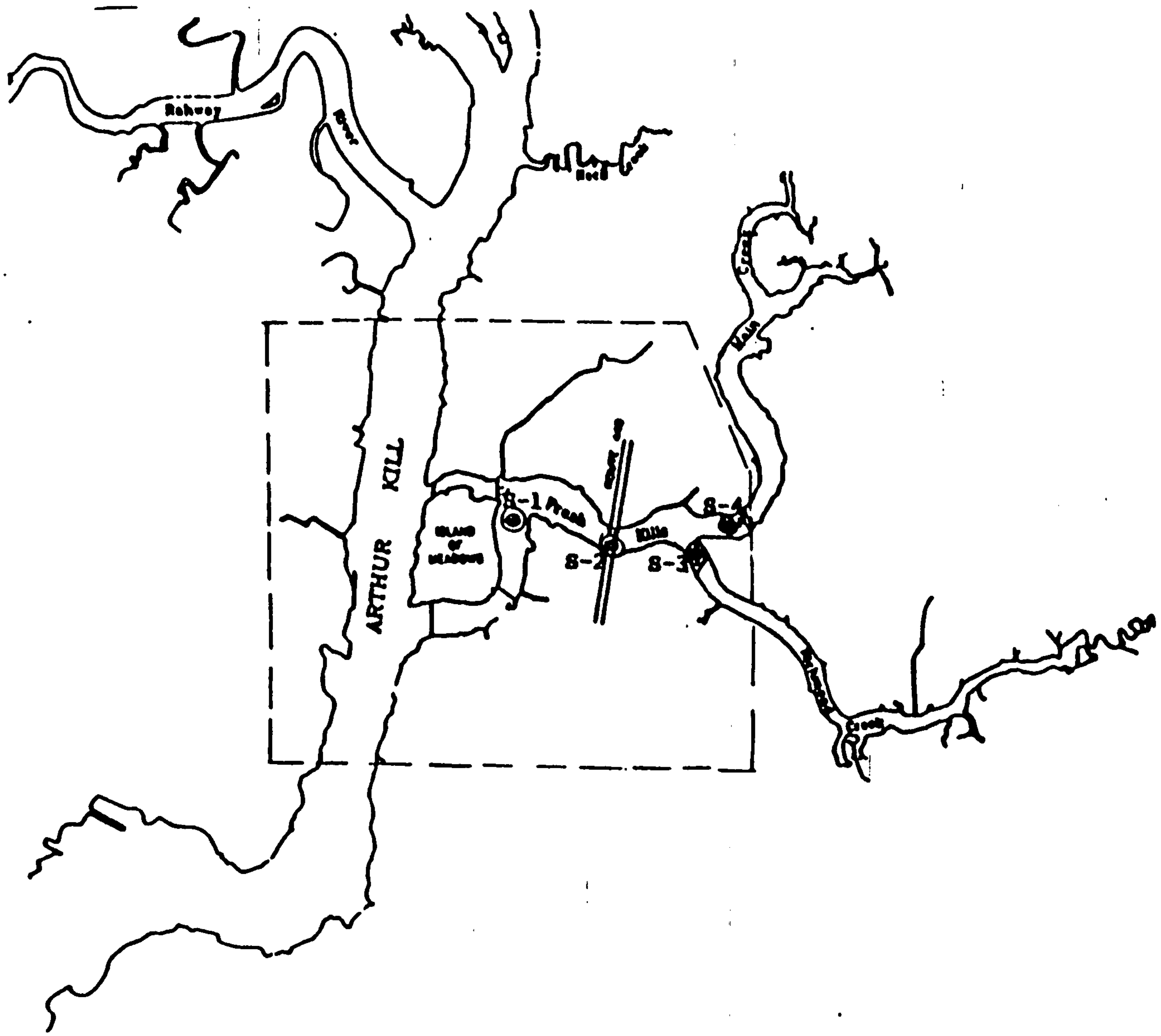


Figure 9-68   Sediment Exchange Analysis Model Domain and Observation Stations

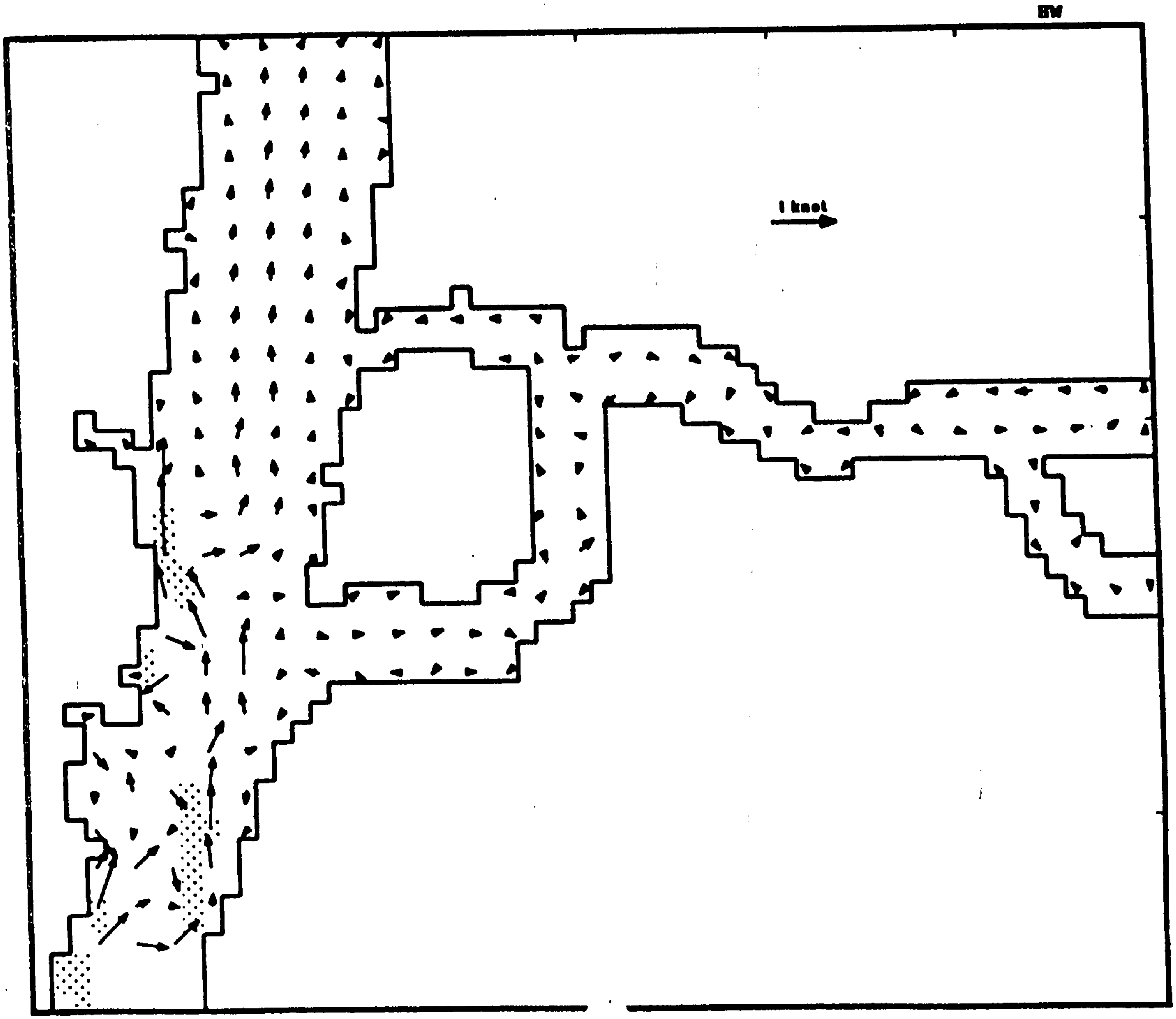


Figure 9-69 Predicted Currents in Fresh Kills and Arthur Kill - High Water

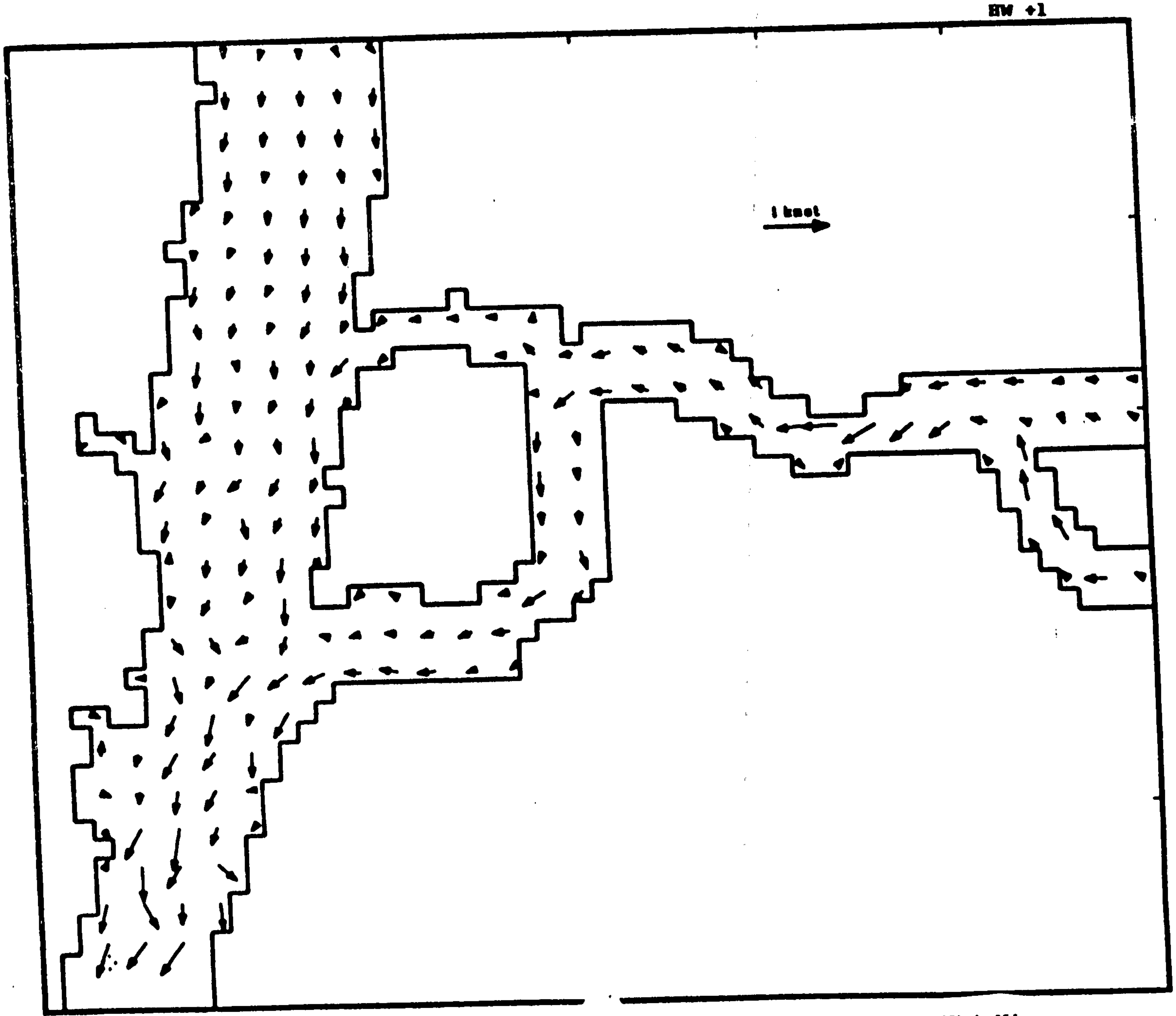


Figure 9-70 Predicted Currents in Fresh Kills and Arthur Kill - One Hour After High Water

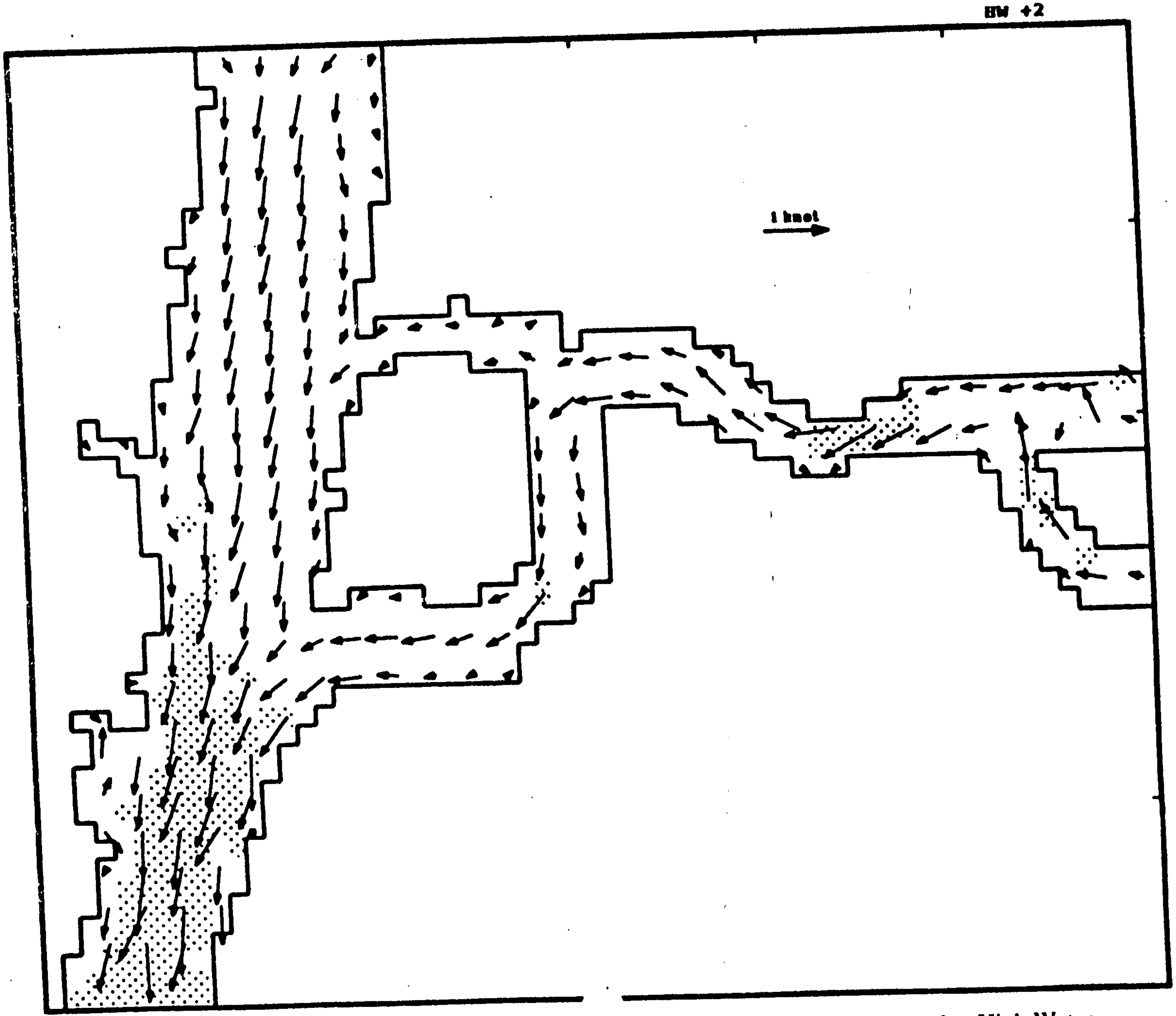


Figure 9.71 Predicted Currents in Fresh Kills and Arthur Kill - Two Hours After High Water

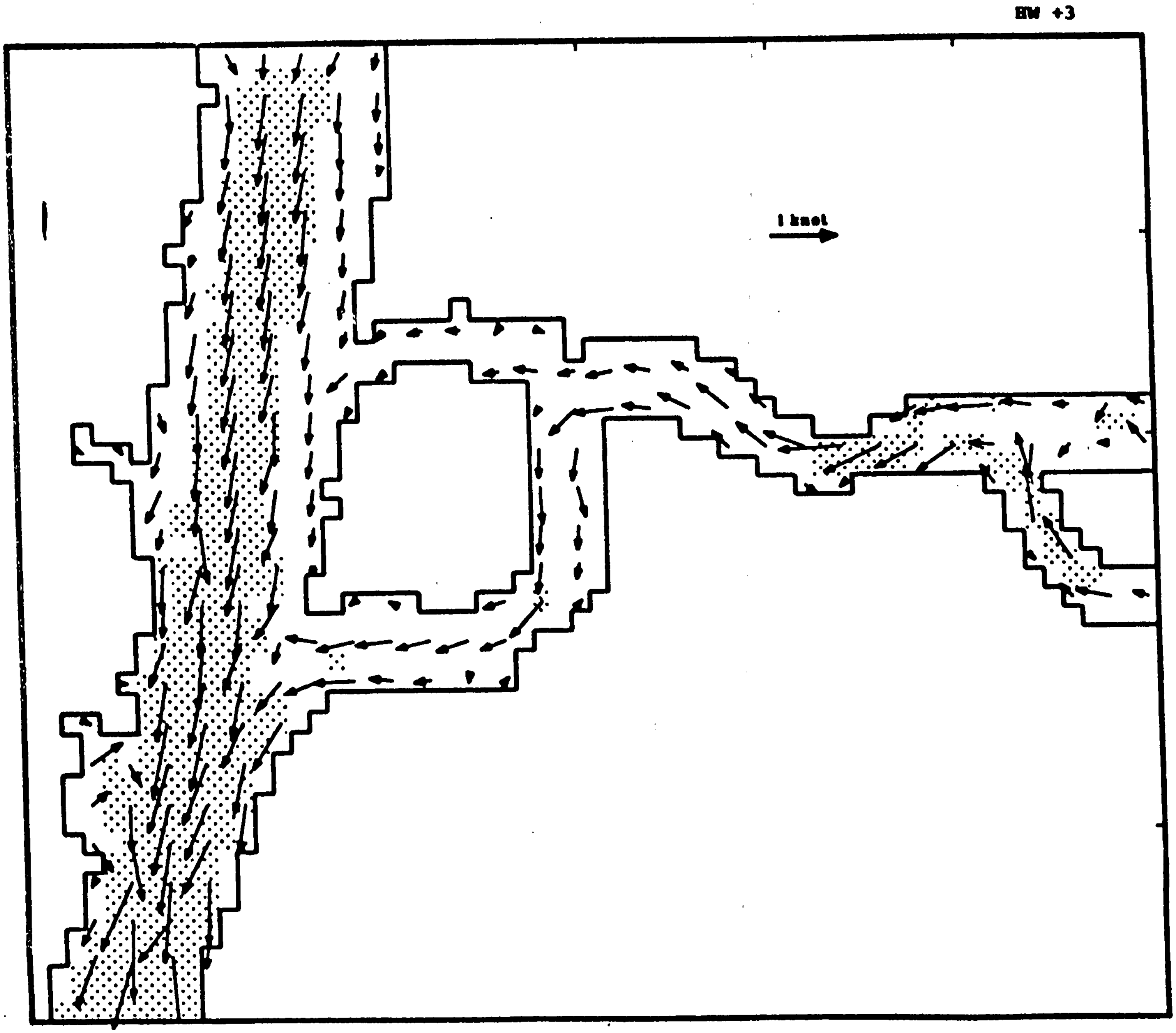


Figure 9-72 Predicted Currents in Fresh Kills and Arthur Kill - Three Hours After High Water

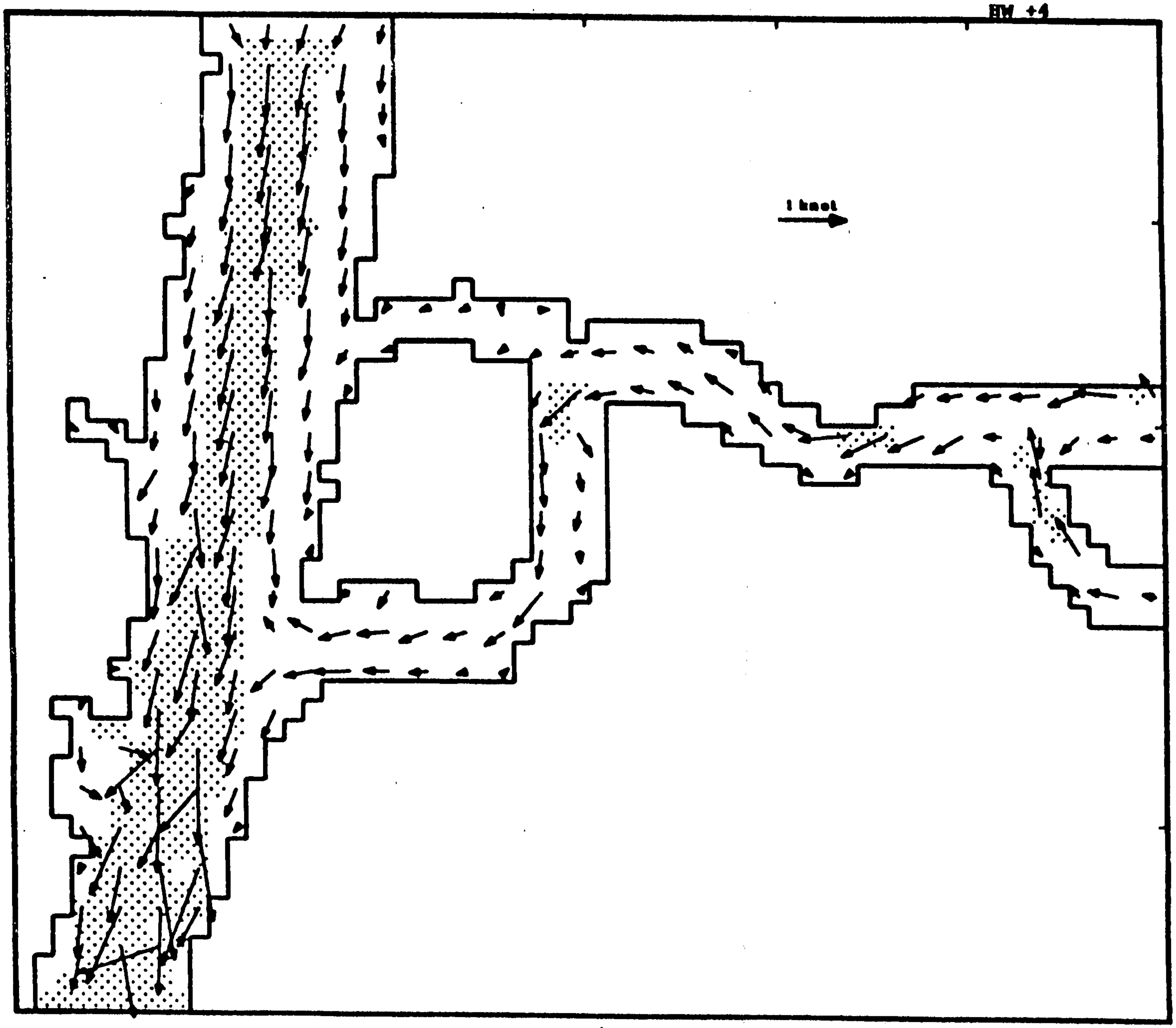


Figure 9-73 Predicted Currents in Fresh Kills and Arthur Kill - Four Hours After High Water

0000722

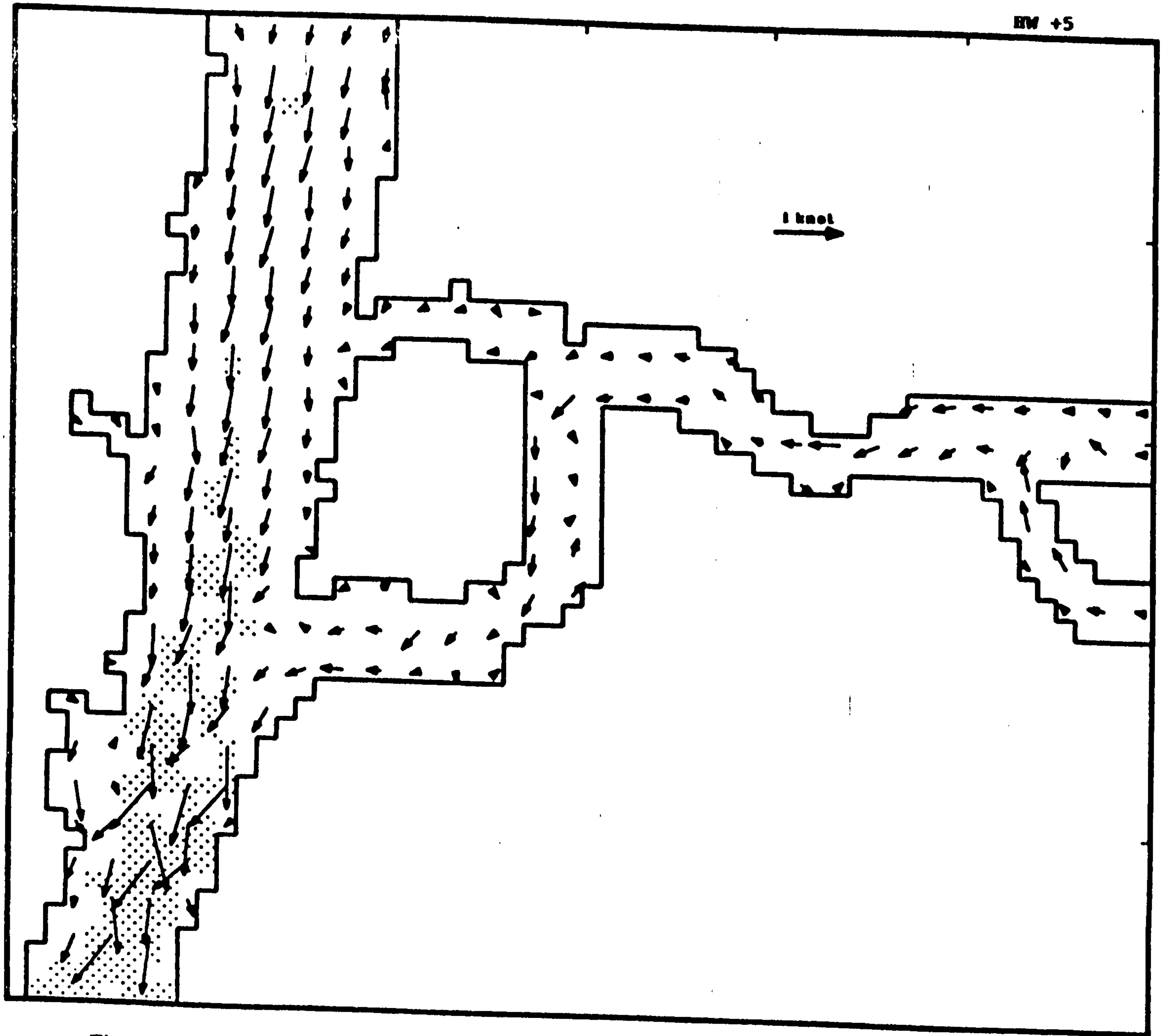


Figure 9-74 Predicted Currents in Fresh Kills and Arthur Kill - Five Hours After High Watei

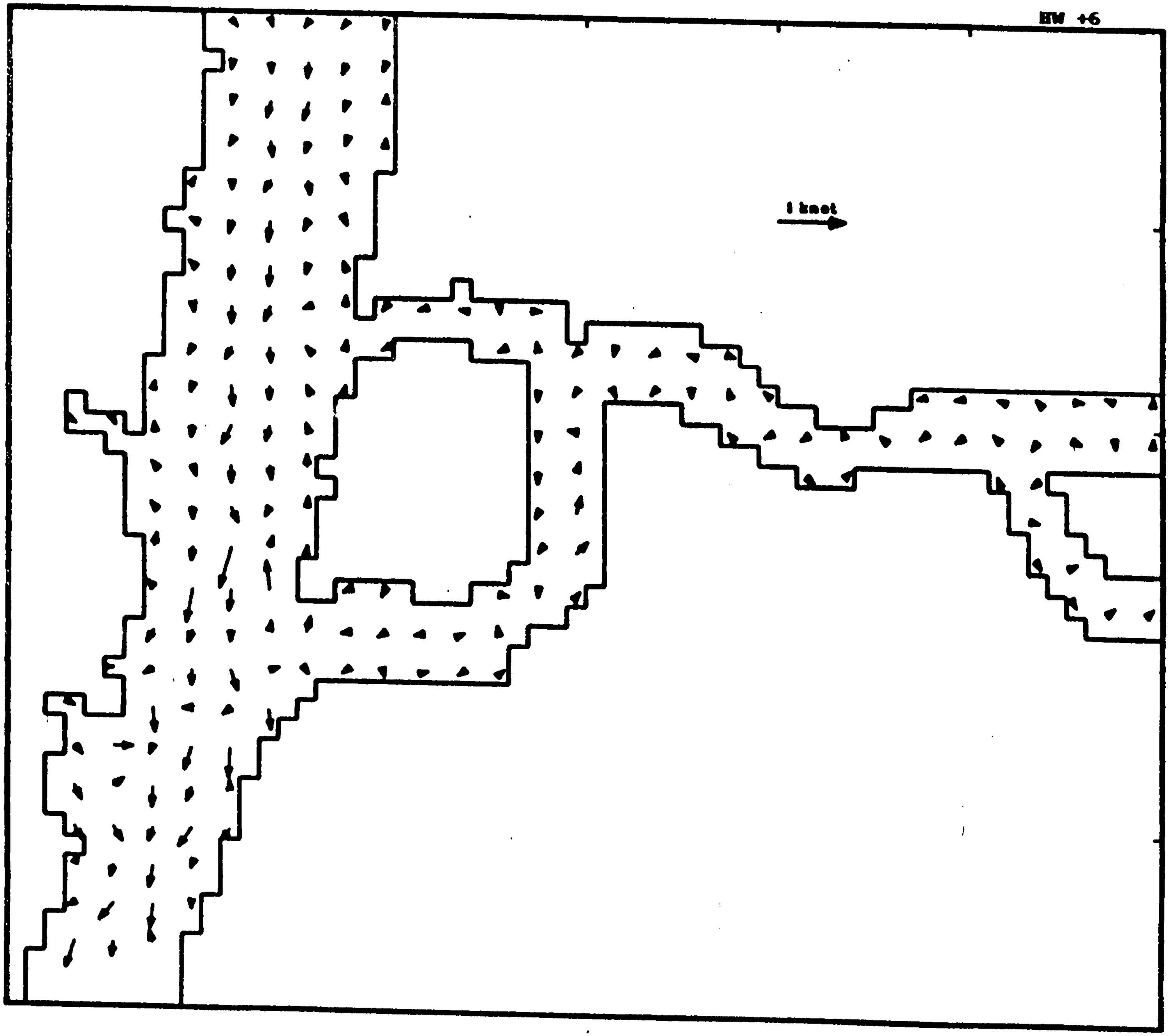


Figure 9-75 Predicted Currents in Fresh Kills and Arthur Kill - Six Hours After High Water

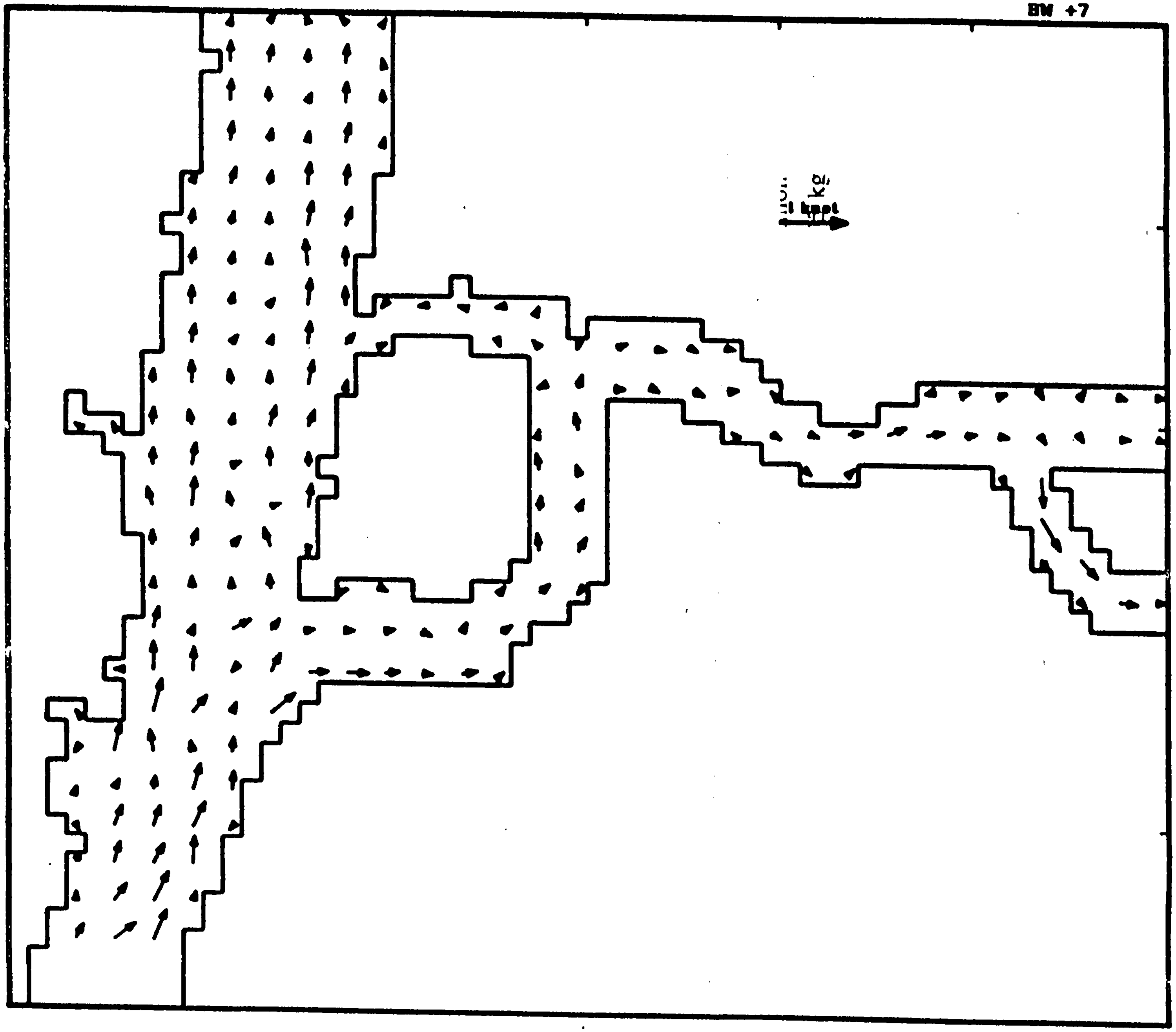


Figure 9-76 Predicted Currents in Fresh Kills and Arthur Kill - Seven Hours After High Water

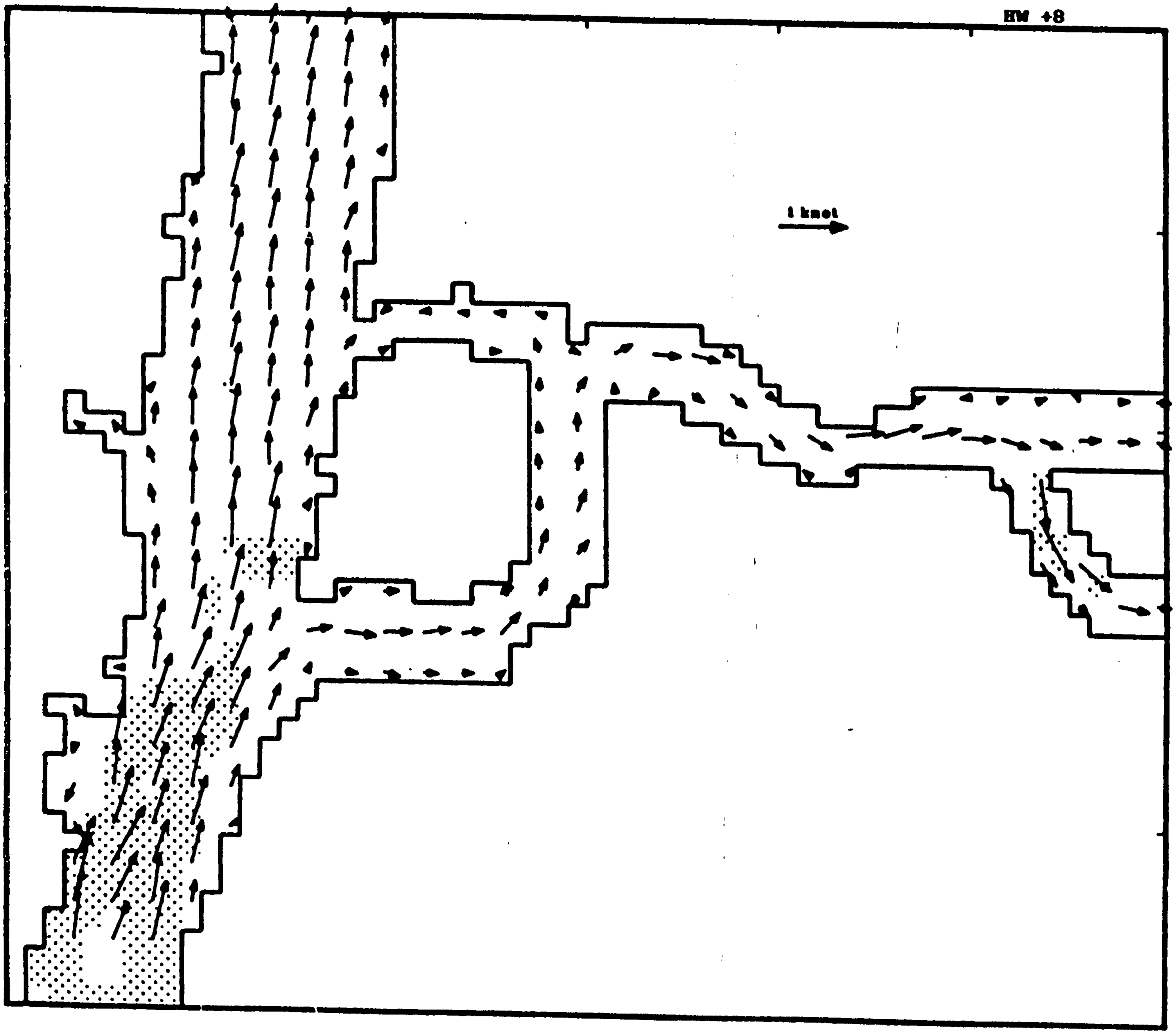


Figure 9-77 Predicted Currents in Fresh Kills and Arthur Kill - Eight Hours After High Water

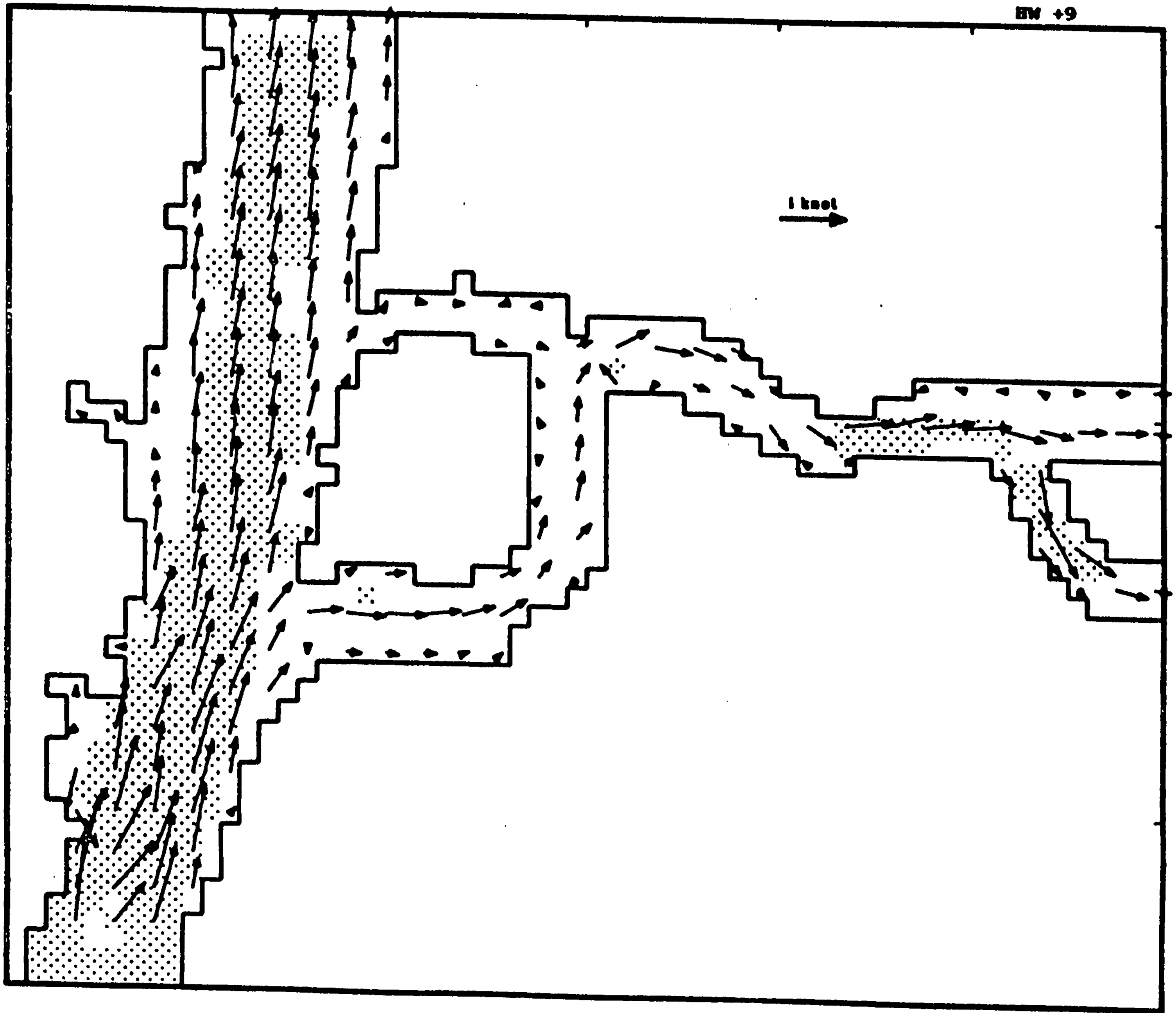


Figure 9-78 Predicted Currents in Fresh Kills and Arthur Kill - Nine Hours After High Water

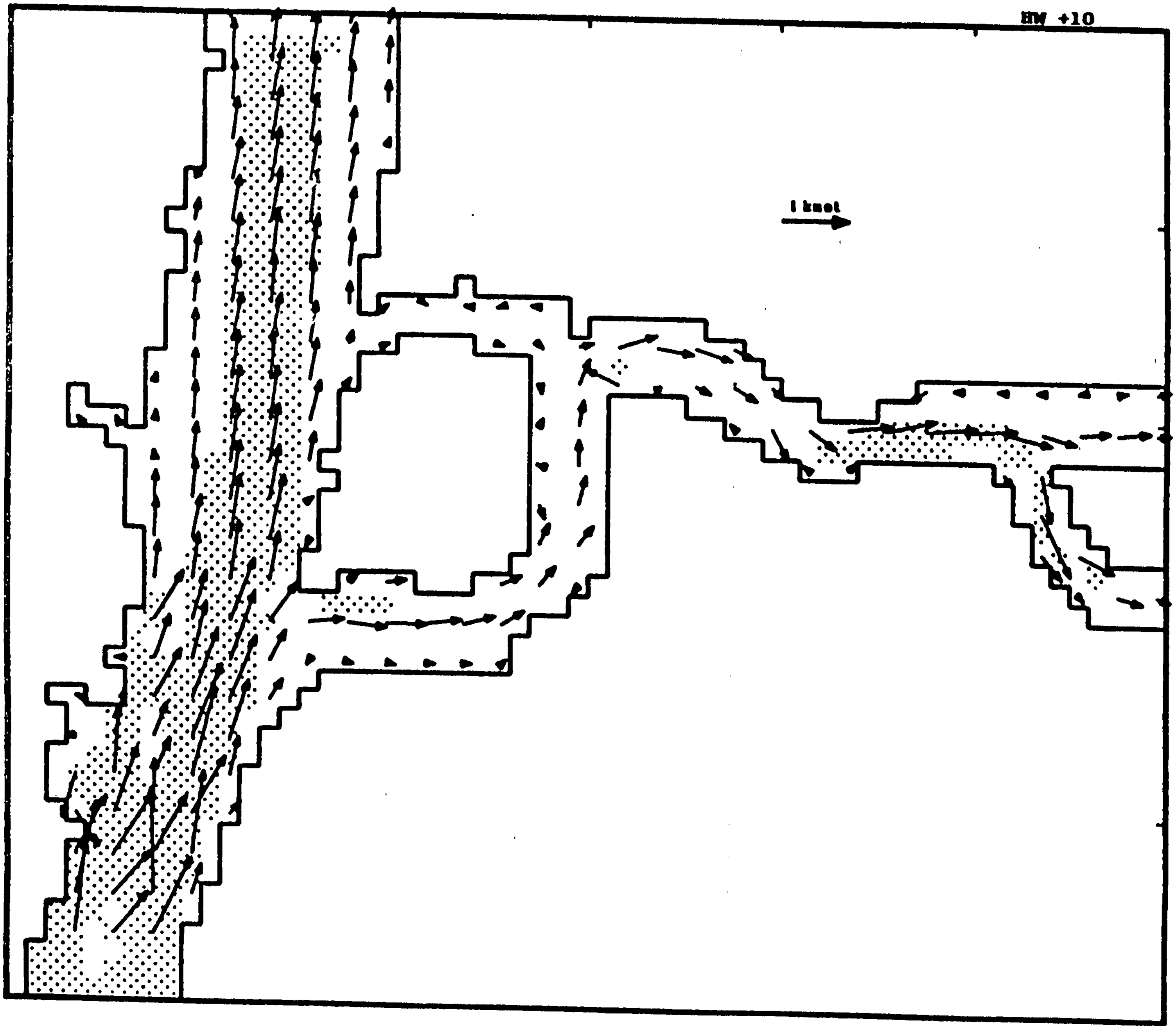


Figure 9-79 Predicted Currents in Fresh Kills and Arthur Kill - Ten Hours After High Water

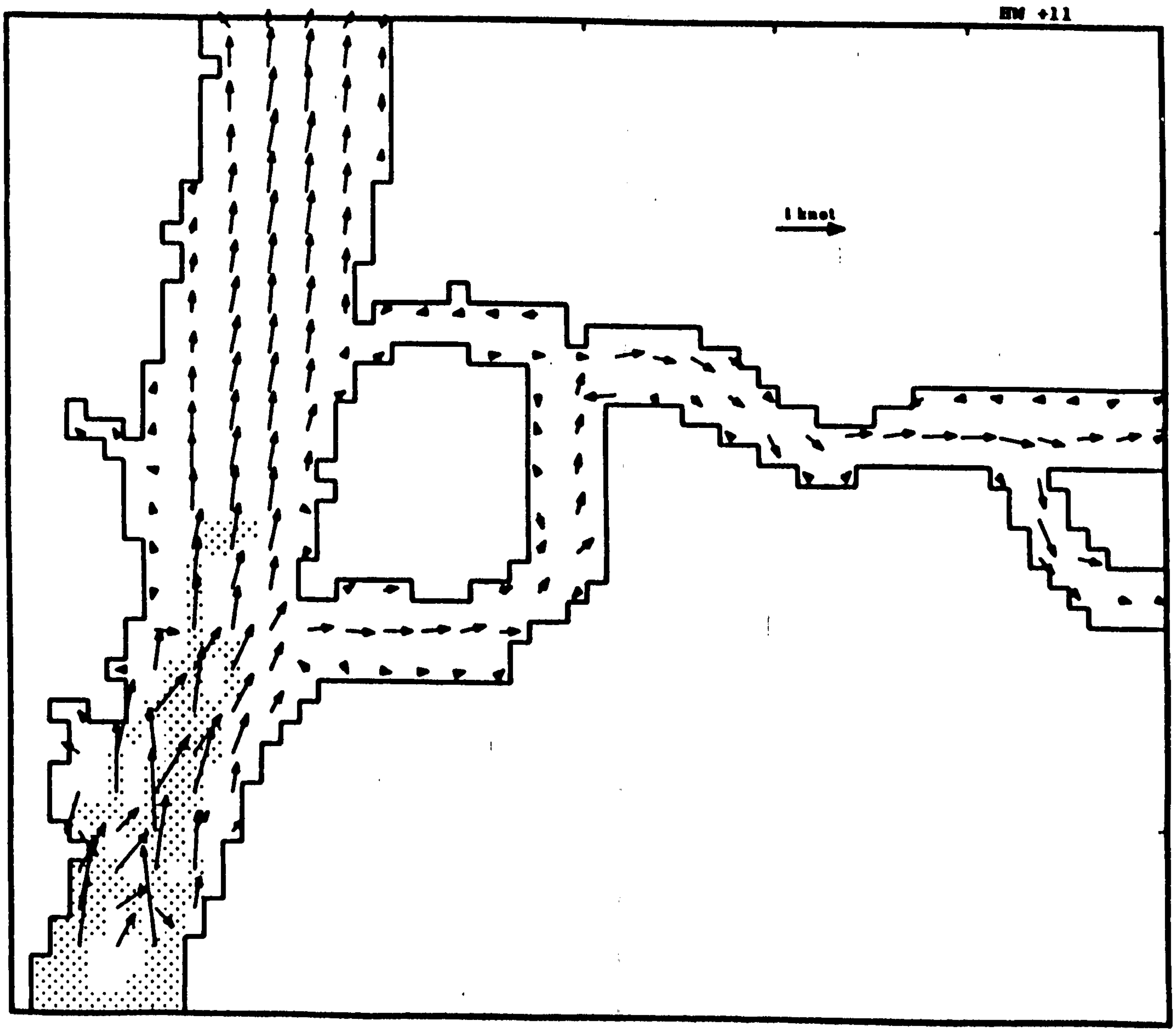


Figure 9.80 Predicted Currents in Fresh Kills and ... Kill ...

TABLE 4-6
ALL REPORTED OIL SPILLS GREATER THAN 1,000 GALLONS IN THE ARTHUR KILL FOR YEARS 1980 - 1989

SPILL DATE	AMOUNT	UNITS	CARGO NAME
11-Jan-80	210,000	gallons	Oil, fuel: No. 1-D
17-Feb-81	1,000	gallons	Oil, fuel: No. 2-D
23-May-81	5,000	gallons	Oil, fuel: No. 1-D
1-Jul-81	1,500	gallons	Oil, fuel: No. 6
4-Aug-81	1,050	gallons	Gasoline: Automotive (4.23 g Pb/gal)
2-Sep-81	1,000	gallons	Not elsewhere specified
16-Nov-81	7,000	gallons	Not elsewhere specified
10-May-82	11,000	pounds	Not elsewhere specified
11-Jul-82	2,200	gallons	Not elsewhere specified
20-Sep-82	1,200	gallons	Oil: Crude
8-Dec-82	1,300	gallons	Styrene
21-Dec-82	4,800	gallons	Kerosene
13-Feb-83	2,500	gallons	Gasoline: Aviation (4.86g Pb/gal)
17-Apr-83	2,100	gallons	Oil, fuel: No.1-D
26-Mar-84	46,368	gallons	Asphalt blending stocks: Straight run residue
26-Mar-84	111,510	gallons	Asphalt
11-Apr-85	20,000	gallons	Oil: Crude
19-Jul-85	1,000	gallons	Oil, fuel: No. 6
7-Mar-86	72,342	gallons	Oil, fuel: No.2-D
24-Jun-86	2,100	gallons	Oil, fuel: No. 2
6-Oct-86	9,500	gallons	Oil, fuel: No. 2
16-Jan-87	10,000	gallons	Methyl n-butyl ketone
11-Feb-87	1,000	gallons	Oil: Diesel
10-Jul-87	56	barrels	Gasoline: Casinghead
9-Mar-88	3,825	gallons	Kerosene
19-Jul-88	2,500	gallons	Not defined
29-Dec-88	3,000	gallons	Oil: Crude
5-Jul-89	2,000	gallons	Oil: Crude

NOTE: Pollution data provided (1980-present) may be ongoing and could change or be deleted at any time.

Source: U.S. Coast Guard, 1990.

THE CITY OF NEW YORK Department of Sanitation

ROBERT P. LEMIEUX
Deputy Commissioner

Waste Management and
Facilities Development
44 Beaver Street
New York, NY 10004
Telephone (212) 837-8001

July 29, 1992

Mr. Norman H. Nosenchuck, P.E.
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, NY 12233

Mr. Gilbert Burns, P.E.
New York State Department of
Environmental Conservation
Region II
47-40 21st Street
Long Island City, NY 11101

RE: **Fresh Kills Landfill Consent Order,**
DEC Case Number D2-9001-89-03
Addendums to QAPP and QAPjP (July 29, 1992)

Dear Mr. Nosenchuck and Mr. Burns:

As a result of discussions with Mr. William Wurster of the New York State Department of Environmental Conservation (DEC) held on July 16, 1992, the New York City Department of Sanitation (The Department) is submitting revised tabulations listing project practical quantitation limits (PQLs), method detection limits (MDLs) and data quality objectives (DQOs) for each of the matrices monitored as part of the Fresh Kills Leachate Mitigation System Project (see Attachments 1, 2 and 3).

Tables listing PQLs, MDLs, and DQOs were submitted as attachments to the July 15, 1992 letter presenting "Addendums to QAPP and QAPjP (July 15, 1992)". However, values of DQOs and MDLs were not available for each parameter analyzed. At the request of Mr. Wurster, the gaps in the DQO tables for which updated water quality and sediment criteria do not exist were to be supplemented with numerical values. Previously, in certain cases, PQL values had been designated as the DQO where water quality standards did not exist at that time. In situations where DQO values had not been assigned for the project, PQL values have now been inserted into the tables to complete the listing, as appropriate for a particular parameter. In cases of certain leachate characteristics, it is not appropriate to list PQLs as the DQO limit because levels of these parameters are commonly detected in unpolluted groundwaters and surface waters at levels above the PQL. For example, PQL values are not listed as DQOs for parameters such as alkalinity, BOD, COD, carbon, color, etc.

With this submittal, the DOS is presenting these values of DQOs, MDLs and PQLs as project guidelines for reporting and evaluating monitoring data from the Fresh Kills project. An MDL study is currently being performed for metals and the new metals' MDLs will be updated when they become available.

Therefore, the Department requests DEC to review and authorize the use of these proposed values for the Fresh Kills Leachate Mitigation System Project.

If you have any questions, please do not hesitate to contact me at (212)837-8458.

Very truly yours,

Ted R. Nabavi, CHMM, REP
Senior Environmental Manager

TN:mb
fk01349(pc)
529363-01349

c: (w/o attachment)
D/C R. Lemieux
D/C J. Levine
A/C A. Zarillo
P. Gleason
H. Rubinstein
S. Kath, Corp Counsel
G. Milstrey, NYSDEC Albany
P. Gallay, Regional DEC
CF

(w/attachment)
S. Bayat, DOS
D. Walsh, Regional DEC
W. Wurster, NYSDEC Albany
J. Koppen, IT
S. Posten, IT
C. Papageorgis, IT
J. Giga, IT

ATTACHMENT 3

DQO, MDL AND PQL VALUES
FOR SEDIMENT SAMPLES

Revised July 29, 1992

I.T. CORPORATION
EDISON, N.J. 08837
(908)225-2000

FRESH KILLS LEACHATE MITIGATION SYSTEM PROJECT ANALYTICAL DATA

Reported on 07/29/92

Values Based upon 100% Solids

MDL Concentrations are based upon initial sample extracts. If sample extracts require GPC cleanup, the MDL will increase by a factor of 2.

	TEST PANEL:		LAB ID: DQO-SD CLIENT ID: DQO-SD COLLECTED: 07/29/92 MATRIX: Sediment			LAB ID: MDL-SD CLIENT ID: MDL-SD COLLECTED: 07/29/92 MATRIX: Sediment			LAB ID: PQL-SD CLIENT ID: MDL-SD COLLECTED: 07/29/92 MATRIX: Sediment			LAB ID: CLIENT ID: COLLECTED: MATRIX:			LAB ID: CLIENT ID: COLLECTED: MATRIX:		
	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
E 310.1	ALKALINITY (as CaCO3)	mg/Kg				10			10								
E 350.1	AMMONIA	mg/Kg				0.2			0.2								
E 405.1	BOD5	mg/Kg					NA			NA							
E 415.2	CARBON, TOTAL ORGANIC	mg/Kg				50			50								
E 325.3	CHLORIDE	mg/Kg				10			10								
E 410.1/.2	COD	mg/Kg				1000			1000								
E 110.2	COLOR	Units					NA			NA							
ASP	CYANIDE, TOTAL	mg/Kg	2000			0.5											
E 130.2	TOTAL HARDNESS	mg/Kg				10			10								
E 7196	HEXAVALENT CHROMIUM	mg/Kg	400			0.5			0.5								
E 353.1	NITRATE	mg/Kg				0.2			0.2								
E 351.2	NITROGEN, TOTAL KJELDAHL	mg/Kg				2.0			2.0								
E 420.2	PHENOLS	mg/Kg	0			0.5			0.5								
E 160.1	TOTAL DISSOLVED SOLIDS	mg/Kg					NA			NA							
E 375.4	SULFATE	mg/Kg				10			10								
SM427C	SULFIDE	mg/Kg				0.4			0.4								
E 180.1	TURBIDITY	NTU					NA			NA							
8150	2,4-D	mg/Kg	0.003			0.001			0.0033								
8150	2,4,5-T	mg/Kg	0.003			0.001			0.0033								
8150	SILVEX	mg/Kg	600			0.0005			0.0017								
ASP	ALUMINUM	mg/Kg				10			40								
ASP	ANTIMONY	mg/Kg	30			3			12								
ASP	ARSENIC	mg/Kg	80			0.5			2								
ASP	BARIUM	mg/Kg	4000			10			40								
ASP	BERYLLIUM	mg/Kg	0.16			0.3			0.5								
ASP	BORON	mg/Kg	7000			20			50								
ASP	CADMIUM	mg/Kg	80			0.3			1								
ASP	CALCIUM	mg/Kg				20			1000								
ASP	CHROMIUM	mg/Kg	624			0.5			2								
ASP	COBALT	mg/Kg				3.0			10								

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	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP	COPPER	mg/Kg	456			2.0			5								
ASP	IRON	mg/Kg				20			200								
ASP	LEAD	mg/Kg	648			0.6			0.6								
ASP	MAGNESIUM	mg/Kg				20			1000								
ASP	MANGANESE	mg/Kg	20000			1.0			3								
ASP	MERCURY	mg/Kg	20			0.1			0.1								
ASP	NICKEL	mg/Kg	2000			2.0			8								
ASP	POTASSIUM	mg/Kg				500			1000								
ASP	SELENIUM	mg/Kg				1.0			1								
ASP	SILVER	mg/Kg	200			1.0			2								
ASP	SODIUM	mg/Kg				50			1000								
ASP	THALLIUM	mg/Kg	6			2.0			1								
ASP	VANADIUM	mg/Kg	600			2.0			5								
ASP	TIN	mg/Kg	50000			20.0			25								
ASP	ZINC	mg/Kg	20000			2.0			2								
ASP	ALDRIN	mg/Kg	0.041			0.0001			0.0017								
ASP	alpha-BHC	mg/Kg	0.11			0.0001			0.0017								
ASP	beta-BHC	mg/Kg	3.9			0.0001			0.0017								
ASP	delta-BHC	mg/Kg	0.0017			0.0001			0.0017								
ASP	gamma-BHC (LINDANE)	mg/Kg	5.4			0.0002			0.0017								
ASP	alpha-CHLORDANE	mg/Kg	0.54			0.0002			0.0017								
ASP	gamma-CHLORDANE	mg/Kg	0.0017			0.0001			0.0017								
ASP	4,4'-DDD	mg/Kg	2.9			0.0002			0.0033								
ASP	4,4'-DDE	mg/Kg	2.1			0.0005			0.0033								
ASP	4,4'-DDT	mg/Kg	2.1			0.0002			0.0033								
ASP	DIELDRIN	mg/Kg	0.044			0.0003			0.0033								
ASP	ENDOSULFAN I	mg/Kg	4			0.0002			0.0033								
ASP	ENDOSULFAN II	mg/Kg	4			0.0001			0.0033								
ASP	ENDOSULFAN SULFATE	mg/Kg	0.096			0.022			0.033								
ASP	ENDRIN	mg/Kg	200			0.0002			0.0033								

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	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP	ENDRIN ALDEHYDE	mg/Kg	0.0033			0.0002			0.0033								
ASP	HEPTACHLOR	mg/Kg	0.16			0.0001			0.0017								
ASP	HEPTACHLOR EPOXIDE	mg/Kg	0.077			0.0001			0.0017								
ASP	ISODRIN	mg/Kg	0.17			0.0004			0.17								
ASP	METHOXYCHLOR	mg/Kg	400			0.001			0.017								
ASP	TOXAPHENE	mg/Kg	0.64			0.02			0.17								
ASP	AROCLOR-1016	mg/Kg	0.192			0.002			0.033								
ASP	AROCLOR-1221	mg/Kg	0.192			0.002			0.033								
ASP	AROCLOR-1232	mg/Kg	0.192			0.002			0.033								
ASP	AROCLOR-1242	mg/Kg	0.192			0.002			0.033								
ASP	AROCLOR-1248	mg/Kg	0.192			0.002			0.033								
ASP	AROCLOR-1254	mg/Kg	0.192			0.002			0.033								
ASP	AROCLOR-1260	mg/Kg	0.192			0.002			0.033								
ASP	ACENAPHTHENE	mg/Kg	5000			0.14			0.33								
ASP	ACENAPHTHYLENE	mg/Kg	0.33			0.17			0.33								
ASP	ACETOPHENONE	mg/Kg	8000			0.16			0.33								
ASP	2-ACETYLAMINOFLUORENE	mg/Kg	0.33			0.26			0.33								
ASP	4-AMINOBIPHENYL	mg/Kg	0.33			0.14			0.33								
ASP	ANILINE	mg/Kg	120			0.01			0.33								
ASP	ANTHRACENE	mg/Kg	2000			0.12			0.33								
ASP	ARAMITE	mg/Kg	28			0.20			0.33								
ASP	BENZO(a)ANTHRACENE	mg/Kg	0.22			0.14			0.33								
ASP	BENZO(a)PYRENE	mg/Kg	0.061			0.17			0.33								
ASP	BENZO(b)FLUORANTHENE	mg/Kg	0.22			0.27			0.33								
ASP	BENZO(ghi)PERYLENE	mg/Kg	0.33			0.33			0.33								
ASP	BENZO(k)FLUORANTHENE	mg/Kg	0.22			0.30			0.33								
ASP	BENZYL ALCOHOL	mg/Kg	20000			0.07			0.33								
ASP	BIS(2-CHLOROETHOXY)METHANE	mg/Kg	0.33			0.25			0.33								
ASP	BIS(2-CHLOROETHYL)ETHER	mg/Kg	0.64			0.16			0.33								
ASP	BIS(2-ETHYLHEXYL)PHTHALATE	mg/Kg	2873			0.17			0.33								

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TEST PANEL:					
LAB ID:	DQO-SD	MDL-SD	PQL-SD		
CLIENT ID:	DQO-SD	MDL-SD	MDL-SD		
COLLECTED:	07/29/92	07/29/92	07/29/92		
MATRIX:	Sediment	Sediment	Sediment		

	METHOD/ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP	4-BROMOPHENYL PHENYL ETHER	mg/Kg	0.33			0.14			0.33								
ASP	BUTYL BENZYL PHTHALATE	mg/Kg	20000			0.16			0.33								
ASP	4-CHLOROANILINE	mg/Kg	200			0.06			0.33								
ASP	CHLOROBENZILATE	mg/Kg	2000			0.43			0.66								
ASP	4-CHLORO-3-METHYLPHENOL	mg/Kg	0.33			0.21			0.33								
ASP	2-CHLORONAPHTHALENE	mg/Kg	0.33			0.14			0.33								
ASP	2-CHLOROPHENOL	mg/Kg	400			0.17			0.33								
ASP	4-CHLOROPHENYL PHENYL ETHER	mg/Kg	2000			0.17			0.33								
ASP	CHRYSENE	mg/Kg	17			0.13			0.33								
ASP	DI-n-BUTYL PHTHALATE	mg/Kg	8000			0.18			0.33								
ASP	DI-n-OCTYL PHTHALATE	mg/Kg	2000			0.17			0.33								
ASP	DIALATE	mg/Kg	12			0.28			0.33								
ASP	DIBENZ(a,h)ANTHRACENE	mg/Kg	0.014			0.19			0.33								
ASP	DIBENZOFURAN	mg/Kg	0.33			0.04			0.33								
ASP	1,3-DICHLOROBENZENE	mg/Kg	288			0.14			0.33								
ASP	1,4-DICHLOROBENZENE	mg/Kg	29			0.15			0.33								
ASP	3,3'-DICHLOROBENZIDINE	mg/Kg	1.6			0.25			0.33								
ASP	2,4-DICHLOROPHENOL	mg/Kg	200			0.30			0.33								
ASP	2,6-DICHLOROPHENOL	mg/Kg	0.50			0.37			0.50								
ASP	DIETHYL PHTHALATE	mg/Kg	60000			0.11			0.33								
ASP	DIMETHOATE	mg/Kg	20			0.08			0.33								
ASP	[illegible](DIMETHYLAMINO)AZOBENZENE	mg/Kg	0.66			0.33			0.66								
ASP	[illegible]-DIMETHYLBENZIDINE	mg/Kg	0.076			0.21			0.33								
ASP	7,12-DIMETHYLBENZ(a)ANTHRACENE	mg/Kg	0.66			0.36			0.66								
ASP	2,4-DIMETHYLPHENOL	mg/Kg	2000			0.17			0.33								
ASP	[illegible]DIMETHYLPHENETHYLAMINE	mg/Kg	0.33			0.32			0.33								
ASP	DIMETHYL PHTHALATE	mg/Kg	80000			0.18			0.33								
ASP	1,3-DINITROBENZENE	mg/Kg	8			0.20			0.33								
ASP	4,6-DINITRO-2-METHYLPHENOL	mg/Kg	8			0.30			1.7								
ASP	2,4-DINITROPHENOL	mg/Kg	200			0.20			0.33								

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	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP	2,4-DINITROTOLUENE	mg/Kg	1			0.18			0.33								
ASP	2,6-DINITROTOLUENE	mg/Kg	1			0.21			0.33								
ASP	DINOSEB	mg/Kg	80			0.26			0.33								
ASP	DIPHENYLAMINE	mg/Kg	2000			0.14			0.33								
ASP	DISULFOTON	mg/Kg	3			0.29			0.33								
ASP	ETHYL METHANESULFONATE	mg/Kg	0.66			0.38			0.66								
8140	FAMPHUR	mg/Kg	0.017			0.006			0.017								
ASP	FLUORANTHENE	mg/Kg	3000			0.18			0.33								
ASP	FLUORENE	mg/Kg	3000			0.16			0.33								
ASP	HEXACHLOROBENZENE	mg/Kg	0.41			0.17			0.33								
ASP	HEXACHLOROBUTADIENE	mg/Kg	90			0.15			0.33								
ASP	HEXACHLOROCYCLOPENTADIENE	mg/Kg	600			0.12			0.33								
ASP	HEXACHLOROETHANE	mg/Kg	80			0.15			0.33								
ASP	HEXACHLOROPROPENE	mg/Kg	0.33			0.31			0.33								
ASP	INDENO(1,2,3-cd)PYRENE	mg/Kg	0.33			0.13			0.33								
ASP	ISOPHORONE	mg/Kg	1800			0.29			0.33								
ASP	ISOSAFROLE	mg/Kg	0.33			0.24			0.33								
ASP	METHAPYRILENE	mg/Kg	0.33			0.70			0.33								
ASP	METHYL METHANESULFONATE	mg/Kg	1.6			0.22			1.6								
8140	METHYL PARATHION	mg/Kg	20			0.004			0.017								
ASP	3-METHYLCHOLANTHRENE	mg/Kg	0.074			0.43			0.66								
ASP	[illegible]-METHYLNAPHTHALENE	mg/Kg	0.33			0.05			0.33								
ASP	[illegible]METHYLPHENOL	mg/Kg	1.7			0.06			1.7								
ASP	[illegible]METHYLPHENOL	mg/Kg	1.7			0.28			1.7								
ASP	4-METHYLPHENOL	mg/Kg	1.7			0.06			1.7								
ASP	[illegible]NAPHTHOQUINONE	mg/Kg	0.33			0.02			0.33								
ASP	[illegible]NAPHTHYLAMINE	mg/Kg	0.33			0.15			0.33								
ASP	2-NAPHTHYLAMINE	mg/Kg	0.33			0.07			0.33								
ASP	2-NITROANILINE	mg/Kg	0.33			0.07			0.33								
ASP	3-NITROANILINE	mg/Kg	0.33			0.07			0.33								

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	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP	4-NITROANILINE	mg/Kg	0.33			0.08			0.33								
ASP	2-NITROPHENOL	mg/Kg	1.7			0.30			1.7								
ASP	4-NITROPHENOL	mg/Kg	1.7			0.21			1.7								
ASP	4-NITROQUINOLINE-1-OXIDE	mg/Kg	0.33			0.23			0.33								
ASP	5-NITRO-o-TOLUIDINE	mg/Kg	0.1			0.11			0.33								
ASP	N-NITROSO-DIPROPYLAMINE	mg/Kg	0.13			0.22			0.33								
ASP	N-NITROSODI-N-BUTYLAMINE	mg/Kg	0.0046			0.22			0.33								
ASP	N-NITROSODIETHYLAMINE	mg/Kg	0.014			0.50			0.66								
ASP	N-NITROSODIMETHYLAMINE	mg/Kg	140			0.23			0.33								
ASP	N-NITROSODIPHENYLAMINE	mg/Kg	0.33			0.14			0.33								
ASP	N-NITROSOMETHYLETHYLAMINE	mg/Kg	0.33			0.14			0.33								
ASP	N-NITROSOMORPHOLINE	mg/Kg	0.33			0.26			0.33								
ASP	N-NITROSOPIPERIDINE	mg/Kg	0.33			0.16			0.33								
ASP	N-NITROSOPYRROLIDINE	mg/Kg	0.33			0.09			0.33								
ASP	NAPHTHALENE	mg/Kg	300			0.16			0.33								
ASP	NITROBENZENE	mg/Kg	40			0.18			0.33								
ASP	O,O,O-TRIETHYL PHOSPHOROTHIOATE	mg/Kg	0.33			0.26			0.33								
8140	PARATHION	mg/Kg	500			0.005			0.017								
ASP	PENTACHLOROBENZENE	mg/Kg	60			0.36			0.66								
ASP	PENTACHLOROETHANE	mg/Kg	0.33			0.10			0.33								
ASP	PENTACHLORONITROBENZENE	mg/Kg	27			0.31			0.33								
ASP	PENTACHLOROPHENOL	mg/Kg	5.8			0.30			1.7								
ASP	PHENACETIN	mg/Kg	0.33			0.16			0.33								
ASP	PHENANTHRENE	mg/Kg	2448			0.13			0.33								
ASP	PHENOL	mg/Kg	50000			0.11			0.17								
ASP	p-PHENYLENEDIAMINE	mg/Kg	0.33			0.03			0.33								
ASP	PHORATE	mg/Kg	0.33			0.22			0.33								
ASP	PRONAMIDE	mg/Kg	6000			0.18			0.33								
ASP	PYRENE	mg/Kg	2000			0.06			0.33								
ASP	SAFROLE	mg/Kg	0.33			0.19			0.33								

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TEST PANEL:					
LAB ID:	DQO-SD	MDL-SD	PQL-SD		
CLIENT ID:	DQO-SD	MDL-SD	MDL-SD		
COLLECTED:	07/29/92	07/29/92	07/29/92		
MATRIX:	Sediment	Sediment	Sediment		

	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP	1,2,4,5-TETRACHLOROBENZENE	mg/Kg	20			0.34			0.66								
ASP	2,3,4,6-TETRACHLOROPHENOL	mg/Kg	2000			0.46			0.66								
ASP	TETRAETHYL DITHIOPYROPHOSPHATE	mg/Kg	40			0.22			0.33								
ASP	THIONAZIN	mg/Kg	0.33			0.26			0.33								
ASP	o-TOLUIDINE	mg/Kg	2.9			0.16			0.33								
ASP	1,2,4-TRICHLOROBENZENE	mg/Kg	2000			0.23			0.33								
ASP	2,4,5-TRICHLOROPHENOL	mg/Kg	8000			0.13			1.7								
ASP	2,4,6-TRICHLOROPHENOL	mg/Kg	64			0.32			0.33								
ASP	sym-TRINITROBENZENE	mg/Kg	4			0.24			0.33								
ASP	ACETONE	mg/Kg	8000			0.006			0.01								
ASP	ACETONITRILE	mg/Kg	500			0.005			0.05								
ASP	ACROLEIN	mg/Kg	0.05			0.026			0.05								
ASP	ACRYLONITRILE	mg/Kg	1.3			0.032			0.05								
ASP	ALLYL CHLORIDE	mg/Kg	200			0.003			0.005								
ASP	BENZENE	mg/Kg	24			0.002			0.005								
ASP	BIS(2-CHLORO-1-METHYLETHYL)ETHER	mg/Kg	100			0.001			0.33								
ASP	BROMODICHLOROMETHANE	mg/Kg	5.4			0.002			0.005								
ASP	BROMOFORM	mg/Kg	89			0.002			0.005								
ASP	BROMOMETHANE	mg/Kg	80			0.003			0.005								
ASP	2-BUTANONE	mg/Kg	4000			0.002			0.010								
ASP	CARBON DISULFIDE	mg/Kg	6000			0.003			0.01								
ASP	CARBON TETRACHLORIDE	mg/Kg	5.4			0.003			0.005								
ASP	CHLOROBENZENE	mg/Kg	2000			0.001			0.005								
ASP	CHLOROETHANE	mg/Kg	540			0.002			0.005								
ASP	CHLOROFORM	mg/Kg	110			0.002			0.005								
ASP	CHLOROMETHANE	mg/Kg	0.05			0.003			0.005								
ASP	DIBROMOCHLOROMETHANE	mg/Kg	8.3			0.001			0.005								
ASP	1,2-DIBROMO-3-CHLOROPROPANE	mg/Kg	0.032			0.008			0.01								
ASP	1,2-DIBROMOETHANE	mg/Kg	0.0082			0.002			0.005								
8010	1,2-DICHLOROBENZENE	mg/Kg	7000			0.0002			0.001								

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METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
ASP trans-1,4-DICHLORO-2-BUTENE	mg/Kg	0.5			0.005			0.5								
ASP DICHLORODIFLUOROMETHANE	mg/Kg	2000			0.002			0.005								
ASP 1,1-DICHLOROETHANE	mg/Kg	8000			0.003			0.005								
ASP 1,2-DICHLOROETHANE	mg/Kg	7.7			0.005			0.005								
ASP 1,1-DICHLOROETHENE	mg/Kg	12			0.005			0.005								
ASP trans-1,2-DICHLOROETHYLENE	mg/Kg	2000			0.003			0.005								
ASP 1,2-DICHLOROPROPANE	mg/Kg	10			0.001			0.005								
ASP cis-1,3-DICHLOROPROPENE	mg/Kg	0.005			0.001			0.005								
ASP trans-1,3-DICHLOROPROPENE	mg/Kg	0.005			0.002			0.005								
ASP 1,4-DIOXANE	mg/Kg	0.50			0.110			0.500								
ASP ETHYL METHACRYLATE	mg/Kg	7000			0.004			0.005								
ASP ETHYLBENZENE	mg/Kg	8000			0.001			0.005								
ASP 2-HEXANONE	mg/Kg	0.01			0.003			0.01								
ASP IODOMETHANE	mg/Kg	0.005			0.002			0.005								
ASP ISOBUTYL ALCOHOL	mg/Kg	20000			0.019			3.3								
ASP METHACRYLONITRILE	mg/Kg	8			0.004			0.005								
ASP METHYL METHACRYLATE	mg/Kg	6000			0.005			0.005								
ASP 4-METHYL-2-PENTANONE	mg/Kg	0.01			0.004			0.01								
ASP METHYLENE BROMIDE	mg/Kg	0.005			0.002			0.005								
ASP METHYLENE CHLORIDE	mg/Kg	93			0.002			0.005								
ASP PROPIONITRILE	mg/Kg	0.5			0.004			0.5								
ASP PYRIDINE	mg/Kg	80			0.003			0.05								
ASP [illegible]RENE	mg/Kg	0.01			0.006			0.01								
ASP [illegible],2-TETRACHLOROETHANE	mg/Kg	270			0.003			0.005								
ASP [illegible]2-TETRACHLOROETHANE	mg/Kg	35			0.001			0.005								
8010 [illegible]RACHLOROETHENE	mg/Kg	14			0.0001			0.001								
ASP [illegible]UENE	mg/Kg	20000			0.002			0.005								
ASP 1,1,1-TRICHLOROETHANE	mg/Kg	7000			0.002			0.005								
ASP 1,1,2-TRICHLOROETHANE	mg/Kg	120			0.002			0.005								
ASP TRICHLOROETHENE	mg/Kg	64			0.002			0.005								

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	METHOD / ANALYTE	UNITS	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED	RESULT	Q	EXTRACTED OR ANALYZED
8010	TRICHLOROFLUOROMETHANE	mg/Kg	20000			0.0002			0.001								
8010	1,2,3-TRICHLOROPROPANE	mg/Kg	400			0.001			0.001								
ASP	VINYL ACETATE	mg/Kg	60000			0.002			0.01								
8010	VINYL CHLORIDE	mg/Kg	0.36			0.0002			0.002								
ASP	XYLENE, (TOTAL)	mg/Kg	200000			0.004			0.01								

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TABLE 2-1
PROJECT SPECIFIC CRITICAL PARAMETERS
FRESH KILLS LANDFILL LEACHATE MITIGATION SYSTEM PROJECT

INDICATOR PARAMETERS AND METALS	
ALL LANDFILL SECTIONS	
Turbidity	Calcium
Total Kjeldahl Nitrogen	Chromium
Ammonia	Chromium + 6
Nitrate	Cobalt
Chemical Oxygen Demand	Copper
Biochemical Oxygen Demand	Cyanide
Total Organic Carbon	Iron
Total Dissolved Solids	Lead
Sulfate	Magnesium
Alkalinity	Manganese
Phenolic Compounds (Total)	Mercury
Chloride	Nickel
Bromide	Potassium
Total Hardness	Selenium
Color	Silver
Boron	Sodium
Aluminum	Sulfide
Antimony	Thallium
Arsenic	Tin
Barium	Vanadium
Beryllium	Zinc
Cadmium	

ORGANIC COMPOUNDS			
LANDFILL SECTION 1/9	LANDFILL SECTION 2/8	LANDFILL SECTION 3/4	LANDFILL SECTION 6/7
Volatiles	Volatiles	Volatiles	Volatiles
1,4-Dioxane	2-Butanone [Methylethylketone]	Benzene	Chlorobenzene
2-Butanone [Methylethylketone]	Toluene	Chlorobenzene	Chloroethane
Acetone	Benzene (J)	Xylene [total]	Toluene
Chlorobenzene	Chloroform (J)		Xylene (total)
Ethylbenzene			2-Butanone [Methylethylketone] (J)
Toluene			2-Hexanone (J)
Xylene [total]			Benzene (J)
Acenotrile (J)			Chloroform (J)
Benzene (J)			
Chloroform (J)			
Semivolatiles	Semivolatiles	Semivolatiles	Semivolatiles
2-Methylnaphthalene	Naphthalene	Naphthalene	Naphthalene
2,4-Dimethylphenol	2-Methylnaphthalene (J)	2-Methylnaphthalene (J)	2-Methylnaphthalene (J)
Aniline	Acenaphthene (J)	Acenaphthene (J)	Acenaphthene (J)
Bis[2-ethylhexyl]phthalate	Fluorene (J)	Bis[2-ethylhexyl]phthalate (J)	Bis[2-ethylhexyl]phthalate (J)
Naphthalene	Phenanthrene (J)	N-Nitrosodiphenlyamine (J)	Di-n-Butyl phthalate (J)
o-Toluidine		Phenanthrene (J)	Di-n-Octyl phthalate (J)
2-Methylphenol (J)			o-Toluidine (J)
Acenaphthene (J)			Phenanthrene (J)
Dimethyl phthalate (J)			
Di-n-Octyl phthalate (J)			
N-Nitrosodiphenlyamine (J)			
Phenanthrene (J)			
Pesticides / Herbicides / PCBs	Pesticides / Herbicides / PCBs	Pesticides / Herbicides / PCBs	Pesticides / Herbicides / PCBs
2,4,5-TP [Silvex]	2,4,5-TP [Silvex]	2,4,5-TP [Silvex]	2,4,5-TP [Silvex]
2,4-D (J)			2-4-D (J)
Aldrin (J)			Aldrin (J)
beta-BHC (J)			gamma-BHC [Lindane] (J)
delta-BHC (J)			
gamma-BHC [Lindane] (J)			

(J) Indicates organic compound identified consistently only as a qualified value

Station	Ammonia (ppm) 1991	Ammonia (ppm) 1992	Average Salinity (ppt) 8/91	Average pH 8/91	Ammonia Criteria (mg/l)	pH Range				Salininty Range (ppt)			
29		16.7 *	22.5 [1]	7.81 [1]	7.5	7.85	7.77			21.2	23.7		
32		19.6 *	20.1 [1]	7.77 [1]	9.3	7.99	7.54			19.6	20.6		
2	51.5 *	32.9 *	23.1	7.25	29	7.23	7.27	7.26	7.22	23.1	24.3	22.3	22.5
1	35.7	74.6 *	22.5	7.06	44	7.15	7.10	6.87	7.10	22.3	22.4	22.3	22.8
18	58.2 *	55.5 *	22.1	6.68	>44	6.91	6.66	6.40	6.73	23.2	22.4	22.9	19.7
3	92.8 *		22.3	7.16	29	7.20	7.16	7.07	7.19	22.2	22.5	22.5	21.8
4	107.0 *	72.2 *	22.2	7.22	29	7.21	7.19	7.21	7.25	22.5	23.5	21.8	21.1
5	69.1 *	94.2 *	20.1	7.20	29	7.07	7.04	7.35	7.35	20.5	21.3	20.5	18.2
6	101.0 *	27.1 *	19.7	7.32	24	7.22	7.07	7.37	7.63	20.5	21.3	19.7	17.3
7	92.6 *		19.2	7.31	24	6.99	7.21	7.47	7.55	19.6	20.8	18.7	17.6
8	220.0 *	89.4 *	18.5	7.28	24	7.33	7.04	7.31	7.44	19.6	20.0	17.5	17.0
9	49.3 *	38.1 *	17.6	7.09	36	6.70	6.98	7.21	7.45	17.6	19.6	18.0	15.3
10	52.0 *	61.9 *	16.7	7.36	17.5	7.08	7.23	7.42	7.70	17.6	19.2	16.2	13.9
11	22.7 *	99.0 *	15.4	7.51	15	7.22	7.39	7.56	7.87	16.8	17.9	15.8	11.1
12	12.4 *	45.3 *	14.3	7.63	11	7.50	7.57	7.62	7.84	16.2	17.0	14.5	9.5
13	114.0 *	82.3 *	20.3	7.11	36	6.98	7.09	7.11	7.24	21.0	25.0	18.0	17.0
14	30.0 *	57.4 *	18.0	7.17	29	7.02	7.12	7.16	7.38	19.0	19.5	18.5	15.0
15	63.0 *	58.7 *	17.5	7.16	28	7.00	7.18	7.11	7.33	20.0	19.0	19.0	12.0
16	53.7 *	100.0 *	16.3	7.18	28	7.03	7.16	7.24	7.27	20.0	17.0	16.0	12.0
28		40.8	6.8 [1]	6.94 [1]	44	7.17	6.70			2.5	11.0		
25		17.5 *	14.6 [1]	7.60 [1]	11	7.07	8.13			9.3	19.9		

* Ammonia concentration above applicable criteria

[1] Salinity or pH range based on August 1992 data since no August 1991 values available

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Appendix L

Sediment and Porewater Metals, and Toxicity

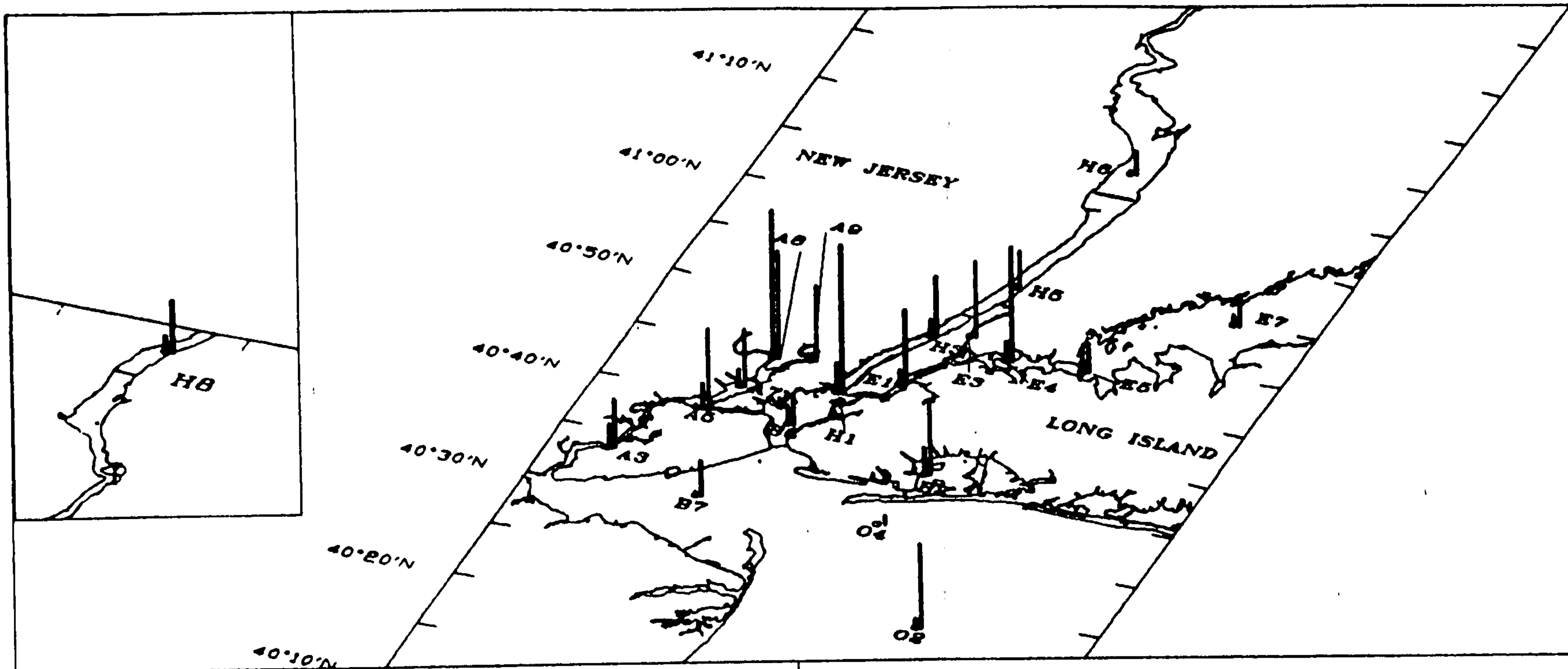
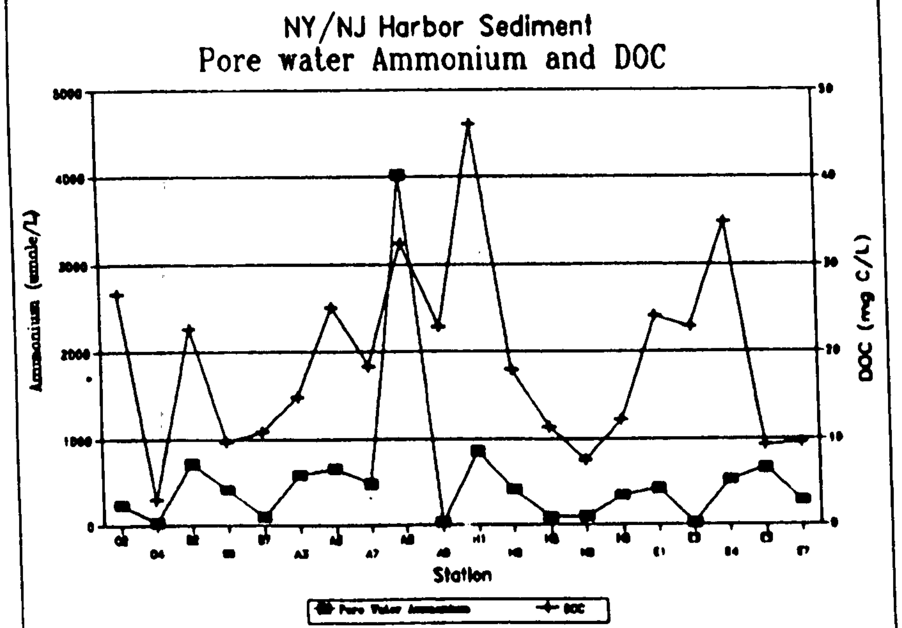


FIGURE 8. AMMONIUM AND DOC RESULTS (parameter scales are different)

| PORE WATER AMMONIUM

| DOC

Source: Battelle, 1992. Sediment toxicity and concentration of trace metals in sediment and pore water in NY/NJ Harbor. Submit to NYCDEP 06/18/92.



ATTACHMENT II.D
Summary of Sediment Chemistry Data for Marshes Creek Compared to Main and Richmond Creeks

FRESH KILLS LEACHATE MITIGATION PROJECT
SURFACE WATER AND SEDIMENT PROGRAM
SEDIMENT DATA FOR SEPTEMBER 1992 (mg/kg)
(REPORTED AS MEAN/ RANGE WHEN APPLICABLE)

PARAMETER	MARSH'S CREEK STATION 25	RICHMOND CREEK STATION 9 – 12	MAIN CREEK STATION 13 – 16
ALKALINITY	1000	1825/1200 (SC–9) – 2600 (SC–11)	2150/1700 (SC–14) – 3000 (SC–16)
ALUMINUM	19,300	12,125/10,200 (SC–10) – 15,300 (SC–11)	11,033/1330 (SC–13) – 18,700 (SC–15)
AMMONIA	17.5	61.1/38.1 (SC–9) – 99 (SC–11)	74.6/57.4 (SC–14) – 100 (SC–16)
ANTIMONY	11.4	13.7/11.9 (SC–9) – 14.9 (SC–12)	13.0/11.3 (SC–14) – 14.8 (SC–16)
ARSENIC	55.3	27.5/19.3 (SC–12) – 39 (SC–9)	30.0/27.4 (SC–16) – 32.8 (SC–15)
BARIUM	141	256.3/174 (SC–12) – 369 (SC–9)	282.8/222 (SC–16) – 327 (SC–15)
BERYLLIUM	ND	ND	ND
BORON	ND	4.5/ND (SC–9) – 4.6 (SC–12)	3.2/ND (SC–14) – 5.5 (SC–16)
CARBON DISULFIDE	ND	ND	48 ug/kg (SC–15)
CADMIUM	2.1	9.5/5.2 (SC–12) – 15.1 (SC–9)	10.4/7.4 (SC–16) – 12.2 (SC–15)
CALCIUM	3190	6702.5/5600 (SC–10) – 7260(SC–11)	6065/5620 (SC–14) – 6980 (SC–13)
CHLORIDE	16,000	21,750/18,000 (SC–12) – 29,000 (SC–10)	21,750/18,000 (SC–14) – 24,000 (SC–16)
CHROMIUM	109	140/107 (SC–12) – 180 (SC–9)	151/126 (SC–16) – 183 (SC–15)
COBALT	14	11.4/10 (SC–10) – 12.7 (SC–11)	16.6/15.4 (SC–13) – 17.2 (SC–15)
COPPER	297	445.3/318 (SC–12) – 635 (SC–9)	450.8/374 (SC–16) – 540 (SC–15)
COD	920,000	558,000/202,000 (SC–9) – 934,000 (SC–10)	341,250/195,000 (SC–14) – 676,000 (SC–13)
IRON	36,500	32,025/28,400 (SC–10) – 36,300 (SC–11)	31,575/29,000 (SC–16) – 37,000 (SC–15)
LEAD	223	270.8/191 (SC–12) – 362 (SC–9)	282.3/265 (SC–13\16) – 301 (SC–15)
MAGNESIUM	8010	8655/7770 (SC–9) – 9750 (SC–11)	8472.5/7590 (SC–14) – 9610 (SC–15)
MANGANESE	354	305.8/289 (SC–10) – 335 (SC–11)	320.5/291 (SC–14) – 348(SC–15)
MERCURY	3.6	3.6/1.4 (SC–12) – 5.9 (SC–9)	4.9/3.1 (SC–15) – 6.3 (SC–14)
NICKEL	54	56/41.1 (SC–10) – 62.5 (SC–12)	60.8/48.3 (SC–13) – 79.5 (SC–14)
POTASSIUM	3860	2955/2630 (SC–12) – 3610 (SC–11)	3265/2750 (SC–14) – 4270 (SC–15)
SELENIUM	1.2	3.6/1.8 (SC–12) – 6.9 (SC–9)	4.1/3.7 (SC–16) – 4.6 (SC–15)
SILVER	ND	4.7/ND (SC–12) – 5.9 (SC–9)	5.6/4.3 (SC–16) – 6.5 (SC–15)
SODIUM	9710	14,600/13,400 (SC–9) – 16,400 (SC–10)	14,425/12,600 (SC–14) – 15,600(SC–15)
SULFIDE	3.9	9.3/8.24 (SC–9) – 10 (SC–10)	11.1/8.89 (SC–14) – 12.9 (SC–15)
2,4,5 – T	ND	7.8 ug/kg (SC–11)	ND
TKN	95.3	114.8/81.1 (SC–9) – 180 (SC–11)	147.8/115 (SC–15) – 200 (SC–16)
TIN	58.5	47.9/38.1 (SC–12) – 74.2 (SC–9)	48.9/40.6 (SC–16) – 63.6 (SC–15)
TOC	43,700	56,225/51,400 (SC–9) – 62,000 (SC–12)	56,525/51,100 (SC–14) – 65,600 (SC–15)
VANADIUM	50.4	49.7/39.6 (SC–10) – 58.7 (SC–9)	45.9/39.2 (SC–16) – 55.9 (SC–15)
ZINC	470	596.8/503 (SC–12) – 721 (SC–9)	613.5/521 (SC–16) – 692 (SC–15)
TOTAL CYANIDE	0.82	1.80/ND (SC–10/11) – 2.8 (SC–9)	0.89/ND(SC–16) – 1 (SC–15)

ATTACHMENT II.E
SWSIP July 26, 1991 Pages 6-11, 6-12
Describing Leachate Bioassay Plan of Study for
Chronic Toxicity

6.4 CHRONIC TOXICITY

The objective of this phase of the investigation is to determine the chronic effects of Fresh Kills Landfill leachate based on results of acute testing.

6.4.1 Null Hypotheses

The null hypotheses to be tested are:

- chronic toxicity, as estimated by 7-day bioassay testing, is not significantly different for each of the four sections of landfill; and
- chronic toxicity is not significantly different over time as measured on a quarterly basis.

6.4.2 Sampling method

Sampling methods, procedures and equipment will be the same as described in Section 6.2.2.

Landfill sections - The choice of landfill sections will be based on the results obtained from the acute toxicity tests.

Schedule - As warranted, based on the need for chronic testing as determined by the results of the acute toxicity tests.

6.4.3 Bioassay Testing

Rationale - Chronic bioassays assess the more subtle, sub-lethal effects of contaminants on aquatic organisms. In many cases, a particular waste stream may not be lethal to the organism but may be responsible for reduced growth or reproduction. These types of responses, while not immediately life-threatening, can have ramifications on the survivability of the organism in the environment. For example, many organisms must reach a required body size to successfully compete with other species; if their growth is slowed, they may be outcompeted for food, protective shelter and eventually survival.

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For the purposes of establishing the potential leachate toxicity effects from Fresh Kills Landfill, the following criterion will be used to determine if chronic bioassays will be conducted in addition to the acute tests. If the resultant LC50 value of the acute bioassay in each landfill section is greater than 50% leachate, chronic tests will also be performed using the same two species. However, if the LC50 is less than 50% then chronic tests will not be performed at this stage. An LC50 of 50% was selected as the action level because LC50 values below this indicate a high degree of acute toxicity.

As indicated in the February 15, 1991 response to NYSDEC comments, chronic bioassays will be conducted if the acute LC_{50} is greater than 50% for a particular species. If the LC_{50} is less than 50%, severe acute effects would preclude the need to conduct chronic toxicity testing for that species. Therefore, chronic bioassays will only be conducted for those samples and those species which result in acute LC_{50} values greater thant 50%.

Procedure - The chronic toxicity tests will be conducted in accordance with IT's Standard Operating Procedures for chronic testing which are based on the EPA document "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms" (EPA/600/4-87/028). The specific SOPs for chronic testing are found in IT Bioassay SOP Manual, Volume IV, Sections A8.0 and A9.0 for the mysid and sheepshead minnow tests, respectively (see Appendix A of this document). Tables 6-2 and 6-3 give the summary of the chronic test conditions for the mysid and sheepshead minnow tests, respectively.

As with the acute tests, the opossum shrimp (i.e., mysid), Mysidopsis bahia, and the sheepshead minnow, Cyprinodon variegatus, will be used for the chronic bioassays where they are conducted.

Chronic testing is comprised of seven-day exposures to the landfill leachate. A series of five geometrically-related concentrations is prepared and monitored for the exposure period. Test protocols specify five replicate chambers per concentration for the mysid test and four replicate chambers for the fish test. The additional replicates for chronic testing is to provide robustness for the statistical evaluation of subtle responses. These

Reference Section for the

Draft Leachate Mitigation Evaluation for Sections 2/8 & 3/4

[Wyckoff_R.WP]FK01951.B

References

Acar, Y.B., ***"Effect of Organic Fluids on Hydraulic Conductivity of Compacted Kaolinite,"*** ASTM STR 874, July 1985, pp. 171-187.

Ahmed, Shabbir and Reza M. Khanbilvardi, 1989, ***"Estimation of the Fresh Kills Landfill Leachate,"*** City College of the City University of New York, Department of Civil Engineering, Prepared for: The New York City Department of Sanitation (December 10, 1989).

Algermissen, S.T., D.M Perkins, P.C. Thenhaus, S.L. Hanson, and B.L. Bender, 1990, ***Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico***; USGS Map - MF2120.

Alther, George, ***"Influence of Inorganic Permeants Upon the Permeability of Bentonite,"*** ASTM STR 874, July, 1985, pp. 64-74.

Ambrose, R.B., Wool, T.A., Connolly, J.P. and R.W. Schany, 1988, ***WASP4, a Hydrodynamic and Water Quality Model,*** U.S. Environmental Protection Agency, Athens, Georgia.

Ambrose, R.B., Jr. and Roesch, S.R. 1982, "Dynamic estuary model performance," ***Journal of Environmental Engineering Division, American Society of Civil Engineers,*** 108, 51-71.

Ambrose, R.B., Jr. 1987, "Modeling Volatile Organics in the Delaware Estuary," ***Journal of Environmental Engineering, ASCS,*** 113(4) 702-721.

Anderson, David C., ***"Effects of Various Liquids on Clay Soil: Bentonite Slurry Mixtures,"*** ASTM STR 874, July, 1985, pp. 93-102.

Ayres, J.E., ***"The First EPA Superfund Cut-off Wall: Design and Specifications,"*** Proceedings of the Third National Symposium on Aquifer Restoration and Groundwater Monitoring, 1983.

Battelle, 1992, ***Evaluation of Trace-Metal Levels in Ambient Waters and Tributaries to New York/New Jersey Harbor for Waste Load Allocation, Final Report Submitted to U.S. Environmental Protection Agency,*** Office of Wetlands, Oceans, and Watersheds and Region II under EPA Contract No. 68-C8-0105.

Bergstrom, Wayne, R., ***"Fly Ash Utilization In Soil-Bentonite Slurry Trench Cutoff Walls,"*** Proceedings of the Twelfth Annual Madison Waste Conference, September 1989, pp. 444-458.

Bodosci, Andrew and Richard M. McCandless, ***"Quick Indicator Tests To Characterize Bentonite Type,"*** Proceedings of the Eleventh Annual Research Symposium, USEPA< April 1985, pp. 274.

Borvenik, M.J., ***"Quality Control of Hydraulic Conductivity and Bentonite Content During Soil/Bentonite Cutoff Wall Construction,"*** Proceedings of the Eleventh Annual Research Symposium, April 1985, pp. 66-79.

Bowen, H.J.M., 1979, ***Environmental Chemistry of the Elements,*** New York, NY: Academic Press, Inc.

Bower, C.E. and J.P. Bidwell, 1978, ***Ionization of ammonia in seawater: effects of temperature, pH and salinity,*** J. Fish. Res. Bd. Can. 35:1012-1016.

Bowie, G.L., Mills, W.B., Porcella, D.B., Campbell, C.L., Pagenkopf, J.R., Rupp, G.L., Johnson, K.M., Chan, P.W.H. and S.A. Gherini, 1985, ***Rates, Constants and Kinetics Formulations in Surface Water Quality Modeling,*** 2nd Edition, EPA/600/3-85/040, U.S. Environmental Protection Agency, Athens, Georgia.

Brown, K. W. and J.C. Thomas, ***"Influence of Concentrations of Organic Chemicals on the Collodial Structure and Hydraulic Conductivity of Clay Soils,"*** Texas A&M University, Proceedings of the Eleventh Annual Research Symposium, USEPA, April 1985, pp. 272.

Brunelle, Thomas M., ***"Effect of Permeameter and Leachate on a Clay Liner,"*** ASCE Geotechnical Special Publication No. 13, pp. 347-361.

Bryant, John L., "Precision and Reliability of Laboratory Permeability Measurements," Proceedings of the Eleventh Annual Research Symposium, USEPA, April 1985, pp. 225-235.

Bureau of Waste Disposal, Department of Sanitation, City of New York, 1992, ***Operations and Maintenance Plan for the Fresh Kills Landfill.***

Canter L.W. and Knox R.C., 1986, ***Groundwater Pollution Control***, Lewis Publishers, Inc., Michigan.

Cedergren, Harry R., 1977, ***Seepage, Drainage and Flow Nets***, John Wiley and Son, Inc., New York.

Chemical Rubber Co., (CRC), 1990, ***Handbook of Chemistry and Physics***, CRC Press, Cleveland, Ohio.

Chow, V.T., 1959, ***Open Channel Hydraulics,*** McGraw-Hill, New York.

City College of New York (CCNY), 1990, ***Leachate Characteristics and Treatment Alternatives at the Fresh Kills Landfill,*** Prepared for New York City Department of Sanitation and New York State Energy Research and Development Authority.

Connors, S.D. and H.L. Cousminer, 1979, "The Staten Island (NY) Cretaceous Coastal Plain: Palynostratigraphy and Sedimentology," in ***Geological Society of America, Programs With Abstracts, Northeast Section***, p. 8.

Covar, A.P. 1976, ***"Selecting the Proper Reaeration Coefficient for Use in Water Quality Models,"*** Presented at the U.S. EPA Conference on Environmental Simulation and Modelling.

Cristini, A., 1992, ***Synthesis of Information on the Distribution of Benthic Invertebrates in the Hudson/Raritan System,*** National Estuary Program Grant #12330036-0.

D'Appolonia, David J., "Soil-Bentonite Slurry Trench Cutoffs," *ASCE Journal of the Geotechnical Engineering Division,* Vol. 106, April 1986, pp. 399-417.

Daniel, D.E., *"Fixed Wall Versus Flexible-Wall Permeameters,"* ASTM STR 874, 1985, pp. 107-124.

Dansby, David A. and Carol A. Price, 1987, *"Graphical Well Analysis Package - Version 2.0,"* Groundwater Graphics, Oceanside, CA.

Davis, John C., 1986, *Statistics and Data Analysis in Geology*, John Wiley and Sons, New York, 646 pp.

Davis, R.A., Jr., 1983, *Depositional Systems - A Genetic Approach to Seddimentary Geology,* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 669 p.

DiToro, D.M. and J.P. Connolly, 1980, *"Mathematical Models of Water Quality in Large Lakes, Part. 2: Lake Erie,"* EPA-608/3-80-065. pp. 90-101.

DiToro, D.M., Fitzpatrick, J.J., and R.V. Thomann, 1981. Rev. 1983, *Water Quality Analysis Simulation Program (WASP) and Model Verification Program (MVP) - Documentation,* Hydroscience, Inc., Westwood, NJ for U.S.EPA, Duluth, MN.

Domenico, P.A., and F.W. Schwartz, 1990, *Physical and Chemical Hydrogeology,*John Wiley & Sons, New York, 824 p.

Drever, J.I., 1988, *The Geochemistry of Natural Waters,* Prentice-Hall, Inc., New York.

Driscoll, Fletcher, G., 1986, *Groundwater and Wells,* Johnson Division, St. Paul, Minnesota.

EA Engineering, Science and Technology (EA), 1989a, *Linden Generating Station Units 1 and 2 Supplemental 316(b) Report,* prepared for Public Service Electric and Gas Company, Newark, NJ.

Emerson, K., R. C. Russo, R.E. Wind, R. V. Thurston. 1975, *Aqueous Ammonia Equilibrium Calculations: Effect of pH and Temperature.* J. Fish. Res. Bd. Can 32:2379-2383.

Evans, J.C., *"Organic Fluids Effects on the Strength, Deformation and Permeability of Soil-Bentonite Slurry Walls,"* Mid-Atlantic Industrial Waste Conference Proceedings, 1985, pp. 275-291.

Feigner and Harris, 1970, *"Documentation Report -- FWQA Dynamic Estuary Model,"* U.S. Department of the Interior, Federal Water Quality Administration.

Fischer, H.B., List, E.J., Koh, R.C.Y., Imberger, J., and N.H. Brooks, 1979, *Mixing in Inland and Coastal Waters,* Academic Press, NY.

Fisher, D.W., Y.W. Isachsen, and L.V. Richard, 1970, "Geologic Map of New York, Lower Hudson Sheet", Map and Chart Series No. 15, *New York State Museum and Science Service.*

Freeman, Harry M., 1989, ***Standard Handbook of Hazardous Waste Treatment and Disposal,*** McGraw-Hill, Inc., New York.

Freeze, R.A. and J.A. Cherry, 1979, ***Groundwater,*** Prentice Hall, New York.

Fungaroli, A.A. and R.L. Steiner, 1979, "Investigation of Sanitary Landfill Behavior", Vol. I. Final Report, ***USEPA-600/1-79-053a,*** Vol. II, Supplement to Final Report, ***USEPA-600/2-79-053c.***

Green, J.W., Arthur D. Little, Inc., K.W. Brown and J.C Thomas, ***"Effective Porosity of Compacted Clay Soils Permeated with Organic Chemicals,"*** Texas A&M University, Proceedings of the Eleventh Annual Research Symposium, USEPA, April 1985, pp. 270-271.

Hazen, A., 1911, "Discussion: Dams on Sand Foundations", ***Transactions, American Society of Civil Engineers,*** Vol. 73, No. 199.

Horne, R. A., 1969, ***Marine Chemistry: The Structure of Water and the Chemistry of the HydroSphere,*** Wiley-Inter Science, NY p. 153.

Hughes, G., R. Landon, and R. Farvolden, 1968, "Hydrology of Solid Waste Disposal Sites in Northeastern Illinois", ***Illinois Geological Survey,*** Urbana, Illinois.

IT Corporation (PAS-Princeton Aqua Science), 1986. ***"Environmental Assessment Howland Hook Marine Terminal Expansion - Staten Island, NY."*** Prepared for United States Lines, Inc., Cranford, N.J.

IT Corporation, 1990, ***"Landfill Leachate Mitigation Investigation Work Plan,"*** Prepared for: City of New York Department of Sanitation, New York, New York (December 31, 1990).

IT Corporation, 1990a, ***"Surface Water and Sediment Investigation Plan,"*** Document No. 529363-00196 Revision 1, dated July 26, 1991. Prepared for City of New York Department of Sanitation.

IT Corporation, 1991, ***"Application for a Permit to Discharge Wastewater from the Proposed Veterans Avenue Leachate Treatment Facility,"*** Prepared for: City of New York Department of Sanitation, New York, New York.

IT Corporation, 1991a, ***"Veterans Avenue Evaluation for Temporary Interim Upgrade Revised Submittal,"*** Prepared for: City of New York Department of Sanitation, New York, New York (April 10, 1991).

IT Corporation, 1991b, ***"Addendum Final Landfill Gas Migration Investigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (October 31, 1991).

IT Corporation, 1991c, ***"Draft Landfill Gas Migration Investigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (July 26, 1991).

IT Corporation, 1991d, ***"Supply Well Survey Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (March 15, 1991).

IT Corporation, 1992a, ***"Interim Surface Water and Sediment Investigation Report,"*** Prepared for: City of New York Department of Sanitation (April 15, 1992).

IT Corporation, 1992b, ***"Interim Hydrogeological Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (July 17, 1992).

IT Corporation, 1992c, ***"Interim Leachate Mitigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (September 14, 1992).

IT Corporation, 1992d, ***"Plan for Additional Surface Water and Sediment Based Studies,"*** Prepared for: City of New York Department of Sanitation, New York, New York (July 1992).

IT Corporation, 1993a, ***"Draft Final Hydrogeological Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (April 10, 1993).

IT Corporation, 1993b, ***"Draft Final Surface Water and Sediment Investigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (April 15, 1993).

IT Corporation, 1993c, ***"Draft Final Leachate Mitigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (June 14, 1993).

IT Corporation, 1993d, ***"Final Hydrogeological Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (November 26, 1993).

IT Corporation, 1993e, ***"Final Surface Water and Sediment Investigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (December 23, 1993).

IT Corporation, 1993f, ***"Final Leachate Mitigation Report,"*** Prepared for: City of New York Department of Sanitation, New York, New York (October 12, 1993).

Jepsen, Christopher P., "Sodium Bentonite: Still A Viable Solution for Hazardous Waste Containment," ***Pollution Engineering,*** Vol. 16, April 1984, pp. 50, 52-53.

JRB Associates, ***"Slurry Trench Construction for Pollution Migration Control,"*** EPA 540/2-84-001, 1984.

JRB, Inc. 1984. ***"Development of Heavy Metal Waste Load Allocations for the Deep River, North Carolina,"*** JRB Associates, McLean,VA for USEPA Office of Water Enforcement and Permits, Washington, D.C.

Kingsbury, G.L., ***"Clay-Chemical Compatibility and Permeability Testing: A Review,"*** Proceedings of the Eleventh Annual Research Symposium, USEPA, April 1985, pp. 226-267.

Lema, J.M., R. Mendez, and R. Blazquez, 1988, "Characteristics of Landfill Leachates and

Alternative for Their Treatment: A Review". ***Water, Air, and Soil Pollution***, Volume 40, pp. 223-250.

Lu, C.S.J., B. Eichenberger, and R.J. Stearns, 1985, ***"Leachate from Municipal Landfills"***, Noyes Publ. Co., Park Ridge, New Jersey, 453p.

Martin, J.L., Ambrose, R.B., and S.C.., McCutcheon (ed.), 1990, ***Technical Guidance Manual for Performing Waste load Allocations,*** U.S. Environmental Protection Agency, Athens, Georgia.

Mashni, C.I., "Laboratory Determination of Dielectric Constant and Surface Tension As Measures of Leachate/Liner Compatibility," ***U.S. Environmental Protection Agency, Proceedings.***

Mayer, G. F. 1982, ***Ecological Stress in the New York Bight: Science and Management,*** Estuarine Research Federation, Columbia, S.C.

McCandless, ***"Investigation of Slurry Cut-off Wall Design and Construction Methods for Containing Hazardous Wastes,"*** EPA/600/52-87/063, Nov. 1987.

McDonald, Michael G. and Arlen W. Harbaugh, 1984, "A Modual Three-Dimensional Finite Difference Groundwater Flow Model," ***U.S. Geological Survey.***

Meisler, H., P.P. Leahy, and L.L. Knobel, 1984, "Effect of Eustatic Sea-Level changes on Saltwater-Freshwater in the Northern Atlantic Coastal Plain," ***U.S. Geological Survey Water Supply Paper 2255***, 28 pp.

Millet, R., "Current USA Practice: Slurry Wall Specifications," ***Journal of the Geotechnical Engineering Division, ASCE,*** Vol. 107, No. GT8, August 1981.

Mitchell, James K., "Chemical Effects on Clay Hydraulic Conductivity", ***ASCE Geotechnical Special Publication*** No. 13, pp. 87-116.

Mott, H.V., ***"Diffusive Transport and Attenuation of Organic Leachates in Cut-Off Wall Backfill Mixes,"*** Proceedings of the Twelfth Annual Madison Waste Conference, September 1989, pp. 421.

New York State Department of Environmental Conservation, 1988a, ***"Draft Environmental Impact Statement ... For Revisions to 6 NYCRR Part 360 - State Wide Regulation for Solid Waste Management Facilities,"*** Albany, NY (April 1, 1988).

New York State Department of Environmental Conservation, 1988b, ***"Draft Final Environmental Impact Statement and Responsiveness Summary for Revisions to 6 NYCRR Part 360 Solid Waste Management Facilities,"*** Albany, NY (August, 1988).

New York State Department of Environmental Conservation, 1990, ***"Order on Consent Between The New York State Department of Environmental Conservation and the City of New York Department of Sanitation,"*** (April, 1990).

New York State Department of Environmental Conservation, 1992, *"Draft 6 NYCRR Part 360 Solid Waste Management Facilities Volume 1, Revisions to New York State's Solid Waste Management Regulations,"* Albany, New York (October, 1992).

New York State Department of Environmental Conservation, 1993, Personal Communication from Leo Frey (IT) to Fred Van Alstyne 6/3/1993.

New York State Department of Environmental Conservation, 1987, *"State Environmental Quality Review - NYCRR Part 617,"* Albany, New York (June 1, 1987).

New York State Department of Health, 1960, "Arthur Kill and Kill Van Kull", *New York City Water Survey Series Report #3.*

NYC DEP (New York City Department of Environmental Protection) 1988, *New York Harbor Water Quality Survey Data 1974 - 1988.*

NYC DEP (New York City Department of Environmental Protection) 1991, *New York Harbor Water Quality Survey Data 1991* (unpublished).

O'Brien & Gere Engineers, Inc., 1991, *"Conceptual Design Report Veterans Avenue Leachate Treatment Facility,"* (January 17, 1991).

O'Brien & Gere Engineers, Inc., 1991, *"Conceptual Design Report Veterans Avenue Leachate Treatment Plant,"* (May 14, 1991).

O'Brien & Gere Engineers, Inc., 1991, *"Fresh Kills Leachate Mitigation System Project: Engineering Report Veterans Avenue Leachate Treatment Plant,"* (May 14, 1991).

O'Brien & Gere Engineers, Inc., 1991, *"Veterans Avenue Leachate Treatment Plant Engineering,"* (June 27, 1991).

O'Connor, D.J. and R.V. Thomann, 1972, *"Water Quality Models: Chemical, Physical and Biological Constituents,"* In: Estuarine Modeling: An Assessment, EPA Water Pollution Control Research Series 16070 DZV, Section 702/71. pp. 102-169.

Parsons, Brinckerhoff - Cosulich, 1981, *"Fresh Kills Preliminary Hydrogeologic Report,"* Prepared for: City of New York Department of Sanitation, New York, New York (December, 1981).

Parsons, Brinkerhoff - Cosulich, 1982, *"Interim Water Quality Baseline Report (Fresh Kills Landfill),"* (August, 1982).

Parsons, Brinckerhoff - Cosulich, 1982, *"Interim Hydrogeologic Report, Fresh Kills Landfill, New York City,"* Prepared for: City of New York Department of Sanitation, New York, New York (September, 1982).

Parsons-Brinckerhoff (PB). 1985, *1985 Draft Environmental Impact Statement for Fresh Kills*

Landfill, Prepared for New York City Department of Sanitation.

Pierce, Jeffrey J., "Effects of Inorganic Leachate On Clay Soil Permeability," ***Proceedings of the Eleventh Annual Research Symposium,*** USEPA, April, 1985, pp. 182-189.

Remson, I., A.A. Fungaroli, A.W. Lawrence, 1968, "Water Movement in an Unsaturated Sanitary Landfill", ***American Society of Civil Engineers, Sani. Eng. Div. Joun.***, Vol. 94, No. SA2 pp307-316.

Remson, I., G.M. Hornberger, F.J. Molv, 1971, ***Numerical Methods in Subsurface Hydrology,*** John Wiley and Sons, New York.

Roesch, S.E., L.J. Clark, and M.M. Bray, 1979, ***"User's Manual for the Dynamic (Potomac) Estuary Model."*** U.S. Environmental Protection Agency, Annapolis, MD. EPA-903/9-79-001.

Rovers, Frank A. and G.J. Farquhar, 1973, "Infiltration and Landfill Behavior," American Society of Civil Engineers, ***Environmental Eng. Div. Jour***. V.99, pp 671-690.

Ryan, Christopher, "Vertical Barrier in Soil for Pollution Containment," ***ASCE Geotechnical Special Publication*** No. 13, pp. 182-204.

Schramm, M., "Permeability of Soils to Four Organic Liquids and Water", Hazardous Waste and Hazardous Materials, Vol. 3, No. 1, 1986.

SCS Engineers, 1991, ***"Final Cover Design Report, Appendix A-3, Milestone 6, Order on Consent, Fresh Kills Landfill,"*** Prepared for: City of New York Department of Sanitation, New York, New York.

SCS Engineers, 1992a, ***"Addendum to Final Cover Design Report, Appendix A-3, Milestone 6, Order on Consent, Fresh Kills Landfill,"*** Prepare for: City of New York Department of Sanitation, New York, New York.

SCS Engineers, 1992b, ***"Draft Closure Plan for Sections 2/8 and 3/4, Appendix A-3, Milestone 7, Order on Consent, Fresh Kills Landfill,"*** Prepared for: City of New York Department of Sanitation, New York, New York.

SCS Engineers, 1992c, ***"Draft Closure Plan for Sections 1/9 and 6/7, Appendix A-3, Milestone 10, Order on Consent, Fresh Kills Landfill,"*** Prepared for: City of New York Department of Sanitation, New York, New York.

SCS Engineers, 1992d, Personal Communication.

SCS Engineers/EcolSciences, 1990, ***Draft Preliminary Fresh Kills Landfill Conceptual Design Report,*** Subtask 3.10. Wetlands and Shorelines, September, 1990.

Soren, J., 1988, "Geologic and Geohydrologic Reconnaissance of Staten Island, New York", ***Water Resources Investigations Report 87-4048,*** U.S. Geological Survey.

Soren, J., 1988, "Geologic and Geohydrologic Reconnaissance of Staten Island, New York", ***Water Resources Investigations Report 87-4048,*** U.S. Geological Survey, Syosset, New York, 22 pp.

Squibb, K.S., J.M. O'Connor, and T.J. Kneip, 1991, ***New York/New Jersey Harbor Estuary Program, Module 3.1: Toxics Characterization Report Institute of Environmental Medicine,*** NYU Medical Center, July 1991.

Stumm, W. and J.M. Morgan, 1981, ***Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters,*** John Wiley and Sons, New York, New York.

Suflita, J.M., Gerba, C.P., Ham, R.K., Palmisano, A.C., Rathje, W.L., and Robinson, J.A. (1992); ***"The World's Largest Landfill,"*** Environmental Science & Technology, Vol. 26, No. 8, p. 1486 -1494.

Taft, J.L., 1990, ***Lower Hackensack River Nutrient Study,*** Report prepared for Najarian and Associates, Inc. Eatontown, NJ.

Tallard, Gillbert, "Slurry Trenches for Containing Hazardous Wastes," ***Civil Engineering, ASCE,*** V54, Feb. 1984 pp. 41-45.

The City College of The City University of New York, 1989 ***"Estimation of the Fresh Kills Landfill Leachate,"*** Prepared for: City of New York Department of Sanitation, New York, New York (December 10, 1989).

The City College of The City University of New York, 1991, ***"Treatability Reports for the Fresh Kills Landfill,"*** Prepared for: City of New York Department of Sanitation, New York, New York.

The City College of The City University of New York, undated ***"Chemical Precipitation of Metal from the Fresh Kills Landfill Leachate,"*** (undated).

The City College of The City University of New York, undated ***"Leachate Characteristics and Treatment Alternatives at the Fresh Kills Landfill,"*** Prepared for: New York State Energy Research and Development Authority and New York City Department of Sanitation (undated).

The City of New York Department of Environmental Protection, 1988-1990, ***"New York Harbor Water Quality Survey,"*** (August 27, 1991).

The City of New York Department of Sanitation, 1985 ***"Preliminary Draft Environmental Impact Statement,"*** (December, 1985).

The City of New York Department of Sanitation, 1992, ***Solid Waste Management Plan.***

Thomann, R.V. 1982. "Verification of water quality models," ***Journal of the Environmental Engineering Division, American Society of Civil Engineers,*** 108(EE5), p. 923.

Thomann, R.V., and J.J. Fitzpatrick. 1982, ***"Calibration and Verification of a Mathematical***

Model of the Eutrophication of the Potomac Estuary," Prepared for Department of Environmental Services, Government of the District of Columbia, Washington, D.C.

Thomann, R.V. 1975, ***Mathematical Modeling of Phytoplankton in Lake Ontario, 1.*** Model Development and Verification. U.S. Environmental Protection Agency, Corvallis, OR. EPA-600/3-75-005.

Thomann, R.V., R.P. Winfield, D.M. DiToro, and D.J. O'Connor. 1976, ***Mathematical Modeling of Phytoplankton in Lake Ontario, 2.*** Simulations Using LAKE 1 Model. U.S. Environmental Protection Agency. Grosse Ile, MI. EPA-600/43-76-065.

U.S. Army Corps of Engineers (USACOE), 1986, ***Arthur Kill Channel, Howland Hook Marine Terminal, Staten Island, NY Feasibility Report, Navigation Channels, Main Report and Environmental Impact Statement, Final Report.***

U.S. Geological Survey (USGS), 1989, ***Annual Flow Data for the Rahway and Elizabeth Rivers.***

U.S. Department of Commerce, 1990, "Raritan Bay and Southern Part of Arthur Kill," ***Map No. 12331,*** NDAA, National Ocean Service.

U.S. Geological Survey, 1981, "Arthur Kill Quadrangle, New York - New Jersey," ***7.5 Minute Series (Topographic).***

United States Environmental Protection Agency (USEPA), 1985, ***"Handbook on Remedial Action at Waste Disposal Sites".***

United States Environmental Protection Agency (USEPA), 1986, ***Quality Criteria for Water,*** EPA 44015-86-001.

United States Environmental Protection Agency (USEPA), 1987, ***Ambient Aquatic Life Water Quality Criteria for Ammonia (saltwater) Draft Document.*** Office of Research & Development, ERL-Narragansett.

United States Environmental Protection Agency (USEPA), 1989, ***"Final RI/FS Guidance".***

United States Environmental Protection Agency (USEPA), 1991, ***"RI/FS Guidance for Municipal Landfill Sites".***

Walton, William C., 1991, ***Principles of Groundwater Engineering,*** Lewis Publishers, Inc., Michigan.

Wayne, R., "Slurry Trench Construction Collier Road Landfill," Bergstrom, ***ASCE Geotechnical Special Publication*** No. 13, pp. 347-361.

Wehran Engineering Co. 1985, ***"Fresh Kills Landfill Solid Waste Disposal Operation Plan."***

Wehran Engineering, 1983a, ***"Hydrogeologic Investigation Fresh Kills Landfill Solid Waste Disposal Operations Plan: Volume I,"*** Prepared for: City of New York Department of