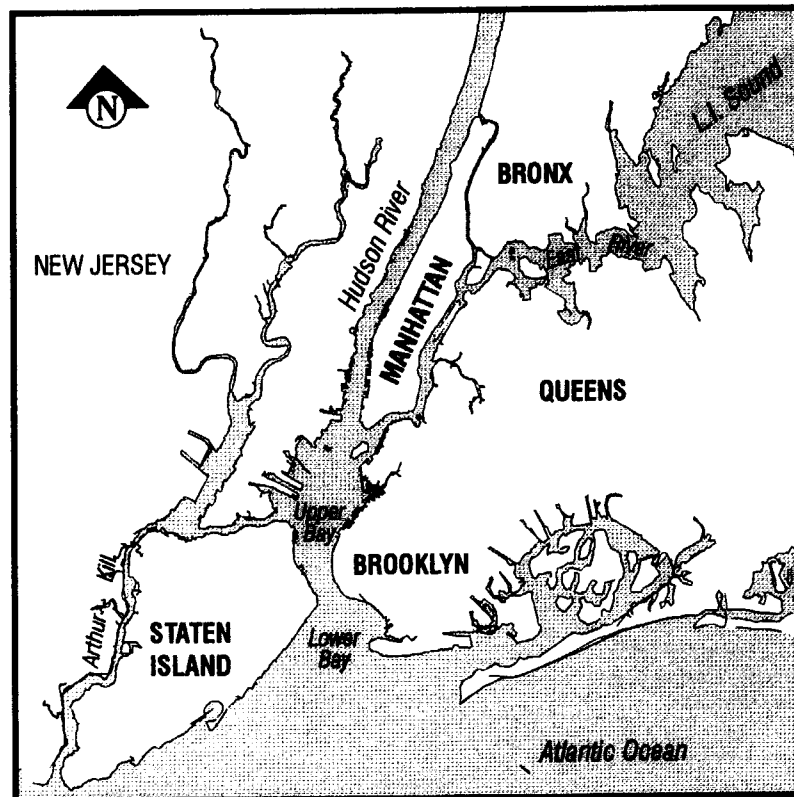


**U.S. Environmental Protection Agency, Region II
New York/New Jersey Harbor Estuary Program
Water Management Division
Surface Water Quality Branch**

**Development of
Total Maximum Daily Loads
and Wasteload Allocations
for Toxic Metals in NY/NJ Harbor**

Modeling Report

September, 1995



HydroQual, Inc.
Environmental Engineers and Scientists

**U.S. Environmental Protection Agency, Region II
New York/New Jersey Harbor Estuary Program
Water Management Division
Surface Water Quality Branch**

**DEVELOPMENT OF TOTAL MAXIMUM DAILY
LOADS AND WASTELOAD ALLOCATIONS
FOR TOXIC METALS IN NY/NJ HARBOR**

MODELING REPORT

Job Number: TETRO103

Prepared by:

**HydroQual, Inc.
1 Lethbridge Plaza
Mahwah, New Jersey 07430**

September 1995

CONTENTS

| <u>Section</u> | | <u>Page</u> |
|----------------|---|-------------|
| | SUMMARY OF FINDINGS | S- 1 |
| 1 | INTRODUCTION | 1- 1 |
| 2 | DATA COLLECTION AND ANALYSIS | 2- 1 |
| 2.1 | REVIEW OF HISTORICAL DATA | 2- 1 |
| 2.2 | JANUARY 1991 AMBIENT SURVEY AND MUNICIPAL MONITORING | 2- 4 |
| 2.2.1 | Inter-Laboratory Comparison | 2- 5 |
| 2.2.2 | Ambient Water Quality | 2- 6 |
| 2.3 | REVIEW SUSPENDED SOLIDS DATA | 2- 7 |
| 2.4 | APRIL 1991 SYNOPTIC WATER COLUMN TURBIDITY SURVEY .. | 2- 8 |
| 2.5 | MAY 1991 INTENSIVE AMBIENT MASTER STATION AND TRIBUTARY SURVEY | 2-10 |
| 2.6 | OCTOBER 1991 LOW FLOW AMBIENT SURVEY | 2-11 |
| 2.7 | FEBRUARY 1992 SEDIMENT SURVEY | 2-14 |
| 2.8 | TRIBUTARY MONITORING | 2-17 |
| 2.9 | COMBINED SEWER OVER FLOW AND WET WEATHER MUNICIPAL INFLUENT MONITORING | 2-18 |
| 2.10 | STORM WATER RUNOFF CHARACTERIZATION | 2-19 |
| 2.11 | ATMOSPHERIC DEPOSITION AND LANDFILL LEACHATE | 2-20 |
| 3 | DETERMINATIONS OF TARGET CONCENTRATIONS | 3- 1 |
| 3.1 | UNDERLYING PROBABILITY DISTRIBUTIONS | 3- 2 |
| 3.2 | BASIS FOR DISSOLVED CRITERIA EVALUATION | 3- 4 |
| 3.3 | BASIS FOR TOTAL RECOVERABLE CRITERIA EVALUATION | 3- 4 |
| 3.4 | DETERMINATION OF TARGET CONCENTRATIONS | 3- 6 |
| 4 | MODEL DEVELOPMENT AND CALIBRATION | 4- 1 |
| 4.1 | ADVECTIVE-DISPERSIVE TRANSPORT | 4- 2 |
| 4.2 | SOLID PHASE VERTICAL TRANSPORT | 4- 3 |
| 4.3 | KINETIC PROCESSES | 4- 4 |
| 4.4 | AMBIENT METALS CALIBRATION | 4- 6 |
| 4.4.1 | Analysis of Accuracy | 4-10 |
| 4.5 | SEDIMENT METALS CALIBRATION | 4-12 |
| 5 | MODEL PROJECTION | 5- 1 |
| 6 | REFERENCES | 6- 1 |
| 7 | FIGURES | 7- 1 |

FIGURES

| <u>Figure</u> | <u>Page</u> |
|--|-------------|
| 2- 1. LOCATION MAP FOR NYCDEP HARBOR SURVEY STATIONS | 7- 1 |
| 2- 2. AREA-AVERAGE AMBIENT METALS CONCENTRATION | 7- 2 |
| 2- 3. AREA-AVERAGE SEDIMENT METALS CONCENTRATION | 7- 3 |
| 2- 4. LOCATIONS MAP FOR INTER-LABORATORY COMPARISONS | 7- 4 |
| 2- 5. JANUARY 1991, AMBIENT SURVEY STATION LOCATIONS | 7- 5 |
| 2- 6. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE COPPER DATA | 7- 6 |
| 2- 7. JANUARY 1991, AMBIENT DISSOLVED COPPER DATA | 7- 7 |
| 2- 8. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE MERCURY DATA | 7- 8 |
| 2- 9. JANUARY 1991, AMBIENT DISSOLVED MERCURY DATA | 7- 9 |
| 2-10. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE NICKEL | 7- 10 |
| 2-11. JANUARY 1991, AMBIENT DISSOLVED NICKEL DATA | 7- 11 |
| 2-12. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE LEAD DATA | 7- 12 |
| 2-13. JANUARY 1991, AMBIENT DISSOLVED LEAD DATA | 7- 13 |
| 2-14. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE SILVER | 7- 14 |
| 2-15. JANUARY 1991, AMBIENT DISSOLVED SILVER DATA | 7- 15 |
| 2-16. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE ARSENIC | 7- 16 |
| 2-17. JANUARY 1991, AMBIENT DISSOLVED ARSENIC DATA | 7- 17 |
| 2-18. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE CADMIUM | 7- 18 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 2-19. JANUARY 1991, AMBIENT DISSOLVED CADMIUM DATA | 7- 19 |
| 2-20. JANUARY 1991, AMBIENT TOTAL RECOVERABLE AND ACID SOLUBLE ZINC | 7- 20 |
| 2-21. JANUARY 1991, AMBIENT DISSOLVED ZINC DATA | 7- 21 |
| 2-22. JANUARY 1991, AMBIENT SURVEY SUSPENDED SOLIDS DATA | 7- 22 |
| 2-23. SUMMARY PLOT OF EXISTING HUDSON RIVER SUSPENDED SOLIDS DATA | 7- 23 |
| 2-24. TEMPORAL TRENDS IN WATER COLUMN SUSPENDED SOLIDS DATA AT FOUR LOCATIONS DURING APRIL 1991, SYNOPTIC SURVEY | 7- 24 |
| 2-25. STATION LOCATIONS FOR MAY 1991, INTENSIVE TIDAL CYCLE SURVEY | 7- 25 |
| 2-26. TEMPORAL PLOTS OF TOTAL RECOVERABLE AND DISSOLVED METALS AT STATION H8-MAY 1991 TIDAL CYCLE SURVEY | 7- 26 |
| 2-27. TEMPORAL PLOTS OF TOTAL RECOVERABLE AND DISSOLVED METALS AT STATION H3-MAY 1991 TIDAL CYCLE SURVEY | 7- 27 |
| 2-28. TEMPORAL PLOTS OF TOTAL RECOVERABLE AND DISSOLVED METALS AT STATION B6-MAY 1991 TIDAL CYCLE SURVEY | 7- 28 |
| 2-29. TEMPORAL PLOTS OF TOTAL RECOVERABLE AND DISSOLVED METALS AT STATION E4-MAY 1991 TIDAL CYCLE SURVEY | 7- 29 |
| 2-30. TEMPORAL PLOTS OF TOTAL RECOVERABLE AND DISSOLVED METALS AT STATION A3-MAY 1991 TIDAL CYCLE SURVEY | 7- 30 |
| 2-31. TEMPORAL PLOTS OF TOTAL RECOVERABLE AND DISSOLVED METALS AT STATION A7-MAY 1991 TIDAL CYCLE SURVEY | 7- 31 |
| 2-32. TEMPORAL PLOTS OF SOLIDS AND CARBON AT STATION H8-MAY 1991 TIDAL CYCLE SURVEY | 7- 32 |
| 2-33. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE COPPER DATA | 7- 33 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 2-34. OCTOBER 1991, AMBIENT DISSOLVED COPPER DATA | 7- 34 |
| 2-35. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE MERCURY DATA . . | 7- 35 |
| 2-36. OCTOBER 1991, AMBIENT DISSOLVED MERCURY DATA | 7- 36 |
| 2-37. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE NICKEL DATA | 7- 37 |
| 2-38. OCTOBER 1991, AMBIENT DISSOLVED NICKEL DATA | 7- 38 |
| 2-39. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE LEAD DATA | 7- 39 |
| 2-40. OCTOBER 1991, AMBIENT DISSOLVED LEAD DATA | 7- 40 |
| 2-41. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE SILVER DATA | 7- 41 |
| 2-42. OCTOBER 1991, AMBIENT DISSOLVED SILVER DATA | 7- 42 |
| 2-43. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE CADMIUM DATA . . | 7- 43 |
| 2-44. OCTOBER 1991, AMBIENT DISSOLVED CADMIUM DATA | 7- 44 |
| 2-45. OCTOBER 1991, AMBIENT TOTAL RECOVERABLE ZINC | 7- 45 |
| 2-46. OCTOBER 1991, AMBIENT DISSOLVED ZINC DATA | 7- 46 |
| 2-47. LOCATION MAP FOR FEBRUARY 1992, SEDIMENT TOXICITY SURVEY STATIONS | 7- 47 |
| 2-48. FEBRUARY 1992, SEDIMENT SEM:AVS RATIOS VERSUS <i>AMPELISCA</i> <i>ABDITA</i> MORTALITIES | 7- 48 |
| 2-49. LOG PROBABILITY DISTRIBUTIONS OF METALS IN THE HACKENSACK RIVER | 7- 49 |
| 2-50. LOG PROBABILITY DISTRIBUTIONS OF METALS IN THE PASSAIC RIVER | 7- 50 |
| 2-51. LOG PROBABILITY DISTRIBUTIONS OF METALS IN THE RARITAN RIVER | 7- 51 |
| 2-52. LOG PROBABILITY DISTRIBUTIONS OF METALS IN THE HUDSON RIVER | 7- 52 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|--|-------------|
| 2-53. CORRELATION BETWEEN METALS AND HACKENSACK RIVER FLOW . . | 7- 53 |
| 2-54. CORRELATION BETWEEN METALS AND PASSAIC RIVER | 7- 54 |
| 2-55. CORRELATION BETWEEN METALS AND RARITAN RIVER | 7- 55 |
| 2-56. CORRELATION BETWEEN METALS AND HUDSON RIVER | 7- 56 |
| 2-57. LOG PROBABILITY DISTRIBUTIONS OF CSO AND WET WEATHER INFLUENT SURVEY DATA | 7- 57 |
| 2-58. COMPARISON OF LOG PROBABILITY DISTRIBUTIONS FOR CSO AND WET WEATHER INFLUENT DATA SETS | 7- 58 |
| 2-59. COMPARISON OF "HEADWORK'S" STP INFLUENT DATA TO WET WEATHER INFLUENT DATA COLLECTED BY BATTELLE OCEAN SCIENCES | 7- 59 |
| 3- 1. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT DISSOLVED- COPPER, JANUARY, MAY, AND OCTOBER 1991 | 7- 60 |
| 3- 2. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT DISSOLVED- MERCURY, JANUARY, MAY, AND OCTOBER 1991 | 7- 61 |
| 3- 3. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT DISSOLVED- NICKEL, JANUARY, MAY, AND OCTOBER 1991 | 7- 62 |
| 3- 4. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT DISSOLVED- LEAD, JANUARY, MAY, AND OCTOBER 1991 | 7- 63 |
| 3- 5. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT PARTICULATE COPPER, JANUARY, MAY, AND OCTOBER 1991 | 7- 64 |
| 3- 6. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT PARTICULATE MERCURY, JANUARY, MAY, AND OCTOBER 1991 | 7- 65 |
| 3- 7. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT PARTICULATE NICKEL, JANUARY, MAY, AND OCTOBER 1991 | 7- 66 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 3- 8. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT PARTICULATE LEAD, JANUARY, MAY, AND OCTOBER 1991 | 7- 67 |
| 3- 9. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT TOTAL RECOVERABLE COPPER, JANUARY, MAY, AND OCTOBER 1991 | 7- 68 |
| 3-10. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT TOTAL RECOVERABLE MERCURY, JANUARY, MAY, AND OCTOBER 1991 | 7- 69 |
| 3-11. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT TOTAL RECOVERABLE NICKEL, JANUARY, MAY, AND OCTOBER 1991 | 7- 70 |
| 3-12. REGIONAL LOG PROBABILITY DISTRIBUTIONS OF AMBIENT TOTAL RECOVERABLE LEAD, JANUARY, MAY, AND OCTOBER 1991 | 7- 71 |
| 3-13. LOG PROBABILITY DISTRIBUTIONS OF PARTICULATE MERCURY FOR A PROJECTED NON-TIDAL CONDITION | 7- 72 |
| 3-14. LOG PROBABILITY DISTRIBUTIONS OF PARTICULATE NICKEL FOR A PROJECTED NON-TIDAL CONDITION | 7- 73 |
| 3-15. LOG PROBABILITY DISTRIBUTIONS OF PARTICULATE LEAD FOR A PROJECTED NON-TIDAL CONDITION | 7- 74 |
| 3-16. LOG PROBABILITY DISTRIBUTIONS OF TOTAL RECOVERABLE MERCURY FOR A PROJECTED NON-TIDAL CONDITION | 7- 75 |
| 3-17. LOG PROBABILITY DISTRIBUTIONS OF TOTAL RECOVERABLE NICKEL FOR A PROJECTED NON-TIDAL CONDITION | 7- 76 |
| 3-18. LOG PROBABILITY DISTRIBUTIONS OF TOTAL RECOVERABLE LEAD FOR A PROJECTED NON-TIDAL CONDITION | 7- 77 |
| 4- 1. SCHEMATIC DIAGRAM OF CHEMICAL TRANSFERS AND KINETICS IN CTAP | 7- 78 |
| 4- 2. DIAGRAM OF EXPANDED 208 MODEL SEGMENTATION | 7- 79 |
| 4- 3. COMPARISON OF CALCULATED AND MEASURED, JANUARY 1991 SALINITY DATA (HIGH FLOW CONDITION) | 7- 80 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|--|-------------|
| 4- 4. COMPARISON OF CALCULATED AND MEASURED, JANUARY 1991, SUSPENDED SOLIDS DATA | 7- 81 |
| 4- 5. COMPARISON OF CALCULATED AND MEASURED JANUARY 1991, SUSPENDED SOLIDS DATA (HIGH FLOW CONDITION) | 7- 82 |
| 4- 6. COMPARISON OF CALCULATED AND MEASURED OCTOBER 1991, SUSPENDED SOLIDS DATA (LOW FLOW CONDITION) | 7- 83 |
| 4- 7. COMPUTATION OF PARTITION COEFFICIENTS | 7- 84 |
| 4- 8. COMPARISON OF CALCULATED AND MEASURED JANUARY 1991, TOTAL RECOVERABLE COPPER | 7- 85 |
| 4- 9. COMPARISON OF CALCULATED AND MEASURED JANUARY 1991, DISSOLVED COPPER DATA | 7- 86 |
| 4-10. COMPARISON OF CALCULATED AND MEASURED OCTOBER 1991, TOTAL RECOVERABLE COPPER | 7- 87 |
| 4-11. COMPARISON OF CALCULATED AND MEASURED OCTOBER 1991, DISSOLVED COPPER | 7- 88 |
| 4-12. COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE JANUARY 1991 MERCURY DATA WITH AND WITHOUT SEDIMENT LOAD | 7- 89 |
| 4-13. COMPARISON OF CALCULATED AND MEASURED DISSOLVED JANUARY 1991 MERCURY DATA WITH AND WITHOUT SEDIMENT LOAD | 7- 90 |
| 4-14. COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE OCTOBER 1991 MERCURY DATA WITH AND WITHOUT SEDIMENT LOAD | 7- 91 |
| 4-15. COMPARISON OF CALCULATED AND MEASURED DISSOLVED OCTOBER 1991 MERCURY DATA WITH AND WITHOUT SEDIMENT LOAD | 7- 92 |
| 4-16. COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE JANUARY 1991 NICKEL DATA | 7- 93 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|--|-------------|
| 4-17. COMPARISON OF CALCULATED AND MEASURED DISSOLVED JANUARY 1991 NICKEL DATA | 7- 94 |
| 4-18. COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE OCTOBER 1991 NICKEL DATA | 7- 95 |
| 4-19. COMPARISON OF CALCULATED AND MEASURED DISSOLVED RECOVERABLE OCTOBER 1991 NICKEL DATA | 7- 96 |
| 4-20. COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE JANUARY 1991 LEAD DATA | 7- 97 |
| 4-21. COMPARISON OF CALCULATED AND MEASURED DISSOLVED JANUARY 1991 LEAD DATA | 7- 98 |
| 4-22. COMPARISON OF CALCULATED AND MEASURED TOTAL RECOVERABLE OCTOBER 1991 LEAD DATA | 7- 99 |
| 4-23. COMPARISON OF CALCULATED AND MEASURED DISSOLVED RECOVERABLE OCTOBER 1991 LEAD DATA | 7-100 |
| 4-24. COPPER LOADINGS TO NY/NJ HARBOR | 7-101 |
| 4-25. MERCURY LOADINGS TO NY/NJ HARBOR | 7-102 |
| 4-26. LEAD LOADINGS TO NY/NJ HARBOR | 7-103 |
| 4-27. NICKEL LOADINGS TO NY/NJ HARBOR | 7-104 |
| 4-28. COMPARISON OF CALCULATED AND MEASURED SEDIMENT COPPER CONCENTRATIONS - JANUARY 1991 | 7-105 |
| 4-29. COMPARISON OF CALCULATED AND MEASURED SEDIMENT COPPER CONCENTRATIONS - OCTOBER 1991 | 7-106 |
| 4-30. COMPARISON OF CALCULATED AND MEASURED SEDIMENT MERCURY CONCENTRATIONS - JANUARY 1991 | 7-107 |
| 4-31. COMPARISON OF CALCULATED AND MEASURED SEDIMENT MERCURY CONCENTRATIONS - OCTOBER 1991 | 7-108 |

FIGURES
(continued)

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 4-32. COMPARISON OF CALCULATED AND MEASURED SEDIMENT NICKEL CONCENTRATIONS - JANUARY 1991 | 7-109 |
| 4-33. COMPARISON OF CALCULATED AND MEASURED SEDIMENT NICKEL CONCENTRATIONS - OCTOBER 1991 | 7-110 |
| 4-34. COMPARISON OF CALCULATED AND MEASURED SEDIMENT LEAD CONCENTRATIONS - JANUARY 1991 | 7-111 |
| 4-35. COMPARISON OF CALCULATED AND MEASURED SEDIMENT LEAD CONCENTRATIONS - OCTOBER 1991 | 7-112 |

TABLES

| <u>Table</u> | <u>Page</u> |
|---|-------------|
| 1- 1 MONITORING PROGRAMS FOR THE TOXIC METALS TMDL/WLA | 1- 2 |
| 2- 1 NYCDEP HARBOR SURVEY SAMPLE COLLECTION, PROCESSING, AND REPORTING METHODS FOR WATER COLUMN TOTAL RECOVERABLE METALS AT GIVEN STATION | 2- 2 |
| 2- 2 AMBIENT WATER QUALITY CRITERIA USED USEPA REGION II FOR HEAVY METALS IN NEW YORK/NEW JERSEY HARBOR | 2- 3 |
| 2- 3 NEW YORK/NEW JERSEY HARBOR AMBIENT SAMPLE COLLECTION LOG FOR OCTOBER LOW FLOW SURVEY. COLLECTION TIME AND DEPTH ARE APPROXIMATE. | 2-13 |
| 2- 4 RESULTS FROM THE FEBRUARY 1992 AMPELISCA ABDITA FLOW- THROUGH SOLID-PHASE TEST | 2-16 |
| 3- 1 TARGET LONG-TERM METALS CONCENTRATIONS | 3- 7 |
| 3- 2 PERCENT REMOVAL REQUIREMENTS | 3- 8 |
| 4- 1 TRIBUTARY FRESHWATER INPUTS AT MODEL BOUNDARIES TO NEW YORK/NEW JERSEY HARBOR FOR HIGH AND LOW FLOW CALIBRATION PERIODS | 4- 2 |
| 4- 2 PARTITION COEFFICIENT ESTIMATES | 4- 6 |
| 4- 3 METAL LOADS TO NY/NJ HARBOR | 4- 8 |
| 4- 4 ACCURACY ANALYSIS RESULTS | 4-12 |
| 5- 1 ILLUSTRATIVE EXAMPLE COPPER WLA SPREADSHEET | 5- 3 |

SUMMARY OF FINDINGS

1. The accurate measurement of trace metals in ambient waters requires the utilization of state-of-the-art "clean" analytical techniques. Historical measurements of trace metals are probably not accurate, and can differ erratically from modern day measurements by at least an order of magnitude.
2. In New York/New Jersey Harbor total recoverable metal is approximately equal to both acid soluble metal and the arithmetic sum of dissolved and particulate metal for the trace metals copper, mercury, nickel, lead, silver, arsenic, cadmium, and zinc.
3. Instantaneous observed concentrations of mercury, nickel, and lead were apparently in excess of the respective numeric criteria adopted for the New York/New Jersey Harbor Wasteload Allocation (WLA) during at least one of the three ambient metals surveys. Based on observed data, the following waterbodies exceeded water quality criteria.

| <u>Mercury</u> | <u>Nickel</u> | <u>Lead</u> |
|------------------|---------------|--------------|
| Hudson River | Hudson River | Hudson River |
| East River | | Kills |
| Inner Harbor | | |
| Raritan Bay | | |
| Kills | | |
| Jamaica Bay | | |
| Hackensack River | | |
| Passaic River | | |
| Newark Bay | | |

4. Total recoverable metals concentrations in New York/New Jersey Harbor vary over the tidal cycle at certain locations. This variability is coincident with variations in

suspended solids concentrations. The effect of the tidal cycle on concentrations of dissolved metals, however, is relatively negligible; the concentrations are approximately constant. Thus, the impact of tides on ambient concentrations of metals in New York/New Jersey Harbor is related only to the metal particulate fraction.

5. During both the January 6 through 12, 1991, and the October 28 through 31, 1991 monitoring periods, there did not appear to be appreciable net deposition of particulate metal from the water column to the sediment bed. The total metal concentration for these surveys balanced as a conservative variable. The January and October surveys are representative of "above average" and "low" flow conditions, respectively. It is recognized that the study did not capture a truly "high" flow event and that a metals balance on a yearly basis may not be conservative. Future studies should consider monitoring the ambient waters for metals during and after a "high" flow event.
6. On a regional basis, concentrations of dissolved and particulate metals are log normally distributed. Regional log probability distributions of total recoverable metals may be approximated by constructing the probability distribution of the arithmetic sum of dissolved and particulate metals concentrations.
7. Variability observed in concentrations of dissolved metals, which is not strongly correlated to tidal cycle position, may be interpreted as the variability which would be observed in particulate metals if no tides were present. This non-tidal variability in harbor metals may be attributed to hydrodynamic variations, loading variations, and analytical errors in sample collection and processing.
8. To perform wasteload allocations based on the criteria developed for chronic toxicity, only the non-tidal variability is considered. Chronic criteria is based on one exceedance in three years of 4-day average concentrations.

