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DELAWARE RIVER BASIN COMMISSION

SEASONAL DISINFECTION STUDY

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Coastal Zone Management Program

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DELAWARE RIVER BASIN COMMISSION
Gerald M. Hansler, Executive Director

SEASONAL DISINFECTION STUDY

U. S. DEPARTMENT OF COMMERCE NOAA
COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

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Executive Summary

The purpose of this project was to obtain data on the bacterial quality of the Delaware River and Bay to determine if Commission water quality standards should be changed to permit seasonal disinfection by dischargers to the tidal Delaware River from the head of tide at Trenton, N.J., to the Pennsylvania-Delaware state line at Marcus Hook, Pa. Current standards require year-round disinfection.

The major source of funding for the project was a \$200,000 grant from the National Oceanic and Atmospheric Administration (NOAA). The remainder of the funding was from municipal contributions.

The data were collected over a two-year period. During the first year dischargers upstream of the Pennsylvania-Delaware state line were excused from providing disinfection from October through April. Continuous disinfection was required at all other times.

The data indicate that bacterial levels in the winter when the disinfection requirement was excused were significantly higher than in the winter with disinfection. The impact extended over the entire length of the river sampled, including the shellfishing area. The greatest impact was in the Philadelphia - Camden area. Bacterial levels during the entire Study period were affected by untreated sewage from combined sewers during both dry and wet weather. Bacterial levels during the first winter were obviously affected by the suspension of disinfection. Only order of magnitude estimates can be made of the impact of the combined sewers.

It is concluded that the current year-round wastewater disinfection requirement should remain in effect. This conclusion should be re-examined after combined sewer overflows have been corrected to essentially eliminate dry weather discharges and reduce wet weather discharges.

Introduction

The Delaware River Basin Commission held a public hearing in September 1983 on a proposal to change its disinfection requirements from year-round to seasonal. The rationale and justification were presented in a June 1983 Commission staff report*. The report discussed the basis of the need for disinfection, the disadvantages of disinfection with particular reference to chlorine, and the data on river bacterial quality available at that time. After consideration of the hearing testimony and further discussion, it was concluded by the Commission that additional data on river bacterial quality were needed.

This project was designed to assess the impact on river bacterial quality of changes in municipal wastewater disinfection practices. The Study design was based on the recommendations of the Commission's Water Quality Advisory Committee, which includes one member from the water pollution control agencies of the Basin states (Delaware, New Jersey, New York, and Pennsylvania) and the U.S. Environmental Protection Agency (EPA). Representatives of the U.S. Food and Drug Administration and the Delaware and New Jersey units responsible for shellfish management and protection participated in the discussions.

A two-year Study was recommended, which began in July 1987 and ended in June 1989. Figure One is a map of the Study area. During the first winter (October 1987 to April 1988) municipal wastewater facilities discharging to the tidal Delaware River between Trenton and the Pennsylvania-Delaware state border (Delaware River Zones 2,3, and 4) were excused from the disinfection requirement. Bacterial criteria for that reach of the Delaware River in water quality standards of the New Jersey Department of Environmental Protection (NJDEP), the Pennsylvania Department of Environmental Resources (PaDER), and the Commission were formally suspended from October 1, 1987 to April 30, 1988. NPDES permits for a total of 26 wastewater treatment facilities were amended by NJDEP and PaDER to suspend the disinfection requirement for the same period. All other treatment requirements remained in effect for these facilities and continuous disinfection was required at all other times.

Samples of the Delaware River and Bay were collected and analyzed by the Delaware Department of Natural Resources and Environmental Control (DNREC) and the New Jersey Department of Environmental Protection (NJDEP) under a series of contracts with the Commission. All field and laboratory work in this Study was carried out in accordance with a quality assurance project plan** approved by EPA. All data obtained have been entered into STORET, the EPA national computer system for water quality data.

* Seasonal Disinfection Policy for the Delaware River, Delaware River Basin Commission, June 1983.

**Quality Assurance Project Plan, Seasonal Disinfection Study, DRBC - QA 004.

Funds to defray the costs of the basic Study program which encompassed analyses for total and fecal coliform (MPN), were provided by a \$200,000 grant from the National Oceanic and Atmospheric Administration and \$23,000 matching non-Federal funds contributed by municipal wastewater discharge operating agencies. Additional municipal contributions were used to support analyses for two new recreational bacterial parameters (enterococcus and E. coli) and a related fecal coliform analysis (mTEC).

This Study was directed to the impact of changes in wastewater disinfection practices on river bacterial quality. The Study assessed health risks only to the extent that the bacterial parameters tested are measures of health risk. Since it is not practical to test for disease-producing organisms, tests for "indicator" organisms are used: counts of "indicator" organisms above a "standard" established on a regulatory basis are considered to be presumptive evidence of the presence of disease-producing organisms at unacceptable levels. The limitations of this approach must be recognized: once established a bacterial standard becomes a constraint upon water quality management by regulatory agencies, yet concentrations of indicator organisms below the standard does not necessarily guarantee safety from disease.

Sampling Program

Two sets of data were collected from the Delaware River and Bay, river run and shellfish area. Each were collected at an average interval of twice per month over the entire 24-month Study period.

Collection and analysis of river run samples was performed by DNREC at a minimum of 40 locations. Of these 40 locations, 15 were in the center of the navigation channel and 25 were at locations between the navigation channel and the shores of the river. The 15 center navigation channel locations are shown on Figure One. Latitude, longitude, river mile, and STORET station number for the 40 locations are given in Table 1.

Sample collection began in upper Delaware Bay in the shellfishing area in the upper reaches of Zone 6, and extended up the Delaware River into Zone 2, a few miles below the head of tide at Trenton, N.J. All samples were analyzed for total and fecal coliform MPN and enterococcus. Samples from locations upstream of River Mile 75 and from all center navigation channel locations were also analyzed for E. coli and fecal coliform mTEC. Enterococcus, E.coli, and fecal coliform mTEC are "membrane filter" analyses.

Collection and analysis of shellfish area samples was performed by NJDEP at 60 locations. The general location of the area from which samples were taken is shown on Figure One. Latitude, longitude, river mile, and STORET station numbers are given in Table 2. There were five cross-sections or "transects" with six to nine sampling loctions each. The remainder of the locations were along the shores of the river or in embayments. All samples were analyzed for total and fecal coliform MPN and half the samples were analyzed for enterococcus.

Sources of Bacteria

In this Study bacterial concentrations were measured at sampling locations in the tidal Delaware River and upper Delaware Bay. The observed concentrations show the combined effects from all sources, which includes wastewater discharges, combined sewers, tributary streams, and non-point sources. The purpose of this Study was to assess the impact on river bacterial concentrations of changes in wastewater discharge characteristics resulting from the suspension of wastewater disinfection.

From October 1, 1987 to April 30, 1988, 26 wastewater treatment plants discharging to Zones 2,3, and 4 of the Delaware River did not practice disinfection. See Table 3 for a list of these discharges, including flow data. During this period the total volume discharged by these facilities averaged 613 mgd. Virtually all of this volume received secondary treatment before discharge. During July and August 1987, the CCMUA Delaware No. 1 plant, with an average flow of 17 mgd, provided primary treatment without disinfection. During the month of September 1987 this plant was upgraded to secondary treatment with disinfection. The Baldwin Run plant (3 mgd), operated by CCMUA, provided secondary treatment without disinfection for the entire two-year Study period. The Falls Township Authority plant (3 mgd) ceased operation in March 1989 and transferred its wastewaters to the Philadelphia - Northeast plant. From October 1, 1988 to April 30, 1989, a combined volume of 595 mgd was discharged by the plants that did not practice disinfection the previous winter.

Bacteriological quality of the Delaware River is affected by over three hundred combined sewer overflows (CSOs) between Trenton and Wilmington*, including 176 in Philadelphia and 66 in Camden. CSOs are designed to discharge a mixture of untreated wastewater and stormwater runoff during wet weather.

A recently completed study** revealed that many of the CSOs in the Philadelphia and Camden area discharge during dry-weather conditions. Analyses reported in that study indicated that the impact of the dry-weather CSOs exceeds that of the wet-weather CSOs. The impact of dry-weather CSOs would be fairly constant over the two-year Seasonal Disinfection Study period, increasing overall river bacterial levels. The impact of wet-weather CSOs would vary depending on rainfall. The report** cited above estimated that correction of dry-weather CSOs would result in a 75-80 percent reduction in the numbers of bacteria discharged under dry and wet weather conditions combined. The report did not estimate the resulting reduction in river bacterial levels.

*Quality Assurance Project Plan, Seasonal Disinfection Study, DRBC - QA 004, p. 25.

**Combined Sewer Overflow Report, Del USA Project Element 8, Delaware Estuary Use Attainability Project, January 1988.

Non-point sources also contribute bacteria to the Delaware River. Runoff originating as rainfall flows overland and is contaminated by fecal and other matter containing bacteria that it comes in contact with. Waterfowl are also a significant source of fecal bacteria. There are extensive waterfowl feeding areas in wetlands bordering the Delaware River and Bay. Sources of bacteria from wetlands are virtually uncontrollable.

Results

To evaluate the effect on river bacterial levels of the suspension of the disinfection requirement for 26 wastewater discharges in Zones 2,3, and 4, from October 1987 through April 1988, geometric means and medians of bacterial concentrations observed at the various sampling locations for that period were compared with the same measures of central tendency for the October 1988 through April 1989 period. The data are presented in a series of graphs in two appendixes, Appendix I, River Run Data, and Appendix II, Shellfish Area Data. Selected graphs are discussed below.

River Runs - Center Channel

Graphs 1.1 to 1.10 present geometric means and medians for each of the five bacterial parameters at the 15 center navigation channel "river run" sampling locations for three periods - October 1987 through April 1988, the "non-disinfection" winter, October 1988 through April 1989, the "disinfection" winter, and May through September 1988, the intervening summer. During the "non-disinfection" winter bacterial levels were higher than during the "disinfection" winter for the entire length of the river represented by the 15 sampling locations. The greatest differences in bacterial levels between the two winters occurred in the reach which received the discharges excused from disinfection in the non-disinfection winter. These differences decrease more or less gradually moving downstream until about River Mile 66. Downstream of River Mile 66, the differences in bacterial levels between the two winters do not appear to decrease moving downstream. This suggests that the higher bacterial levels in the lower river and upper Bay in the non-disinfection winter may not be entirely due to the suspension of disinfection. It is not possible to pinpoint the cause or causes. One likely candidate is streamflow. During the non-disinfection winter, October 1987 to April 1988, the flow of the Delaware River at Trenton, N.J., averaged 11,138 cfs. During the disinfection winter, October 1988 to April 1989, the flow averaged 7,633 cfs. The higher flows in the non-disinfection winter might have transported the bacteria further downstream than in the disinfection winter.

Graph 1.1 (Figure Two) compares geometric mean fecal coliform levels for the two winters and the intervening summer. Also shown are the current Commission fecal coliform criteria and a criterion (2000/100ml) used by some agencies for surface waters as a source of raw water supply.

The current Commission criterion of 770/100 ml in Zones 2, 3, and 4 was exceeded in the non-disinfection winter. This criterion was based on year-round disinfection. The 770/100ml criterion was also exceeded in the non-disinfection winter in the upper reach of Zone 5 for a distance of about four miles.

In parts of Zones 3 and 4 geometric mean fecal coliform levels were as high as 5000/100ml in the non-disinfection winter. Zone 3 is designated in Commission water quality standards as suitable for sources of public drinking water supplies after reasonable treatment. A geometric mean of 2000/100ml is a commonly accepted criterion for a raw water supply. There are no public water supply withdrawals from Zone 3.

In part of Zone 3, the current 770/100ml Commission criterion was exceeded in the disinfection winter and in the summer of 1988. Virtually all wastewater discharges received disinfection during these two periods. Only an insignificant 3 mgd was not disinfected.

Zone 3 is significantly affected by the discharge of untreated sewage from combined sewer overflows (CSOs) under both dry and wet weather conditions. It is believed that the CSOs are the cause of the exceedance of the 770/100ml fecal coliform criterion in the disinfection winter and the summer. The CSOs also contributed significantly to the high bacterial levels observed in Zones 3 and 4 in the non-disinfection winter. The exceedance of the 770/100ml fecal coliform criterion in the upper four miles of Zone 5 in the non-disinfection winter may also be due in large measure, if not entirely, to the CSOs. It is not possible to estimate the impact of the CSOs with any degree of precision. Available water quality models would yield order of magnitude results only. While this would indicate the general impact, it would not be considered definitive. Because of this uncertainty in the area of greatest impact of the CSOs and the distance and time of passage downstream, it is not possible to estimate the effect of the CSOs on the bacterial levels observed in the shellfish area.

Graph 1.1 (Figure Two) shows that fecal coliform levels were higher in the non-disinfection winter than in the disinfection winter for the entire length of the river, including the shellfishing area. The primary cause of the differences in bacterial levels between the two winters was the suspension of disinfection in the Trenton to Marcus Hook reach. Other factors, such as differences in streamflows, may have contributed to the severity and extent of the river affected. Discharges from CSOs, particularly under dry-weather conditions, increased bacterial levels throughout the entire Study period.

Graph 1.2 (Figure Three) compares median fecal coliform levels for the two winters and the intervening summer, along with the fecal coliform criterion for shellfishing waters (14/100ml). Generally, median levels are quite similar to the levels observed for the geometric mean. Graph 1.2 (Figure Three) shows that in the non-disinfection winter the fecal coliform shellfishing criterion was just met at the upper end of the area currently approved for shellfishing. However, at the furthest downstream sampling location the non-disinfection winter median was 11/100 ml, compared to 8/100 ml during the disinfection winter.

Graph 1.4 (Figure Four) compares median total coliform levels for the two winters and the intervening summer, along with the total coliform criterion for shellfishing waters (70/100ml). Medians for the non-disinfection winter are significantly higher than for the disinfection winter over the entire length of the river sampled, including the shellfishing area. In the reach below River Mile 40, where shellfishing is currently permitted, the 70/100ml total coliform shellfishing criterion was met in the disinfection winter but was exceeded in the non-disinfection winter. At the furthest downstream sampling location, the median was 112/100 ml in the non-disinfection winter and 22.5/100 ml in the disinfection winter. This is a significant difference. It is noted that there was no danger to public health during the non-disinfection winter. Although taking of shellfish for direct marketing is permitted, shellfish taken from this area are considered too small and are therefore replanted to allow them to grow to a size more suitable for marketing.

River Runs - Additional Sampling Locations

Under the river-run sampling program, samples were also collected at 25 locations between the center of the navigation channel and the shores of the river. Geometric means and medians for the various bacterial parameters for the two winters at these 25 locations along with the geometric means and medians at the 15 center navigation channel sampling locations are presented in Appendix I in three-dimensional graphs numbered 1.11A through 1.20C. It should be noted that the relationships of the positions of the sampling locations shown on these graphs are "schematic" only, particularly the relationships between the "additional" locations and the center channel locations. Values for the non-disinfection winter are presented in the "A" series, values for the disinfection winter are presented in the "B" series, and the ratios of the non-disinfection winter value to the disinfection winter value are presented in the "C" series. In each of these graphs, the value (or ratio of values) is presented as a vertical bar. Solid black bars apply to the 15 sampling locations in the center of the navigation channel. The values represented by the solid black bars in the "A" series are the values indicated by "diamonds" in Graphs 1.1 - 1.10. In the "B" series, values represented by solid black bars are the values indicated by "x" in Graphs 1.1 - 1.10. Values obtained at sampling locations between the navigation channel and the Pennsylvania or Delaware shore are represented by open

bars denoted in the legend "Left of Chan.(Pa-De)". Values obtained at locations between the channel and the New Jersey shore are represented by bars filled by diagonals rising to the left and denoted in the legend "Right of Chan.(NJ)". There were also two sampling locations between the channel location and the right of channel location. These are represented by bars filled with horizontal lines and denoted by "Mid-River" in the legend.

The relationships between the values obtained at the center channel locations and the values obtained at the additional locations varied; many center channel location values were lower than the values at the nearby additional locations, some were higher. Generally, the relationship between the center and a nearby additional location was the same for both winters, e.g., if the additional location value was higher than the center value in the non-disinfection winter, it was also higher than the center value in the disinfection winter. This suggests that, generally, differences between center location values and the additional location values were influenced more by local factors than by changes in disinfection practices.

The "C" series (Graphs 1.11C - 1.20C) present the ratio of the geometric mean or median value observed in the non-disinfection winter to the value observed in the disinfection winter. Virtually all ratios are greater than one, that is, the value observed in the non-disinfection winter is higher than the value observed in the disinfection winter. This confirms for the 25 sampling locations between the channel and the shores what Graphs 1.1 - 1.10 show for the 15 center navigation channel sampling locations: in the non-disinfection winter bacterial levels were higher than in the disinfection winter for the entire length of the river sampled, including the shellfishing area.

Shellfish Area Sampling

The results of sampling in the shellfish area are presented in Appendix II in three-dimensional graphs numbered 2.1A to 2.6C. Geometric means and medians for fecal and total coliform and enterococcus are presented for the non-disinfection winter in the "A" series, and for the disinfection winter in the "B" series. The ratios of the non-disinfection winter value to the disinfection winter value are presented in the "C" series. The great majority of ratios are more than one, that is, the value observed in the non-disinfection winter is greater than the value observed in the disinfection winter. This is consistent with what was found in the "river-run" data.

In the "C" series graphs for the shellfish area, the highest ratios appear to occur at sampling locations near the shores rather than at sampling locations near the middle of the river. The shellfish area is more than 30 miles downstream from the reach which received undisinfecting wastewater discharges. By the time these wastewaters reached the shellfish area, they would be mixed quite well with the

river water and would have moved downstream with the bulk of the river water, which occurs in mid-river rather than near shore. The higher ratios of non-disinfection winter value to disinfection winter value near the shores suggests that shore effects contributed significantly to the high bacterial levels observed in the shellfish area in the non-disinfection winter. The cause or causes are unknown.

One possibility is a difference in rainfall patterns between the two years, resulting in different impacts from land runoff. Rainfall occurring a day or two prior to the day that the shellfish area was sampled would have had a greater impact on river bacterial levels than rainfall occurring much earlier. Table 4 compares precipitation data at Wilmington for the two winter periods. Precipitation occurring on the day of a survey and on each of the seven days preceding the survey are tabulated. The precipitation recorded for the second through the seventh day was "weighted" by dividing by the number of the day. The sum of the "weighted" precipitation values for the non-disinfection winter is significantly more than the sum for the disinfection winter. This suggests that the rainfall pattern in the non-disinfection winter resulted in runoff contributing more bacteria to the samples collected in that winter than runoff contributed to the samples collected in the disinfection winter.

Fecal and total coliform data for most of the shellfish area sampling locations are also presented in Graphs 2.11A to 2.14H. Fecal and total coliform geometric means and medians for the two winter periods are compared along the five cross-sections or "transects" (series A,B,C,D and E), along the centerline channel profile (series F), and along shore profiles (series G and H). Once again, at nearly all locations, the non-disinfection winter value was significantly greater than the disinfection winter value. The transects also show that in this reach of the river, in both winters the highest values did not occur in the navigation channel, but along the Delaware or west shore or between the channel and the Delaware shore.

Statistical Analysis

To assess the statistical significance of the data, analysis of covariance tests were performed on fecal and total coliform concentrations. The purpose was to determine whether the differences in bacterial levels observed between years were primarily due to chance rather than to changes in disinfection practices.

The data were divided into two groups: (1) upper river - all river run sampling locations above River Mile 55 - encompassing 29 locations, and (2) lower river - the remaining river run sampling locations and all the shellfish area sampling locations - a total of 71 locations. For each data group for each parameter, analysis of covariance tests were performed using the following sources: a. disinfection practices, sampling locations, and the covariate streamflow, utilizing seven-day average flow of the Delaware River at Trenton, N.J. (see Table 7); and b. disinfection practices, sampling locations, and "weighted" precipitation. For the lower river, precipitation at Wilmington, Del., was used (Tables 4 and 5), and for the upper river, precipitation at Philadelphia, Pa., was used (Table 6).

The results are presented in Tables 8, 9, 10, and 11, for the upper and lower river for fecal and total coliform, respectively. All four tables show that bacterial levels were significantly affected by the disinfection practices and sampling location. For example, the probability that the differences between years were due to chance is always less than five percent and nearly always less than one percent (column 6 for the source "disinfection" in column 1).

The tables also show that bacterial levels were affected by both streamflow and precipitation, but the effect was different for each, and different for the upper river than for the lower river. Column 6 in part A of Tables 8 and 9 indicates that the interaction of the covariate streamflow and disinfection was not significant. This means that the response of bacterial levels in the upper river to streamflow was the same in both the non-disinfection winter and the disinfection winter, that is, a given rate of streamflow would produce the same change in bacterial levels in either winter. Since streamflows were significantly greater in the non-disinfection winter, the higher bacterial levels in that winter can be partially attributed to the higher streamflows.

Part B of Tables 8 and 9 indicate that the interaction of the covariate precipitation was very significant. This means that the response to precipitation in the non-disinfection winter was different from the response to precipitation in the disinfection winter. This could be the result of a difference in rainfall patterns between the two winters in relation to the times of sampling surveys. Such a difference would, for example, result in different contributions to bacterial levels due to discharges from combined sewers.

Tables 10 and 11 show that the response to both precipitation and streamflow was different in the two winters in the lower river, including the shellfish area. This is consistent with higher streamflows in the non-disinfection winter transporting bacteria further downstream than in the disinfection winter. It is also consistent with different precipitation patterns in the two winters resulting in different contributions of bacteria from land runoff.

The results of the analysis of covariance tests are consistent with higher bacterial levels in the non-disinfection winter being due to the combined effect of the suspension of disinfection, different streamflows, and different precipitation patterns in the two winters. When the influences of streamflow, precipitation, and sampling location are removed, bacterial levels remain higher in the non-disinfection winter over the entire study area.

Discussion

During the period when the wastewater disinfection requirement was suspended, bacterial levels were significantly higher than during the other portions of the two-year Study period. Higher values occurred over the entire length of the river sampled, and were evident at the

sampling locations in the center of the navigation channel, at the river-run sampling locations between the channel and the shores, and at the sampling locations in the shellfish area. Factors other than the suspension of disinfection, such as dry and wet weather CSOs, land runoff, or streamflows, may have contributed to the higher values. However, it must be recognized that these other factors in combination with the suspension of disinfection resulted in the high bacterial levels. Of the various factors, disinfection is the only one currently subject to control. There is a program underway to correct some of the dry-weather CSOs.

In this Study, there were two sets of samples collected, "river-run" and "shellfish area". There were 40 river-run sampling locations, 15 in the center of the navigation channel, and 25 between the channel and the shores. There were 60 sampling locations in the shellfish area. The key results were evident from the data obtained at the 15 center channel locations. Data from the other 85 locations were essentially consistent with the data from the 15 and did not materially affect the findings.

Samples were analyzed for up to five bacterial parameters - fecal coliform (MPN), total coliform (MPN), fecal coliform (mTEC), E. coli, and enterococcus. The key results were based on total and fecal coliform MPN. Results obtained for the other three parameters were essentially consistent with the results obtained for total and fecal coliform MPN. When this Study was concluded, analyses for total and fecal coliform MPN ceased, but analyses for enterococcus, E. coli, and fecal coliform mTEC on samples taken from the center of the navigation channel are continuing. The data obtained in this Study provide an excellent data base for relating total and fecal coliform MPN to enterococcus, E. coli, and fecal coliform mTEC, and for setting recreational water quality criteria based on E. coli and enterococcus, which are beyond the scope of this report.

Considerable effort during this Study was devoted to obtaining data during the winter months, December, January, and February. The data were examined to determine if the key results were obtainable without the samples collected in December, January, and February. Figure Five compares geometric mean fecal coliform MPN for the period October 1, 1987 - November 30, 1987 and March 1, 1988 - April 30, 1988 with geometric means for the period October 1, 1988 - November 30, 1988 and March 1, 1989 - April 30, 1989. It is evident from a comparison of Figure Five with Figure Two that data for the December - February periods made a significant difference.

Conclusions

1. Bacterial levels in the non-disinfection winter were significantly higher than in the disinfection winter. The impact can be seen for the entire length of the river sampled, including the shellfishing area.

2. In the non-disinfection winter, geometric mean fecal coliform MPN values exceeded 5000/100ml in a zone designated as suitable for water supply in Commission water quality standards. A commonly accepted criterion for a raw water supply is a geometric mean of 2000/100ml. However, there are no public water supply withdrawals in the affected zone.

3. In the non-disinfection winter, geometric mean fecal coliform MPN exceeded the current Commission 770/100ml criterion for a distance of about four miles below the Pennsylvania-Delaware state line.

4. In the non-disinfection winter, median total coliform exceeded the 70/100ml shellfishing waters criterion in the approved shellfishing area. However, there was no danger to public health since, when shellfish are taken from that area, they are replanted to allow them to grow to a size suitable for marketing.

5. In addition to the suspension of disinfection, factors that contributed to the observed bacterial levels include combined sewer overflows under both dry and wet weather conditions, and non-point sources such as runoff from land surfaces resulting from rainfall.

6. Correction of dry weather combined sewer overflows and reduction of wet weather combined sewer overflows would substantially reduce river bacterial levels in the Philadelphia-Camden reach of the Delaware River. It is not possible to predict the length of river where bacterial levels would improve.

7. Bacterial data obtained at the 15 sampling locations in the center of the navigation channel between Torresdale and Ship John Light were essential to arrive at the above conclusions. Data obtained at the other 85 sampling locations confirmed the results but the conclusions would stand without the data from these additional locations.

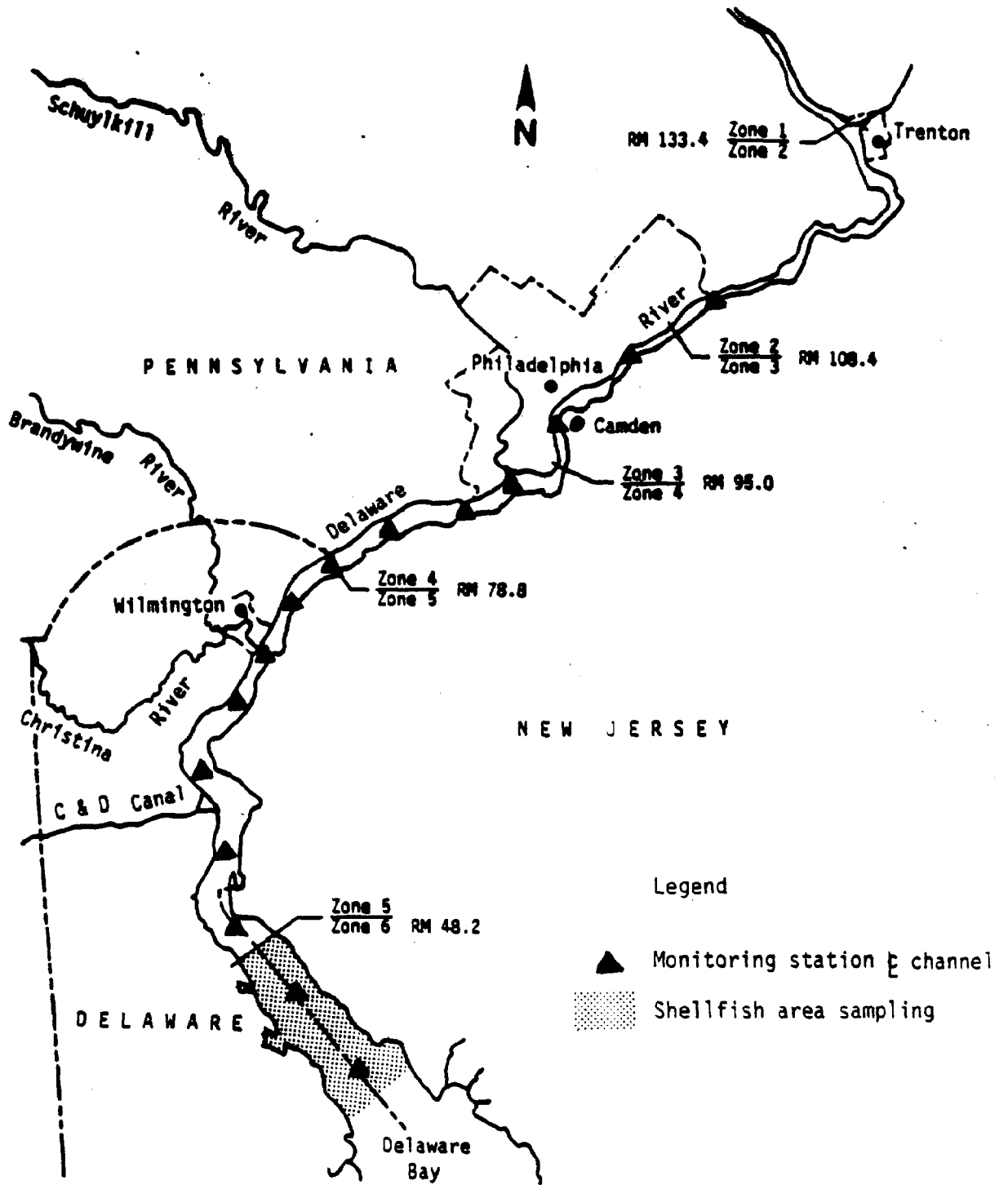
8. Total and fecal coliform MPN measurements were used to reach the above conclusions. The measurements of the other three bacterial parameters provide a valuable data base for setting water quality criteria to protect recreation and for management of Delaware River water quality.

9. Collection of samples during the months of December, January, and February was essential to carry out this Study.

Recommendations

1. The current year-round wastewater disinfection requirement for discharges to the tidal Delaware River should remain in effect.
2. The above recommendation should be re-examined after combined sewer overflows have been corrected to eliminate dry weather flows, and reduce wet weather flows, or if environmental data collected to assess the health protection benefits of current disinfection practices indicate that disinfection is not effective for ensuring such protection.
3. Data for future studies should include analyses for appropriate parameters to support current and proposed standards and assess health risks. To the extent practical, factors such as rainfall, streamflows, and time of sampling should be considered in the study design.
4. Data on the new recreational bacterial parameters collected in this Study should be reviewed and assessed for the purpose of revising current water quality standards.

Figure One



General Location Map

Figure Two

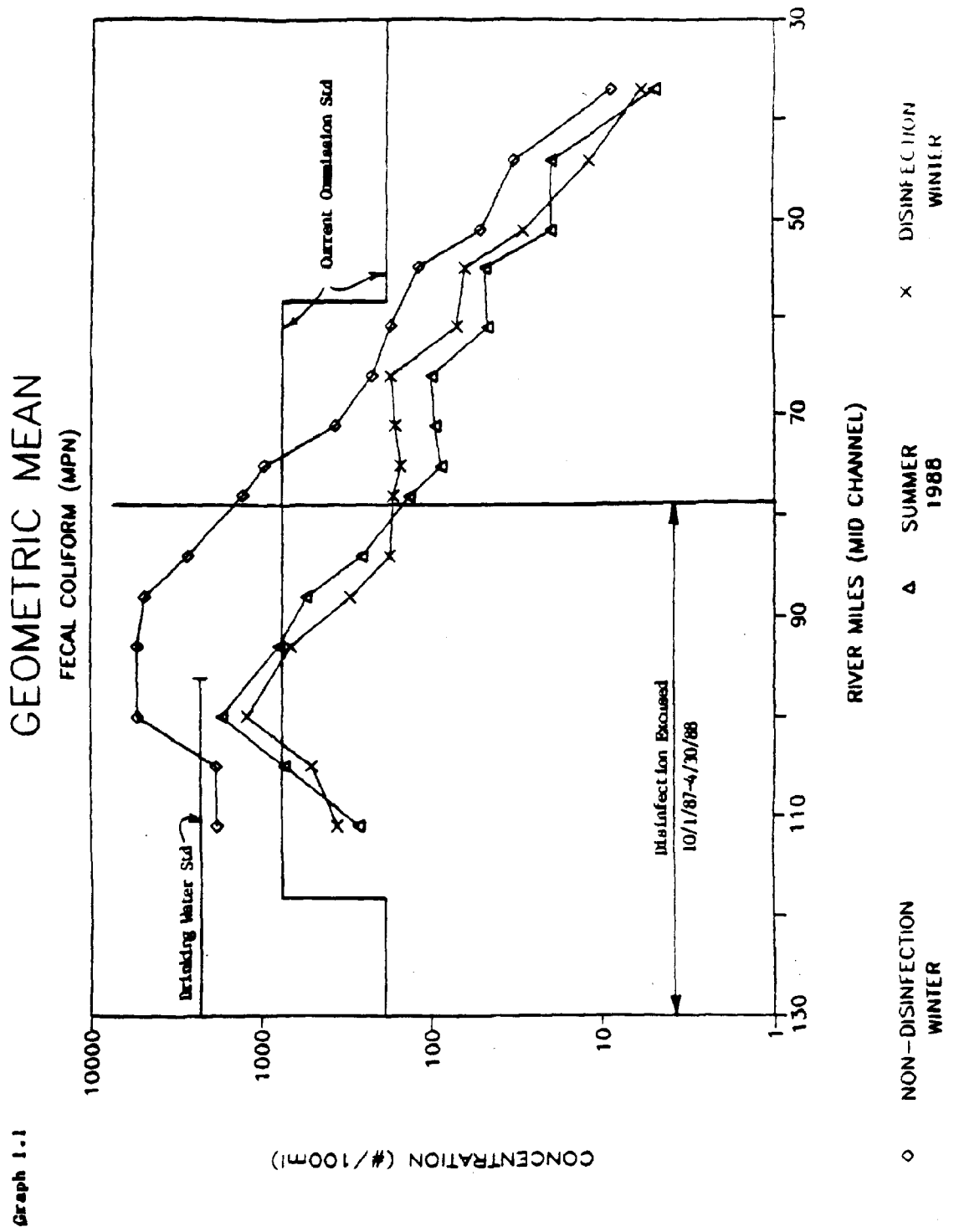
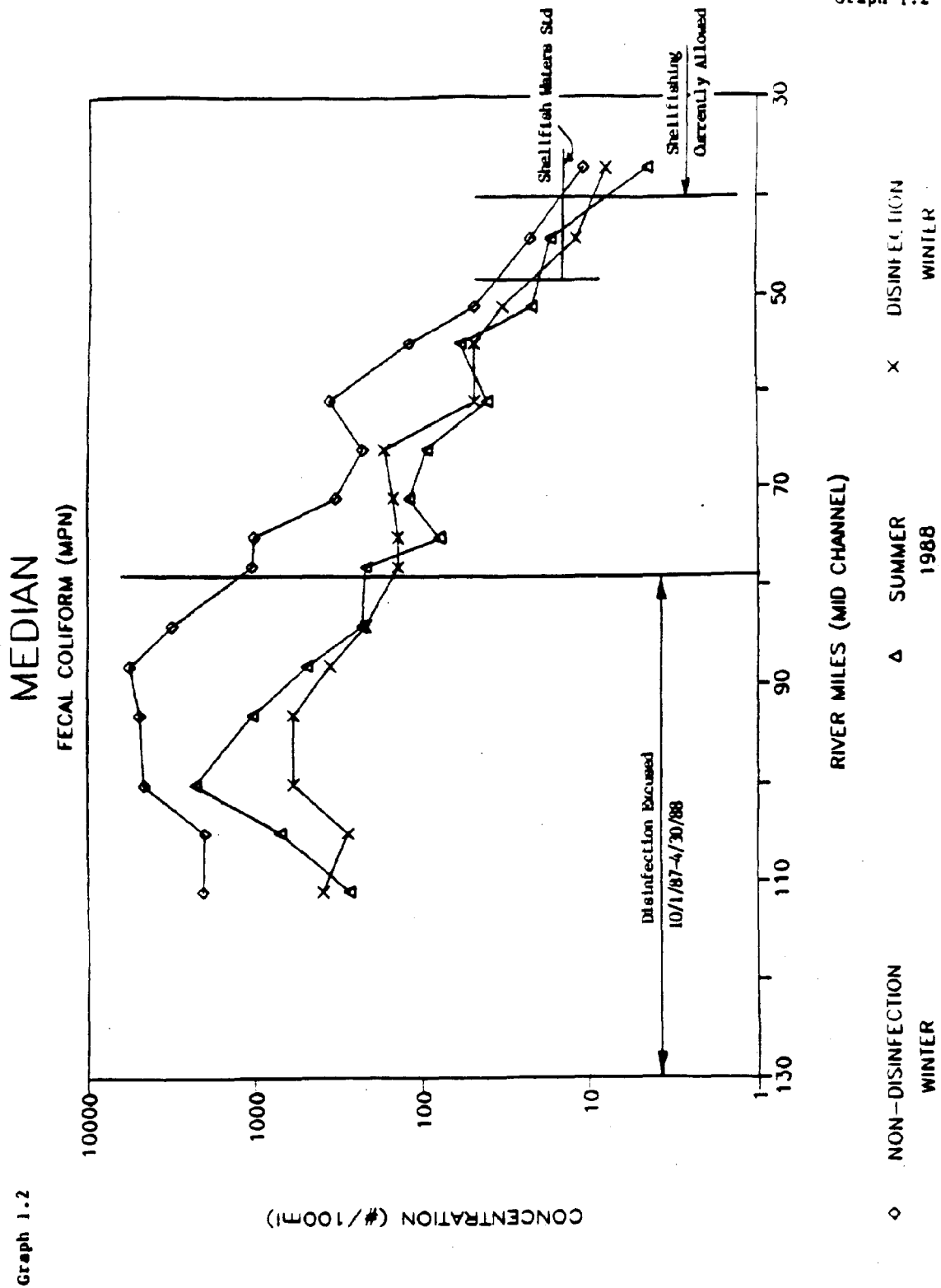


Figure Three



Graph 1.2

Graph 1.2

Figure Four

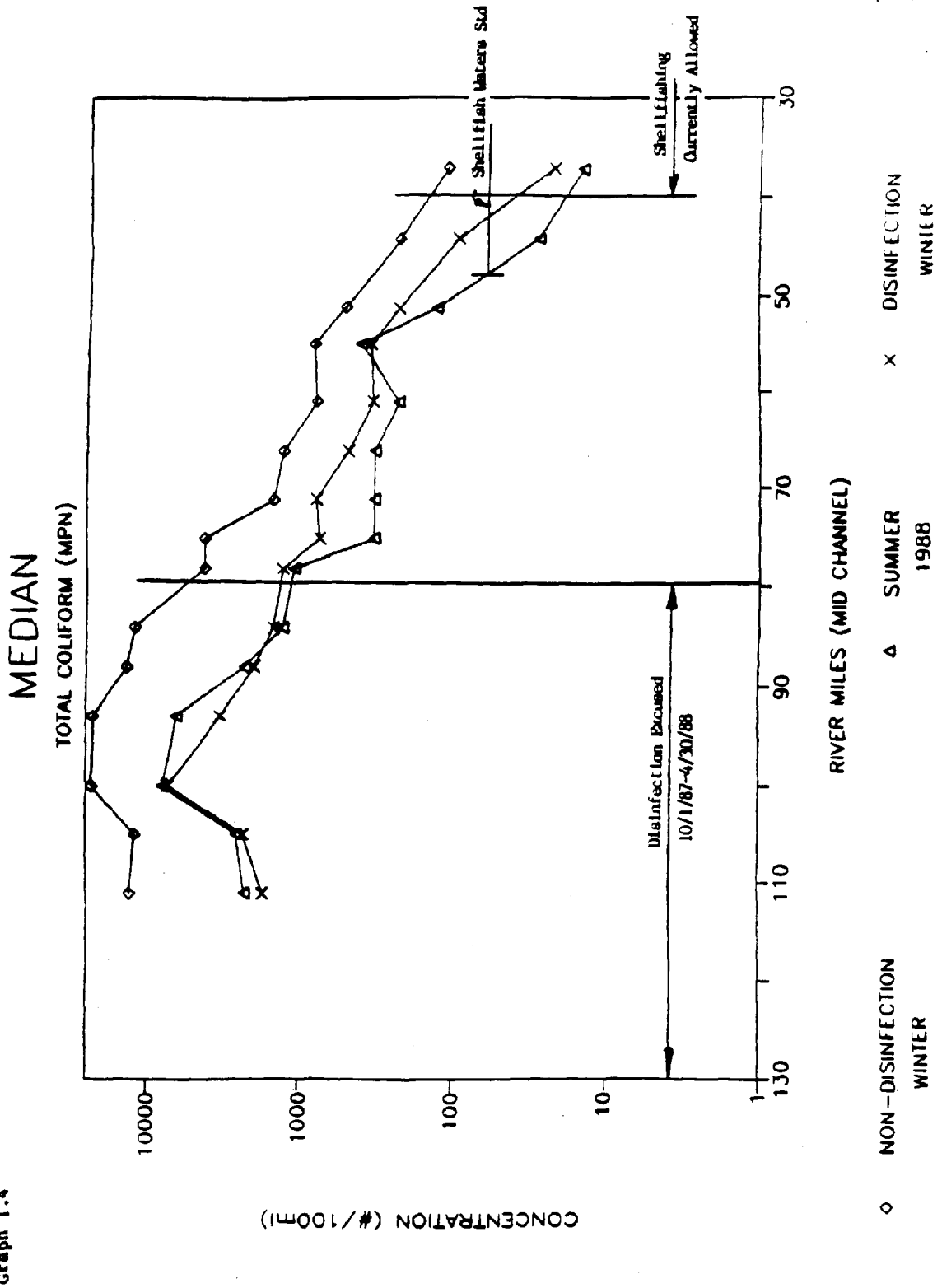


Figure Five

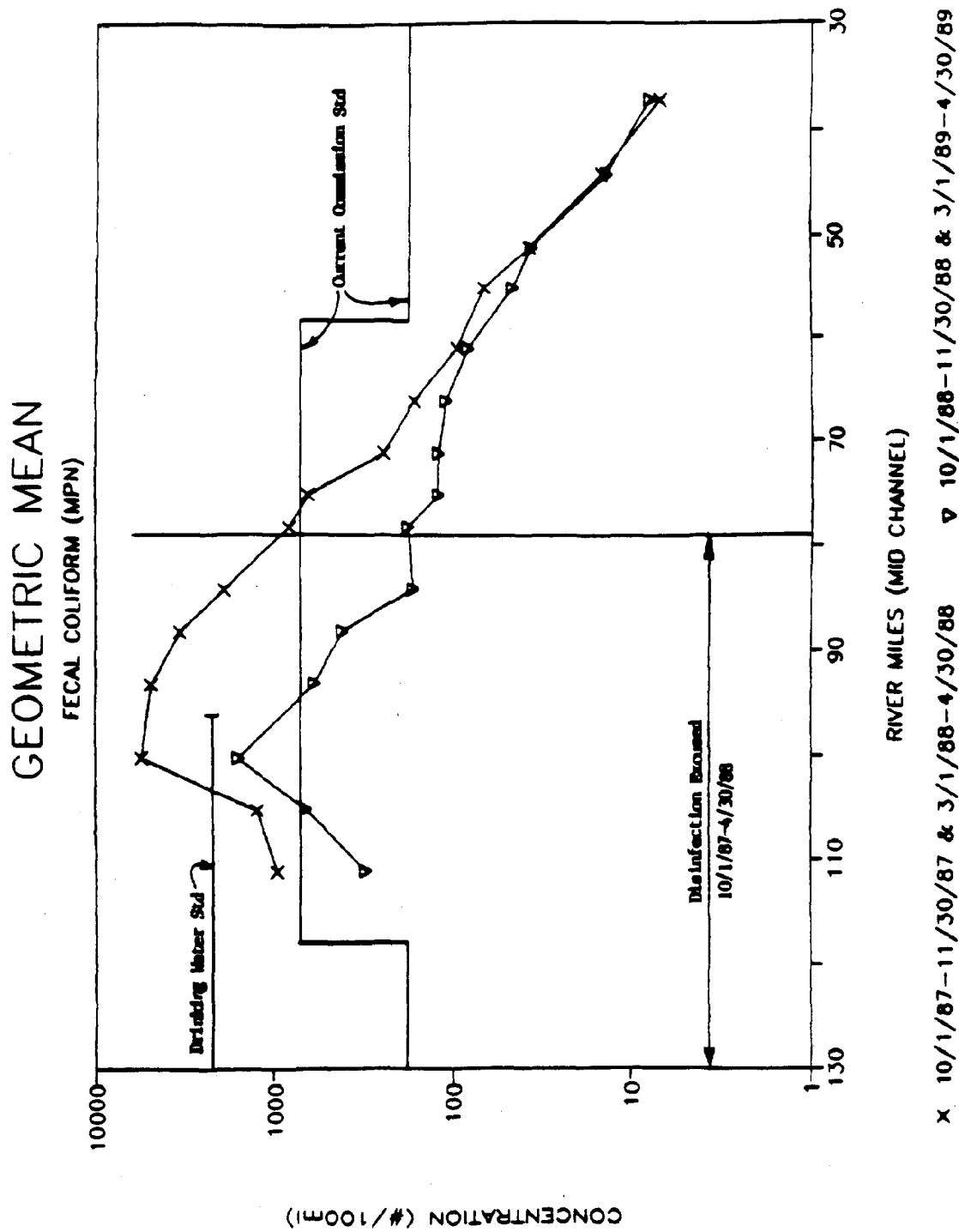


TABLE 1
RIVER RUN SAMPLING LOCATIONS

STORET NUMBER (1)	NAME (2)	LATITUDE (3)	LONGITUDE (4)	RIVER MILE (5)
0910200E	DELAWARE BAY NEAR SHIP JOHN LIGHT OPP. DE SHORE	39 16 50	75 23 30	35.83
091020	DELAWARE BAY @ SHIP JOHN LIGHT (Mid Channel)	39 18 05	75 22 55	36.60
091020NJ	DELAWARE BAY @ MOUTH OF COMANSEY RIVER	39 19 34	75 21 59	37.30
0910170E	DELAWARE BAY OFF BAKEOVEN PT.	39 21 28	75 29 05	43.20
091017	DELAWARE BAY @ MOUTH OF SMYRNA RIVER (Mid Channel)	39 22 33	75 28 05	43.50
091017NJ	DELAWARE BAY NEAR MOUTH OF MAD HORSE CREEK	39 23 51	75 27 17	44.13
0910140E	DELAWARE RIVER @ MOUTH OF APPQUINIMINK RIVER OPP. DE SHORE	39 27 10	75 34 05	50.88
091014	DELAWARE RIVER @ MOUTH OF APPQUINIMINK RIVER (Mid Channel)	39 27 18	75 33 36	50.88
091014NJ	DELAWARE RIVER OFF SALEM NUCLEAR POWER PLANT TOWERS	39 27 32	75 32 56	50.88
091002	DELAWARE RIVER @ REEDY ISLAND (Mid Channel)	39 30 46	75 33 12	54.94
091002NJ	DELAWARE RIVER @ REEDY ISLAND OPP. NJ SHORE	39 30 58	75 32 32	55.28
091200CD	DELAWARE RIVER @ C&D CANAL	39 34 01	75 33 25	59.02
091005NJ	DELAWARE RIVER @ PEA PATCH ISLAND (Mid Channel)	39 35 27	75 33 49	60.55
091008NJ	DELAWARE RIVER @ PEA PATCH ISLAND OPP. NJ SHORE	39 35 55	75 33 37	60.93
091008DE	DELAWARE RIVER @ NEW CASTLE OPP. DE SHORE	39 39 30	75 33 16	65.87
091008	DELAWARE RIVER @ NEW CASTLE (Mid Channel)	39 39 17	75 32 48	65.96
091008NJ	DELAWARE RIVER @ NEW CASTLE OPP. NJ SHORE	39 39 23	75 32 04	66.47
091011	DELAWARE RIVER @ CHERRY ISLAND (Mid Channel)	39 43 11	75 30 24	70.96
091011MR	DELAWARE RIVER @ CHERRY ISLAND MID RIVER	39 43 03	75 30 06	70.92
091011NJ	DELAWARE RIVER OFF CARNEY'S PT.	39 43 00	75 29 40	70.96
332046DE	DELAWARE RIVER @ OLDMAN'S PT. OPP. DE SHORE	39 46 13	75 28 40	74.88
332046	DELAWARE RIVER @ OLDMAN'S PT. (Mid Channel)	39 46 06	75 28 26	74.88
332046NJ	DELAWARE RIVER @ OLDMAN'S PT. OPP. NJ SHORE	39 45 55	75 28 07	74.88
332049	DELAWARE RIVER @ MARCUS HOOK (Mid Channel)	39 48 00	75 25 35	78.24
332049NJ	DELAWARE RIVER @ MARCUS HOOK OPP. NJ SHORE	39 47 49	75 25 11	78.43
892062PA	DELAWARE RIVER @ EDDYSTONE OPP. PA SHORE	39 51 06	75 20 00	84.28
892062	DELAWARE RIVER @ EDDYSTONE (Mid Channel)	39 50 48	75 20 18	83.98
332052PA	DELAWARE RIVER @ PAULSBORO OPP. PA SHORE	39 51 11	75 15 37	88.27
332052	DELAWARE RIVER @ PAULSBORO (Mid Channel)	39 50 53	75 15 54	87.90
892065PA	DELAWARE RIVER @ NAVY YARD OPP. PA SHORE	39 53 02	75 10 52	93.07
892065	DELAWARE RIVER @ NAVY YARD (Mid Channel)	39 52 54	75 10 44	93.18
892065NJ	DELAWARE RIVER @ NAVY YARD OPP. NJ SHORE	39 52 45	75 10 38	93.29
892071	DELAWARE RIVER @ BEN FRANKLIN BRIDGE (Mid Channel)	39 57 10	75 08 14	100.15
892071NJ	DELAWARE RIVER @ BEN FRANKLIN BRIDGE MID RIVER	39 57 09	75 08 07	100.15
892071MR	DELAWARE RIVER @ BEN FRANKLIN BRIDGE OPP. NJ SHORE	39 57 07	75 08 01	100.15
892070PA	DELAWARE RIVER @ BETSY ROSS BRIDGE OPP. PA SHORE	39 59 04	75 04 10	104.65
892070	DELAWARE RIVER @ BETSY ROSS BRIDGE (Mid Channel)	39 59 07	75 04 03	104.67
892070NJ	DELAWARE RIVER @ BETSY ROSS BRIDGE OPP. NJ SHORE	39 59 01	75 03 55	104.70
892077PA	DELAWARE RIVER @ TORRESOALE OPP. PA SHORE	40 02 26	74 59 29	110.65
892077	DELAWARE RIVER @ TORRESOALE (Mid Channel)	40 02 24	74 59 20	110.70

TABLE 2

SHELLFISH AREA SAMPLING LOCATIONS

STORET NUMBER (1)	LATITUDE (2)	LONGITUDE (3)	RIVER MILE (4)	STORET NUMBER (1)	LATITUDE (2)	LONGITUDE (3)	RIVER MILE (4)
SHELL4204	39 25 34	75 31 35	48.14	SHELL4115	39 24 49	75 27 11	44.87
SHELL4204A	39 25 55	75 31 08	48.17	SHELL4111	39 23 08	75 25 03	42.18
SHELL4204C	39 26 25	75 30 34	48.18	SHELL4109	39 22 42	75 24 51	41.70
SHELL4204D	39 26 52	75 30 02	48.32	SHELL4107	39 22 42	75 24 10	41.30
SHELL4204Y	39 25 07	75 32 10	48.10	SHELL4106A	39 22 36	75 23 57	41.08
SHELL4204Z	39 25 19	75 31 56	48.11	SHELL4105	39 22 08	75 24 12	40.82
SHELL4203	39 26 47	75 29 37	48.00	SHELL4104	39 21 50	75 23 55	40.38
SHELL4202	39 26 29	75 29 07	47.45	SHELL4103	39 20 15	75 25 25	39.90
SHELL4201A	39 26 06	75 28 10	46.56	SHELL4103A	39 20 26	75 25 06	39.87
SHELL4116	39 23 56	75 29 41	45.63	SHELL4103C	39 20 48	75 24 40	39.94
SHELL4116A	39 24 21	75 29 00	45.54	SHELL4103E	39 21 16	75 23 58	39.96
SHELL4116C	39 24 53	75 28 22	45.67	SHELL4103F	39 21 31	75 23 39	39.96
SHELL4116E	39 25 26	75 27 40	45.69	SHELL4103H	39 19 10	75 26 45	39.82
SHELL4116X	39 22 40	75 30 47	45.23	SHELL4103X	39 19 26	75 26 28	38.86
SHELL4116Y	39 23 01	75 30 29	45.31	SHELL4103Z	39 19 51	75 25 48	39.86
SHELL4116Z	39 23 39	75 30 00	45.55	SHELL4102F	39 20 14	75 21 02	37.30
SHELL4112	39 22 04	75 27 31	42.75	SHELL4102H	39 20 16	75 20 24	36.91
SHELL4112A	39 22 18	75 27 07	42.71	SHELL4101A	39 20 31	75 21 22	37.82
SHELL4112B	39 22 35	75 26 41	42.66	SHELL4101B	39 20 30	75 20 54	37.42
SHELL4112D	39 22 55	75 26 11	42.67	SHELL4100	39 18 06	75 22 54	36.59
SHELL4112E	39 23 11	75 25 48	42.67	SHELL4100B	39 18 34	75 22 19	36.62
SHELL4112V	39 20 43	75 29 22	42.70	SHELL4100D	39 19 03	75 21 33	36.59
SHELL4112W	39 21 04	75 28 56	42.70	SHELL4100F	39 19 26	75 20 58	36.56
SHELL4112Y	39 21 26	75 28 25	42.70	SHELL4100H	39 19 54	75 20 22	36.59
SHELL4112Z	39 21 43	75 27 57	42.67	SHELL4100J	39 20 14	75 19 48	36.54
SHELLOE1	39 24 13	75 31 34	46.91	SHELL4100K	39 20 14	75 24 45	36.39
SHELLOE2	39 23 21	75 31 07	45.91	SHELL4100M	39 16 34	75 24 22	36.46
SHELLOE3	39 22 14	75 30 32	44.68	SHELL4100Y	39 16 57	75 23 40	36.54
SHELLOE4	39 20 14	75 28 30	41.77				
SHELLOE5	39 21 42	75 30 00	43.90				
SHELLOE6	39 17 52	75 25 44	38.08				
SHELLOE7	39 17 20	75 25 37	37.58				

TABLE 3
DISCHARGES NOT DISINFECTING
OCTOBER 1987 - APRIL 1988

DISCHARGER	PERMIT NO.	RIVER MILE	RUTH CAP. MGD	VOLUME DISCHARGED	
				NON-DIS. WINTER MGD	DIS. WINTER MGD
ZONE 2					
MORRISVILLE	PR0026701	135.0	5.6	4.80	3.86
TRENTON	NJ0020923	131.8	20	18.4	15.5
FIELDSBORO	NJ0031810	127.0	0.10	0.051	0.055
FLORENCE	NJ0023701	123.1	1.5	0.670	0.757
LOWER BUOKS CO.	PR0026468	122.1	10	8.15	7.90
BRISTOL BORO	PR0027294	118.87, 0.3	2.7	2.04	2.15
BURLINGTON TOWNSHIP	NJ0021709	117.12, 0.19	1.65	1.10	1.10
BRISTOL TOWNSHIP	PR0026450	116.91	2.28	1.68	1.95
FALLS TOWNSHIP	PR0026948	115.63, 3.4	3.2	3.05	1.92
BEVERLY	NJ0027481	114.7	1.0	0.490	0.480
DELRAN	NJ0023507	111.0	1.5	1.18	1.42
RIVERTON	NJ0021610	108.6	0.22	0.128	0.158
ZONE 3					
CINNAPINSON	NJ0024007	108.82	2.0	1.30	1.60
PAUMYRA	NJ0024449	107.66	0.53	0.546	0.550
PENNSAUKEN	NJ0025348	104.9	4.0	3.09	3.00
PHILA NE	PR0026689	104.2	210	196	183
CCMUR-BALDWIN RUN	NJ0024481	103.2	4.5	2.56	3.09
CCMUR DEL No. 1	NJ0026182	97.93	80	50.2	53.2
PHILA SE	PR0026662	96.7	112	106	102
ZONE 4					
ATWATER KENT (FT MIFFLIN)	PR0052329	91.5	0.003	0.001	0.001
PHILA SW	PR0026671	90.7	200	181	180
GLOUCESTER COUNTY UR	NJ0024686	89.7	16.5	14.2	14.1
TINICUM	PR0028380	85.28, 1.0	1.4	0.800	0.897
EDDYSTONE	PR0028335	84.0	0.80	0.478	0.454
DELCORA	PR0027103	80.7	44.0	34.4	36.0
LOGAN TWP	NJ0027945	79.0	1.0	0.471	0.506
TOTAL			727	613	595

TABLE 4

PRECIPITATION AT WILMINGTON PRIOR TO SHELLFISH AREA SURVEYS

DATE OF SURVEY (1)	NO. DRY DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)	DATE OF SURVEY (1)	NO. DRY DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)
10/13/87	2	10/11	0.01	0.01	02/09/88	5	02/04	0.35	0.07
	6	10/07	0.30	0.05		7	02/02	0.30	0.04
			0.31	0.06				0.65	0.11
10/28/87	1	10/27	1.04	1.04	02/16/88	1	02/15	0.33	0.33
	7	10/21	0.05	0.01		4	02/12	1.14	0.33
			1.09	1.05		5	02/11	0.62	0.12
								2.09	0.78
11/17/87	6	11/11	0.30	0.05				0.05	0.02
	7	11/10	1.04	0.15	02/22/88	2	02/20	1.18	0.39
			1.34	0.20		3	02/19	0.06	0.01
						6	02/16	0.33	0.05
						7	02/15	1.62	0.43
11/30/87	0	11/30	0.86	0.86				0.07	0.02
	1	11/29	1.13	1.13	03/01/88	3	02/27	0.04	0.01
	2	11/28	0.13	0.07		7	02/23	0.11	0.03
			2.12	2.06				0.02	0.00
12/10/87	0	12/10	0.12	0.12	03/22/88	4	03/18	0.02	0.00
	1	12/09	0.02	0.02				0.02	0.00
	7	12/03	0.06	0.01				0.02	0.00
			0.20	0.15				0.02	0.00
12/15/87	0	12/15	0.66	0.66	04/11/88	3	04/08	0.01	0.00
	4	12/11	0.23	0.06		4	04/07	0.91	0.23
	5	12/10	0.12	0.02		5	04/06	0.02	0.00
	6	12/09	0.02	0.00		7	04/04	0.03	0.00
			1.03	0.70				0.97	0.23
01/25/88	0	01/25	0.82	0.82	04/25/88	2	04/23	0.24	0.12
	5	01/20	0.71	0.14		7	04/18	0.18	0.03
	6	01/19	0.04	0.01				0.42	0.15
	7	01/18	0.31	0.04					
			1.88	1.01					

TABLE 4 (Cont.)
 PRECIPITATION AT WILMINGTON PRIOR TO SHELLFISH AREA SURVEYS

DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)	DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)
10/03/88	0	10/03	0.06	0.06	01/30/89	0	01/30	0.26	0.26
	1	10/02	0.22	0.22		3	01/27	0.02	0.01
			0.28	0.28		4	01/26	0.07	0.02
								0.35	0.29
10/19/88	1	10/18	0.01	0.01	02/14/89	0	02/14	0.29	0.29
			0.01	0.01		1	02/13	0.12	0.12
								0.41	0.41
11/07/88	2	11/05	0.33	0.17	02/28/89	2	02/26	0.29	0.15
	6	11/01	0.70	0.12		4	02/24	0.01	0.00
			1.03	0.29		6	02/22	0.36	0.06
						7	02/21	0.83	0.14
12/01/88	2	11/28	0.48	0.24				1.49	0.35
	3	11/27	1.27	0.42	03/13/89	7	03/06	1.03	0.15
			1.75	0.66				1.03	0.15
12/05/88	7	11/28	0.48	0.07	03/28/89	4	03/24	1.32	0.33
			0.48	0.07		5	03/23	0.01	0.00
						7	03/21	0.06	0.01
								1.39	0.34
12/19/88					04/11/89	2	04/09	0.06	0.03
01/03/89	0	01/03	0.09	0.09		3	04/08	0.01	0.00
	2	01/01	0.16	0.08		4	04/07	0.37	0.09
	6	12/28	0.13	0.02		5	04/06	0.23	0.05
			0.38	0.19		6	04/05	0.41	0.07
01/17/89	2	01/15	0.61	0.31				1.08	0.24
	3	01/14	0.10	0.03					
	5	01/12	0.60	0.12					
			1.31	0.46					

TABLE 4 (Cont.)

PRECIPITATION AT WILMINGTON PRIOR TO SHELLFISH AREA SURVEYS

NON-DISINFECTION WINTER				DISINFECTION WINTER			
DATE OF SURVEY <1>	PRIOR PRECIP <2>	WEIGHTED PRIOR PRECIP <3>	DATE OF SURVEY <1>	PRIOR PRECIP <2>	WEIGHTED PRIOR PRECIP <3>		
10/13/87	0.31	0.06	10/03/88	0.28	0.28		
10/28/87	1.09	1.05	10/19/88	0.01	0.01		
11/17/87	1.34	0.20	11/07/88	1.03	0.29		
11/30/87	2.12	2.06	12/01/88	1.75	0.66		
12/10/87	0.20	0.15	12/05/88	0.48	0.07		
12/15/87	1.03	0.70	12/19/88	0.00	0.00		
01/25/88	1.88	1.01	01/03/89	0.38	0.19		
02/09/88	0.65	0.11	01/17/89	1.31	0.46		
02/16/88	2.09	0.78	01/30/89	0.35	0.29		
02/22/88	1.62	0.43	02/14/89	0.41	0.41		
03/01/88	0.11	0.03	02/28/89	1.49	0.35		
03/22/88	0.02	0.00	03/13/89	1.03	0.15		
04/11/88	0.97	0.23	03/28/89	1.39	0.34		
04/25/88	0.42	0.15	04/11/89	1.08	0.24		
SUM	13.86	6.96	SUM	10.99	3.74		

TABLE 5
PRECIPITATION AT WILMINGTON PRIOR TO RIVER RUN SURVEYS

DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)	DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)
10/06/87	2	10/04	0.01	0.00	02/09/88	5	02/04	0.35	0.07
	3	10/03	0.90	0.30		7	02/02	0.30	0.04
	6	09/30	0.20	0.03				0.65	0.11
			1.11	0.33					
10/26/87	5	10/21	0.05	0.01	02/17/88	1	02/16	0.06	0.06
			0.05	0.01		2	02/15	0.33	0.16
						5	02/12	1.14	0.23
						6	02/11	0.62	0.10
								2.15	0.55
11/04/87									
11/13/87	2	11/11	0.30	0.15	02/22/88	2	02/20	0.05	0.03
	3	11/10	1.04	0.35		3	02/19	1.18	0.39
			1.34	0.50		6	02/16	0.06	0.01
						7	02/15	0.33	0.05
								1.62	0.48
12/09/87	0	12/09	0.02	0.02	03/01/88	3	02/27	0.07	0.02
	6	12/03	0.06	0.01		7	02/23	0.04	0.01
			0.08	0.03				0.11	0.03
12/14/87	3	12/11	0.23	0.08	03/22/88	4	03/18	0.02	0.01
	4	12/10	0.12	0.03				0.02	0.01
	5	12/09	0.02	0.00				0.02	0.01
			0.37	0.11					
01/22/88	2	01/20	0.71	0.35	04/05/88	1	04/04	0.03	0.03
	3	01/19	0.04	0.01		4	04/01	0.04	0.01
	4	01/18	0.31	0.08				0.07	0.04
			1.06	0.44					
					04/21/88	3	04/18	0.18	0.06
						5	04/16	0.02	0.00
						6	04/15	0.09	0.02
								0.29	0.08

TABLE 5 (Cont.)
 PRECIPITATION AT WILMINGTON PRIOR TO RIVER RUN SURVEYS

DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)	DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)
10/12/88	7	10/05	0.05	0.01	01/23/89				
			0.05	0.01	02/07/89	2	02/05	0.02	0.01
			0.05	0.01	02/07/89	4	02/03	0.50	0.12
10/25/88	1	10/24	0.11	0.11				0.52	0.13
	3	10/22	0.08	0.03				0.36	0.36
	4	10/21	1.41	0.47	02/22/89	0	02/22	0.83	0.83
	7	10/18	0.01	0.00				0.04	0.02
			1.61	0.61	02/15	7	02/15	1.52	1.25
11/14/88	1	11/13	0.33	0.33	03/13/89	7	03/06	1.03	0.15
	4	11/10	0.08	0.02				1.03	0.15
			0.41	0.35					
11/28/88	0	11/28	0.48	0.48					
	1	11/27	1.27	1.27	03/27/89	3	03/24	1.32	0.44
			1.75	1.75				0.01	0.00
								0.06	0.01
								0.32	0.05
12/08/88								1.71	0.50
12/15/88	6	12/09	0.02	0.00	04/11/89	2	04/09	0.06	0.03
			0.02	0.00				0.01	0.00
01/09/89	0	01/09	0.01	0.01				0.37	0.09
	1	01/08	0.08	0.08				0.23	0.05
	3	01/06	0.46	0.15				0.41	0.07
	5	01/04	0.02	0.00				1.08	0.24
	6	01/03	0.09	0.02	04/19/89	0	04/19	0.14	0.14
			0.66	0.31				0.06	0.06
								0.75	0.19
								0.55	0.39

TABLE 5 (Cont.)
 PRECIPITATION AT WILMINGTON PRIOR TO RIVER RUN SURVEYS

NON-DISINFECTION WINTER				DISINFECTION WINTER			
DATE OF SURVEY (1)	PRIOR PRECIP (2)	WEIGHTED PRIOR PRECIP (3)	DATE OF SURVEY (1)	PRIOR PRECIP (2)	WEIGHTED PRIOR PRECIP (3)		
10/06/87	1.11	0.33	10/12/88	0.05	0.01		
10/26/87	0.05	0.01	10/25/88	1.61	0.61		
11/04/87	0.00	0.00	11/14/88	0.41	0.35		
11/13/87	1.34	0.50	11/28/88	1.75	1.25		
12/09/87	0.08	0.03	12/08/88	0.00	0.00		
12/14/87	0.37	0.11	12/15/88	0.02	0.00		
01/22/88	1.06	0.44	01/09/89	0.66	0.31		
02/09/88	0.65	0.11	01/23/89	0.00	0.00		
02/17/88	2.15	0.55	02/07/89	0.52	0.13		
02/22/88	1.62	0.48	02/22/89	1.52	1.25		
03/01/88	0.11	0.03	03/13/89	1.03	0.15		
03/22/88	0.02	0.01	03/27/89	1.71	0.50		
04/05/88	0.07	0.04	04/11/89	1.08	0.24		
04/21/88	0.29	0.08	04/19/89	0.95	0.39		
SUM	8.92	2.72	SUM	11.31	5.69		

TABLE 6
PRECIPITATION AT PHILADELPHIA PRIOR TO RIVER RUN SURVEYS

DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)	DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)
10/06/87	2	10/04	0.05	0.03	02/09/88	5	02/04	0.54	0.11
	3	10/03	0.99	0.33		6	02/03	0.01	0.00
			1.04	0.36		7	02/02	0.55	0.08
								1.10	0.19
10/26/87	5	10/21	0.02	0.00	02/17/88	1	02/16	0.11	0.11
			0.02	0.00		2	02/15	0.31	0.16
						3	02/12	1.35	0.27
						6	02/11	0.36	0.06
11/04/87								2.13	0.60
11/13/87	2	11/11	0.34	0.17	02/22/88	2	02/20	0.09	0.05
	3	11/10	0.90	0.30		3	02/19	0.72	0.24
			1.24	0.47		6	02/16	0.11	0.02
						7	02/15	0.31	0.04
12/09/87	6	12/03	0.04	0.01				1.23	0.35
			0.04	0.01	03/01/88	3	02/27	0.03	0.02
						7	02/23	0.04	0.01
12/14/87	3	12/11	0.13	0.04				0.07	0.03
	5	12/09	0.10	0.03	03/22/88	4	03/18	0.01	0.00
			0.23	0.07				0.01	0.00
01/22/88	2	01/20	0.70	0.35	04/05/88	1	04/04	0.07	0.07
	3	01/19	0.02	0.01		4	04/01	0.02	0.01
	4	01/18	0.44	0.11				0.09	0.08
			1.16	0.47	04/21/88	3	04/18	0.18	0.06
						6	04/15	0.10	0.02
								0.28	0.08

TABLE 6 (Cont.)
 PRECIPITATION AT PHILADELPHIA PRIOR TO RIVER RUN SURVEYS

DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)	DATE OF SURVEY (1)	NO. DAYS BEFORE SURVEY (2)	DATE (3)	PRECIP (4)	WEIGHTED PRECIP (5)
10/12/88	4	10/08	0.01	0.00	02/09/89	3	02/06	0.01	0.00
	7	10/05	0.03	0.00		4	02/05	0.03	0.01
			0.04	0.00		6	02/03	0.38	0.06
								0.42	0.07
10/25/88	1	10/24	0.08	0.08	02/22/89	0	02/22	0.46	0.46
	3	10/22	0.23	0.08		1	02/21	1.12	1.12
	4	10/21	1.37	0.34		2	02/20	0.02	0.01
	6	10/19	0.02	0.00		7	02/15	0.35	0.08
	7	10/18	0.01	0.00				2.15	1.67
			1.71	0.50					
11/14/88	1	11/13	0.31	0.31	03/13/89	6	03/07	0.02	0.00
	4	11/10	0.05	0.01		7	03/06	1.07	0.15
			0.36	0.32				1.09	0.15
11/28/88	0	11/28	0.64	0.64	03/27/89	3	03/24	1.24	0.41
	3	11/27	1.14	0.38		4	03/23	0.01	0.00
			1.78	1.02		6	03/21	0.16	0.03
						7	03/20	0.30	0.04
								1.71	0.48
12/08/88					04/11/89	2	04/09	0.05	0.02
12/15/88	4	12/11	0.01	0.00		3	04/08	0.03	0.01
	6	12/09	0.03	0.00		4	04/07	0.28	0.07
			0.04	0.00		5	04/06	0.15	0.03
						6	04/05	0.33	0.06
						7	04/04	0.02	0.00
01/09/89	0	01/09	0.01	0.01				0.86	0.19
	1	01/08	0.12	0.12	04/19/89	0	04/19	0.16	0.16
	3	01/06	0.52	0.17		1	04/18	0.03	0.03
	5	01/04	0.02	0.00		4	04/15	0.67	0.17
	6	01/03	0.03	0.01				0.86	0.36
			0.70	0.31					

TABLE 6 (Cont.)

PRECIPITATION AT PHILADELPHIA PRIOR TO RIVER RUN SURVEYS

NON-DISINFECTION WINTER				DISINFECTION WINTER			
DATE OF SURVEY (1)	PRIOR PRECIP (2)	WEIGHTED PRIOR PRECIP (3)	DATE OF SURVEY (1)	PRIOR PRECIP (2)	WEIGHTED PRIOR PRECIP (3)		
10/06/87	1.04	0.36	10/12/88	0.04	0.00		
10/26/87	0.02	0.00	10/25/88	1.71	0.50		
11/04/87	0.00	0.00	11/14/88	0.36	0.32		
11/13/87	1.24	0.47	11/28/88	1.78	1.02		
12/09/87	0.04	0.01	12/08/88	0.00	0.00		
12/14/87	0.23	0.07	12/15/88	0.04	0.00		
01/22/88	1.16	0.47	01/09/89	0.70	0.31		
02/09/88	1.10	0.19	01/23/89	0.00	0.00		
02/17/88	2.13	0.60	02/07/89	0.42	0.07		
02/22/88	1.23	0.35	02/22/89	2.15	1.67		
03/01/88	0.07	0.03	03/13/89	1.09	0.15		
03/22/88	0.01	0.00	03/27/89	1.71	0.48		
04/05/88	0.09	0.08	04/11/89	0.86	0.19		
04/21/88	0.28	0.08	04/19/89	0.86	0.36		
SUM	8.64	2.71	SUM	11.72	5.07		

TABLE 7

STREAMFLOWS, DELAWARE RIVER AT TRENTON, N.J.

NON-DISINFECTION WINTER				DISINFECTION WINTER			
MONTH, YR	DATE	ON DAYS OF SAMPLE COLLECTION	FLOW 7-DAY AVG CFS	MONTH, YR	DATE	ON DAYS OF SAMPLE COLLECTION	FLOW 7-DAY AVG CFS
(River run dates)				(River run dates)			
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Oct 87	6	11500	10844	Oct 88	12	3090	3189
Oct 87	26	5190	5591	Oct 88	25	5240	4427
Nov 87	4	10800	15229	Nov 88	14	5940	7321
Nov 87	13	9890	9040	Nov 88	28	16300	18471
Dec 87	9	12300	16386	Dec 88	8	6990	8131
Dec 87	14	9100	11114	Dec 88	15	5060	5466
Jan 88	22	12400	7663	Jan 89	9	4890	4527
Feb 88	9	13200	20014	Jan 89	23	4060	5486
Feb 88	17	12900	11544	Feb 89	7	4210	5250
Feb 88	22	14400	14543	Feb 89	22	12000	6114
Mar 88	1	8660	10766	Mar 89	13	5620	5906
Mar 88	22	10800	13857	Mar 89	27	19600	11334
Apr 88	5	13700	17314	Apr 89	11	14100	16800
Apr 88	21	6220	6673	Apr 89	19	11400	11429
Average			10790	Average			8464
			12184				8132

TABLE 7

STREAMFLOWS, DELAWARE RIVER AT TRENTON, N. J.

NON-DISINFECTION WINTER				DISINFECTION WINTER			
MONTH, YR	DATE	ON DAYS OF SAMPLE COLLECTION	FLOW CFS	MONTH, YR	DATE	ON DAYS OF SAMPLE COLLECTION	FLOW CFS
(Shellfish survey dates)	(Shellfish survey dates)	(1)	(2)	(3)	(4)	(5)	(6)
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Oct 87	13	9050	9561	Oct 88	3	4260	3601
Oct 87	28	9620	6031	Oct 88	19	3330	3367
Nov 87	17	8920	10037	Nov 88	7	5880	4144
Nov 87	30	19000	10309	Dec 88	1	10300	13143
Dec 87	10	11700	14729	Dec 88	5	7470	10250
Dec 87	15	9010	10501	Dec 88	19	4450	4661
Jan 88	25	7950	9486	Jan 89	3	4790	5461
Feb 88	9	13200	20014	Jan 89	17	6770	6193
Feb 88	16	12500	11430	Jan 89	30	5070	4740
Feb 88	22	14400	14543	Feb 89	14	3510	3937
Mar 88	1	6650	10766	Feb 89	26	7510	11847
Mar 88	22	10800	13357	Mar 89	13	5520	5906
Apr 88	11	9010	11744	Mar 89	26	17900	12863
Apr 88	25	5200	5394	Apr 89	11	14100	15800
Average		10644	11364	Average		7261	7640

TABLE 8

ANALYSIS OF COVARIANCE

UPPER RIVER - FECAL COLIFORM

A. Streamflow - Delaware River at Trenton (7-day av.) R-Square = 0.57

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection	1	420.0	420.0	311.35	<.01
Station	28	969.6	34.6	25.67	<.01
Flow	1	4.1	4.1	3.02	.083
Disinfection*Flow	1	0.5	0.5	0.36	.551ns
Error	775	1045.3	1.3		
TOTAL	806	2439.4			

Partial Sums of Squares

Disinfection	1	75.7	75.7	56.14	<.01
Station	28	969.9	34.6	25.68	<.01
Flow	1	4.3	4.3	3.21	.074
Disinfection*Flow	1	0.5	0.5	0.36	.551ns

ns - not significant

B. Precipitation - Philadelphia (weighted)

R-Square = 0.65

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection	1	420.0	420.0	383.11	<.01
Station	28	969.6	34.6	31.59	<.01
Precipitation	1	186.5	186.5	170.10	<.01
Disinfection*Prec	1	13.9	13.9	12.68	<.01
Error	775	849.5	1.1		
TOTAL	806	2439.4			

Partial Sums of Squares

Disinfection	1	235.5	235.5	214.82	<.01
Station	28	970.6	34.7	31.62	<.01
Precipitation	1	160.2	160.2	146.17	<.01
Disinfection*Prec	1	13.9	13.9	12.68	<.01

TABLE 9

ANALYSIS OF COVARIANCE

UPPER RIVER - TOTAL COLIFORM

A. Streamflow - Delaware River at Trenton (7-day av.) R-Square = 0.59

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection Station	1	415.3	415.3	330.73	<.01
Flow	28	1003.8	35.8	28.55	<.01
Disinfection*Flow	1	7.8	7.8	6.19	.013
Error	775	973.2	0.5	0.41	.521ns
TOTAL	806	2400.5	1.3		

Partial Sums of Squares

Disinfection Station	1	61.5	61.5	48.99	<.01
Flow	28	1003.6	35.8	28.54	<.01
Disinfection*Flow	1	7.3	7.3	5.80	.016
	1	0.5	0.5	0.41	.521ns

ns - not significant

B. Precipitation - Philadelphia (weighted) R-Square = 0.67

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection Station	1	415.3	415.3	400.53	<.01
Precipitation	28	1003.8	35.8	34.57	<.01
Disinfection*Prec	1	161.3	161.3	155.57	<.01
Error	775	16.6	16.6	15.98	<.01
TOTAL	806	803.6	1.0		

Partial Sums of Squares

Disinfection Station	1	221.4	221.4	213.55	<.01
Precipitation	28	1004.7	35.9	34.61	<.01
Disinfection*Prec	1	148.3	148.3	142.98	<.01
	1	16.6	16.6	15.98	<.01

TABLE 10

ANALYSIS OF COVARIANCE

LOWER RIVER - FECAL COLIFORM

A. Streamflow - Delaware River at Trenton (7-day av.) R-Square = 0.57

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection	1	93.6	93.6	100.22	<.01
Station	70	425.6	6.1	6.51	<.01
Flow	1	95.2	95.2	101.98	<.01
Disinfection*Flow	1	29.3	29.3	31.38	<.01
Error	527	492.0	0.9		
TOTAL	600	1135.7			

Partial Sums of Squares

Disinfection	1	4.5	4.5	4.86	.028
Station	70	314.8	4.5	4.82	<.01
Flow	1	81.4	81.4	87.18	<.01
Disinfection*Flow	1	29.3	29.3	31.38	<.01

B. Precipitation, - Wilmington (weighted) R-Square = 0.50

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection	1	93.6	93.6	87.04	<.01
Station	70	425.6	6.1	5.65	<.01
Precipitation	1	23.8	23.8	22.12	<.01
Disinfection*Prec	1	26.2	26.2	24.38	<.01
Error	527	566.6	1.1		
TOTAL	600	1135.7			

Partial Sums of Squares

Disinfection	1	78.3	78.3	72.82	<.01
Station	70	439.3	6.3	5.84	<.01
Precipitation	1	49.2	49.2	45.72	<.01
Disinfection*Prec	1	26.2	26.2	24.38	<.01

TABLE 11
ANALYSIS OF COVARIANCE

LOWER RIVER - TOTAL COLIFORM

A. Streamflow - Delaware River at Trenton (7-day av.) R-Square = 0.61

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection Station	1	232.8	232.8	190.78	<.01
Flow	70	496.8	7.1	5.82	<.01
Disinfection*Flow	1	173.6	173.6	142.28	<.01
Error	527	96.4	96.4	78.95	<.01
TOTAL	600	643.2	1.2		

Partial Sums of Squares

Disinfection Station	1	17.5	17.5	14.32	<.01
Flow	70	392.5	5.6	4.59	<.01
Disinfection*Flow	1	141.1	141.1	115.59	<.01
Disinfection*Flow	1	96.4	96.4	78.95	<.01

B. Precipitation - Wilmington (weighted)

R-Square = 0.49

Source (1)	Degrees of Freedom (2)	Sum of Squares (3)	Mean Square (4)	F (5)	Prob. (6)
Disinfection Station	1	232.8	232.8	145.90	<.01
Precipitation	70	496.8	7.1	4.45	<.01
Disinfection*Prec	1	0.1	0.1	0.09	.770ns
Error	527	72.0	72.0	45.13	<.01
TOTAL	600	841.0	1.6		

Partial Sums of Squares

Disinfection Station	1	238.8	238.8	149.61	<.01
Precipitation	70	481.1	6.9	4.31	<.01
Disinfection*Prec	1	50.0	50.0	31.30	<.01
Disinfection*Prec	1	72.0	72.0	45.13	<.01

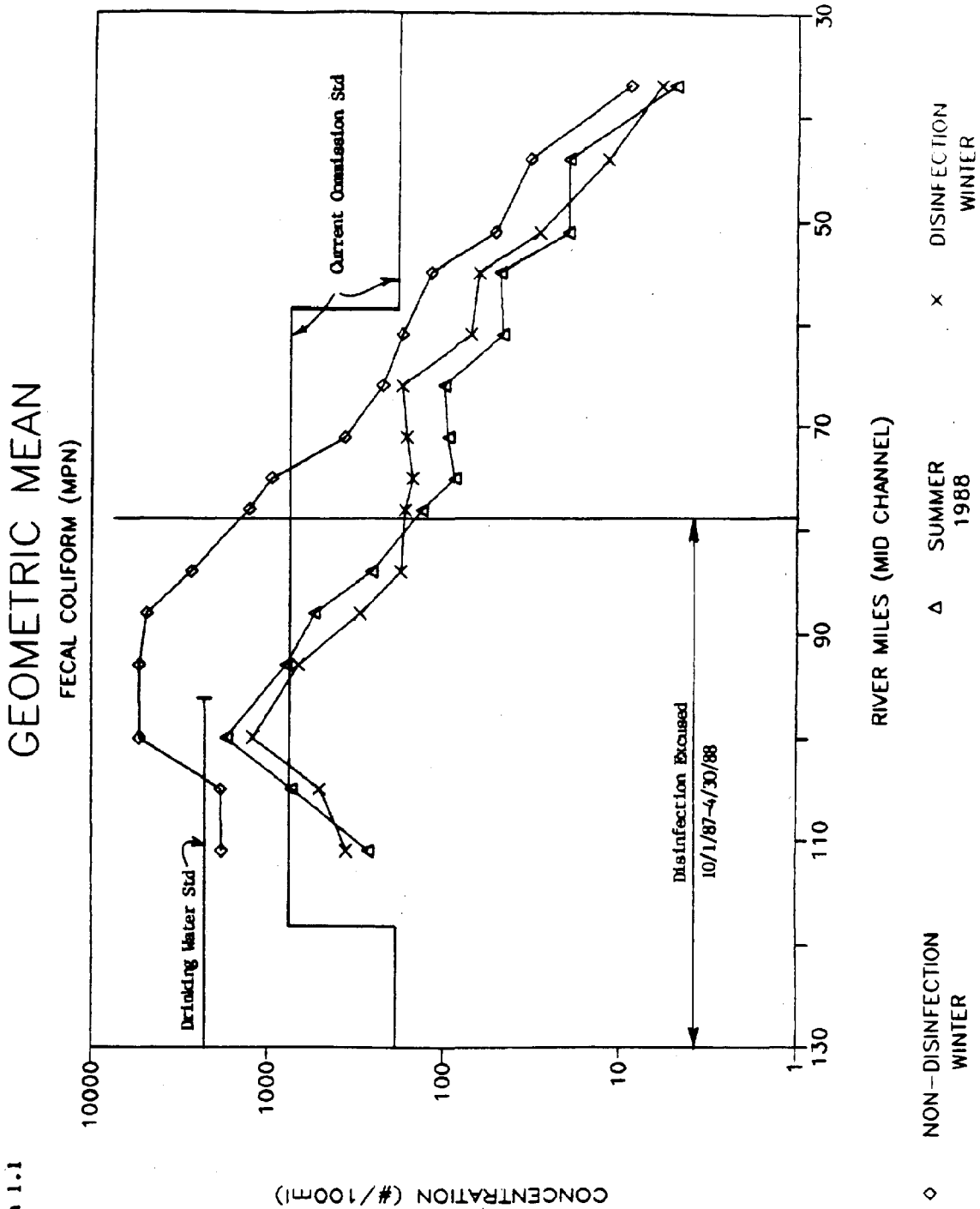
ns - not significant

A P P E N D I C E S

Appendix I - River Run Data

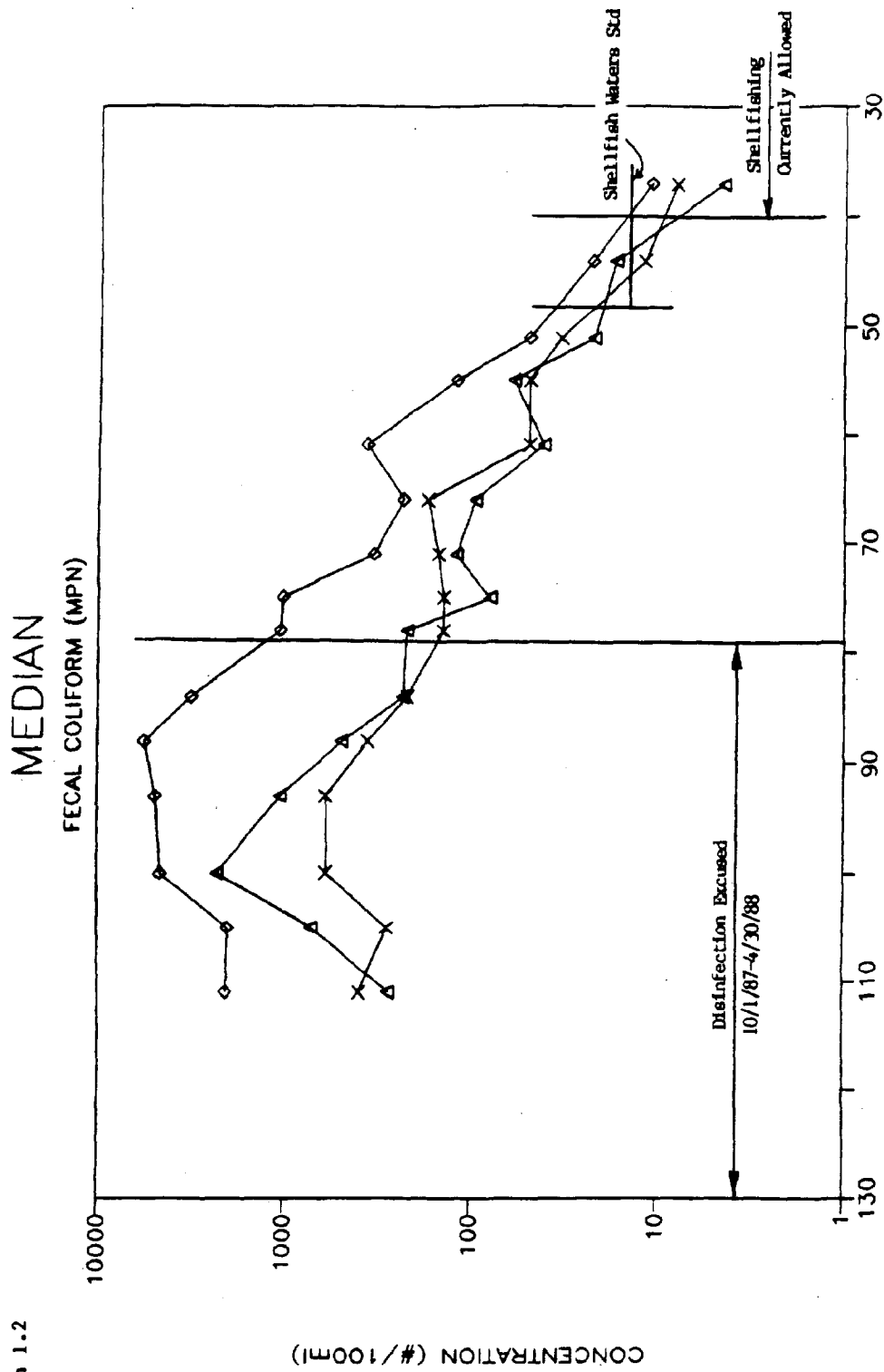
Graph 1.1	Geometric Mean	- Fecal Coliform (MPN)	
Graph 1.2	Median	- Fecal Coliform (MPN)	
Graph 1.3	Geometric Mean	- Total Coliform (MPN)	
Graph 1.4	Median	- Total Coliform (MPN)	
Graph 1.5	Geometric Mean	- Enterococcus	
Graph 1.6	Median	- Enterococcus	
Graph 1.7	Geometric Mean	- E. Coli	
Graph 1.8	Median	- E. Coli	
Graph 1.9	Geometric Mean	- Fecal Coliform (mTEC)	
Graph 1.10	Median	- Fecal Coliform (mTEC)	
Graph 1.11A	Geometric Mean	- Fecal Coliform (MPN)	- Non-disinfection Winter
Graph 1.11B	Geometric Mean	- Fecal Coliform (MPN)	- Disinfection Winter
Graph 1.11C	Geometric Mean	- Fecal Coliform (MPN)	- Ratio of Winter Values
Graph 1.12A	Median	- Fecal Coliform (MPN)	- Non-disinfection Winter
Graph 1.12B	Median	- Fecal Coliform (MPN)	- Disinfection Winter
Graph 1.12C	Median	- Fecal Coliform (MPN)	- Ratio of Winter Values
Graph 1.13A	Geometric Mean	- Total Coliform (MPN)	- Non-disinfection Winter
Graph 1.13B	Geometric Mean	- Total Coliform (MPN)	- Disinfection Winter
Graph 1.13C	Geometric Mean	- Total Coliform (MPN)	- Ratio of Winter Values
Graph 1.14A	Median	- Total Coliform (MPN)	- Non-disinfection Winter
Graph 1.14B	Median	- Total Coliform (MPN)	- Disinfection Winter
Graph 1.14C	Median	- Total Coliform (MPN)	- Ratio of Winter Values
Graph 1.15A	Geometric Mean	- Enterococcus	- Non-disinfection Winter
Graph 1.15B	Geometric Mean	- Enterococcus	- Disinfection Winter
Graph 1.15C	Geometric Mean	- Enterococcus	- Ratio of Winter Values
Graph 1.16A	Median	- Enterococcus	- Non-disinfection Winter
Graph 1.16B	Median	- Enterococcus	- Disinfection Winter
Graph 1.16C	Median	- Enterococcus	- Ratio of Winter Values
Graph 1.17A	Geometric Mean	- E. Coli	- Non-disinfection Winter
Graph 1.17B	Geometric Mean	- E. Coli	- Disinfection Winter
Graph 1.17C	Geometric Mean	- E. Coli	- Ratio of Winter Values
Graph 1.18A	Median	- E. Coli	- Non-disinfection Winter
Graph 1.18B	Median	- E. Coli	- Disinfection Winter
Graph 1.18C	Median	- E. Coli	- Ratio of Winter Values
Graph 1.19A	Geometric Mean	- Fecal Coliform (mTEC)	- Non-disinfection Winter
Graph 1.19B	Geometric Mean	- Fecal Coliform (mTEC)	- Disinfection Winter
Graph 1.19C	Geometric Mean	- Fecal Coliform (mTEC)	- Ratio of Winter Values
Graph 1.20A	Median	- Fecal Coliform (mTEC)	- Non-disinfection Winter
Graph 1.20B	Median	- Fecal Coliform (mTEC)	- Disinfection Winter
Graph 1.20C	Median	- Fecal Coliform (mTEC)	- Ratio of Winter Values

Graph 1.1



Graph 1.1

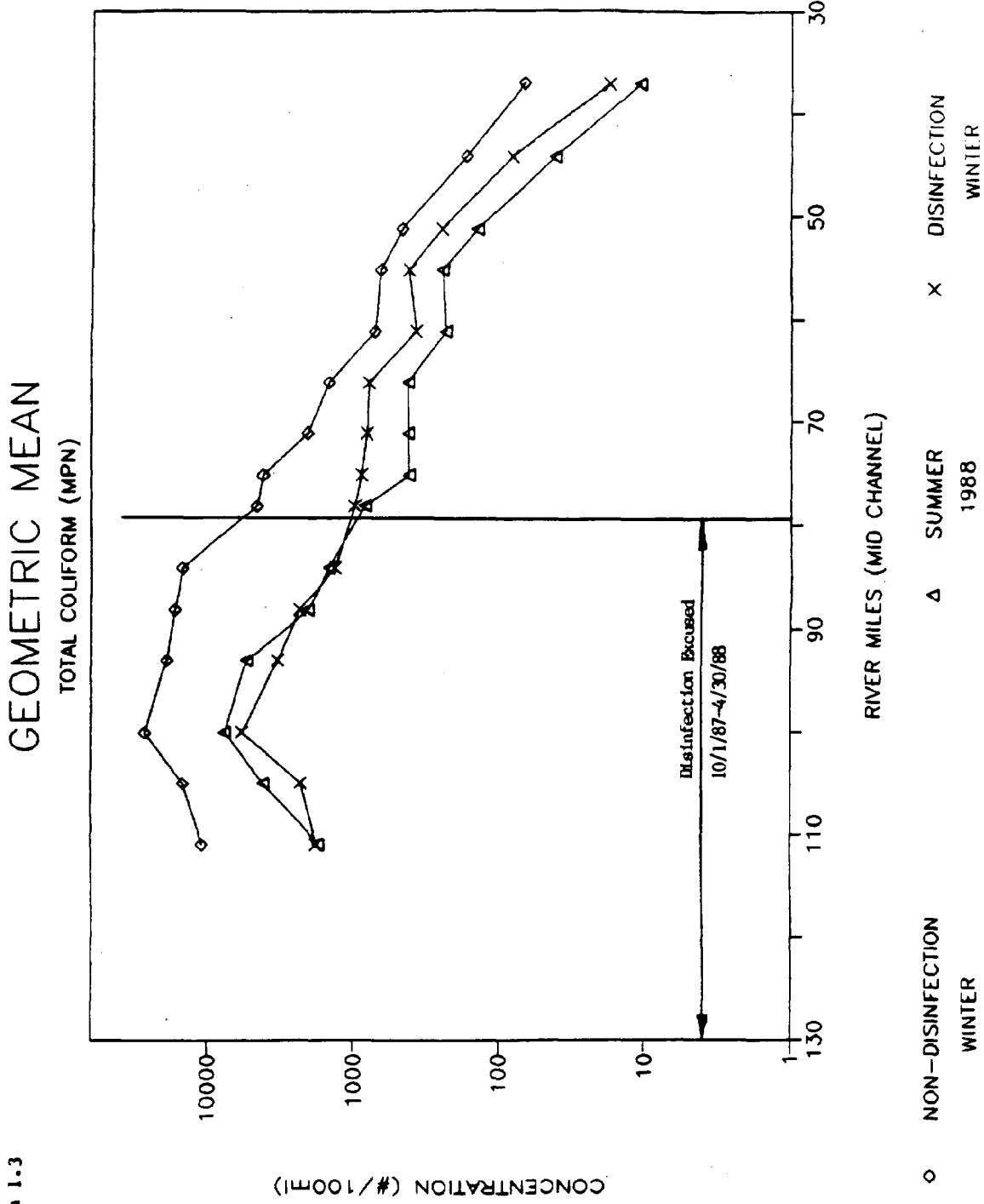
Graph 1.2



Graph 1.2

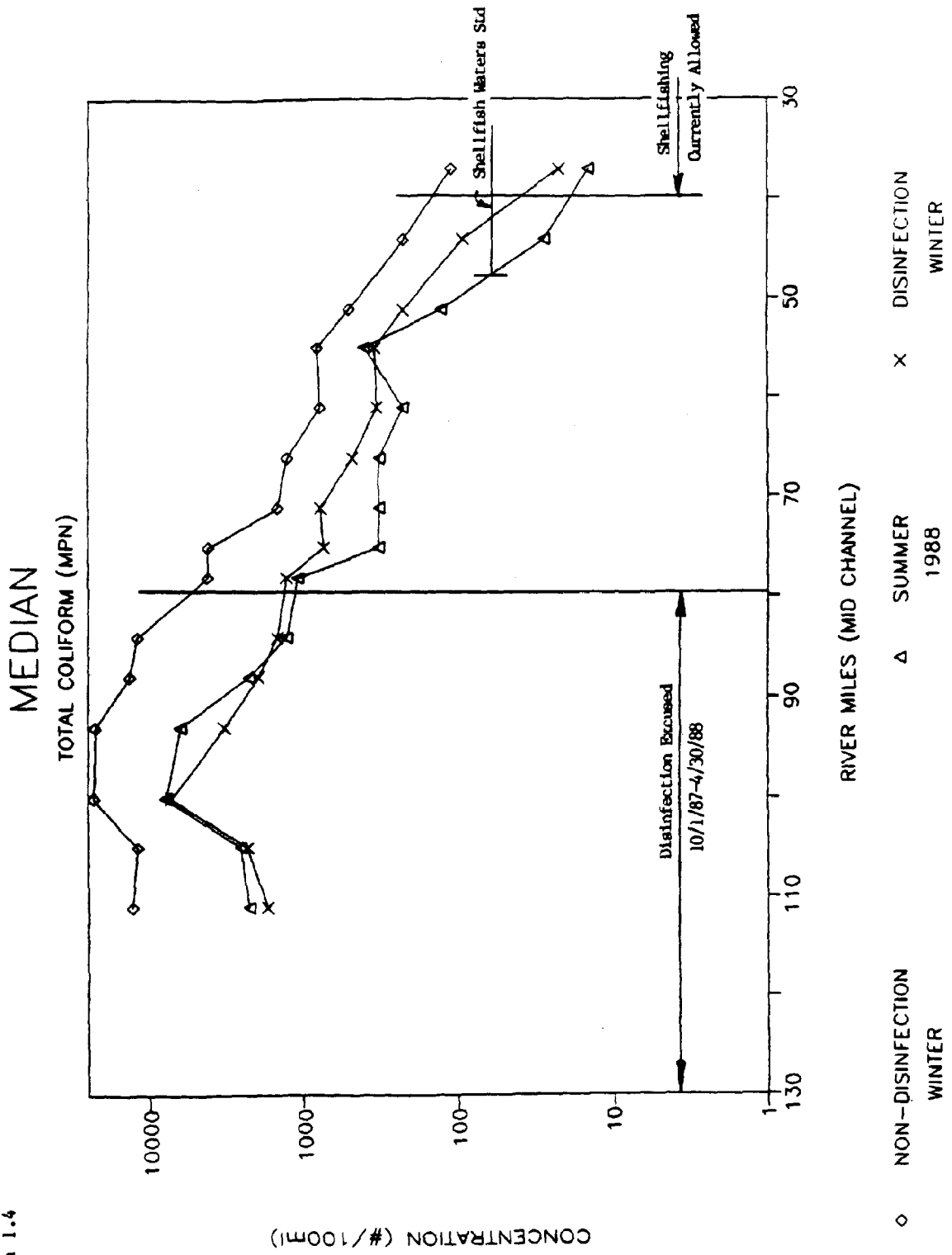
- ◇ NON-DISINFECTION WINTER
- △ DISINFECTION SUMMER 1988
- × DISINFECTION WINTER

Graph 1.3



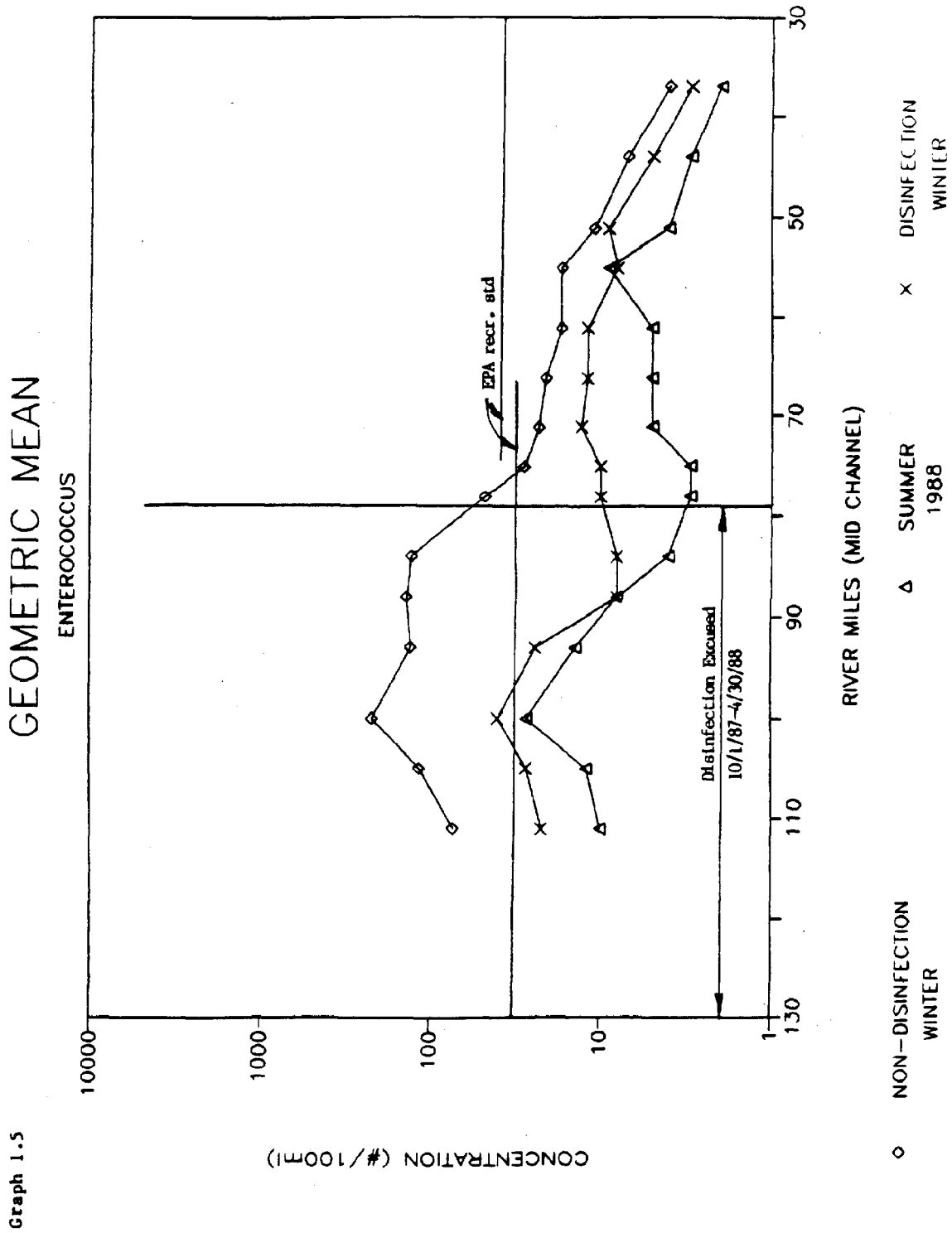
Graph 1.3

Graph 1.4



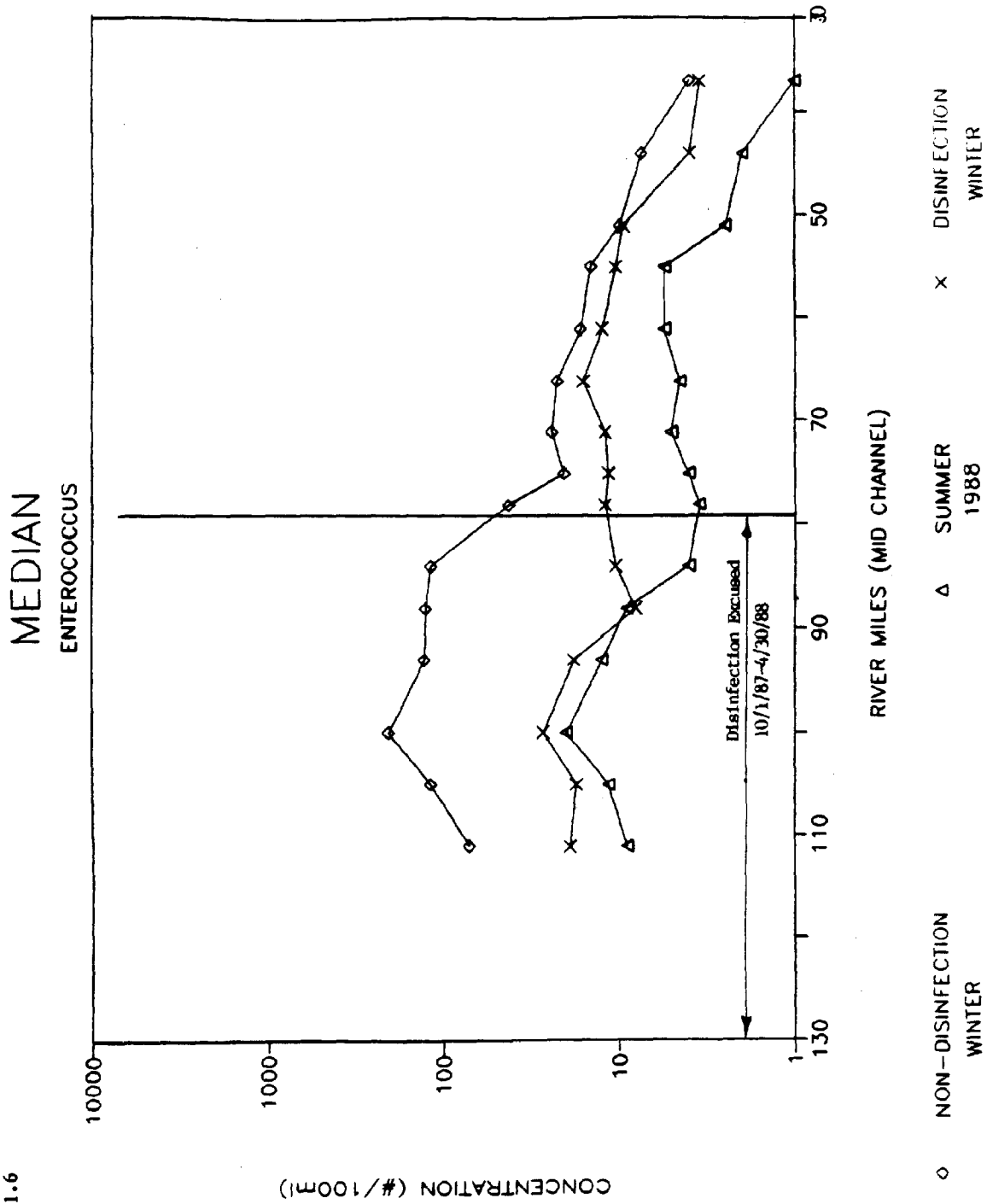
Graph 1.4

Graph 1.5



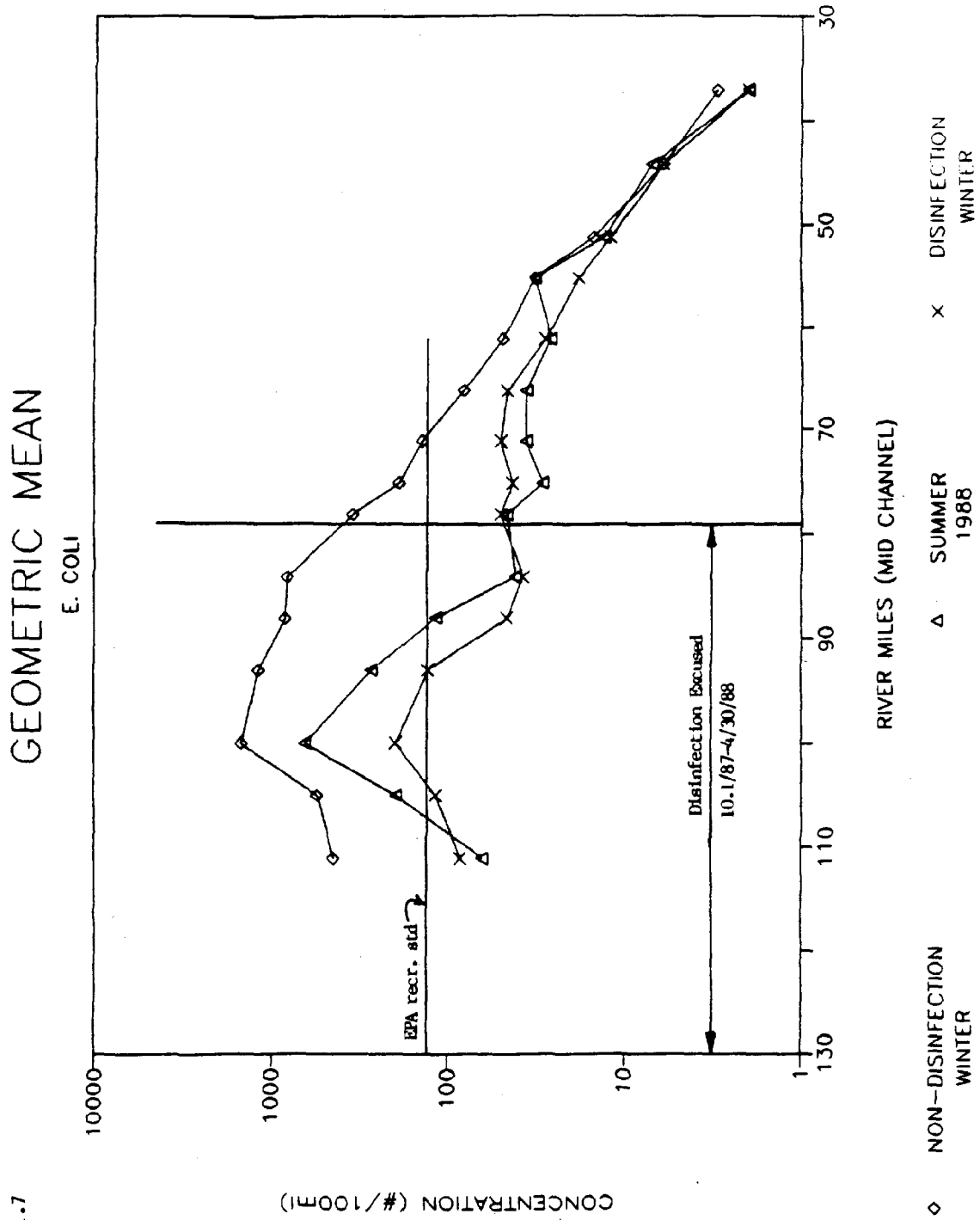
Graph 1.5

Graph 1.6



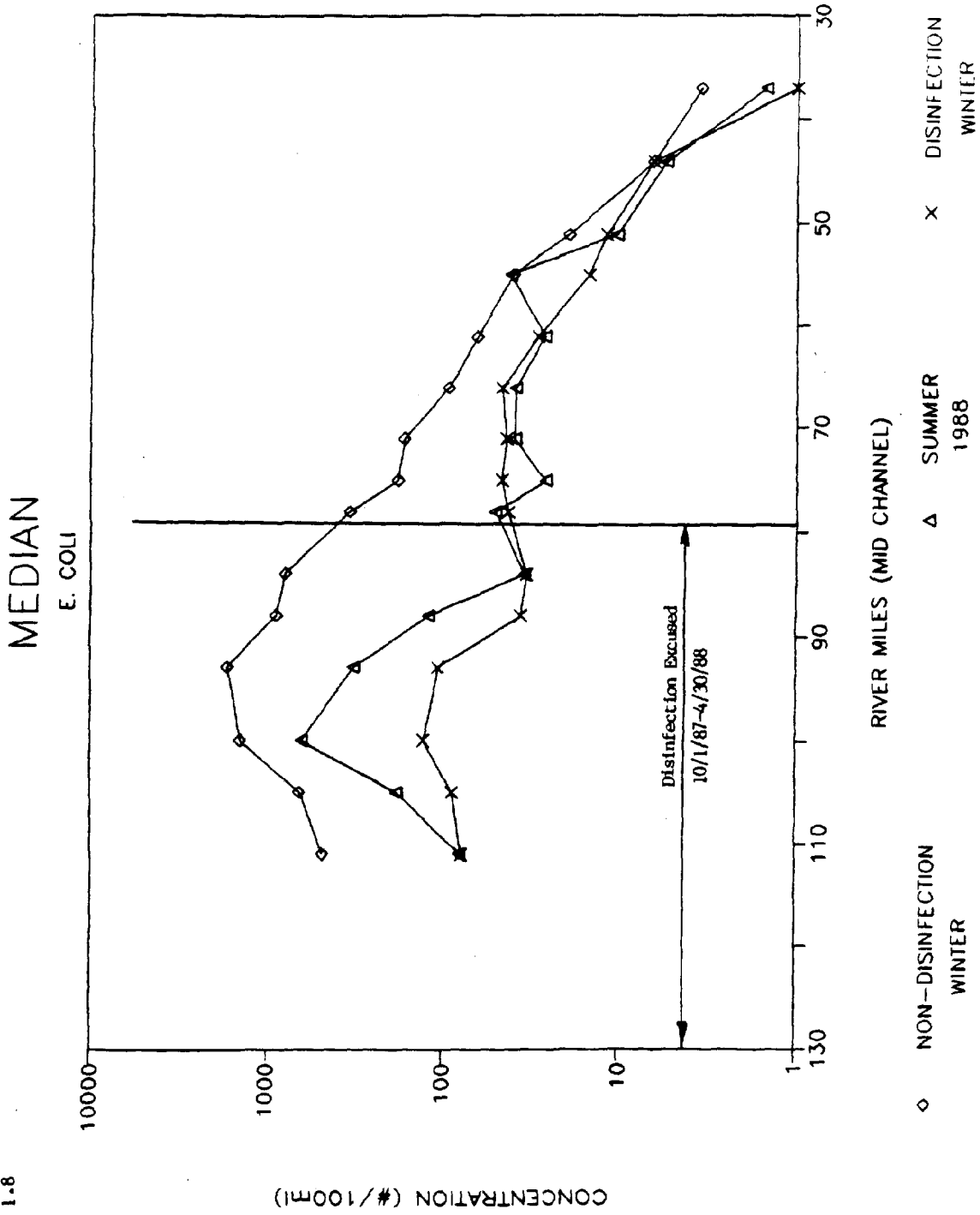
Graph 1.6

Graph 1.7



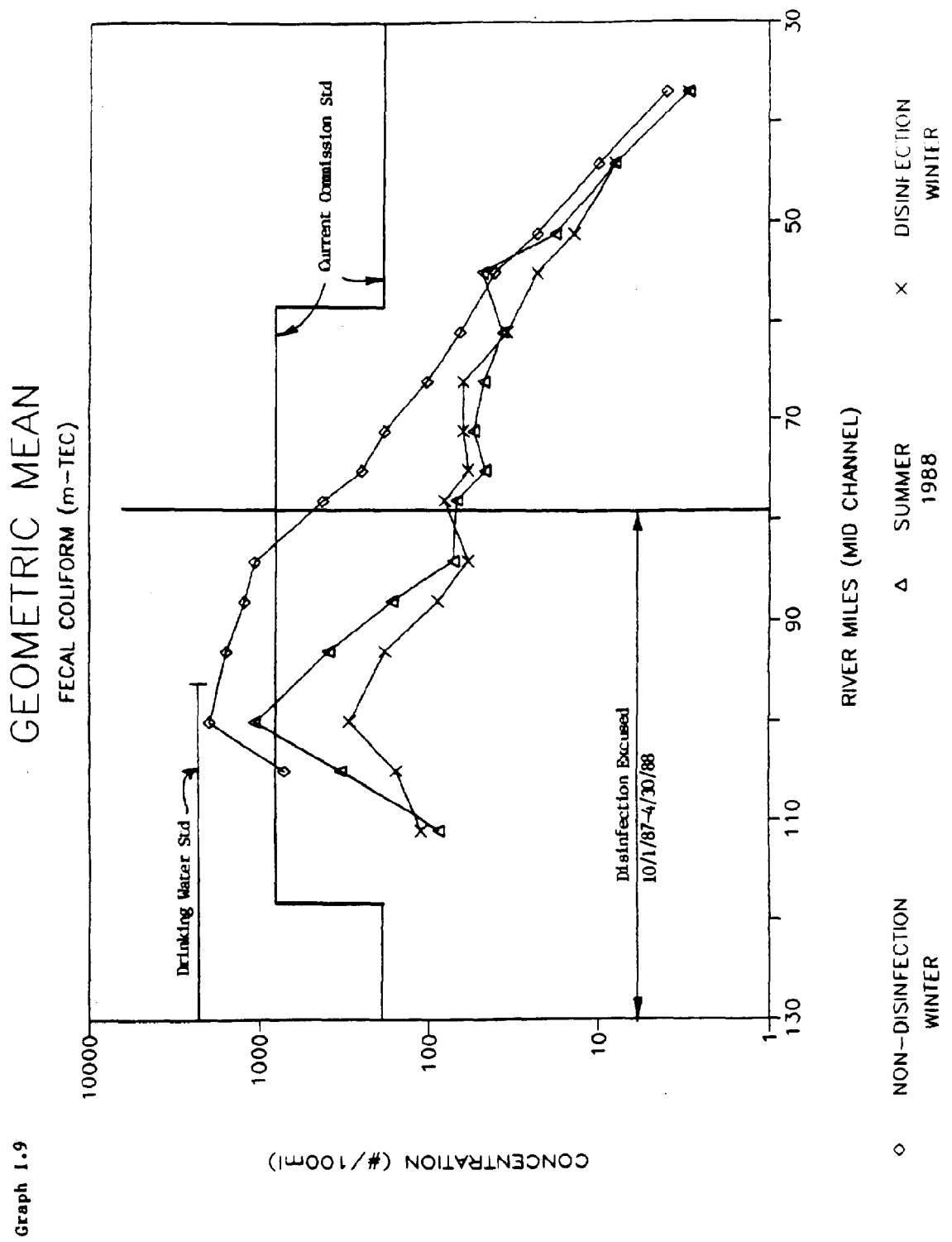
Graph 1.7

Graph 1.8



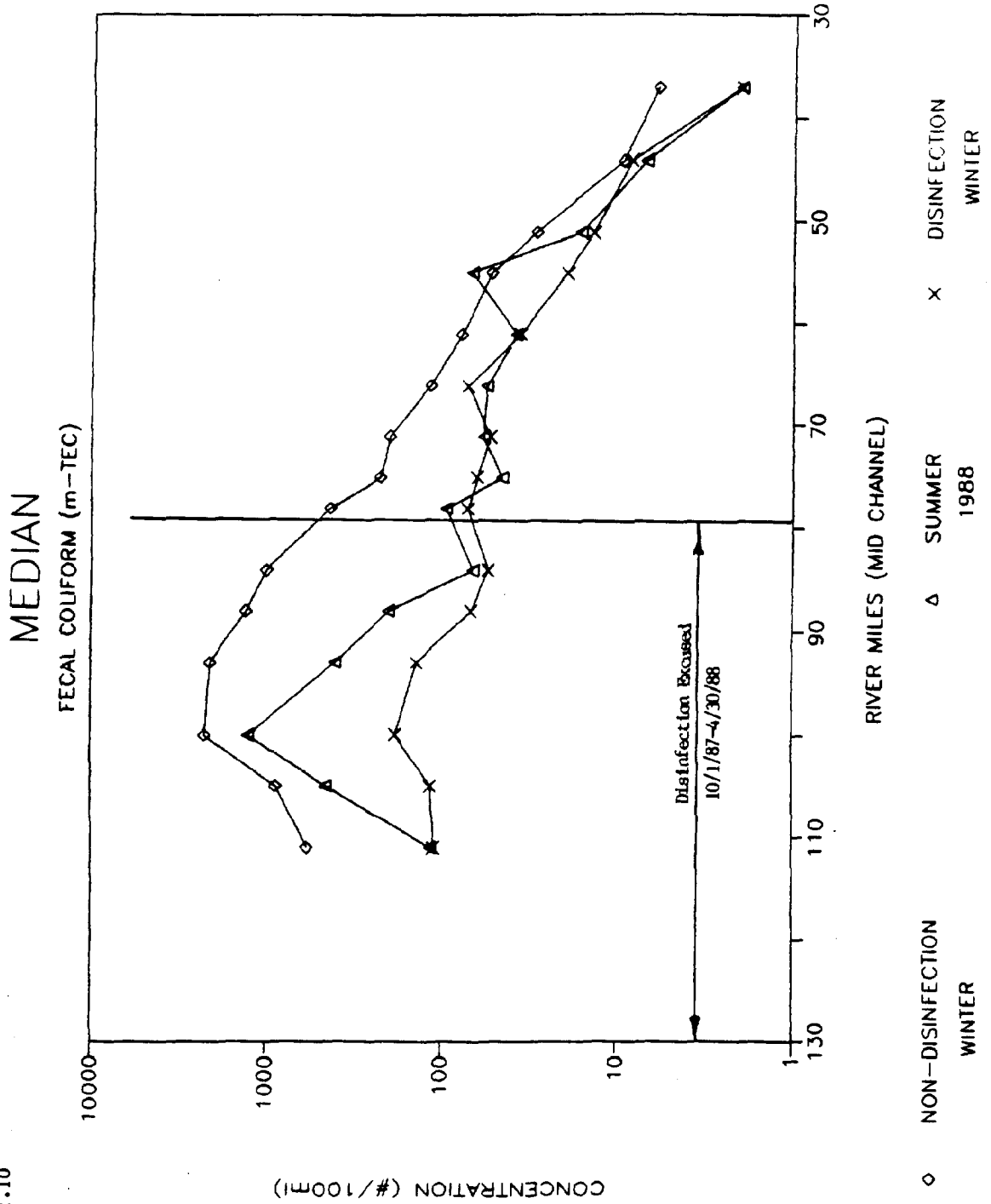
Graph 1.8

Graph 1.9



Graph 1.9

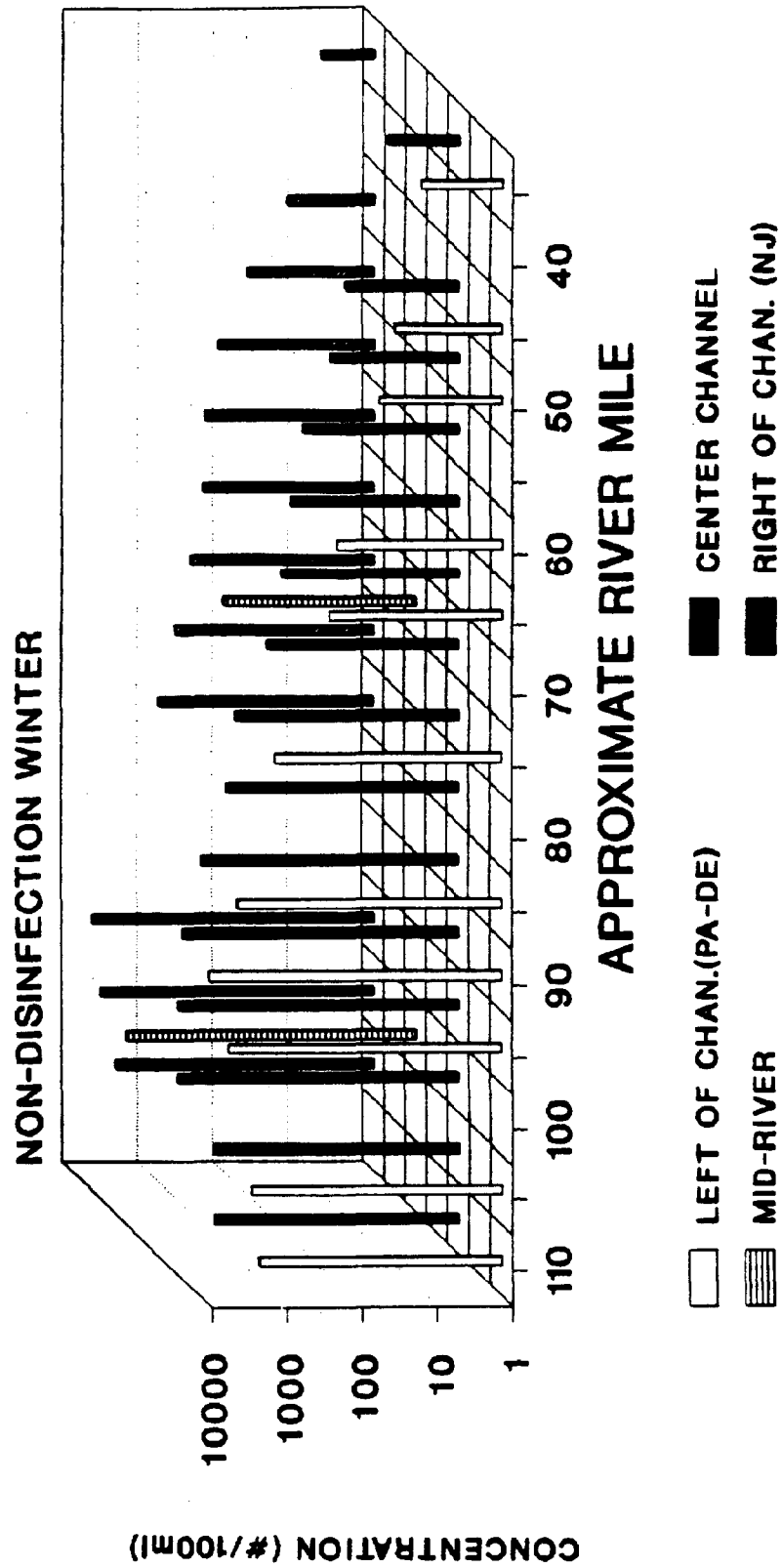
Graph 1.10



Graph 1.10

GEOMETRIC MEAN FECAL COLIFORM (MPN)

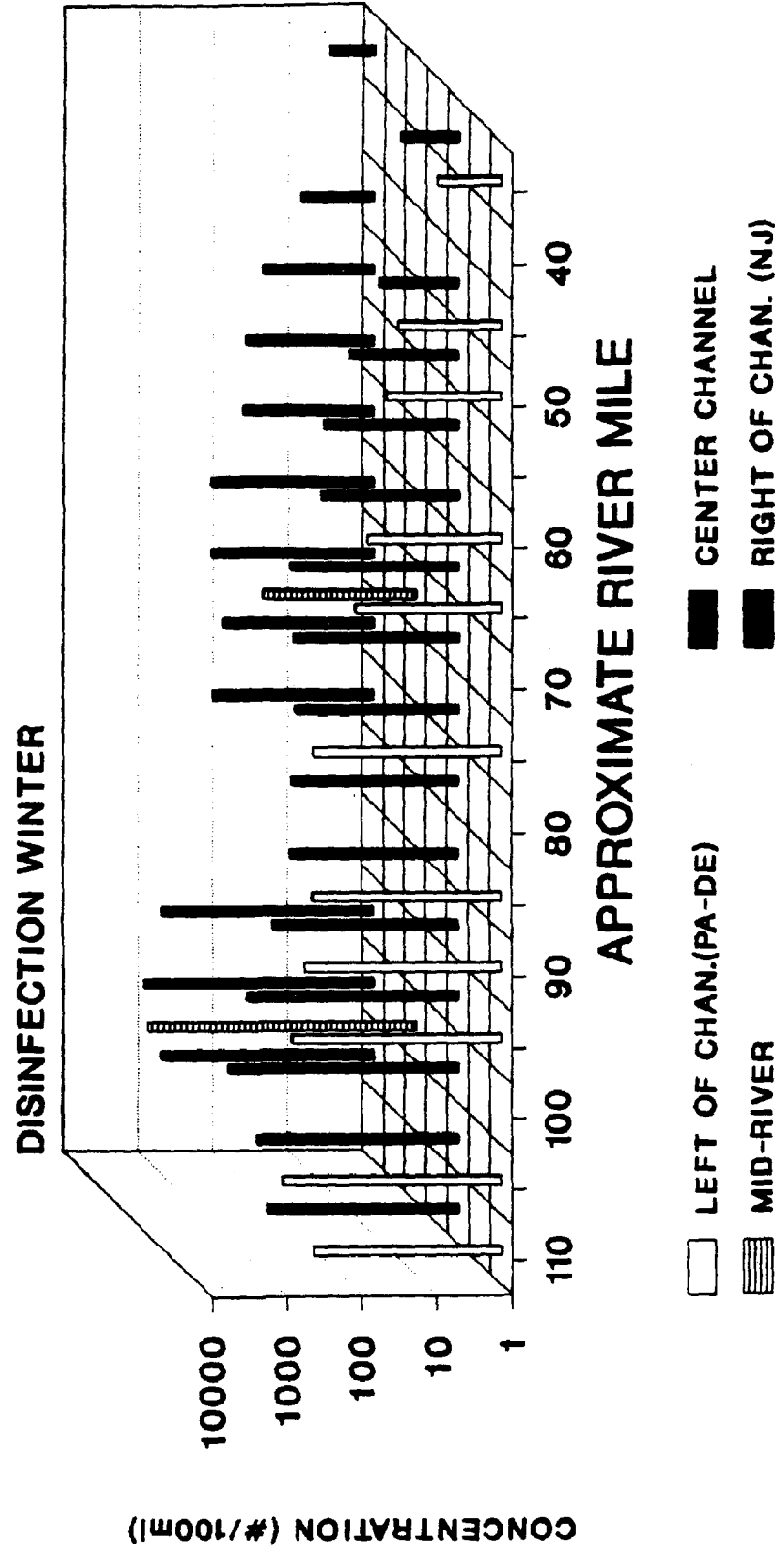
Graph 1.11A



Graph 1.11A

GEOMETRIC MEAN FECAL COLIFORM (MPN)

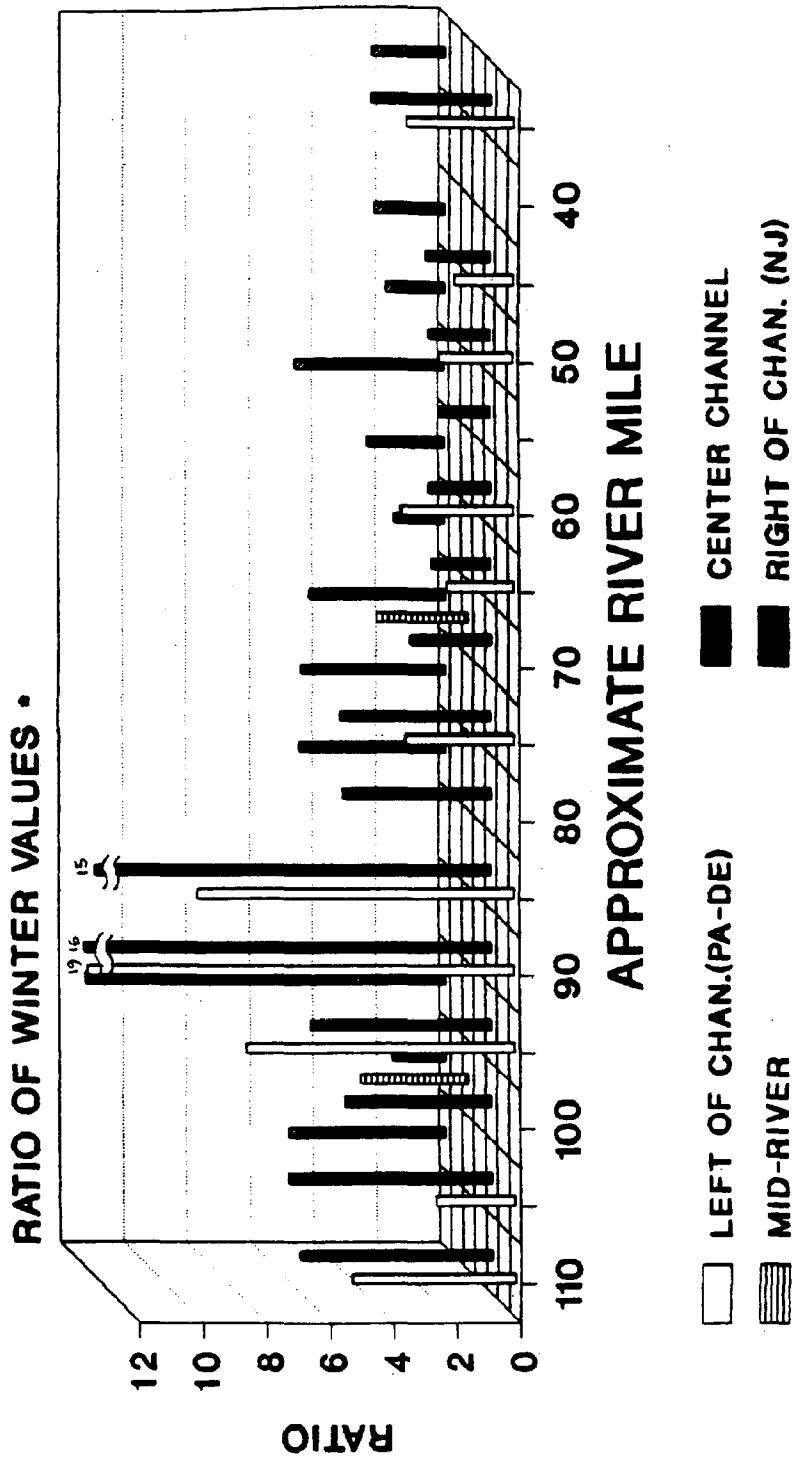
Graph 1.11B



Graph 1.11B

GEOMETRIC MEAN FECAL COLIFORM (MPN)

Graph 1.11C

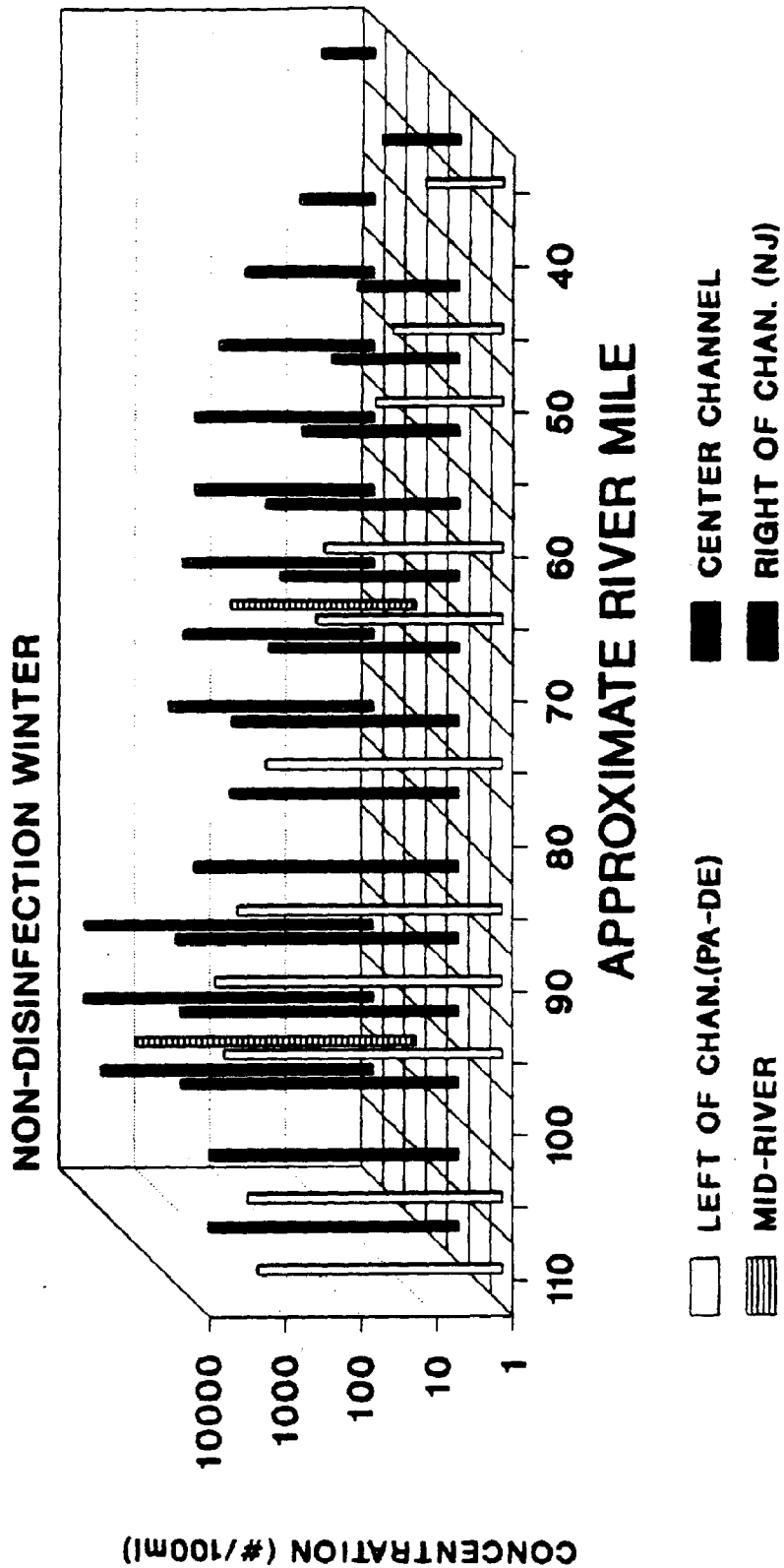


Graph 1.11C

• NON-DISINFECT. WINTER / DISINFECT. WINTER

Graph 1.12A

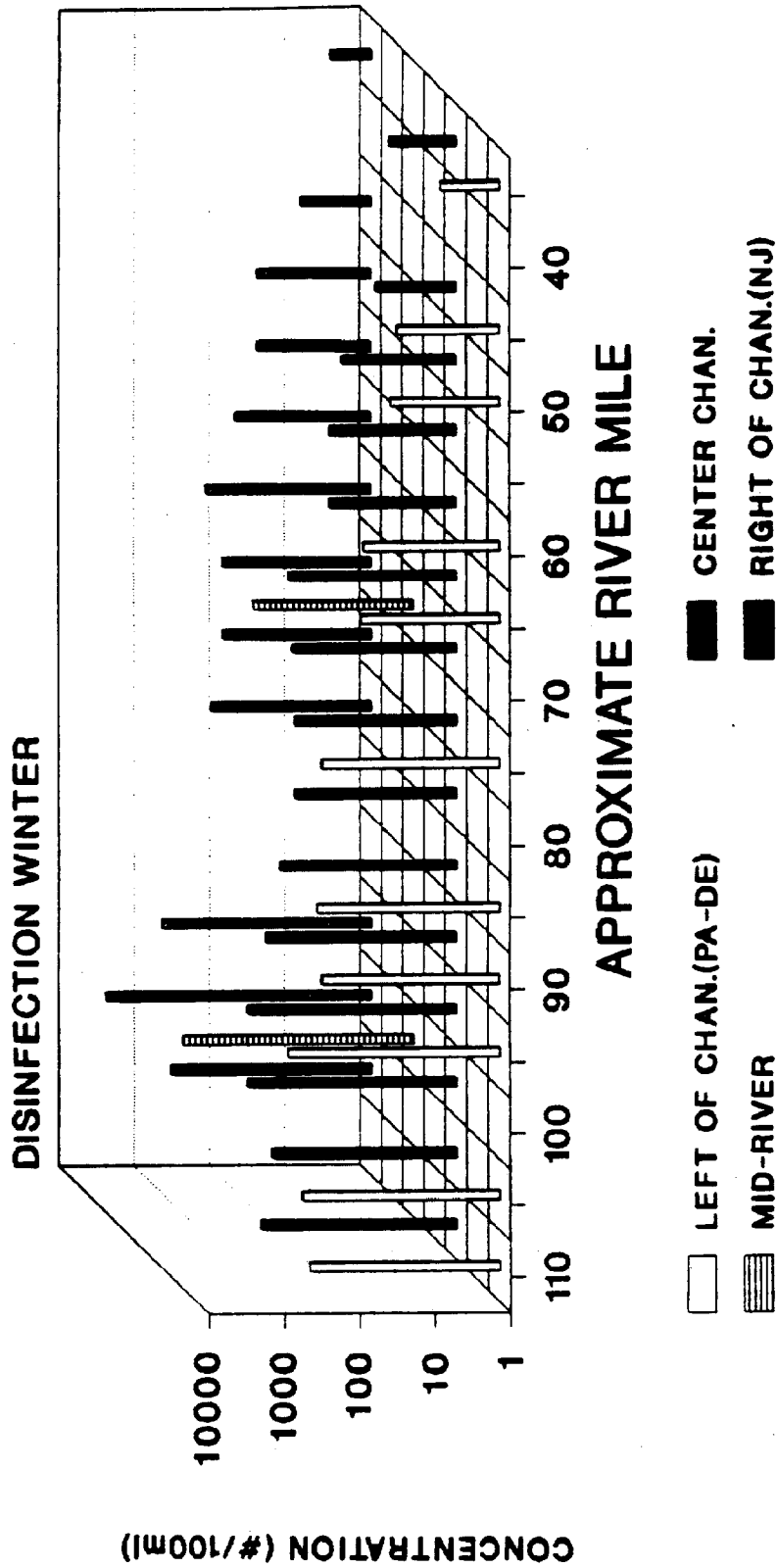
MEDIAN FECAL COLIFORM (MPN)



Graph 1.12A

Graph 1.12B

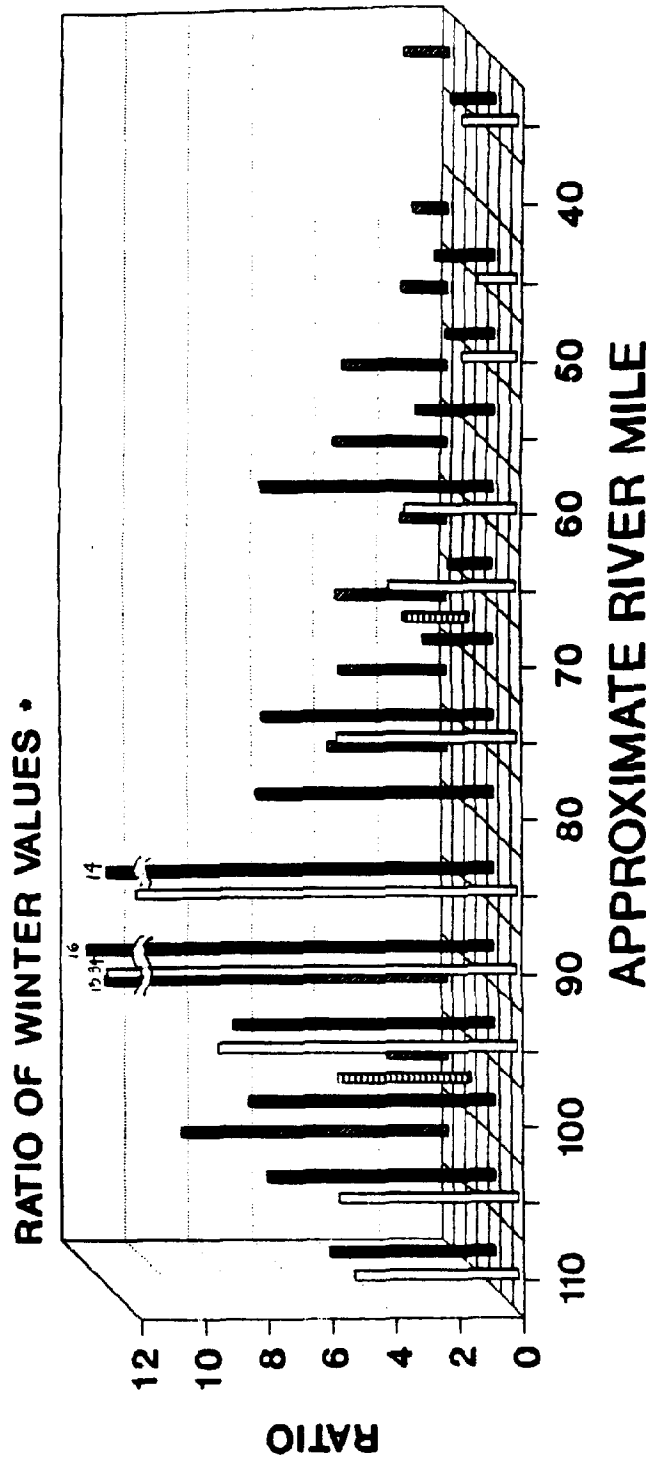
MEDIAN FECAL COLIFORM (MPN)



Graph 1.12B

Graph 1.12C

MEDIAN FECAL COLIFORM (MPN)

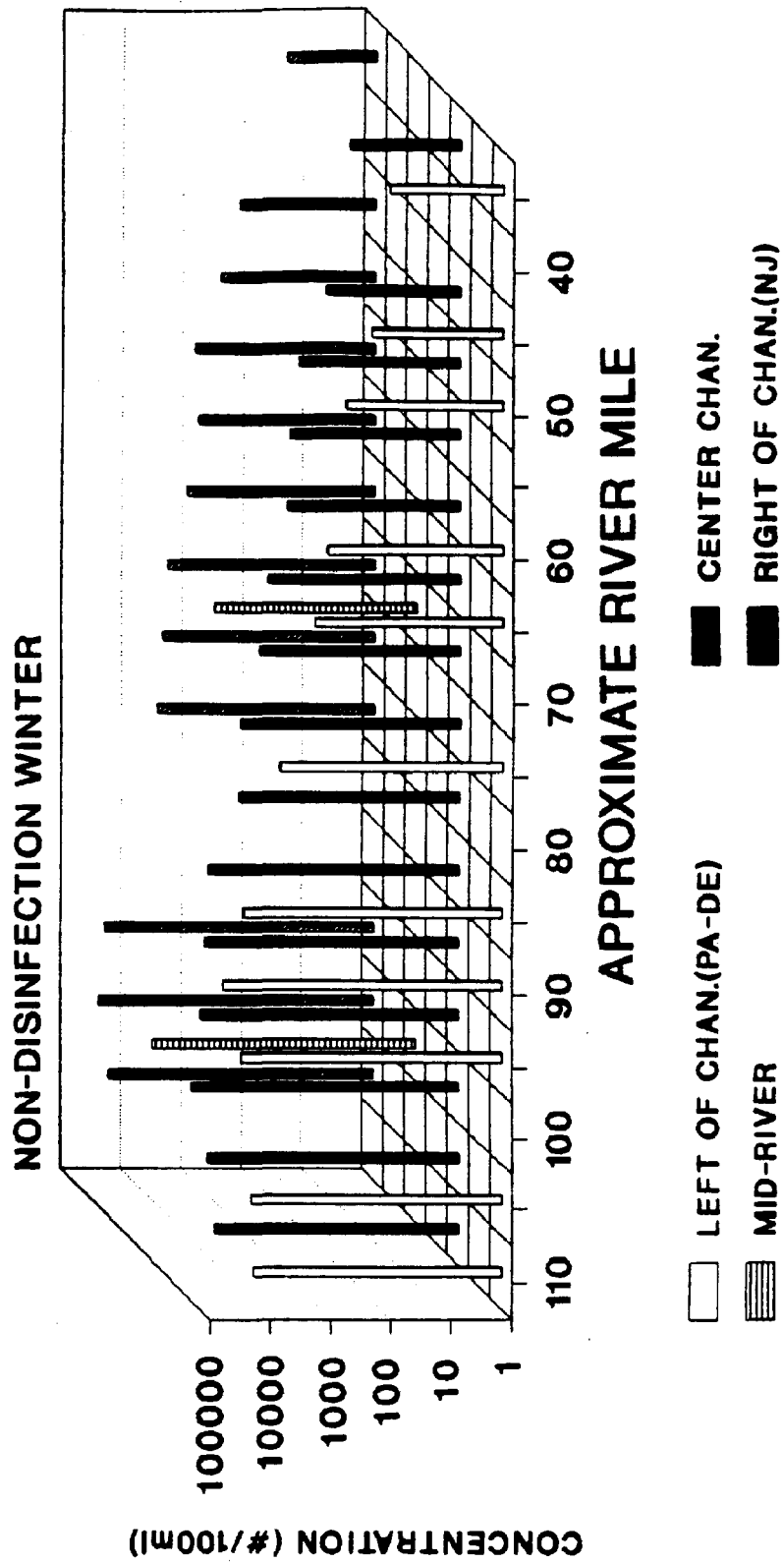


Graph 1.12C

• NON-DISINFECT.WINTER /DISINFECT.WINTER

Graph 1.13A

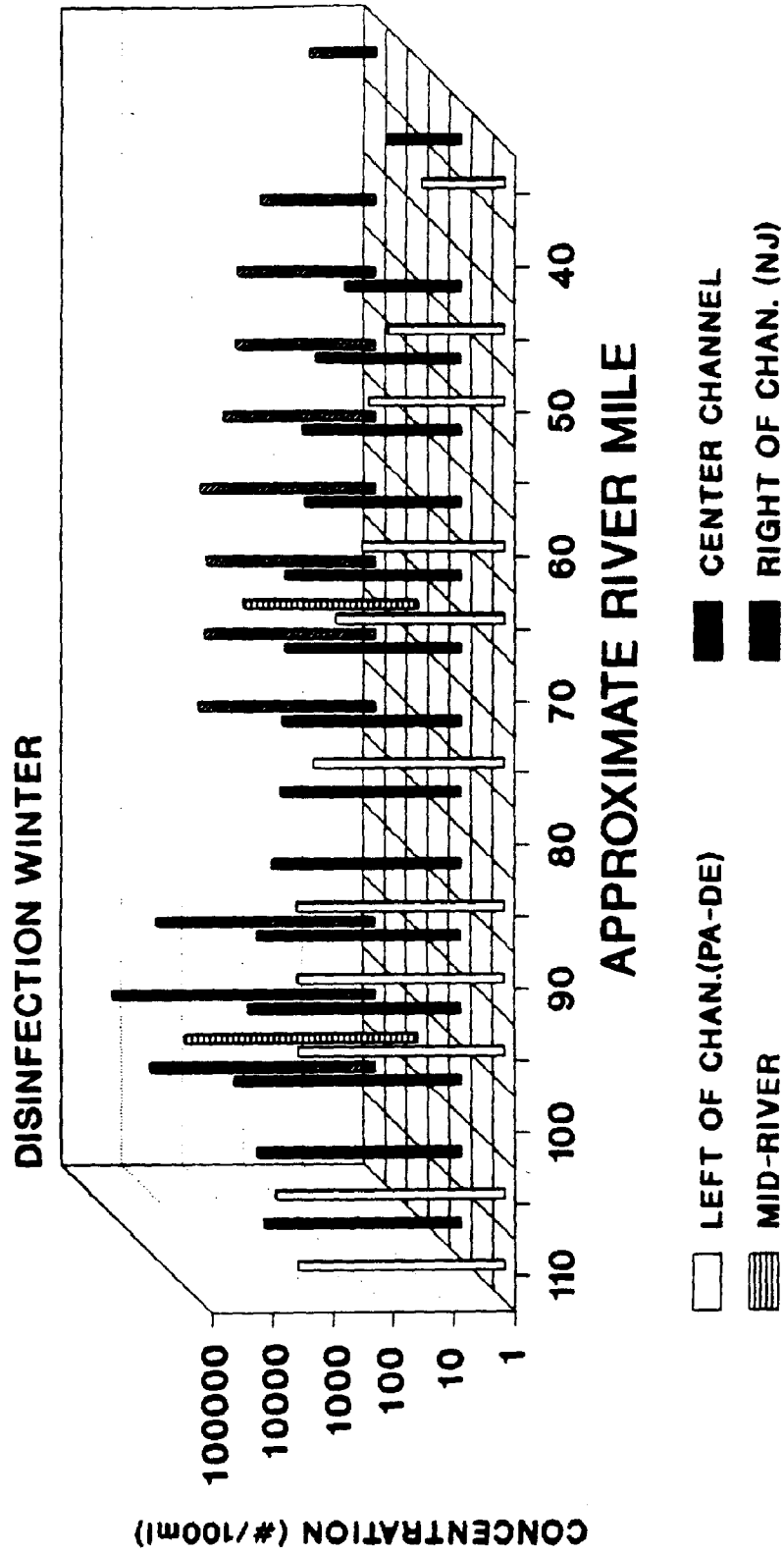
GEOMETRIC MEAN TOTAL COLIFORM (MPN)



Graph 1.13A

GEOMETRIC MEAN TOTAL COLIFORM (MPN)

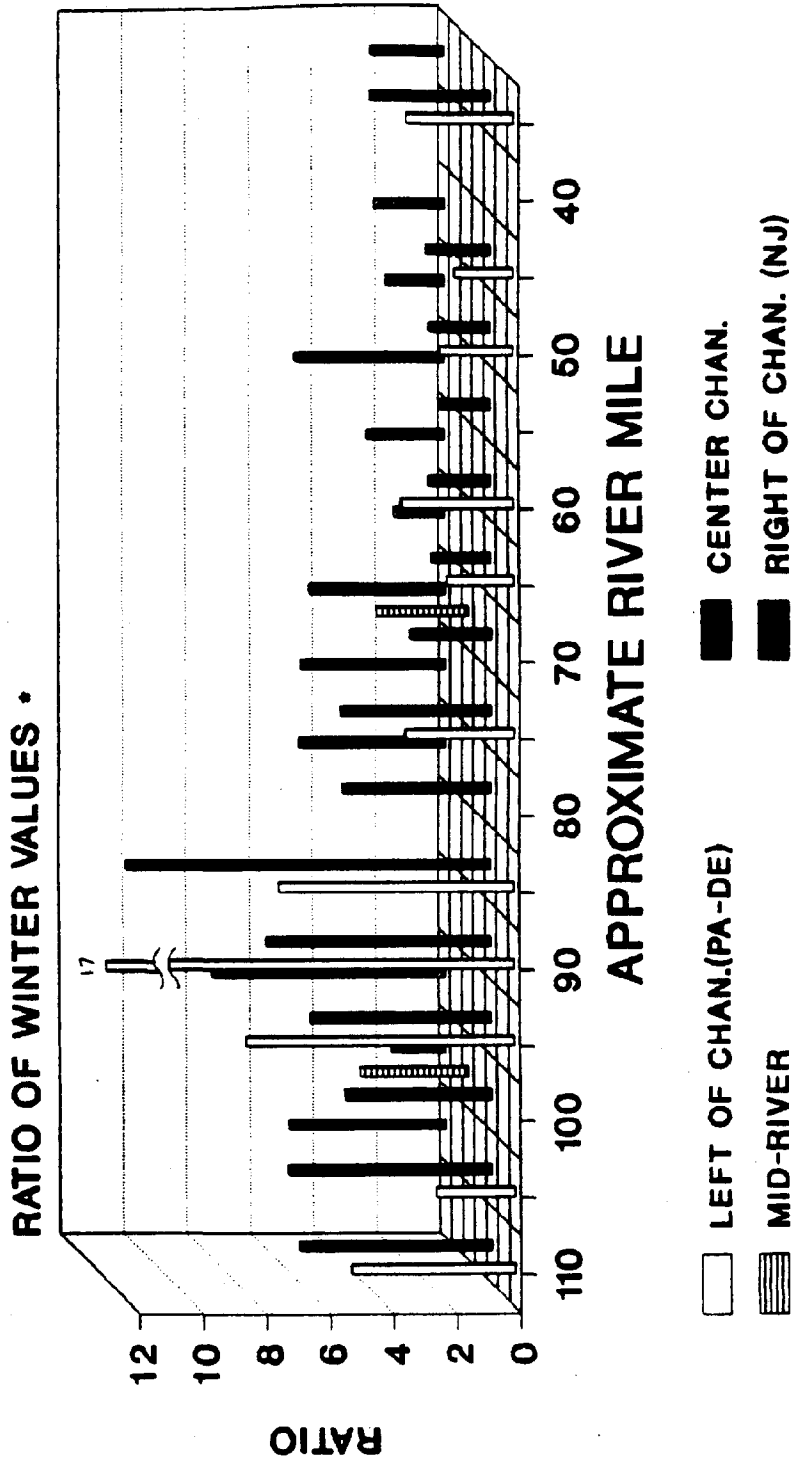
Graph 1.13B



Graph 1.13B

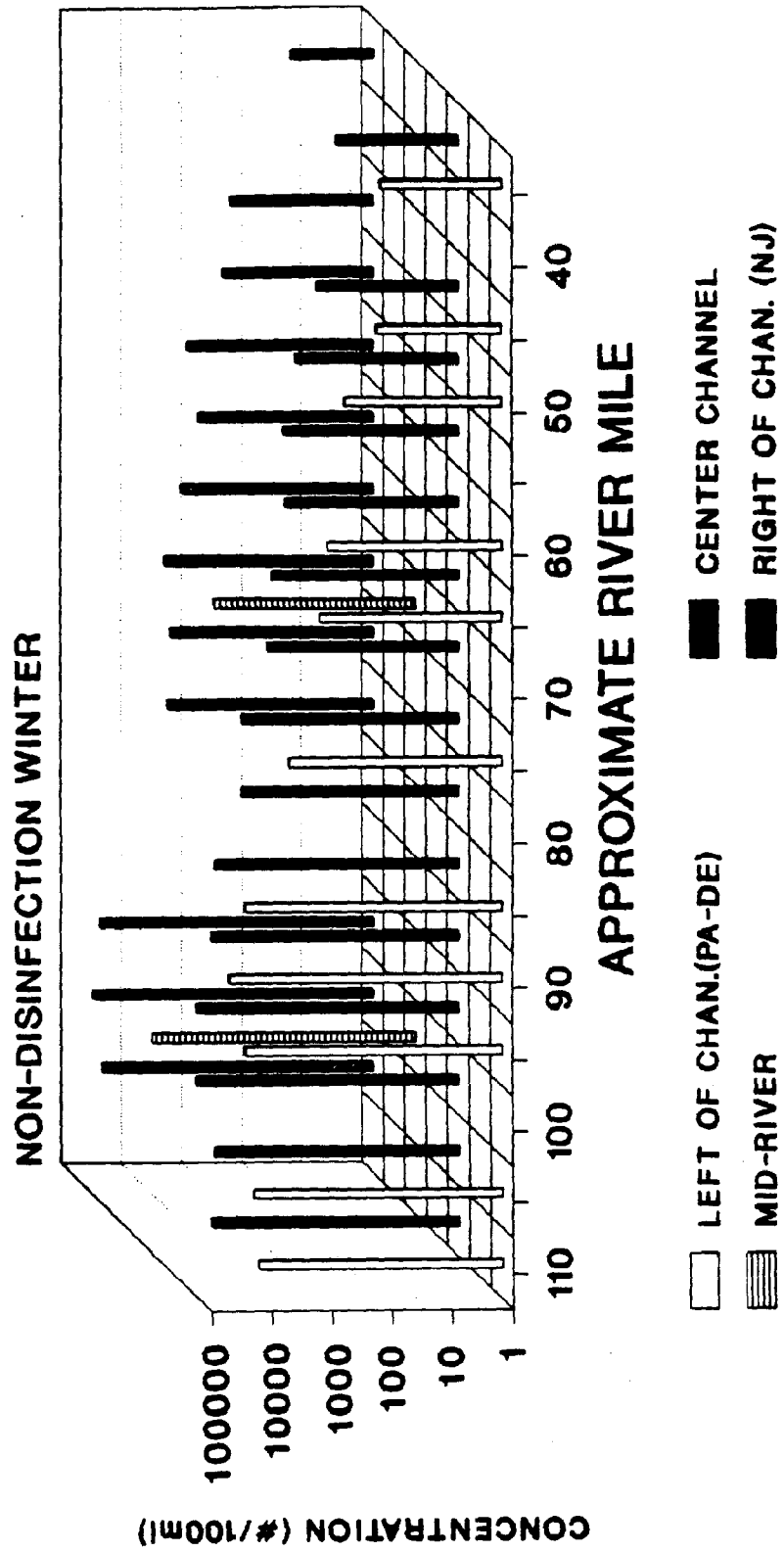
GEOMETRIC MEAN TOTAL COLIFORM (MPN)

Graph 1.13C



MEDIAN TOTAL COLIFORM (MPN)

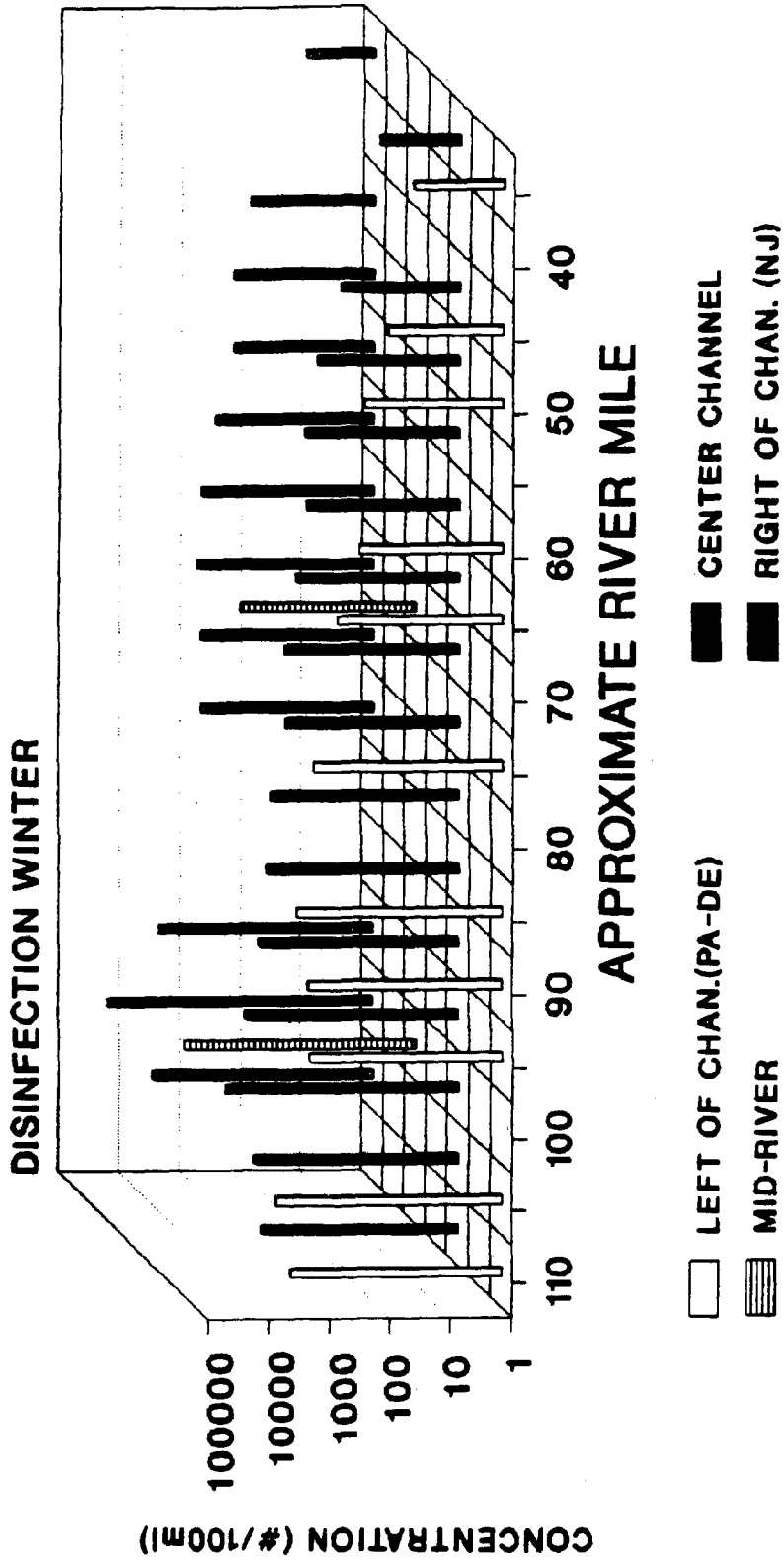
Graph 1.14A



Graph 1.14A

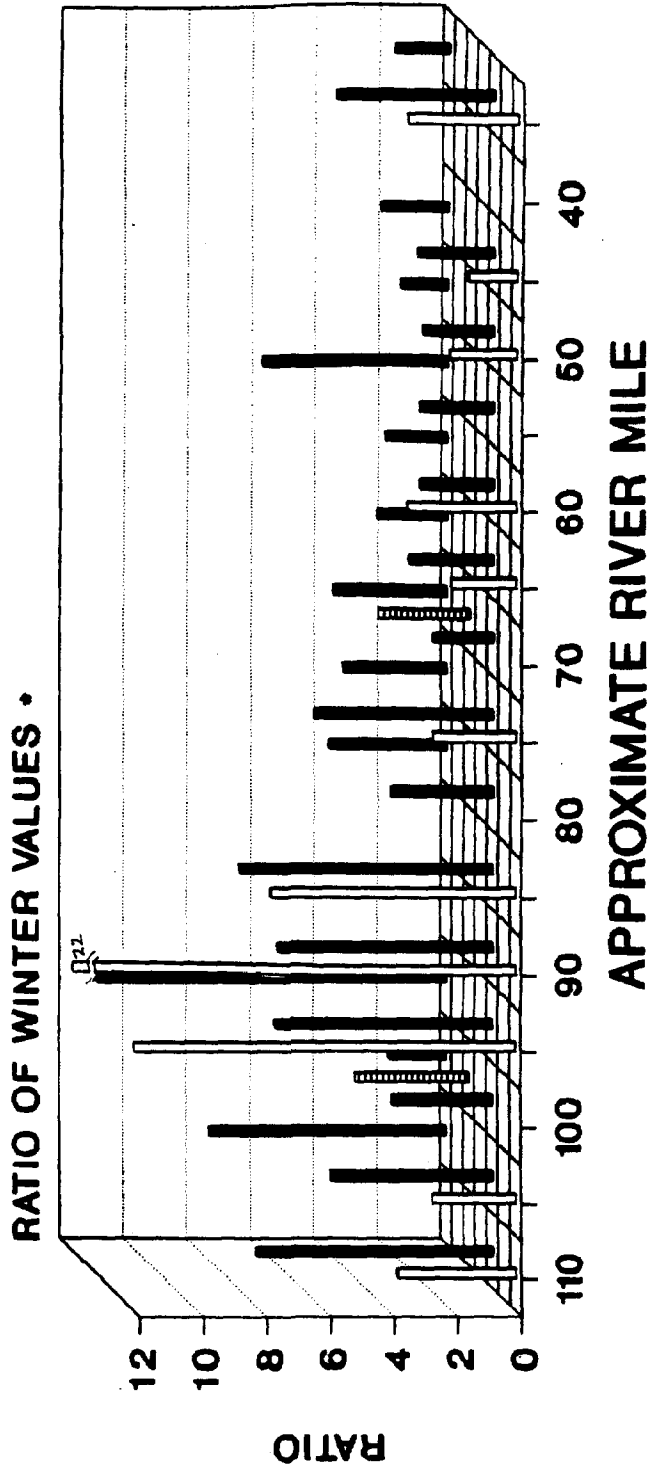
MEDIAN TOTAL COLIFORM (MPN)

Graph 1.14B



Graph 1.14B

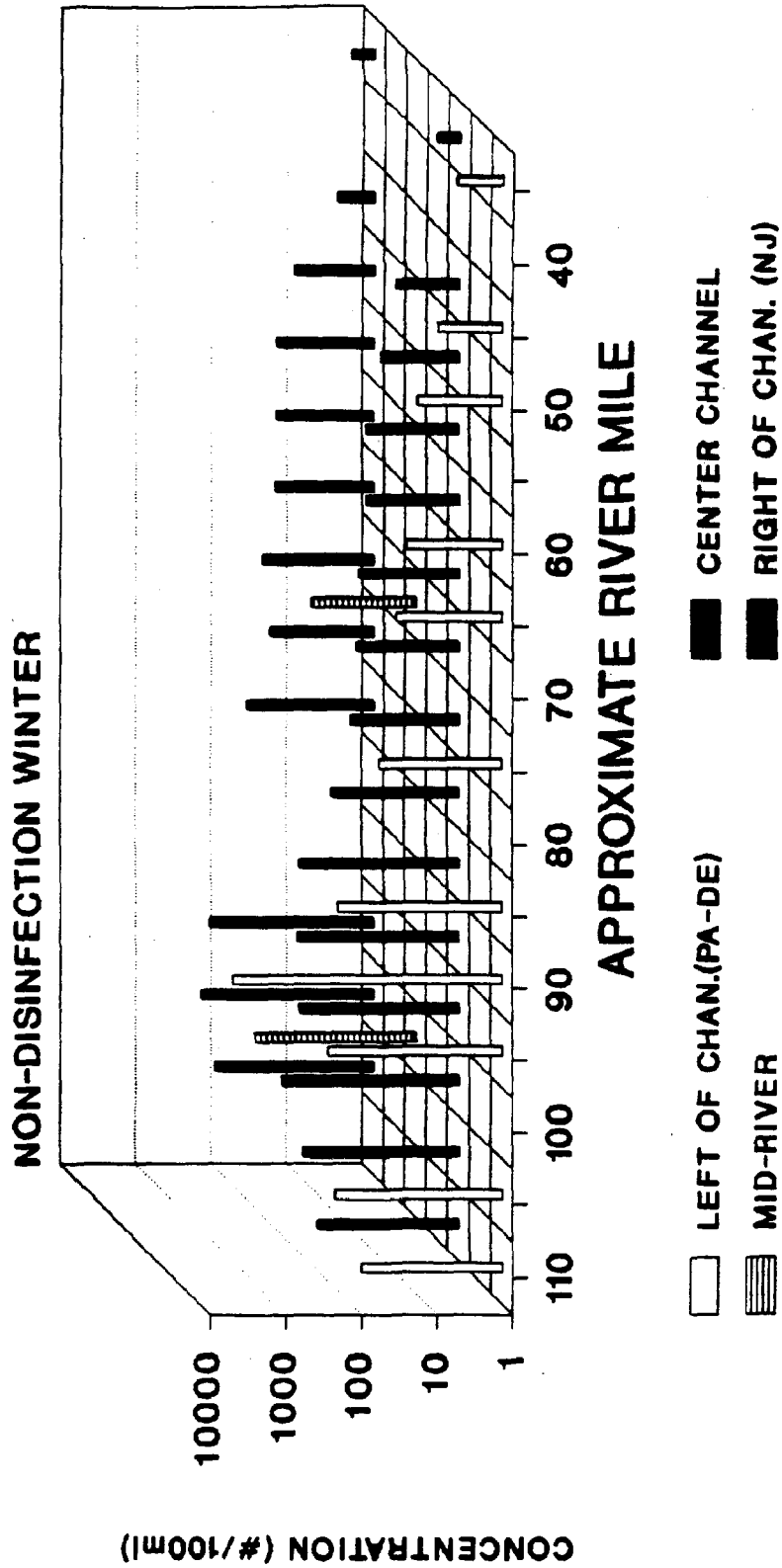
MEDIAN TOTAL COLIFORM (MPN)



• NON-DISINFECT.WINTER / DISINFECT.WINTER

Graph 1.15A

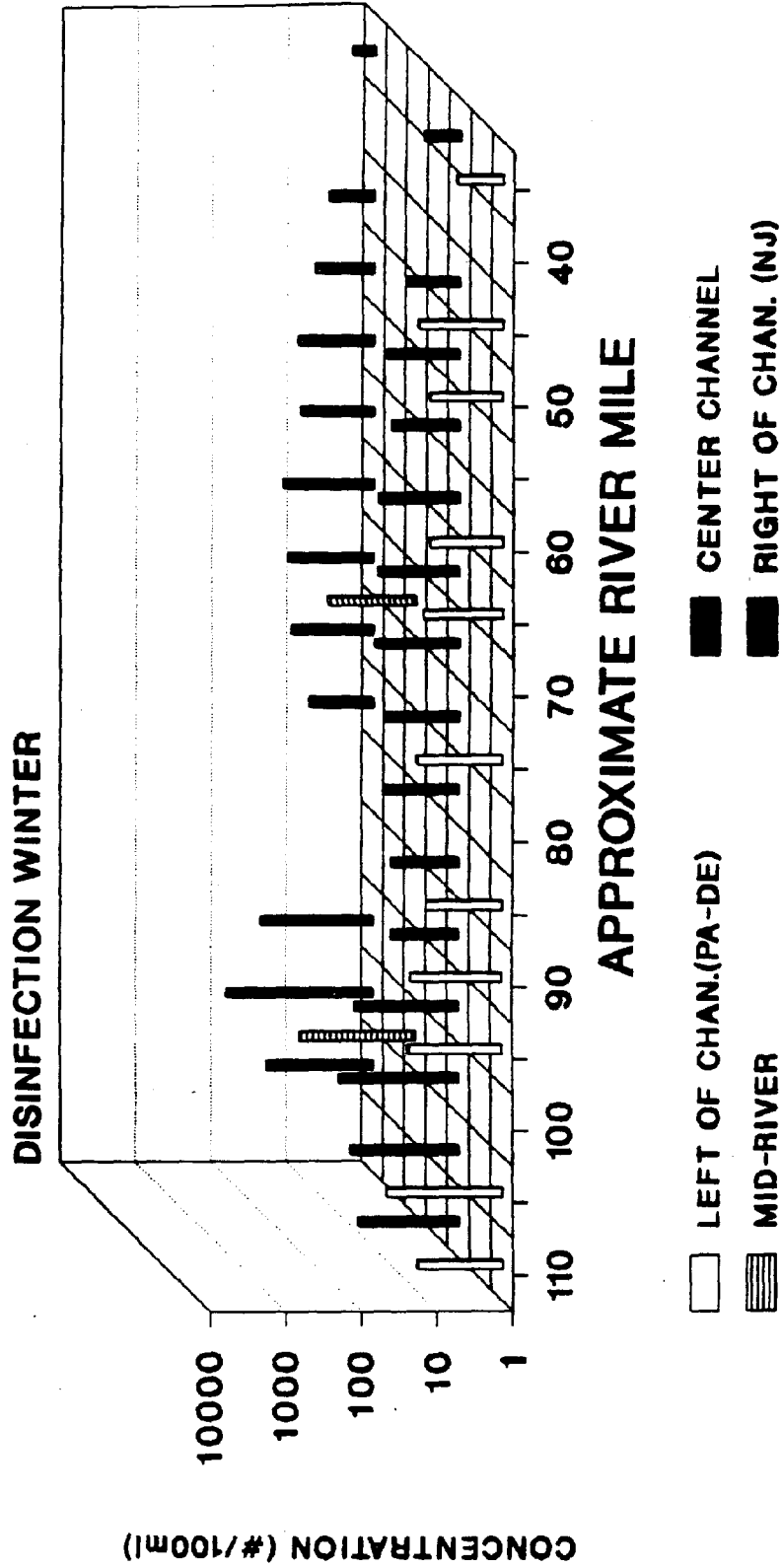
GEOMETRIC MEAN ENTEROCOCCUS



Graph 1.15A

Graph 1.15B

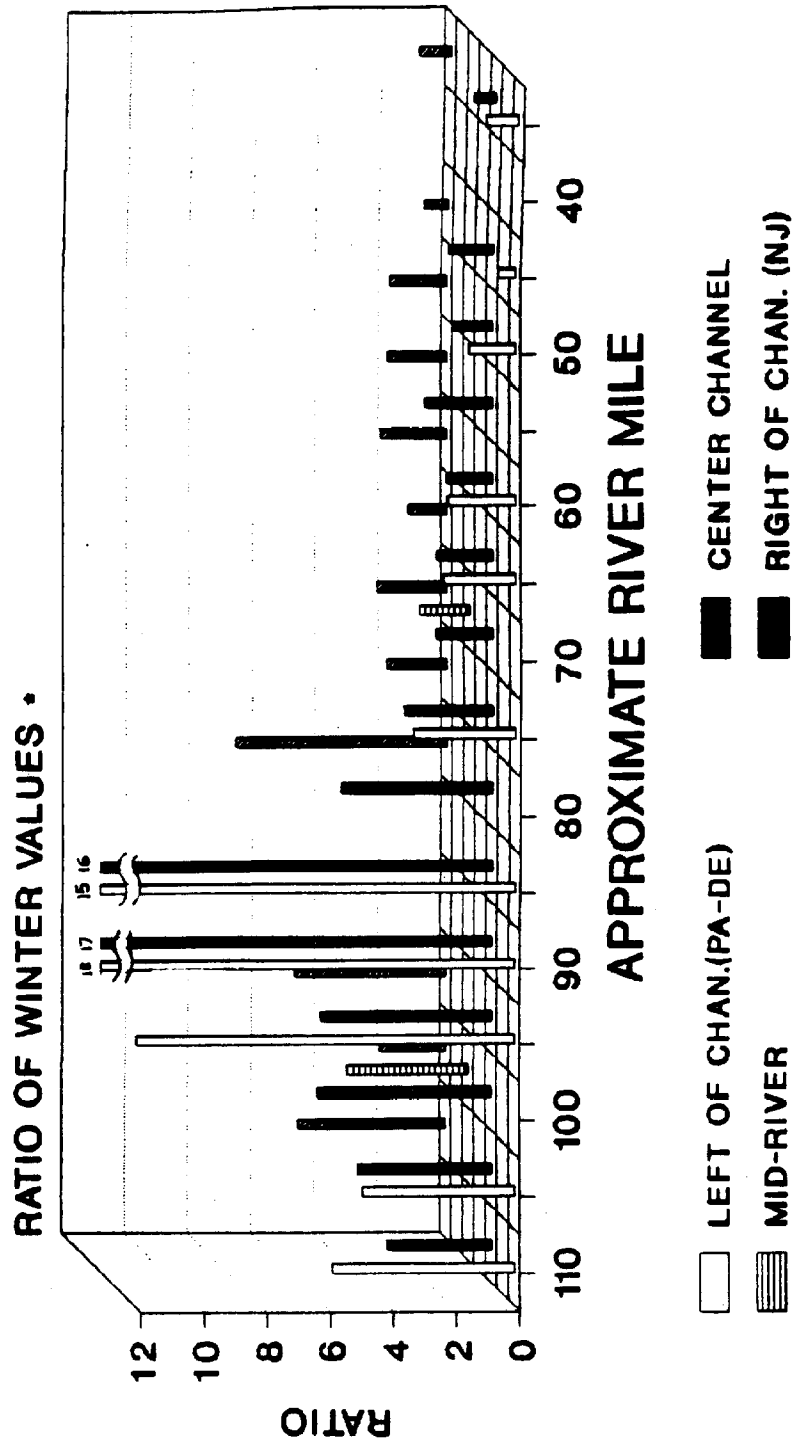
GEOMETRIC MEAN ENTEROCOCCUS



Graph 1.15B

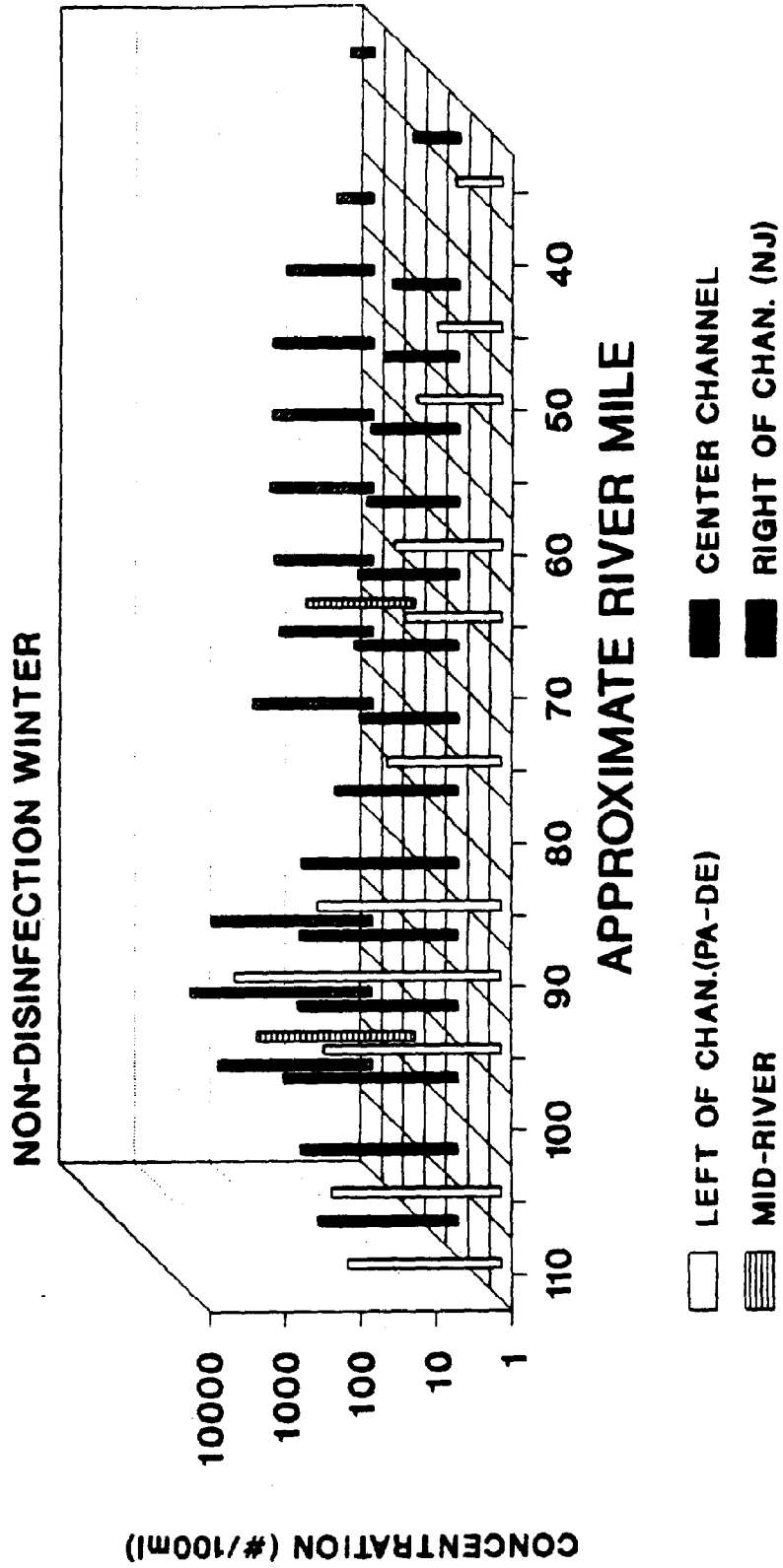
GEOMETRIC MEAN ENTEROCOCCUS

Graph 1.15C



Graph 1.16A

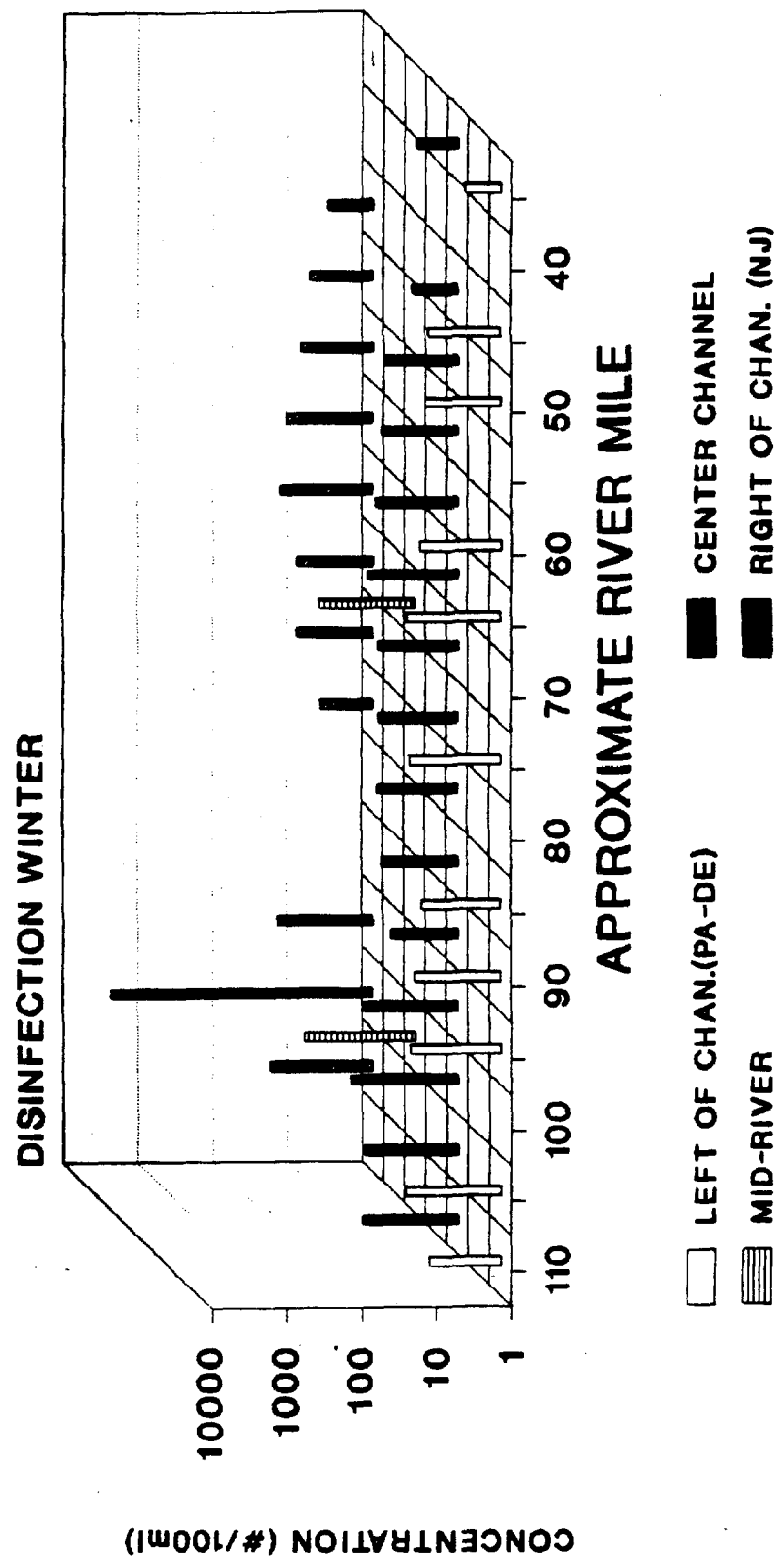
MEDIAN ENTEROCOCCUS



Graph 1.16A

Graph 1.16B

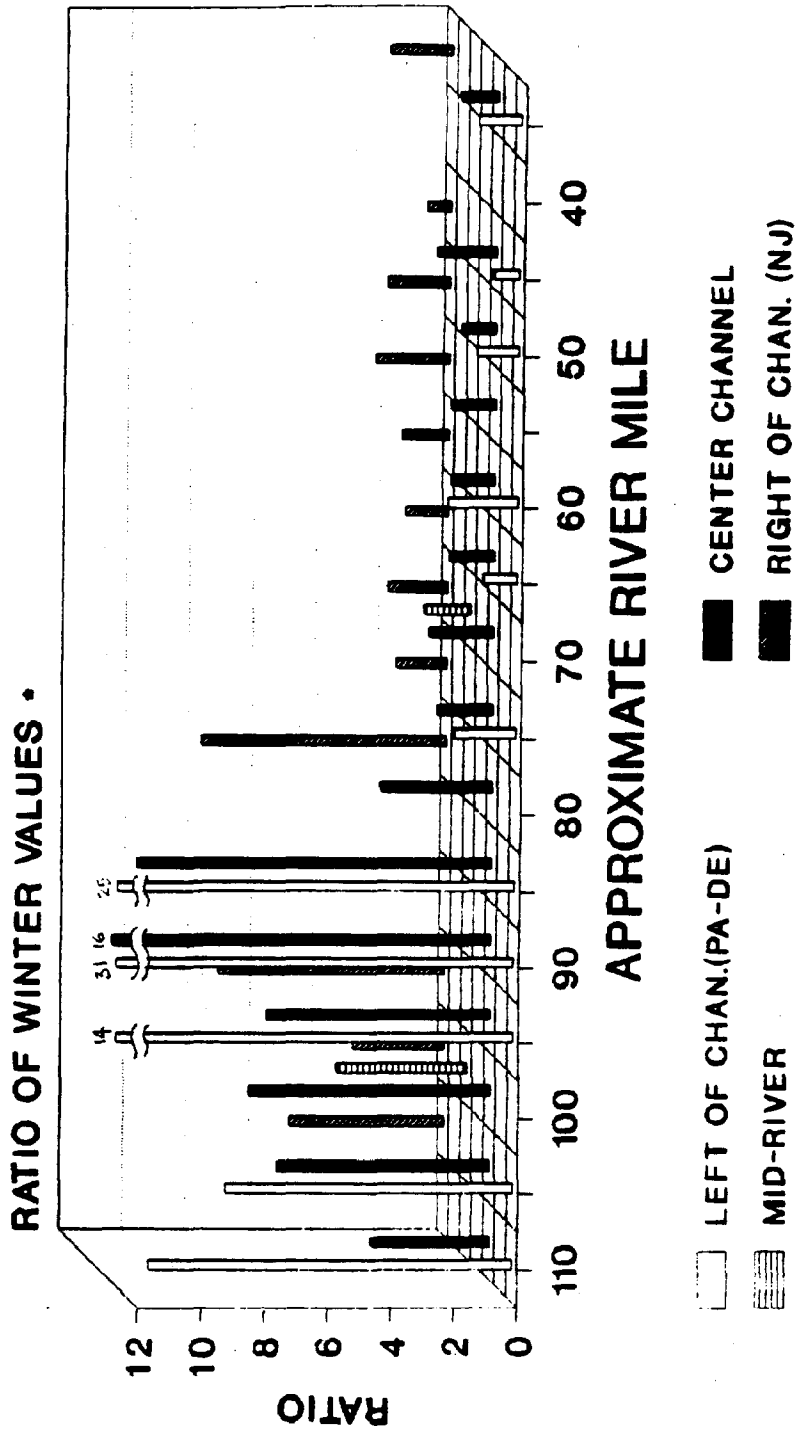
MEDIAN ENTEROCOCCUS



Graph 1.16B

Graph 1.16C

MEDIAN ENTEROCOCCUS

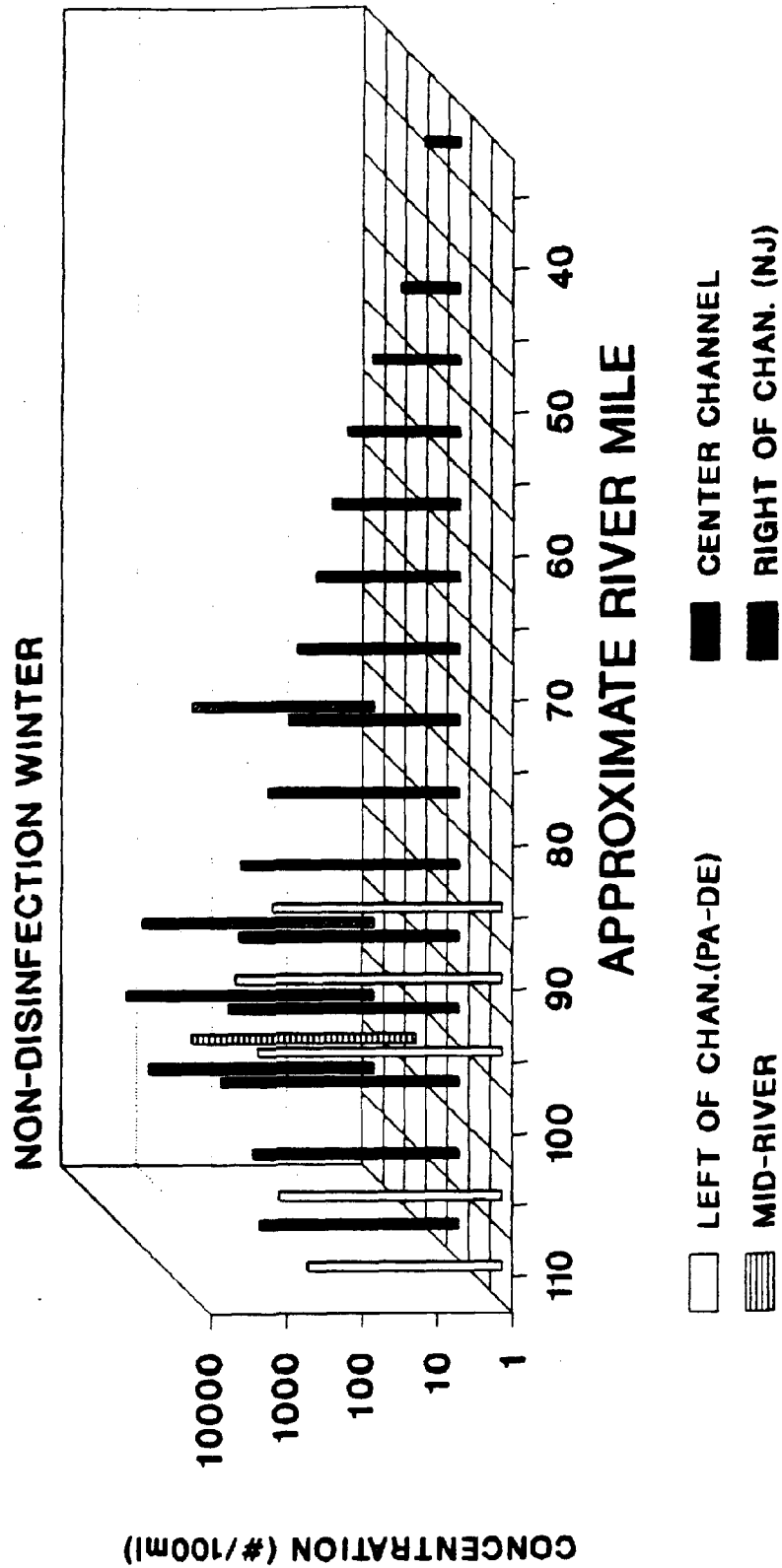


Graph 1.16C

• NON-DISINFECT.WINTER /DISINFECT.WINTER

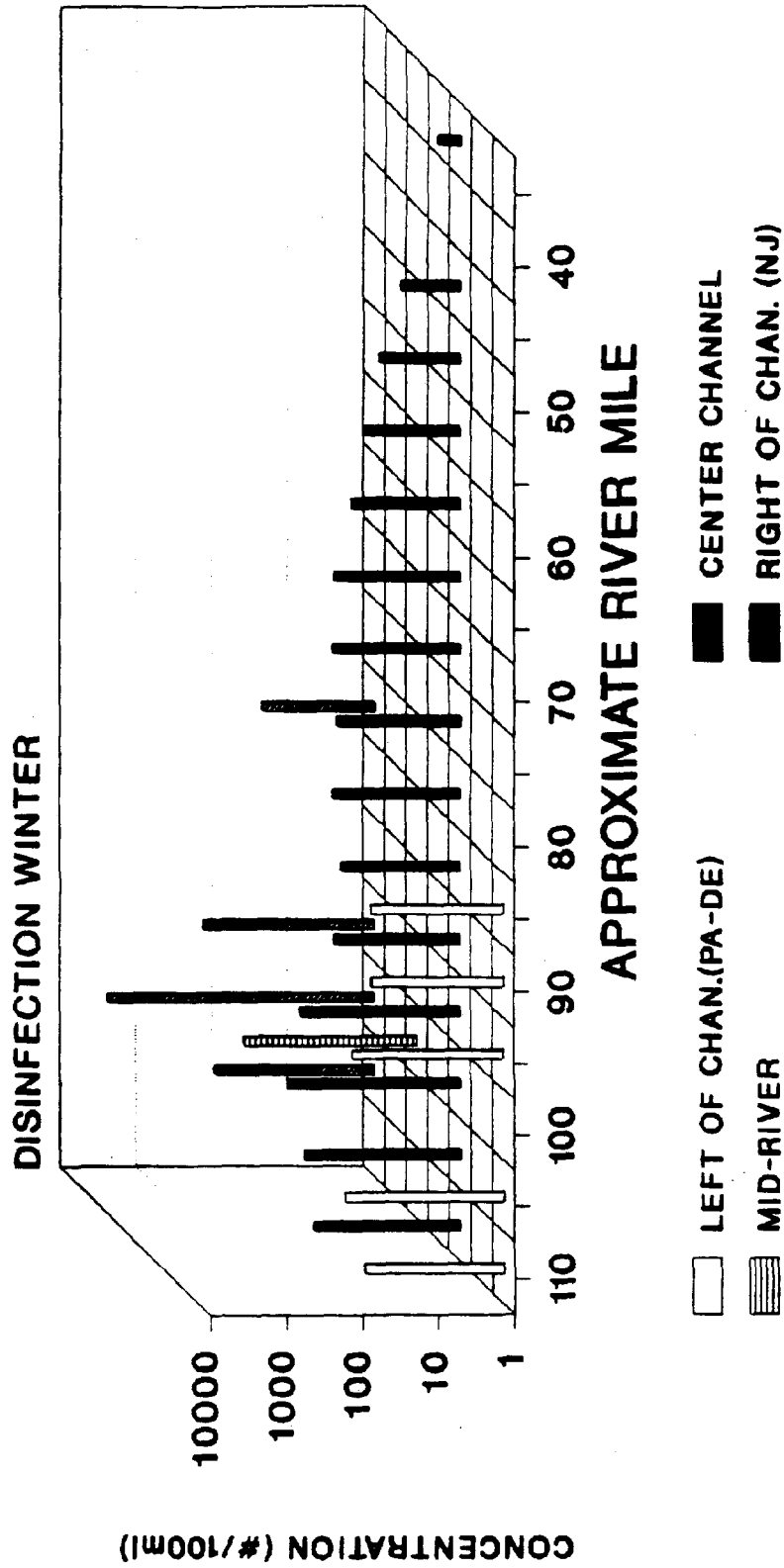
Graph 1.17A

GEOMETRIC MEAN E.COLI



Graph 1.17B

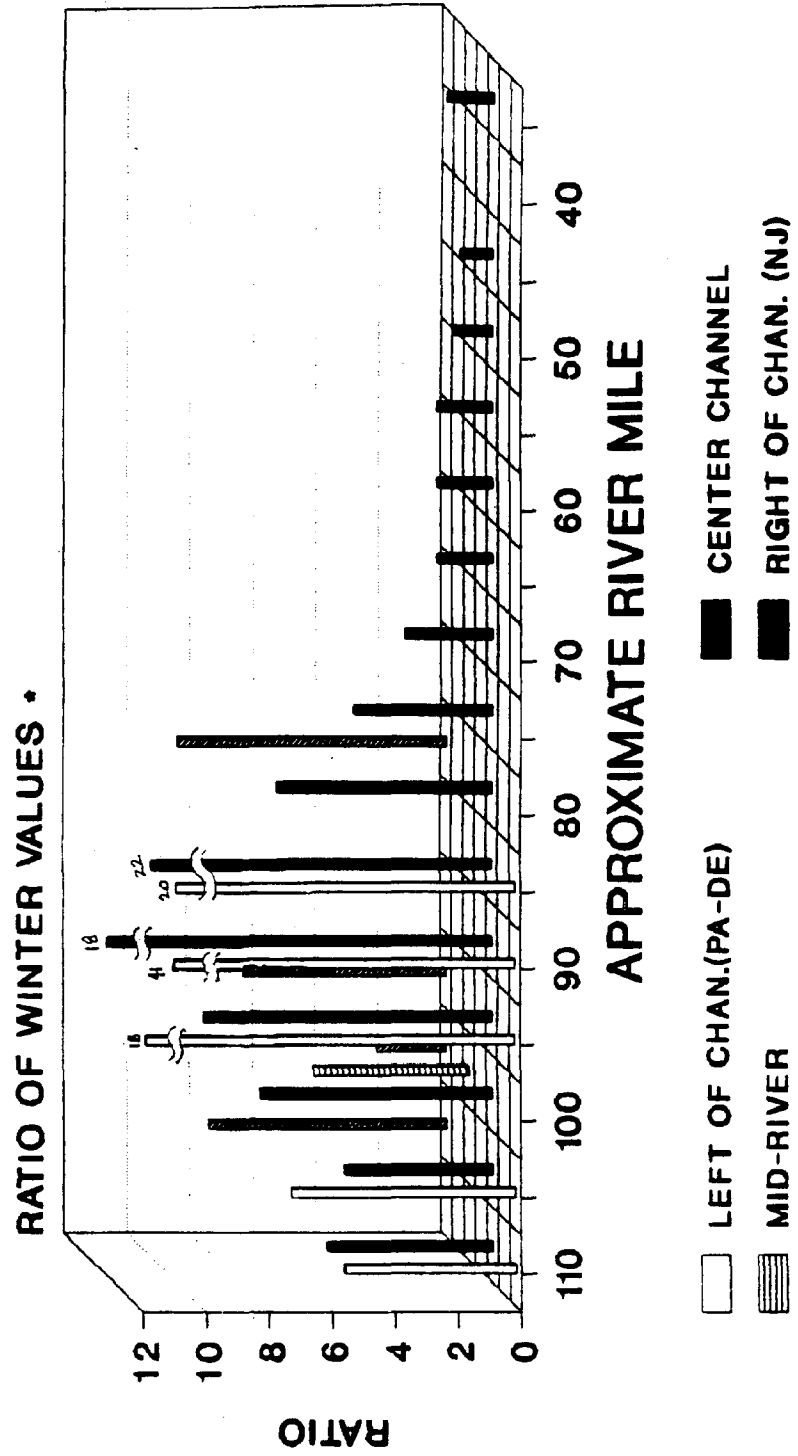
GEOMETRIC MEAN E. COLI



Graph 1.17B

Graph 1.17C

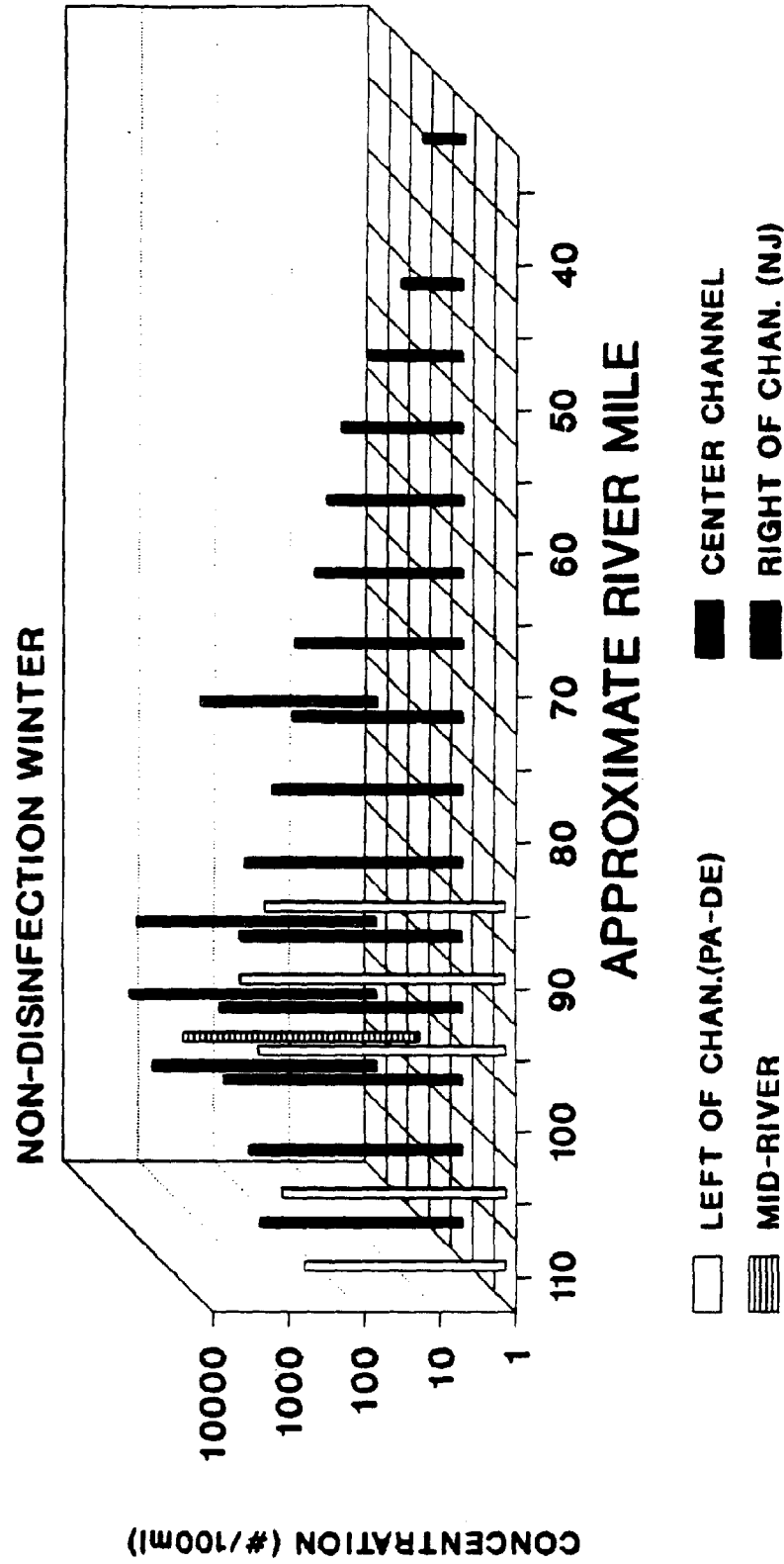
GEOMETRIC MEAN E. COLI



* NON-DISINFECT. WINTER / DISINFECT. WINTER

Graph 1.18A

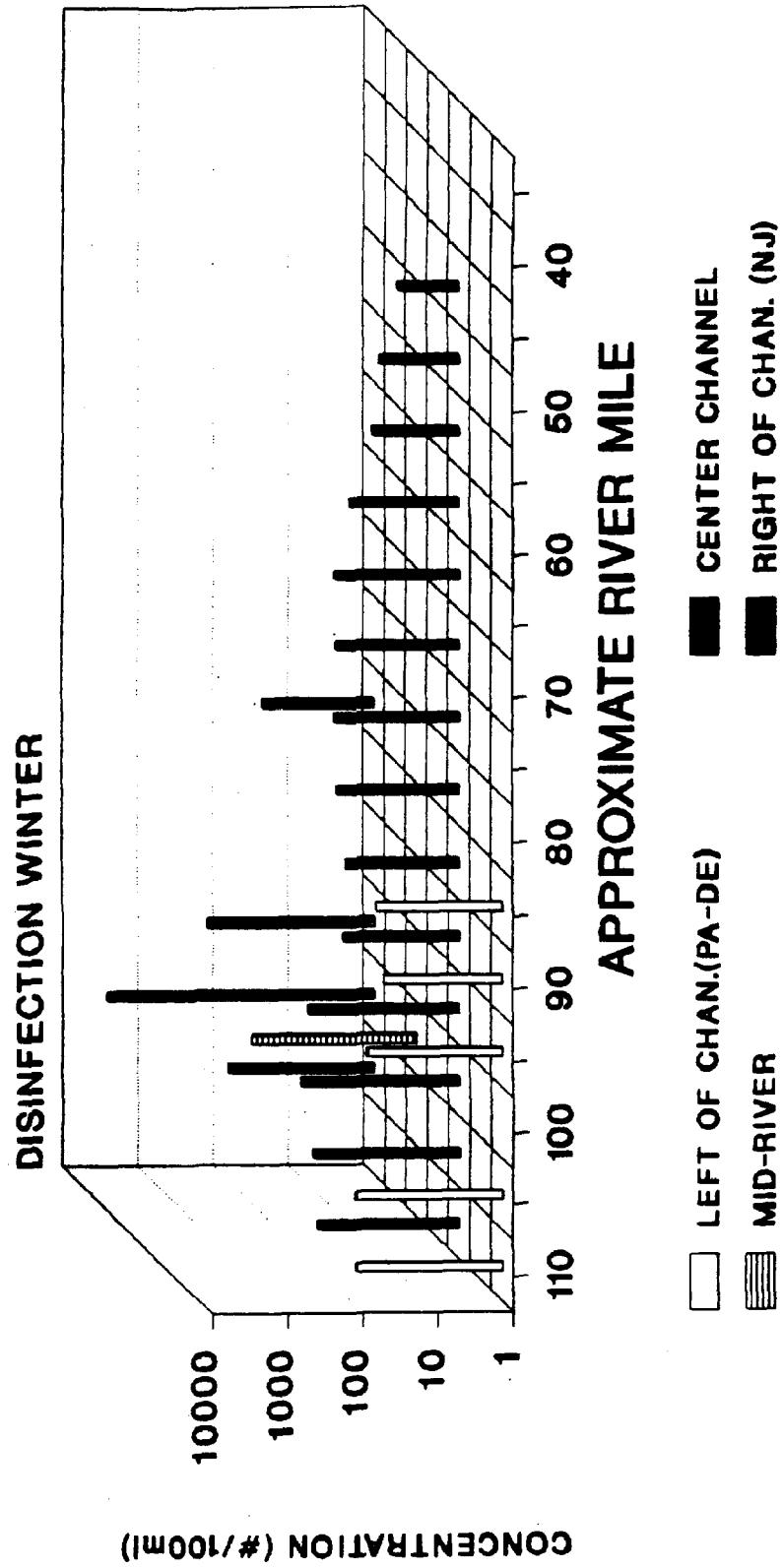
MEDIAN E. COLI



Graph 1.18A

MEDIAN E. COLI

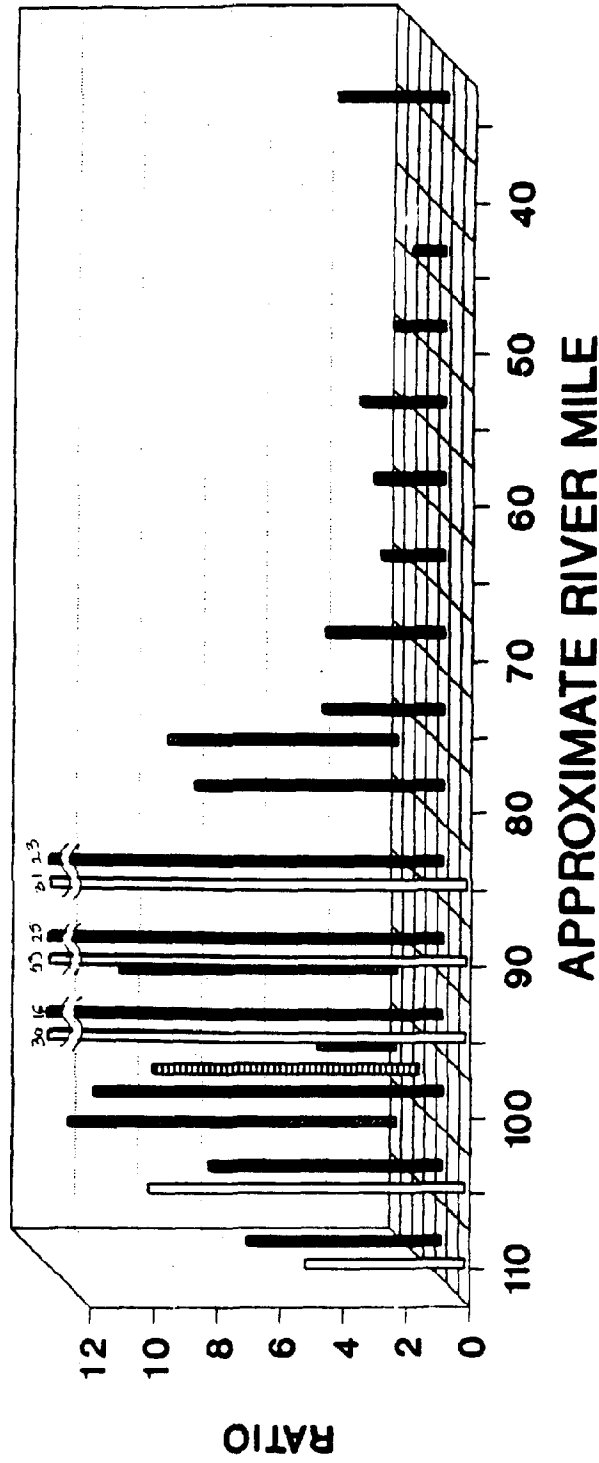
Graph 1.18B



Graph 1.18C

MEDIAN E. COLI

RATIO OF WINTER VALUES •



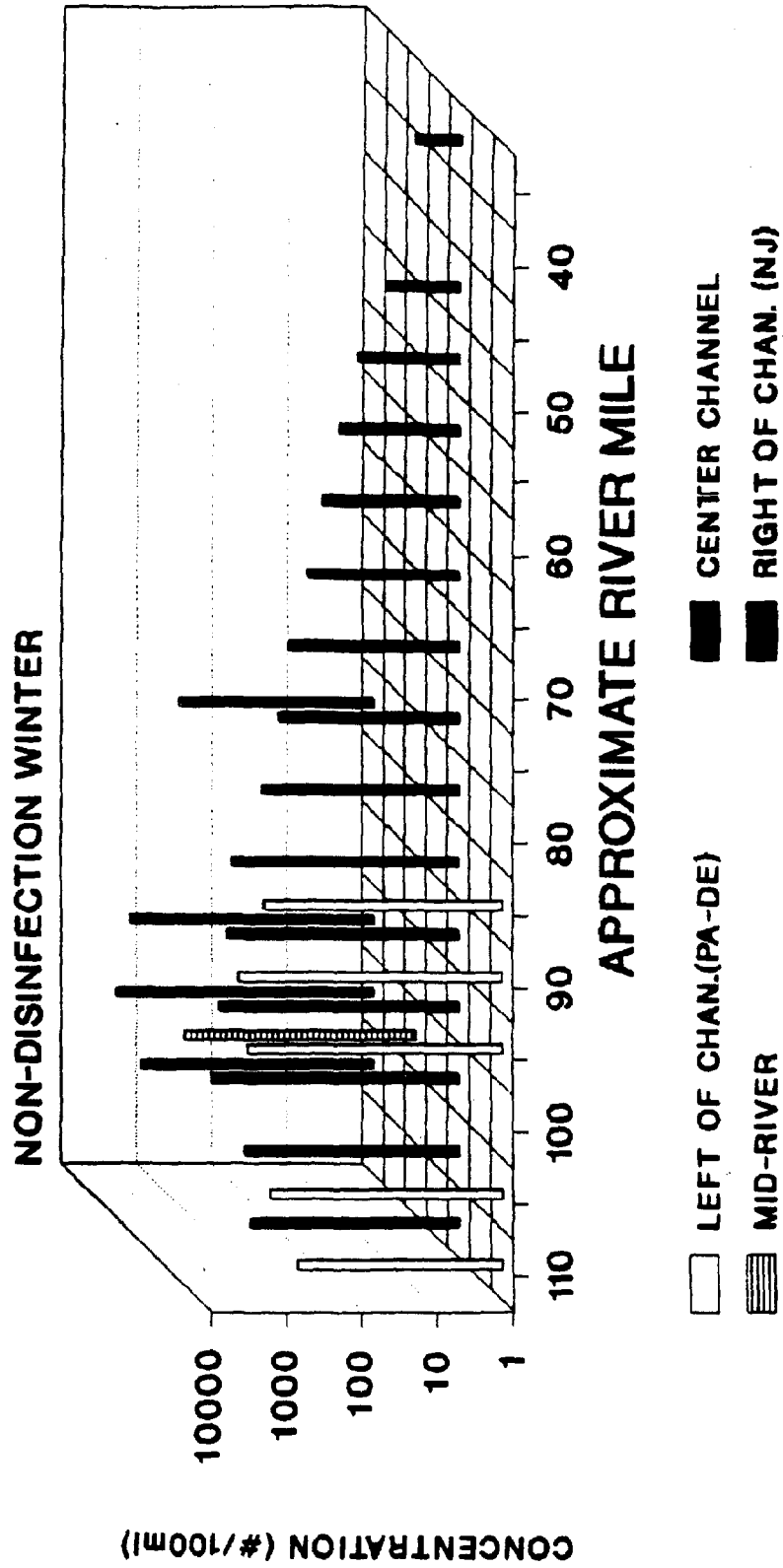
- LEFT OF CHAN.(PA-DE)
- MID-RIVER
- CENTER CHANNEL
- RIGHT OF CHAN. (NJ)

Graph 1.18C

* NON-DISINFECT.WINTER /DISINFECT.WINTER

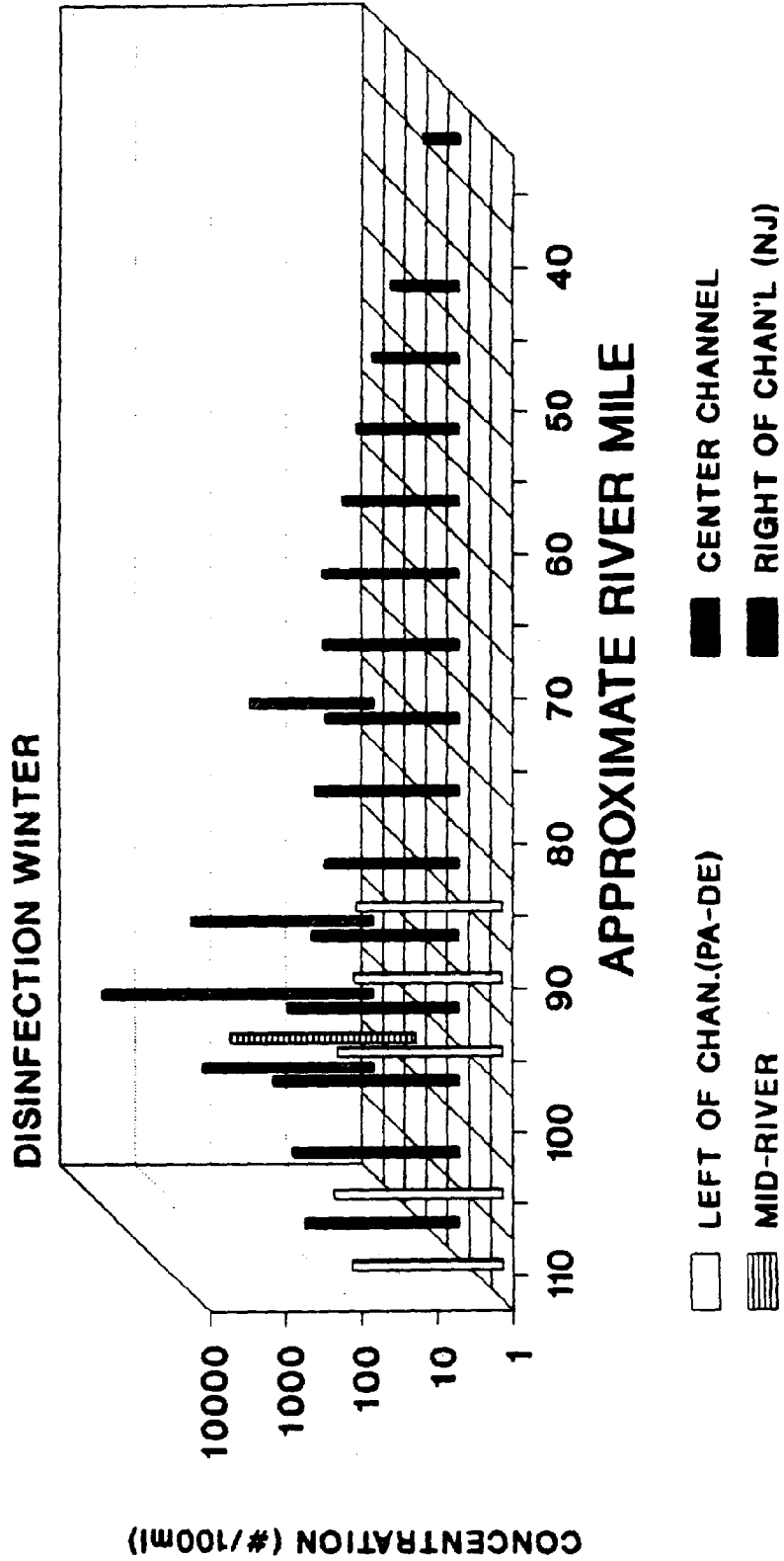
Graph 1.19A

GEOMETRIC MEAN FECAL COLIFORM (m-TEC)



Graph 1.19B

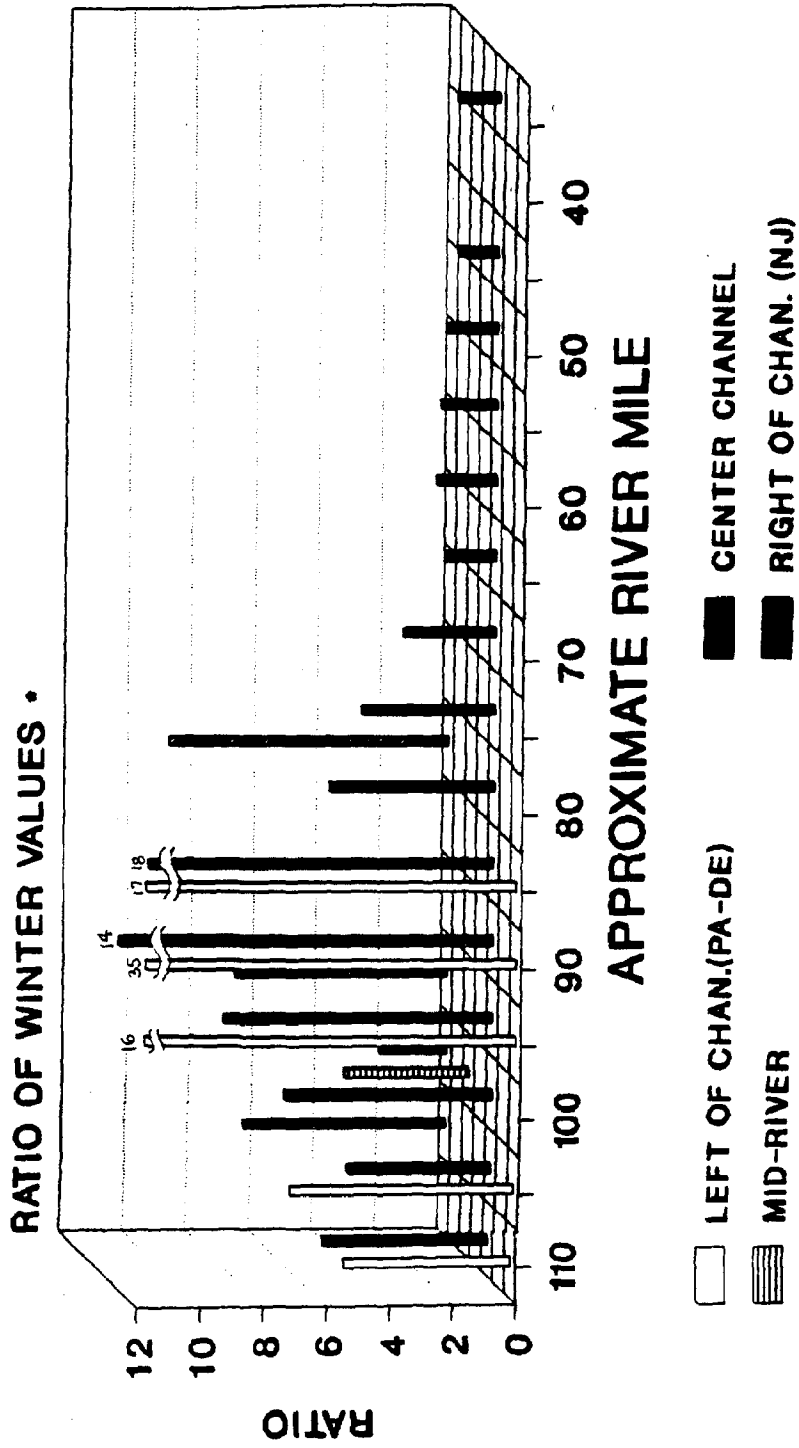
GEOMETRIC MEAN FECAL COLIFORM (m-TEC)



Graph 1.19B

Graph 1.19C

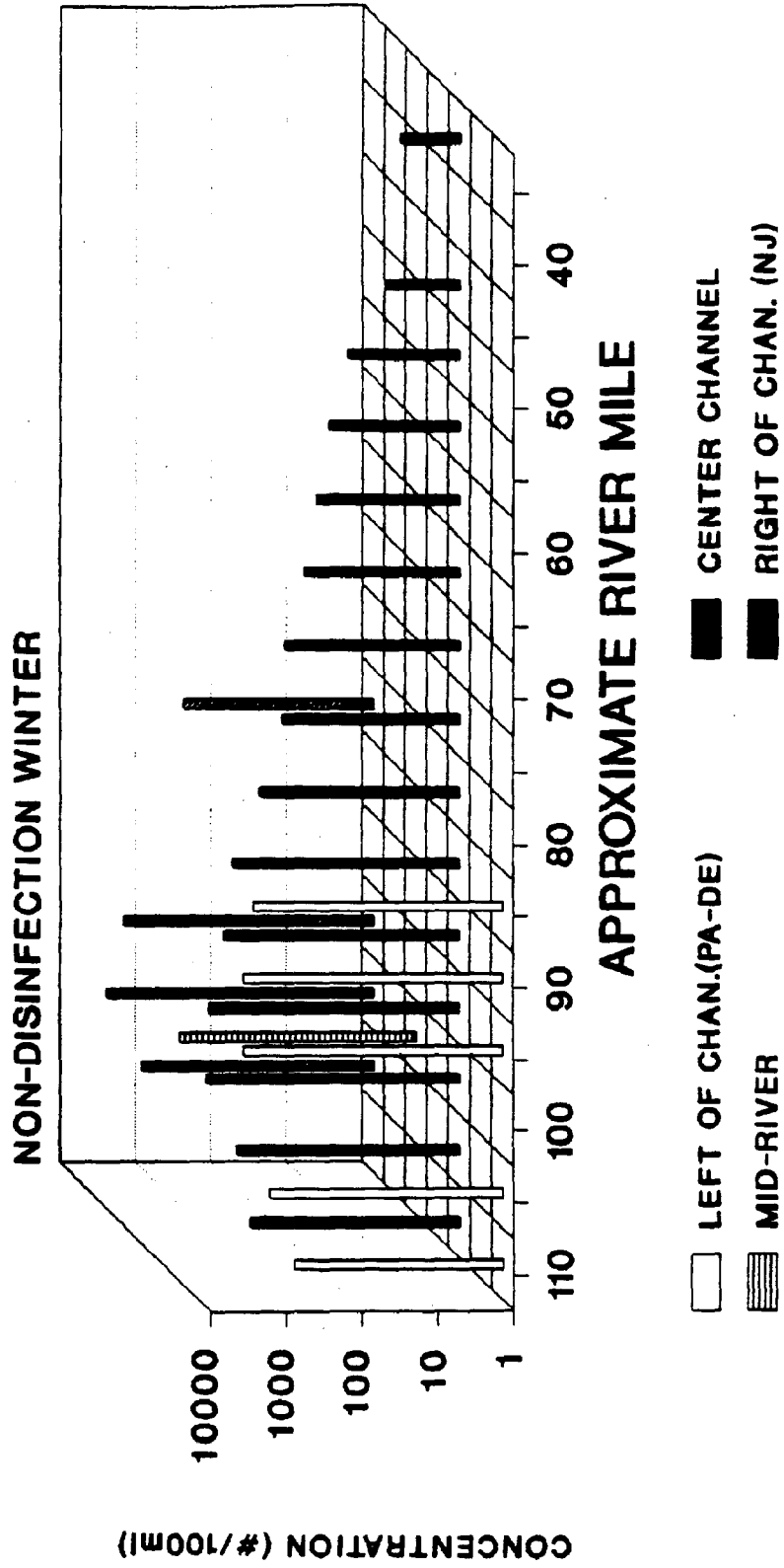
GEOMETRIC MEAN FECAL COLIFORM (m-TEC)



• NON-DISINFECT. WINTER / DISINFECT. WINTER

Graph 1.20A

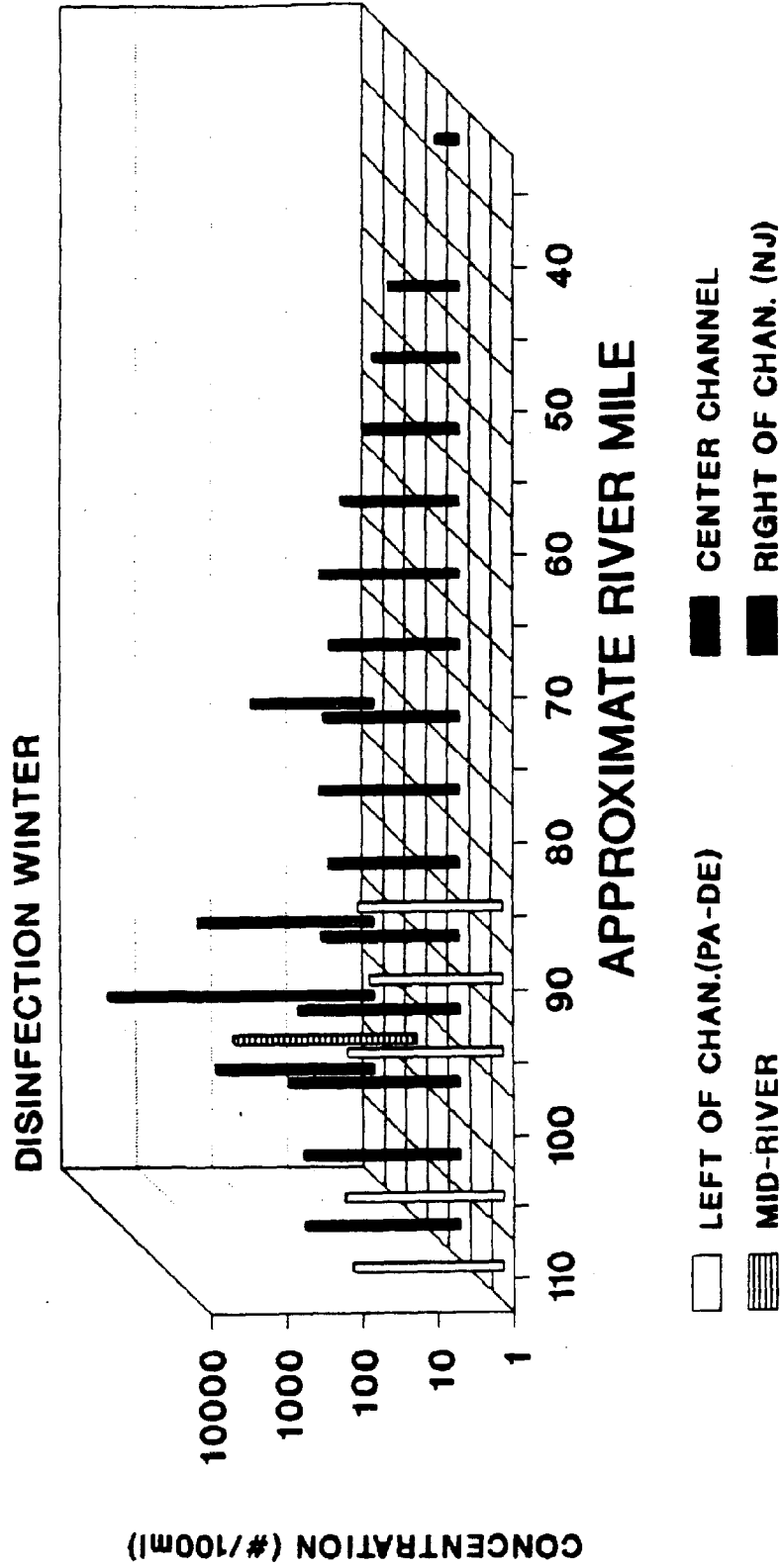
MEDIAN FECAL COLIFORM (m-TEC)



Graph 1.20A

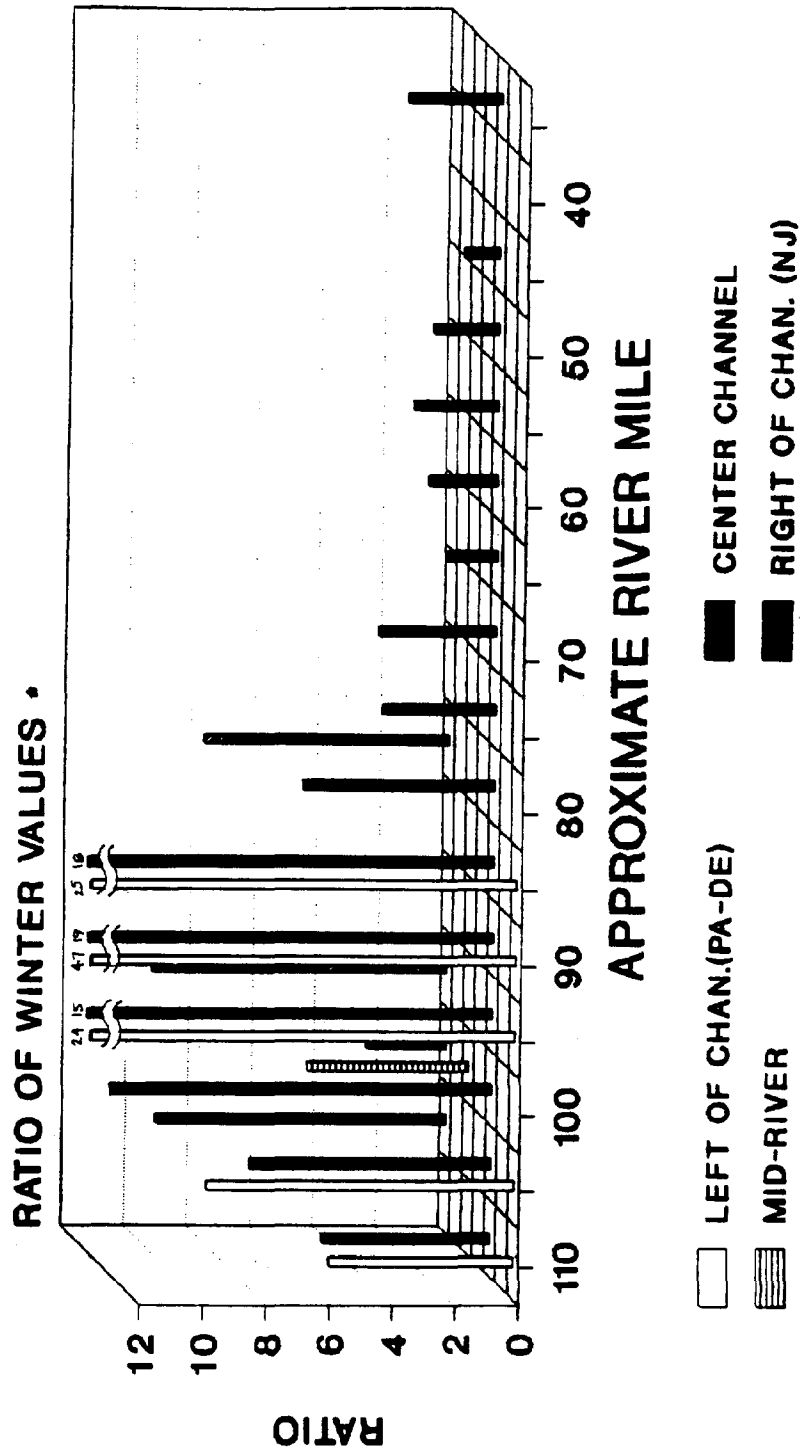
MEDIAN FECAL COLIFORM (m-TEC)

Graph 1.20B



Graph 1.20C

MEDIAN FECAL COLIFORM (m-TEC)



* NON-DISINFECT. WINTER / DISINFECT. WINTER

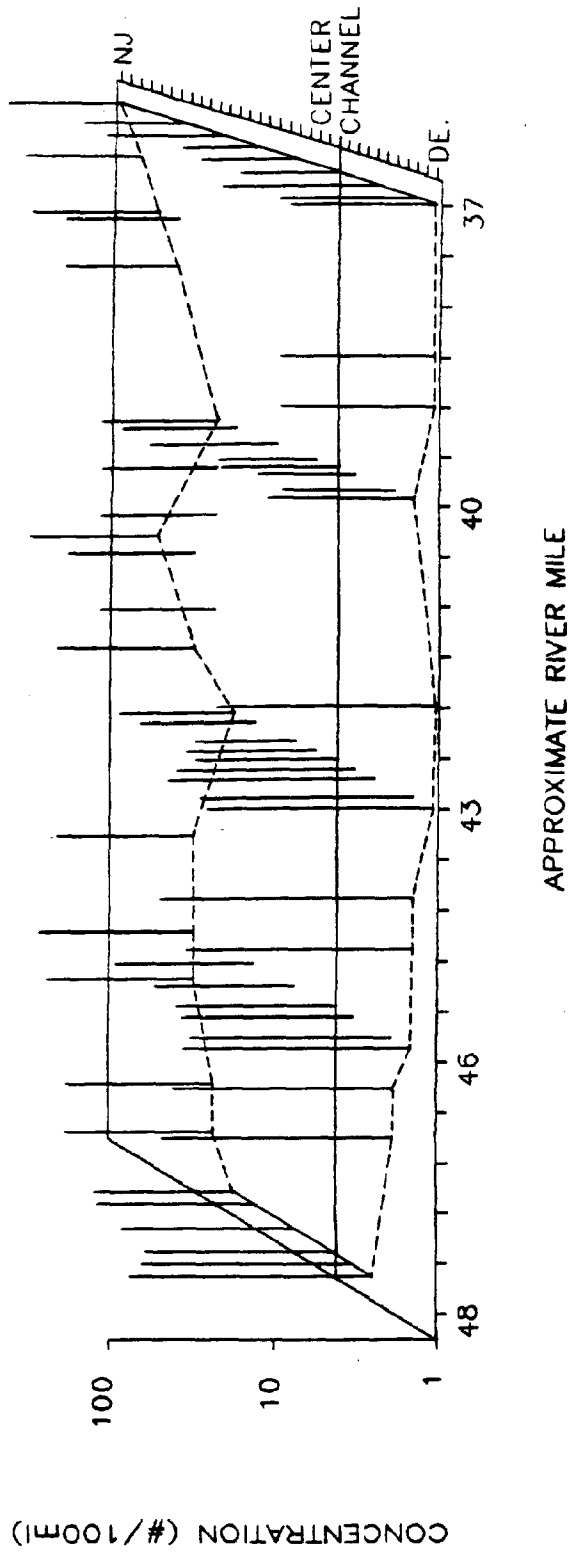
Graph 1.20C

Appendix II - Shellfish Area Data

Graph 2.1A	Geometric Mean	- Fecal Coliform (MPN)	- Non-disinfection Winter
Graph 2.1B	Geometric Mean	- Fecal Coliform (MPN)	- Disinfection Winter
Graph 2.1C	Geometric Mean	- Fecal Coliform (MPN)	- Ratio of Winter Values
Graph 2.2A	Median	- Fecal Coliform (MPN)	- Non-disinfection Winter
Graph 2.2B	Median	- Fecal Coliform (MPN)	- Disinfection Winter
Graph 2.2C	Median	- Fecal Coliform (MPN)	- Ratio of Winter Values
Graph 2.3A	Geometric Mean	- Total Coliform (MPN)	- Non-disinfection Winter
Graph 2.3B	Geometric Mean	- Total Coliform (MPN)	- Disinfection Winter
Graph 2.3C	Geometric Mean	- Total Coliform (MPN)	- Ratio of Winter Values
Graph 2.4A	Median	- Total Coliform (MPN)	- Non-disinfection Winter
Graph 2.4B	Median	- Total Coliform (MPN)	- Disinfection Winter
Graph 2.4C	Median	- Total Coliform (MPN)	- Ratio of Winter Values
Graph 2.5A	Geometric Mean	- Enterococcus	- Non-disinfection winter
Graph 2.5B	Geometric Mean	- Enterococcus	- Disinfection Winter
Graph 2.5C	Geometric Mean	- Enterococcus	- Ratio of Winter Values
Graph 2.6A	Median	- Enterococcus	- Non-Disinfection Winter
Graph 2.6B	Median	- Enterococcus	- Disinfection Winter
Graph 2.6C	Median	- Enterococcus	- Ratio of Winter Values
Graph 2.11A	Geometric Mean	- Fecal Coliform (MPN)	- Transect River Mile 48
Graph 2.11B	Geometric Mean	- Fecal Coliform (MPN)	- Transect River Mile 46
Graph 2.11C	Geometric Mean	- Fecal Coliform (MPN)	- Transect River Mile 43
Graph 2.11D	Geometric Mean	- Fecal Coliform (MPN)	- Transect River Mile 40
Graph 2.11E	Geometric Mean	- Fecal Coliform (MPN)	- Transect River Mile 37
Graph 2.11F	Geometric Mean	- Fecal Coliform (MPN)	- Center Channel Profile
Graph 2.11G	Geometric Mean	- Fecal Coliform (MPN)	- N.J.(East) Shore Profile
Graph 2.11H	Geometric Mean	- Fecal Coliform (MPN)	- Delaware (West) Shore Profile
Graph 2.12A	Median	- Fecal Coliform (MPN)	- Transect River Mile 48
Graph 2.12B	Median	- Fecal Coliform (MPN)	- Transect River Mile 46
Graph 2.12C	Median	- Fecal Coliform (MPN)	- Transect River Mile 43
Graph 2.12D	Median	- Fecal Coliform (MPN)	- Transect River Mile 40
Graph 2.12E	Median	- Fecal Coliform (MPN)	- Transect River Mile 37
Graph 2.12F	Median	- Fecal Coliform (MPN)	- Center Channel Profile
Graph 2.12G	Median	- Fecal Coliform (MPN)	- N.J. (East) Shore Profile
Graph 2.12H	Median	- Fecal Coliform (MPN)	- Delaware (West) Shore Profile
Graph 2.13A	Geometric Mean	- Total Coliform (MPN)	- Transect River Mile 48
Graph 2.13B	Geometric Mean	- Total Coliform (MPN)	- Transect River Mile 46
Graph 2.13C	Geometric Mean	- Total Coliform (MPN)	- Transect River Mile 43
Graph 2.13D	Geometric Mean	- Total Coliform (MPN)	- Transect River Mile 40
Graph 2.13E	Geometric Mean	- Total Coliform (MPN)	- Transect River Mile 37
Graph 2.13F	Geometric Mean	- Total Coliform (MPN)	- Center Channel Profile
Graph 2.13G	Geometric Mean	- Total Coliform (MPN)	- N.J. (East) Shore Profile
Graph 2.13H	Geometric Mean	- Total Coliform (MPN)	- Delaware (West) Shore Profile
Graph 2.14A	Median	- Total Coliform (MPN)	- Transect River Mile 48
Graph 2.14B	Median	- Total Coliform (MPN)	- Transect River Mile 46
Graph 2.14C	Median	- Total Coliform (MPN)	- Transect River Mile 43
Graph 2.14D	Median	- Total Coliform (MPN)	- Transect River Mile 40
Graph 2.14E	Median	- Total Coliform (MPN)	- Transect River Mile 37
Graph 2.14F	Median	- Total Coliform (MPN)	- Center Channel Profile
Graph 2.14G	Median	- Total Coliform (MPN)	- N.J. (East) Shore Profile
Graph 2.14H	Median	- Total Coliform (MPN)	- Delaware (West) Shore Profile

Graph 2.1A

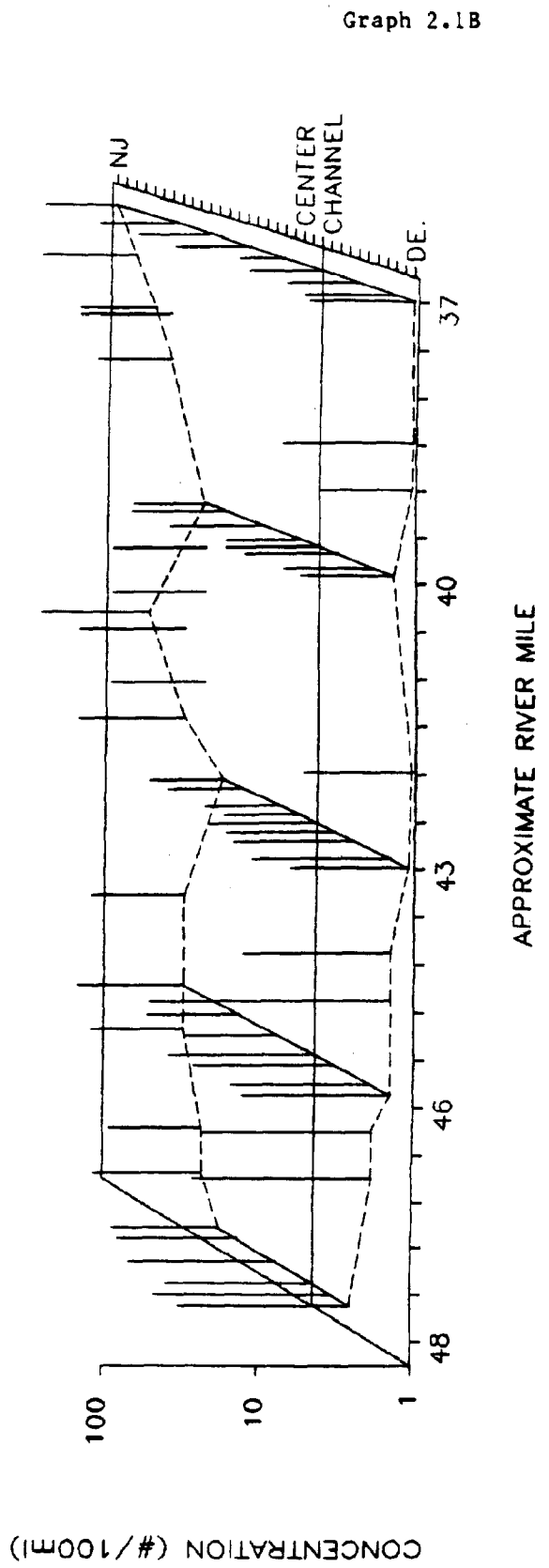
GEOMETRIC MEAN
FECAL COLIFORM (MPN)
NON-DISINFECTION WINTER



Graph 2.1A

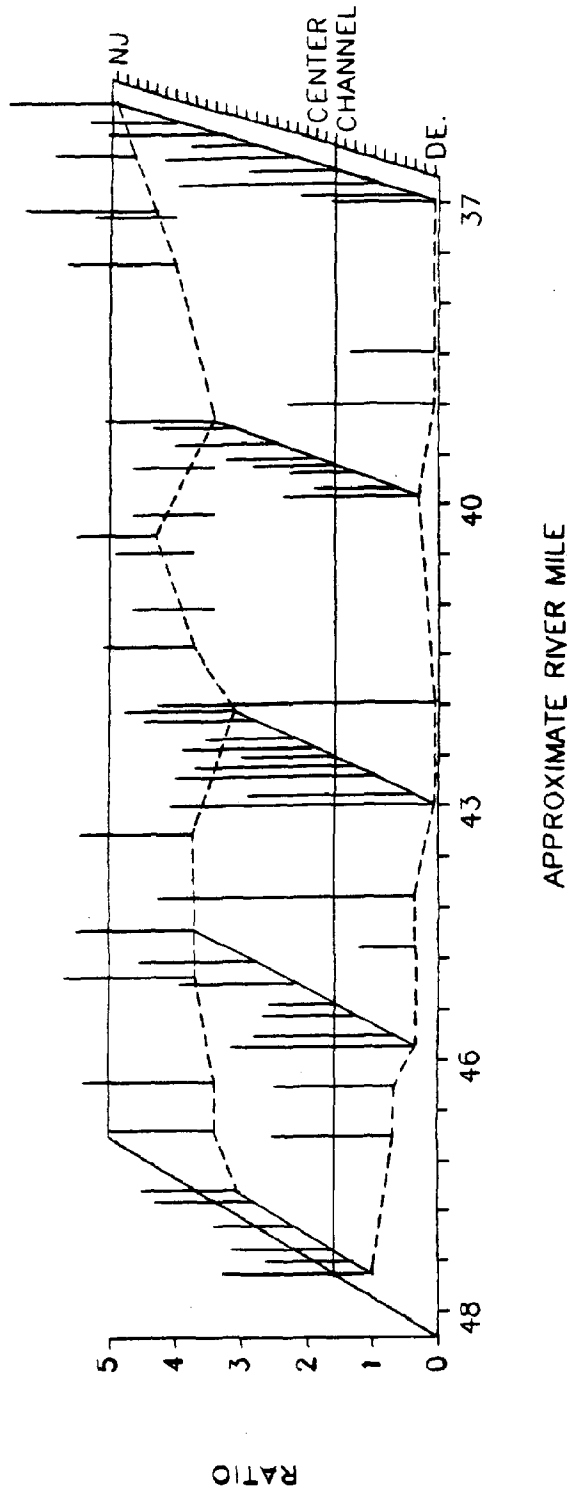
GEOMETRIC MEAN
FECAL COLIFORM (MPN)
DISINFECTION WINTER

Graph 2.1B



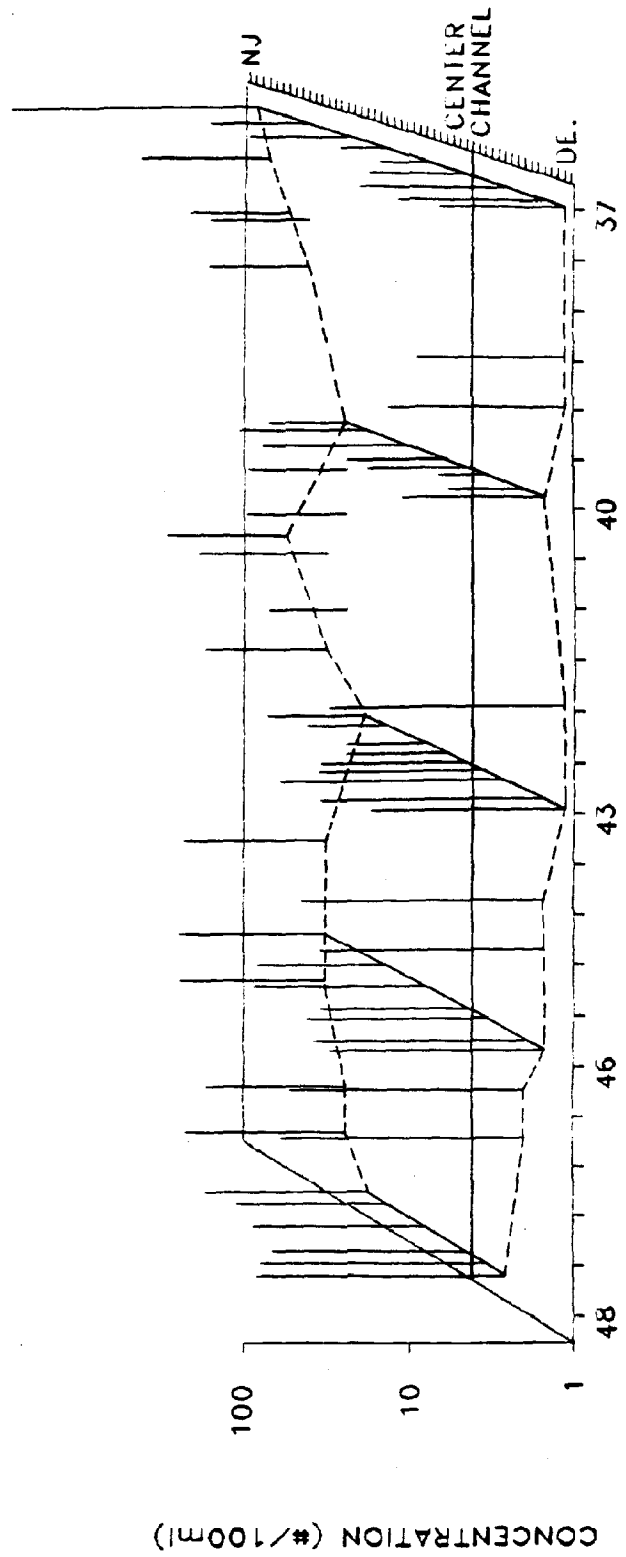
GEOMETRIC MEAN
FECAL COLIFORM (MPN)
RATIO OF WINTER VALUES

Graph 2.1C



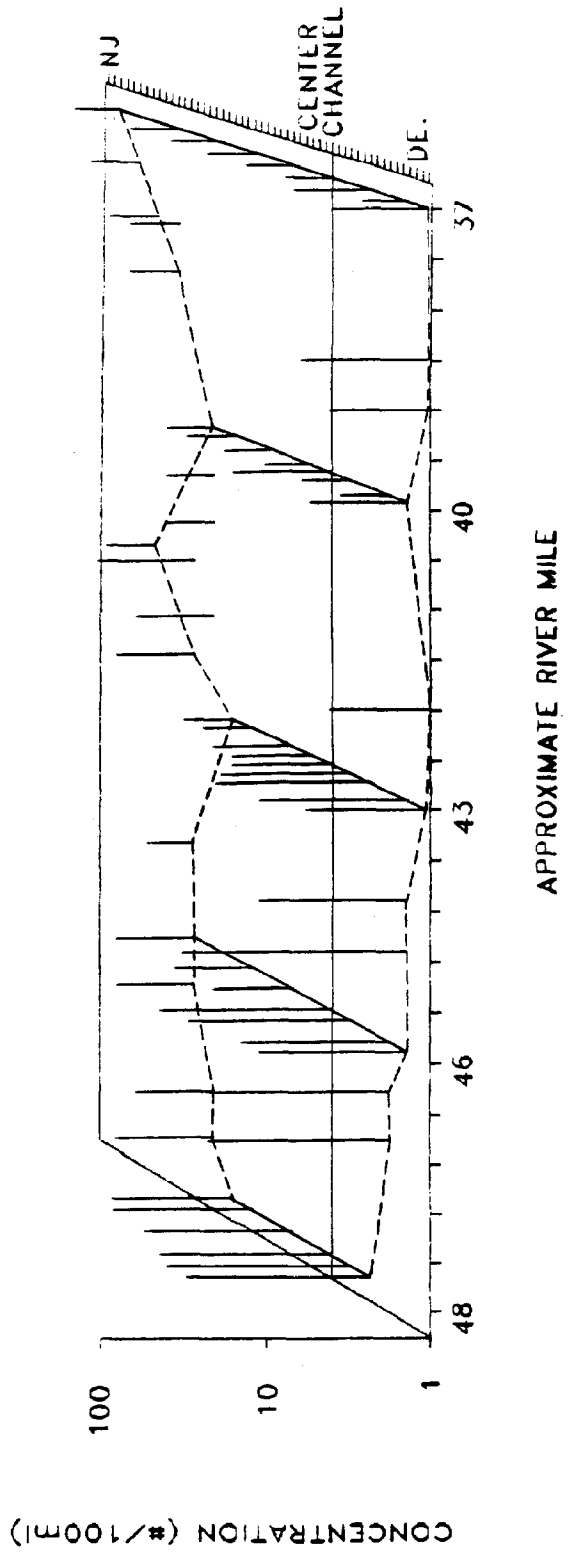
MEDIAN
FECAL COLIFORM (MPN)
NON-DISINFECTION WINTER

Graph 2.2A

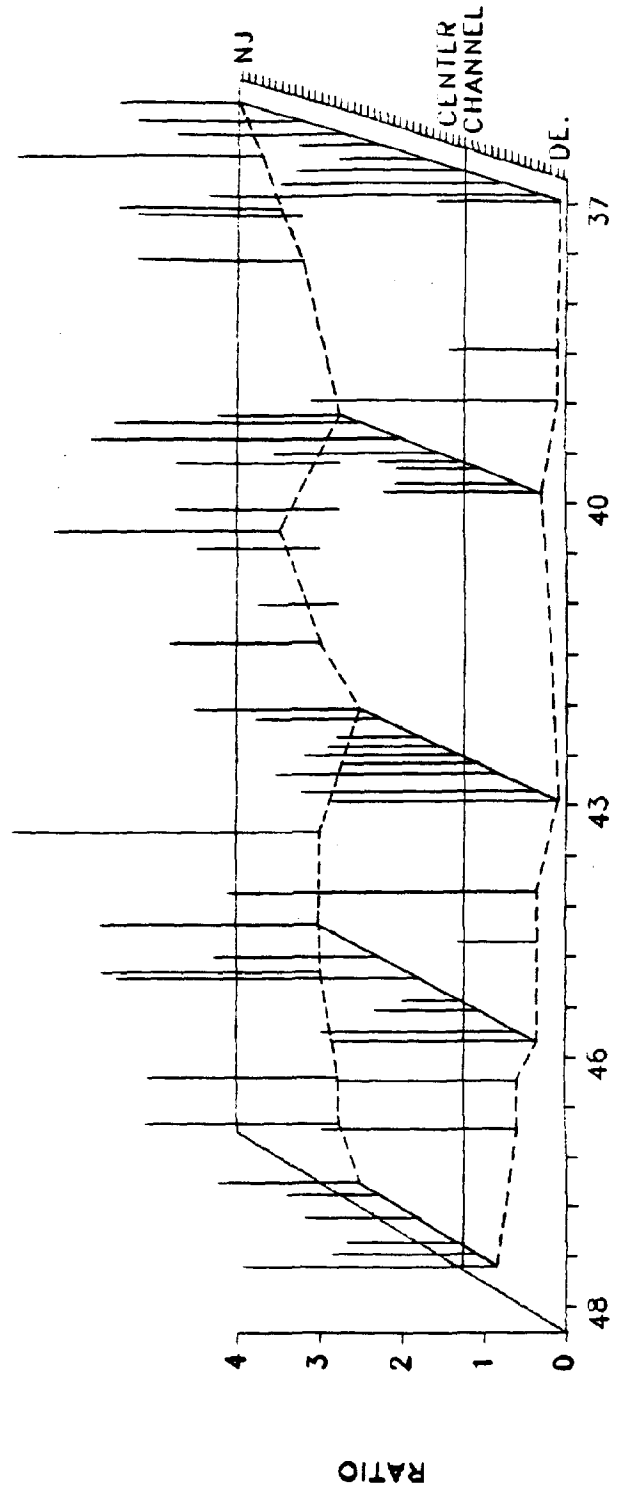


MEDIAN
FECAL COLIFORM (MPN)
DISINFECTION WINTER

Graph 2.2B

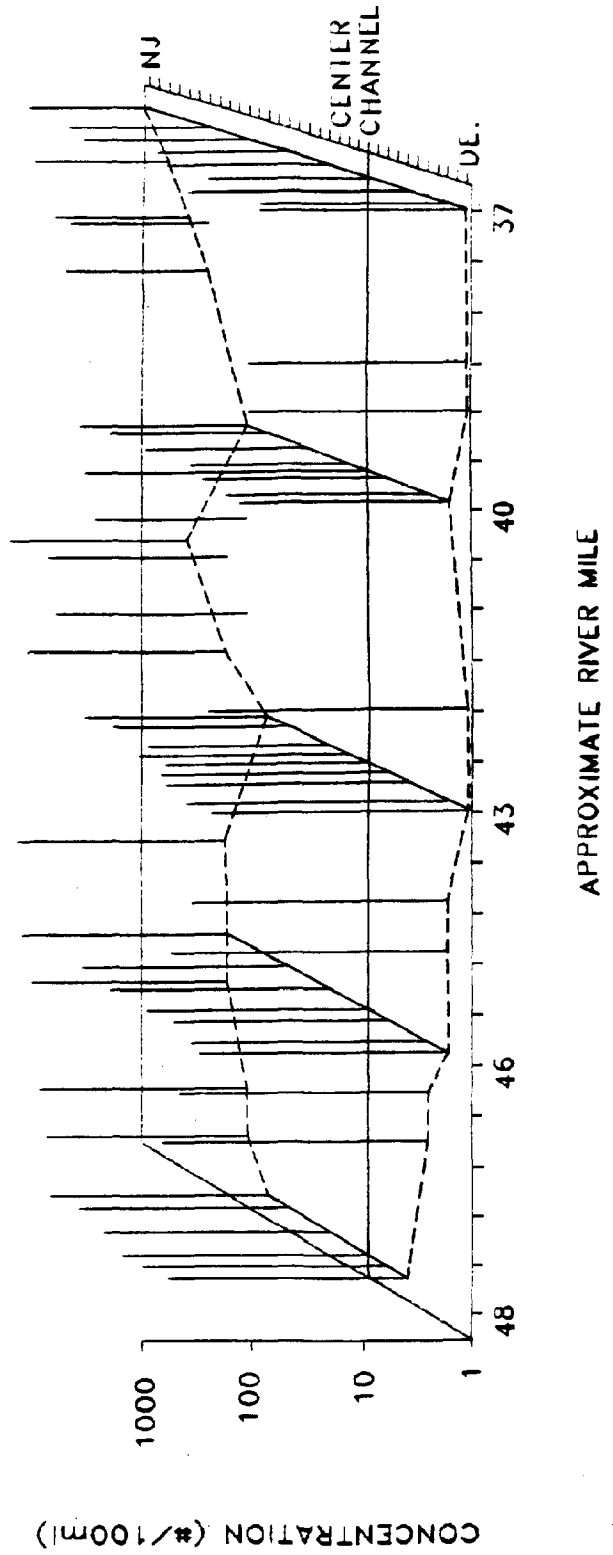


MEDIAN
FECAL COLIFORM (MPN)
RATIO OF WINTER VALUES



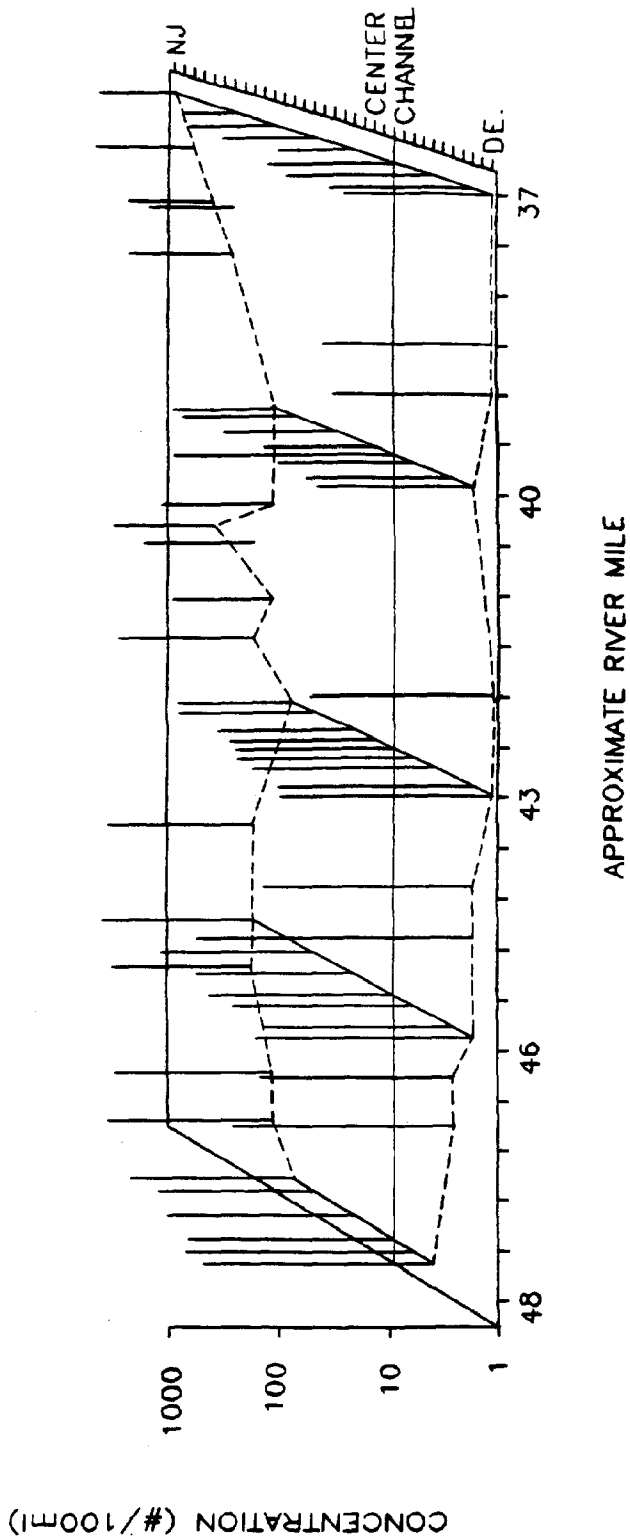
GEOMETRIC MEAN
TOTAL COLIFORM (MPN)
NON-DISINFECTION WINTER

Graph 2.3A



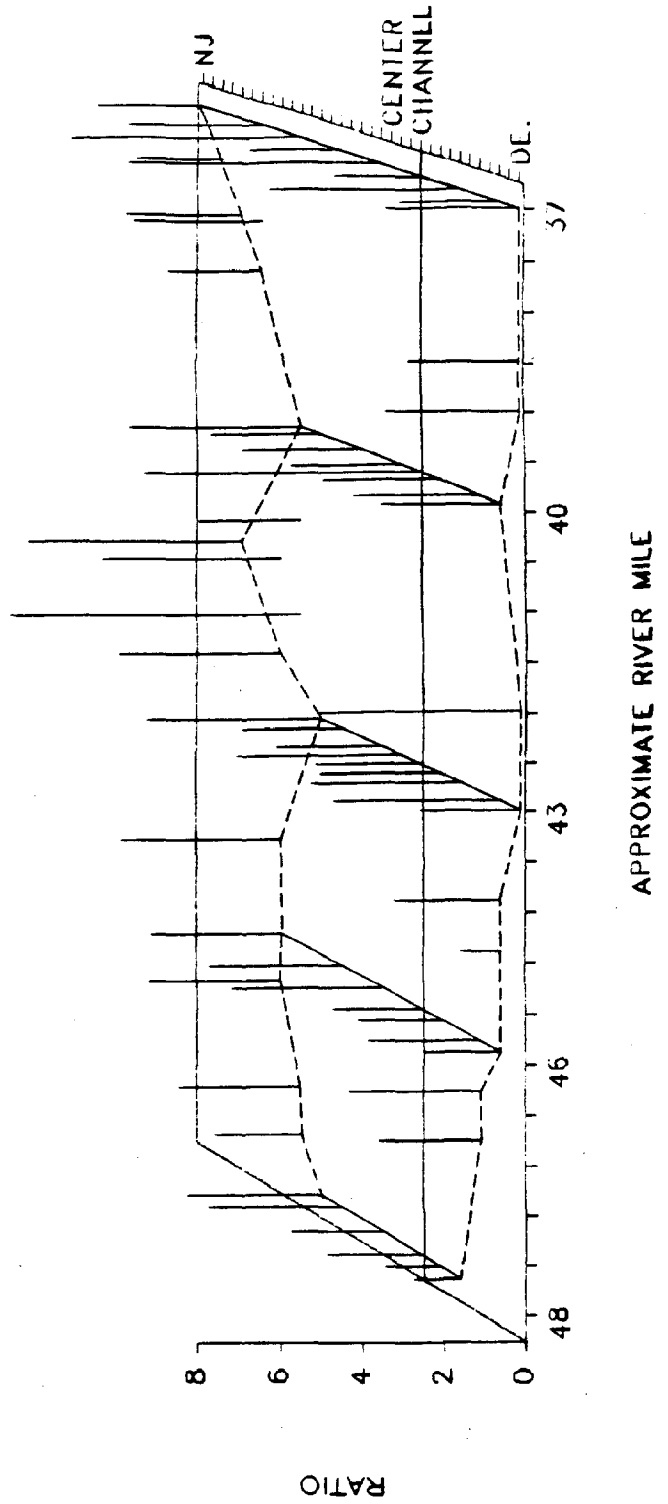
GEOMETRIC MEAN
TOTAL COLIFORM (MPN)
DISINFECTION WINTER

Graph 2.3B



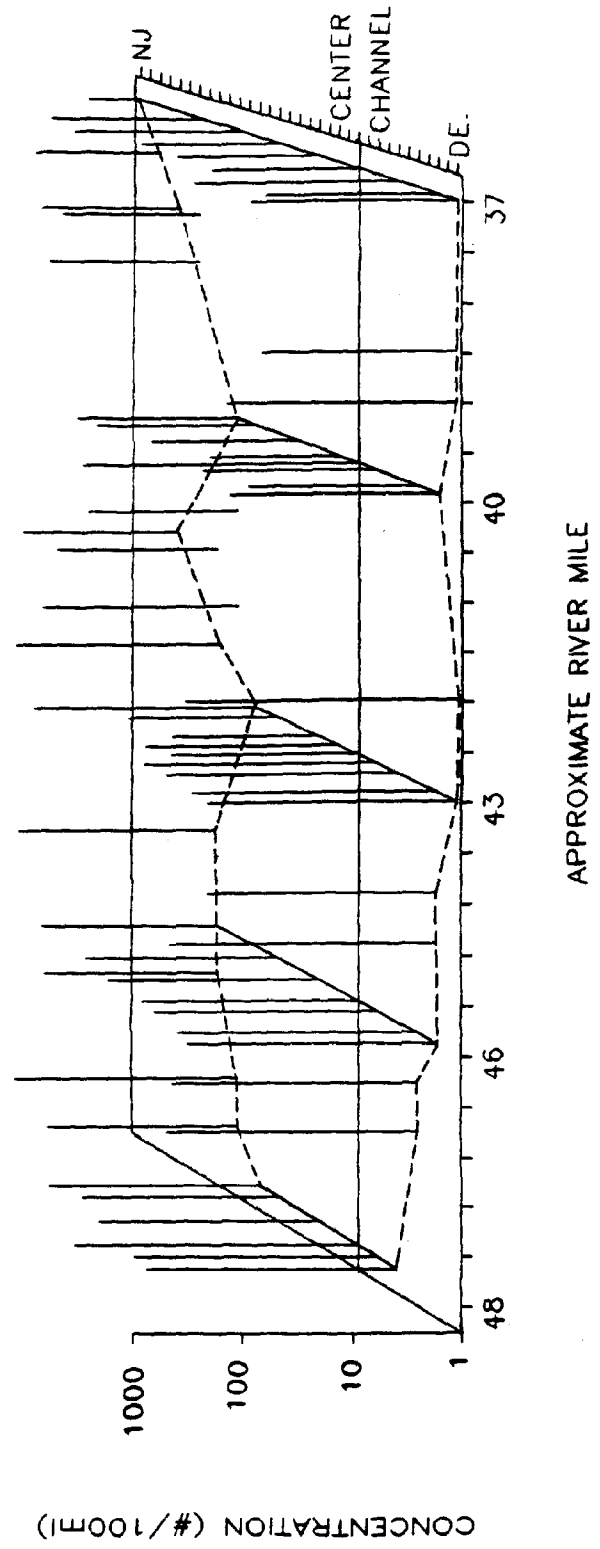
GEOMETRIC MEAN
TOTAL COLIFORM (MPN)
RATIO OF WINTER VALUES

Graph 2.3C



MEDIAN
TOTAL COLIFORM (MPN)
NON-DISINFECTION WINTER

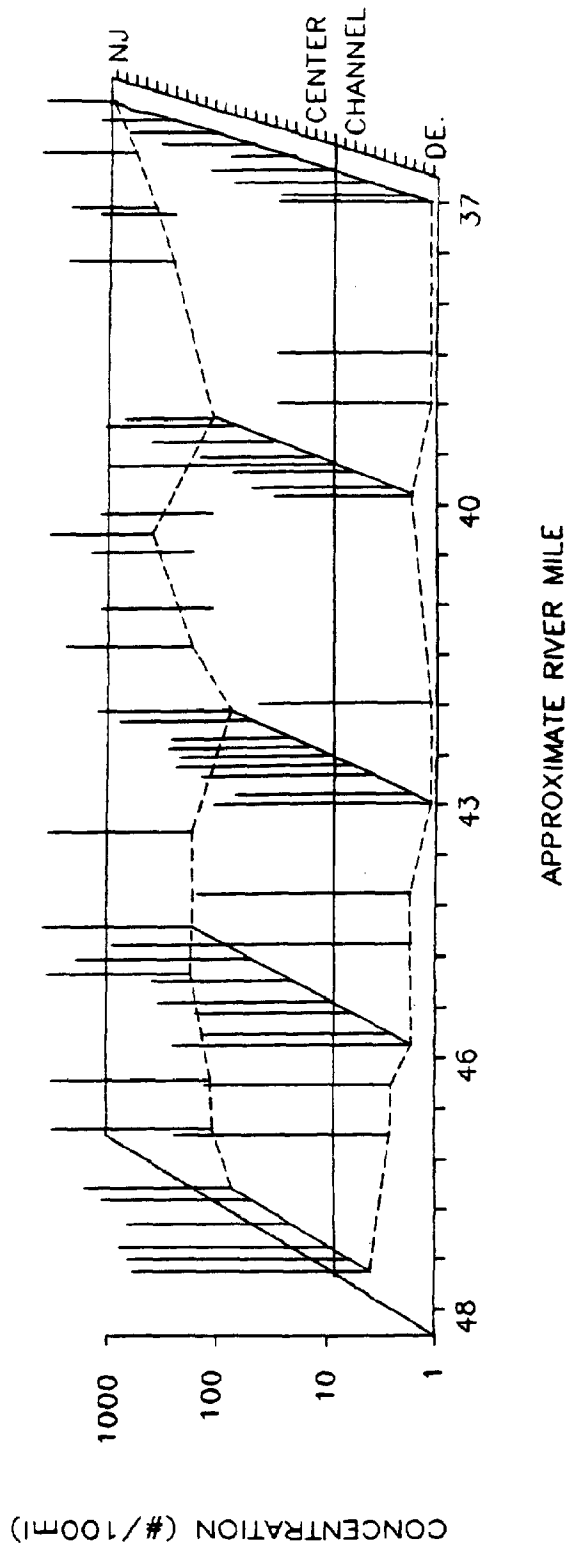
Graph 2.4A



Graph 2.4A

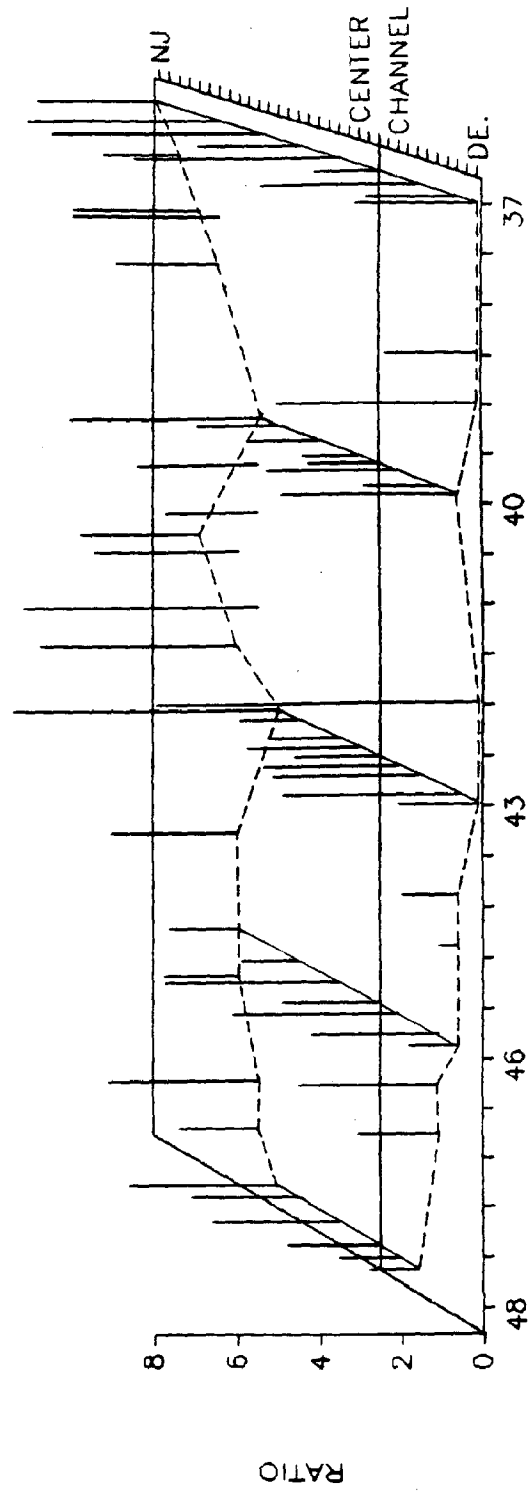
Graph 2.4B

MEDIAN
TOTAL COLIFORM (MPN)
DISINFECTION WINTER



MEDIAN
TOTAL COLIFORM (MPN)
RATIO OF WINTER VALUES

Graph 2.4C

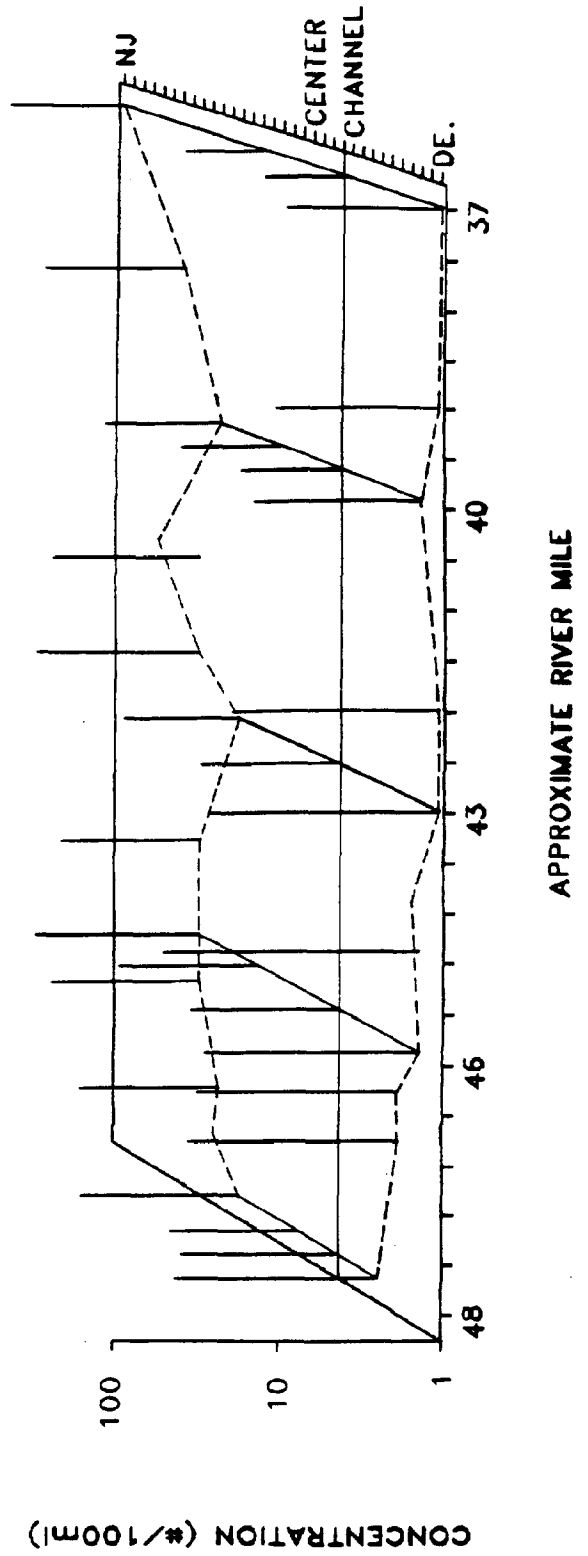


Graph 2.4C

APPROXIMATE RIVER MILE

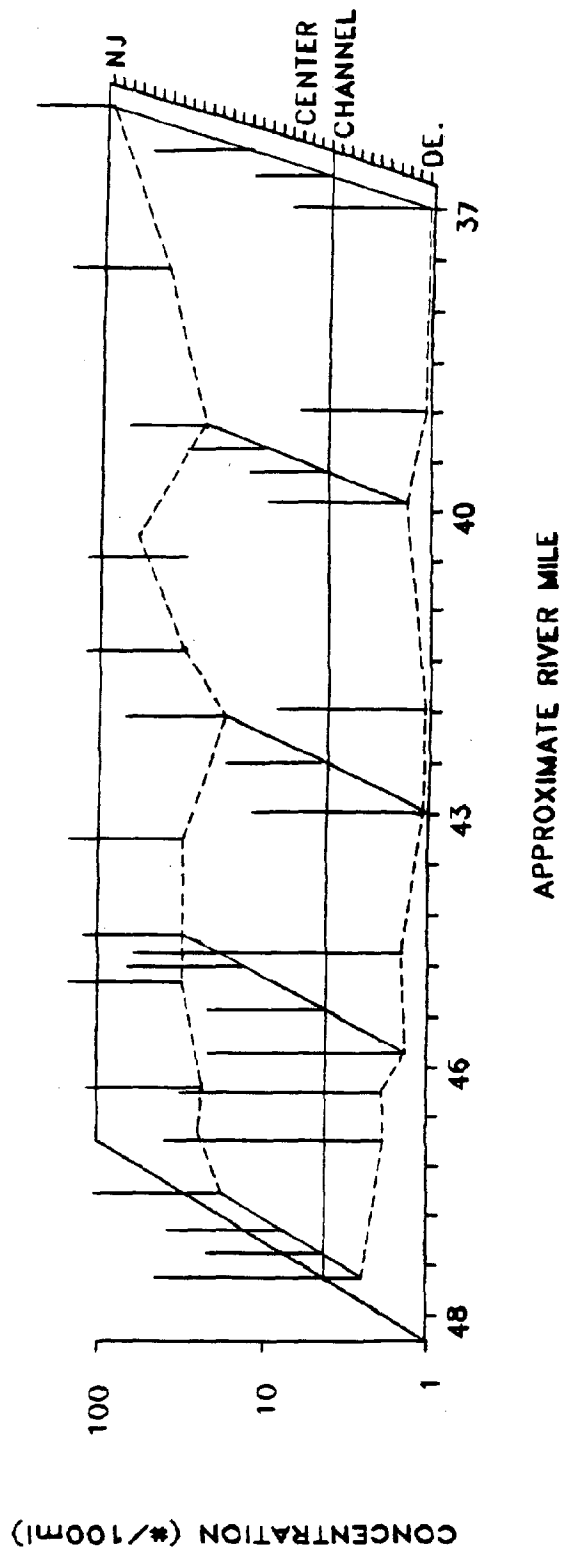
GEOMETRIC MEAN
ENTEROCOCCUS
NON-DISINFECTION WINTER

Graph 2.5A



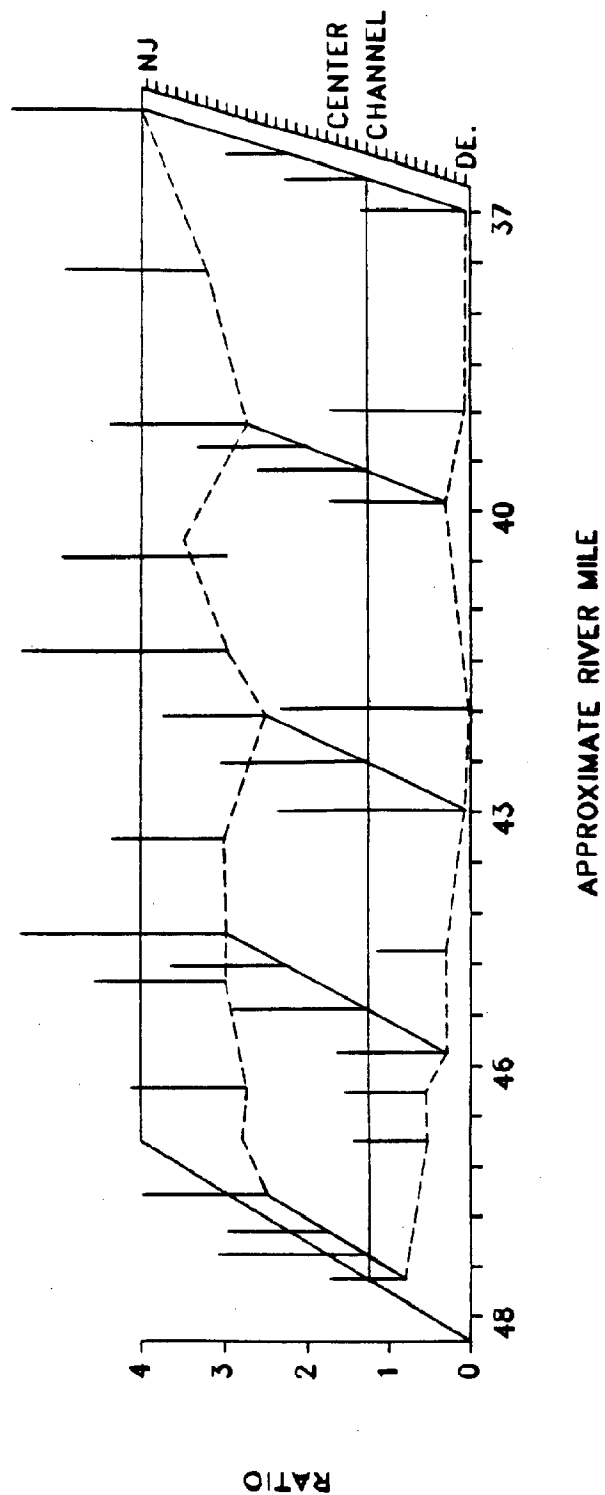
GEOMETRIC MEAN
ENTEROCOCCUS
DISINFECTION WINTER

Graph 2.5B



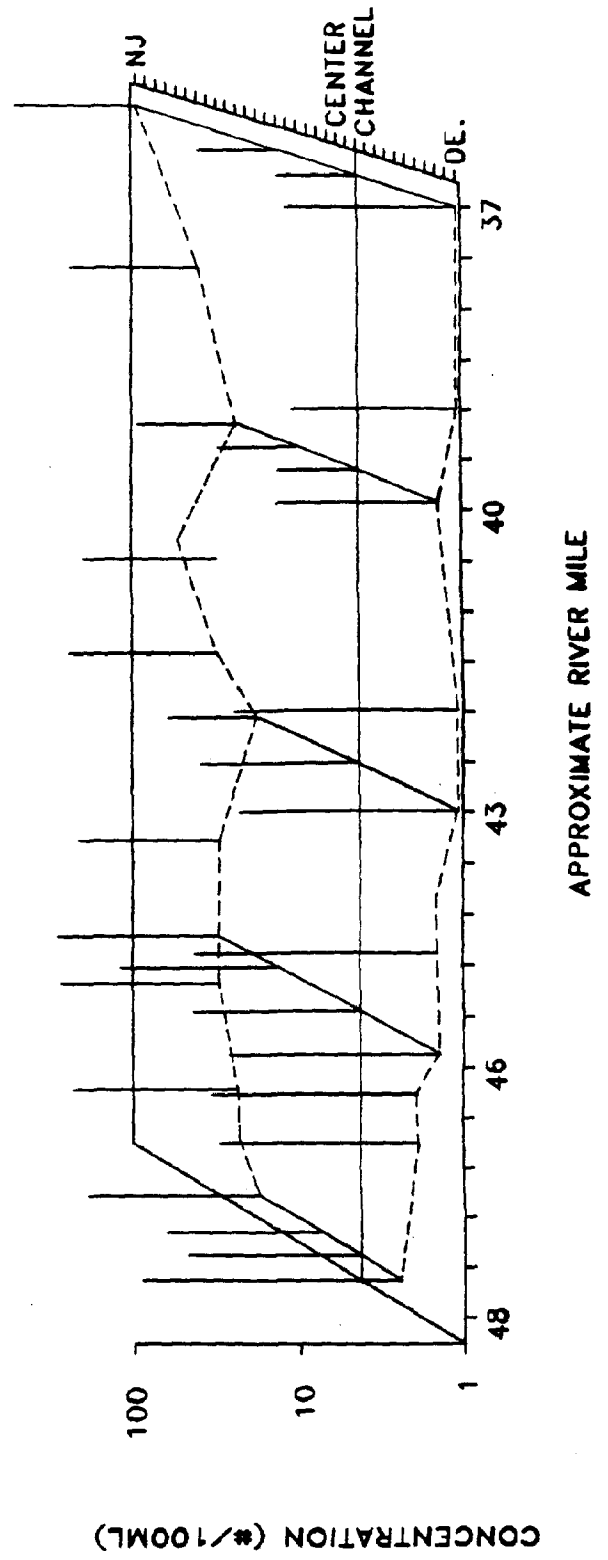
GEOMETRIC MEAN
ENTEROCOCCUS
RATIO OF WINTER VALUES

Graph 2.5C



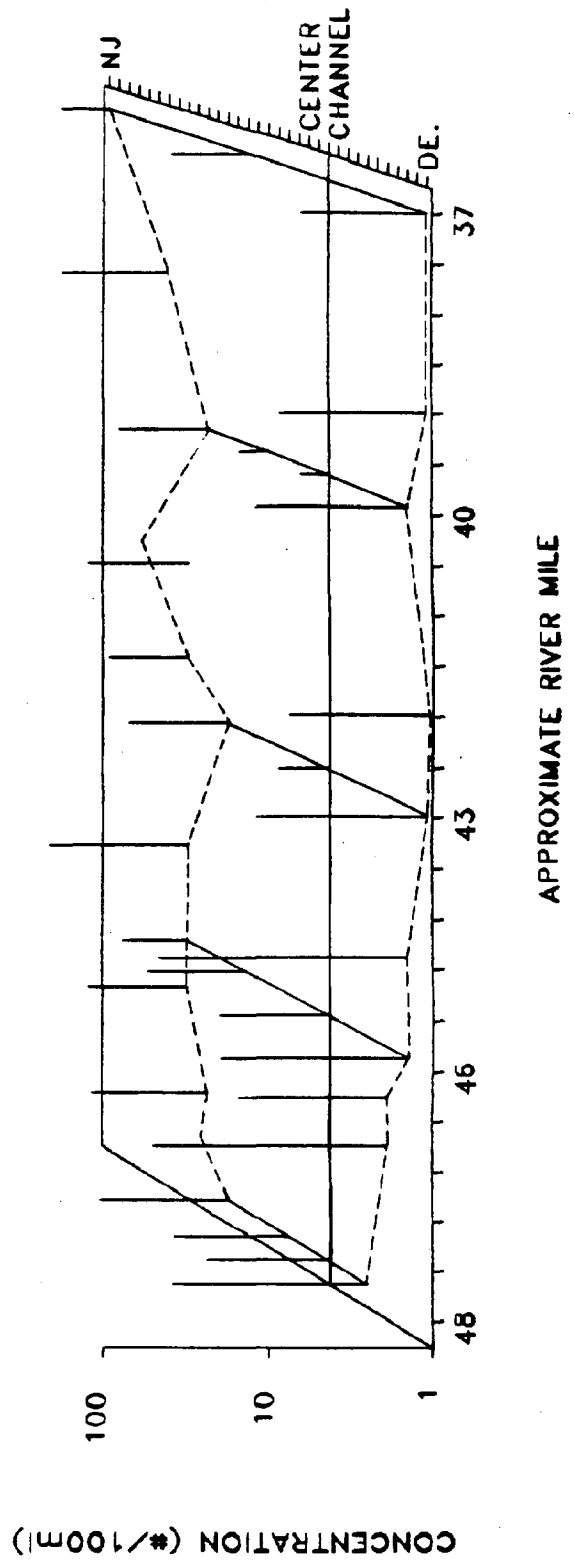
MEDIAN
ENTEROCOCCUS
NON-DISINFECTION WINTER

Graph 2.6A



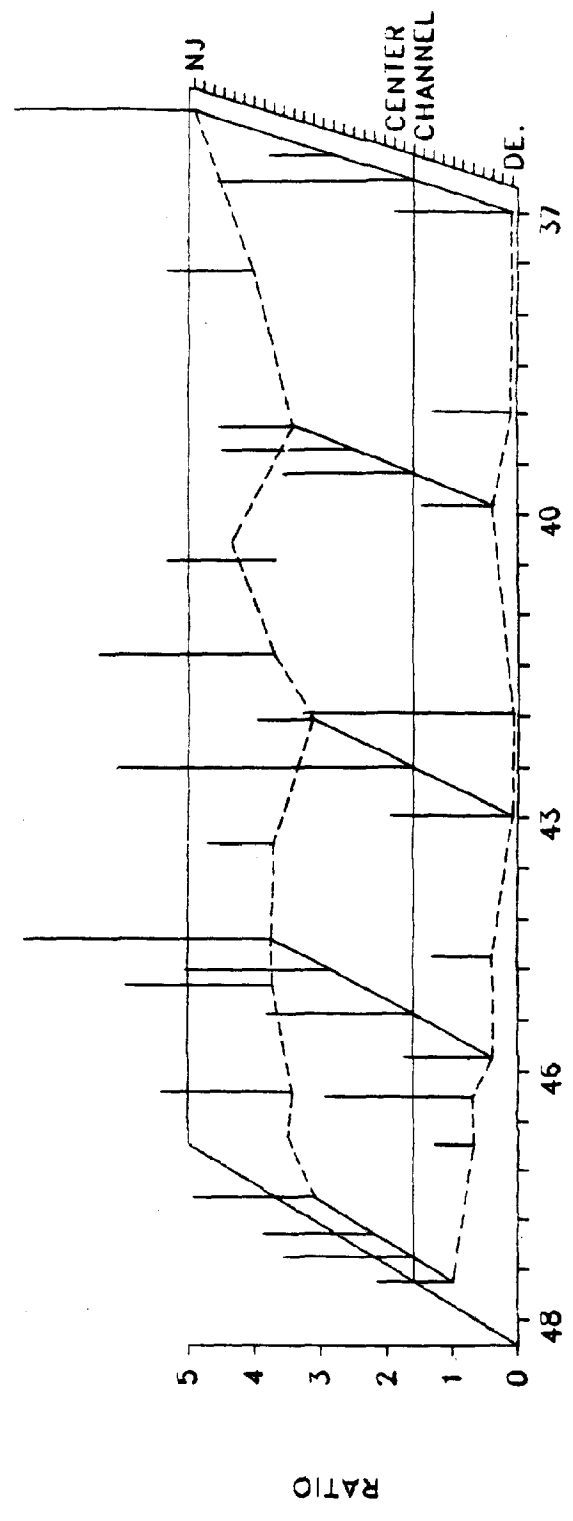
MEDIAN
ENTEROCOCCUS
DISINFECTION WINTER

Graph 2.6B



MEDIAN
ENTEROCOCCUS
RATIO OF WINTER VALUES

Graph 2.6C

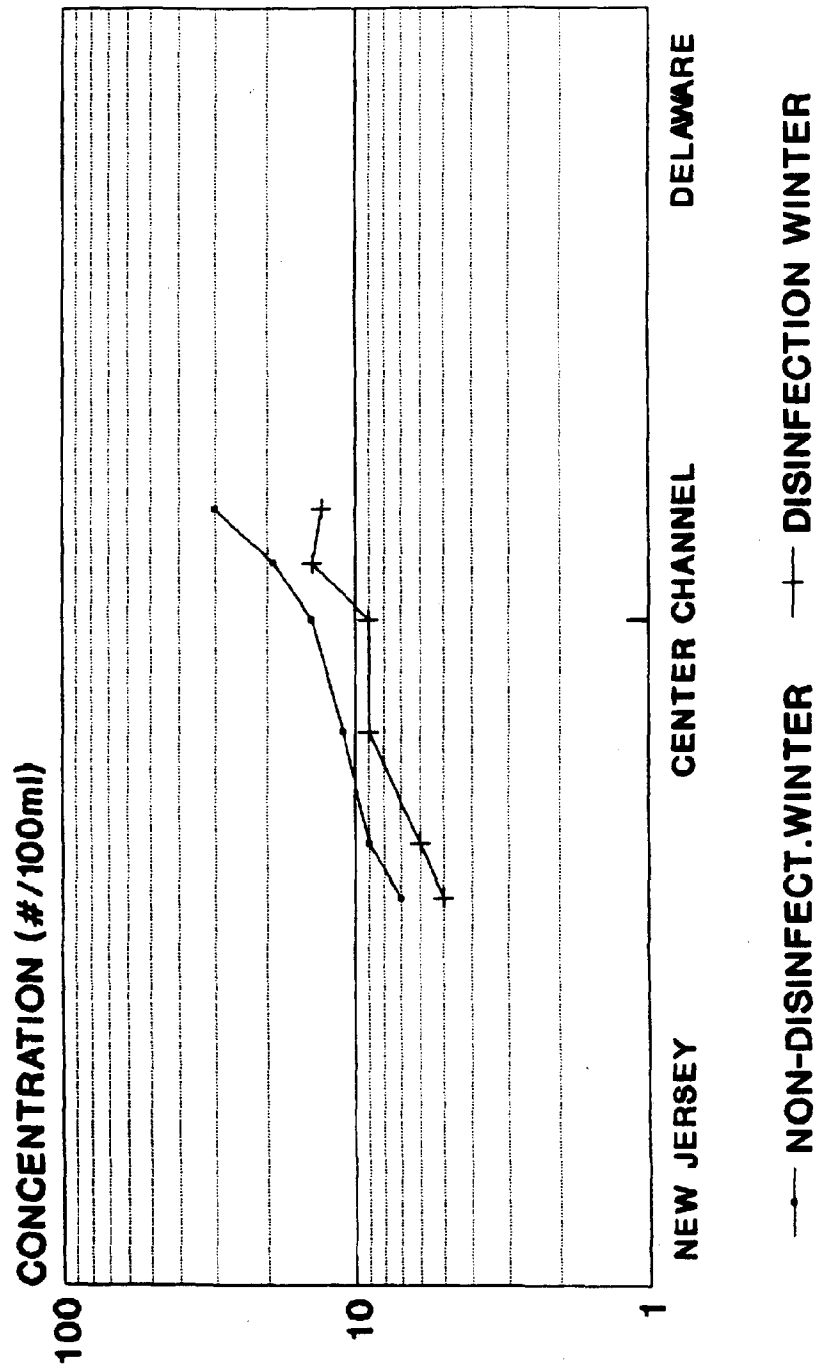


Graph 2.6C

APPROXIMATE RIVER MILE

GEOMETRIC MEAN FECAL COLIFORM (MPN)

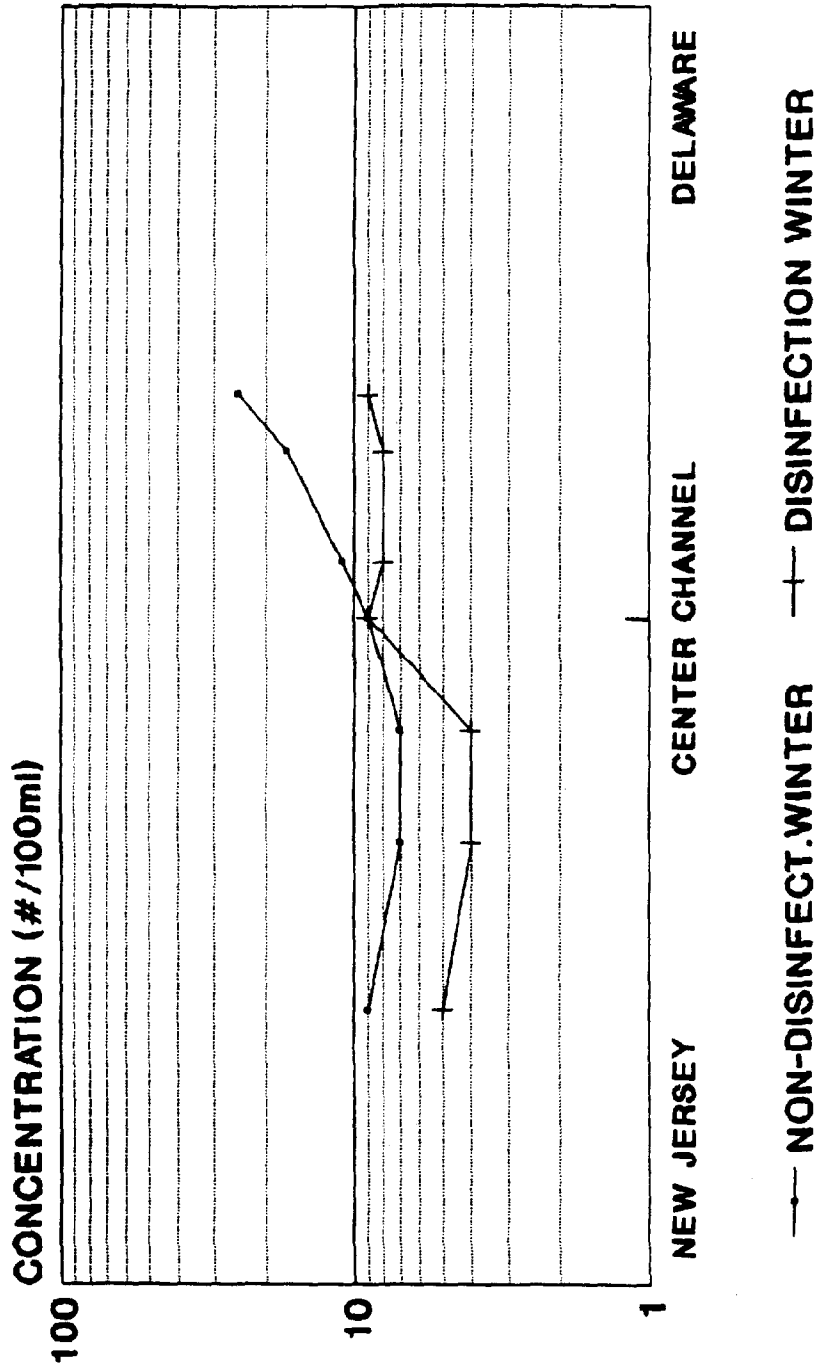
Graph 2.11A



TRANSECT APPROXIMATE RIVER MILE 48

GEOMETRIC MEAN FECAL COLIFORM (MPN)

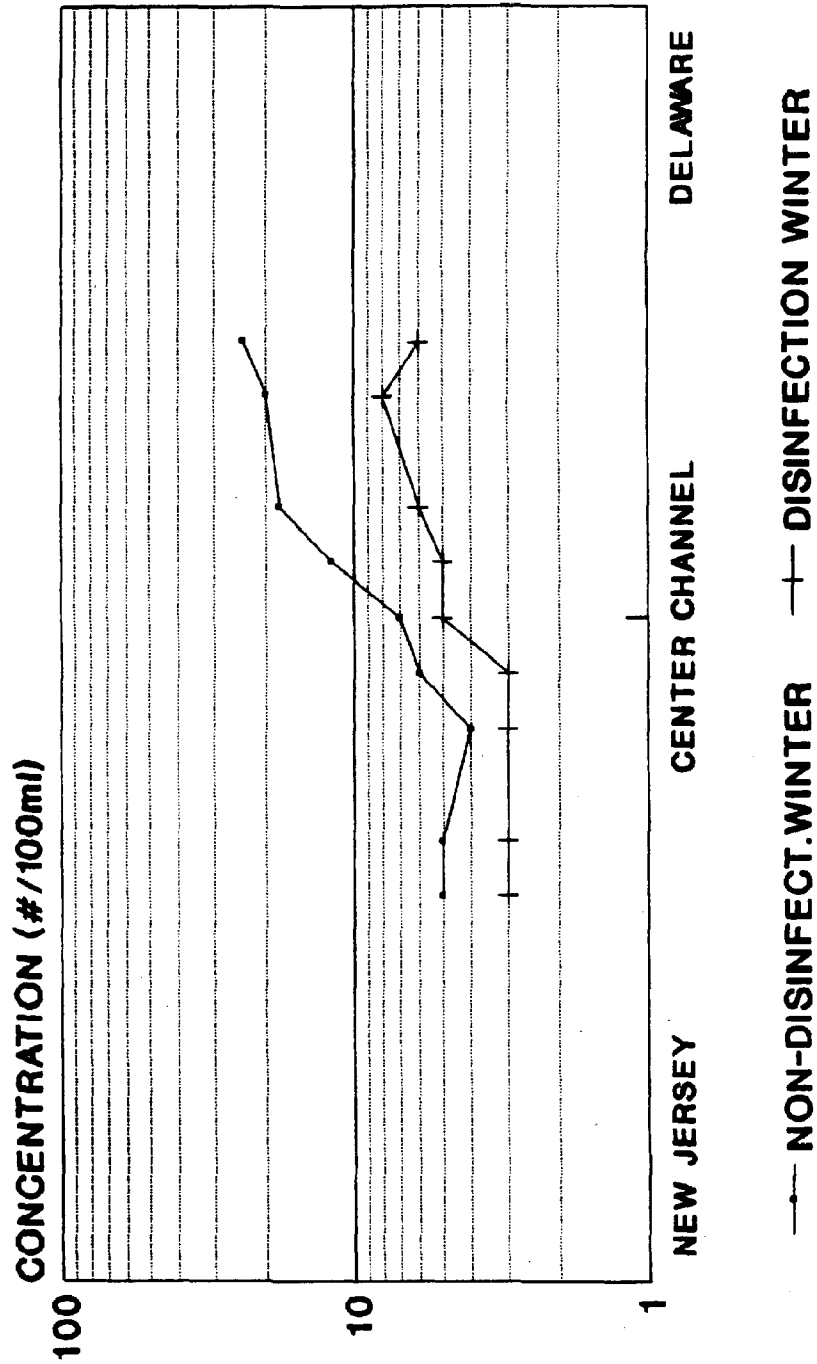
Graph 2.11B



TRANSECT APPROXIMATE RIVER MILE 46

GEOMETRIC MEAN FECAL COLIFORM (MPN)

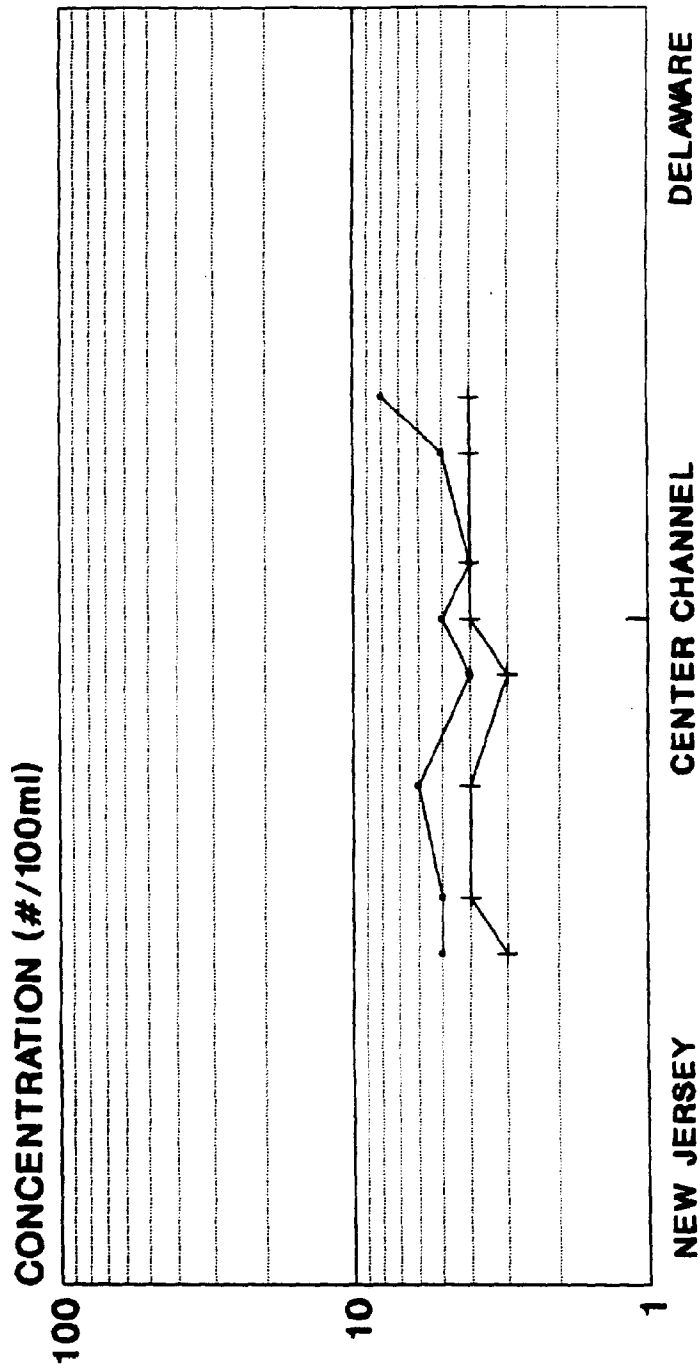
Graph 2.11C



TRANSECT APPROXIMATE RIVER MILE 43

Graph 2.11D

GEOMETRIC MEAN FECAL COLIFORM (MPN)



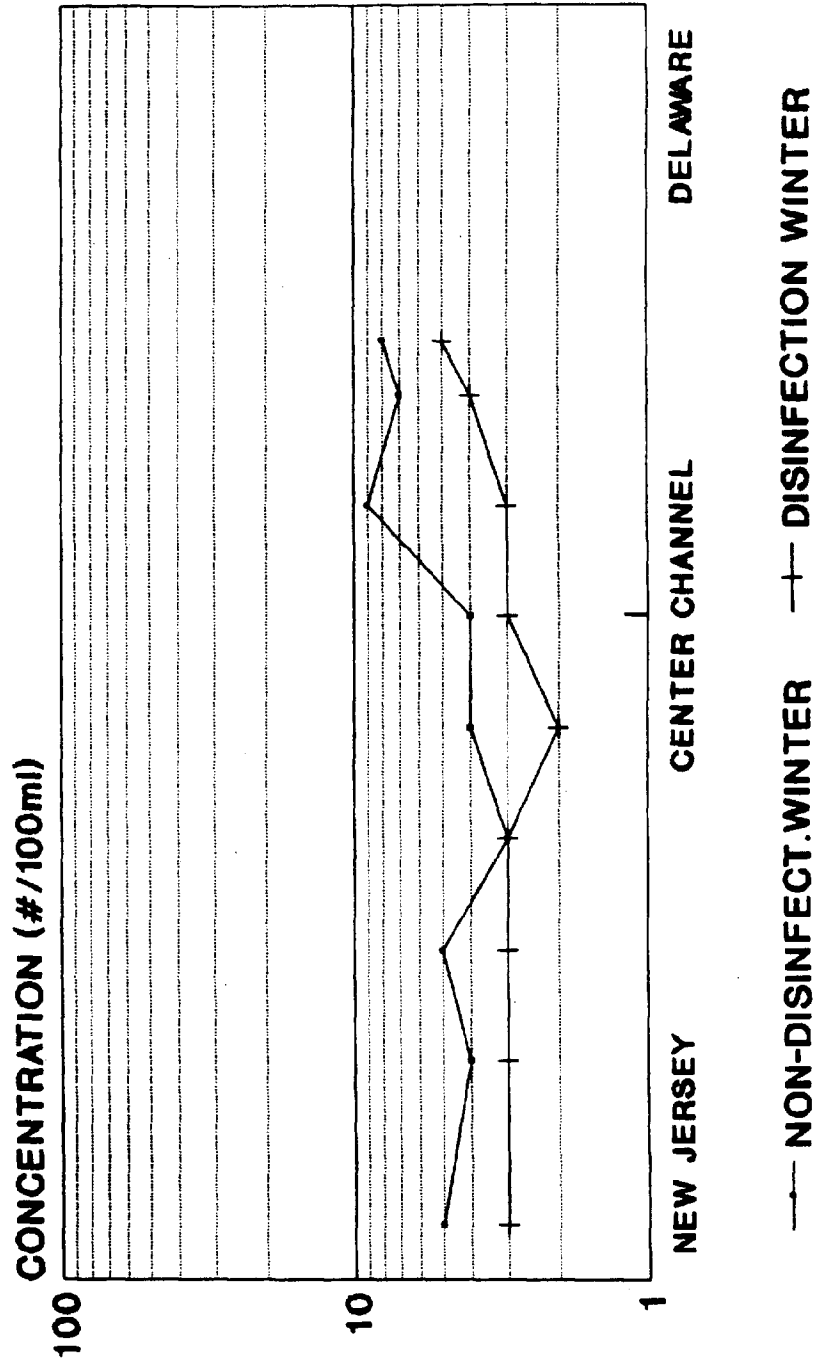
Graph 2.11D

—●— NON-DISINFECT. WINTER -+ - DISINFECTION WINTER

TRANSECT APPROXIMATE RIVER MILE 40

GEOMETRIC MEAN FECAL COLIFORM (MPN)

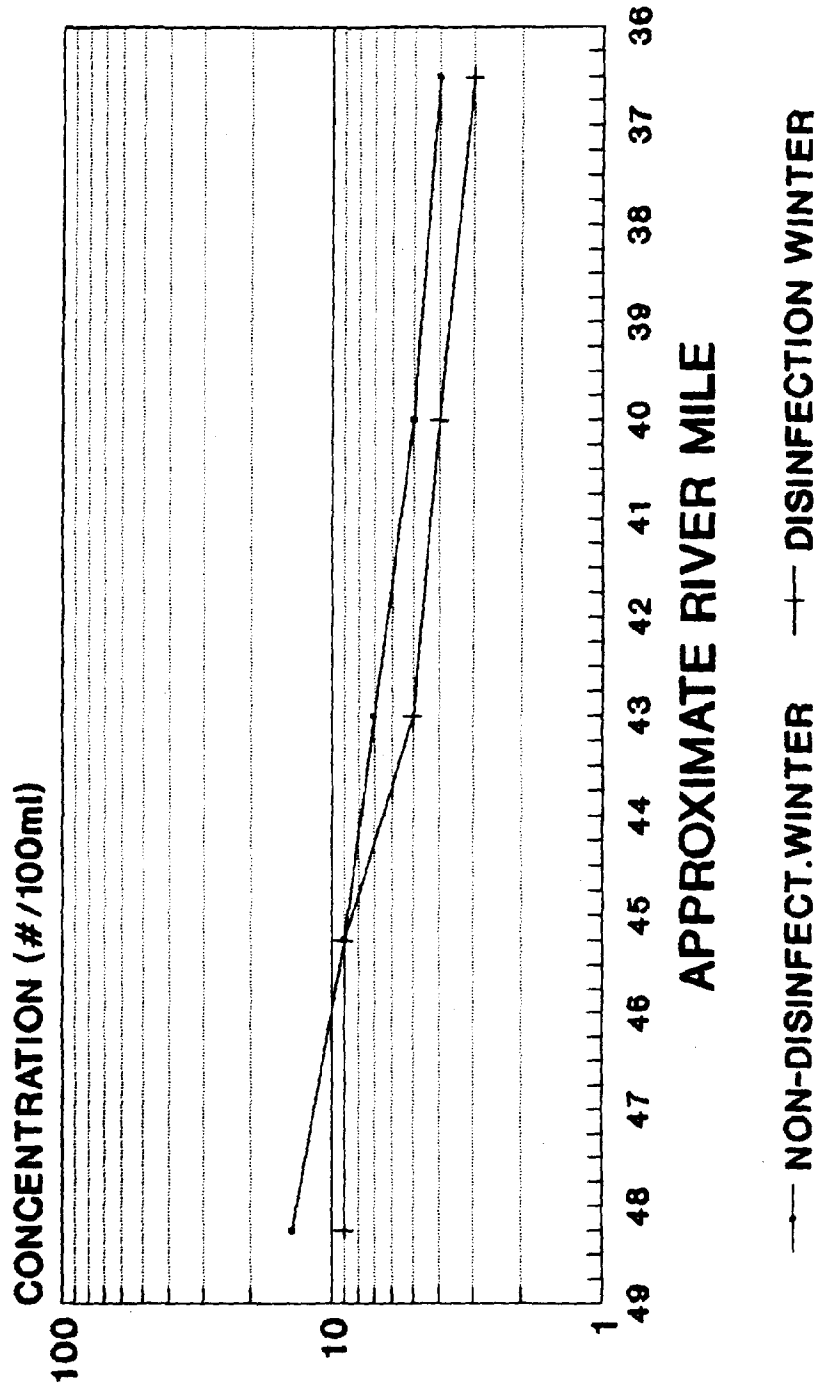
Graph 2.11E



TRANSECT APPROXIMATE RIVER MILE 37

GEOMETRIC MEAN FECAL COLIFORM (MPN)

Graph 2.11F

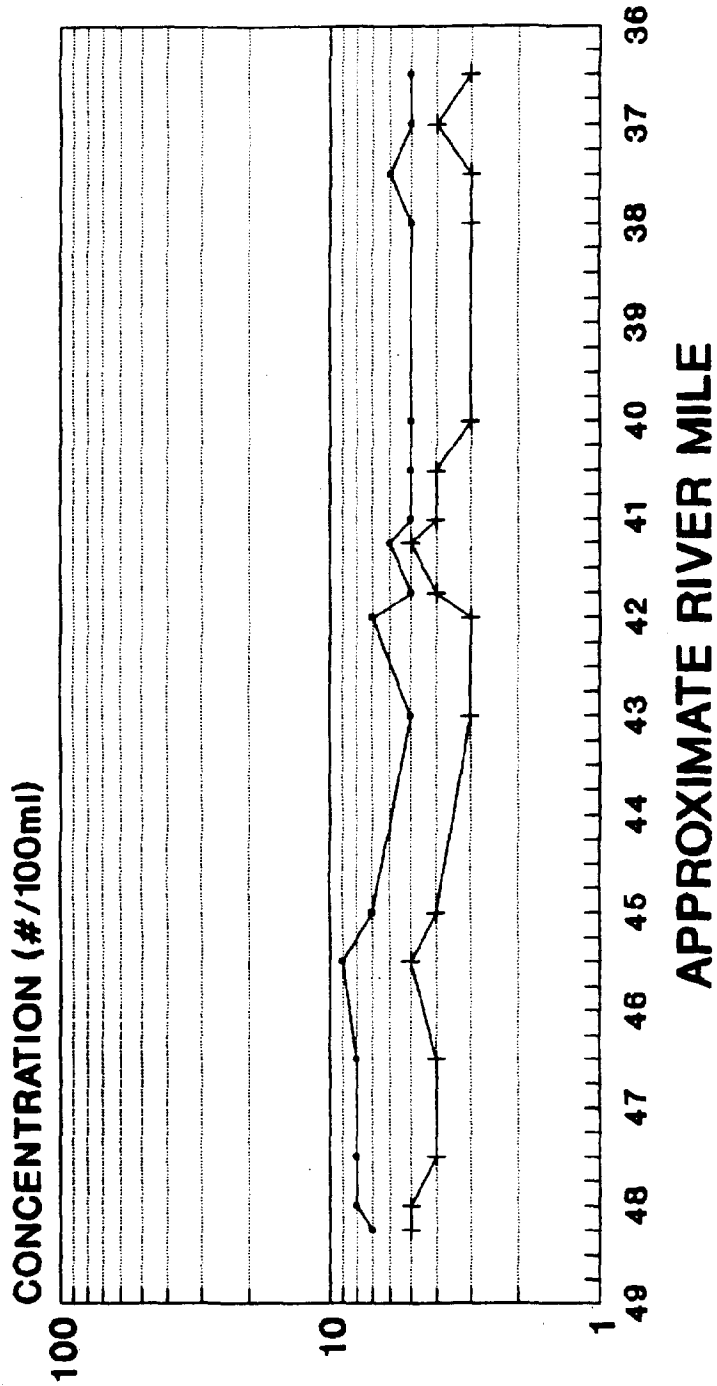


CENTER CHANNEL PROFILE



GEOMETRIC MEAN FECAL COLIFORM (MPN)

Graph 2.11G

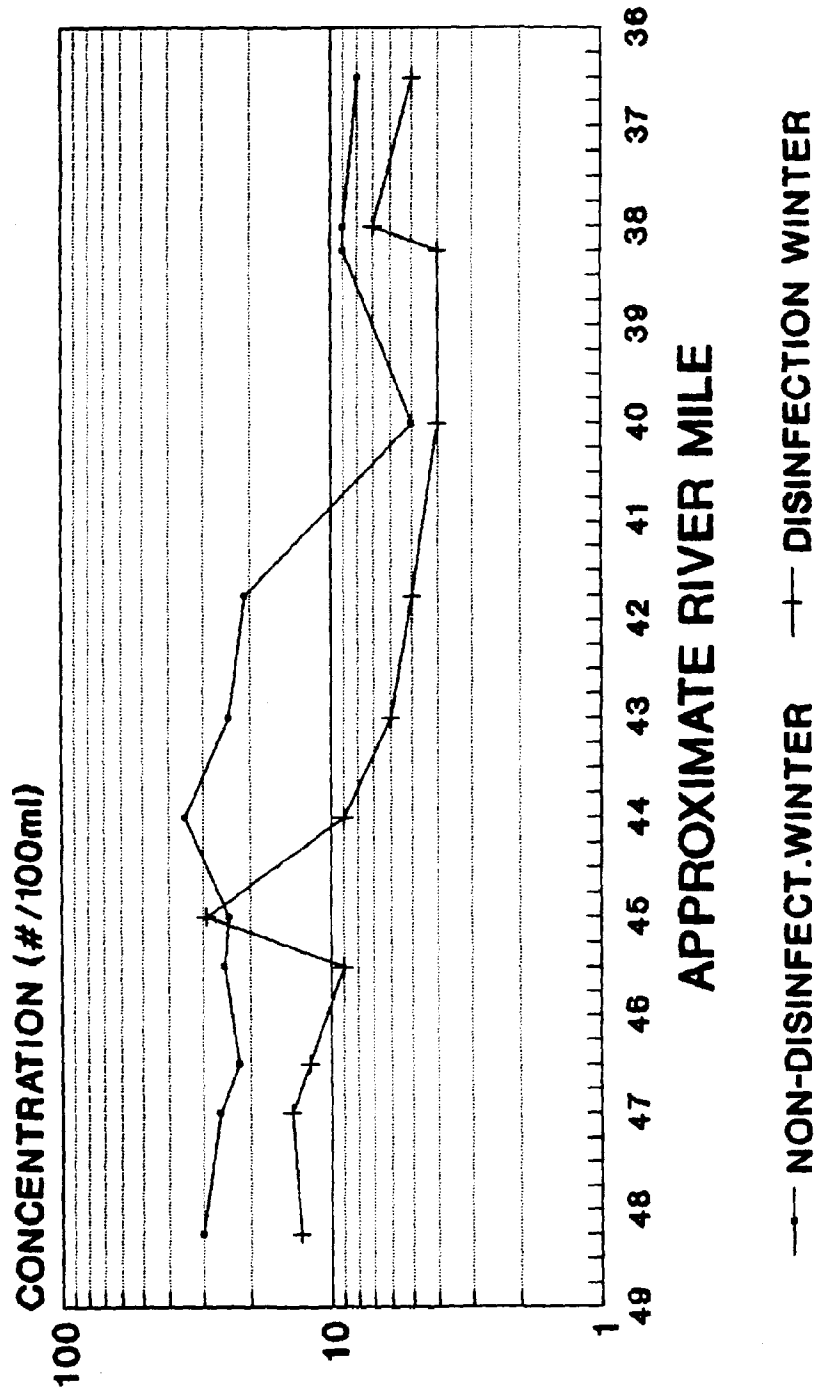


—●— NON-DISINFECT. WINTER —+— DISINFECTION WINTER

NEW JERSEY (EAST) SHORE PROFILE

GEOMETRIC MEAN FECAL COLIFORM (MPN)

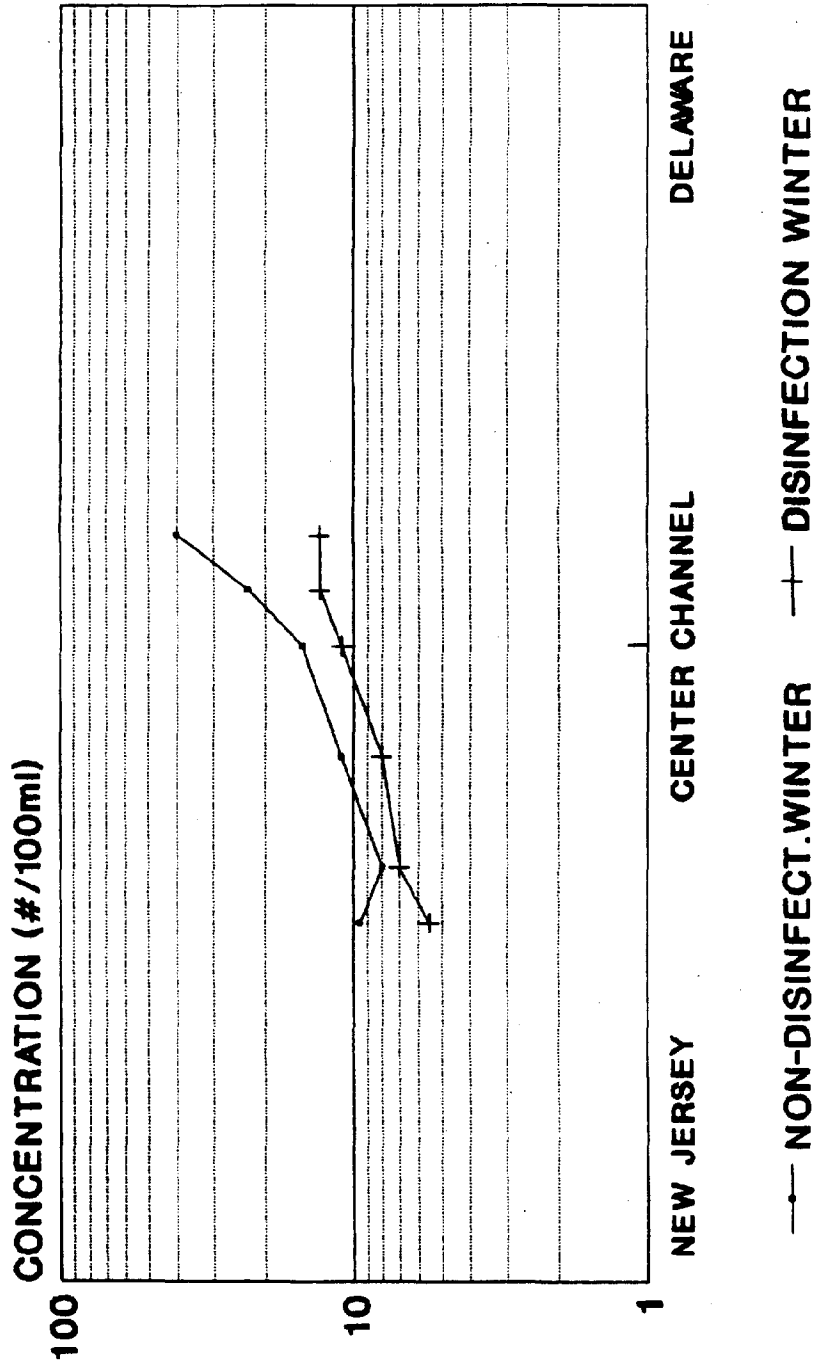
Graph 2.11H



DELAWARE (WEST) SHORE PROFILE

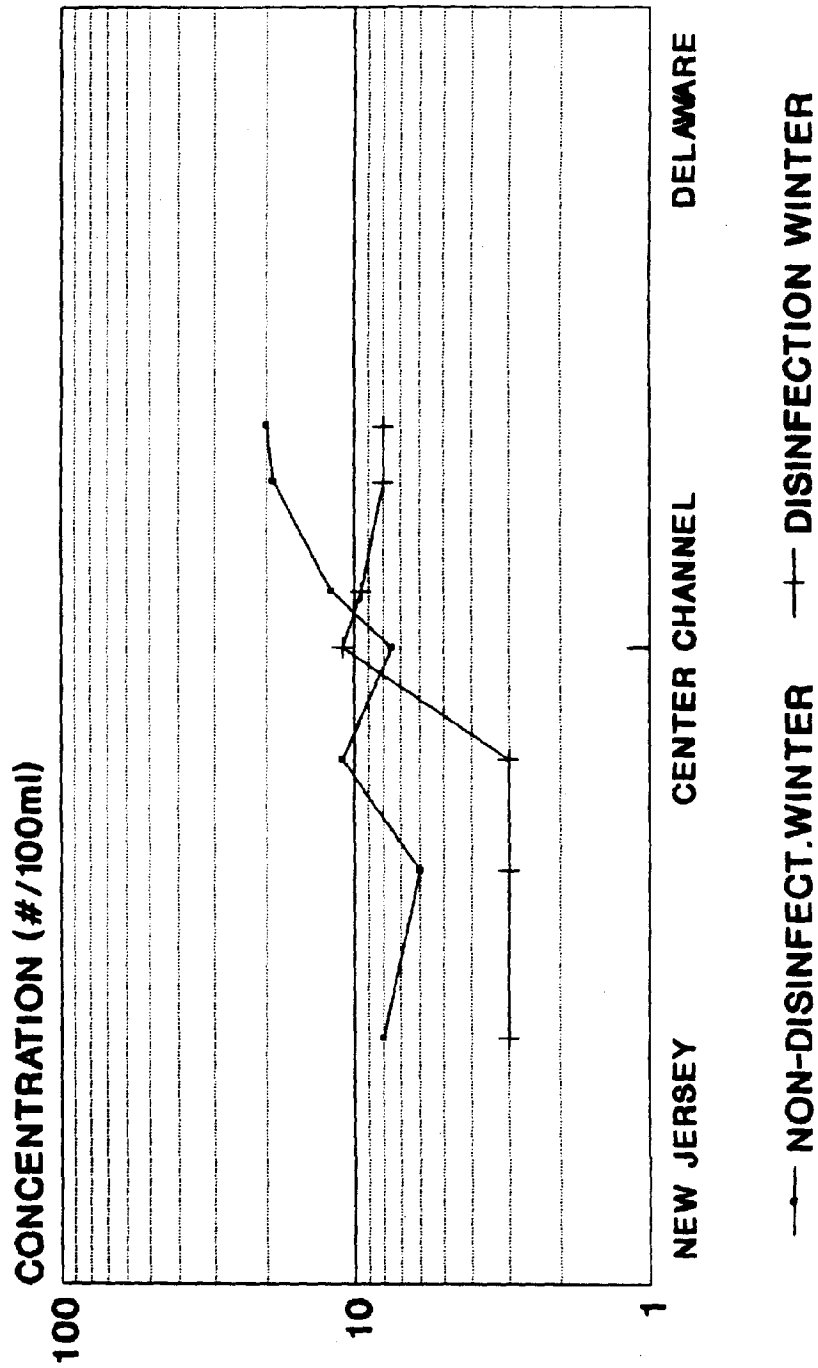
MEDIAN FECAL COLIFORM (MPN)

Graph 2.12A



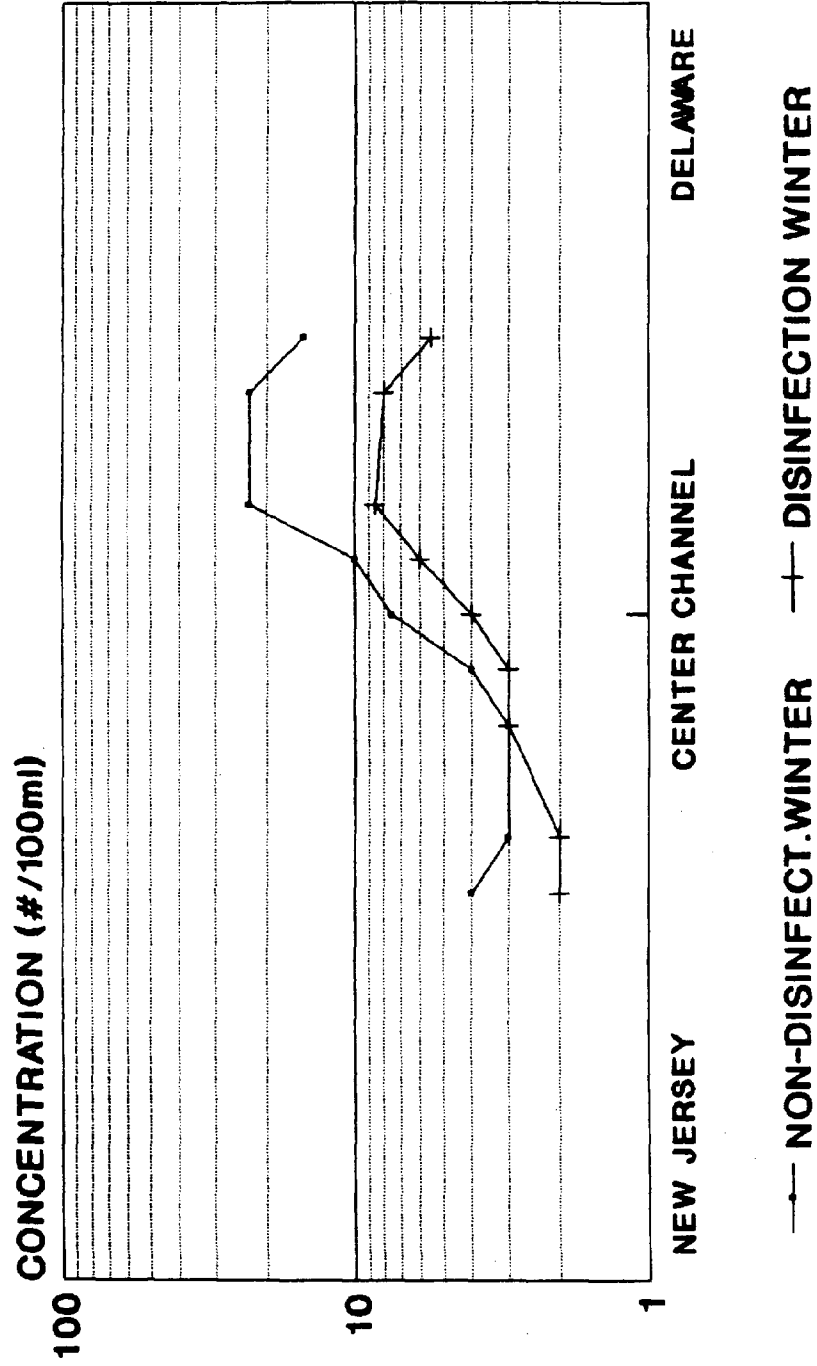
TRANSECT APPROXIMATE RIVER MILE 48

MEDIAN FECAL COLIFORM (MPN)



TRANSECT APPROXIMATE RIVER MILE 46

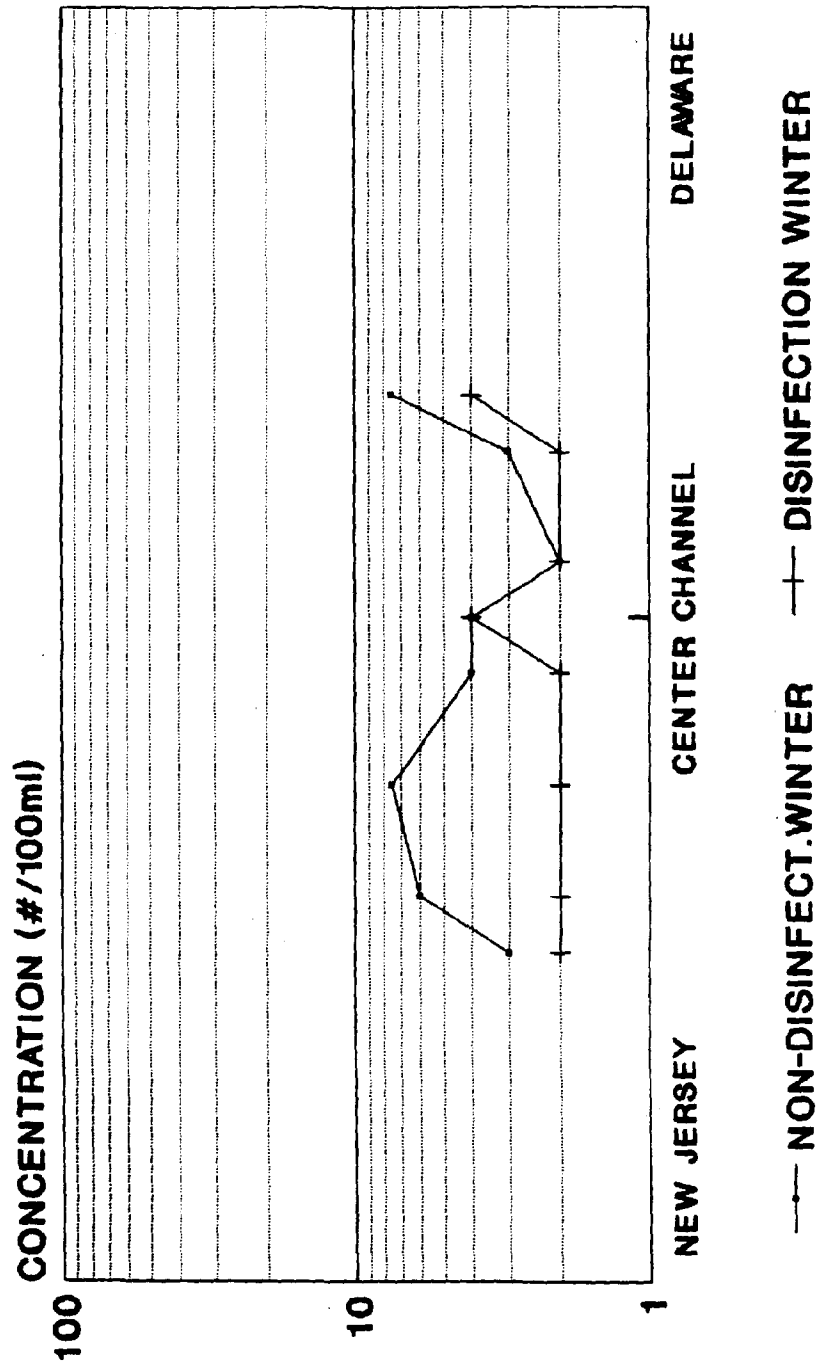
MEDIAN FECAL COLIFORM (MPN)



Graph 2.12C

TRANSECT APPROXIMATE RIVER MILE 43

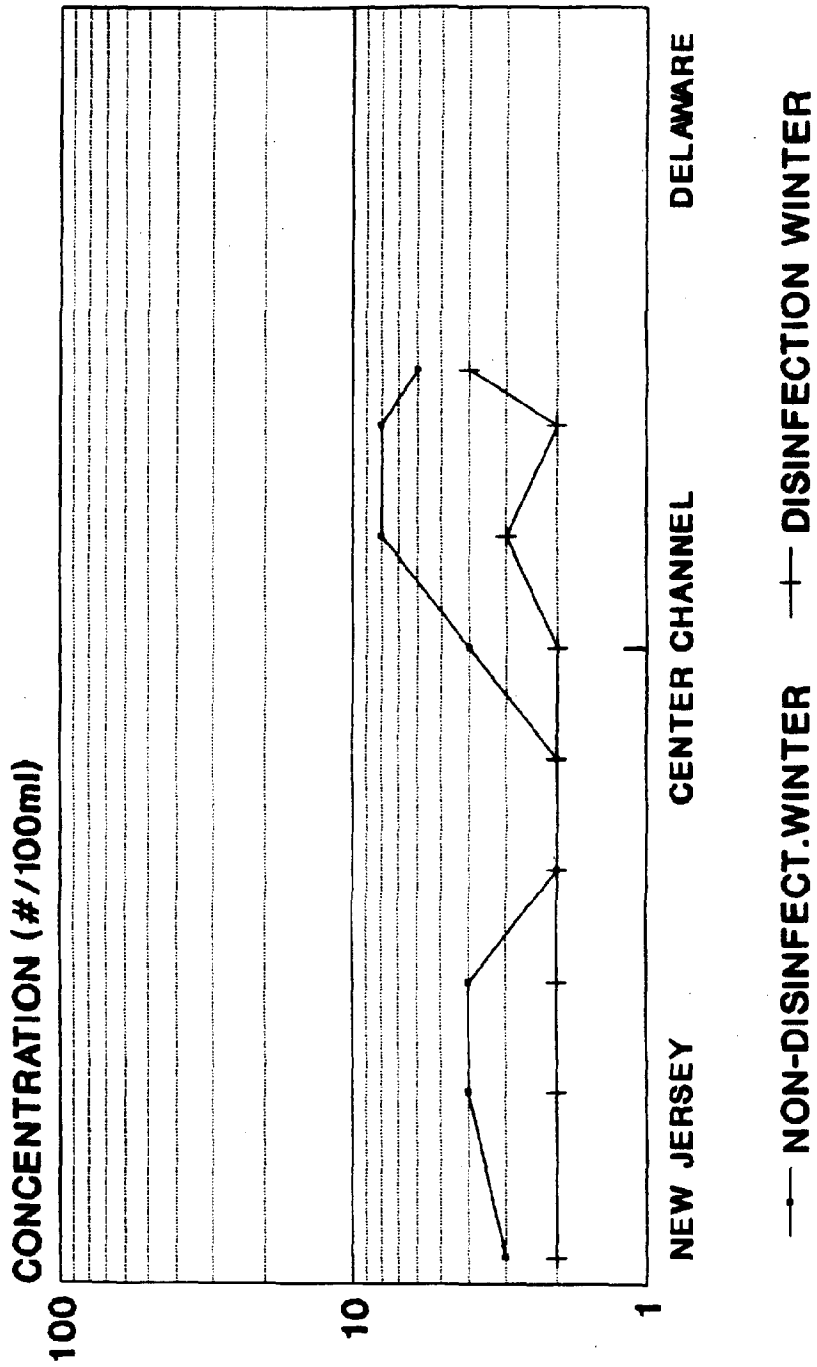
MEDIAN FECAL COLIFORM (MPN)



Graph 2.12D

TRANSECT APPROXIMATE RIVER MILE 40

MEDIAN FECAL COLIFORM (MPN)

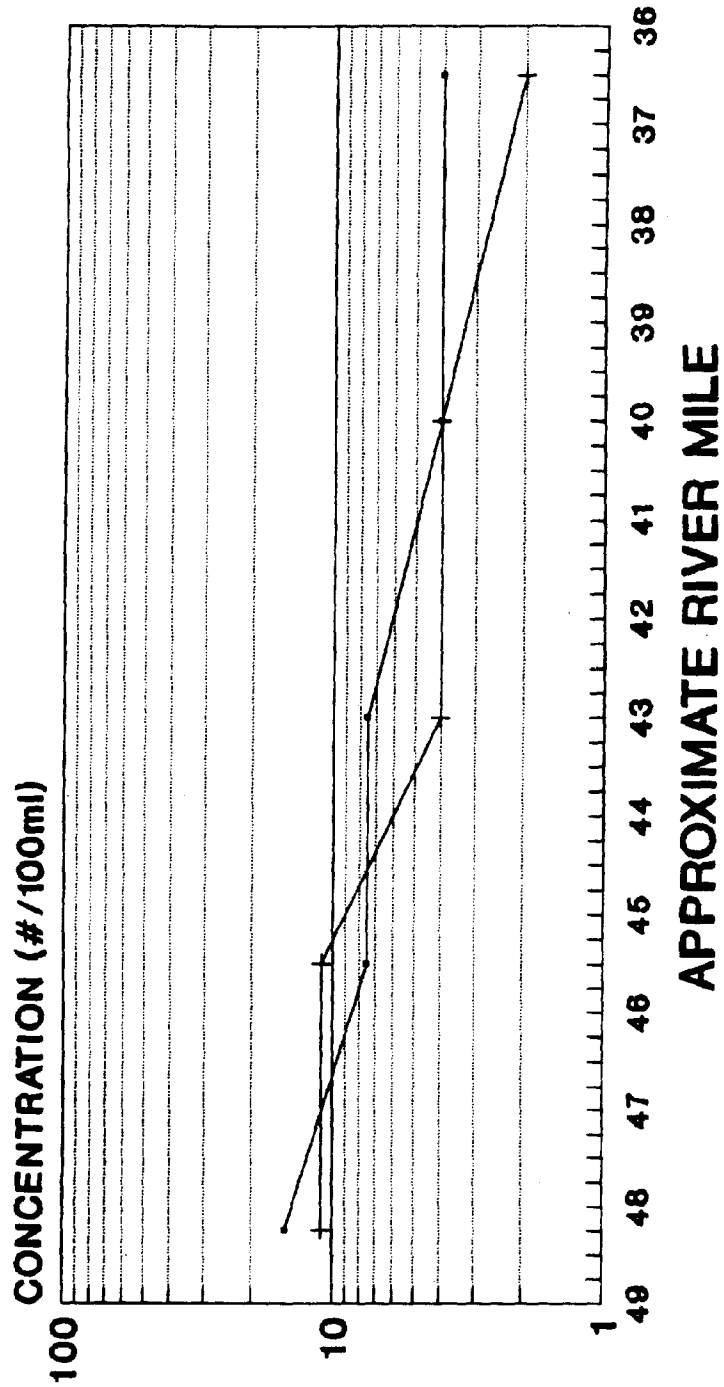


Graph 2.12E

TRANSECT APPROXIMATE RIVER MILE 37

Graph 2.12F

MEDIAN FECAL COLIFORM (MPN)

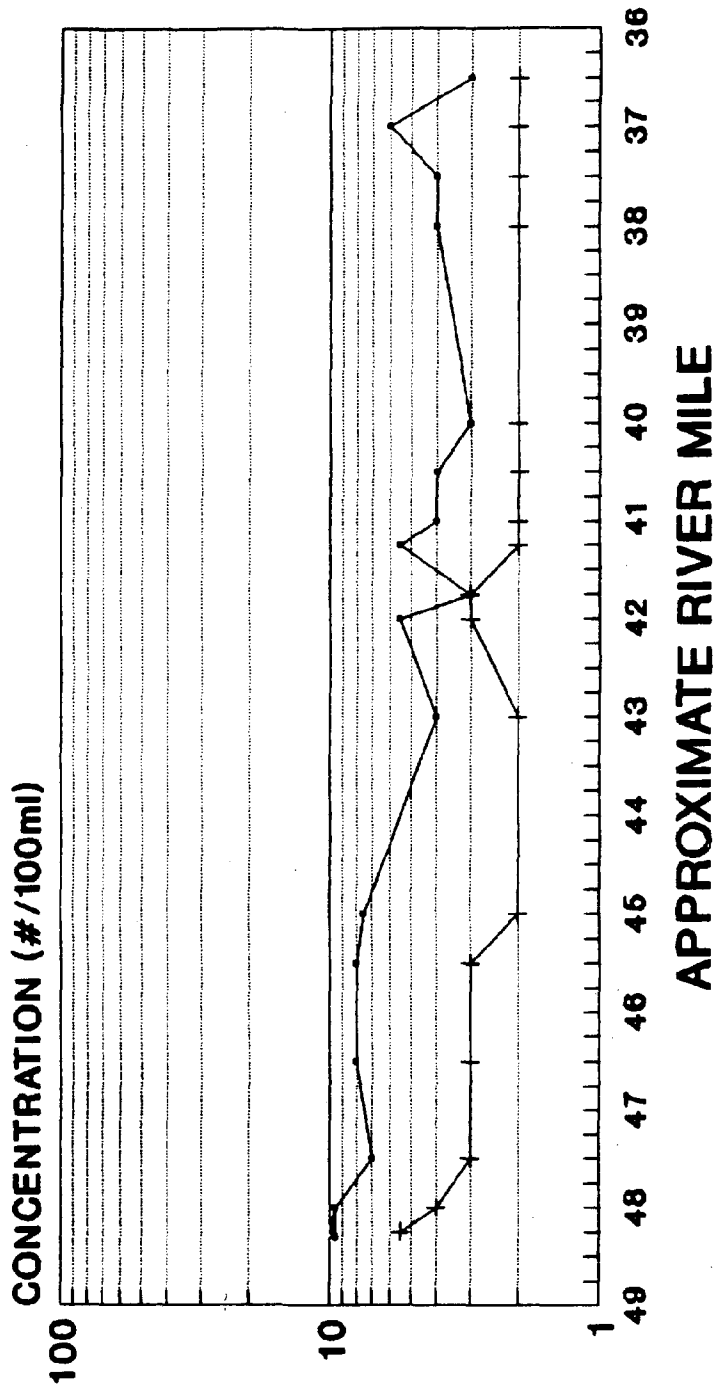


—○— NON-DISINFECT. WINTER - - - + - - - DISINFECTION WINTER

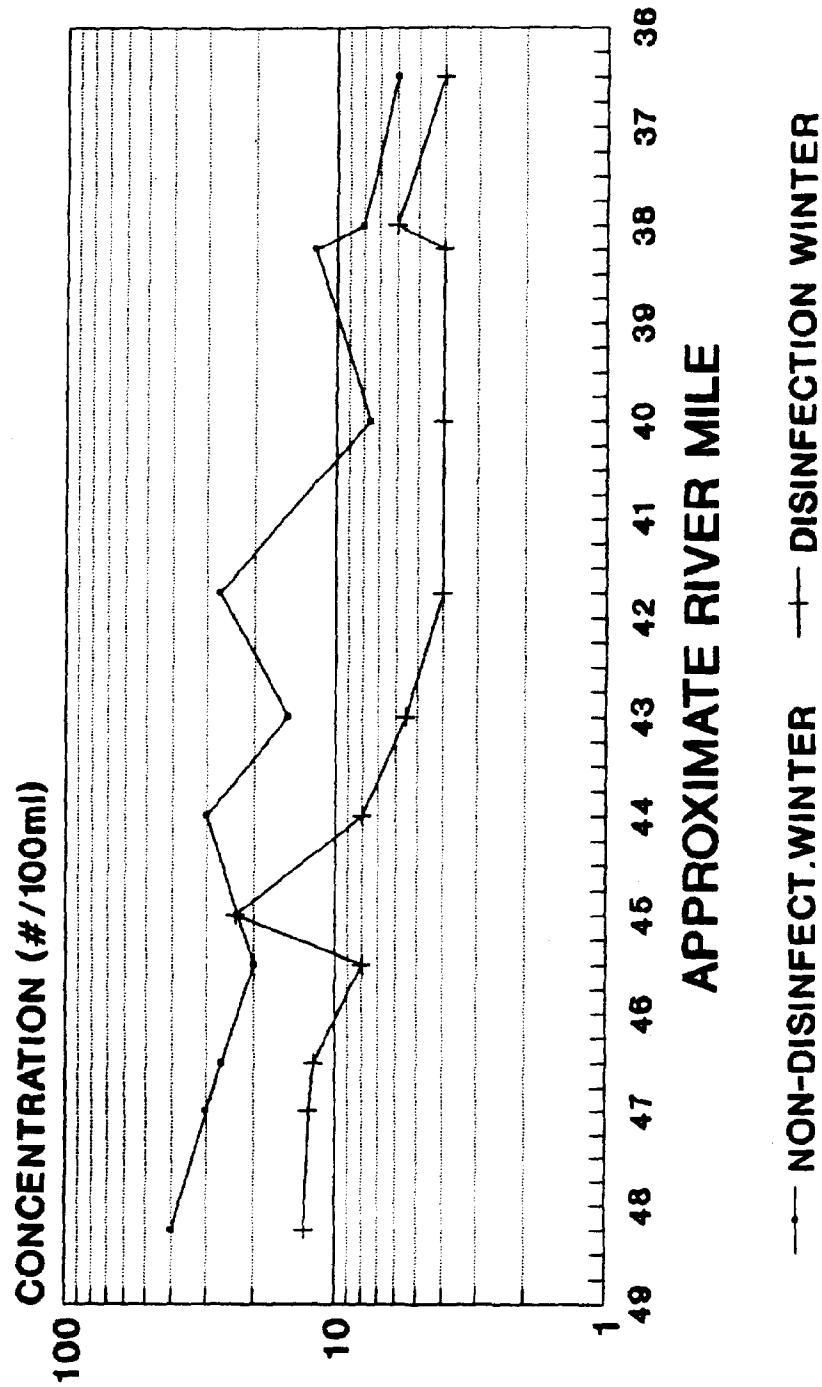
CENTER CHANNEL PROFILE

Graph 2.12G

MEDIAN FECAL COLIFORM (MPN)



MEDIAN FECAL COLIFORM (MPN)

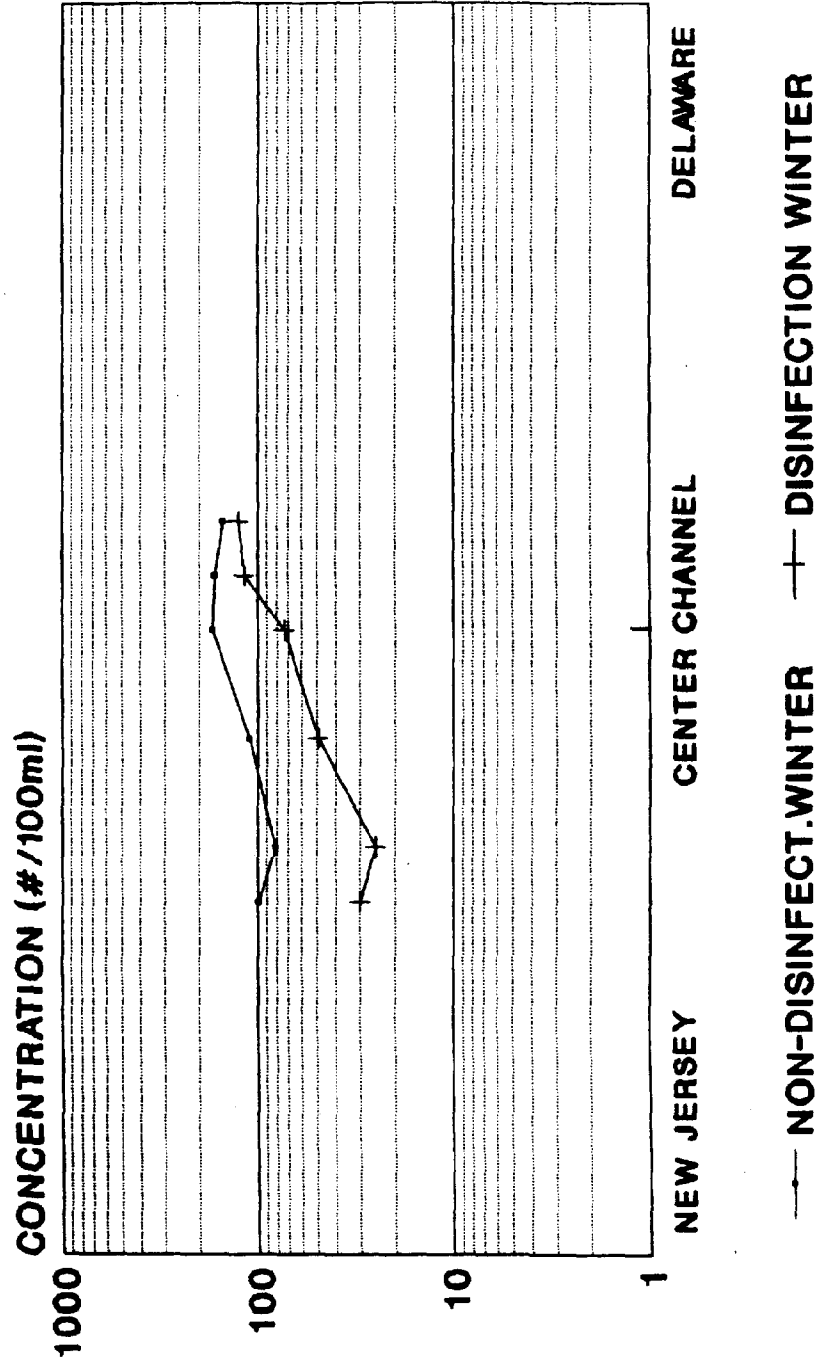


Graph 2.12H

DELAWARE (WEST) SHORE PROFILE

GEOMETRIC MEAN TOTAL COLIFORM (MPN)

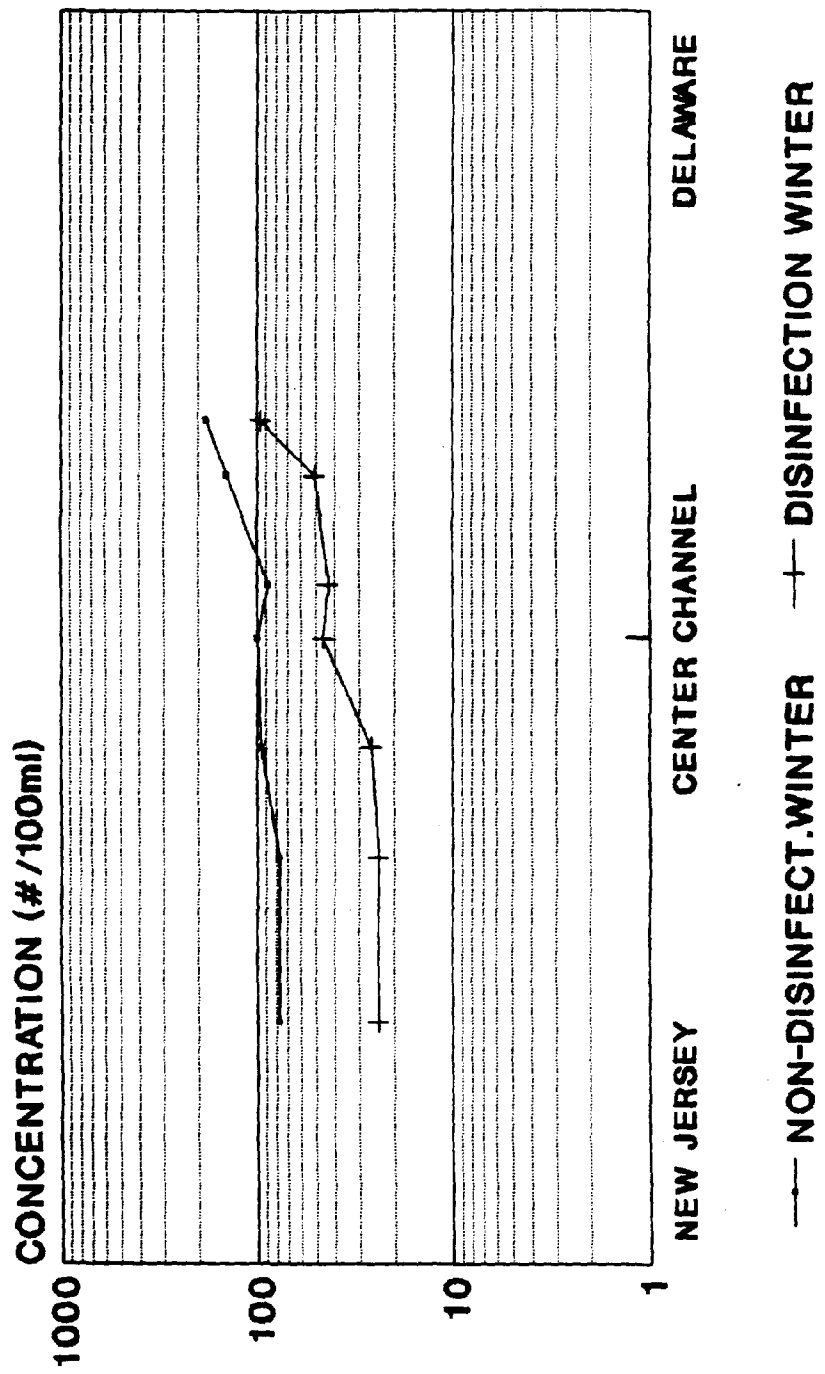
Graph 2.13A



TRANSECT APPROXIMATE RIVER MILE 48

Graph 2.13B

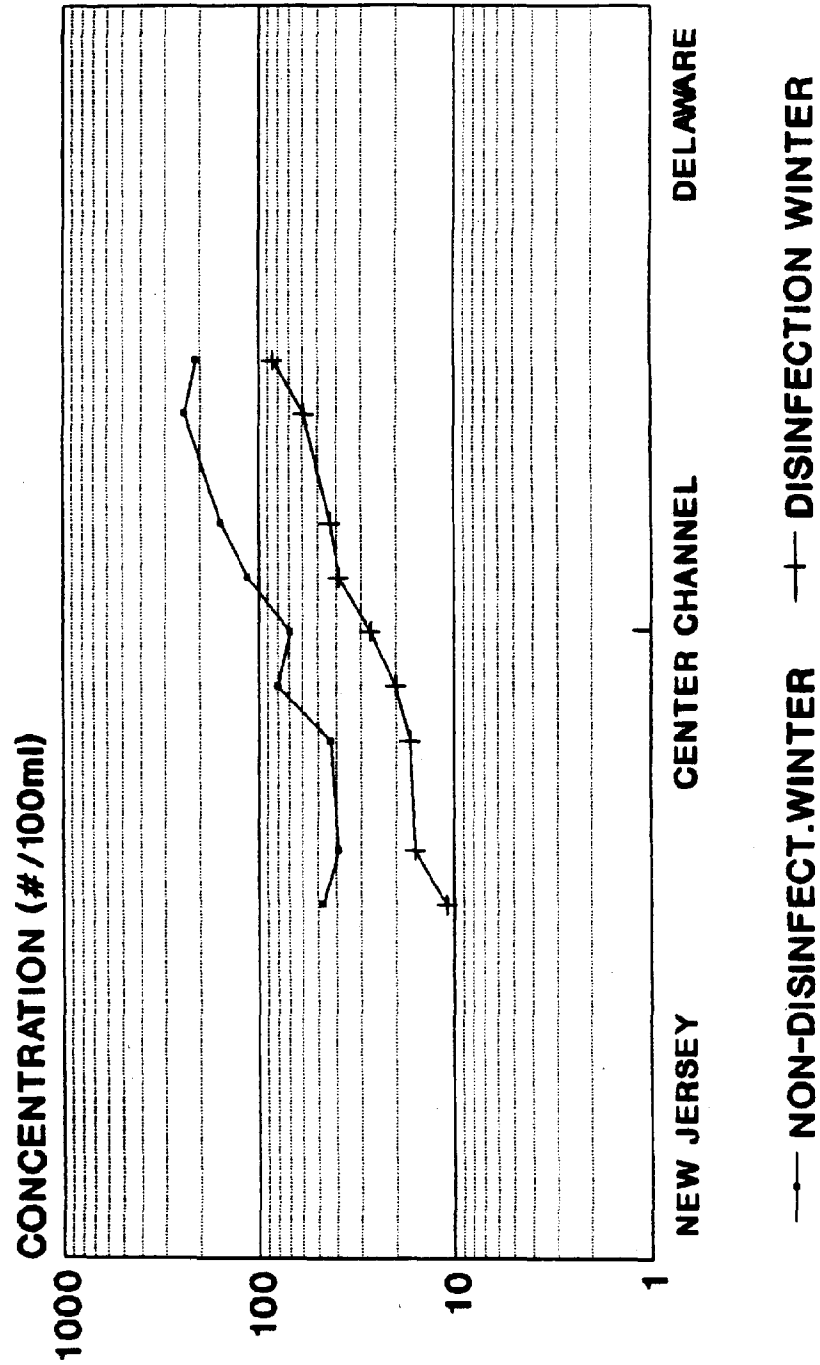
GEOMETRIC MEAN TOTAL COLIFORM (MPN)



TRANSECT APPROXIMATE RIVER MILE 46

GEOMETRIC MEAN TOTAL COLIFORM (MPN)

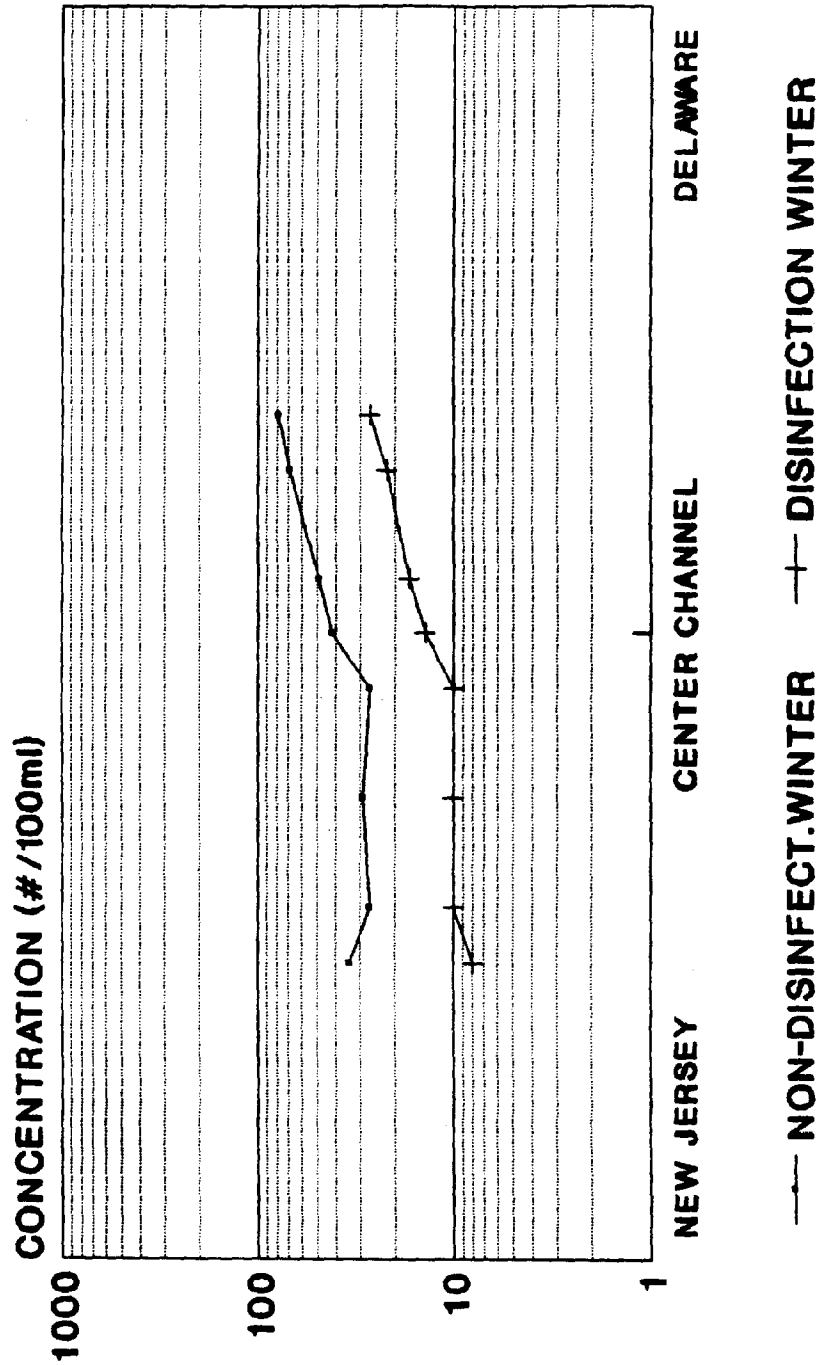
Graph 2.13C



TRANSECT APPROXIMATE RIVER MILE 43

Graph 2.13D

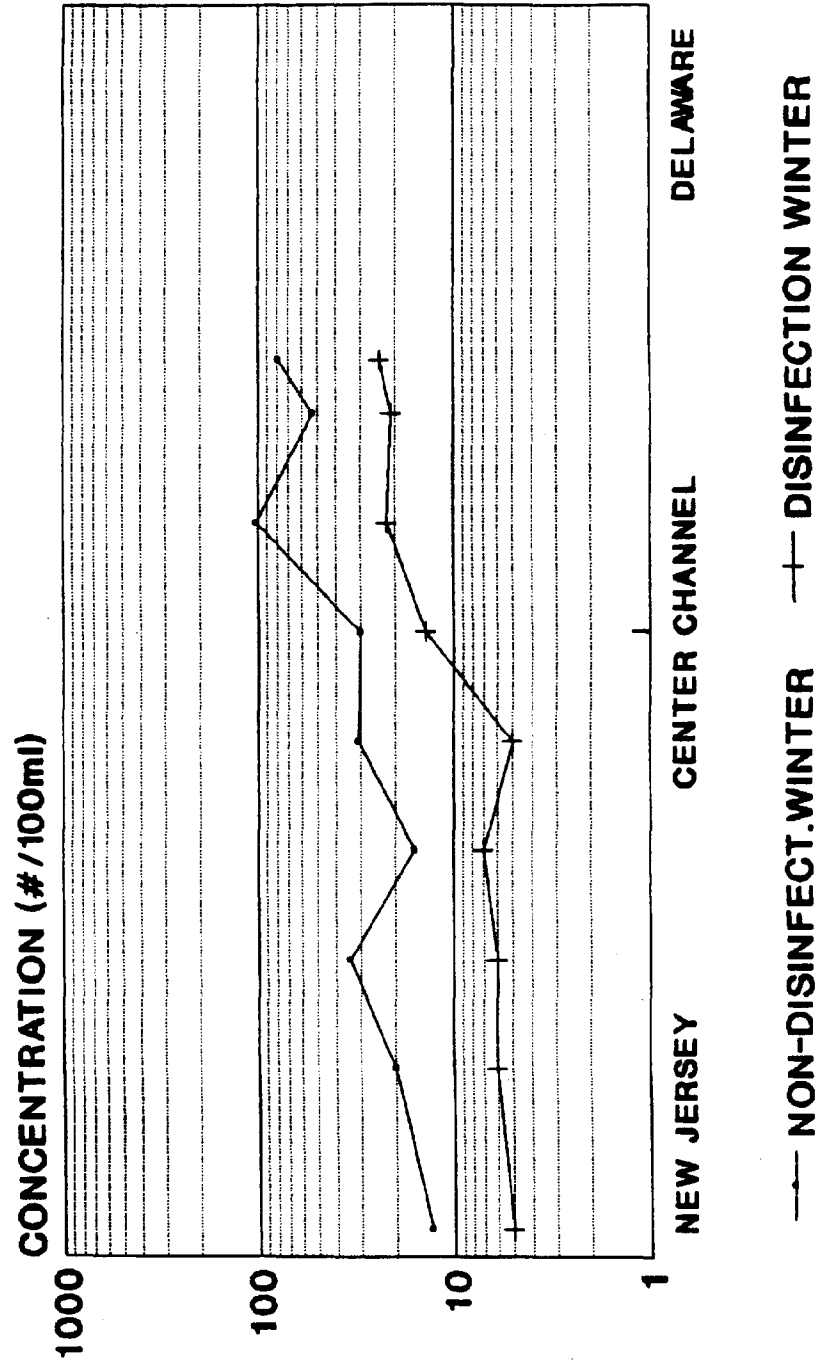
GEOMETRIC MEAN TOTAL COLIFORM (MPN)



TRANSECT APPROXIMATE RIVER MILE 40

Graph 2.13D

GEOMETRIC MEAN TOTAL COLIFORM (MPN)

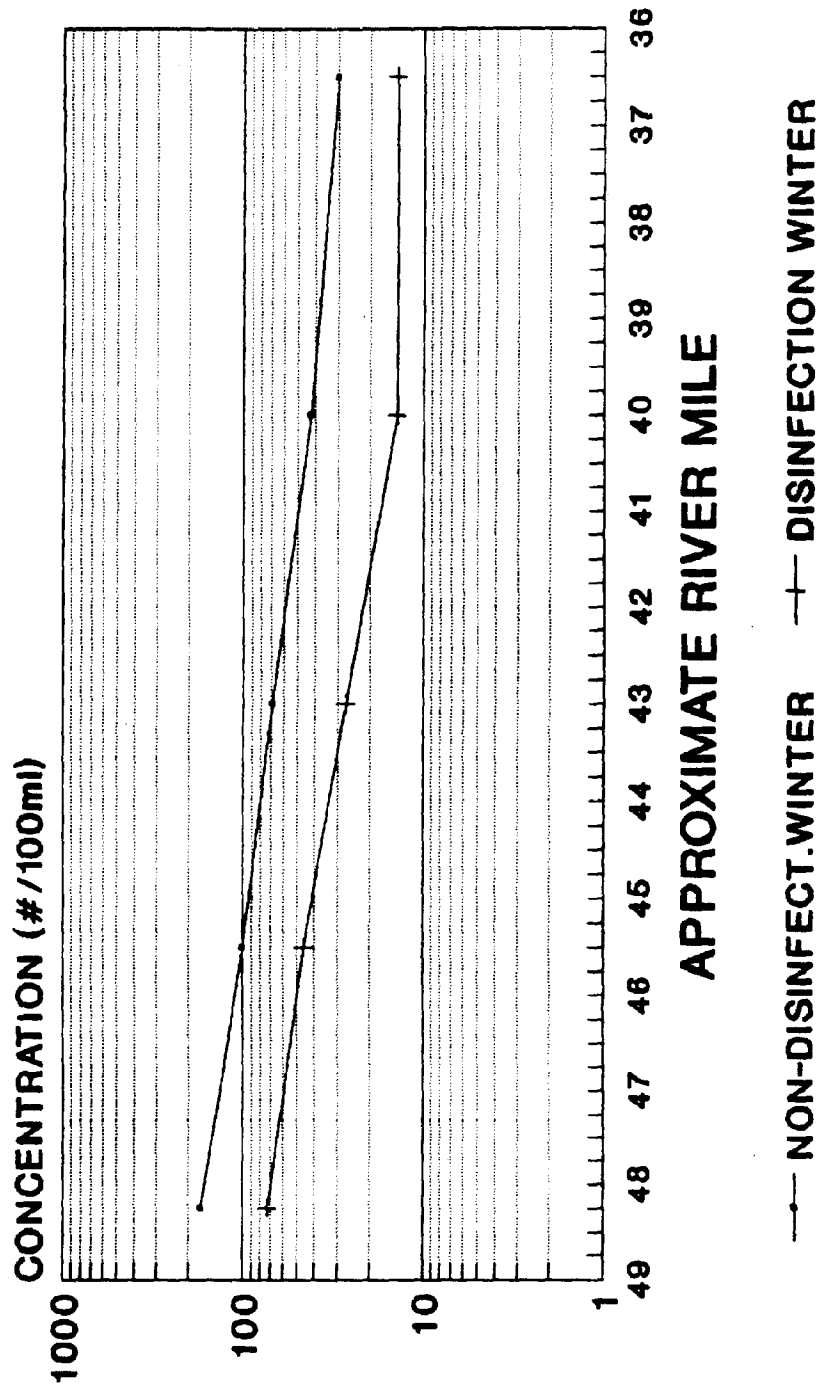


TRANSECT APPROXIMATE RIVER MILE 37

Graph 2.13E

Graph 2.13F

GEOMETRIC MEAN TOTAL COLIFORM (MPN)



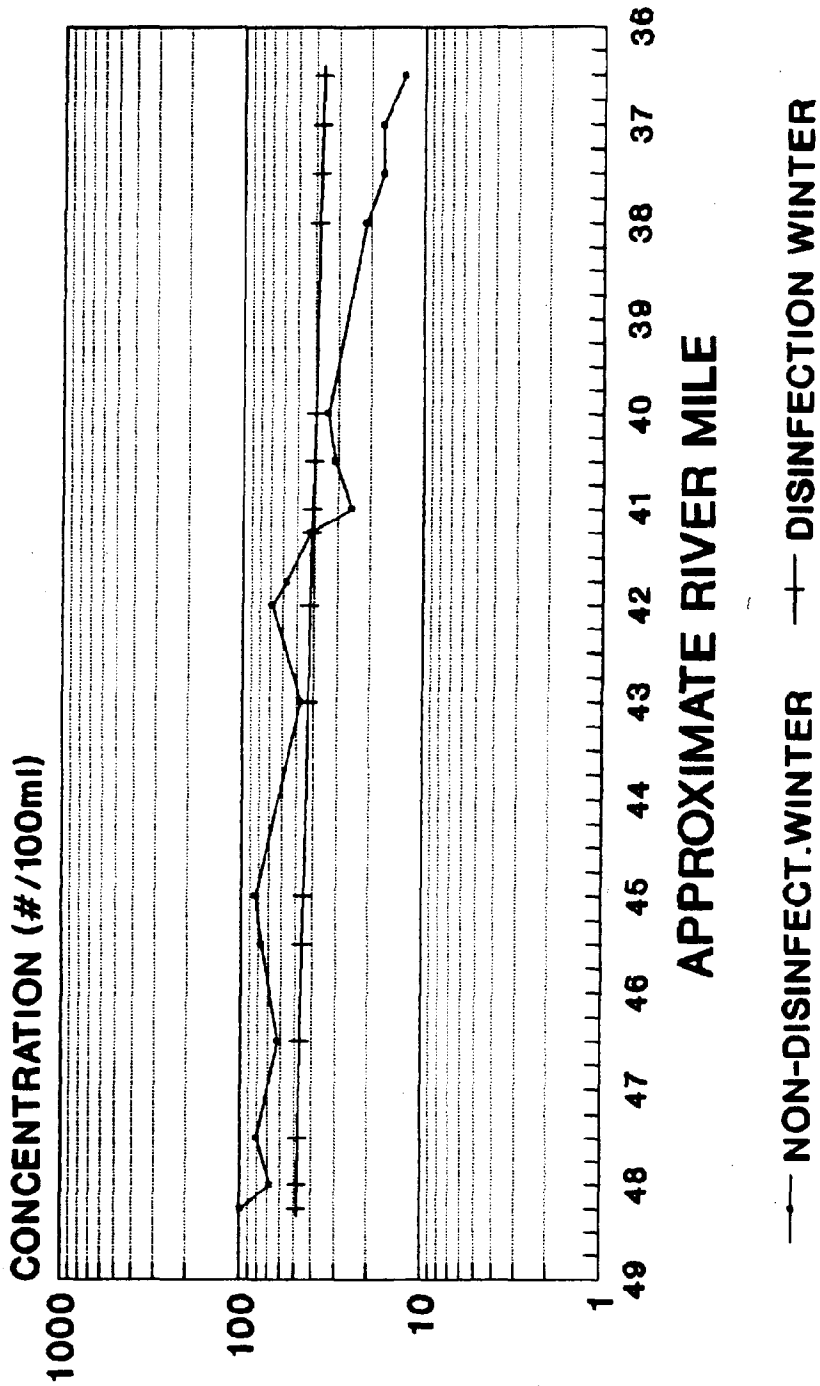
Graph 2.13F

CENTER CHANNEL PROFILE



Graph 2.13G

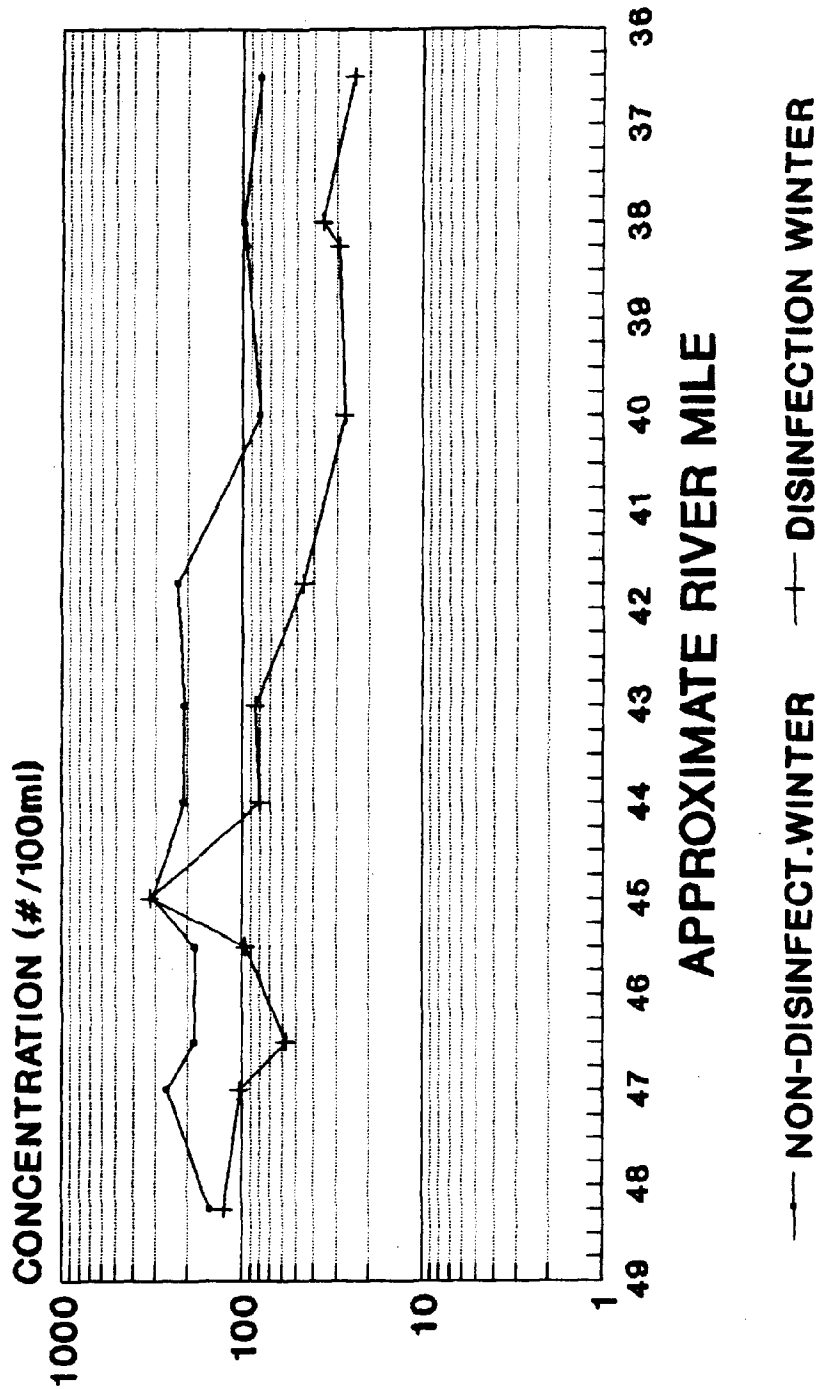
GEOMETRIC MEAN TOTAL COLIFORM (MPN)



NEW JERSEY (EAST) SHORE PROFILE

Graph 2.13H

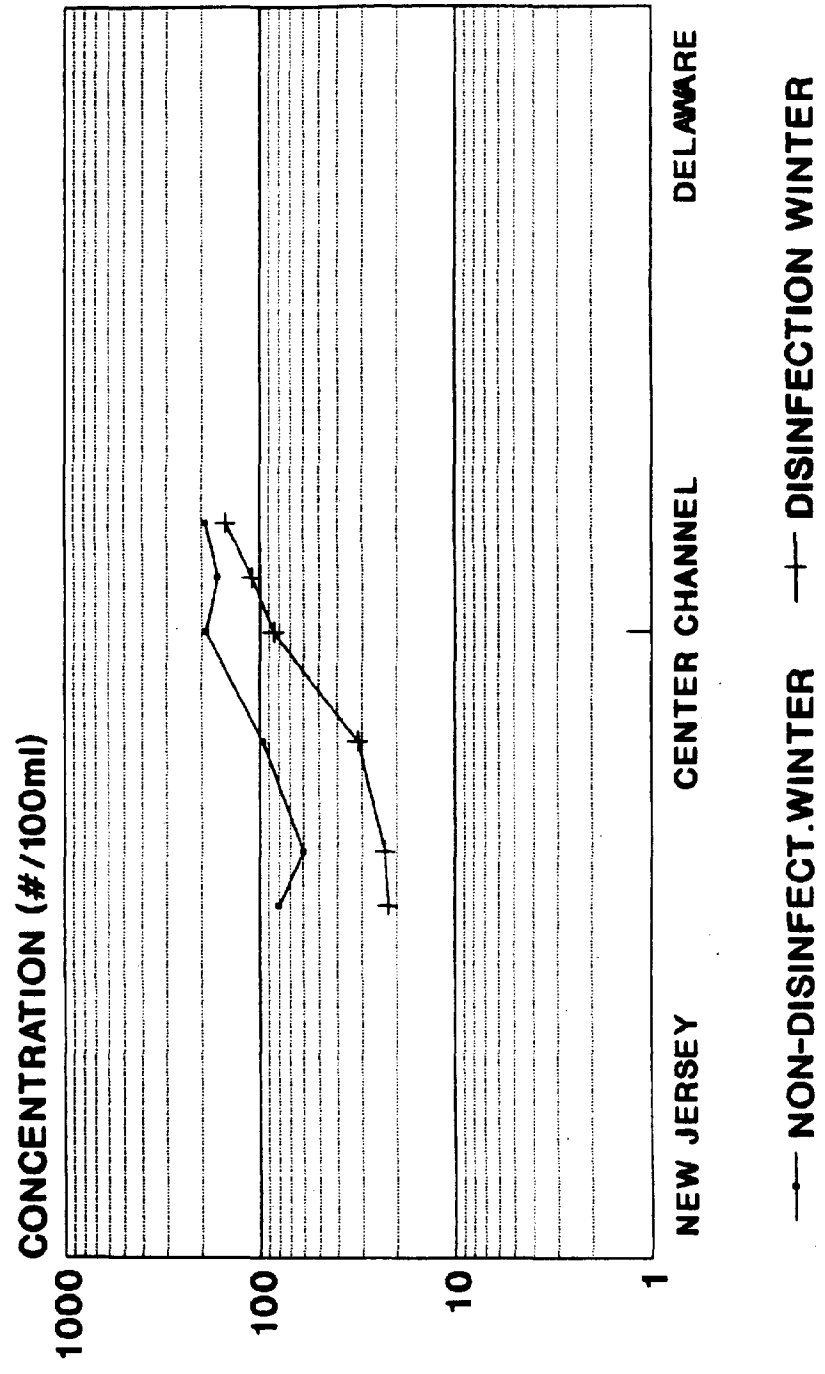
GEOMETRIC MEAN TOTAL COLIFORM (MPN)



DELAWARE (WEST) SHORE PROFILE

MEDIAN TOTAL COLIFORM (MPN)

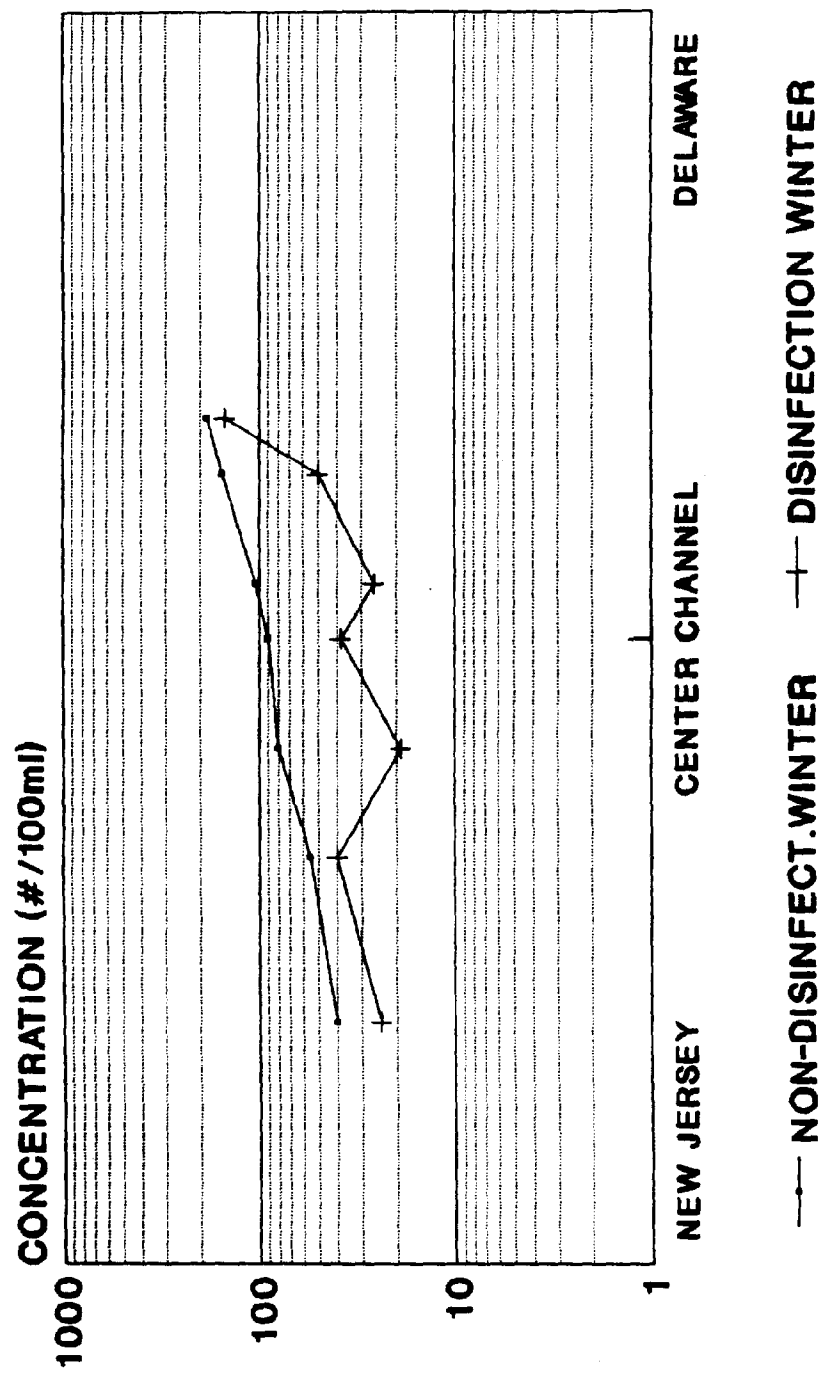
Graph 2.14A



TRANSECT APPROXIMATE RIVER MILE 48

MEDIAN TOTAL COLIFORM (MPN)

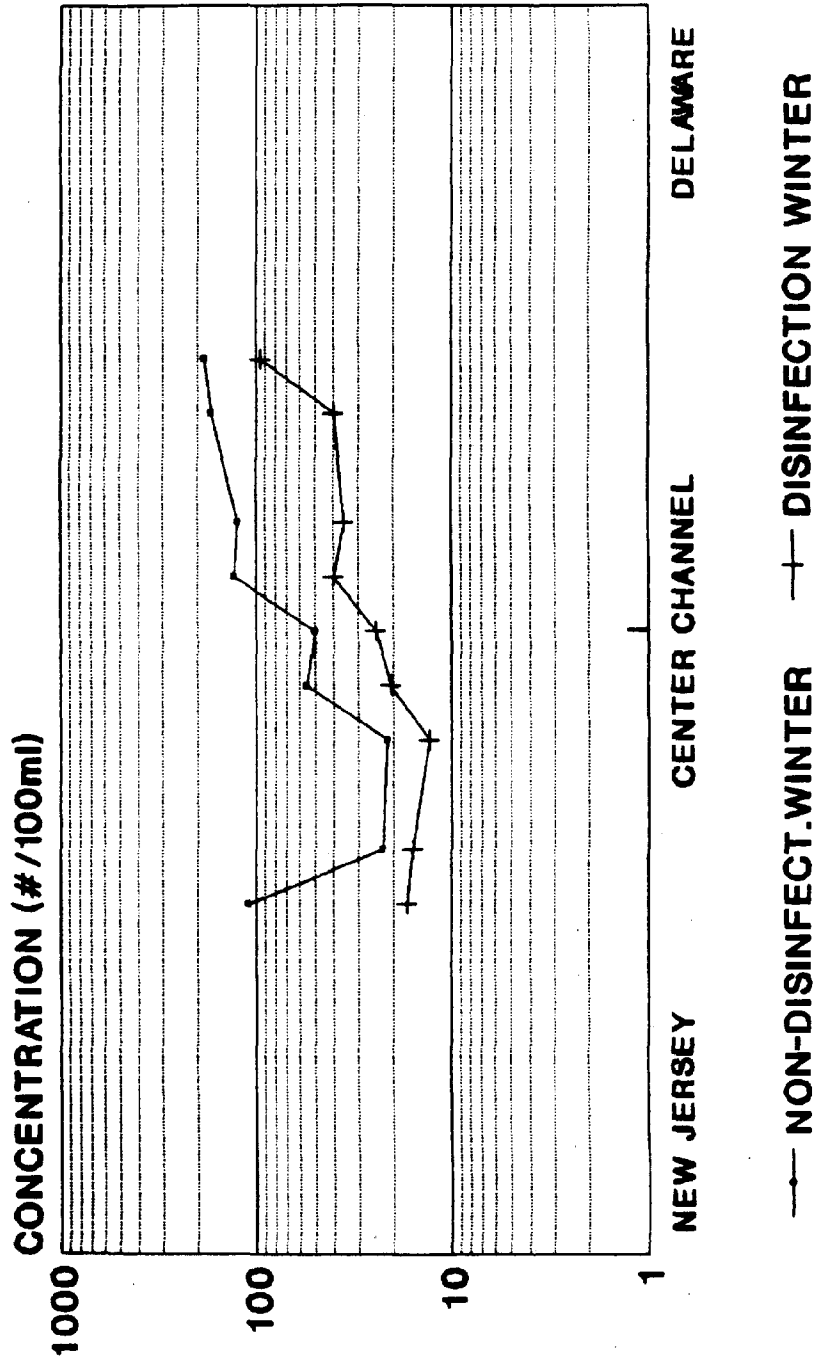
Graph 2.14B



Graph 2.14B

TRANSECT APPROXIMATE RIVER MILE 46

MEDIAN TOTAL COLIFORM (MPN)

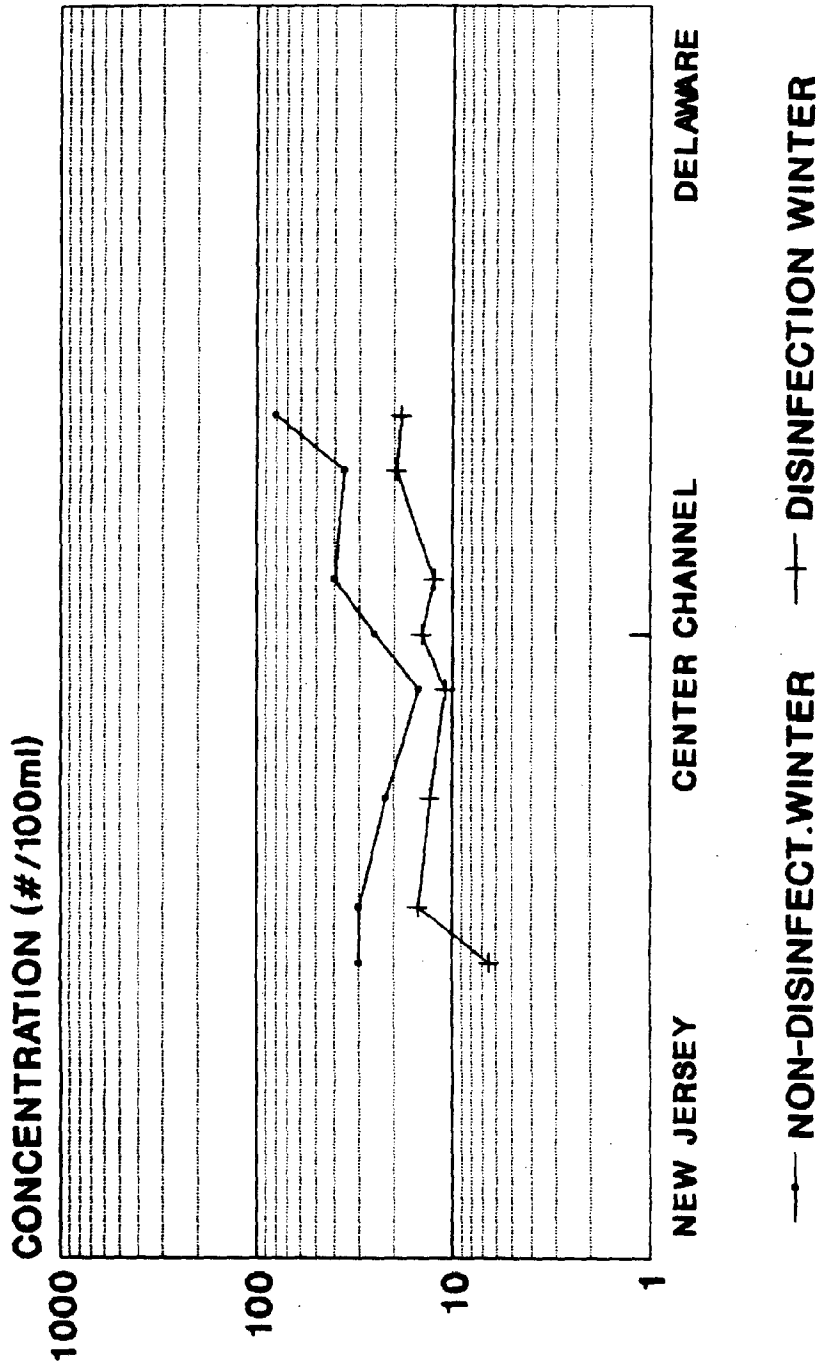


Graph 2.14C

TRANSECT APPROXIMATE RIVER MILE 43

MEDIAN TOTAL COLIFORM (MPN)

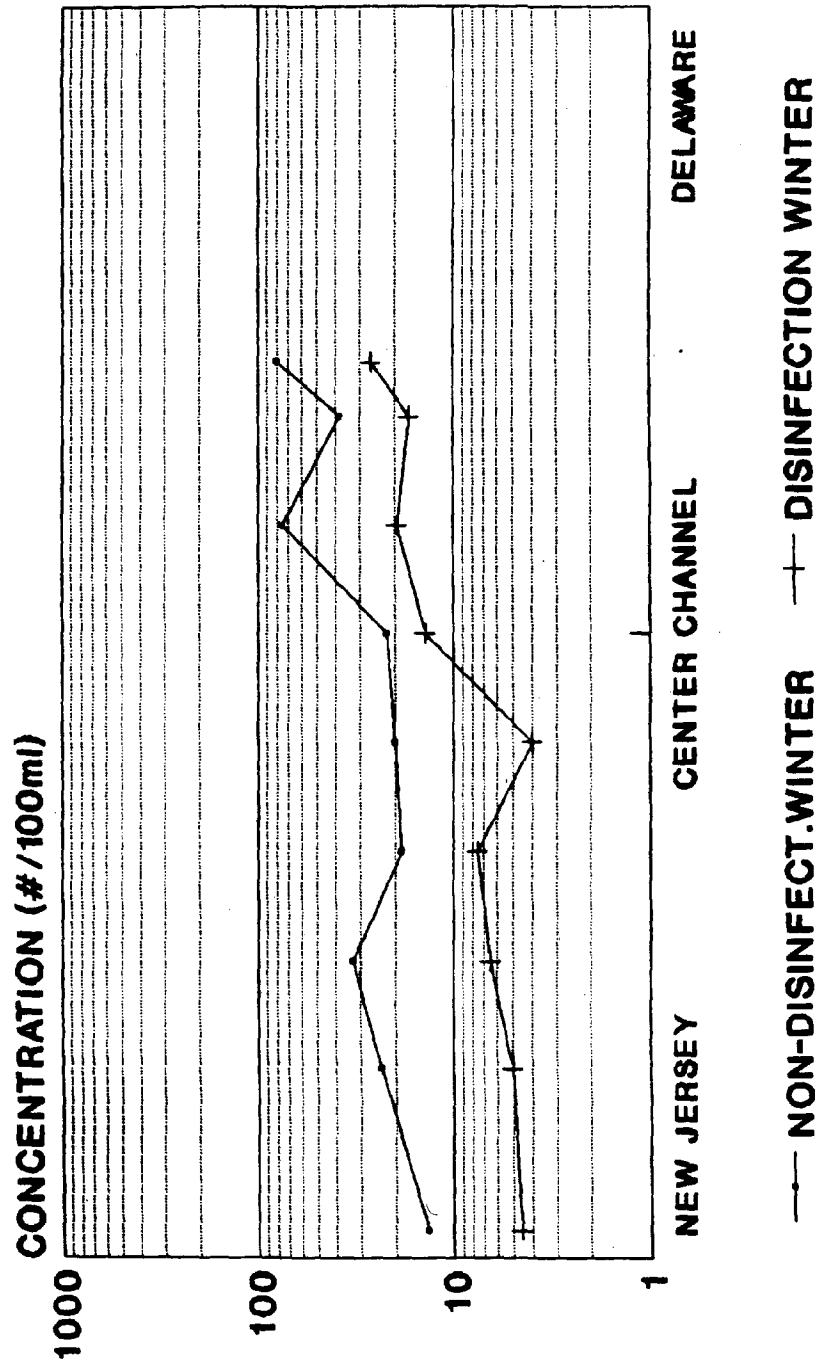
Graph 2.14D



TRANSECT APPROXIMATE RIVER MILE 40

Graph 2.14D

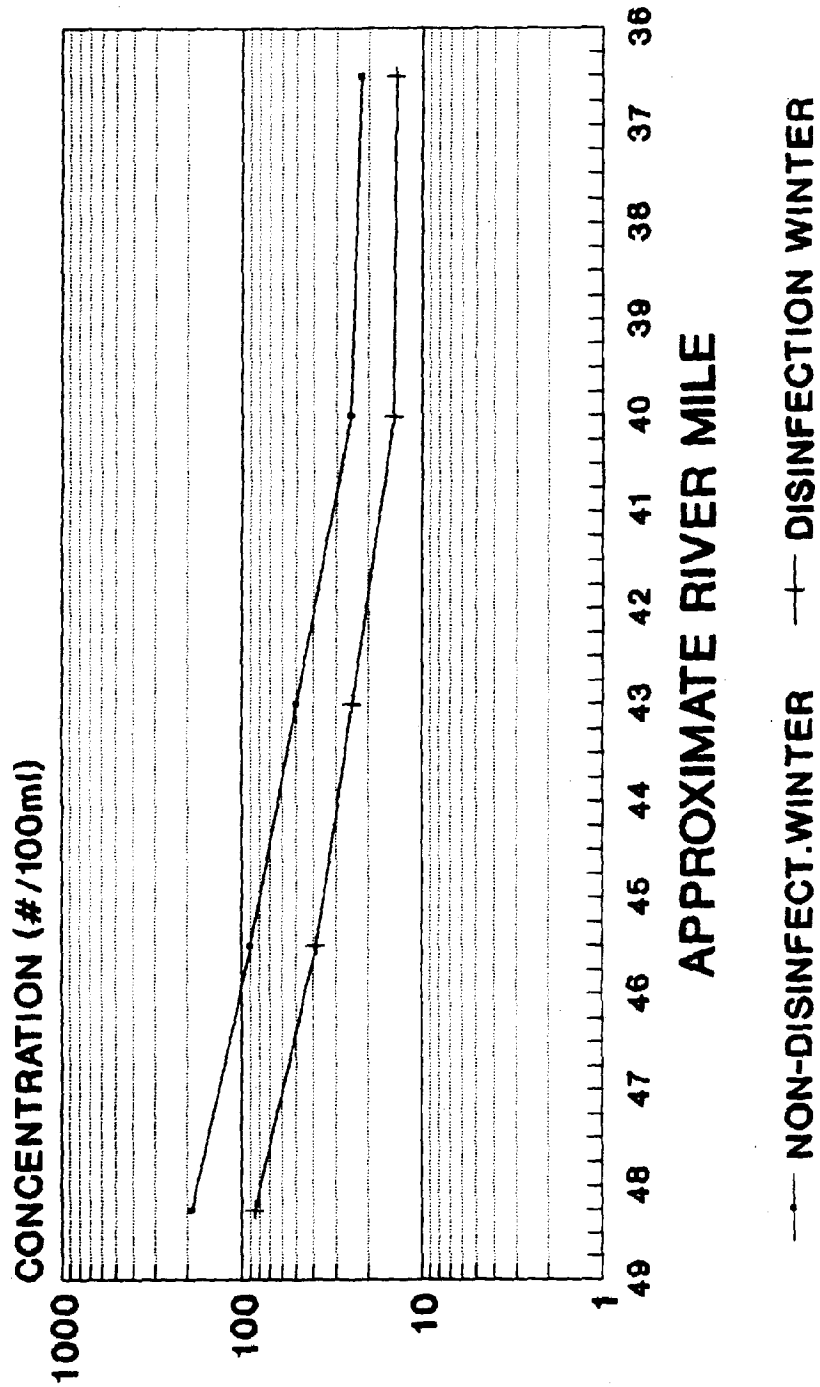
MEDIAN TOTAL COLIFORM (MPN)



Graph 2.14E

TRANSECT APPROXIMATE RIVER MILE 37

MEDIAN TOTAL COLIFORM (MPN)

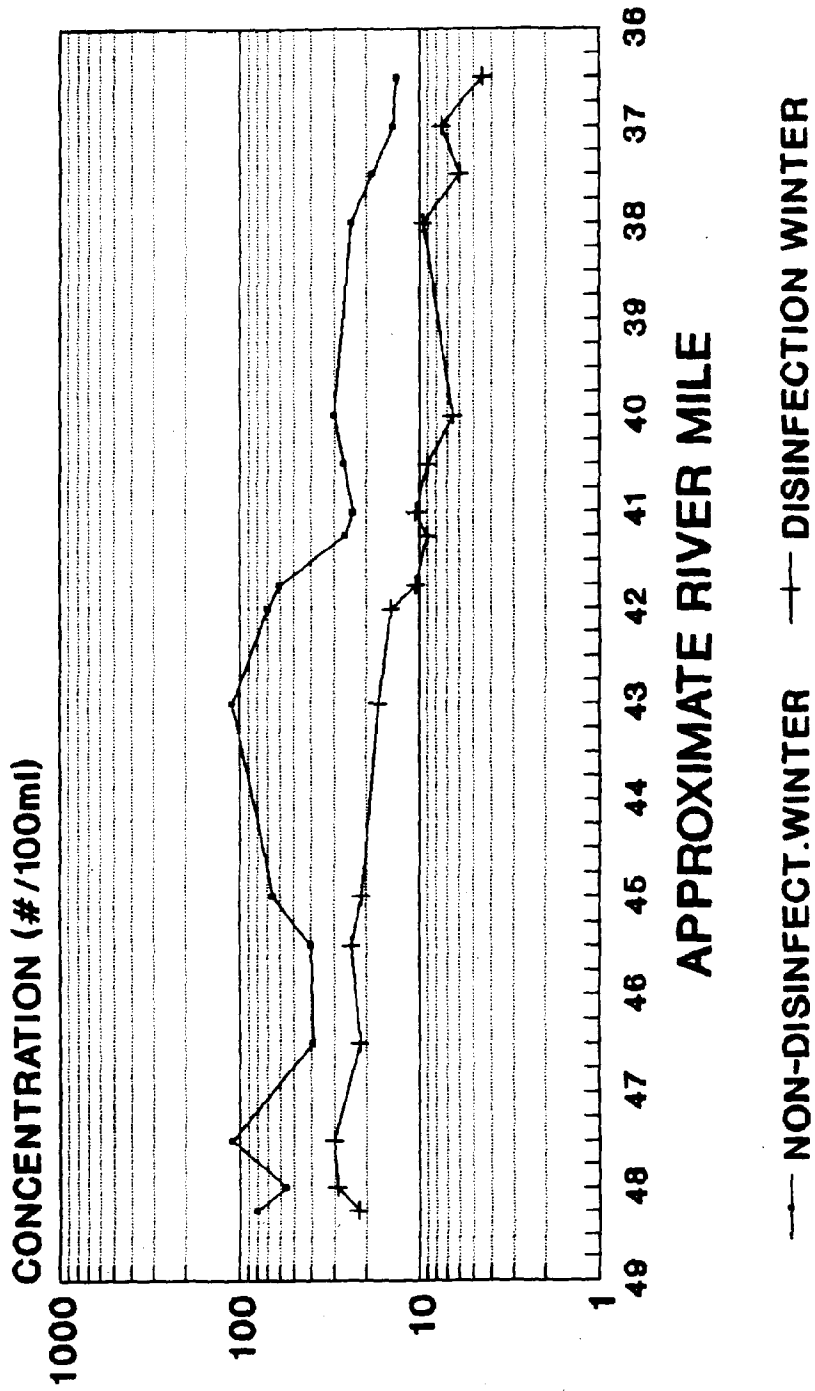


CENTER CHANNEL PROFILE

Graph 2.14F

MEDIAN TOTAL COLIFORM (MPN)

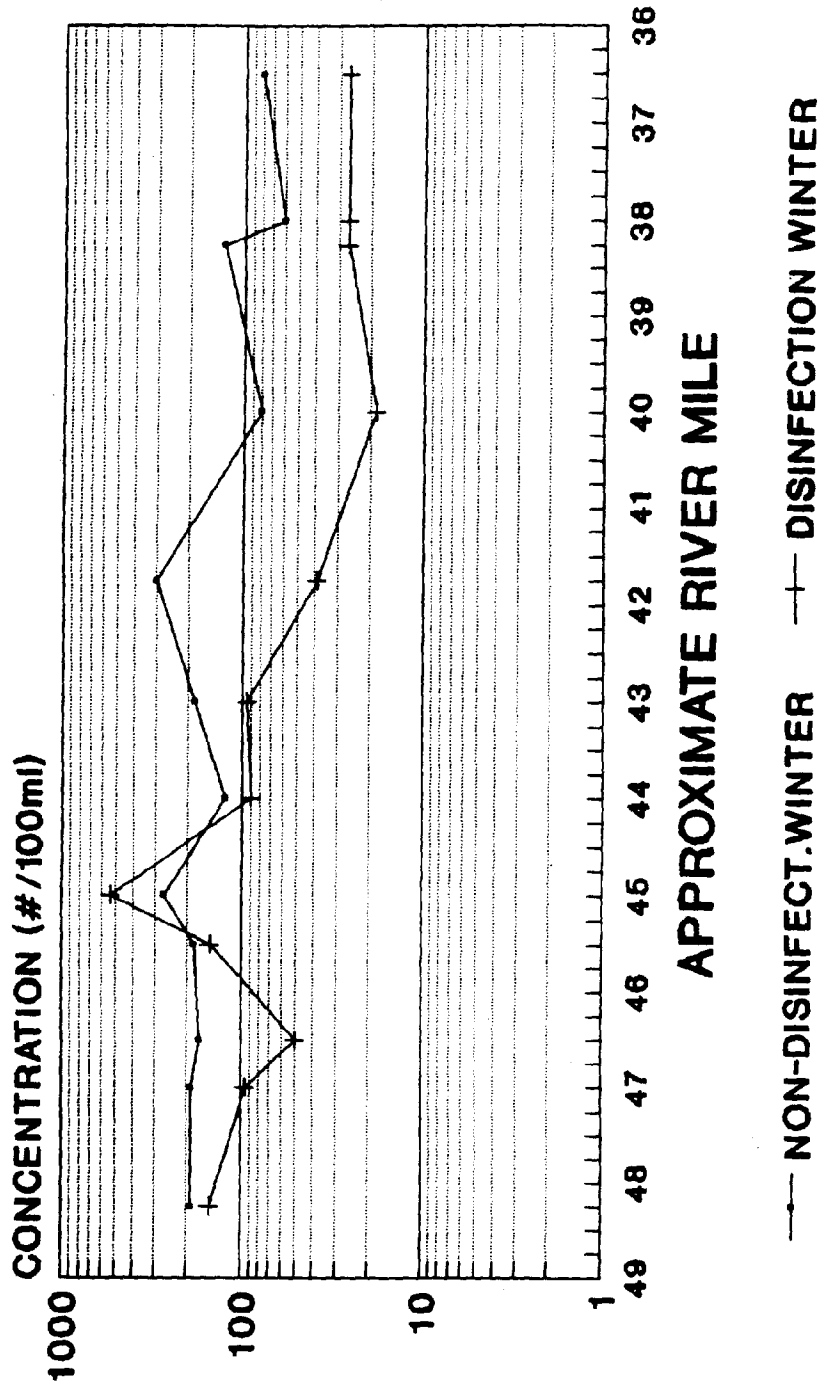
Graph 2.14G



NEW JERSEY (EAST) SHORE PROFILE

Graph 2.14H

MEDIAN TOTAL COLIFORM (MPN)



DELAWARE (WEST) SHORE PROFILE



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