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NATIONWIDE ASSESSMENT OF RECEIVING WATER IMPACTS FROM URBAN STORMWATER POLLUTION
Volume I: Summary

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16. ABSTRACT

Results of this nationwide search for documented case studies of impacts of urban runoff on receiving waters indicate that well-documented cases are scarce. Impacts previously attributed to urban stormwater runoff may be point source impacts in disguise, or they may be masked by greater contributions from other sources. The lack of documentation and clear definition of urban stormwater impacts makes the task of assessing the importance of this pollution source even more difficult. Results for every urbanized area in the United States have been summarized by the quantity or urban runoff, the available dilution capacity in the primary receiving water, the number of times the urban area was cited as having a "problem", the type of receiving waters, the impaired beneficial uses, and the problem pollutants.

The results indicate that numerous definitions of "problems" are being used. Accidental or deliberate discharges from point sources under wet-weather conditions are often the primary cause of wet-weather impacts. The findings suggest the need to intensify monitoring programs so that receiving water impacts can be more realistically evaluated. The present data base is poor.

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impacts, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research, a most vital communication link between the researcher and the user community.

This report assesses the nature and extent to which urban runoff is a documented cause of deleterious receiving water impacts. Few documented cases were found. Receiving water quality is still dominated by the continuing or residual influence of relatively large point source discharges. Urban runoff is actually an umbrella term for all unaccounted for residuals. As such its characteristics vary widely and quantification of its impacts must be done on a case by case basis.

Francis T. Mayo
Director
Municipal Environmental
Research Laboratory

PREFACE

Urban stormwater runoff has been recognized as a potentially significant source of pollution. Studies have shown urban stormwater runoff constituents comparable in concentration to secondarily treated sewage and often comprising a majority of constituent loads to some receiving waters. Nationwide estimates of the cost of controlling urban stormwater run into the billions of dollars.

The prohibitive costs of treating all stormwater outflows have made it necessary to take a more in-depth look at the receiving waters on a case-by-case basis. What <u>are</u> the impacts of stormwater runoff?

Concentrations and loads are high, but what actual impairments of beneficial use occur? What documentation exists? These questions have been the impetus for undertaking this nationwide assessment.

This report summarizes the findings of the study. The detailed city summaries are presented in Volume II.

ABSTRACT

Urban stormwater runoff has been recognized in recent years as a potential major contributor of pollution of receiving water bodies. Assessments of urban stormwater runoff pollutant quantities and characteristics have been made for several years throughout the Unites States, the most ambitious being the Environmental Protection Agency's 208 Areawide Wastewater Management Planning Program. Price tags for abating urban stormwater pollution (through elimination or reduction of discharges) range in the billions of dollars. Projections of high costs have forced a look beyond abatement of discharges to the receiving water bodies for insight as to what are the impacts, where are they, and are they significant?

Results of this nationwide search for documented case studies of impacts of urban runoff on receiving waters indicate that well-documented cases are scarce. Impacts previously attributed to urban stormwater runoff may be point source impacts in disguise, or they may be masked by greater contributions from other sources. In some cases they are offset by hydrological, biological, or geological attributes of the receiving water body.

The lack of documentation and clear definition of urban stormwater impacts makes the task of assessing the importance of this pollution source even more difficult. Efforts to address this aspect include relating sources of pollutants and pollutant types to receiving water characteristics and effects on desired water uses. Characteristics such as stream or lake bed hydraulics, present and potential water uses, established stream standards, ecological data and water quality information have been summarized for 248 urbanized areas. Results of these analyses have been summarized by the quantity of urban runoff, the available dilution capacity in the primary receiving water, the number of times the urban areas were cited as having a "problem", the type of receiving waters, the impaired beneficial uses, and the problem pollutants.

The results indicate that numerous definitions of "problems" are being used. Relatively little substantive data to document impacts have been collected. Impacts are most noticeable in small receiving waters. Impacts from urban runoff are difficult to isolate from other sources such as municipal and industrial wastes. Also, accidental or deliberate discharges from point sources under wet-weather conditions are sometimes the primary cause of wet-weather impacts. The findings suggest the need to intensify monitoring programs so that receiving water impacts can be more realistically evaluated. The present data base is poor.

This work was submitted in fulfillment of Grant No. R-805663-01 by the University of Florida under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period June 20, 1978 to March 20, 1980, and work was completed as of May 23, 1980.

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FIGURES

TABLES

ENGLISH TO METRIC CONVERSION UNITS

cfs x 0.0282 = m^3/s

ft x 0.3048 = m

in x 2.54 = cm

mile x 0.609 = km

sq. mile x 2.590 = km^2

ACKNOWLEDGEMENTS

This report is based on research sponsored by the Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency. Mr. John English, the Project Officer, provided valuable in-house information on receiving water impacts. Mr. Dennis Athayde, his staff, and consultants provided information on EPA's Nationwide Urban Runoff Program. Dr. Tim Stuart and his staff were very helpful in providing access to EPA's fish-kill data. Mr. Richard Field and Mr. Doug Ammon kept us current on the activities of EPA's Storm and Combined Sewer Section in Edison, New Jersey. Mr. David Ziegler of EPA's Washington Office provided current 208 project statements.

Several University of Florida students put together the detailed city by city summaries. Mr. Michael Hartnett (now with EPA Region IV) set up the maps for the entire U.S. and did many of the dilution ratio calculations. Ms. Amy Alford drew many of the maps and helped prepare the final summary tables. Ms. Terese Dicicco obtained the stream flow data and prepared some of the summary tables. Mr. Hal Scarle and Angelo Masullo prepared the city maps. Their help was invaluable and we thank them for their perseverance and good humor.

Ms. Linda Trawick patiently typed the report and the lengthy city summaries.

SECTION I

INTRODUCTION

A previous nationwide assessment indicated urban runoff and combined sewer overflows can be viewed as causing problems since, on a nationwide average, the quantity (13.4 in/yr) is approximately equal to the quantity of sewage (12.8 in/yr), and the annual BOD_5 per acre from a sewage treatment plant with a removal efficiency of 90 percent is 59.4 pounds as compared to 43.6 pounds from urban runoff and combined sewer overflows (1). Loads per acre from combined sewer overflows are approximately four times as large as loads per acre from urban runoff. Furthermore, the cost of controlling these wet-weather flows appears to be competitive with the cost of additional removal of pollutants in sewage. Consequently, if further rèductions in pollutant loads are needed, then wet-weather controls as well as further waste treatment should be evaluated carefully. The anticipated high price tag for such control programs has prompted decision makers to take a harder look at the seriousness of the problem.

This report presents the results of a search through published and unpublished literature, 201 and 208 project documents, EPA-furnished project materials, agency data and permit files, and other miscellaneous data sources to characterize urban wet-weather impacts on receiving waters.

The next three sections present the summary, conclusions and recommendations respectively. Section 5 summarizes the numerous ways in which impacts have been defined during this century. Then Section 6 outlines the major sources of specific information on impacts. National, regional, and local summaries are presented in Section 7. More detailed information is presented for every urbanized area in the United States in appendices A and B, and the detailed city summaries are presented in a separate Volume II of the same title.

SECTION II

SUMMARY

A nationwide study was undertaken to inventory documented receiving water impacts from urban runoff. The search for documentation included published and unpublished literature, Section 201 and Section 208 projects (PL 92-500), EPA furnished project materials, EPA fish kill data files, Nationwide Urban Runoff Program Proposals, and miscellaneous water quality reports and permit files. Major findings are summarized below:

1. Impacts are not clearly defined. Rather they are a composite of the perspectives of professionals from several branches of engineering and science, environmental interest groups, citizens committees, etc. The prevailing philosophical definition of impacts during the past decade was based on a broad-based ecological framework. However, the past year has witnessed a shift back towards the more traditional public health perspective with more interest in cost effectiveness. Against this rather fuzzy backdrop, impacts were tabulated in this report in several ways as viewed by these different groups. From a technical point of view, impacts should be more severe if the dilution capacity of the receiving water is not too large. Thus, dilution ratios were calculated for each of the 248 urbanized area in the United States. Otherwise, "impacts" were estimated by the number of times the urbanized area was cited in any of twelve categories of special studies, e.g., the urbanized area listed urban runoff as a high priority problem in its 208 planning study. Admittedly, this approach is subjective but it appears to be reasonable due to the paucity of available information.

2. Receiving waters are not well defined. The literature contains studies of receiving waters ranging from the smallest of ponds and creeks to major rivers, estuaries, and the ocean. Lacking a clear definition of receiving waters, 1:500,000 USGS Hydrologic Maps were used for all urbanized areas. A dilution ratio calculation was performed for the primary receiving water(s) that is contiguous to the urbanized area. In many cases, receiving waters of notoriety in the literature, e.g., Lake Eola in Orlando, Florida, do not even appear on these maps.

3. Almost 85 percent of the primary receiving waters contiguous to urbanized areas are rivers. The majority of these rivers have an average flow of less than 10,000 cfs. Lakes comprise five percent of the receiving waters and the remaining ten

percent are estuaries or oceans.

4. Over 10,000 fish kill reports for 1970-1979 were reviewed. Less than three percent of these fish kills listed urban runoff as the direct cause.

5. Water quality problems exist at 449 out of a total of 3521 beaches throughout the United States. While urban runoff was not listed as a separate category in this study, it may be a significant factor since almost 50 percent of the closings were due to undefined sewage contamination or unknown causes.

6. Studies of continuous dissolved oxygen records downstream of urbanized areas indicate that worst case circumstances occur after storms in approximately one third of the cases studied. This lowered D.O. is probably due to combined sewer overflows, urban runoff, and storm caused resuspension of benthal materials.

7. Thirty cities are presently conducting intensive studies of urban runoff under joint sponsorship of the city and EPA's Nationwide Urban Runoff Program. Several of these studies will try to document the deleterious receiving water impacts that are caused by urban runoff. There is little direct evidence at this time to document this cause-effect relationship.

8. The National Water Quality Inventory studies indicated that twelve out of twenty six water quality constituents have higher concentrations during higher flow periods. These studies were done for major (>10,000 cfs) rivers which comprise only 19 percent of the primary receiving waters for urbanized areas.

9. Urban runoff was listed as a high priority problem in 88 urbanized areas. However, this prioritization was done with relatively little scientific/technical information.

10. The 1978 NEEDS Survey proposed water quality criteria for wet-weather flows and compared these criteria to the results of computer simulations. However, these criteria are admittedly arbitrary and the model does not include the capability to incorporate the resuspension of benthal deposits. Based on the evaluations of D.O. data described in summary item 6, this factor is very important.

11. The 1979 Congressional Hearings related to urban runoff discussed the disturbing fact that existing treatment plants are being operated poorly. In many of these cases, the results of plant breakdowns, spills, etc. are manifest as urban runoff problems because the discharges are made during wet-weather periods.

12. A total of 120 urbanized areas have combined sewers. Most of these cities are located in the eastern United States. In these areas, the combined sewer overflow problem is more significant than direct urban runoff.

13. The most popular theme of other studies of urban runoff quality was to predict water quality changes in stormwater detention ponds. The primary purpose of these ponds is drainage control. Concern exists that these ponds may have serious water quality problems and act as mosquito breeding areas.

14. On the national level, about 150,000,000 people live in urban areas in the United States. The average annual precipitation in these areas is 33.4 inches. The annual volume of urban runoff is 4 percent larger than the annual volume of sewage. The median receiving water has an annual flow of approximately fifteen times the sum of the urban runoff and sewage. The median number of problem citations per urbanized area is 1.6.

15. Unexpectedly, the number of problem citations per urbanized area increases as the dilution ratio increases. One would expect the opposite to occur since increased dilution capacity should reduce the number of problem citations per urbanized area. Overall, no obvious regional trends in dilution ratio were apparent.

16. Neglecting those states not having at least three urban areas, the following seven states do not have a dilution ratio greater than 10:

    Connecticut (3.0)
    North Carolina (3.5)
    Colorado (3.5)
    California (3.7)
    Utah (5.1)
    Massachusetts (6.2)
    Ohio (7.2)

    At the other extreme, the following three states have dilution ratios greater than 1000:

    Arkansas (1040)
    West Virginia (1525)
    Kentucky (2409)

17. The following nineteen cities have four to six problem citations.

Citations per Urbanized Area	Urbanized Area(s)
6	Philadelphia, PA.
5	Boston, MA, Chicago, IL, Detroit, MI, Lansing, MI, Milwaukee, WI, New York, NY, Seattle, WA, and Washington, D.C.
4	Atlanta, GA, Baltimore, MD, Cleveland, OH, Denver, CO, Des Moines, IA, Mobile, AL, Richmond, VA, Savannah, GA, Syracuse, NY, and Youngstown, OH.

SECTION III

CONCLUSIONS

Based on this nationwide search to document receiving water impacts from urban runoff, the following conclusions can be drawn:

1. Documented case studies of impacts of urban runoff combined sewer overflows on receiving water are scarce. Several reasons may be given for this situation.

   a. Under the anti-degradation philosophy espoused by PL 92-500 in 1972, there was less need to devote resources to receiving water impact assessment. Urban runoff did not become widely recognized as a problem until after 1972. Thus, little attention was given to this problem.

   b. Impacts of sewage effluent, industrial wastes, and other discharges mask the impacts of urban runoff. Even when other sources have been reduced or eliminated, their residual impacts in terms of benthal deposits are often still evident.

   c. The increased reliance on mathematical models for assessing receiving water impacts reduced the level of effort in field sampling programs.

   d. The greatly enhanced emphasis on broad-based environmental impact assessments diverted effort from the more traditional sanitary survey approach to assessing impacts. These studies produced relatively little hard information on impacts from urban runoff.

   e. The cost of sampling programs is relatively high due to the intermittent nature of storm events, wide variations in flow and concentration, and general inexperience with this type of activity.

   f. Expected impacts from urban runoff are relatively subtle and do not cause obvious large-scale problems. Thus, more refined and longer-term sampling efforts are needed to develop reliable cause-effect information. Indeed, if experience in the related area of sediment transport in receiving waters is any indication, it may be many years before these cause-effect relationships are understood.

2. Numerous definitions and interpretations of the word "impact" exist. Thus, it is difficult, if not impossible, to devise meaningful rankings of impacts without an accepted definition of terms.

3. Receiving waters range from the smallest of creeks and ponds to the ocean. No clean line of demarcation exists to distinguish the urban drainage system from the receiving water.

4. Some evidence exists that urban runoff is a cause of fish kills and beach closings. However, this data base is weak.

5. The studies of dissolved oxygen records downstream of urban area have produced the most definitive information regarding the impact of wet-weather flows. This analysis clearly shows how stormwater discharges dampen the diurnal fluctuations in dissolved oxygen and can reduce the overall dissolved oxygen levels. In these cases the causes are some unknown blend of combined sewer overflows, urban runoff, benthal deposits, treatment plant spills, etc. These studies strongly suggest that worst case conditions may not occur during the usually assumed low flow period.

6. Urban runoff is being given greater attention in the newly developing areas of the United States. These areas are more concerned with retaining the present high quality environment in or near their development. On the other hand, the receiving waters in the older, established parts of the county have long been polluted. Thus, urban runoff is viewed as a minor source compared to the more traditional domestic and industrial waste discharges. In these older areas, local citizens have accepted the relatively poor water quality. This is in sharp contrast to some of the new areas where a very strong anti-degradation philosophy prevails.

SECTION IV

RECOMMENDATIONS

Recommendations for future studies are listed below:

1. If receiving water impacts are to be evaluated in a meaningful manner for environmental decision making, then a problem solving framework is needed. During the past several years, emphasis has been placed on broad-based "impact" assessments and inventories. These scientifically oriented studies have provided relatively little directly usable cause-effect information. Unless a well defined problem solving scenario is used, it is difficult, if not impossible, to decide what is important to study. Using a problem solving focus, the problem is first identified, say, a beach is closed. Then, the next question is to find out where the contaminants are coming from. Then, alternative methods of control are explored and the appropriate control is implemented. Lastly, the effectiveness of the control is evaluated relative to whether it accomplishes the desired objective, opening the beach, in this example. By this inductive reasoning, a sufficient number of case studies could be developed to present a sound technical and legal basis for more general control guidelines. By contrast, the broad-based ecological approach relies on deductive reasoning which promulgates specific regulatory guidelines based on abstract analysis of ecological principles. However, these theories are incomplete. The result is a hodge podge of opinions and value systems all purporting to tell us what is right.

2. Regulatory agencies need to establish guidelines for distinguishing urban drainage systems from receiving waters.

3. Careful follow-up studies should be conducted using the continuous dissolved oxygen data base for several cities. The specific focus of these studies should be to document cause-effect relationships.

4. Serious efforts should be made to develop improved receiving water quality standards. Continuing to assume that the "worst case" occurs during the one in ten year low flow period is simply not meaningful. This study has indicated that worst case conditions are some complex combination of known point source discharges, combined sewers overflows, urban runoff, deliberate or accidental treatment plant spills, illicit

industrial wastes, etc. These composite sources cause more severe problems to occur at times other than the accepted critical low flow period. These standards need to include provision for continuous monitoring. At present, these data only exist in a few areas of the United States. Simulation models are not a suitable substitute for these monitors since they cannot, by themselves, represent the complexities of local circumstances.

5. A data base should be established to preserve the results of these studies for future analysis. This information is very costly to acquire and every effort should be made to assure that it is widely available.

SECTION V

IMPACTS DEFINED

Several interrelated views on impact assessment may be gleaned from a review of the literature. Traditionally, two perspectives, public health and sanitary engineering, were of prime importance. The public health approach focused on prevention, whereas sanitary engineering took a cost-effectiveness approach (2). An example from the turn-of-the-century is the controversy over whether cities should be required to treat their waste to reduce downstream water treatment costs. Sanitary engineers argued that the assimilative capacity of the rivers should be considered, and treating the intake water is much more cost-effective than spending larger sums (approximately ten times more) on upstream waste treatment. Cooperative efforts between these two groups led to the development of receiving water standards. Within this context, "impacts" can be defined in terms of whether the "standards" have been violated.

This approach prevailed until 1972 when the Federal Water Pollution Control Act Amendments established the following basic water quality goals and policies for the United States (3,4).

1. The discharge of pollutants into navigable waters should be eliminated by 1985.

2. Wherever attainable, an interim goal of water quality, which provides for the protection and propagation of fish, shellfish, and wildlife and for recreation in and out of water, should be achieved by July 1, 1983.

3. The discharge of pollutants in toxic amounts should be prohibited.

These amendments represented a shift towards the early public health philosophy of anti-degradation with relatively little consideration being given to the cost of attaining these goals. However, the emphasis went beyond anti-degradation for the primary purpose of protecting public health to restoring and maintaining the "integrity" of the Nation's waters.

EPA sponsored a 1975 symposium titled "The Integrity of Water" (5). Distinguished technical people attempted to define "integrity" from physical, chemical, biological, and overall perspectives. The mood of the meeting was that a holistic ecological approach was needed, e.g.,

1. Legislative Requirements, Kenneth M. MacKenthun, EPA. MacKenthun quotes from Aldo Leopold's classic 1949 work "A Sand County Almanac".

   "Examine each question in terms of what is ethically and aesthetically right, as well as economically expedient. A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."

2. Incorporating Ecological Interpretation into Basic Statutes, Thomas Jorling, Director, Center for Environmental Studies, Williamtown, Massachusetts.
   "The new program has a different underpinning. It assumes that man is a component of the biosphere and that relationship we seek to achieve with the environment is what some have called 'harmony'. Under this view, man is an integral, if dominant, part of the structure and function of the biosphere. The intellectual roots of this perspective are found in the study of evolution. The objective of this concept is the maximum patterning of human communities after biogeochemical cycles with a minimum departure from the geological or background rates of change in the biosphere."

3. A Conservationist's View-Ronald Outen, Natural Resources Defense Council, Inc. Washington, D.C.
   "The Federal Water Pollution Control Act Amendments of 1972 contain a basic philosophical shift in water management from one of standards (technological approach) to one of integrity (ecological approach). This is a significant achievement."

   "The fact is you cannot effectively implement the '72 law using 1965 assumptions. Consider the old law. It was premised on the anthropocentric idea, as Mr. Jorling pointed out, that aquatic ecosystems exist for the use of man."

   "This assumption leads one quickly to one perverse result after another. The first order of business becomes the designation of the 'best use'. Next comes the creation of water quality criteria . . . Underpinning this process is the ecologically questionable notion of assimilative capacity. Involving the theory of assimilative capacity, . . ., one is led to the device of defining a mixing zone. . . . Use of this sprawling regulatory scheme to actually abate a source required the execution of a load allocation. . . . Even if by great good fortune and Herculean toil this much were accomplished, the regulator found himself up against a whole series of enforcement delays, conferences, and admonitions that he not cause the unfortunate polluter an economic hardship. . . ."

"Note that all the steps in the process flowed logically from the first assumption, that the aquatic ecosystem exists for the use of human society. With the 1972 Amendments, on the other hand, we have for the first time in the Nation's history, a water pollution control law that takes a holistic view of the aquatic ecosystem. . . . The question, 'How much cleanup is necessary' becomes a meaningless question."

"We must recognize that the field of economics is unequiped to deal with the broad questions of ecosystem structure and functions and therefore the quality of life we want a century, two centuries from now. . . . Rather than responding to individual treatment crises on an ad hoc basis, rather than taking action and then measuring its effect, we must elucidate fundamental ecological principles, then guide all human behavior by those principles".

4. Industry's View, R.M. Billings, Director of Environmental Control, Kimberly-Clark Corporation, Neenah, Wisconsin.

"I believe it is meaningless to talk of 'maintaining the integrity of water'-the integrity of an inanimate thing? Rather we should be stating it as 'integrity in the use of water'. . . . the integrity of the whole can then only be judged as it relates to people. . . . Far too many regulations are being proposed today on the basis of data demonstrating them to be attainable rather than data demonstrating them to be needed."

The above comments indicate the strong feelng at that time that a holistic, ecological approach was needed. However, literal interpretation of this perspective typically led to the conclusion that the only "safe" course of action was to do nothing lest the ecosystem be harmed in some way. Other attempts to define related general measures of welfare such as "environmental quality" and "quality of life," e.g., an anthology of readings from an EPA sponsored symposium on this subject, indicate that this is, at best, a very nebulous subject (6). In the latter 1970's the swing back towards an anthropocentric perspective became more apparent for at least four reasons:

1) No consensus appears to exist on how value criteria such as "integrity" can be defined in an operational sense. Related value criteria such as ecosystem stability have been proposed. However, Ehrenfeld points out that no consensus exists as to the optimal amount of diversity, or the nature of the loss function if the system is modified by man (7). Of course, man depends on the natural system for survival so its value is imputed in terms of its importance in protecting man's well being.

2) An anthropocentric view permits comparison of the efficacy of additional expenditures on water pollution control vs. other investments designed to enhance man's physical and mental health. Along these lines, Eisenbud feels that too much money is being invested in air and

water pollution control programs in New York and that these monies would be better spent on other public health controls, e.g., rat eradication programs, public health clinics (8). Dallaire makes a similar argument with regard to New York City. He points out that the water supply for New York city is carried by two massive water tunnels which are quite old (built in 1917 and 1936) and need to be inspected (9). If one of the two tunnels collapses about one half of the water supply would be lost with catastrophic consequences. This project is receiving lower priority than constructing wastewater treatment facilities because no federal funds are available.

3) The projected costs of controlling the remaining water pollution as espoused by a more literal interpretation of PL 92-500 are staggering-hundreds of billions of dollars for stormwater alone (10,11). Later studies showed that this cost could be reduced substantially by estimating the cost of control over the entire range of removals and selecting a "reasonable" compromise solution, e.g., 70% control in Figure 1 (1,12,13). This point is popularly called the "knee of the curve." Earlier national assessments had asked the cities what they "needed" to control stormwater pollution. Many of these cities used the 2 year, 5 year, or 10 year design storm to size their control units. As is evident from Figure 1, it does not seem reasonable to spend several times more money to go from 70% control to 80+% control. But one can still ask whether it is even reasonable to spend the amount required to reach the "knee of the curve". The current (1980) inflationary trends in the U.S. economy heighten the interest in more cost-effective solutions.

4) A corollary to the result that costs are staggering as one approaches total control of pollutants is the notion of risk in engineering design. Starr addresses the question of risk in engineering design in which people individually, e.g., making travel plans and/or collectively, e.g., flood control works, assess the riskiness of various courses of action (14). Wilson describes the results of attempts to implement a public policy which eliminates the risk to cancer at any cost (15). As an example, he cites a proposed OSHA program which would cost $\$300 \times 10^6$ for every life saved, about one fourth of the lives that would be lost implementing the proposed controls (15). Related examples have appeared in flood control wherein the expected number of construction workers killed building a flood control reservoir exceeds the expected loss of life from flooding (16). Recently, a tragic accident killed 54 workers constructing a cooling tower to control thermal pollution in West Virginia. Similar concerns have been expressed about the wisdom of controlling organics in drinking water (17). Krenkel presents a comprehensive critique of the present philosophy of establishing water quality criteria based on ecological rather than public health concerns (18). Heaney and Waring summarize methods for quantifying water quality benefits (19).

It is apparent from the above discussions that a see-saw effect has been present for many years in the environmental movement as shown below in Figure 2.

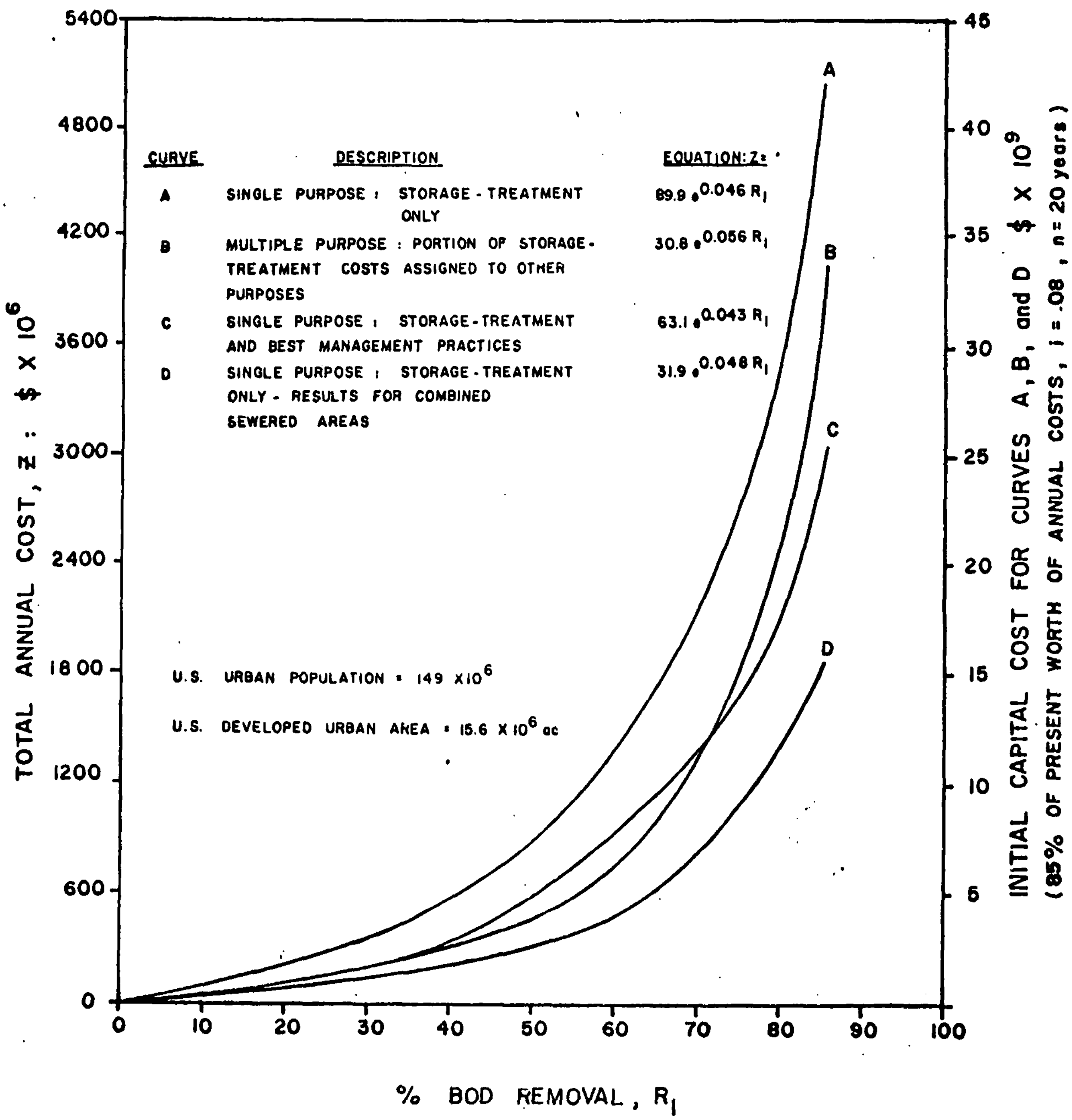


Figure 1. Single Purpose and Multiple Purpose Stormwater Pollution Control Costs for US (1, 12, 13).

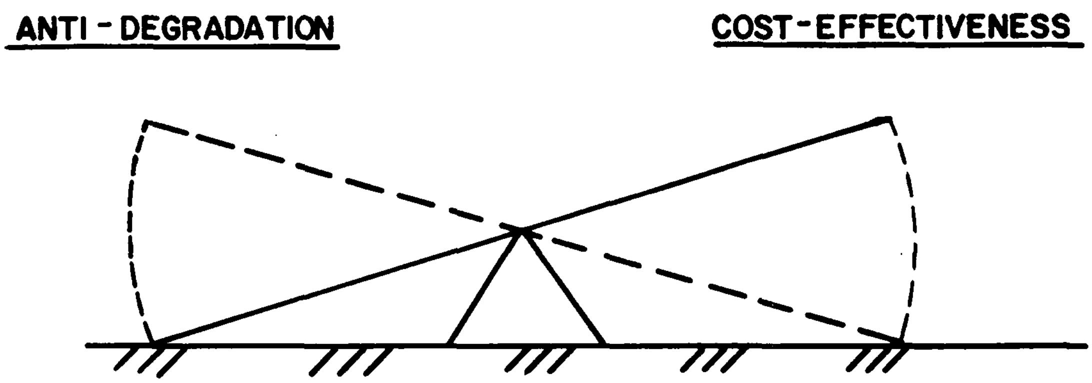


Figure 2. See-Saw Effects of Changing Approaches to Environmental Management

The 1972 Amendments have caused a shift to an anti-degradation philosophy. However, emphasis now has again shifted to cost-effectiveness. Thus, the heated discussions of the early 1900's remain unresolved. Nor is it reasonable to expect that they will be resolved in the next few years because the root issue is one of values and societal goals, neither of which can be defined unambiguously nor are they static. Sinden and Worrell recently published a book describing numerous ways to estimate environmental values (20). While the book catalogs many of the available methods it does not prescribe a "best" way to analyze these difficult problems. The authors state in the preface that this book is addressed to managers, planners, policy analysts, and policy makers. However, in view of the overall uncertainty about this problem, it is hard to imagine a single coherent method emerging which would be useful for such a diverse audience.

The search for impacts was conducted against this backdrop. Referring to Outen's description of the anti-degradation philosophy of the 1972 Amendments, if this line of reasoning is followed then it is unnecessary to assess impacts since this question is no longer relevant. Unfortunately, for the purpose of this study, this attitude resulted in relatively few attempts to seriously assess impacts during the middle and later 1970's. This posture represented a significant departure from the major water quality studies conducted by the U.S. Public Health Service and its successor agencies in the 1960's, e.g., studies of the Delaware River, Potomac River, Great Lakes, Colorado River, San Francisco Bay.

To avoid the accusation of parochialism in adopting, a priori, any one or a combination of the above systems for assessing stormwater "impacts," the literature search was approached with an open mind. However, the need for a more precise definition of an "impact" became apparent early. Definitions of "impact" are almost as numerous as there are investigators, congressmen, regulators, and citizen review committees of urban stormwater problems. The range of impact definitions includes specific cause-effect statements, comparisons of constituent concentrations to numerical standards, sensory perceptions such as odor and color problems, and "perceived" impacts from citizens. All are applicable and valued, with respect to the level of action or understanding desired. However, for a "standard" definition by which to conduct comparative studies at the environmental regulatory agency (EPA) level, a stormwater impact was defined as one which resulted in "loss of beneficial use." Beneficial uses considered are those listed in local, state, and federal water laws, which include drinking water use, fishing and shellfishing, swimming, boating, manufacturing process water use, etc.

The following summary relates "impact level" to "loss of use" in a general overview:

Impact Level	Loss of Use
Policy or Management Planning	Is considered possible or is implied.
Standards or Criteria Violations	Is implied, may be imminent, or can actually occur through restriction of use.
Documented Cases of Cause-Effect	Actually occurs.

Policy or Management Planning--At this level the loss of beneficial use is implied but has not actually occurred. Use of a receiving water body for stormwater discharge may violate (or be in contrast to) a comprehensive plan, environmental agency philosophy, coastal zone management policy, area-wide water use classification system, or some other indicator of intended use.

Standards or Criteria Violations--This is the level at which impact typically has been assessed. The usual approach is to measure constituents of storm or receiving waters, compare measured values with local, state, or federal standards (criteria, or guidelines), and then directly equate impact with the number of constituent standards violated, or the number of days a constituent standard is violated. This same approach is used in cases where key concentrations have not been identified or developed. The presence or absence of a constituent (e.g., EPA list of 129 priority pollutants) is often considered an impact.

The loss of use at this level can be implied, may be imminent, or can actually occur. Whether or not an impact actually occurs is relative to the basis on which a standard is promulgated. In the absence of supporting data, standards are usually set conservatively, so many documented violations of standards <u>imply</u> impact, rather than actually <u>indicate</u> impact (e.g., oxygen standards are violated, but fish kills do not occur). Standards or criteria violations may be considered "paper" impacts.

Documented Cases of Cause-Effect--This was considered the impact level where loss of beneficial use was actually documented. Site-specific evidence of fish kills, beach closings, loss of water supply, citizens' complaints of odor, floating debris, medical records of water-use related disease, and other effects (impacts) caused by or related to stormwater runoff were reviewed. This nationwide survey focused on this level.

Documentation of extreme or unusual events is often easier than identification of trends or subtle changes, especially where complex systems of man and nature are concerned. Questions arise as to the cause of an impact (such as a fish kill). Was it due to an event such as a toxic substance being flushed, or was it due to bioaccumulation (to lethal levels) of a series of events establishing a trend? In general, pulsed (event-driven) systems are under examination when addressing stormwater issues, so causes of impacts considered were short-term. The impact itself, being event- or trend-induced can be manifested quickly or over a long period, and finally, the manifested impact may have short or long-term significance.

The next section summarizes the major sources of information on receiving water impacts. Then the national, state, and local results are presented.

SECTION VI

URBAN AREA SUMMARIES

LITERATURE REVIEW

The category-by-category search and review of literature sources included the following major sources:

1) EPA Cincinnati in-house files (21).
2) EPA's Nationwide Urban Runoff Program (NURP) (22). EPA Headquarters personnel and a team of consultants visited every regional office at least once. During the initial visit, the regional personnel were asked to identify which of these 208 studies indicated that urban runoff was a "problem". Next, the group was asked which areas had receiving water data documenting that an impact existed. They were asked to indicate whether the "problem" related to violation of water quality standards, impairment of beneficial use(s), aesthetics, or other cause(s). Lastly, each regional group was asked to suggest candidate cities for further study. Ideally, these cities should have a clearly identified urban runoff problem, and sufficient interest in solving it to finance 25 percent of the cost of the study. Based on this procedure, 30 cities were selected for further study.

3) EPA's 208 Master Computer File on all urban areas that identified urban runoff as a "priority problem" (23).

4) Computerized Literature Searches

   a. Water Resources Scientific Information Catalog (WRSIC) system of U.S. Department of Interior, Office of Water Research and Technology.

   b. Smithsonian Scientific Information Exchange (SSIE) lists of on-going research projects.

   c. University of Florida's State Technologies Application Center (STAC) information retrieval system which is tied into the NASA system of about 20 million publications.

5) U.S. Environmental Protection Agency Fish-Kill Data (24). Approximately 10,000 individual fish-kill reports were surveyed (See ref. 25 for a general summary).

6) Studies for the National Commission on Water Quality on beach closings (26).

7) 1978 NEEDS Survey (27).

8) Sutron Corp. case studies on relationships of rainfall, stream flow, and dissolved oxygen (28).

9) Abstracts for EPA National Conference titled Urban Stormwater and Combined Sewer Overflow--Impact on Receiving Waters, November 1979.

10) Environmental Protection Agency, Nationwide 201 and 208 Technical Documents and Wastewater Management Plans.

11) North American Water Project (29).

12) 1974 EPA National Water Quality Inventory (30).

13) 1979 Congressional Hearings on Nonpoint Pollution (31).

PRESENTATION OF FINDINGS BY URBAN AREA

According to the Scope of Work, the results of the literature review are to be organized in terms of the following:

-Characteristics of the urban area as it related to types and quantities of pollutants
-Characteristics and types of receiving waters
-Uses of receiving waters and water quality standards
-Kind of impact whether ecological or public health
-Characteristics of impact such as short-term dissolved oxygen sags versus longer term benthic effects
-Key pollutant or pollutants causing the impact

The results from the previous chapter indicate that the whole question of "impacts" remains unclear because of lack of agreement on definition of terms. After several futile attempts to organize the results in different ways, it was decided to present the findings for every urban area in the United States using consistent definitions of key terms such as urban area, urban runoff, and receiving water impacts. A general description of these urban area summaries is presented in this section. The actual summaries are continued in a separate volume. The results for each urban area are then summarized at the state and national level. These results are presented in the next section. The urban area summaries are partitioned into the following categories:

1) Demographic data
2) Hydrologic background
3) Waste sources
4) Receiving waters
    a) Classification

b) Dilution ratio
c) Special studies
d) References to "Other studies" category
e) 1:500,000 USGS State Hydrologic Map for Urban Area and environs
f) Ten years of monthly and annual flow data for primary receiving water(s).

Each of these categories is discussed in the subsections to follow. Then an example urban summary for Tampa is presented.

DEMOGRAPHIC DATA

The 248 urbanized areas included in this study are as defined by the Bureau of the Census of the U.S. Department of Commerce in the 1970 census (32). They are generally characterized as having:

- A central city or urban core of 50,000 or more inhabitants.
- Closely inhabited surroundings, consisting of unincorporated places of 100 housing units or more; and small unincorporated parcels with population densities of 1,000 inhabitants per square mile or more; and
- other small unincorporated areas that may eliminate enclaves, square up the geometry of the urbanized area or provide a linkage to other enumeration districts fulfilling the overall criteria within 1 1/2 miles of the main body of the urbanized area.

For each urban area, the 1970 population, the developed portion of the urbanized area (mi^2), and % combined sewers were tabulated. This information was taken from Heaney et al. (1). Hydrologic background was available for 222 cities based on earlier work by Schneider (33). His summary was included for these cities. Lastly, the annual precipitation, sewage flow, and urban runoff measured in inches/year were included. This information was taken from Heaney et al. (1).

HYDROLOGIC BACKGROUND

Schneider (33) summarized the hydrologic background for 222 cities in 1968. This information is included to provide a general perspective regarding these urban areas. The precipitation data are from Heaney et al. (1).

WASTE SOURCES

The estimated annual volume of sewage and urban runoff is reported in inches over the developed area. The data are from Heaney et al. (1). This unit is selected to permit direct comparison to precipitation data.

RECEIVING WATERS

Classification

Receiving waters can be conveniently classified into four major categories: estuaries (E), lakes (L), oceans (O), and rivers (R). Little ambiguity exists in identifying estuaries or oceans as receiving waters due to their relatively large size. However, rivers can include very small intermittent streams. Small lakes are referred to as ponds. It is not always clear where the urban drainage system ends and the receiving water begins. Some would argue that, from a federal perspective, interest should be restricted to interstate waters, thereby eliminating from consideration many of the smaller receiving waters. At the opposite end of the spectrum, one could argue that all waters, even those flowing through very small open channels, are "receiving waters."

One approach to this question is to define as receiving waters those waters which appears on maps with a name. However, the extent to which the receiving waters appear on maps depends on the scale of map and the purpose for which the map was drawn. For example, Figure 3 shows the Gainesville, Florida area on the USGS State Hydrologic Map (1:500,000). No receiving waters are shown. On the 1:250,000 scale USGS map of the same area, an unnamed river system which drains the western portion of the urban area is shown in Figure 4. A 1:24,000 scale USGS map (see Figure 5) shows a portion of the Hogtown Creek drainage system with the name of the creek indicated. Lastly Figure 6 shows the Rattlesnake Branch of Hogtown Creek at a scale of 1:1200. The general question is "What are the receiving waters for Gainesville?"

Drummond, in an article titled "When is a Stream a Stream," summarizes the criteria used by the major map making organizations in the United States (34). The results are shown in Table 1.

Drainage density is the ratio of the length of streams to the drainage area, or

$$D_d = L/A \tag{1}$$

where D_d = drainage density (miles^{-1}),
L = stream length (miles), and
A = drainage area (miles^2).

Huber et al. determined drainage density as a function of map scale for the Lower Kissimmee River Basin in Florida (35). The results are shown in Table 2 along with the results for Gainesville, Florida using Figures 3 to 6.

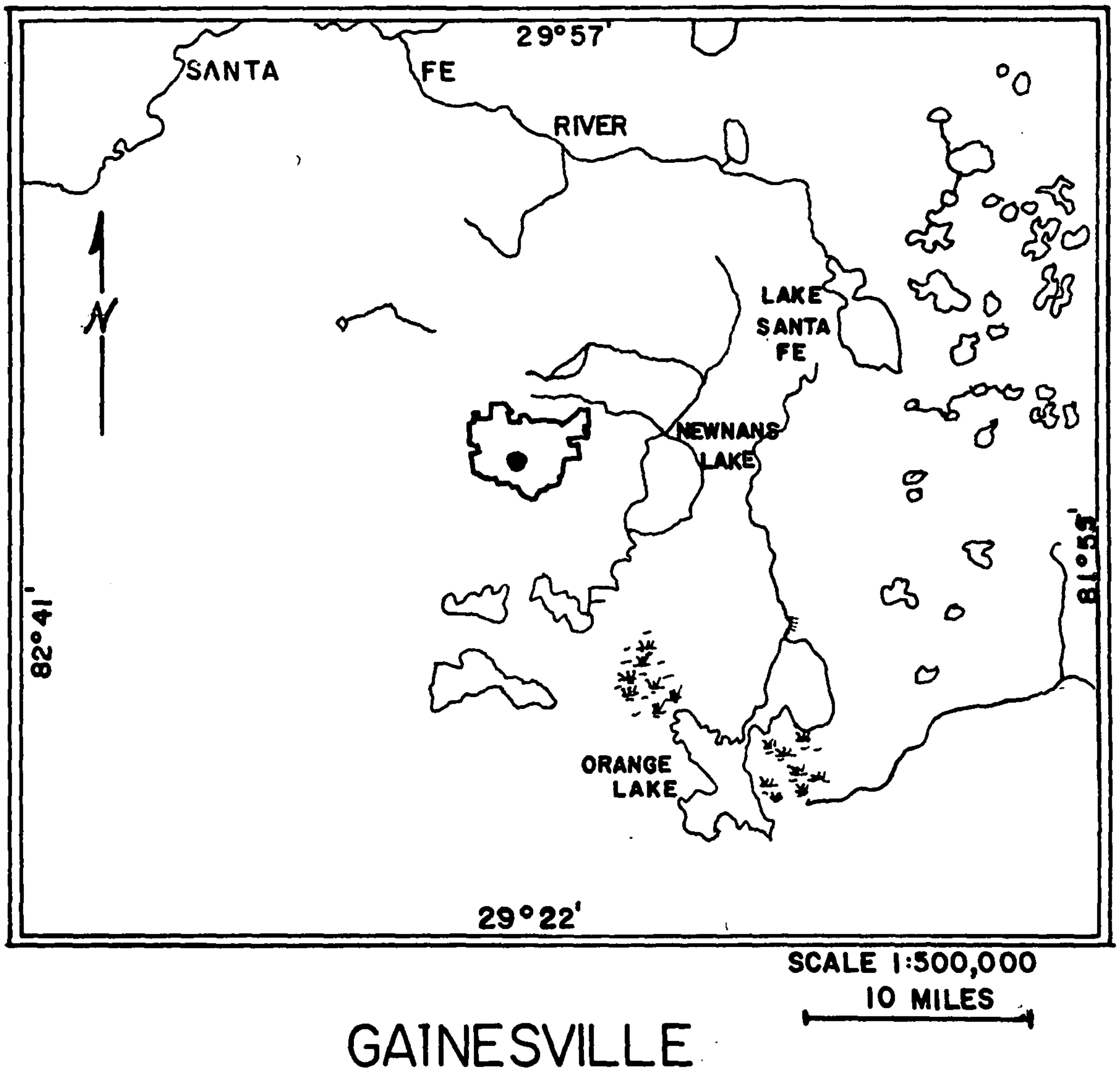


Figure 3. 1:500,000 Scale Map of Gainesville, Florida and Environs.

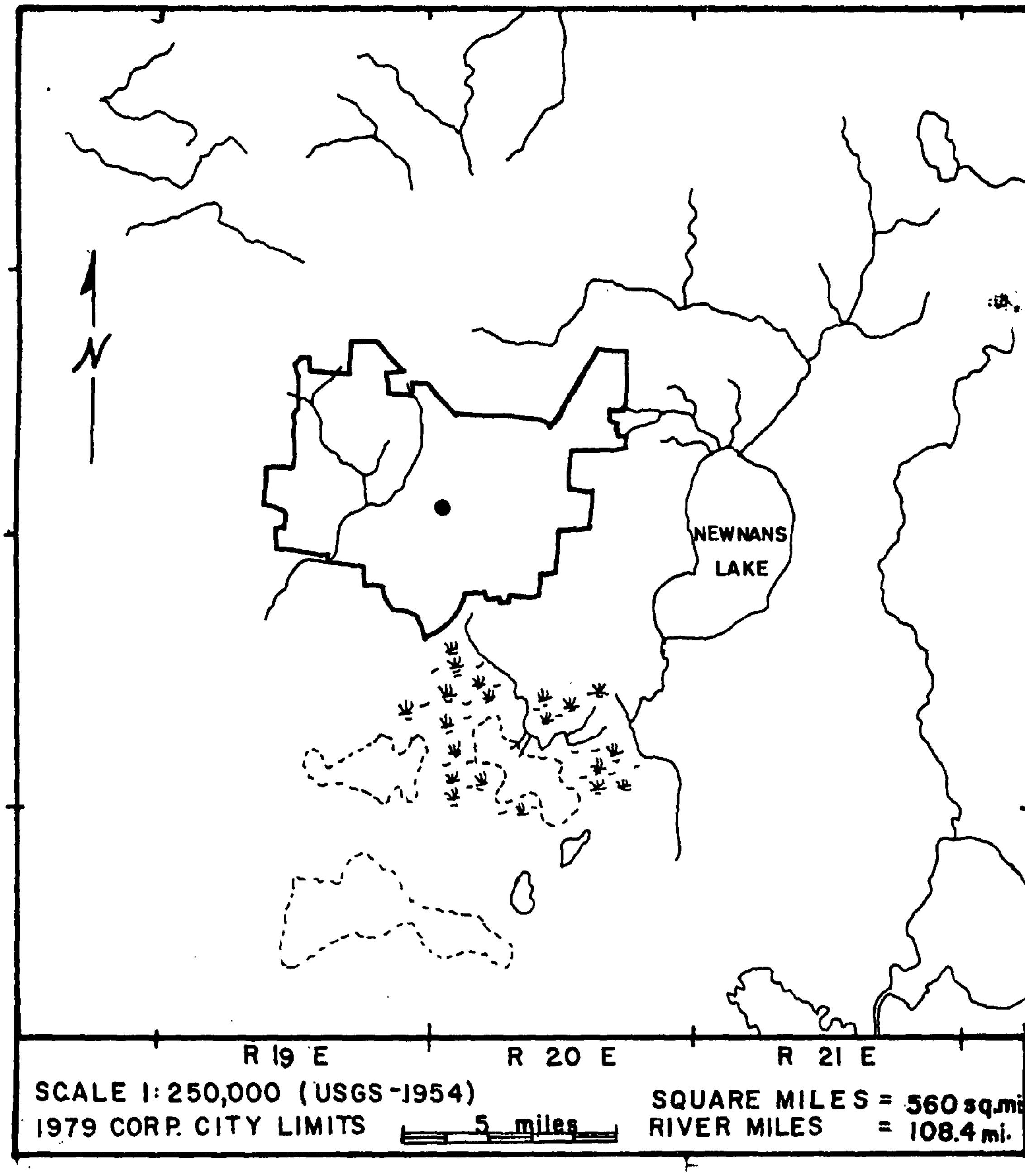


Figure 4. 1:250,000 Scale Map of Gainesville, Florida.

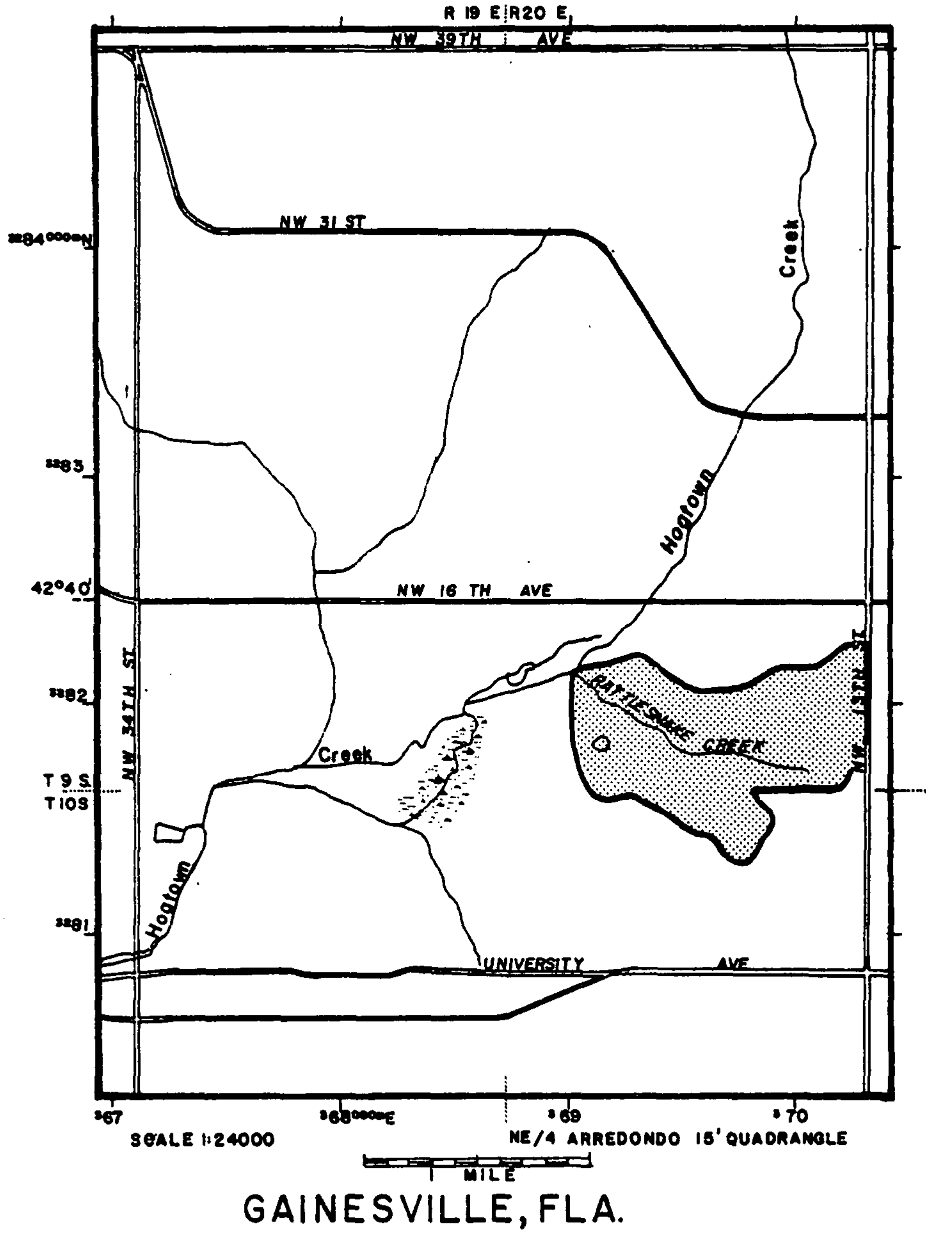


Figure 5. 1:24,000 Scale Map of Part of Hogtown Creek in Western Gainesville, Florida.

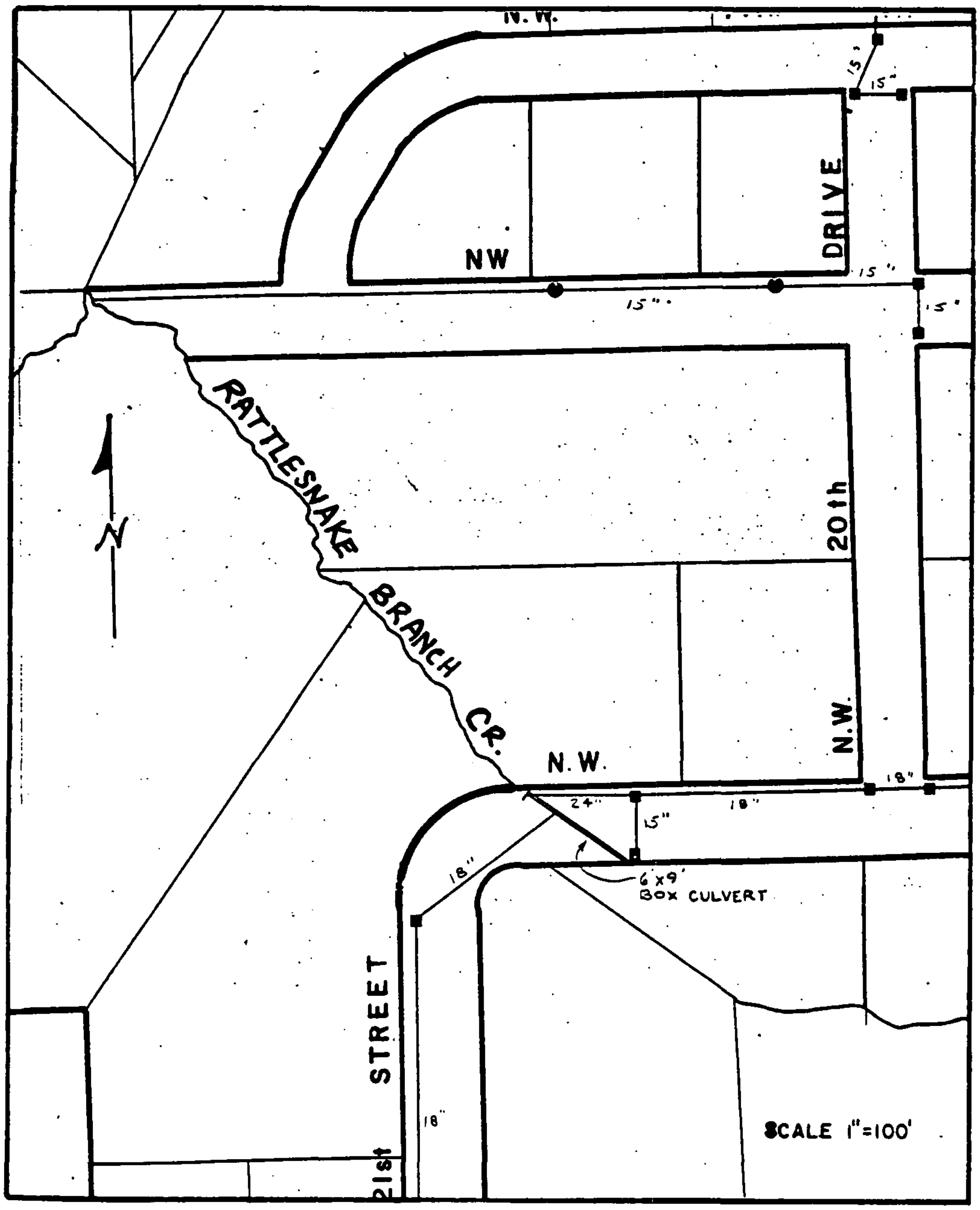


Figure 6. 1:1,200 Scale Map of Rattlesnake Branch of Hogtown Creek in Gainesville, Florida.

Table 1 . Standards for Inclusion of Streams on Topographic Maps of U.S. Mapping Agencies.

	Perennial				Intermittent			
Agency Basic Scales (> 1:75,000) Date of Information	Basic Inclusion Criteria	Channel Criteria	Minimum Stream Length (ground) (map)	Headwaters Termination (ground) (map)	Basic Inclusion Criteria	Channel Criteria	Minimum Stream Length (Ground) (Map)	Headwaters Termination (Ground) (Map)
U.S. Geological Survey 1:24,000—1:31,680—1:48,000 1969 —1:62,500—1:63,360	All Perennial Streams	Established Channels	No Limitations as to Length	1,000 Feet from Divide	All Intermittent Streams	"Dry Wash" Inclusion in Arid Areas	2,000 Feet	1,000 Feet from Divide
U.S. Army Topographic Command 1:12,500—1:25,000—1:50,000 1970	All Perennial Streams	Normal Flow Channels Are Shown	½ Inch (Well-Watered Areas) ¼ Inch (Arid Areas)	½ Inch from Divide	Maximum Number of Drainage Features	Normal Flow Channels Are Shown	½ Inch (Well-Watered Areas) ¼ Inch (Arid Areas)	½ Inch from Divide
Tennessee Valley Authority 1:24,000 1970	Not Distinguished from Intermittent Streams	Established Channels	1,000 Feet	1,000 Feet from Divide	Not Distinguished from Perennial Streams	Established Channels	1,000 Feet	1,000 Feet from Divide
Bureau of Land Management 1:31,680—1:63,360 1970	All Flowing Streams	Established Channels	No Limitations as to Length	——	Every Channeled Stream	Established Channels and Washes	½ Mile	——
Forest Service 1:24,000 1970	All Flowing Streams	Established Channels	Not a Limiting Criterion	——	——	All Established Channels	Not a Limiting Criterion	——
Soil Conservation Service 1:15,840—1:20,000—1:24,000 1963	All Perennial Streams	All Channeled Streams	¼ Inch	To Source of Stream	Some Nonchanneled Drainage Shown	All Established Channels	¼ Inch	To Source of Stream
Coast and Geodetic Survey 1:40,000—1:50,000—1:51,000 1969	All Perennial Streams	Established Channels	No Limitations as to Length	1,000 Feet from Divide	——	Established Channels	2,000 Feet	1,000 Feet from Divide
Oceanographic Office Dept. of the Navy Various Scales 1970	Aid to Navigation	Navigable Streams: to Limit of Navigation; Nonnavigable Streams: Limited to Navigation Aids	No Limitations as to Length	——	Aid to Navigation	Nonnavigable Streams: Limited to Navigation Aids	No Limitations as to Length	——
Lake Survey Center Dept. of Commerce (since 1970) Various Scales from 1:2,500 1970	All Perennial Streams	Any Permanent Channel	½ Inch (Well-Watered Areas)	To Stream Source	——	Any Permanent Channel	1.6 Inch (Well-Watered Areas) ¼ Inch (Arid Areas)	——

(From Drummond, 1974, p. 35-36.)

Scale	Drainage Density (mi/mi^2) for two Areas in Florida	
	Lower Kissimmee River	Hogtown Cr. in Gainesville
1:1200	--	10.61
1:24000	1.82	1.5
1:126700	1.12	--
1:250000	0.45	0.19
1:500000	--	0.06

Table 2. Effect of Map Scale on Drainage Density for Two Areas in Florida.

Including the actual drainage network, i.e., pipes and channels, in the calculations yields much higher densities as shown in Figure 7 (35). For example, the urban drainage density is 17.0 miles/mile^2.

For this national assessment, it is important that the selected scale of maps be published by a single organization which uses standardized procedures for labeling maps. Fortunately the U.S. Geological Survey's map series satisfy this criterion. Also, it is desirable to use maps which display the urban area relative to its immediate hydrologic units. It is also helpful to show nearby political units because water pollution, from a Federal perspective, is an undersirable off-site impact imposed on a downstream user. For example, if urban runoff from a city is polluting its water supply, then no externality exists because the problem is within a single political jurisdiction and it is obviously in the community's best interest to control this pollution. On the other hand if urban runoff from city A is contaminating downstream city B's water supply, than an externality exists and intervention by a higher level of government is appropriate. Based on these criteria, the recently completed USGS State Hydrologic Unit Maps (1:500,000 scale) were selected. Further information regarding these maps is presented in this section.

Receiving waters were divided into two classes: primary and other. The primary receiving water(s) was used to calculate the dilution ratio. The selected receiving water(s) are contiguous to the urbanized area. Other receiving waters listed are those which show on the map as being in or contiguous to the urbanized area and those receiving waters listed as having "problems" in the "special studies" section. For example, referring to Figure 3, the 1:500,000 scale map indicates no primary receiving water for Gainesville. Thus, a zero dilution ratio would be used. In most cases the primary receiving water was evident. Where it wasn't, the city typically was drained by relatively small receiving waters,

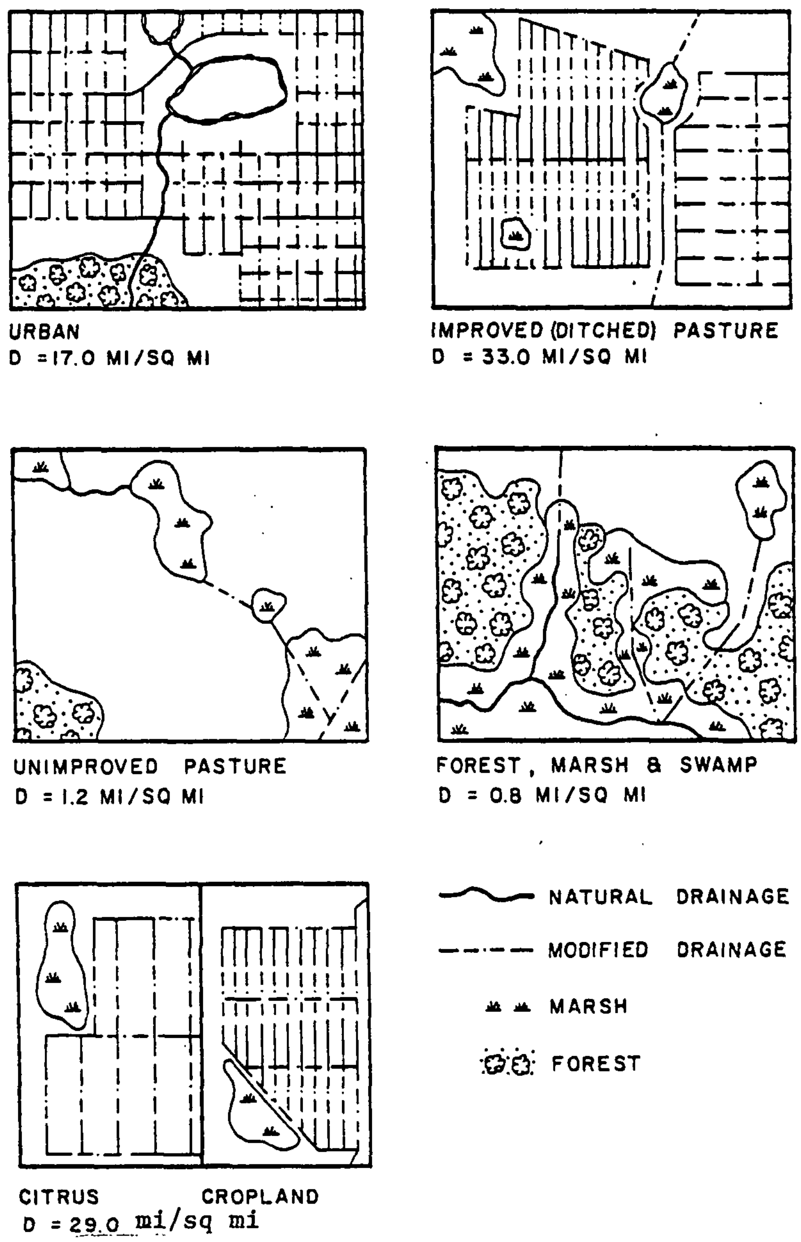


Figure 7. Schematic of Land Use and Measured Drainage Density.(35)

Dilution Ratio

A dilution ratio was calculated for each city as follows:

1) Rivers and Estuaries

a) USGS gage(s) available.

The average annual discharge for the river, denoted q_{abcd} where the abcd subscript denotes the station number, is converted from ft^3/sec. to inches per year averaged over the urban area using equation (2).

$$h_{rec} = K\, q_{abcd}/A_u \quad (2)$$

where h_{rec} = annual depth of receiving water flow averaged over the developed portion of the urbanized area (in/yr);

K = conversion factor = 13.57 to convert from ft^3/sec to in-mi^2/yr;

q_{abcd} = long-term average river discharge (ft^3/sec); and

A_u = developed portion of urbanized area (mi^2).

For example, for Gadsden, Alabama, the primary receiving water is the Coosa River whose average discharge (q_{2400}) is 9070 ft^3/sec. The developed portion of the urban area, A_u, is 15.3 mi^2 in area. Thus, if this flow rate were allowed to accumulate onto the urban area for one year, its depth would be

$$h_{rec} = 13.57\ (9070)\ /15.3$$

$$h_{rec} = 8040 \text{ in/yr.}$$

The dilution ratio is defined as

$$d.r. = \frac{h_{rec}}{h_{ur} + h_s} \quad (3)$$

where d.r. = dilution ratio (dimensionless);

h_{rec} = annual depth of receiving water flow averaged over developed portion of urban area (in/yr);

h_{ur} = annual depth of urban runoff (in/yr), and

h_s = annual depth of sewage (in/yr).

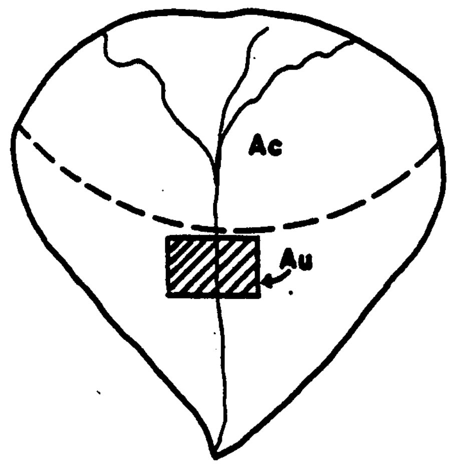
For Gadsden, Alabama, h_{ur} = 19.2 in/yr., and h_s = 9.3 in/yr. Using equation (3) yields

$$d.r. = \frac{8040}{19.2+9.3}$$

$$d.r. = 282$$

b) No flow data available.

Sometimes, receiving water flow data are not available especially for smaller receiving waters. In this case, an approximate dilution ratio is calculated as follows



$$d.r. = A_c/A_u \tag{4}$$

where d.r. = dilution ratio (dimensionless)

A_c = area of upstream catchment (mi^2) measured from USGS State Hydrologic Map, and

A_u = area of developed portion of urbanized area from Heaney et al. (1).

2) Lakes

The dilution ratio when lakes are the receiving water is calculated in the same manner as for ungaged rivers, i.e.

$$d.r. = A_l / A_u \tag{5}$$

where A_l = lake area, mi^2.

3) Oceans

The dilution ratio for ocean disposal is assumed to be greater than 1000.

Special Studies--

The next section for each urban area is a tabulation of special studies which have been divided into the following twelve categories:

1) 208 urban runoff priority area - This category includes a printout from EPA files of all urban areas which felt that urban runoff is a "priority problem". The print outs were run in early 1980 (23). However, most of the reports are three or four years old. Nevertheless they represent the best available local estimates of what types of urban runoff problems exist in their areas. A sample print out is presented in Table 3.

2) Fish kill reports - The U.S. Public Health Service began reporting fish kills on June 1, 1960 (25). This is a voluntary program. Thus, many fish kills go unreported. Also, it is very difficult to determine the exact cause of the kill. Over, 10,000 fish kill reports for 1970-79 were reviewed (24). Copies of those reports which related to runoff from urban areas were extracted and filed by urban area or as "other" in the state summary. The fish kills for each state are indicated on the state maps.

3) Beach closings - Battelle Memorial Institute, in a study for the National Commission on Water Quality, tabulated beach closings for the United States (26). These results were reviewed and those areas for which the cause of the closing was related to runoff were identified in the urban area or state summary. The beach closings are indicated on the state map. As with fish kill reports, this represents only a sample of the total beach closings. Also, the listed cause of the closing is sometimes only a guess.

4) EPA's Nationwide Urban Runoff Program Test City

5) City cited in Sutron Corp. dissolved oxygen study

6) City listed in 1978 NEEDS Survey case studies

7) City cited in National Commission on Water Quality study

8) City cited in National Eutrophication Survey

9) City cited in National Water Quality Inventory Studies

10) City cited in 1979 Congressional Hearings

11) Combined sewer area

12) City cited in other studies

Table 3. Problem Description for 208 Area Listing Urban Runoff as a Priority Problem.

***** PROBLEM DESCRIPTION ***** (Tuscaloosa, AL)

THE URBAN STORMWATER IN THE TUSCALOOSA AREA IS SUSPECTED OF CAUSING PROBLEMS IN WATER QUALITY IN THE TRIBUTARY STREAMS AND POSSIBLY IN THE WARRIOR RIVER. IT IS KNOWN THAT SEDIMENT IS A PROBLEM, HOWEVER, THE DEGREE OF PROBLEM FROM METALS, COLIFORM BACTERIA AND OXYGEN CONSUMING WASTE IS NOT KNOWN. HOWEVER, WATER QUALITY STANDARDS ARE DEFINITELY EXCEEDED DURING STORMS. DURING STORM EVENTS THESE POLLUTANTS MAY BE GREATER THAN THE DISCHARGE OF POLLUTANTS FROM POINT SOURCES AND COULD OVERSHADOW ANY ADDITIONAL TREATMENT PROVIDED FOR THE POINT SOURCES.

THE WARRIOR RIVER IS PRESENTLY USED FOR BOATING IN CERTAIN BEACHES. NO ESTIMATE CAN BE MADE OF THE ECONOMIC VALUE OF SOLUTION OF THIS PROBLEM, HOWEVER, IT IS KNOWN THAT AT LEAST ONE-THIRD OF THE POPULATION IS AFFECTED BY IT DIRECTLY BY THE LOSS OF RECREATIONAL USES AND THREATENED WATER SUPPLIES. IT IS IMPORTANT THAT THE MAGNITUDE OF THE PROBLEM FROM URBAN STORMWATER RUNOFF BE EVALUATED TO DETERMINE THE DEGREE OF PROTECTION NEEDED. THESE POLLUTANTS MAY BE INTERFERING WITH FISH AND WILDLIFE USES OF THE TRIBUTARY STREAMS. IF NO ACTION IS TAKEN TOWARD CORRECTING THESE PROBLEMS, FUTURE GROWTH IN THE AREA WILL CAUSE THE PROBLEMS TO BECOME MORE SEVERE WITH TIME TO THE POINT THAT MANY OPTIONS MAY BE FOREGONE. THE HIGH QUALITY WATER OF LAKE TUSCALOOSA USED FOR RECREATIONAL PURPOSES AND PUBLIC WATER SUPPLY, IS BEING THREATENED BY FUTURE URBAN DEVELOPMENT AND RESULTANT RUNOFF PROBLEMS. 11/76

***** STUDY OVERVIEW *****

AN EVALUATION OF THE EXISTING PROBLEMS CAUSED BY URBAN STORMWATER RUNOFF IS BEING MADE BY EXTENSIVE SAMPLING DURING STORM EVENTS IN TRIBUTARY STREAMS. THE SAMPLING WILL EVALUATE THE AMOUNT OF POLLUTANTS BEING WASHED OFF FROM DIFFERENT TYPES OF LAND USES. ALSO, THE SAMPLING WILL DETERMINE THE CONCENTRATIONS OF POLLUTANTS WITHIN THE RECEIVING STREAM. THIS INFORMATION WILL THEN BE USED AS INPUT INTO DYNAMIC MODELS WHICH WILL SIMULATE STORMS UNDER VARIOUS CONDITIONS AND EVALUATE THE WATER QUALITY EFFECTS OF THESE STORMS. THE DATA AND MODELS WILL BE USED TO EVALUATE THE MAGNITUDE OF THE PROBLEMS AND DETERMINE WHAT IMPROVEMENTS CAN BE MADE WITH DIFFERENT TYPES OF CONTROL MEASURES.

ALTERNATIVE CONTROL STRATEGIES FOR URBAN RUNOFF POLLUTANTS WILL BE EVALUATED. THESE ALTERNATIVES WILL INCLUDE BOTH STRUCTURAL AND NONSTRUCTURAL MEANS FOR REDUCING CERTAIN TYPES OF POLLUTANTS. EXISTING AND FUTURE REGULATORY AND MANAGEMENT AGENCIES FOR CONTROLLING THE URBAN RUNOFF POLLUTANTS WILL BE EVALUATED. IT IS EXPECTED THAT LOCAL ORDINANCES FOR CONTROL OF SOIL EROSION AND STORM DRAINAGE WILL BE PROPOSED. SO FAR, TWO ALTERNATIVES HAVE BEEN PRESENTED: ONE WITH SEVERAL SMALL TREATMENT FACILITIES, AND ANOTHER WHICH WOULD AGGREGATE FLOW TO ONE CENTRAL TREATMENT FACILITY.

SOME EFFORT WILL BE MADE TO PASS A LOCAL ORDINANCE FOR STORM DRAINAGE CONTROL, BUT NO PROMISES CAN BE MADE AT THIS TIME, SINCE ORDINANCES ARE SUBJECT TO LOCAL POLITICAL PRESSURES. TIMING IS KEY, AND NOT SUBJECT TO EASY PREDICTION. 11/76

MAPS

The cities and receiving waters were drawn exactly as shown on the 1:500,000 maps. Receiving waters were identified in capital letters if they were identified on the 1:500,000 map. These distinctions are important to maintain a relative perspective regarding receiving waters throughout the U.S. The USGS does not have a completely unambiguous way to select which receiving waters are labeled, e.g., sometimes the receiving water is not labeled because there is not room on the map. Nevertheless, this is the most consistent method that proved to be feasible. A summary of this map series, extracted from a USGS brochure, is presented below.

> This map series shows Hydrologic Units that are basically hydrographic in nature. The Cataloging Units shown will supplant the Cataloging Units previously used by the U.S. Geological Survey in its Catalog of Information on Water Data (1966-72). The previous U.S. Geological Survey Catalog-Indexing System was by map number and letter, such as 49M. The boundaries as shown have been adapted from "The Catalog of Information on Water Data" (1972), "Water Resources Regions and Subregions for the National Assessment of Water and Related Land Resources" by the U.S. Water Resources Council (1970), "River Basins of the United States" by the U.S. Soil Conservation Service (1963, 1970), "River Basin Maps showing Hydrologic Stations" by the Inter-Agency Committee on Water Resources, Subcommittee on Hydrology (1961), and State planning maps.
>
> The Political Subdivision Code has been adopted from "Counties and County Equivalents of the States of the United States" presented in Federal Information Processing Standards Publication 6-2, issued by the National Bureau of Standards (1973) in which each county or county equivalent is identified by a 2-character State code and a 3-character county code.
>
> The Regions, Subregions and Accounting Units are aggregates of the Cataloging Units. Regions and Subregions are currently (1974) used by the U.S. Water Resources Council for comprehensive planning, including the National Assessment, and as a standard geographical framework for more detailed water and related land-resources planning. The Accounting Units are those currently (1974) in use by the U.S. Geological Survey for managing the National Water Data Network.

STREAMFLOW DATA

For each urban area, the average annual receiving water discharge was estimated using the long-term average discharge listed in a series of U.S. Geological Survey Water Supply Papers presenting monthly and annual summaries of streamflow and reservoir data for the period from October 1, 1950 to September 30, 1960. The series of reports is a condensation of the annual series of daily records. The results are summarized in the twenty volumes listed below: Figure 8 is a map of these areas.

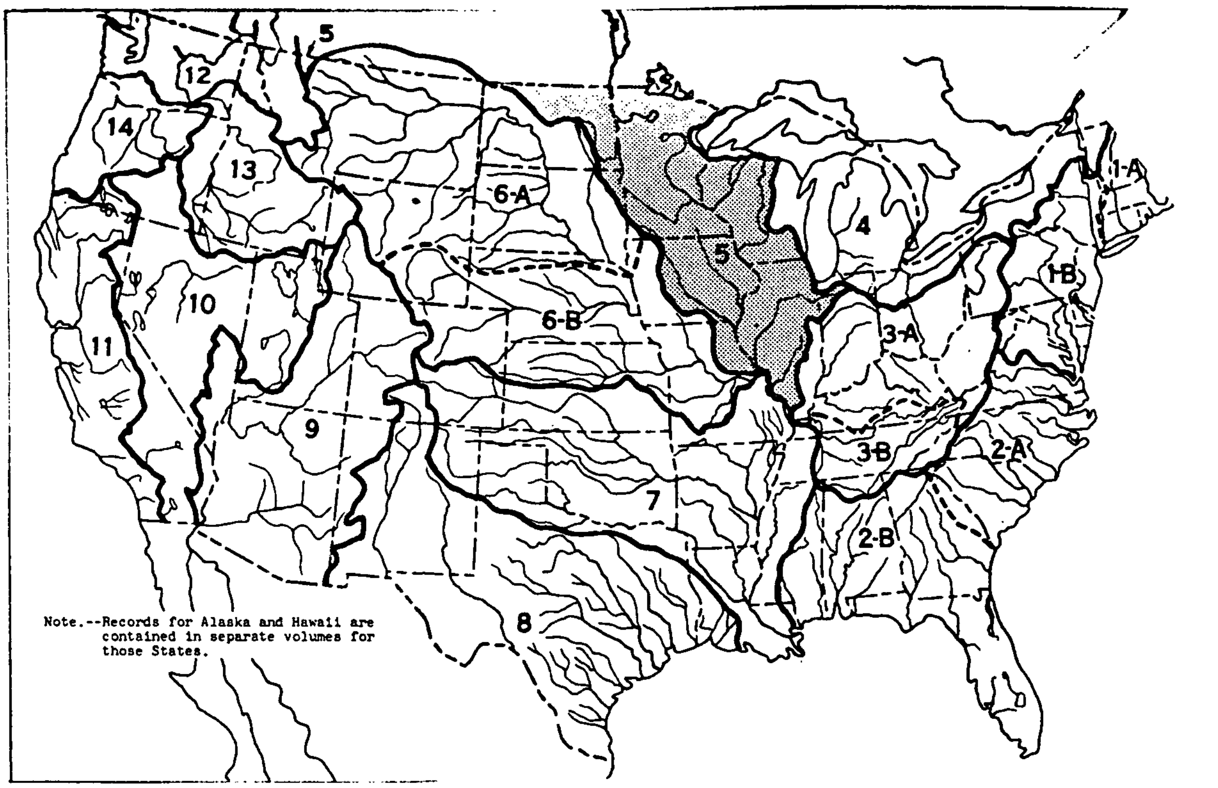


Figure 8. Areas Covered by U.S.G.S. Surface Water Records.

WSP	Part	Area
1721	1-A	North Atlantic slope basins, Maine to Connecticut.
1722	1-B	North Atlantic slope basins, New York to York River.
1723	2-A	South Atlantic slope basins, James River to Savannah River.
1724	2-B	South Atlantic slope and eastern Gulf of Mexico basins Ogeechee River to Pearl River.
1725	3-A	Ohio River basin except Cumberland and Tennessee River basins.
1726	3-B	Cumberland and Tennessee River basins.
1727	4	St. Lawrence River basin.
1728	5	Hudson Bay and upper Mississippi River basins.
1729	6-A	Missouri River basin above Sioux City, Iowa.
1730	6-B	Missouri River basin below Sioux City, Iowa.
1731	7	Lower Mississippi River basin.
1732	8	Western Gulf of Mexico basins.
1733	9	Colorado River basin.
1734	10	The Great Basin.
1735	11	Pacific slope basins in California.
1736	12	Pacific slope basins in Washington and upper Columbia River basin.
1737	13	Snake River basin.
1738	14	Pacific slope basin in Oregon and Lower Columbia River Basin.
1739	--	Hawaii.
1740	--	Alaska.

A sample station is shown in Table 4. This monthly and annual streamflow summary is included so that the interested reader can examine seasonal and extreme flows.

Table 4. Monthly and Annual Streamflow Summary for the Hillsborough River near Tampa, Florida. Source is USGS Water Supply Paper 1724.

Location.--Lat 28°01'25", long 82°25'40", in sec.29, T.28 S., R.19 E., on left bank just upstream from spillway of Tampa reservoir dam, at Thirtieth Street, 5½ miles north of Tampa, Hillsborough County.

Drainage area.--650 sq mi, approximately.

Records available.--October 1938 to September 1960.

Gage.--Water-stage recorder. Datum of gage is at mean sea level, datum of 1929 (city of Tampa bench mark). Prior to Oct. 1, 1945, at site 1.4 miles upstream at datum 0.66 higher.

Average discharge.--22 years (1938-60), 685 cfs (495,900 acre-ft per year), adjusted for diversion.

Extremes.--1938-60: Maximum discharge, 14,600 cfs Mar. 21, 1960; maximum gage height, 22.89 ft Aug. 2, 1960; no flow Nov. 30 to Dec. 2, 1945.
Maximum stage known, 25.6 ft Sept. 7, 1933, at former site and datum, from floodmarks, affected by backwater prior to failure of Tampa power dam, 1.4 miles below former gage. A discharge of 16,500 cfs was measured Sept. 9, 1933.

Remarks.--Flow regulated by Tampa reservoir since Oct. 1, 1945. Capacity of reservoir insufficient to affect monthly figures of runoff. Diversion at point 1¼ miles above station for water supply by city of Tampa. Records of chemical analyses for the period November 1956 to September 1958 are published in reports of the Geological Survey.

Monthly and yearly mean discharge, in cubic feet per second a/

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1951	615	236	364	353	234	199	406	186	52.4	144	498	697	333
1952	751	221	358	185	169	521	598	80.1	257	226	644	429	371
1953	787	391	141	188	321	171	1,065	217	170	469	1,965	4,371	852
1954	2,795	640	1,795	850	250	177	103	97.8	327	723	1,199	308	781
1955	268	109	129	125	216	76.6	65.1	33.1	34.3	215	800	1,099	264
1956	191	197	120	83.1	174	42.9	13.9	14.8	8.48	31.5	35.9	324	102
1957	742	172	46.1	34.8	49.4	366	759	388	318	528	1,834	1,790	588
1958	1,348	157	119	414	486	1,975	847	204	74.5	494	811	238	601
1959	144	170	134	887	417	3,082	2,022	740	1,853	2,705	2,738	3,597	1,546
1960	1,957	805	217	231	464	4,926	1,358	154	220	1,200	4,713	4,276	1,718

a Unadjusted for diversion by city of Tampa.

Monthly and yearly discharge, in acre-feet

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1951	37,830	14,040	22,400	21,710	13,010	12,240	24,160	11,410	3,120	8,870	30,600	41,450	240,800
1952	46,180	13,160	22,000	11,390	9,700	32,030	35,560	4,920	15,270	13,910	39,620	25,550	269,300
1953	48,410	23,240	8,680	11,590	17,820	10,490	63,360	13,320	10,140	28,830	120,900	260,100	616,900
1954	171,900	38,070	110,400	52,280	13,880	10,860	6,150	6,010	19,440	44,450	73,720	18,310	565,500
1955	16,500	6,510	7,940	7,660	11,980	4,710	3,870	2,040	2,040	13,190	49,190	65,400	191,000
1956	11,730	11,730	7,370	5,110	10,030	2,640	830	908	505	1,940	2,210	19,280	74,280
1957	45,640	10,250	2,830	2,140	2,750	22,490	45,140	23,880	18,920	32,470	112,800	106,500	425,800
1958	82,870	9,350	7,320	25,440	27,000	121,500	50,380	12,520	4,440	30,380	49,890	14,170	435,300
1959	8,850	10,110	8,230	54,530	23,180	189,500	120,300	45,520	110,200	166,300	168,300	214,000	1,119,000
1960	120,400	47,900	13,370	14,230	26,700	302,900	80,840	9,440	13,070	73,770	289,800	254,400	1,247,000

Note.--Figures given herein prior to October 1956, not previously published.

Yearly discharge, in cubic feet per second

Year	WSP	Water year ending Sept. 30									Calendar year			
		Observed					Adjusted a/				Observed		Adjusted a/	
		Maximum day: Discharge	Maximum day: Date	Minimum day	Mean	Acre-feet	Mean	Per square mile	Runoff in inches		Mean	Acre-feet	Mean	Runoff in inches
1950	-	-	-	-	-	-	-	-	-		498	*360,700	526	10.99
1951	1204	1,500	Sept.24,25,1951	24	333	*240,800	361	0.555	7.53		342	*247,900	370	7.74
1952	1234	1,900	Apr.5,1952	28	371	*269,300	399	.614	8.36		370	*268,300	398	8.33
1953	1274	6,830	Sept.30,1953	37	852	*616,900	882	1.36	18.42		1,183	*856,900	1,213	25.33
1954	1334	b2,890	July 31,1954	28	781	*565,500	810	1.25	16.91		381	*276,000	411	8.57
1955	1384	1,980	Sept.15,1955	30	264	*191,000	296	.455	6.16		264	*190,900	296	6.18
1956	1434	810	Sept.28,1956	6.4	102	*74,280	138	.212	2.91		141	102,200	179	3.73
1957	1504	3,810	Aug. 10,1957	20	588	425,800	623	.958	13.01		645	466,600	681	14.20
1958	1554	3,180	Oct. 6,1957	31	601	435,300	638	.982	13.34		501	362,900	539	11.27
1959	1624	7,390	Mar.23,24,1959	84	1,546	1,119,000	1,586	2.44	33.11		1,759	1,274,000	1,799	37.57
1960	1704	c14,600	Mar. 21,1960	17	1,718	1,247,000	1,760	2.71	36.84		-	-	-	-

* Not previously published.
a Adjusted for diversion by city of Tampa; diversion records furnished by city of Tampa Water Department.
b Maximum daily discharge for flood event whose crest occurred in the water year indicated. Maximum daily discharge, 6,800 cfs Oct. 1, 1953, on the recession from the crest that occurred in the preceding water year.
c Momentary maximum.

SUMMARY

The above information was compiled for every urbanized area. These summaries are contained in Volume II of this report. The summary for Tampa, Florida is presented below for illustrative purposes.

Example of Urban Area Summaries

TAMPA

Demographic data

1970 population - 369,000; Urbanized area - 68.8 sq. mi., % combined sewers - 0

Hydrologic background (Schneider, 1968) (33).

The municipal and industrial supplies for the Tampa area come chiefly from the Hillsborough River. Because of seasonal distribution of rainfall and the limited storage capacity of the city reservoir, this source is inadequate during dry periods, and a supplemental supply from a large spring (Sulphur Spring) is utilized. Adequate quantities of water are available from the Floridan aquifer to meet the future water requirements of the area.

Much of the metropolitan area is subject to hurricane damage because of its location near sea level and because of extensive residential development along the waterfront. Tampa, which is in the lower reaches of the Hillsborough River, is subject to flood damage during periods of excessive rainfall. However, this problem will be alleviated in the near future as flood regulation reservoirs and bypass channels are completed upstream from the city. Other problems of major importance are encroachment of saline water on fresh ground-water supplies, disposal of municipal waters, and the effects of the metropolitan complex on the coastal waters.

Precipitation - 52.0 in/yr

Waste sources

Sewage - 11.2 in/yr.; Urban runoff - 19.3 in/yr

Receiving waters

Primary - Hillsborough River
Mean annual flow - 135.3 in/yr (Q_{3045})
Dilution ratio - 4.4
Other - Hillsborough and Tampa Bays

Special studies

The Hillsborough River is the primary river draining the Tampa area. The upstream portion of this river is used as a water supply source for the City of Tampa. It receives urban runoff. The lower portion of the river moves through the City of Tampa where it receives inputs from a variety of sources including landfill leachate, water treatment plant alum sludge, and overloaded sanitary sewers. The discharge from the Hillsborough River enters Hillsborough Bay. The bay has serious water quality problems and extensive sludge accumulations due to the discharge of primary treatment plant effluent until very recently. Tampa is one of the EPA Nationwide Urban Runoff Program study areas.

Tampa was one of three cities selected as case studies of estimating the impact of improved water quality on beach closings. (Battelle, 1976) (26). The results are summarized below.

Tampa-St. Petersburg, Florida. The population region for this study case included Pasco, Pinellas, Hillsborough, and Manatee Counties with a combined 1970 population of 1,185,664. In addition to the resident population, there are an estimated 4,432,000 businessmen, vacationers, and other travelers coming to this area each year. Many of these individuals come expressly for the purpose of swimming on their vacations. It is estimated that over 80 percent of the tourists participate in the winter and about 60 percent in the summer.

In recent years, six smaller beaches in Pinellas County have been closed intermittently as a result of high coliform counts following heavy rainfall. In Hillsborough County, a beach along the Hillsborough River has been closed permanently since 1972 as a result of bacterial contamination. These areas total 2,450 frontage feet or 1.4 percent of the estimated 178,320 feet of beach frontage in the four-county area.

Because of the availability of abundant high quality beaches, the effect from storm runoff on estimated total resident and tourist swimming activity days is negligible. For the specific beaches that were intermittently affected by high coliform counts, assuming that swimmers avoid them completely, an annual increase of 1 percent in resident and .12 percent tourist activity days as estimated. Because these estimates assume complete seasonal closure, actual loss in activity days would be lower assuming individuals use these beaches intensively when water quality is acceptable. Also, no determination of the specific type and level of use of the affected beaches was obtained during the course of data collection.

References

Federal Water Pollution Control Admin. 1969. Problems and Management of Water Quality in Hillsborough Bay, Florida. NTIS PB-217 147, U.S. Dept. of Commerce, Springfield, Va. 94 pp.

Lopez, M.A., and D.M. Michaelis. 1979. Hydrologic Data from Urban Watersheds in the Tampa Bay Area, Florida, USGS Water-Resources Investigations 78-125. 51 pp.

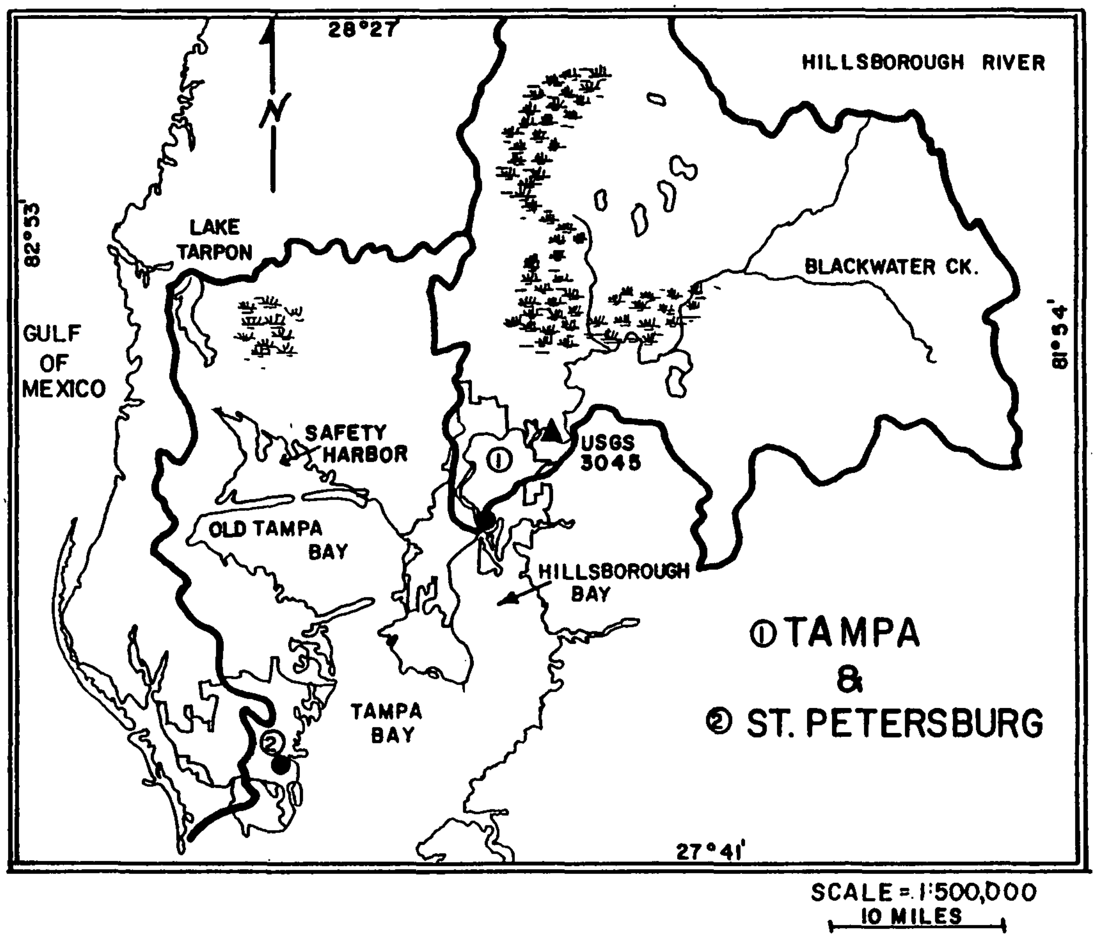


Figure 9. 1:500,000 Scale USGS Hydrologic Map for the Tampa, Florida Area.

SECTION VII

RESULTS

NATIONAL

The national results present summary statistics based on the urbanized area reports. General information regarding population, land use, precipitation and runoff, and wastewater flows is presented elsewhere (1). This section emphasizes receiving water impacts. As mentioned earlier, no single definition of impacts can be used. An urban area is viewed as having an actual or potential urban runoff "problem" if any of the following conditions apply.

1) The local or state 208 agency viewed urban runoff as a priority problem. (24.1%)
2) Runoff related fish kills have been reported during 1970-79. (12.8%)
3) A runoff related beach closing was reported. (4.6%)
4) It is a National Urban Runoff Program (NURP) study area. (7.7%)
5) The urbanized area was selected by the Sutron report as having a potential dissolved oxygen problem. (3.7%)
6) The urbanized area was listed in the 1978 NEEDS Survey case studies. (2.8%)
7) The urbanized area was studied in the National Commission in Water Quality Studies. (0.7%)
8) The urbanized area was mentioned in the National Eutrophication Survey. (0.0%)
9) The urbanized area was mentioned in the 1974 National Water Quality Inventory. (0.1%)
10) The urbanized area was mentioned in the 1979 Congressional Hearings. (4.9%)
11) The urbanized area has combined sewers. (27.5%)
12) The urbanized area was mentioned in other studies. (11.1%)

The percent of the problems by category are shown in parentheses. Thus any urbanized area may have a "problem" as defined by these twelve conditions some of which are interrelated. Table 5 shows the distribution by percent of the 248 urbanized area according to whether they had zero, one, two through six problem citations. Table 5 indicates that almost two-thirds of the urbanized areas had zero or one citation; about 30 percent had two or three citations; and the remaining cities had four, five, or six citations. The nineteen cities which had four to six citations are generally older and larger than average.

DILUTION RATIO

Table 6 shows the percentage of urbanized areas that discharge into

Number of Times Urbanized Area was Cited as Having an Urban Runoff Problem.	Percent of Total
0	29.0
1	33.3
2	20.6
3	9.5
4	4.0
5	3.2
6	0.4
Total	100.0

Table 5. Distribution of Problem Categories for Urbanized Areas in the United States

Category	% of Urban Areas
A. Rivers	
1. Creeks and shallow streams (0-100 cfs)	19.8
2. Upstream feeders (100-1000 cfs)	21.3
3. Intermediate channels (1000-10,000 cfs)	24.4
4. Main drainage rivers (10,000-100,000 cfs)	15.1
5. Large rivers (>100,000 cfs)	3.9
Sub-total, Rivers	84.5
B. Lakes	
1. Small ponds, back waters	0.4
2. Lakes	4.7
Sub-total, Lakes	5.1
C. Estuaries and Ocean	
1. Shallow estuary or bay (d<10 feet)	0.4
2. Medium depth estuary or bay (10<d<30)	2.3
3. Deep estuary or bay (d>30)	2.7
4. Open ocean or beach	5.0
Sub-Total, Estuaries & Oceans	10.4
Total, A, B, and C	100

Table 6. Distribution of Primary Receiving Waters for Urbanized Areas in the United States

each of 11 categories of primary receiving waters. The results indicate that about 84 percent of the discharge is to rivers, 5 percent to lakes, and 11 percent to estuaries or oceans. However, this distribution can be misleading because many of the impacted areas of major significance are not the primary receiving water. For example, the primary receiving water for Cincinnati, Ohio is the Ohio River. However, the 208 problem statements identifies the Little Miami River as having runoff related water quality problems.

FISH KILLS

Fish In Urban Areas

Urban receiving water bodies, for a variety of reasons other than stormwater runoff (e.g., habitat alteration, multi-source pollutants, temperature), may not have abundant fish populations. In fact, abundance of aquatic life in general is most often inversely proportional to the degree of urbanization. However, many fish kills have been related to stormwater runoff, combined sewer overflows (CSO's), storm sewers, or rainfall events. Table 7 summarizes storm-water/storm-sewer related fish-kill reports in the EPA files (24) for the period for January 1970 to May 1979. It gives the number of fish kills reported for a given year relative to the seven categories listed. A brief description of each category is presented in order of appearance in the table.

Pollutant Spilled into Storm Sewer

The pollutant in this category may or may not have been flushed by a rainfall event (not indicated on fish kill report). Typically this is a human event-type impact where someone dumps a toxic substance into a storm drain, or a toxic substance accidentially spills and drains into a storm sewer.

Storm Sewer Discharge from Rainfall Event

This is distinguished from the previous category in that the person filling out the fish-kill report stated that the kill was due to discharge during a storm event. This category overlaps the previous one in instances where residuals of a spilled toxic substance remain in the storm sewer until adequate flushing occurs.

Combined Sewer Outfall

Fish kills occur downstream of identified combined sewer overflows (CSO's).

Rainfall-Runoff Related to Land Use

This fish-kill category includes reports which do not specify drainage ways, storm sewers, or sheet flow but document fish kills following rainfall-runoff events. The attempt to classify relative to land use is a very rough estimate. Fish-kill reports are not detailed

TABLE 7. SUMMARY OF NUMBER OF STORM-WATER/STORM-SEWER RELATED FISH-KILL REPORTS, U.S. EPA DATA, 1970 to MAY, 1979 BY CAUSE OF KILL*

Year	Pollutant Spilled into Storm sewer	Storm Sewer Discharge From Rainfall Event	Combined Sewer Outfall	Rainfall-Runoff Related to Land Use			Acid Mine Drainage-Storm Event Related	Landfill Leachate-Storm Event Related	Other
				Comm/Ind	Residential/ Suburban	Agric.			
1970	7	4	3	3	7	4	3	2	3
1971	4	2	3	3	11	12	2	2	7
1972	1	2	3	1	4	9	5	8	1
1973	-	2	1	3	7	4	3	5	4
1974	6	3	1	3	5	15	2	1	-
1975	6	-	3	3	5	5	-	1	1
1976	2	2	1	2	6	7	-	1	4
1977	5	2	-	3	3	2	2	1	2
1978	1	2	-	-	1	5	-	-	1
1979	-	1	-	1	-	1	-	2	-
Total	32	20	15	22	49	64	17	23	23

Comm = commercial land use
Ind = industrial land use
Agric = agricultural land use

*Source: *Raw Data from EPA* (24)

enough to identify the specific sources of runoff, or how the runoff actually gets into the receiving water body.

Acid Mine Drainage-Storm Event Related

Acid mine drainage, a nonurban stormwater problem, was included in the table for two reasons: the mining activity may be borrow material for roads, or a town built around a mine; and it is useful to compare the number of acid mine related fish kills to those related to stormwater /storm sewers. Acid mine drainage is a fairly well documented problem; the numbers of reported kills are comparable.

Landfill Leachate Storm-Event Related

Most landfills are products of urban activity, even though many are located in agricultural or fringe areas.

Other

This category includes fish-kill reports not suitable under the other headings but of interest due to location (a receiving water body under stormwater runoff study, e.g. Trinity River in Texas), or apparent stormwater-related kill (indicated, not directly stated).

Some general comments pertinent to the survey of the fish-kill data are:

1. Because many urban streams are grossly polluted from a variety of sources, no fish remain. Hence, no fish kills are reported.

2. Very few of the reports (a total of 20 for the period 1970-1979) state stormwater runoff directly as the cause of fish kills.

3. There are several instances of storm water flushing pesticides, sewage deposits, herbicides, dumps of oil, etc.

4. In several instances accidental dumps of toxic substances into storm sewers are flushed prematurely by rainfall events. A good example is a hotel or drug store fire where fire department runoff goes into a storm drain.

5. Many citations indicate fish kills due to "eutrophication," or "natural causes." General water quality deterioration or nutrient enrichment, could in part, be due to stormwater runoff. However these were not included in Table 7.

6. The EPA instructions for filling out fish-kill reports group sewerage, storm water, and CSO's into a single category (sewerage system). If the person filling out the form does not specify the type of system, it is anyone's "best guess" as to which

type of system caused the kill. The Sewerage System category contains the largest number of fish kills. Unless CSO's or storm sewers were specifically cited, they were not counted and recorded in Table 7. For this reason, Table 7 understates the actual number of CSO or storm sewer-related kills.

7. In a true urban stream, the resident fish population may be adapted to pollutant loads, and/or pulses; or the population may become dominated by more pollutant tolerant species. The fish-kill data do have some information concerning species of fish killed, but no historical information is available.

8. Fish-kill frequency data are relative. If an area experiences a severe kill that wipes out the fish population, subsequent events do not record kills. Conversely, a severe kill could wipe out a resident population, but in-migration from a nearby water body would mask reduction in the local population on a longer term basis.

9. Fish-kill reports are prepared by people with a variety of positions and backgrounds. The inherent variability in such a nationwide reporting system makes numbers and statistics for this type of data base very subjective and less reliable.

The monthly distribution of fish kills as a percentage of the total number of fish killed and the total number of reports is shown in Figure 10. As expected, relatively more kills occur during the warmer months of the year.

BEACH CLOSINGS

The National Commission on Water Quality placed heavy emphasis on attempting to evaluate the benefits associated with water pollution control (26). A total of 3,521 beaches throughout the United States were surveyed. Of these beaches, 449 had water quality problems. Table 8 shows the proportion of the closings due to various causes. While urban runoff is not identified as a separate category, the majority of the closings may be attributable to this cause. For example, within the coliform related problem category, almost 50 percent of the total closings are due to undefined sewage contamination or unknown causes.

LOW DISSOLVED OXYGEN

The Sutron Corp. (28) in an EPA sponsored national assessment, related the magnitude of dissolved oxygen (D.O.) deficits and the presence of storm runoff downstream of urban areas. Based on a initial screening of over 1,000 D.O. monitors located throughout the United States, over 100 water quality monitoring sites in and downstream of urban areas were selected. Approximately one-third of these monitors indicated at least a 60 percent probability of a higher than average dissolved oxygen deficit occuring at times of higher than average streamflow.

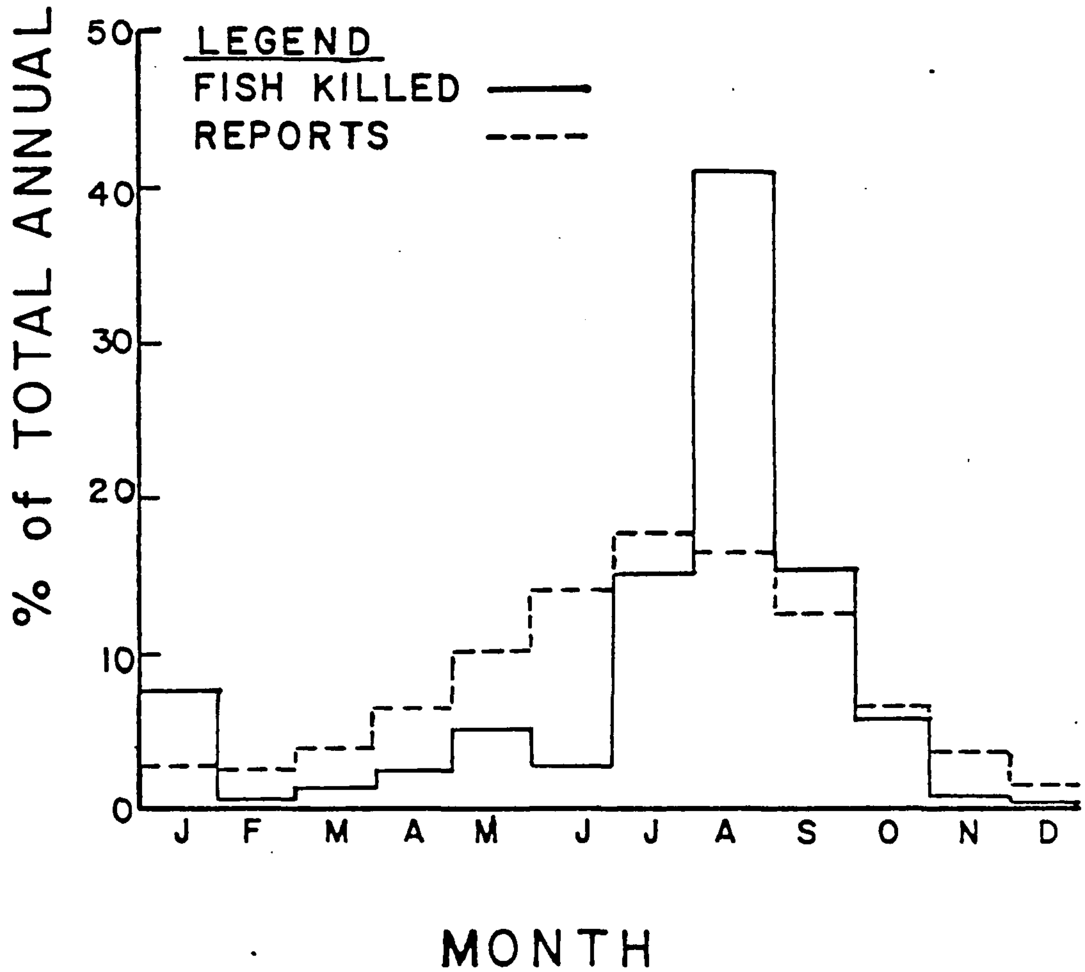


Figure 10. Monthly Distribution of Fish Kills as a Percentage of Total Fish Killed.

TABLE 8. Causes of Water Quality Related Beach Closings in the United States.

Cause	Number	Percent Total
Algae, Scum	11	1.8
Turbidity	13	2.2
High Coliform or Fecal Coliform Count Due To:		
Flood, Wind, Heavy Rainfall	41	6.8
Agricultural Runoff	10	1.7
Sewage Treatment Plant Malfunction, Spills, Overflows	42	6.9
Undefined Sewage Contamination or Unknown	337	55.7
Other	71	11.
Unknown	80	13.
Total	605	100

*Source: Raw Data From Battelle (26).

Of the areas where a low D.O. , high streamflow correlation was observed, a more detailed hourly analysis was performed. These results were striking! During steady-state, low-flow conditions the D.O. fluctuates diurnally between 1 and 7 mg/l. However, after a storm begins, the diurnal fluctuations are completely dampened. The minimum wet-weather D.O. is 1 to 1.5 mg/l lower than the dry-weather minimum, and remains that way for 1 to 5 days. As the impact of the storm dissipates, the D.O. resumes its original cyclic behavior. This relationship, for the Scioto River at Chillicothe, Ohio, (downstream of Columbus, Ohio) is shown in Figure 11. It suggests the need to reexamine the traditional approach to defining "critical" conditions in receiving waters based on receiving water quality during an extended dry period. For example, the most popular critical period is the one in ten year seven day low flow in the receiving water.

In this study (28), the two most severe cases of low D.O. were the Trinity River near Dallas, Texas and Wilsons Creek near Springfield, Missouri. The authors' independent analysis indicates that both of these receiving waters have large deposits of sludge from primary sewage treatment plants. Thus, a significant part of the problem is attributable to resuspension of this benthal material.

NATIONWIDE URBAN RUNOFF PROGRAM CASE STUDIES

This detailed evaluation of urban runoff problems in cities throughout the United States yielded 30 case studies. Each of these applicants indicated that they have a "problem" and that they were willing to do something about it. However, little definitive evidence was presented to support the contention of a receiving water problem. Descriptions of the receiving water problem for some of these projects are presented below for illustrative purposes.

1. Baltimore, Maryland--Studies by Olivieri and his co-workers (37) appear to be the best available source of information on the bacteriological quality of urban stormwater. Their results indicate that "urban runoff" is really a composite of all unaccounted for residuals leaving an urban area via the watercourses. It includes illicit industrial waste, cross connections with the sanitary sewer system, septic tank seepage, landfill leachate, etc. Thus, sanitary surveys of local receiving waters are needed to characterize the actual problems that exist, e.g., unauthorized or unknown cross contamination.

2. Myrtle Beach, South Carolina--Bacteriological contamination of the city's beaches occurs after heavy rains. Urban runoff is the alleged cause although it might be illicit interconnections with the sanitary sewer system.

3. Tampa, Florida--Deterioration of the City of Tampa surface water supply in the Upper Hillsborough River appears to be partially attributable to urbanization of the riparian lands. Water quality in the Lower Hillsborough River and Hillsborough

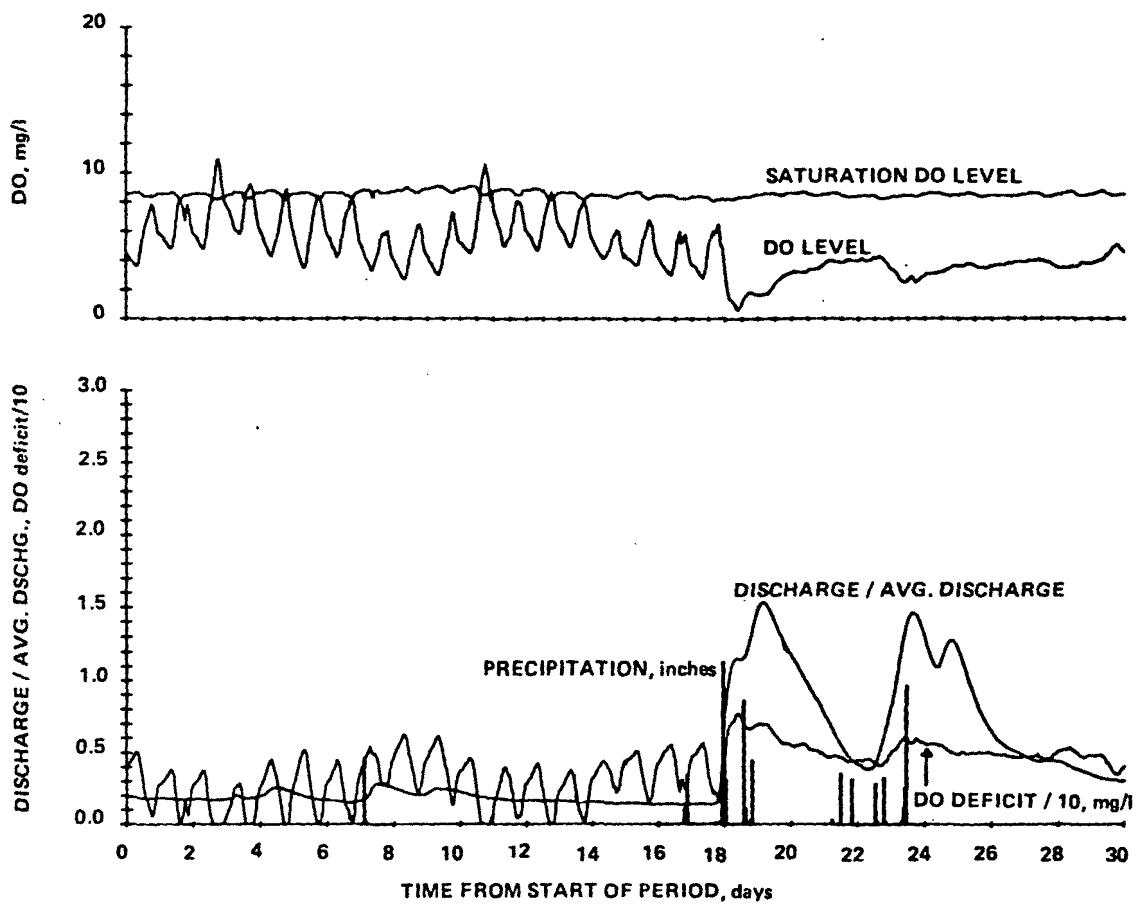


Figure 11. Observed Relationship Between Diurnal Dissolved Oxygen Concentration and Storm Events for the Scioto River at Chillicothe, Ohio (28).

Bay is degraded by landfill leachate, contaminated spring water, sanitary sewer system overflows, zoo runoff, as well as the more general forms of urban runoff. These receiving waters have been seriously impacted by sewage and water treatment plant sludges, industrial wastes, incinerator leachate, and other problems. The relative importance of urban runoff is to be determined.

4. Milwaukee, Wisconsin--Milwaukee has very serious combined sewer overflow problems and a large accumulation of sewage sludges.(38) The problem is relatively well documented and the City of Milwaukee is committed to take remedial action.

5. Austin, Texas--Town lake, a water supply source for the city, has received urban runoff for a number of years. Urbanization is proceeding upstream along the lake. There is general evidence that water quality in the lake has deteriorated but the exact extent is unknown. Are stringent controls on urban runoff needed and/or should the City of Austin move its water supply further upstream?

6. Bellevue, Washington--The City of Bellevue seeks to preserve the salmon runs. Efforts are being made to prevent deterioration of the local streams. This requires effective ordinances and extensive monitoring. What would such a program cost and how effective will it be?

NATIONAL WATER QUALITY INVENTORY

The National Water Quality Inventory (30) is a compilation of reference level violations in major waterways. The causes of these violations were not segregated so the contribution of storm water is not known. The frequency of violations is of interest in that many of the water bodies have been identified relative to storm-water/receiving water bodies.

Parameters addressed were:

Suspended solids*
Turbidity*
Color*

Ammonia*
Nitrite
Nitrate (as N)
Nitrate (as NO_3)*
Nitrite plus nitrate*
Organic nitrogen
Total Kjeldahl nitrogen
Total phosphorus*
Total phosphate
Dissolved phosphate

Sulfates
Alkalinity
pH*

Dissolved oxygen
BOD_5*
COD (.025N)*
Total coliforms*
Fecal coliforms*
Phenols
Odor

Dissolved solids (105°C)
Dissolved solids (180°C)
Chlorides

* Higher pollutant levels in periods of high flow.

Table 9 shows the percentage of these parameters exceeding reference levels. These receiving waters are relatively large and do not provide a good representation of the mix of urbanized area receiving waters shown in Table 6. Figure 12 shows a map of large rivers of the United States. Thirty of thirty five of these receiving waters show on the map as large rivers. Based on the dilution calculations, these receiving waters would not be expected to have serious problems from wet-weather flows from urban areas.

208 PRIORITY PROBLEM AREA

Urban runoff was identified as being a "priority problem" in 88 urbanized areas throughout the United States. Based on reviews of numerous 208 studies and inquiries to EPA regional coordinators, very few of these problem areas have extensive sampling data to support the allegation that urban runoff problems exist. Rather the problem assessment is based on areas where deterioration is evident and urban runoff appears to be a cause of the problem. Nevertheless, this is probably the best single source of information on impacts as viewed at the local level.

1978 NEEDS Survey

Simulated receiving water impact studies were done for fifteen urban areas. The "problem" assessment is in terms of comparing calculated receiving water concentrations to prespecified standards. Some calibration data were available. The unique part of this study was the use of criteria for three levels of water quality: 1) aesthetics, 2) fish and wildlife, and 3) recreation. No measure of aesthetics was used. For fish and wildlife, requiring a minimum dissolved oxygen of 2.0 mg/l for four consecutive hours determines the required level of treatment. One violation per year was permitted. Similar criteria were established for other constituents.

This approach is limited by the facts that: 1) the simulation models do not adequately predict the receiving water response as evidenced by the data of Keefer et al. (28); 2) the dose-response information is very weak; and 3) no local assessment of problems is included. It is highly improbable that a simple simulation model could realistically portray local problems.

NORTH AMERICAN WATER PROJECT

This report presents summary information on twenty one studies of lakes throughout the United States (29). Five of these studies relate urban runoff loadings to receiving water quality in four cities: Minneapolis, Minn.; Lake George, New York; Madison, Wisc.; and Seattle, Wash. Of these five studies, Lake Wingra in Madison, Wisc. is the only

Table 9. Major Waterway Rankings-Percent of Parameters Exceeding Reference Levels*.

0 to 7	7 to 17	Over 17
Upper Missouri River	Rio Grande River	Hudson River
Columbia River	Alabama-Coosa Rivers	Delaware River
Lower Tennessee River	Upper Ohio River	Middle Mississippi River
Snake River	Susquehanna River	Lower Arkansas River
Willamette River	Upper Red River	Lower Ohio River
Boston Harbor	Lower Colorado River	Lower Mississippi River
Upper Mississippi River	Potomac River	Middle Ohio River
Yukon River	Detroit Area-Tributaries	Lower Missouri River
Chicago Area-Lake Michigan	Scaramento River	Chicago Area-Tributaries
Upper Tennessee River	Lower Red River	Mississippi near Minneapolis
Detroit Area-River	Brazos River	Upper Arkansas River
	Upper Colorado River	Middle Missouri River

*Based on the number of parameters having medians which exceed reference levels selected for comparative purposes.

Source: Data from EPA (30)

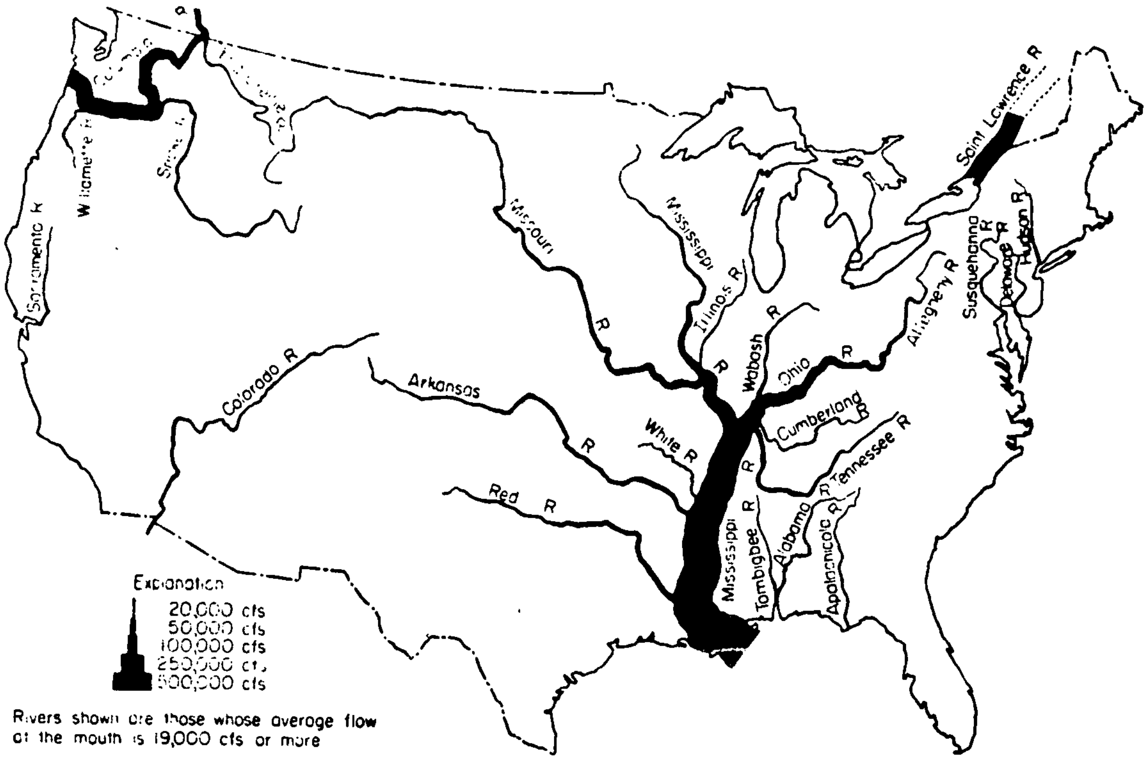


Figure 12. Large Rivers in the United States (39).

lake in which urban runoff is the primary input. There is an extensive data base for Lake Wingra based on long-term studies at the University of Wisconsin. No major problems are evident.

1979 CONGRESSIONAL HEARINGS

The recent Hearings reflect the changing attitude toward water pollution control, i.e., the growing concern over the high cost of advanced waste treatment (AWT), and the influence of nonpoint pollution in preventing achievement of the 1983 goal of fishable/swimmable waters. Case studies of Dallas and Minneapolis demonstrated the need to examine water quality criteria on a case by case basis. Also, the question of defining fishable/swimmable waters arose. Lastly, attempts to document successes to date revealed how little substantive impact information is available. Another disturbing fact was the reported poor performance of the newly installed treatment plants.

COMBINED SEWERED AREAS

A total of 120 out of 248 urbanized areas include combined sewer systems. Most of these cities are located in the eastern U.S. (96 out of 120 are in EPA's eastern regions 1 to 5). These urban areas remain the higher priority wet-weather pollution control problems.

OTHER STUDIES

The primary impetus for the other urban runoff studies was local concern over the quality aspects of on-site stormwater detention ponds which are very popular in new urban developments. Sufficient concern exists in some areas to justify studies to assess the impact of urban runoff on domestic water supplies. It is especially in these newer areas with excellent environmental quality, e.g., the Sun Belt, that public support for installing environmentally sound drainage systems is very high. By contrast, the receiving water quality problems in older parts of the U.S. are already dominated by more traditional waste sources. Thus, they are not as enthusiastic about urban runoff quality control.

REGIONAL SUMMARY

The summaries for the cities and states were aggregated for each of the ten EPA regions. The results, presented in Table 10, provide these indicators of wet-weather receiving water impacts: the ratio of wet-to-dry weather flow, the median dilution ratio, and the average number of problem citations per city. Comparison of the wet-to-dry-weather flow ratio indicates, as expected, that urban runoff is of greater relative importance in the wetter parts of the U.S. However, the receiving water flow in the wetter parts of the country tends to be larger. Thus, the impact of urban runoff may be significant in arid parts of the U.S. due to less dilution capacity. Region 9, which covers much of the arid southwestern United States, has the lowest median dilution ratio of any of the ten regions. However, one should not use the median dilution ratio as a strong basis for ranking the problems in the ten regions.

EPA Region	No. of Urbanized Areas[a]	Precipitation in/yr.	Urban Population 1000's	Wet/Dry Flow[b] Ratio	Median Dilution Ratio	Problems Citations Per Urbanized Area
1	25	41.1	9050	1.39	4.8	1.3
2	10	40.5	21983	0.86	83	2.0
3	24	42.1	16203	1.21	29.5	1.6
4	43	49.6	18745	1.69	100	1.6
5	52	32.7	32610	0.99	15.2	1.7
6	40	35.3	14753	1.20	13.9	0.7
7	15	31.9	7291	1.09	124	1.4
8	11	17.4	3735	0.49	6.8	1.1
9	21	16.9	20731	0.42	1.0	1.0
10	7	26.9	4265	1.09	112	2.1
Total/Avg.	248	33.4	149366	1.04	15.2*	1.6*

(a) Urbanized areas are as defined in U.S. Census. See reference 1.

Table 10. Regional Summaries of Receiving Water Impact Information.

*Urbanized area weighted regional median.

(b) Annual wet-weather runoff from urbanized area divided by annual sewage flow.

For some regions, e.g., region 8, the sample size is small. As mentioned earlier, the "primary" receiving water is often not the one in which urban runoff "problems" are observed. The distribution of dilution ratios within a region varies widely. Thus, the median dilution ratio may mislead the casual reader to perceive a normal distribution about the median. It is not possible to make any simple generalizations regarding the regional nature of the urban runoff problem.

The average number of problems per city ranges from a low of 0.7 in region 6 to a high of 2.1 in region 10. Comparison of problems per city to median dilution ratio indicates wide variability. However there is a generally positive trend, i.e., the number of problems per city increases as dilution ratio increases. One would expect the opposite to occur since increased dilution capacity should reduce the number of problem citations per urbanized area.

STATE SUMMARIES

Whereas the regional summaries did not indicate any apparent regional trends with regard to dilution ratios, the state summaries do help indicate the general ranking of states which might be expected to have relatively severe urban runoff problems. Neglecting those states not having at least three urban areas, the following seven states do not have a dilution ratio greater than 10.

Connecticut (3.0)
North Carolina (3.5)
Colorado (3.5)
California (3.7)
Utah (5.1)
Massachusetts (6.2)
Ohio (7.2)

At the other extreme, the following three states have median dilution ratios greater than 1000.

Arkansas (1040)
West Virginia (1525)
Kentucky (2409)

However, Kentucky with the highest median dilution ratio, contains Lexington, a head-water city with a dilution ratio of about zero. Thus, caution needs to be exercised in attempting to generalize regarding state summary information.

LOCAL SUMMARIES

The results for all urbanized areas in the United States are summarized in two types of tables. The first type summarizes the demographic, flow and dilution ratio data, and number of problem citations. The second type indicates whether the city is in a 208 area and has identified urban runoff as a priority problem; the type of receiving waters; and the type of impacts, beneficial uses, and problem pollutants. The first set of tables is presented as Appendix A. The entries in this set of tables give specific quantitative measures of potential problems, e.g., the dilution ratio and number of problem citations. The second set of tables, presented as Appendix B, is softer information but does provide some general indication of areas of concern.

The most direct measure of the relative importance of urban runoff is to examine the number of citations per city for the 248 urbanized areas. As Table 5 indicated, 7.6 percent of the urbanized areas have four to six citations. Table 11 lists these nineteen urbanized areas along with the number of citations.

Citations per Urbanized Area	Urbanized Area(s)
6	Philadelphia, PA.
5	Boston, MA, Chicago, IL, Detroit, MI, Lansing, MI, Milwaukee, WI, New York, NY, Seattle, WA, Washington, D.C.
4	Atlanta, GA, Baltimore, MD, Cleveland, OH, Denver, CO, Des Moines, IA, Mobile, AL, Richmond, VA, Savannah, GA, Syracuse, NY, and Youngstown OH.

Table 11. Urbanized Areas with Four, Five and Six Urban Runoff Problem Citations.

Based on this extensive national search for impacts, the hope was that general trends and correlations might become apparent, e.g., heavy metals problems are most common in the southeastern United States. However, overall analysis of the data base indicates that it would be counter-productive to place much faith in these data because they were not really collected in a systematic, scientific manner. Using heavy metals as an example, it is doubtful that few, if any, of the cities listing heavy metals as a "problem" could substantiate this connection with proper scientific evidence. Rather, the information was probably based on reading the literature and noting the general concern regarding pollution from heavy metals.

The significance of stormwater impacts on receiving water bodies cannot be assessed at this time. The sparseness of documented cases, the lack of detailed data, and the general focus of stormwater investigations into water quality dynamics (and away from actual impacts) do not provide a substantial basis for determinations.

Nationwide attention has been focused on impact documentation. Thus, the data bases are just now beginning to be extensive enough to address scientific correlation of constituents with respect to impacts, and because some possible sources of impact documentation have not been searched at site-specific levels, the amount of documentation identified is probably much less than what exists. In other words, documentation is only beginning to be found because the search has just begun.

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APPENDIX A

SUMMARIES OF DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

The following tables present information on annual precipitation, 1970 population and land area, annual wet-weather flow, sewage flow, primary receiving water flow, dilution ratio, and number of problem citations for every urbanized area in the United States. Results are summarized by State and EPA region. Detailed descriptions of each column are presented in the main body of the report.

State Connecticut

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Bridgeport	42.0	413	77.3	15.5	11.2	8.8	0.33	11,2
Bristol	43.0	72	15.2	15.4	10.1	78.9	3	0
Danbury	42.0	67	15.1	14.6	9.3	38.2	1.6	0
Hartford	42.0	465	80.1	16.0	12.2	2830	100	11
Meriden	45.0	98	21.6	15.7	9.4	129	5.2	2,3
New Britain	43.0	131	23.0	16.2	12.0	--	~0	0
New Haven	45.0	348	61.4	16.9	11.8	100	3.5	3,11
Norwalk	44.0	107	20.8	16.1	10.9	91.8	3.4	11
Stamford	45.0	185	35.4	16.5	11.0	16.5	0.6	0
Waterbury	46.0	157	29.7	16.9	11.0	111	4	11
Other	43.7	301	56.2	16.1	11.3	--	--	2,3
Total/Avg.	43.7	2344	435.8	16.1	11.3	85.4	3.2	0.9

State Maine

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Lewiston	44.0	65	15.3	15.1	9.0	5240	218	11
Portland	43.0	106	22.2	15.3	10.1	411	16	11
Other	43.5	336	73.4	15.2	9.6	--	--	1
Total/Avg.	43.5	507	111	15.2	9.6	2900	117	1.0

State Massachusetts

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Boston	43.0	2652	434.3	16.6	12.8	11.8	0.5	1,4,6,10,11
Brockton	45.0	149	27.9	16.6	11.2	--	0	1,10
Fall River	45.0	139	25.2	16.9	11.8	5.7	0.2	11
Fitchburg	46.0	78	17.6	16.0	9.3	156	6.2	1,5,11
Lawrence	41.0	200	39.6	14.9	10.7	2530	98.7	11
Lowell	40.0	183	33.9	14.8	11.4	2870	110	1,11
New Bedford	41.0	134	22.3	15.8	12.8	--	>1000	5,11
Pittsfield	44.0	63	13.8	15.4	9.5	110	7.9	0
Springfield	45.0	514	103.8	16.2	10.4	2190	82	5,4,11
Worchester	46.0	247	45.7	17.1	11.4	71.2	2.5	1,11,5
Other	43.6	454	79.3	16.4	12.0	--	--	10,3,2
Total/Avg.	43.6	4813	843.4	16.4	12.0	176	6.2	2.4

State <u>New Hampshire</u>

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

				FLOW in/yr				
URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Manchester	40.0	95	18.6	14.5	10.7	3890	154	11
Nashua	42.0	61	13.0	14.9	9.9	5900	238	11
Other	41.0	261	52.3	14.7	10.4	--	--	10
Total/Avg.	41.0	417	84.1	14.7	10.4	4920	196	1.0

State Rhode Island

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Providence	40.0	795	141.1	15.0	11.8	76.9	2.9	1,11
Other	40.0	31	5.4	15.0	11.8	--	--	0
Total/Avg.	40.0	826	146.5	15.0	11.8	76.9	2.9	2

State Vermont

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
No Urbanized Areas								
Total/Avg.	35.0	143	27.6	12.8	11.0	--	--	0
Total/Avg. for Region 1	40.5	9050	1648.4	18.2	21.2	105	3.5	1.32

State New Jersey

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Atlantic City	42.0	134	27.7	15.0	10.2	--	>1000	0
New York City Metro	43.0	5688	1067.7	15.9	11.2	--	83	1,11,3
Philadelphia Metro	43.0	202	32.2	16.7	13.0	4930	166	1,11
Trenton	42.0	274	44.2	16.4	13.1	3700	125	1,5
Vineland	44.0	74	17.4	15.1	8.9	136	5.7	0
Other	42.0	--	--	15.9	11.2	--	--	1
Total/Avg.	42.8	6372	1189.2	15.9	11.2	3390	125	1.4

State New York

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Albany	38.0	486	87.1	14.2	11.8	2160	83	11
Binghampton	36.0	167	29.6	13.5	11.8	2950	116	11
Buffalo	36.0	1086	158.4	14.4	14.4	47500	1650	11
New York City	43.0	10519	379.3	29.8	58.2	448	5.7	1,4,6 3,10,11
Rochester	32.0	601	96.6	12.3	13.0	390	15.4	4,6,12,11
Syracuse	38.0	376	61.7	14.6	12.7	25.8	0.95	1,6,12 11
Utica	44.0	180	35.3	16.0	10.7	296	11.1	11
Other	38.1	2196	139.3	18.2	33.2	--	--	2
Total/Avg.	38.1	15611	987.3	18.2	33.2	792	15.4	2.4
Total/Avg. for Region 2	40.5	21983	2176.5	18.2	21.2	296	83	2.0

State Delaware

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Wilmington	45.0	371.	64.8	17.0	12.0	128.	4.4	3,11
Other	45.0	24.	4.6	17.0	12.0	--	--	0
Total/Avg.	45.0	395	69.4	17.0	12.0	128.	4.4	2

State Washington D.C.

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Washington	41.0	757.	58.6	20.7	26.9	2540.	53.3	1,4,10 11,12
Other	41.0	--	2.4	20.7	26.9	--	--	0
Total/Avg.	41.0	757.	61	20.7	26.9	2540	53.3	5,10,11

State Maryland

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr: WET WEATHER	FLOW in/yr: SEWAGE	FLOW in/yr: PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Baltimore	43.0	1580	229.6	17.3	14.4	22	0	1,3,12, 4
Washington Metro	41.0	473	78.1	15.8	12.8	2540	53.3	1,4,10, 11,12
Other	42.0	1425	143.2	16.9	14.0	--	--	
Total/Avg.	42.0	3005	450.9	16.9	14.0	1280	26.6	1,4.5

State Pennsylvania

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Allentown	44.0	364	61.3	16.8	12.4	510	17.5	11,5
Altoona	44.0	82	13.5	17.1	13.0	--	~0	11
Erie	38.0	175	28.5	14.6	12.8	--	~0	11
Harrisburg	38.0	241	43.8	14.2	11.6	10700	416	11
Johnstown	45.0	96	16.8	17.0	12.0	308	10.6	11
Lancaster	43.0	117	21.4	16.0	11.5	240	8.7	11,12
Philadelphia	43.0	3819	537.2	17.5	14.9	1370	42.3	1,11,5, 12,6,2
Pittsburg	37.0	1846	334.0	13.8	11.6	1300	51.2	11
Reading	42.0	168	26.9	16.3	13.0	540	19.5	0
Scranton	39.0	204	41.8	14.0	10.3	87.4	3.6	11
Wilkes-Barre	39.0	223	42.2	14.3	11.1	4570	180	11
York	40.0	123	22.0	15.1	11.9	149	5.5	0

State Pennsylvania Cont'd

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Other	41.0	975	155.3	15.9	13.2	--	--	2
Total/Avg.	41.0	8433	2106	15.9	13.2	407	14.0	1.4

State Virginia

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Lynchberg	40.0	71	16.5	13.8	9.2	2190	127	11
Newport News	45.0	268	56.4	16.0	10.0	Ocean	>1000	0
Norfolk	45.0	668	134.	16.3	10.5	Ocean	>1000	0
Petersburg	43.0	101	19.9	15.6	10.7	798	30.6	0
Richmond	44.0	416	77.5	16.3	11.3	1320	47.8	1,2,3,11
Roanoke	42.0	157	30.7	15.3	10.7	169	6.5	1,11,10
Washington, D.C. Metro	41.0	1251	138	18.2	19.0	1100	29.5	1,4,10, 11,12
Other	42.9	1	0	16.6	13.0	--	--	0,2
Total/Avg.	42.9	2933	472.1	16.6	13.0	1415	47.8	1.9

State West Virginia

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Charleston	45.0	158	30.8	16.5	10.9	6360	232	11
Huntington	40.0	121	22.9	14.7	11.0	46000	1790	11
Steubenville Metro	40	40	10.3	13.3	8.1	106000	4980	11
Wheeling	39.1	93	16.5	14.7	11.9	33600	1260	11
Other	41.0	268	52.5	15.2	10.8	--	--	2
Total/Avg.	41.0	680	132.9	15.2	10.8	39650	152.5	1.0
Total/Avg. for Region 3	42.1	16203	2530	16.3	13.5	1200	36.4	1.6

State Alabama

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi ^{2}	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Birmingham	53.0	558	108.7	19.4	10.8	17	~0	2
Gadsden	55.0	68	15.3	19.2	9.3	8040	282	0
Huntsville	52.0	146	33.3	18.1	9.2	17200	630	0
Mobile	68.0	258	56.5	24.1	9.6	9160	272	1,2,12 10
Montgomery	54.0	139	26.6	20.0	11.1	11700	377	0
Tuscaloosa	53.0	86	17.7	19.0	10.1	5800	201	1
Other	55.8	756	155.4	20.3	10.2	--	--	2
Total/Avg.	55.8	2011	413	20.3	10.2	8450	277	1.0

State Florida

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Ft. Lauderdale	60.0	614	114.1	22.4	11.3	Ocean	>1000	1,12
Gainesville	52.0	69	13.9	19.4	10.7	20	<1	12
Jacksonville	53.0	530	116	18.7	9.6	646	22.8	0
Miami	60.0	1220	185.2	23.9	13.9	Ocean	>1000	1,12,2
Orlando	51.0	305	60.2	18.5	10.6	Small Lakes	<1	1,12,2
Pensacola	63.0	167	32.1	23.2	10.9	Bay	>1000	1,2
St. Petersburg	55.0	495	89.8	20.6	11.6	Bay	>1000	1,7,3
Tallahassee	57.0	78	14.8	21.0	10.9	Small Lakes	<1	1,12
Tampa	52.0	369	69.2	19.3	11.2	135	4.4	4,12,7,1
West Palm Beach	62.0	228	58.5	22.4	10.3	Ocean	>1000	1,2
Other	56.5	1330	242.2	21.3	11.5	--	--	4,2,1,3,12
Total/Avg.	56.5	5465	996.1	21.3	11.5	748	228	2.0

State Georgia

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Albany	48.0	76	18.6	16.3	8.5	4512	182	11
Atlanta	47.0	1173	222	17.3	11.1	189	0	1,11,6 12
Augusta	39.0	149	28.6	14.2	10.9	4900	195	11
Columbus	49.0	209	43.4	17.6	10.2	1950	70	12,11
Macon	44.0	128	25.1	16.1	10.8	1420	52.8	1,10
Savannah	52.0	164	31.6	19.1	10.9	4900	163	1,10,11 2
Other	46.5	869	--	17.1	10.8	--	--	2
Total/Avg.	46.5	2768	539.1	17.1	10.8	4548	116	2.3

State Kentucky

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Huntington Metro	40.0	47	9.5	14.5	10.7	110000	4380	11
Lexington	44.0	160	26.6	17.0	12.8	15	~0	0
Louisville	41.0	739	127.1	15.6	12.2	12200	438	1,11
Owensboro	44.0	53	8.6	17.3	13.4	211000	6860	11
Other	42.3	516	117.8	15.8	12.3	--	--	2
Total/Avg.	42.3	1687	288.8	15.8	12.3	67200	2409	1.0

State Mississippi

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Biloxi	58.0	121	25.3	20.8	10.1	908	29.4	0
Jackson	51.0	190	36.2	18.8	11.0	2050	68.7	2
Other	54.5	676	133.8	19.6	10.6	--	--	0
Total/Avg.	54.5	987	195.4	19.6	10.6	1408	49.0	0.5

State North Carolina

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Asheville	48.0	72	14.8	17.1	10.1	1880	69.2	1
Charlotte	43.0	280	53.6	15.8	11.0	12	~0	0
Durham	43.0	101	20.3	15.6	10.6	12	~0	1,10,12
Fayetteville	47.0	161	32.5	17.0	10.4	1620	59.3	0
Greensboro	42.0	152	29.5	15.3	10.8	12	~0	0
HighPoint	46.0	94	19.6	16.4	10.0	834	3.16	0
Raleigh	46.0	152	30.5	16.6	10.4	945	3.5	1
Wilmington	52.0	58	12.2	18.7	10.2	6290	217	0
Winston-Salem	47.0	142	28.5	17.0	10.4	1400	50	4
Other	46.0	1075	214.2	16.4	10.5	--	--	2
Total/Avg.	46.0	2287	455.7	16.4	10.5	94	3.5	.7

State South Carolina

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Charleston	47.0	228	45.1	17.1	10.6	--	>1000	1
Columbia	47.0	242	47.9	17.1	10.6	2430	87.7	1
Greenville	46.0	157	31.2	16.6	10.5	34.4	1.3	1
Other	46.7	606	120.7	17.0	10.6	--	--	1,4,10
Total/Avg.	46.7	1233	245.6	17.0	10.6	2420	87.7	1.0

State Tennessee

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Chattanoga	54.0	224	46.8	19.3	10.1	10700	365	1,11
Knoxville	46.0	190	38.2	16.6	10.5	4637	171	12
Memphis	48.0	664	115.8	18.2	12.0	53600	1770	11
Nashville	45.0	448	100.4	15.7	9.4	2730	112	1
Other	48.3	781	154.2	17.3	10.6	--	--	0
Total/Avg.	48.3	2307	456.1	17.3	10.6	7480	268	1.8
Total/Avg. for Region 4	49.6	18745	3589.2	18.6	11.0	945	99.8	1.58

State Illinois

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Aurora	34.0	233	42.3	12.6	11.5	257	10.7	0
Bloomington	36.0	69	12.2	13.6	12.1	13.6	<1	0
Champaign	37.0	100	14.5	15.1	15.1	48	1.6	4
Chicago	33.0	5714	771	13.6	15.6	13.6	<1	1,11,4,12,3
Davenport-Metro	34.0	112	20.5	12.7	11.7	31500	1290	1,11
Decatur	37.0	100	19.2	13.6	11.1	240	9.7	1,11,2
Joliet	33.0	156	28.9	12.1	11.3	2780	112	0
Peoria	35.0	247	48.7	12.6	10.6	3880	168	1
Rockford	36.0	206	36.1	13.5	12.0	1420	55.7	1,7
Springfield	35.0	121	21.0	13.3	12.2	37.2	1.5	11
Other	35.0	2163	311	13.4	14.6	--	--	2
Total/Avg.	35.0	9221	1325	13.4	14.6	286	10.2	1.5

State Indiana

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Anderson	36.0	81	31.8	10.6	5.4	165	10.3	11,12
Chicago Metro	33.0	1000	176	12.4	11.9	12.4	<1	1,11,4 12
Evansville	41.0	142	24.5	15.5	12.1	72400	4233	11
Fort Wayne	34.0	225	39.8	12.7	11.8	534	22	11,5
Indianapolis	40.0	820	166	14.4	10.4	115	4.6	2,11
Lafayette	35.0	79	12.5	13.6	13.1	6930	260	12,11
Muncie	39.0	90	15.4	14.8	12.3	192	7.4	11
South Bend	36.0	288	54.0	13.2	11.2	788	32.3	11
Terra Haute	41.0	81	15.3	15.0	10.9	9050	350	
Other	37.2	565	107	13.3	11.0	--	--	3,2
Total/Avg.	37.2	3371	642	13.3	11.0	535	22	1.7

State Michigan

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Ann Arbor	31.0	179	29.5	11.9	12.8	204	8.3	4
Bay City	28.0	78	14.6	10.3	11.5	3670	168	11
Detroit	31.0	3970	612	12.1	13.6	177	6.9	1,4,6, 11,2
Flint	30.0	330	57.1	11.3	12.1	217	9.3	1,11
Grand Rapids	31.0	353	68.9	11.2	10.7	695	32	1,11
Jackson	34.0	78	15.7	12.2	10.4	103	4.6	1,11
Kalamazoo	34.0	152	31.2	12.1	10.3	365	16.3	0
Lansing	31.0	230	41.6	11.5	11.7	274	11.8	1,4,2, 11,12
Muskegon	32.0	106	21.6	11.4	10.2	1700	93	1
Saginaw	28.0	148	25.9	10.5	12.0	1350	60	11
Other	31.0	935	153	11.9	12.9	--	--	2,3
Total/Avg.	31.0	6559	1071	11.9	12.9	348	14.0	2.0

State Minnesota

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Diluth	29.0	105	23.3	10.1	9.6	1280	64.7	11
Fargo Metro	21.0	31	5.7	7.8	12.2	1060	53	11
Minneapolis	25.0	1704	336	9.0	10.6	277	14.1	12,11
Rochester	29.0	57	9.9	11.0	12.6	141	6.0	0
Other	26.0	630	124	9.1	10.6	--	--	3,2
Total/Avg.	26.0	2527	499	9.1	10.6	661	336	1.0

State Ohio

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Akron	38.0	543	104.0	13.9	11.0	55.6	2.2	5, 1,12
Canton	38.0	244	43.6	14.2	11.7	32.0	1.2	1,9,11
Cincinnati	34.0	1110	196	12.7	11.9	6720	273	1,12,11
Cleveland	32.0	1960	357	11.8	11.5	29.2	1.3	1,11,12,5
Columbus	36.0	790	139	13.5	12.0	323	12.7	5,11
Dayton	35.0	686	124	13.0	11.6	227	9.2	1,5,12
Hamilton	40.0	91	17.7	14.5	10.7	2540	101	11
Lima	36.0	70	15.5	12.5	9.3	134	8.6	11
Lorain	35.0	192	40.6	12.4	10.0	109	4.9	11
Mansfield	43.0	78	16.1	15.3	10.1	4.3	~0	0
Springfield	40.0	94	15.8	15.3	12.5	114	4.1	5,11
Steubenville	40.9	45	7.8	15.2	12.4	106000	4980	11
Toledo	32.0	488	89.8	11.8	11.4	735	31.7	11,5,12

State Ohio (Cont'd)

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Youngstown	42.0	395	72.2	15.7	11.6	161	5.9	1,5,11 12
Other	37.2	1235	226	12.9	11.5	--	--	3
Total/Avg.	37.2	8021	1465	12.9	11.5	176	7.2	2.2

State Wisconsin

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Appleton	29.0	130	22.8	10.9	12.2	2500	108	1,11
Duluth Metro	29.0	33	80	9.8	8.8	Lake	>1000	0
Green Bay	27.0	129	27.8	9.4	9.8	2040	106	1,12,11
Kenosha	32.0	84	13.3	12.6	13.8	Lake	>1000	11
La Crosse	31.0	63	11.8	11.3	11.0	31800	1430	11
Madison	31.0	205	37.5	11.4	11.4	56.1	2.5	1,12
Milwaukee	28.0	1252	236	10.2	11.1	381	17.9	4,12,6, 11,1
Oshkosh	28.0	55	8.4	10.8	13.2	600	25	1
Racine	32.0	117	18.8	12.4	13.1	Lake	>1000	0
Other	29.7	843	156	10.5	11.3	--	--	2
Total/Avg.	29.7	2911	540	10.5	11.3	2330	107	1.7
Total/Avg. for Region 5	32.7	32610	5542	12.3	12.4	300	14.1	1.66

State Arkansas

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Fort Smith	43.0	76	75	15.0	9.3	25200	1040	11
Little Rock	49.0	223	44.2	17.8	10.6	13000	458	10,4
Pine Bluff	52.0	61	10.9	19.3	11.3	5200	1700	11
Other	48.0	602	121	17.4	10.4	--	--	0
Total/Avg.	48.0	962	193	17.4	10.4	28900	1040	1.3

State Louisiana

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Baton Rouge	60.0	249	45.6	22.4	11.4	7100	0	2
Lafayette	59.0	78	14.1	22.2	11.6	554	16.4	0
Lake Charles	58.0	88	17.1	21.4	10.9	2950	91.3	0
Monroe	50.0	90	18.3	18.1	10.5	13200	461	0
New Orleans	64.0	962	80.3	31.8	25.3	102000	1760	12,3
Shreveport	45.0	234	45.4	16.4	10.8	7610	280	0
Other	56.0	705	91.4	16.2	--	--	--	2
Total/Avg	56.0	2406	312	24.1	16.2	11600	289	.5

State New Mexico

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Albuquerque	9.0	297	56.4	3.1	11.0	272	19.3	10,12
Other	9.0	414	79.5	3.1	11.0	--	--	2
Total/Avg.	9.0	711	136	3.1	11.0	272	19.3	20

State Oklahoma

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Lawton	30	96	19.3	10.7	10.4	528	25	0
Oklahoma City	31.0	580	124	10.9	9.8	16	0.8	2,10
Tulsa	37.0	371	75.8	13.2	10.3	1160	49	1
Other	32.7	693	716	11.7	10.0	--	--	2
Total/Avg.	32.7	1740	364	11.7	10.0	524	25	1.0

State Texas

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Abilene	24.0	90.0	20.6	8.2	9.2	411	23.6	0
Amarillo	20.0	127	25.9	7.2	10.3	241	13.9	0
Austin	33.0	264	48.0	12.2	11.6	707	29.7	1,4
Beaumont	54.0	116	25.3	19.1	9.6	3944	137	11
Brownsville	27.0	53.0	9.5	10.1	12.2	7130	320	0
Bryan	39.0	51.0	11.1	13.7	9.6	290	12.4	0
Corpus Christi	28.0	213	45.8	9.8	9.8	259	13.2	1,2
Dallas	35.0	1338	276	12.5	10.2	73.9	3.3	1,12
El Paso	8.0	337	62.8	2.7	11.2	246	10	1
Fort Worth	30.0	677	144	10.5	9.8	39.7	2	0
Galveston	43.0	62.0	12	15.8	11.1	--	>1000	1,11
Harlingen	26.0	50.0	11.1	9.0	9.6	2570	138	0
Houston	46.0	1678	303	17.2	11.6	11	0.4	12

State Texas Cont'd

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Laredo	19.0	70.0	12.5	7.0	11.7	4800	257	0
Lubbock	18.0	150	30.9	6.3	10.1	--	0	0
McAllen	21.0	91.0	17.0	7.6	11.2	--	0	0
Midland	14.0	60.0	12.3	4.8	10.0	--	0	0
Odessa	14.0	82.0	14.6	5.1	11.8	--	0	0
Port Arthur	54.0	116	25.3	19.1	9.7	--	0	1
San Angelo	19.0	64.0	13.5	6.6	10.0	157	9.5	0
San Antonio	28.0	772	134	10.5	12.1	5.6	0.3	1,2
Sherman	39.0	55.0	11.7	13.7	9.7	--	0	0
Texarkana	46.0	58.0	12.3	16.4	10.0	--	0	1
Texas City	45.0	84.0	19.5	15.5	9.0	--	>1000	0
Tyler	45.0	60.0	11.8	16.4	10.7	--	3.8	1
Waco	32.0	119	26.8	11.1	9.4	1290	62.9	2

State Texas Cont'd

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

				FLOW in/yr				
URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Wichita Falls	29.0	98.0	19.5	10.4	10.6	229	10.9	0
Other	31.0	1990	392	12.3	10.7	--	--	2
Total/Avg.	31.0	8934	1749	12.3	10.7	230	10.0	0.6
Total/Avg. for Region 6	31.0	14753	2754	13.4	11.2	243	13.2	0.7

State Iowa

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Cedar Rapids	33.0	132	27.0	11.8	10.4	1540	69.6	0
Davenport	34.0	114	25.3	11.8	9.4	25600	1210	1,11
Des Moines	31.0	225	50.6	11.2	10.6	1020	47	1,6,12 11
Dubuque	33.0	65	11.2	12.4	12.0	49211	2020	0
Sioux City	25.0	96	20.5	8.7	9.7	21800	1190	0
Waterloo	32.0	113	24.3	11.2	9.7	1320	63	0
Other	31.3	840	173	11.1	10.2	--	--	0
Total/Avg.	31.3	1615	332	11.1	10.2	13400	630	1.0

State Kansas

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Kansas City	34.0	274	49.1	12.7	11.7	15600	667	1,4,11
Topeka	34.0	132	25.7	12.3	10.8	2870	124	11
Wichita	31.0	302	55.9	11.4	11.3	265	11.7	0
Other	33.0	777	143	12.1	11.4	--	--	2
Total/Avg.	33.0	1485	274	12.1	11.4	2915	124	1.3

State Missouri

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Columbia	37.0	59	13.1	12.9	9.5	152	6.8	2
Kansas City Metro	34.0	828	169	12.1	10.2	4450	200	1,4,11
Springfield	41.0	121	25	14.6	10.1	--	0	6,5,2
St. Joseph	35.0	77	22.0	11.2	7.2	23100	1250	11
St. Louis	37.0	1883	305	14.3	13.0	7780	285	1,4,11
Other	36.8	2191	55.8	13.5	11.6	--	--	0
Total/Avg.	36.8	3278	590	13.5	11.6	5020	200	2.2

State Nebraska

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

				FLOW in/yr				
URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Lincoln	27.0	153	27.9	9.9	11.4	107	5	2
Omaha	26.0	492	87.8	9.7	11.8	4390	204	11
Other	26.5	268	48.1	9.7	11.7	--	--	0
Total/Avg.	26.5	913	164	9.7	11.7	2226	104	1.0
Total/Avg. Region 7	31.9	7291	1360	12.2	11.2	2870	162	1.4

State Colorado

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Boulder	19.0	69	10.3	7.4	14.2	131	6	0
Colorado Springs	13.0	205	41.1	4.5	10.5	--	0	1
Denver	14.0	1047	180	5.1	12.2	17.9	1	1,11,4 10
Pueblo	12.0	103	18.0	4.3	11.8	542	34	10,11
Other	14.5	313	54.5	5.1	12.0	--	--	1,2
Total/Avg.	14.5	1737	304	5.1	12.0	60	3.5	1.8

State Montana

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Billings	13.0	71	13.4	4.6	11.0	6610	424	0
Great Falls	15.0	71	12.6	5.4	11.8	7300	424	0
Other	14.0	230	42.6	5.0	11.4	--	--	0
Total/Avg.	14.0	372	68.6	5.0	11.4	6550	424	0

State North Dakota

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Fargo	21.0	54	9.5	7.8	12.2	707	35.3	0
Other	21.0	220	38	7.8	12.2	--	--	2
Total/Avg.	21.0	274	47.5	7.8	12.2	707	35.3	0

State South Dakota

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Sioux Falls	25.0	75	14.1	9.1	11.2	351	173	1,11
Other	25.0	222	41.6	9.1	11.2	--	--	4
Total/Avg.	25.0	297	106	9.1	11.2	351	173	2

State Utah

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Ogden	17.0	150	29.3	6.0	10.8	85.6	5.1	1
Provo	13.0	104	22.7	4.4	9.7	107	7.6	0
Salt Lake City	15.0	479	92.0	5.3	11.0	69.2	4.2	1,4
Other	15.0	121	23.9	5.3	10.7	--	--	0
Total/Avg.	15.0	854	168	5.3	10.7	81.6	81.6	1.3

State Wyoming

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Total/Avg.	15.0	201	38.6	5.3	11.0	--	--	1
Total/Avg. for Region 8	17.4	3735	734	5.6	11.5	119	6.8	1.1

State Nevada

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

				FLOW in/yr				
URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Las Vegas	4.0	237	48.8	1.2	10.1	--	0	12
Reno	7.0	100	18.9	2.3	11.0	489	36.7	1,12,11
Other	5.5	59.0	12.1	1.5	10.4	--	--	2
Total/Avg.	5.5	396	79.8	1.5	10.4	292	18.4	2.0
Total/Avg. for Region 9	16.9	20731	3268	5.5	13.0	1.15	0	1.0

State Arizona

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Phoenix	7.0	863	173	2.3	10.5	2.3	<1	0
Tucson	11.0	294	55.0	3.8	11.2	3.8	<1	1
Other	9.0	251	49.2	2.7	10.6	--	--	0
Total/Avg.	9.0	1408	277	2.7	10.6	3.6	<1	0.5

State California

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Bakersfield	11.0	176	31.5	3.9	11.6	410	26.5	0
Fresno	11.0	263	46.8	3.9	11.9	90	5.7	4
Los Angeles	13.0	8351	1190	5.1	14.8	--	0	4,2,10
Modesto	25.0	106	19.4	9.2	11.6	1100	53	0
Oxnard	15.0	245	49.6	5.2	10.4	31.5	2	0
Sacramento	18.0	634	122	6.4	10.9	2630	155	6,11
Salinas	15.0	62	10.4	5.6	13.0	--	0	1
San Bernadino	18.0	584	122	6.2	10.0	--	0	0
San Diego	11.0	1198	216	3.9	11.7	--	0	1,3,12
San Francisco	21.0	2988	469	8.1	13.4	Bay	>1000	12,11,1
San Jose	14.0	1025	173	5.1	12.4	45.5	2.6	12
Santa Barbara	18.0	130	22.8	10.6	12.2	--	>1000	0
Santa Rosa	30	75	15.3	10.6	10.2	--	0	0

State California Cont'd

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Seaside	16.0	93	22.8	10.6	12.2	--	>1000	1
SimiValley	25.0	160	11.4	8.9	10.5	--	0	0
Stockton	14.0	160	27.9	5.1	12.0	81.6	4.8	2
Other	17.2	1892	314	5.7	13.4	--	--	2,3
Total/Avg.	17.2	18142	2854	5.7	13.4	70.7	3.7	1.0

State Hawaii

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Honolulu	23.0	442	73.6	8.7	12.6	Ocean	>1000	0
Other	23.0	196	32.5	8.7	12.6	--	--	0
Total/Avg.	23.0	638	106	8.7	12.6	Ocean	>1000	0

State Alaska

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
No Urbanized Areas								
Total/Avg.	30.0	638	30.6	10.6	10.1	--	--	1,12

State Washington

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr			DILUTION RATIO	PROBLEM CITATIONS
				WET WEATHER	SEWAGE	PRIMARY RECEIVING WATER		
Seattle	35.0	1238	226	13.0	11.5	742	30.3	1,4,10,11,
Spokane	17.0	230	42.4	6.1	11.4	2350	132	11
Tacoma	39.0	332	64.2	14.3	10.9	Bay	>1000	1,11
Other	30.3	675	125	12.3	11.4	--	--	1,2
Total/Avg.	30.3	2475	458	12.3	11.4	3130	132	2.3
Total/Avg. for Region 10	26.9	4265	789	12.4	11.4	2675	108	2.1
Total for U.S.	33.3	149366	24409	13.4	12.8	300	14.1	1.4

State Idaho

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Boise	11.0	85	16.1	3.9	11.4	2620	171	1
Other	11.0	302	55.8	3.9	11.4	--	--	1,2
Total/Avg.	11.0	387	71.9	3.9	11.4	2620	171	1.0

State Oregon

DEMOGRAPHIC, FLOW, AND DILUTION RATIO DATA

URBAN AREA	PRECIPITATION in/yr	1970 POPULATION 1000's	1970 DEVELOPED AREA, mi^2	FLOW in/yr WET WEATHER	FLOW in/yr SEWAGE	FLOW in/yr PRIMARY RECEIVING WATER	DILUTION RATIO	PROBLEM CITATIONS
Eugene	38.0	139	26.7	13.9	10.9	2790	112	4,11
Portland	40.0	825	150	14.9	11.6	2730	103	4,6,11
Salem	40.0	93	18.3	14.6	10.8	16800	5.9	12
Other	39.3	346	63.5	14.7	11.4	--	--	2
Total/Avg.	39.3	1403	259	14.7	11.4	2690	103	2.0

APPENDIX B

SUMMARIES OF TYPES OF RECEIVING WATER IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

The following tables present information on types of receiving water impacts, beneficial uses, and problem pollutants for every urbanized area in the United States. Results are summarized by state and EPA region. In some cases, no entry regarding urban runoff is included because information was not available. Thus, it is unknown whether such areas have experienced urban runoff problems.

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 1

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Beneficial Uses	Standards Violation	Public Concern	Beneficial Uses: Water Supply	Contact Recreation	Non-contact Recreation	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
CT, Bridgeport							X																
CT, Bristol			X																				
CT, Danbury			X																				
CT, Hartford					X																		
CT, Meriden			X																				
CT, New Britain			X																				
CT, New Haven						X																	
CT, Norwalk					X																		
CT, Stamford					X																		
CT, Waterbury			X																				
ME, Lewiston					X																		
ME, Portland	X					X																	
MA, Boston	X	X				X			X					X		X							X
MA, Brockton	X		X			X													X			X	X
MA, Fall River						X																	

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 1 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
MA, Fitchburg	X		X						X				X	X		X		X				X	X
MA, Lawrence					X																		
MA, Lowell	X				X				X	X			X	X	X	X		X				X	X
MA, New Bedford						X																	
MA, Pittsfield	X		X																				
MA, Springfield					X																		
MA, Worchester	X		X																				
NH, Manchester					X																		
NH, Nashua					X																		
RI, Providence	X					X			X	X			X			X		X		X	X	X	X
REGION 1 TOTAL	8	1	9	0	7	7	3	0	4	2	0	0	3	3	1	4	0	3	1	1	1	4	5

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 2

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Beneficial Uses	Standards Violation	Public Concern	Beneficial Uses: Water Supply	Contact Recreation	Non-contact Recreation	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
NJ, Atlantic City							X																
NJ, New York City Metro	X																						
NJ, Philadelphia Metro	X	X			X			X										X	X		X		X
NJ, Trenton	X	X			X													X	X				X
NJ, Vineland					X																		
NY, Albany	X				X																		
NY, Binghamoton					X																		
NY, Buffalo					X																		
NY, New York City	X					X												X	X	X		X	X
NY, Rochester				X																			
NY, Syracuse	X			X																			
NY, Utica					X																		
REGION 2 TOTAL	6	2	0	3	6	1	1	1	0	0	0	0	0	0	0	0	0	3	3	1	1	1	4

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS
REGION 3

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Beneficial Uses	Standards Violation	Public Concern	Water Supply	Contact Recreation	Non-contact Recreation	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
DE, Wilmington					X																		
DC, Washington	X				X	X				X		X					X		X		X	X	
MD, Baltimore	X	X				X			X			X	X	X	X	X		X	X	X	X		X
MD, Washington D.C. Metro	X				X	X				X		X					X		X		X	X	
PA, Allentown					X																		
PA, Altoona			X																				
PA, Erie				X																			
PA, Harrisburg					X																		
PA, Johnstown			X																				
PA, Lancaster			X																				
PA, Philadelphia	X	X			X			X										X	X				X
PA, Pittsburg	X				X																		
PA, Reading					X																		
PA, Scranton			X																				
PA, Wilkes-Barre					X																		

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 3 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
PA, York			X																				
VA, Lynchberg			X																				
VA, Newport News							X																
VA, Norfolk	X						X		X	X			X	X	X	X	X	X	X				
VA, Petersburg					X																		
VA, Richmond	X	X			X	X			X					X	X		X	X					
VA, Roanoke	X	X			X				X	X			X	X	X		X	X	X			X	X
VA, Washington D.C. Metro	X				X	X				X		X					X		X		X	X	
WV, Charleston					X																		
WV, Huntington					X																		
WV, Steubenville Metro					X																		
WV, Wheeling					X																		
REGION 3 TOTAL	9	4	6	1	17	3	2	1	4	5	0	4	3	4	4	2	6	5	8	1	4	5	3

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 4

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
AL, Birmingham	X		X																				
AL, Gadsen					X																		
AL, Huntsville					X																		
AL, Mobile	X					X			X				X	X	X				X				
AL, Montgomery	X				X																		
AL, Tuscaloosa	X				X				X	X		X	X	X	X		X			X			X
FL, Ft. Lauderdale	X		X				X						X	X		X	X	X	X	X			X
FL, Gainesville			X																				
FL, Jacksonville						X																	
FL, Miami	X		X				X		X	X						X							
FL, Orlando	X			X														X		X			
FL, Pensacola	X					X			X	X			X	X									
FL, St. Petersburg	X						X																
FL, Tallahassee	X	X	X	X						X				X				X	X	X	X	X	X
FL, Tampa	X				X		X																

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 4 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Beneficial Uses	Standards Violation	Public Concern	Beneficial Uses: Water Supply	Contact Recreation	Non-contact Recreation	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
FL, W. Palm Beach	X		X				X			X	X				X	X	X		X			X	
GA, Albany			X																				
GA, Atlanta	X	X	X							X		X	X	X	X		X	X	X		X	X	X
GA, Augusta					X																		
GA, Columbus					X																		
GA, Macon	X	X	X						X	X				X	X				X			X	
GA, Savannah	X	X	X			X			X	X				X	X		X						X
KY, Huntington Metro					X																		
KY, Lexington			X																				
KY, Louisvlle	X	X			X					X							X				X	X	X
KY, Owensboro					X																		
MS, Biloxi						X																	
MS, Jackson	X		X																				
NC, Ashville	X		X							X													
NC, Charlotte			X																				

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS
REGION 4 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
NC, Durham			X	X													X						
NC, Fayette-ville			X																				
NC, Greensboro			X																				
NC, Highpoint			X																				
NC, Raleigh	X		X																				
NC, Wilmington					X	X																	
NC, Winston-Salem			X																				
SC, Charleston	X					X			X	X	X		X	X	X		X	X					X
SC, Columbia	X				X					X		X	X	X	X		X	X		X			X
SC, Greenville	X		X						X	X			X	X	X		X						X
TN, Chattanooga	X			X	X								X	X	X		X				X	X	
TN, Knoxville	X				X																		
TN, Memphis	X				X																		
TN, Nashville	X				X							X	X	X	X			X	X			X	
REGION 4 TOTAL	27	5	21	4	16	7	5	0	8	13	2	4	10	13	10	3	11	7	7	5	2	4	9

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 5

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Colliform Bacteria
IL, Aurora			X																				
IL, Bloomington			X																				
IL, Champaign - Urbana			X																				
IL, Chicago	X	X		X	X					X							X		X	X			X
IL, Davenport Metro					X																		
IL, Decatur					X																		
IL, Joliet					X																		
IL, Peoria					X																		
IL, Rockford					X																		
IL, Springfield	X	X	X						X								X		X	X	X		
IN, Anderson			X																				
IN, Chicago Metro	X	X		X	X					X							X		X	X			X
IN, Evansville					X																		
IN, Fort Wayne			X																				
IN, Indianapolis	X	X																					

SUMMARY OF RECEIVING WATER TYPE, IMPACT, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 5 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
IN, Lafayette					X																		
IN, Muncie			X																				
IN, South Bend	X				X																		
IN, Terra Haute	X				X																		
MI, Ann Arbor			X																				
MI, Bay City					X	X																	
MI, Detroit	X	X	X		X													X	X		X		
MI, Flint	X	X	X							X		X	X	X							X		
MI, Grand Rapids	X		X						X			X	X	X			X						
MI, Jackson	X		X																				
MI, Kalamazoo	X		X																				
MI, Lansing	X		X						X	X			X	X			X	X					X
MI, Muskegon	X		X	X					X	X													X
MI, Saginaw					X																		X
MN, Duluth				X	X																		

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 5 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
MN, Fargo Metro					X																		
MN, Minneapolis					X																		
MN, Rochester			X																				
OH, Akron	X		X							X										X	X	X	X
OH, Canton			X																				
OH, Cinncinnati	X	X			X					X									X	X			X
OH, Cleveland	X			X																			
OH, Columbus					X																		
OH, Dayton	X				X													X		X	X		X
OH, Hamilton					X																		
OH, Lima			X																				
OH, Lorain			X	X																			
OH, Mansfield			X																				
OH, Springfield			X																				
OH, Steubenville					X																		

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 5 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
OH, Toledo	X			X	X																		
OH, Youngstown	X	X																					
WI, Appleton					X																		
WI, Duluth Metro				X																			
WI, Green Bay				X	X																		
WI, Kenosha				X																			
WI, La Crosse					X																		
WI, Madison	X		X										X	X		X		X	X				
WI, Milwaukee				X	X												X		X				
WI, Oshkosh				X																			
WI, Racine					X																		
REGION 5 TOTAL	21	7	24	11	28	1	0	0	4	7	0	2	4	4	0	1	6	4	7	6	5	2	8

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 6

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
AR, Fort Smith	X				X																		
AR, Little Rock	X				X																		
AR, Pine Bluff	X				X				X	X				X	X		X	X			X		X
LA, Baton Rouge	X				X																		
LA, Lafayette			X																				
LA, Lake Charles					X																		
LA, Monroe					X																		
LA, New Orleans						X																	
LA, Shreveport					X																		
NM, Albuquerque					X																		
OK, Lawton					X																		
OK, Oklahoma City	X		X																				
OK, Tulsa	X	X			X					X				X	X			X					X
TX, Abilene			X																				
TX, Amarillo			X																				

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS
REGION 6 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
TX, Austin	X				X										X		X						
TX, Beaumont																							
TX, Brownsville																							
TX, Bryan																							
TX, Corpus Christi	X					X			X				X	X	X				X	X			X
TX, Dallas					X																		
TX, El Paso					X																		
TX, Ft. Worth			X																				
TX, Galveston						X																	
TX, Harlington																							
TX, Houston	X				X					X			X	X				X	X		X		X
TX, Laredo					X																		
TX, Lubbock			X																				
TX, McAllen	X		X																				
TX, Midland			X																				

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 6 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
TX, Odessa			X																				
TX, Port Arthur																							
TX, San Angelo				X	X																		
TX, San Antonio	X	X	X						X		X					X		X	X	X	X	X	
TX, Sherman			X																				
TX, Texarkana	X		X						X					X	X		X	X		X			X
TX, Texas City						X																	
TX, Tyler			X																				
TX, Wichita Falls			X																				
TX, Waco			X																				
REGION 6 TOTAL	12	2	15	1	16	4	0	0	3	3	1	0	2	4	5	1	3	5	3	3	3	1	6

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 7

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
IA, Cedar Rapids					X																		
IA, Davenport					X																		
IA, Des Moines	X	X			X								X	X			X	X					
IA, Dubuque					X																		
IA, Sioux City					X																		
IA, Waterloo					X																		
KS, Kansas City Metro	X	X			X				X	X			X	X			X		X	X			X
KS, Topeka					X																		
KS, Wichita					X																		
MO, Columbia			X																				
MO, Kansas City	X	X			X				X	X			X	X			X		X	X			X
MO, Springfield			X																				
MO, St. Joseph					X																		
MO, St. Louis	X	X			X				X	X			X	X						X			X
NE, Lincoln			X																				

SUMMARY OF RECEIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 7 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
NE, Omaha					X																		
REGION 7 TOTAL	4	4	3	0	13	0	0	0	3	3	0	0	4	4	0	0	3	3	2	3	0	0	4

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 8

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Beneficial Uses	Standards Violation	Public Concern	Beneficial Uses: Water Supply	Contact Recreation	Non-contact Recreation	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
CO, Boulder			X																				
CO, Colorado Springs	X		X																X				
CO, Denver	X	X	X						X	X			X	X				X	X				X
CO, Pueblo					X																		
MT, Billings	X				X																		
MT, Great Falls					X																		
ND, Fargo					X																		
SD, Sioux Falls	X		X						X				X	X				X				X	X
UT, Ogden	X		X						X	X					X						X	X	
UT, Provo	X		X																				
UT, Salt Lake City	X	X	X							X			X	X			X				X	X	X
REGION 8 TOTAL	7	2	7	0	4	0	0	0	3	3	0	0	3	3	1	0	2	2	2	0	2	3	3

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 9

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
AZ, Phoenix			X																				
AZ, Tucson	X		X					X													X		
CA, Bakersfield			X																				
CA, Fresno			X																				
CA, Los Angeles			X																				
CA, Modesto			X																				
CA, Oxnard			X																				
CA, Sacramento			X																				
CA, Salinas			X																				
CA, San Bernandino			X																				
CA, San Diego	X		X				X		X	X			X	X	X		X		X	X		X	X
CA, San Francisco							X																X
CA, San Jose			X																X	X	X		
CA, Santa Barbara			X																				
CA, Santa Rosa			X																				

SUMMARY OF RECIVING WATER TYPES, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS

REGION 9 (continued)

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types						Impacts			Beneficial Uses					Problem Pollutants						
			Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
CA, Seaside							X																
CA, Simi Valley			X																				
CA, Stockton			X																				
HI, Honolulu							X																
NV, Las Vegas	X		X							X					X		X						X
NV, Reno	X		X							X					X		X						X
AK, None																							
REGION 9 TOTAL	4	1	13	0	4	0	5	1	1	2	0	0	1	1	2	0	2	0	2	2	2	1	2

SUMMARY OF RECEIVING WATER TYPE, IMPACTS, BENEFICIAL USES, AND PROBLEM POLLUTANTS
REGION 10

Urban Area	208 Area	Urban Runoff A Priority Problem	Receiving Water Types: Small Stream	Lake	River	Estuary	Ocean	Ground-water	Impacts: Impaired Bene-ficial Uses	Stan-dards Viola-tion	Public Concern	Beneficial Uses: Water Supply	Contact Recrea-tion	Non-contact Recrea-tion	Fish and Wildlife	Asthetics	Problem Pollutants: BOD COD DO	Nutrients	Sediments	Heavy Metals	Other Toxics	Oil and Grease	Coliform Bacteria
ID, Boise	X	X						X	X		X	X	X	X	X					X		X	X
OR, Eugene	X				X																		
OR, Portland	X	X			X																		
OR, Salem	X		X																				
WA, Seattle	X	X	X			X			X						X	X			X			X	
WA, Spokane					X																		
WA, Tacoma						X																	
REGION 10 TOTAL	5	3	1	0	4	2	0	1	2	0	1	1	1	1	2	1	0	0	1	1	0	2	1