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Contract No. DACW43-80-D-0025

Final Report

# SURFACE WATER QUALITY INVESTIGATION OF THE RICHLAND CREEK, ILLINOIS BASIN

Prepared for:

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July 1980

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The objective of this study is to evaluate the interaction of water quality degradation, basin land-use, and flood control alternatives in Richland Creek, IL. The extent of water quality degradation is evaluated for causes of existing pollution and the potential occurrence of future detrimental effects. Land use patterns in the basin are analyzed to determine water quality impacts and the feasibility of various flood control alternatives. The interaction of these three factors, water quality, land-use, and flood control alternatives are used to formulate recommendations.

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# SURFACE WATER QUALITY INVESTIGATION OF THE RICHLAND CREEK, ILLINOIS BASIN

Contract No. DACW43-80-D-0025

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# DISCLAIMER

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# 1.0 SUMMARY AND CONCLUSIONS

## Objective

The objective of this study is to evaluate the interaction of water quality degradation, basin land-use, and flood control alternatives in Richland Creek, Illinois. The extent of water quality degradation is evaluated for causes of existing pollution and the potential occurrence of future detrimental effects. Land use patterns in the basin are analyzed to determine water quality impacts and the feasibility of various flood control alternatives. The interaction of these three factors (water quality, land-use, and flood control alternatives) are used to formulate recommendations.

## Violations of Water Quality Standards

Violations of Illinois Water Pollution Regulations in Richland Creek are summarized in Table 1-1. Several other parameters listed in the regulations were tested and were found to be in compliance.

Chronic violations of fecal coliforms, pH, iron, and manganese standards occurred. These violations occurred at most of the stations, and were observed in at least twice out of the four sampling visits. In two instances, total dissolved solids, mercury, and sulfate concentrations were in violation of the standards. Zinc and ammonia each violated the standards on one occasion. The metals and pH violations have a potentially serious impact for aquatic life in Richland Creek. The combination of depressed pH and high metals concentrations results in high levels of dissolved metals, the most toxic metal form for aquatic life. The other major violation, high fecal coliform counts, represents a human and wildlife health hazard caused by possible high concentrations of mammalian pathogens.

The magnitude of standards violations observed during this study may actually be moderate compared to violations which could occur during the summer and early autumn. At those times additional stresses could be imposed upon aquatic life due to increased temperatures and depressed DO levels. Moreover, during these seasons, flows may be even lower. The incidence of violations increased during the lower flows encountered in this study and it appears that water quality would be depressed further during the lower flow regime typical of the warmer months.

## Causes of Water Quality Degradation

The three most significant causes of water quality degradation in the Richland Creek Basin are acid mine drainage, sewage treatment plant discharges, and agricultural runoff. These factors appear in sequence as one travels downstream from the northern to the southern regions of the Richland Creek Basin.

Table 1-1. VIOLATIONS OF ILLINOIS WATER POLLUTION REGULATIONS IN RICHLAND CREEK

| Parameter | Site Number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Fecal Coliform | | C | C | C | C | C |
| pH | C | O | O | O | O | O |
| $NH_3$ | | O | | | | |
| Fe | C | C | C | C | C | C |
| $SO_4$ | O | O | | | | |
| Mn | C | C | O | O | O | O |
| Hg | | | | O | | O |
| TDS | O | O | | | | |
| Zn | O | | | | | |

C = Chronic Violation
O = Occasional Violation

Acid mine drainage, principally from abandoned coal mines in the northern headwaters, imposes a severe stress on Richland Creek. This stress is most pronounced during low flow periods, when other ground water discharges and runoff are at a minimum. Acid mine drainage results in extremely high levels of iron, manganese, sulfates, and dissolved solids in the northern part of Richland Creek, and these effects are observed, to a lesser extent, all the way to the creek's confluence with the Kaskaskia River. In the reaches where acid mine drainage is most conspicuous, ferric hydroxide precipitate (yellowboy) coats the substrate of the creek and suppresses biological activity.

Sewage treatment plant (STP) discharges are the only major point sources in the Basin. Most of the eight STP discharges are located near the Belleville and Swansea area, and the effects of these discharges are evident downstream of Belleville. Elevated levels of fecal coliforms, ammonia, total Kjeldahl nitrogen, nitrate, orthophosphate, and total phosphorus were observed at sampling sites downstream of Belleville, and historical data indicate that during low summer flows, Richland Creek is occasionally almost anaerobic in this area. Aside from contribution of microbes, nutrients, and oxygen-demanding organic wastes, the STP discharges near Belleville do have some beneficial effects as well, insofar as they help neutralize and dilute the acid mine drainage pollution from upstream. Based on biological data, however, the stretch of Richland Creek downstream of Belleville is so polluted that the biological community is limited to mostly pollution tolerant forms.

Much of the remainder of the Richland Creek Basin is impacted by agricultural runoff, which results in high concentrations of microbes, nutrients, and suspended solids. These conditions accompany periods of precipitation. The constituents of agricultural runoff generally have a low level of acute toxicity as opposed to the more toxic acid mine drainage pollutants and deoxygenation caused by STP discharges. Nevertheless, agricultural runoff has a broad influence in the Richland Creek Basin, and causes chronic degradation.

Urban runoff from Belleville probably also degrades Richland Creek, but its effects are difficult to isolate due to the polluted characteristics of the creek in this reach.

## Effects of Flood Control Alternatives on Water Quality

The flood control alternatives available for Richland Creek are summarized solely in regard to water quality effects in the following paragraphs.

- Channelization - This alternative would have more severe impacts than any other alternative. Principal negative impacts would be relocation of flood damages downstream, potential for decreased water quality in the Belleville reach due to temperature increases and potentially lower flows, and the possibility of increased sedimentation due to bank slump. Although this alternative would provide decreased flood damage within the City of Belleville, its impact on water quality would be to accentuate existing pollution problems.
- Richland Creek Dam - The Richland Creek Dam, which would be located upstream of Belleville, would decrease flood damage throughout the downstream area by regulating the flow. This alternative would also stabilize the flow regime, thereby reducing some of the negative impacts associated with low flows. It would provide the option of treating the headwaters (contained by the reservoir) to reduce the magnitude of negative effects associated with the acid mine drainage. A potential negative impact of this option upon water quality is the possibility of increased acid mine effects if a mine shaft is flooded. Also, the dam would transform existing lotic aquatic habitat to lentic habitat.
- Richland Creek Dam and Channelization - This alternative would provide greater flood protection than either of the above options alone. Some of the negative water quality impacts associated with channelization alone would be ameliorated by the ability of the dam to stabilize the flow regime. The major negative impacts upon water quality would be the potential for increased acid mine effects as discussed for the dam alone option, and the elimination of habitat and potential for downstream flooding caused by channelization.
- Greenbelt Corridor - This option would provide an opportunity for Richland Creek to recover from anthropogenic impacts by natural means. Increased shade along the river banks would serve to decrease the temperature and increase dissolved oxygen levels during the warmer season. The most attractive feature of this option is that the negative impacts associated with construction and habitat alteration would not occur, and if water quality improves, a healthy ecosystem could be re-established.
- Non-Structural Measures - Floodplain regulations to discourage development in the flood plain or require construction of flood resistant structures would benefit water quality primarily by decreasing urban runoff.

- No Action - This alternative would allow the existing water quality problems to continue or more likely to increase as urban development continues.

# 2.0 INTRODUCTION

Recognition of the importance of the water environment, including control of its quality and quantity, as well as measures to alleviate damage from flooding, erosion, and siltation is a fairly recent occurrence influenced by a number of aspects. These include public policy, changing concepts in planning and management techniques, continuing urban expansion, and increasing environmental awareness. The objective of this investigation of Richland Creek is to collect and evaluate existing data to assist in the development of alternative strategies for understanding and managing water quality and associated water related programs in the basin. By examining these data, the extent and causes of water quality degradation in Richland Creek can be determined, and mitigative measures can be identified. Background information and technical data concerning the principal physical, hydrologic and developmental characteristics of the Richland Creek Basin are presented in this section.

The Richland Creek Basin is located in southwestern Illinois in the counties of Monroe, Randolph and St. Clair. The basin, having a general north-south alignment, is approximately 28 miles long, 9 miles wide and drains an area of about 243 square miles. Richland Creek flows 38.4 miles in a generally southerly direction to its confluence with the Kaskaskia River at approximately Mile Point 22.0 (see Figure 2-1).

## 2.1 HISTORY OF FLOODING

Periodic flooding is a recurrent theme in historical accounts of the Richland Creek Basin. The history of floods on Richland Creek extends from the early 1900's to the present time with ten major floods recorded between 1908 and 1957.

Floods on Richland Creek have been costly. Major urban damages occur in the five-mile long floodplain area in the city of Belleville. In this location, the floodplain is occupied by residential, commercial, and municipal structures. Average annual flood damages within the city are estimated at $371,000, while flood damages in agricultural areas below Belleville average about $100,000 (Southwestern Illinois Metropolitan and Regional Planning Commission (SIMRPC), 1976).

Although Richland Creek has experienced several major floods, the flood of 15 June 1957 is considered to be the most severe, with the highest flood level since 1874. The 1957 flood resulted in the loss of three lives and damages of approximately $2.7 million. In the Belleville area, most damages occurred in the

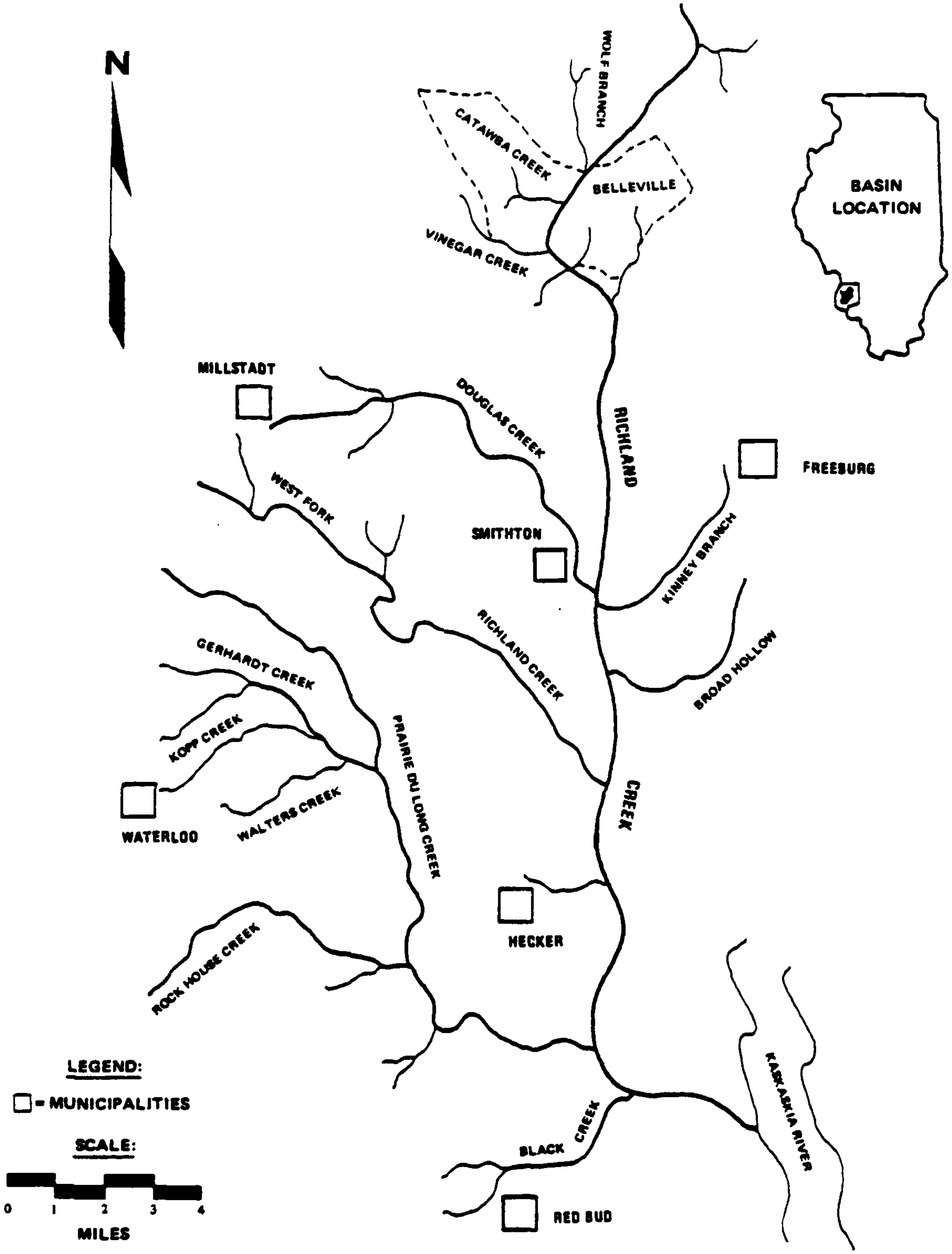

FIGURE 2-1 RICHLAND CREEK BASIN

floodplain and involved 254 residential dwellings, 51 business properties, numerous municipal streets and utility lines, the sewage treatment plant and approximately 75 vehicles.

Current population and development projections indicate that the northern (upstream) portion of the Richland Creek Basin, the Belleville-Swansea-O'Fallon area, will continue to experience the pressures and problems associated with urbanization. Increased urbanization in this area, much of which is occurring in the headwaters of Richland Creek, can be expected to increase the amount and velocity of stormwater runoff which must be accomodated in downstream areas.

## 2.2 FLOOD CONTROL ACTIVITIES

Efforts to control overbank flooding along Richland Creek and to provide drainage in agricultural areas began in the early 1900's with the formation of local drainage districts. Since that time, several studies and projects concerning flooding and drainage problems within the basin have been initiated by both local and federal agencies. The major planning and implementation efforts of these agencies are discussed below.

### 2.2.1 Local Efforts

Organized local efforts to control overbank flooding and to provide drainage within the Richland Creek Planning Basin began with the formation and subsequent activities of several single-purpose districts:

- Richland Creek Drainage District #1
- Richland Creek Drainage District #2 of Smithton Township
- Richland Creek Drainage District #3 of Prairie du Long Township
- Richland Creek Drainage District #4 of Prairie du Long Township

The four districts, which collectively contain approximately 7,355 acres along the main stem of Richland Creek, were organized about 1912 for the purpose of straightening and improving the main channel of Richland Creek from the southern corporate limits of Belleville to Illinois Route 156, about 13 miles downstream. Today only one of these districts, Richland Creek Mutual Drainage District #3 of Prairie du Long Township, maintains an active status. The district's most recent activity involved the removal of logs and debris from the channel about two years ago.

The St. Clair County Soil and Water Conservation District (SWCD), through a variety of functions relating to soil and water conservation and the control and prevention of floodwater and sediment damages, has been active in the Richland Creek area for many years. Since 1957, the SWCD has applied for and acted as one of the local sponsoring organizations for two P.L. 566 Watershed Programs in the basin. Since these programs are administered, funded, and accomplished by the U.S. Department of Agriculture through the Soil Conservation Service, they will be discussed in the section concerning federal agency activities.

In addition to the special-purpose agencies discussed above, local responsibility in storm drainage and flood damage abatement within the basin lies with local units of government. The responsibility of these local entities, for the most part, involves solving localized flooding problems through the provision of secondary drainage system facilities, i.e., those drainage facilities which collect and convey stormwater runoff from municipalities, unincorporated areas, and county and township roads to the major drainage system. In the Richland Creek Basin, however, the communities of Belleville and Swansea have suffered damages from overbank flooding of Richland Creek and have subsequently been involved in major drainage system activities.

The city of Belleville has long been interested in installing improvements to reduce the frequency and extent of Richland Creek floods and the resultant damage to urban property within its corporate limits. An initial study of the flooding problem was made following the August 1946 flood by the consulting engineer firm of Alvord, Burdick, and Howson. A report of these findings prompted passage of a city bond issue to finance the enlargement of highway and street bridges over Richland Creek.

Since the flood of 1957, the city has spent more than $200,000 improving the capacity of the main channel of Richland Creek within its corporate boundaries. This work was accomplished during the 1960's by channel dredging, desedimentation of box culverts to as-built conditions, and removal of old railroad abutments. Belleville has also taken an active part in providing local assurances for federal flood control studies in the Richland Creek Basin.

### 2.2.2 Federal Efforts

Flood control activities of the federal government in the Southwestern Illinois Region have historically been accomplished through the Soil Conservation Service and the U.S. Army Corps of Engineers. Although there are no federal projects either authorized or constructed in the Richland Creek Basin at the present time, both agencies have been active in basin study and planning activities in the past.

### 2.2.2.1 Soil Conservation Service

Two P.L. 566 watershed projects have been initiated in the Richland Creek Basin since 1957: the Richland Creek Watershed Project and the West Fork Richland Creek Watershed Project. The activities and status of these projects are discussed below.

The Richland Creek Watershed Project, which covers the 28,270-acre upstream portion of the Richland Creek Basin, was approved for planning in June 1958. The work plan was completed in April 1966 but, due to lack of local interest, the project was terminated in October 1971. Sponsors for the project were the St. Clair County Soil and Water Conservation District and the City of Belleville. Principal problems included flood damages to residential, business, and municipal property in the City of Belleville; and inadequate recreational facilities for the Belleville area. Average annual flood damages were estimated (1966) to be $348,800. Estimated total cost of the project was $1,120,002 ($542,918 Federal and $577,084 non-Federal).

Planned structural measures consisted of one multi-purpose (flood prevention-recreation) reservoir, basic recreation facilities, and one flood control reservoir. Installation of these structures in conjunction with channel improvements proposed by the Corps of Engineers would reduce average annual flood damages in the city of Belleville by 99.6 percent. Based on 1966 conditions, average annual benefits resulting from the installation of P.L. 566 structures were estimated to be $198,810. Average annual costs were $58,990; the ratio of benefits to costs was 3.4:1.0 (SIMRPC, 1976).

The West Fork Richland Creek Watershed Project, which includes 17,000 acres, is located seven miles southwest of the Belleville area near the Village of Millstadt. P.L. 566 assistance in this watershed was applied for in April 1967 and was approved by the Governor in September 1967. Sponsors for the project included the St. Clair County Soil and Water Conservation District, the Village of Millstadt, and Millstadt Township. Principal problems, as stated in the application, included flood damages to crops, roads, and bridge structures; serious erosion; need for additional water supply; and lack of adequate recreational facilities. Annual flood damages to cropland were estimated to average $21,000.

In a preliminary investigation completed in June 1970, the Soil Conservation Service evaluated a multiple-purpose floodwater retarding and municipal water supply lake near Millstadt. Estimated total cost of the reservoir was $450,000 ($125,000 Federal, $325,000 non-Federal). SCS engineers and economists estimated flood damages would be reduced approximately

50 percent with installation of the dam, a benefit of $11 per acre per year. Local flood control costs of $60,000 would be about $60 per acre benefitted. This project was terminated in June 1975 at the request of the local sponsors.

### 2.2.2.2 Corps of Engineers

Pursuant to resolutions adopted by the Committee on Public Works of the United States Senate, September 16, 1948 and July 18, 1957, and the resolution adopted by the House of Representatives, 20 August 1957, the St. Louis District, Corps of Engineers was assigned the preparation of a report to determine the advisability of providing improvements on Richland Creek in the interest of flood control and related purposes.

As a result of the Corps study, the District Engineer determined that the plan of improvement which would afford the greatest overall benefit to the Richland Creek Basin would consist of: (1) two headwater detention reservoirs, proposed by the Soil Conservation Service; and (2) urban channel improvements of maximum capacity consistent with space limitations through Belleville, including necessary bridge modification; and clearing, cleaning, and rectification of the existing channel some 20 miles below the City of Belleville by the Corps of Engineers.

The project was authorized for construction by the Flood Control Act of 1962. After completion of initial preconstruction planning activities, however, the project was placed on the inactive list because local interests could not provide the necessary local assurances. Furthermore, because local interests were unable to provide local assurances within the time required by the 1962 authorizing Act, the project was automatically deauthorized on 30 September 1974.

## 2.3 BASIN DESCRIPTION AND DEVELOPMENT CHARACTERISTICS

### 2.3.1 Basin Demographic and Urban Land-Use Characteristics Affecting Water Quality

The Richland Creek Basin can be characterized as an urbanizing portion of the St. Louis metropolitan area. Of the basin's 238 square-mile area, approximately 13.74 square miles (5.7 percent) is classified as urbanized. Existing urban development is heavily concentrated in the upper portions of the basin. The northern communities of Belleville, Swansea, O'Fallon, and Shiloh represent the basin's major urban concentration.

This area will probably continue to be urbanized at a fairly constant rate. The economy of the area is dependent on a large number of firms and installations within the region, providing attractive employment opportunities as well as requisite housing and service needs. Commuting to work in more highly urbanized centers of southwestern Illinois and the St. Louis area is also characteristic of numerous basin residents. Present and planned transportation projects will continue to encourage this situation.

The Richland Creek Basin is recognized as a major development area within the St. Louis metropolitan area. Growth trends in selected parts of the area are strong and several recently announced major projects could significantly increase the rate of urbanization and growth occurring in the study area. The primary zone of development is located along the northern edge of the basin and can be conceptualized as a portion of the urbanizing front of the metropolitan area.

Development is occurring at an accelerated pace in the St. Clair County portion of the area in the vicinity of Fairview Heights and O'Fallon. This growth has occurred largely in response to three major factors: commercial development at Fairview Heights located immediately north of the basin, construction of Interstate 64, and growth of Scott Air Force Base. In addition, construction of a major coal gassification plant at New Athens will likely have a significant economic impact on the Richland Creek Basin although the facility will be located a few miles east of the study area.

In the Monroe and southern St. Clair County portion of the study area, there are two potential projects that could greatly accelerate economic development in this portion of the basin. The greatest potential economic impact in the area would result if the St. Louis Metropolitan Airport is built at a site northeast of Waterloo. All sections of the economy except the agricultural sector are expected to benefit greatly from this development. For example, a recent environmental impact study projected a total of more than 13,000 employees at the airport by 1990. This employment probably reflects only a small fraction of the overall economic development that would be generated by the airport project. The project will directly diminish the agricultural sector by the loss of up to 20,000 acres of predominantly agricultural land at the airport site.

Accompanying the Richland Creek Basin's increased urbanization is a corresponding increase in population. Based on the 1970 census, the population of the Richland Creek Basin has been estimated to be approximately 72,000, with the majority of individuals, approximately 59,000, residing in the highly urbanized northern portion. The communities of Belleville, Swansea, O'Fallon, and Shiloh represent the largest concentration of people in this area. The City of Belleville and its environs has the largest population in the basin, being the center for county governmental activities and the second largest city in St. Clair County. Belleville and Swansea are the only communities vulnerable to damages from overbank flooding of Richland Creek. All other communities are situated at elevations well above flood-damaging stage.

Population projections for Belleville and the adjacent community of Swansea (Table 2-1) indicate that the northern portion of the basin will continue to represent the focal point of the area's urbanization. Between 1970 and 2000, the populations of Belleville and Swansea are expected to increase by 40 and 71 percent, respectively.

Significant increases are also projected in county populations, including St. Clair County, which comprises a large portion of the study area. Table 2-2 presents these projected changes.

Continuing population growth coupled with increasing urbanization in the northern portion of the Richland Creek Basin has the potential to affect Richland Creek water quality in a number of ways. The three factors that will probably exert the greatest influence are increased urban runoff, increased use of landfills and open dumps, and an increase in the amount of wastewater generated by greater numbers of people. These aspects of increased pollution potential are discussed below.

### 2.3.1.1 Urban Runoff

The impact of stormwater runoff on water quality depends on physical, chemical, and biological characteristics associated with the particular waterway receiving the runoff as well as the quality and quantity of runoff it receives.

Most polluting materials introduced through urban runoff are generated from street surface contaminants (e.g., pavement wear, dirt, grease and oil from motor vehicles, etc.) and accumulated litter and discarded trash. Although the effects of these materials on water quality vary, a number of impacts are common to almost all instances.

High suspended sediment levels which may be present in urban runoff, especially near construction sites, pose potential sedimentation and turbidity impacts on receiving waters. Runoff which discharges into and mixes with still or slowly flowing receiving waters loses velocity and the capacity

Table 2-1. POPULATION CHARACTERISTICS FOR SELECTED COMMUNITIES, TOWNSHIPS, AND COUNTIES IN THE BASIN

| | 1970 Population | 2000 Population | Population Percent Change |
|---|---|---|---|
| Belleville | 41,699 | 59,400 | 40 |
| Swansea | 5,432 | 7,600 | 71 |
| Waterloo | 4,546 | 7,250 | 59 |

SOURCE: U.S. Department of Commerce, Bureau of the Census, U.S. Census of Population, 1970; Southwestern Illinois Metropolitan and Regional Planning Commission (SIMRPC), 1976.

Table 2-2. COUNTY POPULATION TRENDS AND PROJECTIONS

| | 1960 | 1970 | 1980 | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|
| Madison | 224,689 | 250,911 | 251,606 | 251,286 | 258,823 | 273,835 | 277,098 |
| St. Clair | 262,509 | 285,309 | 286,571 | 286,876 | 293,968 | 297,117 | 200,794 |
| Monroe | 15,507 | 18,831 | 20,885 | 21,386 | 21,503 | 22,970 | 24,002 |
| TOTAL AREA | 502,705 | 555,051 | 559,062 | 559,548 | 574,294 | 593,922 | 601,894 |

SOURCE: SIMRPC, 1980.

to transport suspended sediment. This results in deposition of a portion of the sediment in and downstream of the discharge area. With successive storms, sediment build-up can smother and destroy the benthic fauna or flora in the deposition area. If runoff discharges into and mixes with receiving waters of similar or greater velocity, sediment can remain suspended for greater distances and will not build up in the discharge area, resulting in gradual sedimentation over a longer reach of the waterway.

Suspended materials can also be produced in the receiving water body by bottom scouring effects at the point of runoff discharge. This sediment will be redeposited elsewhere in the receiving water body, especially if it is still or of low velocity, with the resultant impacts mentioned above. Bottom scouring destroys bottom fauna and flora in the discharge area and is a recurring event. The scoured area, deeper than the surrounding bottom, will act as a sump in which organic and inorganic debris collects between storm events. Decaying debris will negatively impact water quality due to increased biochemical oxygen demand (BOD) and decreased dissolved oxygen (DO) levels.

Increased turbidity created by suspended sediment and other materials causes a decrease in DO levels in the water column, negatively impacts phytoplankton, fish, and other aquatic life in the basin, and inhibits photosynthetic activity in the receiving waters. Fish spawning and nursery activities are especially harmed by increased turbidity and suspended sediment. As discussed later, high turbidity levels presently occur in Richland Creek during storms due to suspended sediment in runoff from downstream agricultural areas.

Urban runoff is usually characterized by high DO levels which may initially improve the quality of receiving waters, particularly if they are highly polluted. However, suspended organic debris in runoff may be deposited onto the bottom of the receiving water body, particularly if it is still or slow-flowing. This debris, which causes an increase in BOD and a decrease in DO in the water column as it decays, negatively impacts aquatic fauna and flora.

High nutrient levels which may occur in runoff generally degrade water quality and encourage excessive growth of algae and other aquatic plants. This excessive growth, which is prevalent in areas that are not well flushed, negatively impacts aquatic fauna by creating high BOD levels and decreased DO levels upon death and decay of the plants.

Heavy metals, pesticides, high levels of oil and grease, and other toxic pollutants also occur in urban runoff. These substances, if present in significant concentrations, impose long-term adverse impacts to water quality. For example, deicing compounds used in snow removal present a large scale source of chlorides and other materials. Other pollution substances have natural origins (leaf decay, animal wastes, etc.) as well as human activity sources (street litter, fertilizer, etc.).

### 2.3.1.2 Landfills and Open Dumps

In addition to urban runoff, urban centers (as well as rural communities) negatively impact water quality through production of solid wastes. After disposal, water contacting these wastes can be polluted by contact with surface waters (runoff) or by leaching through the disposal area.

There are six land disposal facilities in the Richland Creek Basin (see Figure 2-2 and Table 2-3). These facilities are all classed as sanitary landfills by the Illinois Environmental Protection Agency (IEPA), indicating that the facilities meet the requirements of the IEPA and have a state permit to operate. These requirements are based on keeping wastes covered and attempting to minimize runoff from the landfills. According to the Southwestern Illinois Metropolitan and Regional Planning Commission (1978), there are no known open dumps in the Richland Creek Basin. Two of the landfills, Belleville/Wagner and Belleville/Municipal, monitor for ground water pollution, which could occur primarily through leachate.

Leachate is contaminated water which is produced by ground water or infiltrating surface water moving through solid waste in a landfill. Leachate may leave the landfill as a spring at the ground surface or percolate through the soil into the ground water. Depending upon the form of the actual discharge, leachate and surface runoff can be either a point source of pollution or a non-point source. The polluting characteristics of leachate and runoff are primarily a function of the waste composition, the amount of infiltrating water, and its quality, particularly pH. Leachate, and to a lesser extent surface runoff, commonly contain high concentrations of heavy metals, other inorganics, organics, and biological contaminants, including microbial waste products.

The impacts of leachate and runoff are cumulative and long-term and involve both existing and closed landfills. It can take over a year for a landfill to reach field capacity and produce leachate, however, once started, the landfill will continue to produce leachate for several more years. Surface runoff is generally an immediate problem, but can be controlled by covering and revegetating waste areas on collection and treatment.

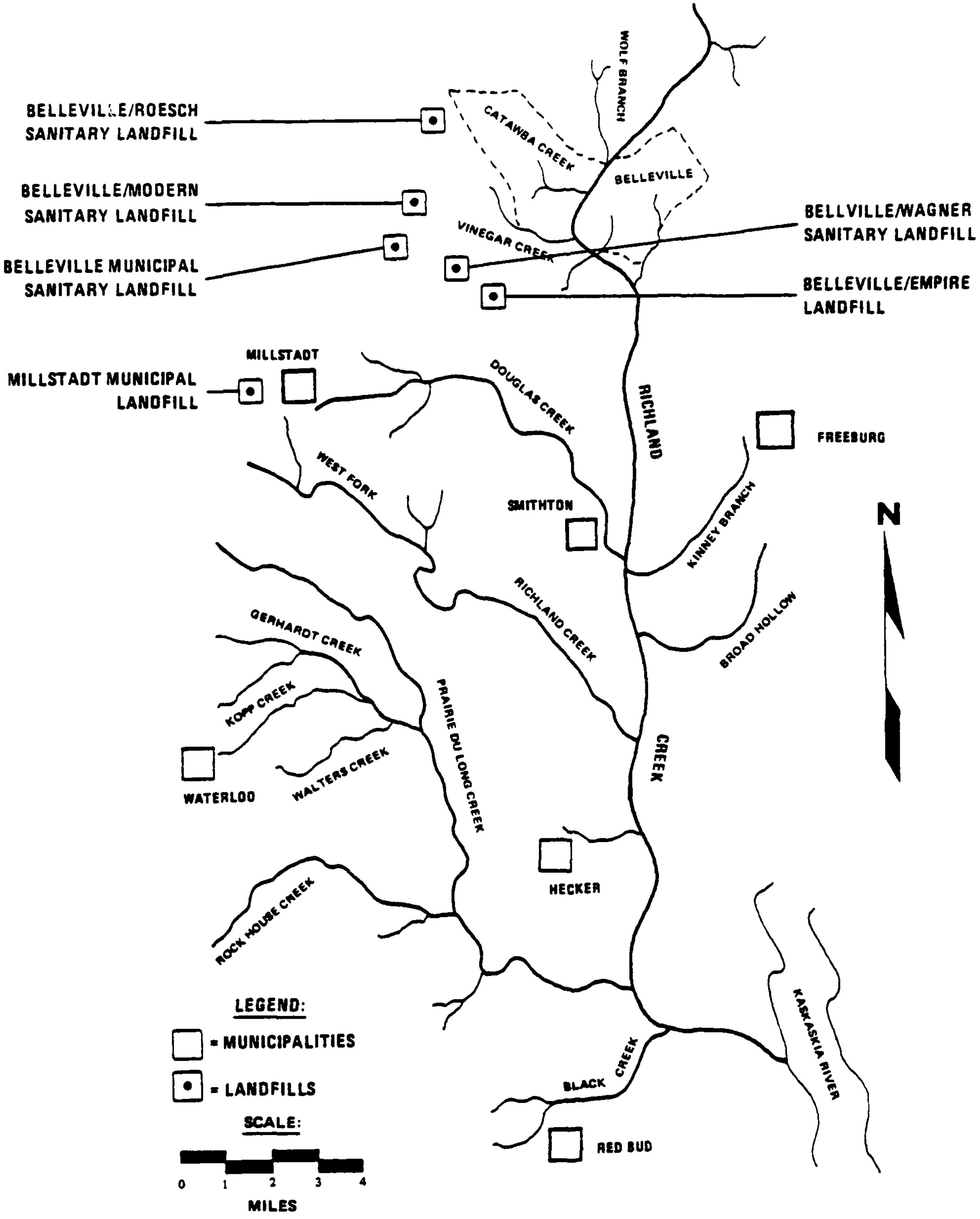

FIGURE 2-2 LANDFILL LOCATIONS – RICHLAND CREEK BASIN

Table 2-3. LANDFILLS IN THE RICHLAND CREEK BASIN

| Landfill | Area (acres) | Estimated Life | Physical Characteristics |
|---|---|---|---|
| Belleville/Roesch | 1 | 1981 | Hillside |
| Belleville/Modern | 100 | 1997 | Strip Mine |
| Belleville Municipal | 37 | 1959 | Level |
| Belleville Wagner | 70 | 1979 | Strip Mine |
| Belleville/Empire | Unknown | Unknown | Unknown |
| Mellstadt Municipal | 23 | 1969 | Level |

SOURCE: SIMRPC, 1978d.

Many of the chemical constituents of leachate are common to all municipal landfills. Other components, such as certain heavy metals (Cr, Ni, Cd) or synthetic organic compounds (pesticides, solvents, PCBs , etc.) are usually contributed by wastes specific to a site. Inorganic contaminants associated with leachate include the anions chloride, sulfate, bicarbonate, and phosphate. Common cations are sodium, potassium, calcium, magnesium, iron, manganese, and ammonia. The cations are subject to attenuation by cation exchange reactions on adsorptive surfaces. Except for phosphate, the anions are not appreciably affected by sorption reactions. Inorganic contaminants which are generally considered toxic to varying degrees include heavy metals, boron, selenium, arsenic, and nitrate. The three latter elements occur as anions, which are only slightly affected by sorption processes. Heavy metals, however, are effectively sorbed to clays and other soil materials.

Organic constituents are the end products of the decomposition (usually anaerobic) of the organic wastes disposed of in the landfill. If water-soluble organic matter has been deposited, it may be present in an unaltered form. Attenuation of the organics occurs from adsorption and microbial degradation in the zone of aeration. While little is known on the toxicity of the organics, they are considered undesirable based on the odor typically associated with leachate.

The fact that several of the landfills in the basin are located in abandoned mines indicates that much of the leachate draining through these landfills could be acidic. This would tend to increase the solubility of many heavy metals and some organic contaminants, and could be a significant long-term source of pollution to both ground and surface water. Increased population, and concomitant increases in solid waste production, could accentuate this problem in the future.

### 2.3.1.3 Sewage Treatment Plant Discharges and Other Point Sources of Pollution

With increases in population projected for the Richland Creek Basin, additional demands will be placed on existing wastewater treatment facilities in the area. A list of the facilities that discharge into Richland Creek is presented in Table 2-4. The locations of these facilities are given in Figure 2-3.

Population growth in the basin will most likely result in increased quantities of treated or partially treated wastewater entering Richland Creek. The adverse effects of these discharges will depend largely on the quantity of discharged material and the treatment process that it has undergone.

Table 2-4. POINT SOURCES IN RICHLAND CREEK

| Facility | Average Discharge | Treatment Process |
|---|---|---|
| Arapahoe Village | 0.025 MGD | 3-cell aerated lagoon |
| Augustine's Restaurant | 0.040 MGD | Extended aeration package plant |
| Millstadt | 0.170 MGD | Contact stabilization unit, filtration + 1 cell lagoon |
| Tamarack Country Club | 0.007 MGD | Aeration, polishing pond disinfection |
| Smithton | 0.008 MGD | 2-cell lagoon and filter disinfection |
| Swansea | 0.5 MGD | Activated sludge, followed by polishing lagoon, design flow .65 MGD |
| Freeburg West | 0.3 MGD | 2 contact stabilization plants 2- .2 MGD cont. stab. in parallel filtration, disinfection. Old plant retained for storm retention .4 MGD |
| Belleville #1 | 6.0 MGD | Krause activated sludge anaerobic digester, sand filtration, disinfection, design flow - 10.4 MGD |
| Belleville #3 | 0.075 MGD | Contact stabilization disinfection, design flow 0.4 MGD |
| Combined Sewers | | |

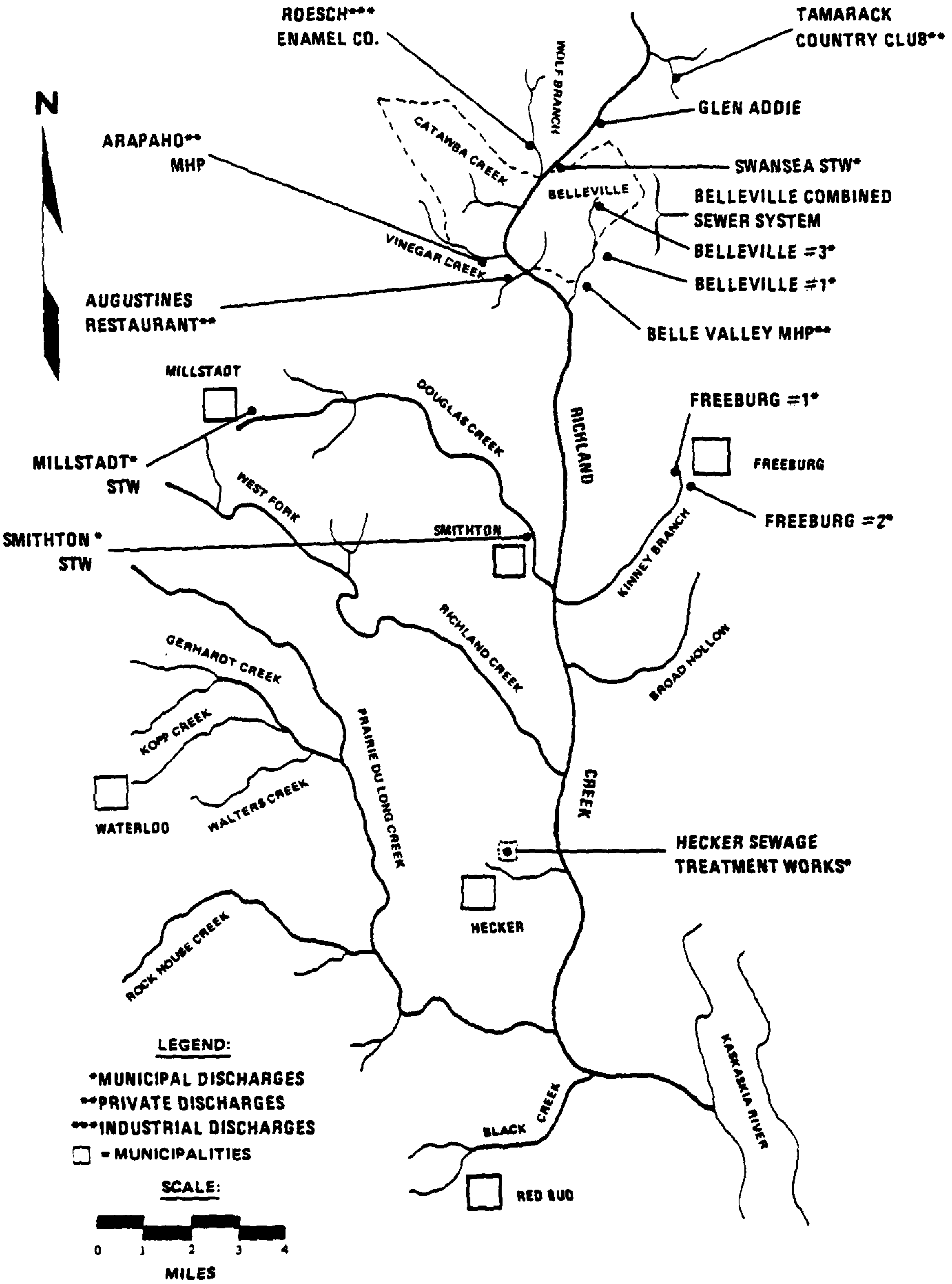

FIGURE 2-3 POINT SOURCE DISCHARGES—RICHLAND CREEK BASIN

A general characterization of affected water quality parameters is presented below as well as impacts common to each parameter.

Increases in soluble organics can result in dissolved oxygen depletion, depending on the assimilative capacity of the waterway, both at the discharge source and downstream areas. Some soluble organics, such as phenols, can impart undesirable tastes and odors to receiving waters. Nutrients, particularly nitrogen and phosphorus, may be increased above ambient levels causing enhanced eutrophication of downstream areas and potentially affecting recreational usage. Color and turbidity are often affected, resulting in undesirable aesthetic effects. Increases in suspended solids often result in the formation of "sludge banks" when concentrations of these materials reach excessive amounts. These formations frequently destroy productive benthic areas and often generate undesirable gases in sediment materials. Combined stormwater systems often discharge significant amounts of floating material, debris, oil, and grease directly into the waterway during and following significant rainfall events. This occurs in both Belleville and Swansea. In general, increased waste loads generated from increased urbanization have detrimental effects on receiving body water quality.

### 2.3.2 Basin Geological and Rural Land Use Characteristics Affecting Water Quality

In any given area, the uppermost geologic strata is of most importance to surface water quality. In the Richland Creek Basin, the soils are almost entirely of glacial origin. To a large extent, the soil type, topographic patterns, and underlying geologic formations dictate land uses in the Richland Creek Basin.

#### 2.3.2.1 Mining Activities

There are five minerals that presently are or have the potential to be mined in the counties of St. Clair, Madison, and Monroe. These are sand and gravel, stone, crude oil, coal, and clay. Of these, the most important, as measured by past value produced and known reserves, is coal. Currently, none of the coal mines in the basin are being worked, but ample coal reserves remain in the St. Clair County portion of the basin and mining operations may be resumed in the future. The coal found in the region is of the bituminous variety and underlies the majority of the basin. The line depicting the western limit of the region's major coal seam, Herrin No. 6, is shown in Figure 2-4. This figure also shows the location of mining areas that have been depleted through past operations.

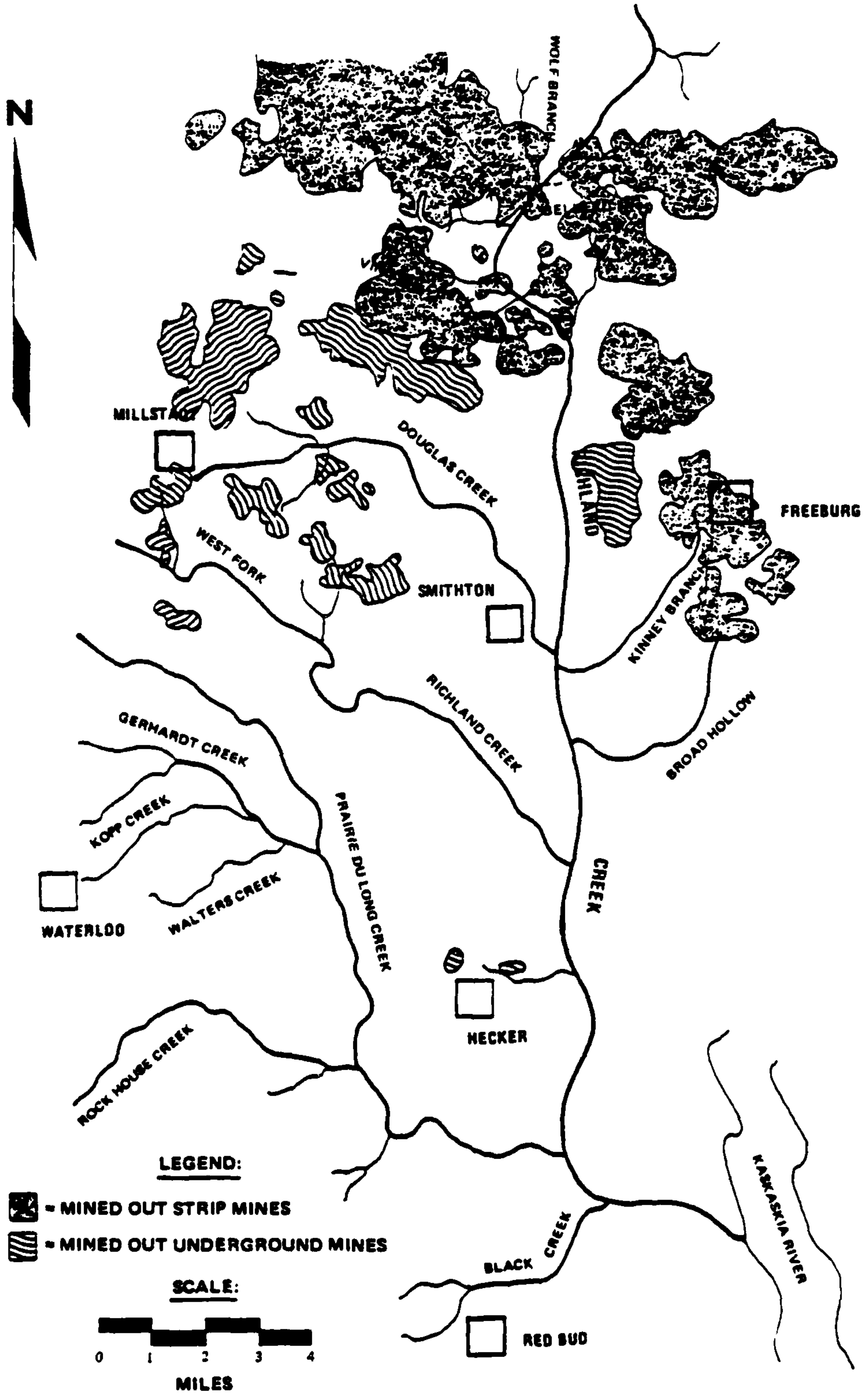

FIGURE 2-4 COAL MINING CHARACTERISTICS OF THE RICHLAND CREEK BASIN. SOURCE: SIMRPC, 1978d.

The fact that significant amounts of coal have been extracted from the study area indicates that these past activities have the potential to impact on the basin's water quality. The most serious pollutant arising from mining activities is mine drainage generated by oxidation of pyritic metals with air in the presence of water. This drainage is an acidic mixture of iron salts, other salts and sulfuric acid.

Mine drainage arises from both underground and surface mining sources, and from coal and many metal mining operations. Coal deposits and so-called hard rock mineral deposits are commonly associated with pyrite and marcasite, which are disulfides of iron. Acid mine drainage can find its way into surface waters, where the acid and sulfate may result in severe deterioration in stream quality. The acid can react with clays to yield aluminum concentrations sufficient for fish kills, and with limestone to yield very hard waters, which are expensive to soften. The acid can also selectively extract heavy metals present in trace quantities in mineral and soil formations, resulting in toxic conditions in lakes and streams.

Many chemical reactions produce acid mine drainage. The most important, however, are those involving the oxidation of pyrite. Mine drainage from pyrite oxidation is generally shown as occurring in three steps: (1) oxidation of pyrite to ferrous sulfate and sulfuric acid; (2) oxidation of ferrous sulfate to ferric sulfate; and (3) hydrolysis of ferric sulfate. The oxidation of pyrite to ferrous sulfate and sulfuric acid (step 1) is rapid if the pyrite is exposed to moist air. Moisture condensation, flooding, and natural drainage processes flush the ferrous sulfate-acid mixtures into watercourses, where dissolved oxygen in the water will slowly oxidize the ferrous iron to ferric iron (step 2). This oxidation may be catalyzed by other metals (i.e., manganese, copper, and aluminum), or by bacteria (Ferrobacillus ferroxidans). Finally, as the ferric sulfate is diluted by a receiving stream, it is hydrolyzed to form colloidal ferric hydroxide (so-called yellowboy) and sulfuric acid (step 3). This condition was noted during May 1980 in the headwater areas of Richland Creek.

Mining refuse (waste materials left at or near mining sites) is another source of water quality contamination in the study area. Much of this refuse frequently contains pyrite material which can be oxidized to acidic substances. The resultant acid water may remain in the pile until a rainstorm, at which time it is flushed into nearby watercourses. Mine drainage "slugs" during storms are very detrimental to surface water quality.

Mining operations also generate wastes, commonly called spoil, in the form of disturbed rock and soil. If this spoil is left in piles, erosion and runoff will carry sediment into streams, adversely affecting water quality and aquatic life. Similarly, waste pyritic materials in gob piles, spoil banks, or tailings ponds will react with air and water to produce mine drainage. Moreover, after a particular mining operation is abandoned, mine drainage will continue to be generated unless disturbed land is effectively reclaimed and underground shafts and tunnels are properly shut down.

Since surface mining of coal creates large areas of disturbed land, it can also cause sedimentation. This distrubed land is highly erodible and can contribute large quantities of sediment to surface waters if the land is not properly reclaimed after mining or if proper techniques for sediment control are not employed in the mining operation.

Sediment introduced to a water course such as Richland Creek occurs largely after heavy rainfall events. The extent of sedimentation depends on many factors; the most important of which are proximity of the mining operation to the waterway, rainfall intensity and duration, and the composition of the excavated materials.

### 2.3.2.2 Agricultural Activities

Within the Richland Creek Basin area (St. Clair, Monroe and Randolph Counties), approximately 73 percent of the land use is devoted to some form of agricultural production. Table 2-5 presents a breakdown of agricultural land usage. Over 460 farms occupy more than 95,800 acres with each farm having an average area of 210 acres. Agricultural industry in the basin is devoted to both livestock and cash crop production. Livestock production focuses on raising cattle and hogs.

Crops occupy more than 65 percent of farmland in the Richland Creek Basin with pasture and other farm uses comprising the remainder of the agricultural area. The major crops produced in the basin include soybeans (38 percent of cropland), corn (30 percent of cropland), and wheat (26 percent of cropland). Other crops, including alfalfa, hay, and oats account for the remaining 6 percent. More specific crop statistics are presented in Table 2-6.

The agricultural industry in the Richland Creek Basin directly supports approximately 1,450 persons living on farms and indirectly supports an estimated dependent population of about 1,100. As a basic industry, agriculture creates indirect employment opportunity in a wide variety of service-related

Table 2-5. AGRICULTURAL LAND UTILIZATION - RICHLAND CREEK BASIN

| Townships | % in Basin | Persons Living on Farms | Land/ Farms (acres) | No. of Farms | Average Sized Farms (acres) | Total Township Land Area (acres) | Farm Land Use | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | % Crops | % Pasture | % Other |
| St. Clair County | | | | | | | | | |
| Caseyville | .10 | 30 | 929 | 10 | 91.09 | 23,040 | 70.7 | 6.1 | 23.2 |
| O'Fallon | .10 | 46 | 1,568 | 13 | 120.63 | 23,040 | 60.3 | 20.3 | 19.4 |
| Shiloh | .10 | 29 | 1,671 | 9 | 192.04 | 21,340 | 72.3 | 6.5 | 21.2 |
| St. Clair | .80 | 118 | 7,651 | 54 | 142.74 | 23,040 | 65.2 | 14.4 | 20.4 |
| Stookey | .25 | 25 | 2,367 | 10 | 242.71 | 19,180 | 63.7 | 14.1 | 22.2 |
| Smithton | 1.00 | 256 | 22,810 | 75 | 304.13 | 23,040 | 76.1 | 9.2 | 14.7 |
| Freeburg | .20 | 78 | 2,938 | 25 | 115.67 | 23,040 | 59.4 | 30.4 | 10.2 |
| Millstadt | .80 | 346 | 19,844 | 114 | 174.68 | 31,040 | 68.5 | 5.7 | 25.8 |
| Prairie du Long | .05 | 18 | 1,171 | 4 | 275.61 | 23,040 | 79.4 | 3.5 | 17.1 |
| TOTAL | | 946 | 60,949 | 314 | 184.36 | 209,800 | 68.4 | 12.2 | 19.4 |
| Monroe County | | | | | | | | | |
| T3S R9W | .60 | 106 | 7,665 | 33 | 232.27 | 23,040 | 59.3 | 8.4 | 32.3 |
| T2S R10W | .20 | 31 | 2,458 | 10 | 250.79 | 23,040 | 61.3 | 12.0 | 26.7 |
| T3S R7-8W | .90 | 144 | 9,012 | 42 | 213.04 | 26,550 | 69.4 | 11.4 | 19.2 |
| T4S R9W | .03 | 6 | 438 | 2 | 231.77 | 27,200 | 57.1 | 21.9 | 21.0 |
| T1 & 2S R9W | .90 | 104 | 8,788 | 32 | 278.97 | 15,150 | 63.6 | 8.0 | 28.4 |
| T1S R10W | .20 | 35 | 2,737 | 9 | 318.27 | 17,640 | 68.3 | 6.9 | 24.3 |
| N 1/2 T3S R10W | .03 | 3 | 182 | 1 | 202.36 | 11,520 | 57.7 | 15.4 | 26.9 |
| TOTAL | | 429 | 31,280 | 129 | 246.78 | 144,140 | 62.4 | 12.0 | 25.6 |
| Randolph County | | | | | | | | | |
| Pt. T4S R8W | .20 | 71 | 3,590 | 20 | 181.33 | 23,040 | 68.9 | 14.5 | 16.6 |
| Total Drainage Basin | | | | | | | | | |
| St. Clair | | 946 | 60,949 | 314 | 1,659.30 | 209,800 | 615.6 | 110.2 | 174.2 |
| Monroe County | | 429 | 31,280 | 129 | 1,727.47 | 144,140 | 436.7 | 84.0 | 179.3 |
| Randolph County | | 71 | 3,590 | 20 | 181.33 | 23,040 | 68.9 | 14.5 | 16.6 |
| TOTAL | | 1,446 | 95,819 | 463 | 209.89 | 376,980 | 65.9 | 12.3 | 21.8 |

SOURCE: Illinois Department of Agriculture, Bureau of Agriculture Statistics, Farm Census, 1974.

Table 2-6. AGRICULTURAL STATISTICS - RICHLAND CREEK BASIN

| Township | Total Harvested Cropland (A.) | % Corn | % Soybeans | % Wheat | % Other Crops |
|---|---|---|---|---|---|
| St. Clair County | | | | | |
| Caseyville | 6,572 | 28.4 | 47.8 | 20.2 | 3.6 |
| O'Fallon | 9,446 | 29.0 | 41.2 | 14.7 | 15.1 |
| Shiloh | 12,083 | 32.5 | 43.4 | 19.3 | 4.8 |
| St. Clair | 6,239 | 29.9 | 41.4 | 24.4 | 4.3 |
| Stookey | 6,031 | 22.0 | 38.5 | 31.8 | 7.7 |
| Smithton | 17,360 | 34.1 | 36.5 | 21.5 | 7.9 |
| Freeburg | 8,716 | 26.8 | 42.8 | 21.2 | 9.2 |
| Millstadt | 16,986 | 26.6 | 35.3 | 27.8 | 10.3 |
| Prairie du Long | 18,602 | 25.4 | 43.1 | 24.5 | 7.0 |
| Monroe County | | | | | |
| T3S R9W | 7,581 | 22.6 | 41.0 | 26.1 | 10.3 |
| T2S R10W | 7,529 | 29.8 | 30.4 | 28.6 | 11.2 |
| T3S R7-8W | 6,950 | 29.1 | 28.8 | 21.4 | 20.7 |
| T4S R9W | 8,335 | 26.6 | 27.8 | 23.8 | 21.8 |
| T1&2S R9W | 6,216 | 27.5 | 30.6 | 29.0 | 12.9 |
| T1S R10&11W | 9,352 | 35.4 | 25.1 | 29.5 | 10.0 |
| N 1/2 T3S R 10W | 3,508 | 26.7 | 36.2 | 27.2 | 9.9 |
| Randolph County | | | | | |
| T4S R8W - Red Bud | 12,370 | 31.9 | 25.7 | 21.7 | 20.7 |

SOURCE: Illinois Department of Agriculture, Bureau of Agriculture Statistics, Annual Farm Census, 1974.

and support industries within the area, such as fertilizer/fuel suppliers, equipment distributors and agricultural product wholesalers.

Agricultural activities significantly influence the quality of Richland Creek. In general, the pollutants resulting from point and non-point agricultural discharges include sediments, salts, nutrients, pesticides, organics and pathogens. Sediment resulting from agricultural soil erosion is one of the most acute problems presently occurring in the Richland Creek Basin. Table 2-7 presents a breakdown of erosion characteristics related to the five major land uses occurring in the Richland Creek Basin. As indicated in this Table, it is clear that cropland and associated pasturage areas are major sources of sedimentation in Richland Creek.

Concurrent with the introduction of suspended materials into this water, other undesirable substances are introduced. Eroded material from agricultural areas frequently contain significant amounts of fertilizers. In general, the composition of fertilizers varies according to crop requirements and soil types, but most contain significant amounts of nitrogen, phosphorus and potassium. The introduction of these substances, even in small amounts, can seriously affect water and sediment quality. Phosphorus, in particular, contributes significantly to undesirable increases in productivity. Livestock wastes, concentrated in feed lot areas, also contribute these substances as well as pathogenic organisms to adjacent waterways.

Pesticides, designed to increase crop yields by exterminating destructive organisms, are often introduced into waterways by agricultural erosion. Although most pesticides are designed to be lethal only to target organisms, introduction into waterways can cause mortality to aquatic organisms. With respect to agricultural areas, the four types of pesticides most frequently employed are insecticides, fungicides, herbicides, and rodenticides.

The threat from pesticides is due to their persistence and toxicity in the aquatic environment. Fish and other food chain organisms accumulate these materials as well as their metaolites or degradation products. This phenomenon of biological accumulation is especially significant with fat-soluble pesticides.

There are three modes of transport of pollutants from agricultural and pasturage areas to water: (1) by runoff to surface water; (2) by infiltration and percolation to subsurface water; and (3) by wind to surface waters.

Table 2-7. SEDIMENTATION DATA FOR RICHLAND CREEK BASIN

| Land Use | Acres | % of Total Area | *Gross Erosion (tons)* Per Acre Per Yr. | *Gross Erosion (tons)* Total | % Sediment Yield to Richland | Soil Erosion In Tons Per Year Per Acre | Soil Erosion In Tons Per Year Total |
|---|---|---|---|---|---|---|---|
| Urban | 8,968.1 | 6 | .2 | 1,438 | 0.1 | .06 | 503 |
| Woodland | 15,191.1 | 10 | 1.0 | 15,046 | 0.7 | .30 | 4,893 |
| Cropland | 120,233.8 | 77 | 16.9 | 2,035,802 | 97,8 | 5.50 | 663,114 |
| Pasture | 7,937.7 | 5 | 3.9 | 31,016 | 1,5 | 1.30 | 10,027 |
| Extraction/ Water | 3,674.5 | 2 | 0.0 | - | 0,0 | - | - |
| TOTAL | 156,006.0 | 100 | 13.3 (Avg.) | 2,083,302 | 100 | 4.30 (Avg.) | 678,537 |

SOURCE: SIMRPC, 1978c, District Conservationists, Soil Conservation Service, St. Clair and Monroe Counties.

Runoff from croplands, animal feedlots and pasture areas is a major mode of transport of pollutants that enter a water resource. Subsurface drainage may also carry quantities of pollutants that are dissolved in water. Surface water carries suspended sediment in large quantities. Many pollutants, such as phosphates and pesticides, are tightly bound to sediments, and are thereby transported to waterway sediments. This mode of introduction can adversely affect water quality. For example, even though phosphorus is held strongly by bottom sediments, the net release of even a small fraction to the water column can stimulate undesirable algal growth.

Groundwater pollution from agricultural activities is usually caused by increased nitrate concentrations from percolation and infiltration. Although these compounds have their origins in many substances associated with cropland activities, leachate from fertilizers and feedlot operations has been shown to be the greatest contributor. Groundwater salinity can also be increased through crop irrigation and return to the water table.

Wind erosion in agricultural areas is also responsible for the introduction of significant amounts of sediment to nearby waterways and resultant water pollution. The movement of soil by wind action takes place through three mechanisms: (1) saltation; (2) surface creep; and (3) atmospheric suspension. Saltation denotes the bouncing movement of particles within a layer close to the ground surface. Surface creep is induced by the impact of particles descending from saltation. Atmospheric suspension is the process by which fine soil particles are lifted into the turbulent airstreams and may be carried long distances.

The three major factors controlling wind erosion are the characteristics of the wind, the soil, and the soil surface. The proportion of soil moved by wind varies widely for different soils. Coarsely granulated soils erode by saltation and surface creep; finely pulverized soils, by saltation and atmospheric suspension. Ninety percent of the soil moved by wind is through saltation or surface creep processes; the balance occurring through atmospheric suspension.

Cumulatively, the influences of agricultural and mining activities, as well as demographic and urban land-use characteristics in the basin, have a severe impact on water quality in Richland Creek. The results of water quality testing at sites in the basin are given in the following section.

# 3.0 WATER QUALITY RESULTS

In order to determine existing water quality conditions in Richland Creek, a series of physicochemical and biological measurements were made at six sites. The locations of these sites are shown in Figure 3-1 and descriptions are provided in Table 3-1. Grab samples were taken at midstream and mid-depth at each site on the following dates: 26 March 1980, 9 April 1980, 23 April 1980, and 7 May 1980. Weather conditions ranged from clear to intermittent rain. Flows were generally low except on 9 April 1980, when they were moderate.

The samples were analyzed for thirty-one physicochemical parameters. A complete list of physicochemical parameters is presented in Table 3-2. Methods used for sampling, preserving, and analyzing for these parameters were in accordance with those specified in "Standard Methods for the Examination of Water and Wastewater" (Am. Pub. Health Assoc., 1976), and "Methods for the Chemical Analysis of Water and Wastewater", (EPA, 1979a). Specifications on the analytical procedures used are provided in Appendix A.

Biological examination of Richland Creek included analysis of fecal coliforms and fecal streptococci concentrations, as well as evaluation of macroinvertebrate community structure. Sampling for macroinvertebrates was conducted twice at each site: 9 April 1980, and 7 May 1980. Procedures used for biological analysis are included in Appendix A.

The means and ranges of the values observed for each physicochemical and microbiological parameter at each site are listed in Tables 3-3 through 3-7. Individual values for each sampling visit are provided in Appendix B. The number of individuals of each of the macroinvertebrate taxa, their tolerance status, and the macroinvertebrate community index (MCI) (Hite and King, 1974) for each site are listed in Table 3-8. The results listed in Tables 3-3 through 3-8 are interpreted in Section 4, relative to existing stream conditions, identification of existing and potential water quality problems, and flood control alternatives.

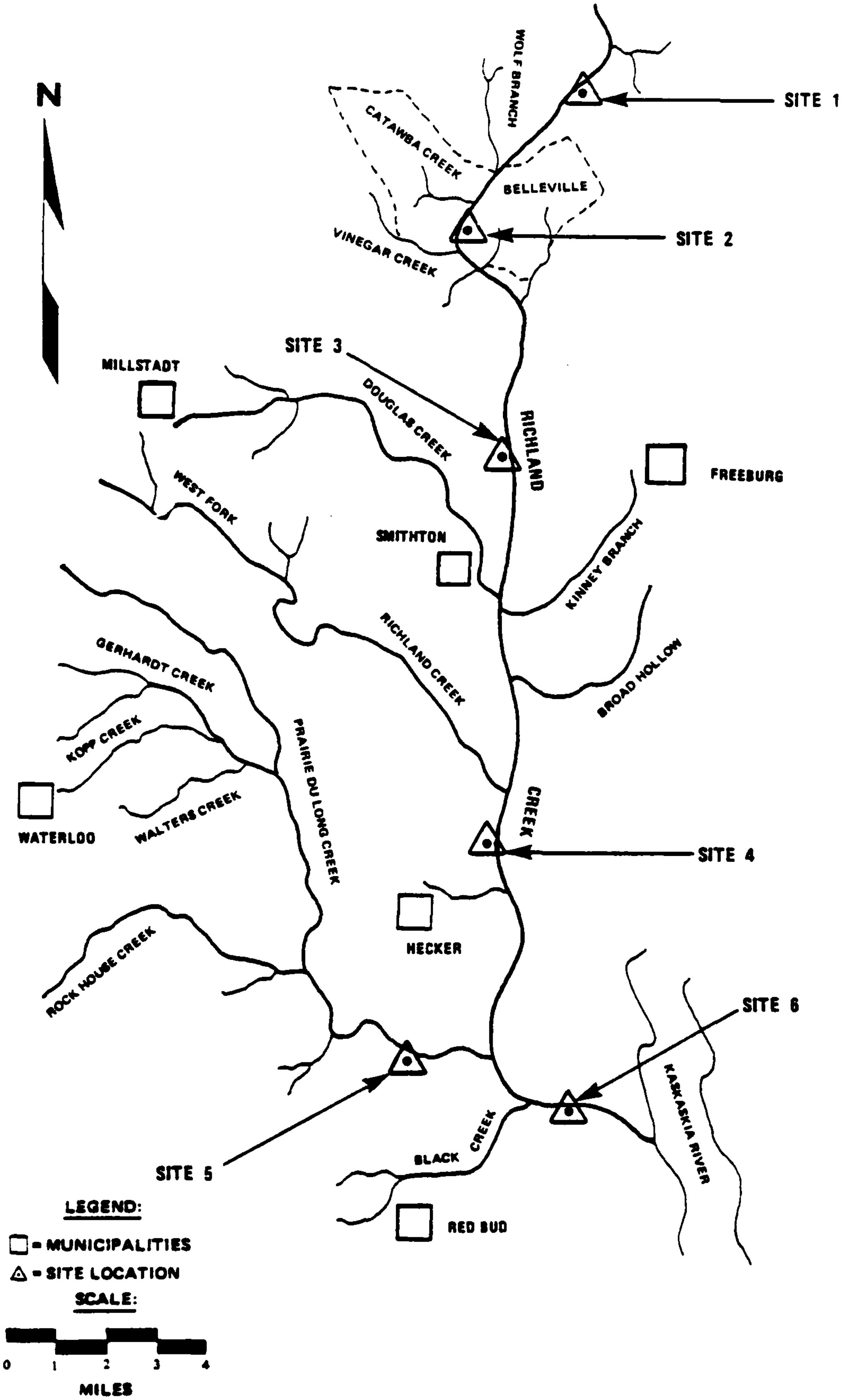

FIGURE 3-1 LOCATION OF SAMPLING SITES – RICHLAND CREEK BASIN

Table 3-1. DESCRIPTIONS OF SAMPLING SITE LOCATIONS

| Site | |
|---|---|
| 1 | Richland Creek at Old Collinsville Road TlN, R8W, NE 1/4 Section 15 St. Clair County, Illinois. |
| 2 | Richland Creek at Highway 159 (South end Belleville), St. Clair County, Illinois, TlN, R8W, SE 1/4 Section 28. |
| 3 | Richland Creek at Highway J-19, 5.7 miles downstream from Belleville STP#1, St. Clair County, Illinois, T2S, R8W, SE 1/4 Section 22. |
| 4 | Richland Creek at Highway 156, NE of Hecker, St. Clair County, Illinois, T2S, R8W, NW 1/4, Section 2, upstream of bridge. |
| 5 | Praire du Long Creek, south of Hecker, St. Clair County, Illinois, T3S, R8W, NW 1/4, Section 21, Praire Du Long Township, 3.7 miles south of Hecker at Route 159. |
| 6 | Richland Creek, NE of Red Bud, Illinois, Monroe County, T3S, R8W, SW 1/4, Section 23. |

## Table 3-2. PHYSICOCHEMICAL PARAMETERS

### Physical Parameters

Air Temperature
Water Temperature
Flow
Specific Conductance
Turbidity

### Synoptic Parameters

pH
Total Alkalinity
Carbon Dioxide ($CO_2$)
Dissolved Oxygen (DO)
Chemical Oxygen Demand (COD)
Total Hardness

### Solids and Major Anions

Total Dissolved Solids (TDS)
Total Suspended Solids (TSS)
Volatile Suspended Solids (VSS)
Chloride (Cl)
Sulfate ($SO_4$)

### Nutrients

Nitrate-N ($NO_3$)
Nitrite-N ($NO_2$)
Ammonia-N ($NH_3$)
Total Kjeldahl Nitrogen (TKN)
Ortho Phosphate ($PO_4$)
Total Phosphorus (TP)

### PCBs and Metals

Polychlorinated Biphenyls (PCBs)
Arsenic (As)
Cadmium (Cd)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Zinc (Zn)

## Table 3-3. PHYSICAL PARAMETERS

| Site | | Air Temperature (°C) | Water Temperature (°C) | Flow (cfs) | Specific Conductance (µmhos) | Turbidity (JTU) |
|---|---|---|---|---|---|---|
| 1 | Mean | 16.3* | 13.5 | 4.3* | 753 | 25 |
| | Range | 8.2-29.8 | 6.0-23.3 | 1.0-7.5 | 470-1,280 | 7 - 50 |
| 2 | Mean | 15.8* | 14.1 | 6.9* | 780 | 13 |
| | Range | 7.5-25.8 | 8.0-23.0 | 3.6-10.0 | 550-1,120 | 6 - 22 |
| 3 | Mean | 17.3* | 14.4 | 23.1* | 898 | 18 |
| | Range | 8.0-29.0 | 10.0-21.5 | 10.7-35.7 | 650-1,090 | 11 - 30 |
| 4 | Mean | 21.0** | 14.4 | 25.8* | 776 | 57 |
| | Range | 14.0-28.0 | 10.0-21.5 | 18.5-32.1 | 470-1,010 | 18 - 165 |
| 5 | Mean | 18.8** | 13.8 | 24.6* | 493 | 63 |
| | Range | 10.0-27.5 | 7.0-20.2 | 8.0-47.1 | 370-610 | 22 - 160 |
| 6 | Mean | 12.0** | 14.8 | 118.1* | 656 | 123 |
| | Range | 8.0-20.0 | 10.0-19.5 | 26.9-264 | 362-930 | 31 - 380 |

*Average of three analyses

**Average of two analyses

## Table 3-4. SYNOPTIC PARAMETERS

| Site | | pH | Total Alkalinity (mg/1) | Carbon Dioxide (mg/1) | Dissolved Oxygen (mg/1) | Chemical Oxygen Demand (mg/1) | Total Hardness (mg/1) |
|---|---|---|---|---|---|---|---|
| 1 | Mean | 4.9 | 50.0 | >1,100* | 11.4 | 18.2 | 413.5 |
| | Range | 3.1-6.7 | 0 | 25->3,000 | 9.1-14.5 | 11-36 | 351-553 |
| 2 | Mean | 6.1 | 102.2 | >1,030* | 12.3 | 24.5 | 415.5 |
| | Range | 4.7-7.3 | 22-159 | 12->3,000 | 10.3-14.8 | 16-35 | 336-549 |
| 3 | Mean | 6.2 | 180.0 | >1,740* | 9.7* | <19.8 | 455.2 |
| | Range | 5.0-7.4 | 130-232 | 10->3,000 | 6.6-11.9 | <5-38 | 403-498 |
| 4 | Mean | 6.1 | 161.0 | 1,210* | 8.6 | 24.2 | 390.8 |
| | Range | 5.1-7.2 | 103-214 | 38-2,200 | 7.2-9.8 | 11-36 | 289-462 |
| 5 | Mean | 7.4 | 178.8 | 17 | 10.8 | 13.2 | 252.0 |
| | Range | 7.0-7.8 | 151-222 | 6-32 | 8.5-12.4 | 5-24 | 230-281 |
| 6 | Mean | 6.9 | 158.5 | 284 | 10.6 | 23.2 | 326.2 |
| | Range | 5.5-7.7 | 107-201 | 6-1,100 | 9.3-11.9 | 18-29 | 219-424 |

*Average of three analyses

## Table 3- 5. SOLIDS, MICROBES, AND MAJOR ANIONS

| Site | | Total Dissolved Solids (mg/l) | Total Suspended Solids (mg/l) | Volatile Suspended Solids (mg/l) | Fecal Coliforms (CTS/100 ml) | Fecal Streptococci (CTS/100 ml) | Chloride (mg/l) | Sulfate (mg/l) |
|---|---|---|---|---|---|---|---|---|
| 1 | Mean | 710 | 17 | 3.3 | <59.7* | 53* | 26.2 | 418 |
| | Range | 530-1180 | 5-35 | 2-4.2 | <1-95 | 22-80 | 25-28 | 270-750 |
| 2 | Mean | 675 | 12.8 | 5.2 | 2500 | 584 | 26.8 | 335 |
| | Range | 510-1020 | .6-20 | 3-8 | 10- 6300 | 5-1210 | 4-52 | 220-600 |
| 3 | Mean | 730 | 43.8 | <5.8 | 782 | 1120 | 21 | 318 |
| | Range | 580-900 | 18-80 | <2-9 | 170-1900 | 245-2700 | 4-65 | 290-360 |
| 4 | Mean | 568 | 109.2 | 12.5 | 1000 | 1500 | 22.2 | 270 |
| | Range | 390-840 | 46-272 | 4-26 | 110-3400 | 190-5300 | 5-52 | 190-340 |
| 5 | Mean | 462 | 108.2 | 12 | 1420 | 1320 | 5.8 | 118 |
| | Range | 340-720 | 46-264 | 3-30 | 30-5200 | 220-3900 | 1-16 | 110-130 |
| 6 | Mean | 558 | 205.8 | 20.2 | 1610 | 2200 | 10.5 | 190 |
| | Range | 330-740 | 66-550 | 5-50 | 110-5900 | 350-7050 | 1-32 | 110-240 |

*Average of three analyses

## Table 3-6. NUTRIENTS AND PCBs

| Site | | Nitrate-N (mg/l) | Nitrite-N (mg/l) | Ammonia-N (mg/l) | Total Kjeldahl Nitrogen (mg/l) | Ortho Phosphate (mg/l) | Total Phosphorus (mg/l) | PCBs (µg/l) |
|---|---|---|---|---|---|---|---|---|
| 1 | Mean | 1.40 | <0.06 | <0.20 | 0.52 | <0.04 | 0.07 | < 0.5*** |
| | Range | 0.75-1.73 | <.05-.12 | <0.05-0.29 | 0.4-0.6 | <0.02-0.09 | 0.05-0.09 | - |
| 2 | Mean | 1.03 | <0.08 | 1.24 | 3.27 | <0.05 | 0.34 | < 0.5*** |
| | Range | 0.20-1.52 | <.05-.14 | 0.84-1.97 | 2.1-6.0 | <0.02-0.15 | 0.10-0.70 | - |
| 3 | Mean | 2.20 | <0.25 | 0.98 | 2.9 | 0.82 | 1.0 | < 0.5*** |
| | Range | 0.70-3.30 | <.05-.60 | 0.73-1.19 | 2.0-5.3 | 0.33-1.75 | 0.5 -1.9 | - |
| 4 | Mean | 2.37 | <0.20 | 0.77 | 2.57 | 0.71 | 0.78 | < 0.5*** |
| | Range | 1.33-3.47 | <.05-.51 | 0.49-0.92 | .92-4.2 | 0.22-1.65 | 0.23-1.85 | - |
| 5 | Mean | 1.47 | <0.05 | <0.41 | <0.82 | 0.03 | 0.19 | - |
| | Range | 0.66-2.79 | <.05-.05 | <0.05-0.36 | <0.2-1.4 | 0.02-0.05 | 0.12-0.25 | - |
| 6 | Mean | 1.74 | <0.05 | 0.63 | 1.9 | 0.23 | 0.56 | < 0.5** |
| | Range | 0.09-3.2 | <.05-.06 | 0.06-1.20 | 1.6-2.5 | 0.17-0.31 | 0.27-0.74 | - |

**Average of two analyses.
***Average of three analyses.

Table 3-7. METALS

(All units in μg/l)

| Site | | Arsenic | Cadmium | Copper | Iron | Lead | Manganese | Mercury | Zinc |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mean | <5 | <6 | <50 | 9,110 | <28 | 4,000 | <0.5 | 380 |
| | Range | - | <5-7 | - | 1,100-20,000 | <5-<100 | 2,200-6,000 | - | 10-1,100 |
| 2 | Mean | <5 | <5 | <50 | 2,740 | <30 | 2,300 | <0.5 | <260 |
| | Range | <5-6 | <5-6 | - | 1,200-5,000 | <5-<100 | 1,300-4,700 | - | <10-700 |
| 3 | Mean | <5 | <5 | <50 | 1,850 | <34 | 920 | <0.5 | <66 |
| | Range | - | - | - | 1,200-2,930 | 7-<100 | 750-1,030 | - | <10-105 |
| 4 | Mean | <6 | <5 | <50 | 4,700 | <36 | 910 | <0.8 | <72 |
| | Range | <5-7 | - | - | 1,330-13,400 | 7-<100 | 690-1,300 | <0.5-1.6 | <10-177 |
| 5 | Mean | <5 | <5 | <50 | 4,750 | <33 | 490 | <0.5 | <35 |
| | Range | <5-6 | - | - | 1,100-13,400 | <5-<100 | 270-730 | - | <5-76 |
| 6 | Mean | <8 | <5 | <50 | 9,310 | <30 | 860 | <0.5 | <54 |
| | Range | <5-17 | - | - | 1,170-29,300 | <5-<100 | 570-1,200 | <0.5-0.6 | <10-131 |

Table 3-8. MACROINVERTEBRATE COMMUNITY STRUCTURE

| Taxonomic Groupings | Tolerance Status* | NUMBER OF ORGANISMS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| ANNELIDA | | | | | | | |
| Oligochaeta | T | 1 | 38 | 24 | 3 | | 3 |
| Hirudinea | T | | | 1 | | | |
| ARTHROPODA | | | | | | | |
| Crustacea | | | | | | | |
| Isopoda | M | 8 | | 7 | 12 | 82 | 169 |
| Amphipoda | I | 2 | | 19 | | 8 | 14 |
| Decapoda | I | 1 | 2 | 1 | 4 | 1 | |
| Insecta | | | | | | | |
| Collembola | F | | | 4 | | | |
| Ephemeroptera | | | | | | | |
| Leptophlebiidae | M | | | | | 1 | |
| Heptageniidae | I | | | | 35 | 72 | 2 |
| Caenidae | F | | | 25 | 9 | 3 | 8 |
| Baetidae | I | | | 3 | | | |
| Odonata | | | | | | | |
| Anisoptera | M | | | | 2 | | |
| Zygoptera | | | | | | | |
| Coenagriidae | M | | | 14 | 7 | 20 | 8 |
| Agriidae | I | | | 1 | | 2 | 1 |
| Hemiptera | | | | | | | |
| Gerridae | F | 9 | | 2 | | 1 | |
| Veliidae | F | 18 | | | | 1 | |
| Corixidae | F | | | | 1 | | 9 |
| Gelastocoridae | F | | | | | | 2 |
| Megaloptera | | | | | | | |
| Sialidae | M | | | 1 | | | |
| Trichoptera | | | | | | | |
| Hydropsychidae | M | 2 | | | | 21 | 1 |
| Leptoceridae | I | 1 | | | | | |
| Hydroptilidae | I | | | 1 | | | |
| Coleoptera | F | 2 | | 9 | 2 | 11 | 8 |
| Diptera | | | | | | | |
| Tipulidae | I | 1 | | | 1 | | |
| Culicidae | T | 1 | | | 6 | | |
| Simuliidae | M | | 1 | 30 | 73 | 128 | 7 |
| Chironomidae | T | 1 | 73 | 382 | 289 | 48 | 17 |
| Heleidae | F | | | 1 | | 10 | 3 |
| Tabanidae | M | 1 | | | | | |
| MOLLUSCA | | | | | | | |
| Gastropoda | | | | | | | |
| Physidae | T | | | 1 | 1 | | |
| Lymnaeidae | F | | | | | 2 | 1 |
| Pelecypoda | | | | | | | |
| Sphaeriidae | M | | | | 1 | 1 | 3 |

*T = Tolerant
M = Moderate
F = Facultative
I = Intolerant

Table 3-8. MACROINVERTEBRATE COMMUNITY STRUCTURE (Continued)
DATA SUMMARY

| CATEGORY | NUMBER OF ORGANISMS/TAXA | | | | | |
|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| Sum of Intolerant Taxa | 4 | 1 | 5 | 2 | 4 | 3 |
| Sum of Moderate Taxa | 3 | 1 | 4 | 5 | 6 | 5 |
| Sum of Facultative Taxa | 3 | 0 | 5 | 3 | 6 | 6 |
| Sum of Tolerant Taxa | 3 | 2 | 4 | 4 | 1 | 2 |
| Sum of All Taxa | 13 | 4 | 18 | 14 | 17 | 16 |
| Sum of Intolerant Organisms | 5 | 2 | 25 | 40 | 83 | 17 |
| Sum of Moderate Organisms | 11 | 1 | 52 | 95 | 253 | 188 |
| Sum of Facultative Organisms | 29 | 0 | 41 | 12 | 28 | 31 |
| Sum of Tolerant Organisms | 3 | 111 | 408 | 299 | 48 | 20 |
| Sum of Organisms | 48 | 114 | 526 | 446 | 412 | 256 |
| Macroinvertebrate Community Index | 3.7 | 0.2 | 1.2 | 2.0 | 5.3 | 4.6 |

# 4.0 DISCUSSION

The physicochemical and biological results provided in Section 3 present a fairly clear picture of water quality in Richland Creek during low and moderate flow conditions. During high flows, the physicochemical conditions in Richland Creek and its tributaries could differ significantly, especially for parameters such as nutrients and solids that reflect non-point source loading. Conditions during extremely low flows could also diverge from the results since the ratio of flows derived from point sources to flows derived from ground-water discharges would increase. Some seasonal effects may also occur that would not be represented in the samples analyzed for this study. Nevertheless, the water quality data reported here span a considerable range of flow conditions and are probably representative of prevailing baseline water quality in Richland Creek.

All surface waters in the State of Illinois are regulated under the Water Quality Standards promulgated by the Illinois Pollution Control Board (1979). These standards are set for several different potential uses, e.g., public and food processing water supply; secondary contact and indigenous aquatic life waters; effluents. The designation covering Richland Creek and its tributaries, and in particular the six sampling sites in this study, are the "General Standards" which apply to most of the surface waters of Illinois. These standards are summarized in Table 4-1, and are compared to the observed levels, where applicable, throughout the following sections (4.1 - 4.4).

Physicochemical water quality results are discussed in Section 4.1, and biological data are discussed in Section 4.2. A summary of existing conditions is provided in Section 4.3. The ramifications of these data with respect to flood control alternatives are discussed in Section 4.4.

## 4.1 PHYSICOCHEMICAL PARAMETERS

In general, the physicochemical parameters analyzed in this study indicate that Richland Creek is impacted by acid mine drainage in its headwaters, sewage treatment plant (STP) discharges in the Belleville area, and agricultural runoff in the lower part of its basin. Each of the physicochemical parameters analyzed is discussed under one of the following categories: physical parameters; synoptic parameters; solids and major anions; nutrients; and PCBs and metals.

## Table 4-1. ILLINOIS POLLUTION CONTROL BOARD GENERAL WATER QUALITY STANDARDS

| Water Quality Constituent | General Standard |
|---|---|
| pH | 6.5 - 9.0 |
| Dissolved Oxygen (DO) | Not less than 5.0 mg/l<br>Not less than 6.0 mg/l for more than 16 consecutive hours |
| Phosphorus (as P) | Not to exceed 0.05 mg/l at any reservoir or lake, or in any stream where it flows into a reservoir or lake |
| Radioactivity | |
| Gross Beta | Not to exceed 100 pico curies/ liter (pCi/l) |
| Radium 226 | Not to exceed 1 pCi/l |
| Strontium 90 | Not to exceed 2 pCi/l |
| Fecal Coliforms | Not to exceed a geometric mean of 200/100 ml, nor shall 10% of the samples during a 30-day period exceed 400/100 ml |
| Temperature | |
| April - November | Not to exceed 90°F |
| December - March | Not to exceed 60°F |
| Other Pollutants | |
| Ammonia Nitrogen (as N) | Not to exceed 1.5 mg/l |
| Arsenic (total) | Not to exceed 1.0 mg/l |
| Barium (total) | Not to exceed 5.0 mg/l |
| Boron (Total) | Not to exceed 1.0 mg/l |
| Cadmium (total) | Not to exceed 0.05 mg/l |
| Chloride | Not to exceed 500 mg/l |
| Chromium (total hexavalent) | Not to exceed 0.05 mg/l |
| Chromium (total trivalent) | Not to exceed 0.05 mg/l |
| Copper (total) | Not to exceed 0.02 mg/l |

Table 4-1. (Cont.)

| Water Quality Constituent | General Standard |
|---|---|
| Cyanide | Not to exceed 0.025 mg/l |
| Fluoride | Not to exceed 1.4 mg/l |
| Iron (total) | Not to exceed 1.0 mg/l |
| Lead (total) | Not to exceed 0.1 mg/l |
| Manganese (total) | Not to exceed 1.0 mg/l |
| Mercury (total) | Not to exceed 0.0005 mg/l |
| Nickel (total) | Not to exceed 1.0 mg/l |
| Phenols | Not to exceed 0.1 mg/l |
| Selenium (total) | Not to exceed 1.0 mg/l |
| Silver (total) | Not to exceed 0.005 mg/l |
| Sulfate | Not to exceed 500 mg/l |
| Total Dissolved Solids | Not to exceed 1,000 mg/l |
| Zinc (total) | Not to exceed 1.0 mg/l |

Source: Illinois Pollution Control Board, 1979.

### 4.1.1 Physical Parameters

Physical parameters, as defined in this report, consist of air temperature, water temperature, flow, specific conductance, and turbidity. The data for these parameters provide a foundation for interpretation of chemical and biological characteristics, since chemical and biological characteristics are largely controlled in stream systems by the physical environment.

Air temperature reflects the variations in microclimate among the sites. Sites 1 through 4 on Richland Creek, and Site 5 on Prairie du Long Creek are all characterized by moderately open space with some trees along the shoreline. Accordingly, the mean temperatures at these sites are all higher than at Site 6 (see Table 3-3), which is located in a more heavily wooded stretch of the stream. This is a result of the greater sunlight, or solar radiation penetration at Sites 1 through 5 and indicates that if all other factors were equal, there could be a greater potential primary productivity in the upstream reaches than downstream at Site 6. The differences in air temperature are also related to the fact that Site 6 was generally sampled earlier in the day than were the other sites.

Water temperature shows an increasing trend downstream along the main stem of Richland Creek (Sites 1, 2, 3, 4, and 6) (see Table 3-3). Water temperatures at Prairie du Long Creek (site 5) are similar to those at Site 1 (upstream of Belleville), being slightly lower than prevailing temperatures at mid- and lower Richland Creek stations. This may indicate that groundwater discharge comprises a higher proportion of flow at Sites 1 through 5 than at other sites. The slight difference may also be due to the influence of warm point source discharges in Belleville. The moderately warm temperatures (mean of all values, 14.2°C) during springtime indicate that summer water temperatures would be high enough to prohibit occurrence of most cold-water organisms (e.g., trout, stonefiles). None of the temperatures observed at any of the sites violated the Illinois General Water Quality Standards for temperature.

Flow in Richland Creek varies from means of 4.3 cfs at Site 1 to 118.1 cfs at Site 6 (see Table 3-3). As previously mentioned, these results span a considerable range of flows, despite the absence of high or extremely low flow conditions. Based on the measurements, there is relatively small change in flows from Site 1 to Site 2, a considerable increase to Site 3, little difference in Sites 3 and 4, and a dramatic increase from Site 4 to Site 6. These relationships follow the input of tributaries and point source discharges to the main stem of Richland Creek. Flow in Prairie du Long Creek (Site 5) exhibits the same relative range (8.0 - 47.1 cfs) as the other sites. The range of flow is greatest at Site 6 (26.9 - 264 cfs). The value of

264 cfs was measured 2 days after heavy rains. By this time, water levels at the upper sites had already fallen to normal, but stream stage had not yet subsided at Site 6.

Specific conductance is highest at upstream sites (see Table 3-3), probably due to the influence of acid mine drainage (AMD) in the headwaters of the basin. The highest individual value recorded, 1,280 μmhos, was observed at Site 1 during the lowest flow conditions. This coincided with the appearance of an orange ferric hydroxide precipitate on the substrate, a strong indication that acid mine wastes impact the stream. During higher flows, conductance dropped considerably (at Site 1, 470 μmhos) indicating that the source of the dissolved materials causing the high conductance was definitely not runoff. Apparently, tributaries in the southern half of the Richland Creek Basin are not as severely impacted by AMD, since conductance, as well as several other parameters, recover to more typical levels at Sites 5 and 6.

Turbidity in Richland Creek and Prairie du Long Creek is moderate to high. Mean levels vary from 13 JTU at Site 2 to 123 JTU at Site 6 (see Table 3-3). Turbidity at Sites 2 and 3 is lower than at other sites, indicating that the nearby Belleville STP discharges do not cause significant turbidity problems. Sites 4, 5, and 6 had maximum values of 165, 160, and 380 JTU, respectively, as compared to maximum values at Sites 1, 2, amd 3 of 50, 22, and 30 JTU. This reflects the influence of agricultural runoff in the lower Richland Creek Basin, especially since the maximum turbidity values at Sites 4, 5, and 6 all occurred during the second sampling trip, when the stream was falling after heavy rains. The turbidity observed in Richland Creek and Prairie du Long Creek is probably high enough to impair photosynthetic activity in the deeper areas of the streams.

### 4.1.2 Synoptic Parameters

For the purpose of this study, synoptic parameters comprise pH, total alkalinity, carbon dioxide ($CO_2$), dissolved oxygen (DO), chemical oxygen demand (COD), and total hardness. These parameters are among the most commonly measured in water quality studies, and they manifest the effects of numerous constituents and processes. The following discussion of the synoptic parameters is based on the results given in Table 3-4 and Appendix B.

Of these parameters, pH is often called the "master variable" because of its control over solubility, sorption, and ionization processes (Stumm and Morgan, 1970). The pH of Richland Creek ranges from acidic during low flows to circumneutral at higher flows. The variation is most pronounced at Sites 1 and 2, which range from minima of 3.1 and 4.7 to maxima of 6.7 and 7.3, respectively. As one travels downstream, the pH becomes more neutral due to the buffering capacity introduced by Prairie du Long Creek (pH 7.0 - 7.8) and other tributaries. Acidic conditions in Richland Creek probably result from acid mine drainage in the northern headwaters near Site 1. All five of the sites on the main stem of Richland Creek frequently violate the Illinois General Water Quality Standards (pH between 6.5 and 9.0). With respect to pH as a master variable, the observed acidic pH values indicate the potential for elevated mobility of heavy metals; availability of hydrogen sulfide, phenol, hydrogen cyanide, carbon dioxide, and other soluble gases for biological uptake in the electrically neutral state (generally more toxic); and several other effects which directly or indirectly stress aquatic biota. The lowest pH value observed, 3.1 at Site 1, was accompanied by a drastic reduction in the number and variety of macroinvertebrates present at the site as compared to an earlier collection which represented higher prevailing flows and higher pH. The low pH in much of Richland Creek is synoptic of one of the major water quality problems in the watershed, that of acid mine drainage.

Alkalinity is a measure of the acid buffering capacity of water, and is generally due to the presence of carbonates, bicarbonates, phosphates, hydroxides, and similar compounds. Despite the low pH values, the alkalinity of Richland Creek and Prairie du Long Creek water is generally moderate to high, indicating that these streams could resist further degradation. Alkalinity displays an inverse relationship with pH, as would be expected, and ranges from the minimum observed value of 0 mg/l at Site 1 to the maximum observed value of 232 mg/l at Site 3. The alkalinity of water in the Richland Creek system is probably derived from carbonate rock in the watershed, alkaline materials from STP and other discharges, lime from agricultural runoff, and other similar sources.

Dissolved carbon dioxide ($CO_2$) concentrations in Richland Creek are very high, primarily due to the prevailing acidic conditions. A nomographic technique (APHA, 1976) was used to estimate $CO_2$ based on measured pH, alkalinity, and dissolved solids. For the occasions where pH was below 6.0, the validity of the results is questionable. Nevertheless, it is certain that $CO_2$ in Richland Creek is very high (mean values range from 284 mg/l at Site 6 to 1,740 mg/l at Site 3), and this may be a mechanism by which acidic conditions cause toxic effects on biota. In Prairie du Long Creek, the mean $CO_2$ concentration is 17 mg/l, which is a more typical level for surface waters.

Dissolved oxygen levels in Richland Creek and Prairie du Long Creek are in the healthy range at all sites. Concentrations at Sites 1, 2, and 6 in Richland Creek, and Site 5 in Prairie du Long Creek are typically near saturation values. There is an apparent oxygen sag below Belleville at Sites 3 and 4, although oxygen does not fall below 66 percent of saturation value at either of these sites. During the summer months when extreme low flow conditions are encountered, DO may be more of a problem due to introduction of oxygen-demanding substances from the Belleville STPs. During the sampling period for this study, however, DO levels were well within tolerable limits for aquatic organisms, and above the Illinois General Water Quality Standards.

Chemical oxygen demand (COD) is fairly consistent throughout Richland Creek (means range from 18.2 mg/l to 24.2 mg/l for Sites 1, 2, 3, 4, and 6). Interestingly, the Belleville STP discharges do not appear to add significant COD to Richland Creek. As with several other parameters, Prairie du Long Creek shows better water quality than Richland Creek insofar as the mean COD is 13.2 mg/l. Oxygen depletion is less apt to occur where the concentration of oxidizable organic compounds is lower.

Total hardness is the sum of the calcium and magnesium ion concentrations, expressed as calcium carbonate. According to the classification scheme presented by EPA (1976a), water in Richland Creek is very hard, and water in Prairie du Long Creek is hard. Much of the hardness of the Richland Creek water is undoubtedly due to dissolution of carbonate rocks by acidic water. Since calcium, magnesium, and other polyvalent cations are generally more soluble in acidic conditions than basic conditions, the limestone rock contacted by the water in the Richland Creek Basin is dissolved readily. If this rock were not present in the watershed to provide some buffering capacity, the acid mine drainage problem would be much more acute.

### 4.1.3 Solids and Major Anions

Seasonal variation in rainfall and surface runoff, and the geochemical nature of the drainage basin strongly influence the composition of waters of small streams, imparting considerable individuality to these streams. This variability is even observed along the gradient of the same stream, being markedly influenced by edaphic factors, human activities, and channel morphology. The presence of solids and the major anions in water greatly influence the biota of the stream and the utilization of the water by humans.

Total dissolved solids consist of inorganic salts, small amounts of organic matter, and other dissolved materials. The principal inorganic anions dissolved in water include the carbonates, chlorides, sulfates, and nitrates; the principal cations are sodium, potassium, calcium, and magnesium. Excess dissolved solids may render the water unfit for human consumption as well as consumption by livestock and wildlife, and may seriously impact the biota of the stream.

The general tendency is toward a downstream decrease in total dissolved solids (TDS) in Richland Creek (see Table 3-5). Undoubtedly, the presence of drainage from mine spoils upstream accounts for the mean value of 710 mg/l at Site 1. Similarly, the mean value of 730 mg/l at Site 3 may be explained by the presence of the sewage treatment plant upstream of this site. The two remaining downstream stations show a gradual decrease with Site 6 being influenced by the relatively low average value of 462 mg/l for Prairie du Long Creek, which serves to dilute the concentration of the main stem. At all mainstem Richland Creek sites, TDS is highest at low flows, reflecting the input of dissolved solids from acid mine drainage.

Illinois Pollution Regulations require that total dissolved solids not exceed 1,000 mg/l for the General Standards which are applicable to Richland Creek. As can be seen from Table 3-5, Sites 1 and 2 have values higher than 1,000 mg/l at times, though the mean value is less than 1,000 mg/l. All other stations meet this requirement.

The total suspended solids, a measure of the organic and inorganic particulate matter, show a general downstream increase (see Table 3-5). Such a trend is typical of streams flowing through agricultural areas, due to erosion from cropland. The low value at Site 2 may be attributed to the fact that the stream segment between Sites 1 and 2 flows through Belleville for most of its distance and the runoff of this area is basically urban. Total suspended solids at all stations were highest during highest flows, reflecting the importance of non-point source loading.

Concentrations of volatile suspended solids enable a rough approximation of the amount of organic matter present. The trend for this parameter was generally the same as that for total suspended solids, though considerably less in magnitude, as would be expected. Stations along the mainstem of Richland Creek showed an increase in volatile suspended solids downstream, reflecting input from both STP discharges and agricultural runoff.

Two of the major constituents of the total dissolved solids are chloride and sulfate. The General Standards of the Illinois Water Pollution Regulations specify a maximum level of 500 mg/l for both of these parameters. As shown in Table 3-5, chloride concentrations never exceed this value and are highest at Sites 2 and 3, indicating the effects of STP discharges near Belleville. Chloride is a common constituent of wastewater, but is not usually a major component of acid mine drainage or runoff. Sulfate levels decrease downstream, but at times exceed the Standards at Sites 1 and 2. The higher upstream concentrations of these two parameters, and particularly the high sulfate concentration may again be attributed to the mine spoils near the headwaters of Richland Creek.

### 4.1.4 Nutrients

Nitrogen and phosphorus are the two most important plant nutrients. Nitrogen can exist as ammonium, nitrite, or nitrate ions; the latter being the most available form for plant growth. Phosphorus occurs both as simple ionic orthophosphate and as bound phosphate in soluble and particulate form (Hynes, 1970).

Nitrate nitrogen, as shown in Table 3-6, shows noticeable increases downstream of Site 2, at Sites 3 and 4. These increases are most likely due to the discharges from the sewage treatment plants in Belleville and Freeburg. Another potential source of this nutrient in Richland Creek is agricultural runoff. This factor may be responsible for the sustained higher levels downstream and in the Prairie du Long tributary. Highest nitrate levels tended to occur during the earlier part of the study, when farmers were applying fertilizer to soil. Notably, the lowest level is at Site 2, located within the town of Belleville, an area which receives virtually no agricultural runoff.

The nitrite ion is formed from the nitrate or ammonium ions by certain microorganisms found in soil, water, and sewage. In well oxygenated natural water systems, nitrite is rapidly oxidized to nitrate. However, when nitrate-containing soils or sediments become anaerobic, a process known as denitrification takes place and the nitrate may be converted to nitrite, molecular nitrogen, or nitrous oxide (EPA, 1976). Automobile exhausts are also a source of nitrite.

Examination of Table 3-6 reveals that the highest nitrite levels occur at Sites 3 and 4. These increased levels are probably due to the presence of sewage discharges and automobile traffic in the more populated area of the Richland Creek Basin. Occasional oxygen sags in the vicinity of the sewage treatment plants in Belleville and Freeburg may also promote the denitrification process in the sediments. Other than Sites 3 and 4, nitrate levels are in a moderately healthy range.

Ammonia is a biologically active compound present in most waters as a normal biological degradation product of nitrogenous organic matter. The presence of large quantities of nitrogenous organic matter, as in sewage discharges, will result in increased ammonia levels in the stream. The highest ammonia levels found in Richland Creek were at Sites 2 and 3, which corresponds to the area most affected by sewage discharges. Downstream levels of ammonia in Richland Creek decrease with a considerable dilution from the Prairie du Long tributary. The General Standards of the Illinois Water Pollution Regulations specify that the ammonia nitrogen level shall not exceed 1.5 mg/l. In one instance, Site 2 (1.97 mg/l) exceeded this concentration.

Total Kjeldahl nitrogen (TKN) is a measure of the amount of organic nitrogen and ammonia in the water. As such, it might be expected to parallel the ammonia nitrogen levels. This trend was observed in Richland Creek, with the highest concentrations being recorded at Sites 2 and 3, followed by a general decrease downstream. TKN is probably contributed primarily from STP discharges, since levels were highest during low flows.

The phosphate compounds of streams are primarily derived from chemical processes along the stream course and from agricultural runoff and STP discharges (Reid and Wood, 1976). Ionic orthophosphate is the form which is readily available as a plant nutrient. A large source of phosphorus results from the widespread use of phosphate detergents and for this reason, high concentrations are usually present in sewage discharges.

Orthophosphate concentrations in Richland Creek show approximately a sixteen-fold increase between Sites 2 and Site 3 (as shown in Table 3-6), immediately downstream of the largest STP discharge. Thereafter, the level decreases downstream with significant dilution being provided by Prairie du Long Creek. Since orthophosphate levels are highest at Sites 3 and 4 at lowest flows, this confirms the influence of STP discharges.

Total phosphorus concentrations in Richland Creek show a noticeable increase at Sites 2 and 3, followed by a gradual decrease downstream. Hynes (1970) notes that in turbulent waters, the fertility is measurable in terms of total phosphate due to bound phosphate being continuously released by bacterial action. As a general rule, the nutrients soon enter plants and are then recycled fairly fast in a free-flowing stream.

The productivity of most natural waters is limited by the availability of phosphorus, and the nitrogen to phosphorus ratio in most waters usually ranges from 12:1 to 16:1 (Stumm and Morgan, 1970). The ratios (determined by summing the mean nitrogen levels for ammonia, nitrite, and nitrate and dividing by the mean orthophosphate phosphorus level) in Richland Creek range from 4:1 at Site 3 to 64:1 at Prairie du Long Creek. These ratios suggest that in some areas of Richland Creek, phosphorus may not be the limiting nutrient. This does not affect a free flowing stream as much as a lake, but could have serious implications if any part of Richland Creek were impounded to create a reservoir. A ratio of 4:1 would indicate the potential for rapid eutrophication, since both nitrogen and phosphorus are in abundant supply. The area that has the greatest nutrient loading, and the lowest N:P ratio, is the segment around Sites 3 and 4. The effects of the upstream STP discharges and agricultural runoff from adjacent areas combine to have a significant impact on the nutrient dynamics in this reach of Richland Creek.

### 4.1.5 PCBs and Metals

PCBs and metals analyzed for this study represent some of the most toxic pollutants potentially present in the Richland Creek Basin. In general, concentrations of these pollutants were low or undetectable, with some exceptions. The following discussion is based on the data provided in Appendix B and summary results in Tables 3-6 and 3-7.

No PCBs were detected in any of six samples taken on the mainstem of Richland Creek. Nevertheless, intermittent PCB contamination could occur due to spills of transformers or runoff from urban areas.

The metals analyzed for this study were arsenic, cadmium, copper, iron, lead, manganese, mercury, and zinc. All eight were analyzed in the total form (rather than dissolved or suspended). Of these, four (iron, manganese, mercury, and zinc) violated the Illinois General Water Quality Standards at one site or more for at least one of the four samples taken at each site.

The only metal which exceeded the standards for every observation at every site was iron (Fe). The mean of all observed values was 5.41 mg/l, well above the 1.0 mg/l standard. Fe concentrations at Sites 3, 4, 5, and 6 reached a maximum during the highest flows sampled, with observed values of 2.9, 13.6, 13.4, and 29.3 mg/l, respectively. At Site 1, Fe concentrations peaked at 20.0 mg/l during the lowest flow observed. Compared to the other sites, Fe levels at Site 2 were fairly constant with a range of 1.2 to 5.0 mg/l. High Fe concentrations during low flows at Site 1 are easily explained as resulting from the acid mine drainage that impacts this stretch of Richland Creek. Pyrite ($FeS_2$) in association with mined-out coal deposits typically contributes large loads of iron via acid mine drainage. The correlation of Fe concentrations with flow at Sites 3-6 is more difficult to interpret, however, since it seems to indicate that Fe is being introduced by runoff, which would be fairly unusual. A possible hypothesis to account for the high flow-high Fe correlation is that bed sediments from upstream, rich in Fe, are scoured, suspended in the water column, and transported downstream during high flows. This does not explain the high Fe concentrations in Prairie du Long Creek, however, which may be due to iron-bearing ground water or runoff from mine gob piles. Levels of iron in excess of 1 mg/l can stress aquatic biota by either interfering with internal metabolic processes or physically damaging gills and smothering the benthos when it precipitates and forms a floc. EPA (1976a) cites studies which report $LC_{50}$ values of 0.32 mg/l for mayflies, stoneflies, and caddisflies. Even carp (Cyprinus carpio), one of the most hardy of all freshwater fish, are killed by iron at concentrations of 0.9 mg/l at pH of 5.5 (cited by EPA, 1976a).

Manganese (Mn) concentrations at all mainstem Richland Creek stations exceeded the Illinois General Water Quality Standard of 1 mg/l at least once during the course of the study. All samples taken from Sites 1 and 2 exceeded 1 mg/l, again demonstrating the influence of acid drainage from coal mines in this region of the basin. Mn shows a general decreasing trend in the downstream direction. At Sites 3 and 4 on Richland Creek, the 1 mg/l standard was exceeded only once during the study, and occurred during the lowest flows. At Site 6, Mn exceeded 1 mg/l only once, but at this site it occurred during the highest flows. At Prairie du Long Creek (Site 5), the range of concentrations was 0.27 to 0.73 mg/l, with the highest value occurring during lowest flow. Where Mn concentrations are highest during low flows, ground water and mine drainage are probably the most significant sources; where Mn concentrations are highest during high flows (Site 6 only), scouring of bed sediments from upstream sources is probably the major source.

Zinc (Zn) exceeded the 1 mg/l Illinois Standard only once, at Site 1 during lowest flow. Zn, like Fe, Mn, and several other metals, is commonly associated with acid mine drainage. Zn shows a distinct decreasing trend from upstream to downstream, indicating that the mine drainage is probably the only major source of zinc in the basin. The lack of Zn loading from non-point sources is further indicated by the range of Zn levels at Site 1, from 0.01 to 1.1 mg/l. Since the concentration is inversely related to flow, the low levels during periods when non-point source input is highest shows that the runoff actually dilutes the base flow. Because zinc toxicity is lower in hard waters, and zinc levels are generally low and hardness is high, the levels of zinc at all sites except Site 1 probably do not stress aquatic biota.

Mercury (Hg) was detected in two samples, one at Site 4, and one at Site 6. The source of Hg at these sites is unknown. Both instances where Hg was detected represent violations of the Illinois General Water Quality Standard of 0.5 μg/l. Those levels could cause some toxic effects, depending on the form in which Hg is present (e.g., methylmercury, inorganic Hg).

Arsenic, cadmium, and lead levels did not exceed the Illinois General Water Quality Standards at any of the sites. In most cases, these elements were not detected in the samples. Therefore, it is difficult to either identify any trends in the concentrations of these pollutants or determine what major sources of the pollutants are.

Likewise, copper was not detected at any of the sites. The detection limit for copper was 50 µg/l, however, which is higher than the Illinois Standard of 20 µg/l. Therefore, it is not possible to state whether copper concentrations exceed the standards or not.

## 4.2 BIOLOGICAL PARAMETERS

The biological methods used in this study, which include analyses of bacteria and of macroinvertebrate community structure, complement the analysis of physical and chemical water parameters because they provide a measure of the cumulative effect of existing water quality on the biota of the creek. Indeed, water quality would be of little interest if the biota were not affected by pollution.

### 4.2.1 Fecal Coliforms and Fecal Streptococci

Fecal coliforms and fecal streptococci were sampled at all 6 sites during each of the four sampling trips. Samples were preserved and analyzed according to the procedures outlined in Appendix A-2. The results (Table 3-5) indicate a large range in bacterial concentration for all stations except Site 1, which showed no values greater than 95 CTS/100 ml. Site 2 had the highest single value and mean (arithmetic) fecal coliform count (5,900 CTS/100 ml and 1,610 CTS/100 ml, respectively), probably a result of effluent discharged at Swansea, upstream of the station. The greatest fecal streptococci contamination occurred at Site 6, where the highest value recorded was 7,050 CTS/100 ml and the average concentration was 2,200 CTS/100 ml.

Fecal coliforms and fecal streptococci in natural waters derive from mammalian wastes. An examination of the relation between concentrations of these bacteria and magnitude of flow can provide information on the sources of microbial pollution. At Richland Creek, the highest concentrations of fecal coliforms and fecal streptococci, at all sampling sites, occurred during the highest measured flows (9 April 1980, see Appendix B-2). This is indicative of a large input of water from non-point sources, such as runoff from agricultural lands. Increased concentrations of these microorganisms may also result from overflow of STPs, due to input from storm sewers.

The ratio of fecal coliforms to fecal streptococci in waste water is also indicative of the source of waste. The only species which produces fecal wastes with a fecal coliform/fecal streptococci ratio greater than 1 is man, whose ratio is 4.4. Because fecal streptococci die more quickly than fecal coliforms in fresh water, this ratio tends to increase with time and distance from source. The ratios of fecal coliforms to fecal streptococci, calculated for each station on each sampling trip, are presented in Table 4-2. This ratio is highest at Site 2 (range of 1.0-5.7) and indicates that STPs probably contribute most of the fecal bacteria measured at this site. Downstream of Site 2, the fecal coliform/fecal streptococci ratio is generally less than 1, which probably reflects a large input of animal waste from agricultural operations. This finding corroborates other evidence indicating that a large portion of the microbial contamination in Richland Creek is from non-point sources.

Table 4-2. RATIO OF FECAL COLIFORM TO FECAL STREPTOCOCCI FOR SIX SITES SAMPLED AT RICHLAND CREEK

| DATES | SAMPLING SITES | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| March 26 | - | - | 0.8 | 0.4 | 0.2 | 0.3 |
| April 9 | 1.7 | 5.7 | 0.7 | 0.6 | 1.3 | 0.8 |
| April 23 | 1.0 | 3.0 | 0.7 | 0.6 | 0.1 | 0.3 |
| May 7 | 0.1 | 1.0 | 0.5 | 1.8 | 1.0 | 0.3 |

Illinois General Water Quality Standards, which are applicable to Richland Creek, stipulate that the geometric mean of 5 fecal coliform samples shall not exceed 200 per 100 ml ( Illinois Water Pollution Control Board, 1979). The geometric means of 4 samples taken at each of the six sampling stations on Richland Creek are presented below:

FECAL COLIFORMS (CTS/100 ml)

| Station 1 | Station 2 | Station 3 | Station 4 | Station 5 | Station 6 |
|---|---|---|---|---|---|
| 20 | 263 | 513 | 363 | 288 | 398 |

All sites except Site 1 exceeded the Illinois General Water Quality Standards for fecal coliforms. There is no comparable standard for fecal streptococci. The high microbial levels in Richland Creek and Prairie du Long Creek indicate that contact uses of the water should be discouraged for public health reasons.

## 4.2.2 Benthic Macroinvertebrates

### 4.2.2.1 Background

Benthic macroinvertebrates were sampled on 9 April and 7 May 1980 at each of the six sampling sites according to the methods described in Appendix A-2. Analysis of the benthic macroinvertebrate community is useful in water quality studies because these organisms are differentially sensitive to pollution. The macroinvertebrate community in natural, unpolluted waters is generally characterized by high species diversity, with no taxa numerically dominant over the others. As waters become polluted, the species diversity of the macroinvertebrate community generally decreases as the organisms intolerant of pollution are eliminated and the tolerant species continue to flourish. Benthic fauna are sensitive to a number of water quality parameters, including pH, DO, temperature, total suspended solids, and concentrations of various pollutants.

The effects of organic pollution on many common benthic macroinvertebrates are known, as a result of numerous investigations. This information has been used to classify invertebrates by their pollution tolerance and to develop indices which relate macroinvertebrate community structure to the degree of organic pollution (Beck, 1955). Tolerance of benthic fauna to other forms of pollution, however, is not well documented. Acid mine drainage (AMD) for example, is known to decrease the diversity and abundance of aquatic insect fauna (EPA, 1973b). Yet no classification system exists which ranks these fauna according to their relative tolerance to AMD pollution.

In the present study, macroinvertebrate community structure in relation to water quality of Richland Creek was analyzed after the method used by Hite and King (1974) in their study of the macroinvertebrates of the Richland Creek Basin. The 6 stations sampled in our study were identical to sites sampled in 1974, with exception of our Site 1, which was approximately 1 mile downstream of the corresponding 1974 site. Thus, the results of the 1974 and 1980 sampling efforts can be generally compared. Each taxon identified was categorized as to organic pollution tolerance, using the following criteria from Hite and King, 1974:

- Intolerant: Organisms whose life cycle is dependent upon a narrow range of environmental conditions. They are rarely found in areas of organic enrichment and are replaced by more tolerant species upon degradation of their environment.

- Moderate: Organisms which lack the extreme sensitivity to environmental stress displayed by intolerant species but cannot adapt to severe environmental degradation. Such organisms normally increase in abundance with slight to moderate levels of organic enrichment.

- Facultative: Organisms which display the ability to survive over a wide range of environmental conditions and possess a greater degree of tolerance to adverse conditions than either intolerant or moderate species. The facultative tolerance status also includes all organisms which depend upon surface air for respiration.

- Tolerant: Organisms which not only have the ability to survive over a wide range of environmental extremes, but are generally capable of thriving in water of extremely poor quality and even anaerobic conditions. Such organisms are often found in great abundance in areas of organic pollution.

The total number of organisms in each pollution category was then used to calculate the Macroinvertebrate Community Index (MCI), as used by Hite and King (1974). This index, a modification of Beck's index (1955), weights each group of macroinvertebrates according to sensitivity to organic pollution. The MCI has an advantage over simply noting the presence/absence of organisms of each pollution tolerance category, in that the relative abundance of each category is used. The MCI is thus less susceptible to the error introduced by downstream drift of anomolous taxa. This index is calculated according to the following formula:

$$\text{MCI} = \frac{(I + 0.5M + 0.25F) \times 10}{N}$$

Where: I = Number of intolerant organisms
M = Number of moderate organisms
F = Number of facultative organisms
N = Total number of organisms

The MCI, which has a range of 0-10, can be used to rank waters according to the pollution tolerance of the macroinvertebrate community. A low MCI indicates the presence of relatively few pollution intolerant species while a high value characterizes a community with a large representation of intolerant organisms.

Use of this index as an indicator of water quality has certain limitations, however (EPA, 1973, Freed and Slimak, 1978). First, this technique provides positive evidence only of polluted water because tolerant organisms can be found in both polluted and unpolluted waters. Second, tolerance to organic pollution is not necessarily related to sensitivity to other forms of pollution, and intolerant organisms may be present in waters which are polluted with other than organics. Finally, comparisons between the MCI of different studies are of limited value because of the different conditions under which studies are conducted. Factors such as microhabitats sampled, sampling techniques, and season affect the outcome of macroinvertebrate sampling.

In addition to the MCI, a pollution classification system was used to categorize sampling stations according to the representation of pollution intolerant macroinvertebrates (Hite and King, 1974). In order of decreasing organic pollution, the categories used are balanced, unbalanced, semi-polluted, and polluted aquatic environments. The criteria for each classification are presented in Appendix A-2.

### 4.2.2.2 Analysis of Macroinvertebrate Data

The number of individuals and pollution tolerance status of each taxon collected at the 6 sampling sites are given in Table 3-8. The pollution classification and MCI of each of the 6 stations sampled in 1974 and 1980 are presented in Table 4-3. A graphical representation of the MCI and the percentage of intolerant, moderate, facultative, and tolerant organisms is presented in Figure 4-1. Table 4-3 and Figure 4-1 indicate that in our study, MCI decreased downstream of Site 1, but increased from Site 2 downstream. Site 5, on a tributary of Richland Creek, had a higher MCI than any of the sampling sites on Richland Creek. The same general trend was apparent in 1974, although most sites in 1974 had higher MCI values than in 1980. The following sections describe, in more detail, the macroinvertebrate community characteristics of each site.

At Site 1, the predominant group of macroinvertebrates in the 1980 study was the facultative group, which comprised 60 percent of the organisms collected. The MCI was 3.7 and the area was classified as semi-polluted (10 percent intolerant organisms). The 1974 data, collected at a site upstream of Station 1, had a larger representation of intolerant organisms (32 percent), and had a higher MCI (5.9). Hite and King considered this an unbalanced station. The difference in the findings of 1974 and 1980 may be attributable to an effluent discharge which is located between the two sites, upstream of the site sampled in 1980.

Table 4-3. MACROINVERTEBRATE COMMUNITY INDEX (MCI) AND POLLUTION CLASSIFICATION FOR RICHLAND CREEK SITES SAMPLED IN 1974 (HITE AND KING, 1974), AND 1980

| 1980 STUDY | | | 1974 STUDY | | |
|---|---|---|---|---|---|
| Site Number | Pollution Classification | MCI | Site Number | Pollution Classification | MCI |
| 1 | Semi-polluted | 3.7 | OC-02 | Unbalanced | 5.9 |
| 2 | Semi-polluted | 0.2 | OC-07 | Semi-polluted | 1.4 |
| 3 | Semi-polluted | 1.2 | OC-11 | Semi-polluted | 1.5 |
| 4 | Semi-polluted | 2.0 | OC-13 | Semi-polluted | 3.7 |
| 5 | Unbalanced | 5.3 | OCB-57 | Unbalanced | 4.0 |
| 6 | Semi-polluted | 4.6 | OC-15 | Balanced | 7.5 |

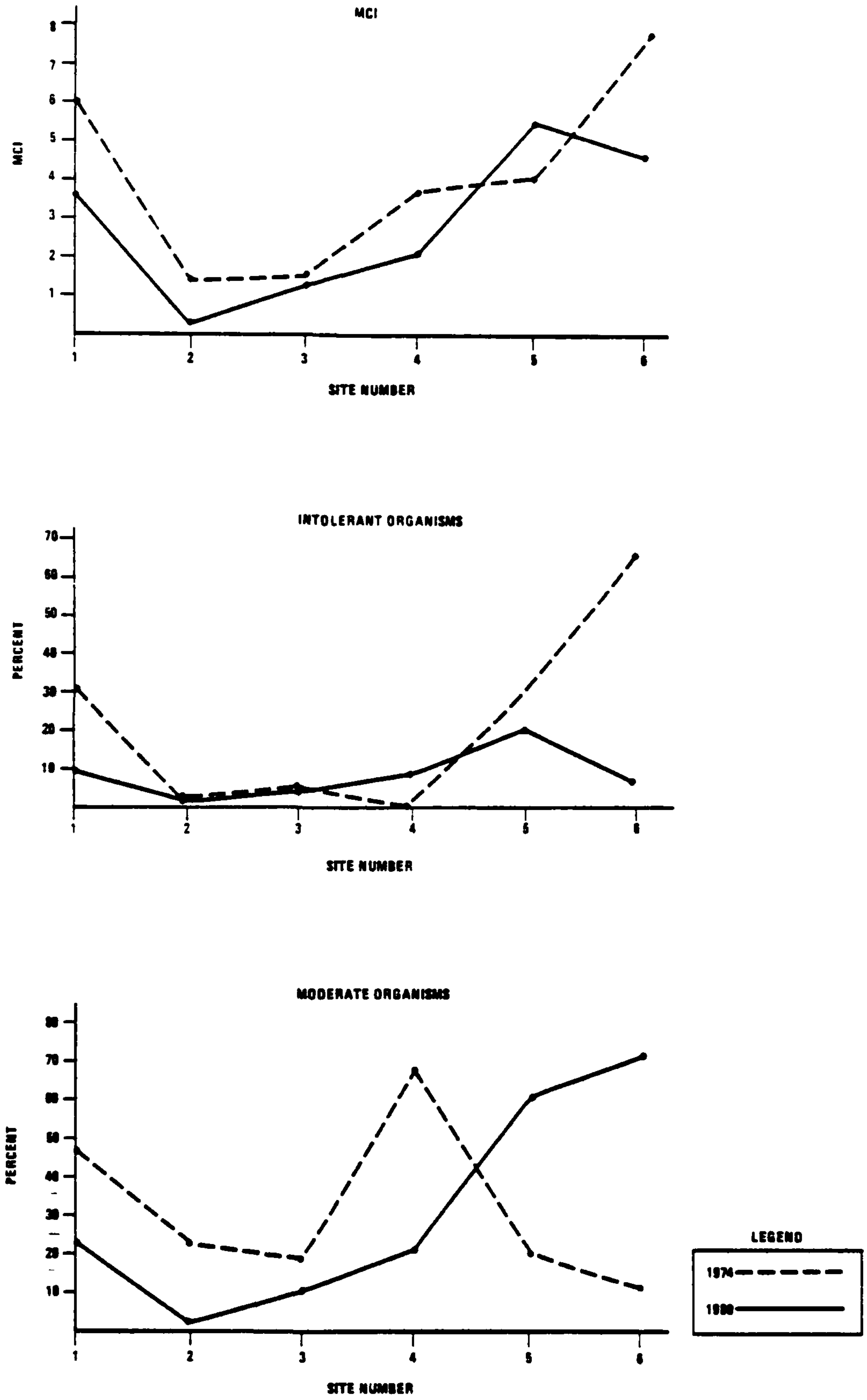

FIGURE 4-1 MACROINVERTEBRATE COMMUNITY INDEX (MCI) AND PERCENT OF TOTAL NUMBER OF INDIVIDUALS BY POLLUTION TOLERANCE STATUS IN 1974 AND 1980– RICHLAND CREEK BASIN

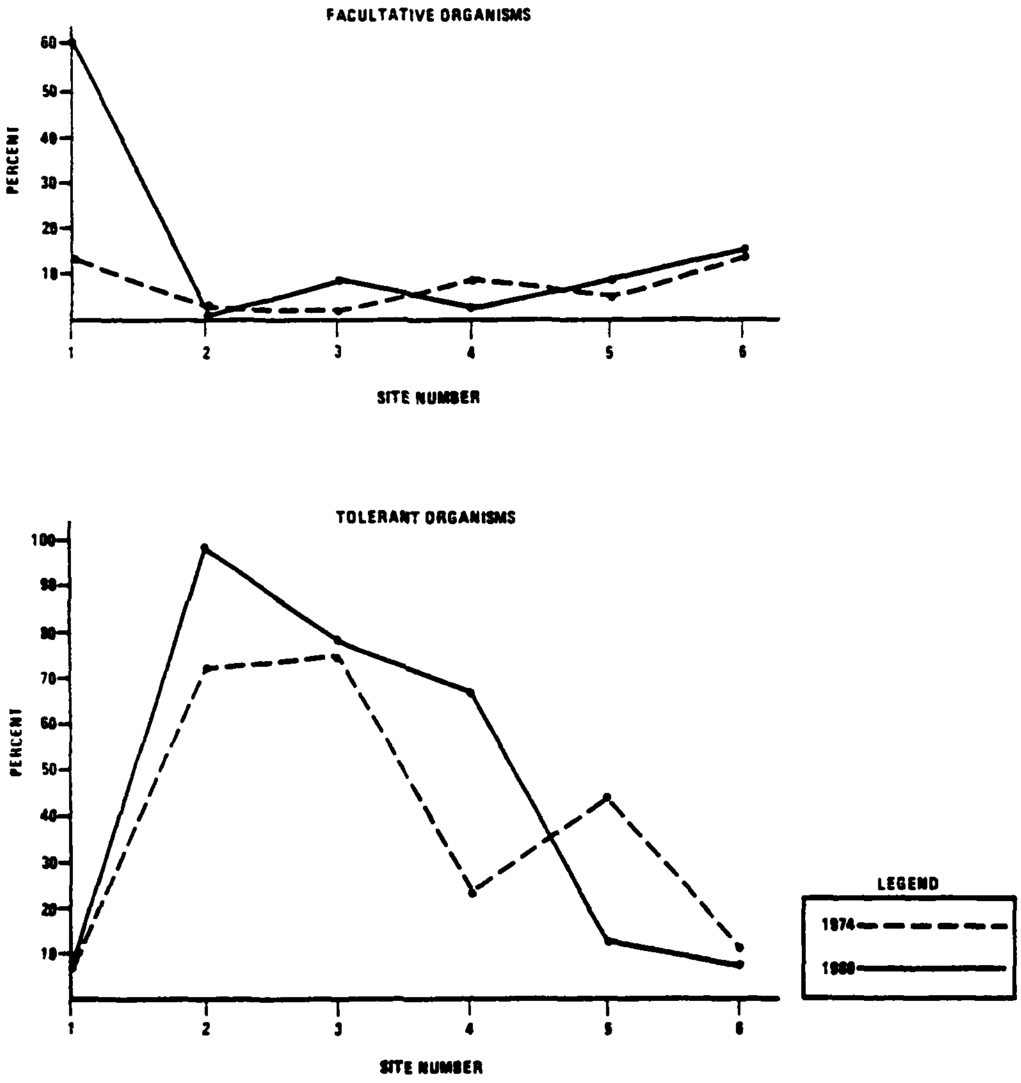

FIGURE 4-1 (CON'T) MACROINVERTEBRATE COMMUNITY INDEX (MCI) AND PERCENT OF TOTAL NUMBER OF INDIVIDUALS BY POLLUTION TOLERANCE STATUS IN 1974 AND 1980– RICHLAND CREEK BASIN

Site 2 appeared to be the most polluted of the 6 sites sampled in both 1974 and 1980. In this study only 2 percent of the macroinvertebrates collected at this site were considered intolerant, while 97 percent were classified as tolerant. The MCI was 0.2 and the stream was categorized as semi-polluted. The macroinvertebrate community structure, as determined by MCI and percentage of intolerant organisms, was similar in 1974. The relatively high organic pollution in this area of Richland Creek is probably due to effluent discharge from the Swansea STP, upstream.

In both 1974 and 1980, the section of Richland Creek in the vicinity of Site 3 was classified as semi-polluted, with 5-6 percent of the macroinvertebrates considered intolerant, a slight improvement over Site 2. The MCI for this site in 1980 was 1.2, similar to the value calculated in 1974. In both studies, the tolerant organisms were dominant (75-78 percent).

The water quality of Richland Creek appeared to improve between Sites 3 and 4, probably due to addition of waters of relatively high quality by Douglas Creek and West Fork Richland Creek. The MCI at Site 4 was 2.0 in this study, and the 9 percent representation of intolerant organisms classified this station as semi-polluted. Tolerant organisms made up 67 percent of the macroinvertebrates collected. Hite and King (1974) also classified this stream segment as semi-polluted. No intolerant taxa occurred in their collection, which was dominated by moderate organisms (69 percent). The data suggest that since 1974 there has been a proportional increase in both tolerant and intolerant organisms and a decrease in moderate taxa.

Site 5, on Prairie du Long Creek (a tributary of Richland Creek), had the highest MCI value (5.3) of the 6 stations sampled in 1980 and was the only station classified as unbalanced in this study, with intolerant and moderate organisms representing 20 and 61 percent of the macroinvertebrates, respectively. The 1974 MCI was lower (4.0) due to the presence of fewer moderate organisms. Despite the absence of point sources of pollution on this creek, Prairie du Long was expected to be unbalanced because it is an intermittent stream (Hite and King, 1974).

In the present study, the MCI at Site 6 was 4.6; higher than any other station sampled on Richland Creek, but lower than the Prairie du Long sampling site. Seven percent of the macroinvertebrates collected were intolerant, categorizing this site as semi-polluted. Moderate organisms dominated the community, representing 73 percent of the collection. In 1974 this site was among the least polluted of the 65 sites sampled in the Richland Creek Basin, and was classified as balanced by Hite and King. The MCI was 7.5 and 65 percent of the macroinvertebrates were intolerant.

### 4.2.3 Summary of Biological Data

The 1980 biological sampling effort in the Richland Creek Basin indicates that, according to the classification scheme of Hite and King (1974), most of this creek is semi-polluted. The only sampling site where more than 11 percent of the macroinvertebrates were intolerant was on a tributary of Richland Creek. Degradation occurred between Sites 1 and 2. The macroinvertebrate data suggest that water quality improves gradually downstream of Station 2. The proportion of intolerant organisms, however, did not steadily increase in the downstream direction. Sites 1 and 4 had the highest percentage of intolerant organisms (10 percent and 9 percent, respectively). Concentrations of fecal coliforms and fecal streptococci did not decrease in the downstream direction and fecal coliforms exceeded the State standards at all sites except Site 1. The noticeable increase in fecal coliforms and fecal streptococci during periods of higher flow suggest that non-point sources contribute significantly to microbial contamination of Richland Creek.

MCI, percentage intolerant macroinvertebrates, and stream pollution classification were generally higher in 1974 than in 1980. There findings, however, do not necessarily indicate that water quality has deteriorated since 1974, because other factors may have contributed to differences in the results of the two studies. Of special consideration in the comparison of these studies is the difference in sampling seasons. Our data were collected in April and May while all of the 1974 data were collected in June or July, except for Site 5, which was collected in April.

## 4.3 SUMMARY OF EXISTING CONDITIONS IN RICHLAND CREEK

Richland Creek currently exhibits water quality problems characteristic of random, unplanned human influence. A chronic flooding problem exists in the urban area due to unplanned development of the flood plain. This is further complicated by acid mine drainage (AMD) in the headwaters, sewage treatment plant (STP) discharges in the Belleville area, and agricultural runoff in the lower part of the basin. Together, these problems result in relatively poor water quality which violates several of the Illinois Water Pollution Regulations and severely reduces the biological integrity of the stream.

Site 1 is severely affected by the acid mine drainage occurring in the headwaters. This results in low pH values, high sulfate concentrations, and high concentrations of iron, manganese, and zinc. Some of these effects appear to be intermittent, depending upon flow conditions, presence of runoff, and related factors. During periods when acid mine effects are absent, the site is capable of supporting a more diverse macroinvertebrate fauna, perhaps enhanced by downstream drift from unaffected tributaries upstream. This suggests that the site would support a healthy biota if the acid mine drainage were eliminated. Concentrations of fecal coliforms and fecal streptococci at Site 1 are the lowest of the 6 sampling stations and do not violate State Standards.

Site 2, lcoated in the urban area of Belleville, is degraded by sewage discharges from the Swansea STP and several smaller sewage discharges in Belleville. These discharges result in the highest ammonia and total Kjeldahl nitrogen levels observed in Richland Creek during this study. During low flows, the effects of acid mine drainage are still quite noticeable at Site 2, with elevated concentrations of iron, manganese, zinc, and sulfate; and depressed pH. Much of the stream segment between Sites 1 and 2 receives urban runoff during storm events.

Biological quality at Site 2 is the poorest of the six stations due to the chronic organic pollution and intermittent acid mine effects. The few macroinvertebrate taxa present are generally pollution tolerant. The geometric mean fecal coliform count at this station exceeds the Illinois Standards, and the ratio of fecal coliform to fecal streptococci suggests that the origins of this pollution are STP discharges. Aesthetic quality at this site is also degraded by the presence of large quantities of discarded rubbish.

Site 3, although located in a rural area, is the first site downstream of Belleville STPs 1 and 3. The effects of these additional sewage discharges are noticeable in that this site has the highest nutrient loading of the six sites in the study. High concentrations of all the nitrogen and phosphorus parameters were measured at this site. Agricultural runoff during storm events may also contribute to this nutrient loading.

Site 3 has the highest geometric mean fecal coliform count, perhaps attributable to both the sewage discharges and agricultural runoff. The ratio of fecal coliforms to fecal streptococci suggests that the agricultural contribution is high. Some improvement in biological quality is apparent at this site as evidenced by the reappearance of moderate numbers of pollution intolerant organisms.

Site 4 is also located in a predominantly agricultural area. Fecal coliforms and fecal streptococci are present in large numbers, in a ratio suggestive of animal origin, and the highest mean nitrate concentration was observed at this site. These observations may be accounted for by agricultural runoff, which is probably also responsible for the noticeable increase in suspended solids at this site. Biological quality shows improvement; the largest number of intolerant organisms for the main stem of Richland Creek occurs at this site.

Site 5, Prairie du Long Creek, is a major tributary of Richland Creek. This site has better water quality than any of the 5 sites along the main stem of Richland Creek. Prairie du Long Creek flows through an agricultural area for most of its length, a fact which probably accounts for the high fecal streptococci and fecal coliform counts (again in excess of the Illinois Standards), and the low fecal coliform/fecal streptococci ratio. The suspended solids concentrations at this site were roughly equivalent to those at Site 4 on the main stem of Richland Creek. This again may be due to erosion of cropland. Moderately high concentrations of iron were observed at this site, possibly indicating the presence of acid mine drainage or runoff from mine gob piles in the headwaters.

Biological integrity was highest at this site, which had the highest percentage of intolerant organisms and the highest MCI of the 6 sites sampled.

Site 6 is located in a heavily wooded stretch of Richland Creek downstream of the agricultural areas of Sites 3 and 4. This site is characterized by high concentrations of both total suspended solids and volatile suspended solids. The erosion and agricultural runoff upstream of this site are the most probable causes of this increase. Turbidity is quite high also, as would be expected in this case. The highest iron concentration occurred at this site, though this fact is difficult to explain. The highest total suspended solids concentrations at Site 6 occurred concurrently with the high iron concentration, which implies that iron deposits within the sediments could have been released by scouring of the stream bed. Since iron was measured as total metal (as opposed to dissolved), the addition of acid preservative to the sample would have solubilized the iron bound to the suspended sediments.

Biological samples at Site 6 had fewer intolerant organisms than Sites 3,4, and 5, but more than the upstream Sites 1 and 2. The increased sediment load at this site may smother many organisms by clogging the gills. Also, the presence of the heavy forest cover and the increased turbidity reduce the amount of light in the water column at this site, probably lowering the primary productivity of photosynthetic organisms. This, in turn, may reduce the available food supply of some benthic macroinvertebrates. The highest fecal streptococci counts occurred at this site and fecal coliforms exceeded the Illinois Standards. The low ratio of fecal coliforms to fecal streptococci indicate that their source is predominantly agricultural.

This section has presented a brief synopsis of present stream conditions and problems at each of the sites along Richland Creek evaluated during this study. The next section (4.4) discusses these conditions and problems in relation to various flood control alternatives.

## 4.4 EFFECTS OF VARIOUS FLOOD CONTROL ALTERNATIVES

Six alternative plans to reduce the flood hazard of Richland Creek in the Belleville area have been considered. These six plans are:

(1) Channel improvement within the City of Belleville

(2) Richland Creek Dam

(3) Combination of Richland Creek Dam and Belleville channel improvement

(4) Establishment of a "greenbelt" corridor through Belleville

(5) Non-structural measures , i.e., regulating floodplain development

(6) No action

This section will discuss the possible impacts of each of these alternatives on Richland Creek water quality in the context of the existing stream conditions.

The segment of Richland Creek which flows through the City of Belleville and is responsible for flood damage within the city is approximately three miles long. The proposed channel improvements involve removal of 5 feet from each side of the stream. This would effectively deepen the stream by 5 feet and widen it by 10 feet. The proposed channel improvement would provide sufficient capacity to contain the 10-year frequency flood.

A number of adverse impacts are possible if this channelization is chosen. The soils in the area are predominantly in the Wakeland series and have poor stability. Such soils are not suitable for embankments and slumping could be a serious problem. In addition, some dense forest occurs along the three mile stretch of Richland Creek within Belleville. This unique wildlife habitat within the city would be largely destroyed as a result of the dredging activity.

The aquatic habitat within the stream would also be destroyed for an indefinite period of time. Although this stream habitat within Belleville is of poor quality and does not represent an important natural resource, the increased sediment load of the stream resulting from the dredging activity would adversely affect the more productive habitat downstream. Sediment discharge will decrease after construction, but sedimentation may persist at higher than normal levels for a number of years as the stream channel adjusts to new flow regimes (Yorke, 1978). The predominance of the Wakeland series soil in this area, which has a tendency to slump, will aggravate this problem.

Increased sediment discharges associated with dredging are of special concern in Richland Creek because downstream concentrations of suspended solids are already very high.

Another possible adverse impact of channelization in this area results from the presence of sewage discharges. The disturbance of organic bed material and the release of nutrients may increase the biochemical oxygen demand and cause oxygen deficiencies downstream. This problem could be further magnified by the increase in water temperature often associated with channel widening. This temperature increase results from increased water surface area, reduced velocity, and increased solar radiation caused by removal of streambank vegetation.

Another impact which could have serious consequences downstream is that an improved channel will cause floodwaters to move quickly through the enlarged portion of the channel and concentrate at some point downstream where the channel narrows. This has the effect of moving the flood damage downstream to a new area. Flooding problems have occurred previously in Richland Creek along the agricultural areas and this factor must be weighed against the benefit of decreased flood damage within the urban area.

Furthermore, channelization could reduce the base flow from ground-water discharge in the area. As a result, during low flows, Richland Creek would be composed predominantly of STP effluent, accentuating DO problems and eutrophication that has occurred in the past.

The second flood control alternative considered for Richland Creek involves the construction of a 180 acre reservoir in the headwaters region. The proposed reservoir would be constructed upstream of Site 1 and would serve to retain some of the waters resulting from storm events.

Most of the area which would be flooded by this reservoir consists of dense bottomland forest having a significant habitat value for wildlife. Flooding would eliminate this habitat and replace it with a deep water aquatic habitat. If the water quality is suitable for aquatic organisms, the new deep water habitat and the edge habitat at the water-woodland interface might have greater benefit.

The important question here relates to the water quality of the proposed reservoir. As shown in this study, the headwaters of Richland Creek are severely impacted by acid mine drainage. The same negative impacts presently experienced in the lotic habitat could occur in the lentic habitat created by the reservoirs. Indeed, flooding of this area could magnify the problem by continually increasing the contact between water and acid mine materials. Moreover, careful study would be required to ensure that the reservoir would not be undermined by abandoned mines or that limestone underlying the reservoir would not dissolve, either of which could have serious structural consequences.

Other structural problems may arise due to the nature of the soils in the area. As mentioned in regard to the channelization alternative, the predominant soil type in the area is the Wakeland series. The Alford series also occurs within the area of the proposed reservoir. Both of these soil types have poor structural qualities. This would present problems in the construction and operation of the dam.

These structural problems are further magnified by the fact that the proposed dam is in a zone of moderate earthquake damage (on the Modified Mercalli Scale). The poor structural qualities of the area soils and the potential for earthquake damages would necessitate special design criteria.

Reservoirs designed for flood control usually smooth out the flow variability of a stream. Throughout most of the year, moderate flows would occur. This could reduce the effects of scouring downstream and lessen some of the related problems such as the transport of iron-containing sediments and the overall high sediment load currently experienced in Richland Creek.

The third flood control alternative consists of a combination of the stream channelization within the City of Belleville, and the construction of the upstream reservoir. The impacts and benefits of this alternative would be a combination of those previously described for the individual impacts. The principal benefit of this option lies in the fact that this combination would allow the flow from the 100-year storm event to be contained within the channel without overbank flooding.

A potential problem could occur if the reservoir discharge were taken from the top layer of water. The upper layer of water in a reservoir typically increases in temperature during the warmer seasons. Combined with the warming effect of the wider channel, this could produce significantly elevated temperatures downstream in Richland Creek. If the elevated temperatures occurred in areas with organic enrichment, serious oxygen sags could occur.

The fourth flood control alternative involves the establishment of a "greenbelt" corridor within the City of Belleville. This would involve purchase of property along the flood plain area and the establishment of a minimum damage floodable area. Such an area could become an elongated park of approximately 250 acres along Richland Creek within the City of Belleville. In view of the fact that this alternative represents an essentially natural condition, few, if any, adverse environmental impacts would be anticipated. The principal problem with this alternative lies in the cost of acquiring the land required to establish the "greenbelt" corridor.

The fifth flood control alternative is a non-structural option involving floodplain regulations. This alternative would attempt to discourage development within the flood plain and/or require that structures built within the floodplain be flood resistant. This alternative does not eliminate the potential hazard to existing structures. The benefits of this alternative, while similar to those associated with the establishment of a "greenbelt", would become available only over a long term, as existing structures were abandoned or upgraded to flood resistant types. In some respects this alternative also resembles the sixth alternative, that of no action.

The alternative of no action would allow the existing problems to continue and quite probably magnify. As the population of the urban area increases, problems resulting from sewage discharge, urban runoff, and extensive development of the flood plain will increase. As shown in this study, Richland Creek is already severely degraded in many areas and the expected magnification of current problems will result in continued poor water quality.

# 5.0 RECOMMENDATIONS

The recommendations presented in this section are based on consideration of the relationships between present water quality, land-use, and flood control alternatives in the Richland Creek Basin. Recommendations designed to improve the water quality in Richland Creek are first discussed. These measures, for the most part, could be implemented regardless of the flood control alternative chosen. Recommendations regarding choice of flood control alternatives are then presented. The six flood control alternatives discussed in Section 4.4 are ranked according to their expected impacts on water quality in Richland Creek.

## 5.1 RECOMMENDATIONS ON WATER QUALITY IMPROVEMENT IN RICHLAND CREEK

The findings of this study indicate that there are three major sources of water quality degradation in Richland Creek: acid mine drainage (AMD), sewage treatment plants (STPs), and non-point source pollution from agricultural runoff. Significant improvement in the water quality of this creek can be achieved if measures are taken to control these sources of pollution.

The effects of AMD can be reduced by controlling the infiltrating water and/or controlling erosion from tailings (EPA, 1976b). Among the available techniques for infiltration control are installation of surface blankets, surface water diversion, ground water diversion, removal of tailings from the water course, and diversion of polluted discharge. New techniques are also being developed to treat AMD in order to precipitate out heavy metals and to backfill mines with inert material or tailings. Further study would be necessary to determine the best plan for control of AMD in Richland Creek.

As stated previously, the STPs on Richland Creek degrade water quality in a number of ways. The microbial contamination, low dissolved oxygen levels, and high nutrient levels associated with the STPs could be reduced by increasing the sewage treatment capacity and/or diverting storm sewers from STPs in the Belleville-Swansea area.

The degradation of Richland Creek by agricultural sources could be ameliorated only by widespread adoption of measures designed to control erosion, sedimentation, and runoff. Minimum cultivation techniques, vegetational buffers between fields and stream banks, and contour plowing would reduce the microbial contamination, suspended solids, nutrients, and turbidity in the lower Richland Creek Basin.

## 5.2 RECOMMENDATIONS ON FLOOD CONTROL ALTERNATIVES IN RICHLAND CREEK

From the perspective of water quality, the greenbelt alternative (Alternative 4 in Section 4.4) is recommended as the flood control plan which would cause the fewest environmental impacts. As discussed in Section 4.4, this plan would preserve and enhance existing terrestrial, fish, and benthic habitat, while protecting the City of Belleville from the 100-year flood. In the long run, the reduction of flood damages by flood plain regulation (Alternative 5) might achieve the same goals as the greenbelt alternative. The success of this strategy, however, would be dependent on the effectiveness of the regulations implemented.

The flood control alternative involving a dam in the northern portion of Richland Creek (Alternative 2) is ranked second to the greenbelt alternative in its expected impact on water quality. Although the dam would destroy some terrestrial and lotic aquatic habitat, these impacts might be mitigated by the beneficial effects on downstream water quality. The reservoir would augment the stream flow during periods of low base flow, thus reducing the relative effects of STP discharges on water quality. Properly placed water outlet ports could provide for the release of water from the best level in the reservoir (in terms of water quality). Finally, it might be possible to treat reservoir waters with sodium hydroxide, lime, or some other base or buffer, thus reducing the acidity. Although costly, this latter measure would significantly mitigate the effects of AMD on Richland Creek and if implemented, might make the dam the best choice for flood control from the perspective of water quality.

Alternative 3, consisting of a dam in conjunction with channelization of Richland Creek in Belleville, would be preferable to channelization alone (Alternative 1), both in terms of flood protection and water quality. A dam upstream of the channel would mitigate the adverse impacts of channelization (Section 4.4), because the dam would moderate the hydrograph. The unfavorable effects of channelization during low base flows would be offset by the release of water from the dam. Similarly, the dam would reduce the maximum flood stage in Belleville, thus reducing the sedimentation downstream of the channel.

Finally, the least desirable flood control alternatives are no action (Alternative 6) and channelization (Alternative 1). No action, however, would be preferable to channelization because the water quality of Richland Creek would not be affected if no flood control measures were taken. Channelization, while protecting Belleville from the 10-year storm, would contribute to further degradation of water quality in Richland Creek, as discussed in Section 4.4.

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# APPENDIX A

Part I:   PHYSICAL AND CHEMICAL METHODS

Part II:  BIOLOGICAL METHODS

# APPENDIX A - Part I

## PHYSICAL AND CHEMICAL METHODS

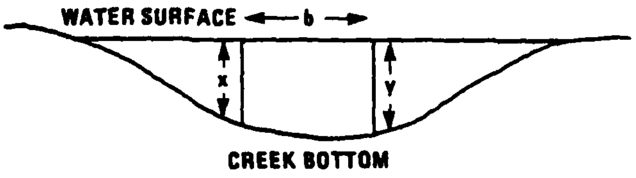
### A-1.1 PARAMETERS MEASURED IN THE FIELD

Air and water temperature, specific conductance, pH, dissolved oxygen, and flow were measured in the field. Table A-1 shows the makes and model numbers of the instruments used for these measurements.

Table A-1. MEASUREMENT OF PHYSICAL AND CHEMICAL PARAMETERS IN THE FIELD

| Parameter | Make | Model |
|---|---|---|
| Air Temperature<br>Water Temperature<br>Specific Conductance | Yellow Springs Instruments | SCT 33 |
| pH | Cole Parmer | Digi-Sense 5985-20 |
| Dissolved Oxygen | Yellow Springs Instruments | 54 A |
| Flow | Marsh-McBirney | 201 |

Flow (cfs) was estimated at each sampling site in the following manner. Depending on the width and bottom topography of the creek, water velocity measurements were taken at 3 to 12 locations along a cross-section of the creek. At each of these locations, the velocity was measured at 1 or 2 depths, depending on the overall depth of the water column. A single measurement was taken at 6/10 of depth of the water column (measured from the surface) where the water column was less than 3 feet. Where the water depth was greater than 3 feet, velocity measurements were made at 2/10 and 8/10 of the depth (measured from the surface). The area of each cross-sectional cell (delineated by water surface, bottom, and sounding sites) was estimated, as shown below.



$$\text{AREA (FT}^2\text{)} = \tfrac{1}{2}b\,(x+y)$$

The average velocity for each cross-sectional cell was calculated as the arithmetic mean of the 2 to 4 velocity measurements, except for cross-sectional cells that were bordered on one side by the creek bank (where the velocity would be zero). For these cells the average velocity was calculated as 7/10 of the mean velocity at the side closest to the center of the creek. Finally, flows of all cross-sectional cells were summed to obtain an estimate of the flow through the whole cross-section of the creek.

### A-1.2 PARAMETERS ANALYZED IN THE LABORATORY

The parameters listed in Table A-2 were analyzed in the laboratory following the protocol recommended by EPA (1979a) and The American Public Health Association (1976). Laboratory analysis of PCBs followed the procedure outlined by EPA (1979b). Carbon dioxide was calculated from other parameters by the nomographic method (Am. Pub. Health Assoc., 1976).

## Table A-2. PHYSICAL AND CHEMICAL PARAMETERS ANALYZED IN THE LABORATORY

| Parameter | Method |
|---|---|
| Dissolved Orthophosphate | Manual colorimetric, ascorbic acid |
| Total Phosphorus (TP) | Persulfate digestion followed by manual colorimetric |
| Ammonia ($NH_3$-N) | Automated colorimetric phenate |
| Total Kjedahl Nitrogen (TKN) | Manual digestion followed by automated colorimetric |
| Nitrite ($NO_2$) | Automated colorimetric method |
| Nitrate ($NO_3$) | Automated cadmium reduction |
| Chemical Oxygen Demand (COD) | Titrametric |
| Hardness | Titrametric, EDTA |
| Total Dissolved Solids (TDS) | Gravimetric |
| Total Suspended Solids (TSS) | Gravimetric |
| Volatile Suspended Solids (VSS) | Gravimetric |
| Chloride (Cl) | Titrametric, mercuric nitrate |
| Sulfate ($SO_4$) | Automated colorimetric, methylthymol blue |
| Total Alkalinity | Potentiometric titration |
| Turbidity | Nephelometric |
| Iron (Fe) | Flame atomic absorption (AA) |
| Mercury (Hg) | Cold vapor AA |
| Copper (Cu) | Flame AA |
| Lead (Pb) | Flame AA |
| Manganese (Mn) | Flame AA |
| Cadmium (Cd) | Flame AA |
| Arsenic (As) | Furnace AA |
| Zinc (Zn) | Flame AA |

## APPENDIX A - Part II

## BIOLOGICAL METHODS

### A-2.1 FECAL COLIFORMS AND FECAL STREPTOCOCCI

Procedures outlined in Standard Methods for the Examination of Water and Wastewater, 14th Edition (American Public Health Association, 1976), were followed in the quantitative analysis of fecal coliform and fecal streptococci, with one exception. The holding time of samples prior to analysis was as much as 24 hours, which exceeded the recommended 6-hour period. Since the samples were refrigerated, and since water temperatures of the samples were initially low, the extended holding time probably had little effect on the results.

### A-2.2 MACROINVERTEBRATES

Macroinvertebrates were collected by dip nets and Surber nets at each of the 6 sampling sites on 9 April and 7 May 1980. An attempt was made to exhaustively sample each type of aquatic habitat represented at each sampling site. Sampling was not terminated until 10 minutes after no new taxa appeared in the collections. The macroinvertebrates were preserved in ethanol in the field.

At Versar, the macroinvertebrates were identified, using Pennak (1979), and counted. A pollution tolerance category was assigned to each taxa, using the criteria outlined in Section 4.2.2.1 and previous classifications according to Hite and King (1974). Data from both sampling trips were pooled for each sampling site and used to calculate the macroinvertebrate community index (MCI) (see Section 4.2.2.1).

Finally, each sampling site was assigned a pollution classification according to the Illinois Environmental Protection Agency Environmental Classification (Hite and King, 1974). These pollution categories are explained below:

- Balanced Environment: Intolerant organisms are many in number and species, or more in numbers than other forms present.

  Intolerant present = >50%

  Moderate, Facultative and Tolerant
  usually present = ≤50%

- Unbalanced Environment: Intolerant organisms are less in number than other forms combined, but combined with moderate forms, they usually outnumber tolerant forms.

  Intolerant present = $\leq 50\%$ but not $<11\%$

  Moderate, Facultative and Tolerant usually present = $\geq 50\%$

- Semi-polluted Environment: Intolerant organisms are few or may not be present. Moderate and/or facultative organisms present.

  Intolerant present = $\leq 10\%$

  Moderate, Facultative and Tolerant usually present = $\geq 90\%$

- Polluted Environment: Intolerant organisms absent, only tolerant organisms present or no organisms present.

  Tolerant present = 100%*

- Natural or Artificial Bare Area

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*Organisms which are not adapted to inhabit a polluted environment are occasionally collected as a result of drift and are not representative.

# APPENDIX B

Part I: PHYSICAL CHARACTERISTICS OF INDIVIDUAL STREAM SITES

Part II: CUMULATIVE DATA FOR INDIVIDUAL SAMPLING BATCHES

# APPENDIX B - Part I

## PHYSICAL CHARACTERISTICS OF INDIVIDUAL STREAM SITES

### SITE No. 1

Bed Substrate: Course sand, yellowboy (acid mine)
Precipitate observed

Bank Description: Eroding fringe woodland bank
Concrete bridge abutment on each stream bank

Channel Geometry: U-shaped channel

Highest flow observed - 4.35 m wide
0.3 m maximum depth

Lowest flow observed - 2.2 m wide
0.38 m maximum depth

### SITE No. 2

Bed substrate: Cobble, covered with *Sphaerotilus* bacteria
Riffle habitat

Bank Description: Weeded banks in urban setting
Channel separated under bridge by concrete abutments

Channel Geometry: Flat bottom channel, gradual sloping banks
Channel abraded past bridge abutments

Highest flow observed - 2.4 m wide
0.27 m maximum depth

Lowest flow observed - 2.19 m wide
0.15 m maximum depth

### SITE No. 3

Bed Substrate: Sandy, silty, some organic litter, some small rocks, log jams up and down stream
Depositing zone

Bank Description: Unvegetated banks, covered with recently deposited silt, V-shaped banks, several large erosion gullies, concrete abutments on both banks, bordered by fields

Channel Geometry: V-shaped channel

Highest flow observed - 6.9 m wide
0.7 m maximum depth

Lowest flow observed - 4.2 m wide
1.05 m maximum depth

### SITE No. 4

Bed Substrate: Sandy, silty, some organic litter, some small rocks, log jams up and down stream
Depositing zone

Bank Description: Rooted emergent aquatic vegetation, covered with recently deposited silt, gradual slope, U-shaped bank, concrete bridge abutments on both banks, bordered by fields

Channel Geometry: U-shaped channel

Highest flow observed - 7.2 m wide
0.78 m maximum depth

Lowest flow observed - 6.6 m wide
0.6 m maximum depth

### SITE No. 5

Bed Substrate: Sandy, silty, some rocks, log jams up and down stream, depositing zone

Bank Description: Steep grassy banks, some rooted emergent vegetation, large erosion gullies under bridge abutments on both banks, bordered by fringe woodland and open field

Channel Geometry: Steep V-shaped channel

Highest flow observed - 4.4 m wide
1.4 m maximum depth

Lowest flow observed - 3.3 m wide
0.7 m maximum depth

### SITE No. 6

Bed Substrate: Sandy, silty, log jams up and down stream,
Depositing zone, some large rocks, some refuse

Bank Description: Covered with recently deposited silt, slightly eroding, U-shaped banks with gradual slope, refuse observed, woodland bank, organic litter

Channel Geometry: U-shaped channel

Highest flow observed - 13.9 m wide
2.5 m maximum depth

Lowest flow observed - 10.6 m wide
1.8 m maximum depth

## APPENDIX B - Part II

## CUMULATIVE DATA FOR INDIVIDUAL SAMPLING BATCHES

## GENERAL CHEMISTRY PARAMETERS (mg/l)

SAMPLE BATCH NO. 1
(Sampled 26 March 1980)

| Site No. | Dissolved Ortho-Phosphate | TP | $NH_3$-N | TKN | $NO_2$ | $NO_3$ | COD | Hardness | TDS | TSS | VSS | Cl | $SO_4$ | Total Alkalinity | Turbidity* (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.09 | 0.07 | 0.29 | 0.6 | <0.05 | 1.44 | 12. | 392. | 590. | 22. | 3. | 28. | 360. | 49. | 50. |
| 2 | 0.02 | 0.28 | 0.84 | 2.2 | <0.05 | 1.35 | 16. | 390. | 580. | 12. | 4. | 46. | 280. | 113. | 22. |
| 3 | 0.34 | 0.50 | 0.85 | 2.1 | 0.18 | 3.25 | 18. | 424. | 650. | 18. | <2. | 65. | 290. | 158. | 14. |
| 4 | 0.34 | 0.50 | 0.78 | 2.6 | 0.15 | 3.47 | 31. | 362. | 570. | 46. | 4. | 52. | 240. | 151. | 22. |
| 5 | 0.05 | 0.25 | 0.34 | 1.4 | <0.05 | 2.79 | 24. | 234. | 360. | 46. | 3. | 16. | 120. | 157. | 48. |
| 6 | 0.19 | 0.64 | 0.47 | 1.6 | 0.05 | 2.67 | 22. | 272. | 560. | 66. | 5. | 32. | 180. | 146. | 40. |
| Method Detection Limit | 0.02 | 0.02 | 0.05 | 0.1 | 0.05 | 0.05 | 5. | 1. | 20. | 2. | 2. | 1. | 10. | 1. | 1. |

*Turbidity in Nephelometric Turbidity Units (NTU).

METALS (mg/l)

SAMPLE BATCH NO. 1
(Sampled 26 March 1980)

| Site No. | As | Cd | Cu | Fe | Pb | Mn | Hg | Zn |
|---|---|---|---|---|---|---|---|---|
| 1 | <0.005 | <0.005 | <0.05 | 8.37 | <0.1 | 2.74 | <0.0005 | 0.239 |
| 2 | <0.005 | <0.005 | <0.05 | 3.03 | <0.1 | 1.93 | <0.0005 | 0.135 |
| 3 | <0.005 | <0.005 | <0.05 | 1.26 | <0.1 | 1.03 | <0.0005 | 0.068 |
| 4 | <0.005 | <0.005 | <0.05 | 1.33 | <0.1 | 0.75 | <0.0005 | 0.053 |
| 5 | <0.005 | <0.005 | <0.05 | 1.10 | <0.1 | 0.27 | <0.0005 | <0.005 |
| 6 | <0.005 | <0.005 | <0.05 | 1.17 | <0.1 | 0.57 | <0.0005 | 0.023 |
| Detection Limit | 0.005 | 0.005 | 0.05 | 0.05 | 0.1 | 0.05 | 0.0005 | 0.005 |

## PHYSICAL PARAMETERS

SAMPLE BATCH NO. 1
(Sampled 26 March 1980)

| Site No. | Air Temp (°C) | Water Temp (°C) | Dissolved Oxygen (mg/l) | pH | $CO_2$ (mg/l) | Est. Flow (cfs) | Specific Conductance (µmho) | Fecal Coliform (Colonies/100 mls) | Fecal Streptococci (Colonies/100 mls) | PCBs (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 6 | 14.5 | 5.6 | 280 | * | 470 | * | * | <0.5 |
| 2 | 14 | 8 | 10.3 | 6.4 | 90 | * | 600 | 10** | 5** | |
| 3 | 15 | 10 | 11.9 | 5.2 | 2,200 | * | 800 | 800 | 990 | <0.5 |
| 4 | 14 | 10 | 9.8 | 5.1 | 2,200 | * | 650 | 140 | 325 | |
| 5 | 10 | 7 | 12.4 | 7.8*** | 5.7 | * | 370 | 163 | 860 | |
| 6 | 8 | 10** | 11.9 | 7.7*** | 6.1 | * | 480 | 285 | 920 | <0.5 |

*Data Not available.

**Estimated.

***pH measured in lab not more than six (6) hours after sampled.

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## GENERAL CHEMISTRY PARAMETERS (mg/l)

SAMPLE BATCH NO. 2
(Sampled 9 April 1980)

| Site No. | Dissolved Ortho-Phosphate | TP | $NH_3$-N | TKN | $NO_2$ | $NO_3$ | COD | Hardness | TDS | TSS | VSS | Cl | $SO_4$ | Total Alkalinity | Turbidity* (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | <0.02 | 0.05 | 0.29 | 0.6 | <0.05 | 1.71 | 36. | 351. | 540. | 35. | 4.2 | 25. | 290. | 59. | 35. |
| 2 | 0.02 | 0.28 | 1.05 | 2.1 | <0.05 | 1.52 | 35. | 336. | 510. | 20. | 5.6 | 5. | 220. | 115. | 15. |
| 3 | 0.33 | 0.50 | 0.73 | 2.0 | <0.05 | 3.30 | <5. | 403. | 580. | 80. | 7.4 | 9. | 290. | 130. | 30. |
| 4 | 0.22 | 0.23 | 0.91 | 1.9 | <0.05 | 2.04 | 11. | 289. | 470. | 272. | 26.0 | 25. | 190. | 103. | 165. |
| 5 | 0.03 | 0.12 | 0.36 | <0.2 | <0.05 | 1.51 | 5. | 230. | 340. | 264. | 30.0 | 3. | 110. | 151. | 160. |
| 6 | 0.17 | 0.27 | 0.80 | 2.5 | <0.05 | 1.03 | 24. | 219. | 330. | 550. | 50.0 | 6. | 110. | 107. | 380. |
| Method Detection Limit | 0.02 | 0.02 | 0.05 | 0.2 | 0.05 | 0.05 | 5. | 1. | 20. | 2. | 2.0 | 1. | 10. | 1. | 1. |

*Turbidity in Nephelometric Turbidity Units (NTU).

## METALS (mg/l)

## SAMPLE BATCH NO. 2
(Sampled 9 April 1980)

| Site No. | As | Cd | Cu | Fe | Pb | Mn | Hg | Zn |
|---|---|---|---|---|---|---|---|---|
| 1 | <0.005 | <0.005 | <0.05 | 7.00 | <0.005 | 2.30 | <0.0005 | 0.171 |
| 2 | <0.005 | <0.005 | <0.05 | 1.76 | 0.013 | 1.30 | <0.0005 | 0.061 |
| 3 | <0.005 | <0.005 | <0.05 | 2.93 | 0.015 | 0.78 | <0.0005 | 0.105 |
| 4 | 0.007 | <0.005 | <0.05 | 13.6 | 0.029 | 0.90 | <0.0005 | 0.177 |
| 5 | <0.005 | <0.005 | <0.05 | 13.4 | 0.021 | 0.53 | <0.0005 | 0.076 |
| 6 | 0.017 | <0.005 | <0.05 | 29.3 | <0.005 | 1.20 | <0.0005 | 0.131 |
| Detection Limit | 0.005 | 0.005 | 0.05 | 0.025 | 0.005 | 0.05 | 0.0005 | 0.005 |

### PHYSICAL PARAMETERS

### SAMPLE BATCH NO. 2
(Sampled 9 April 1980)

| Site No. | Air Temp (°C) | Water Temp (°C) | Dissolved Oxygen (mg/l) | pH | $CO_2$ (mg/l) | Est. Flow (cfs) | Specific Conductance (μmho) | Fecal Coliform (Colonies/100 mls) | Fecal Streptococci (Colonies/100 mls) | PCBs (μg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8.2 | 9 | 12.5 | 6.7 | 25 | 7.5 | 550 | 95 | 57 | * |
| 2 | 7.5 | 9.5 | 13.5 | 7.3 | 12 | 10.0 | 550 | 6,300 | 1,100 | * |
| 3 | 8 | 10 | 10.6 | 7.4 | 10 | 35.7 | 650 | 1,900 | 2,700 | * |
| 4 | 8 | 10 | 9.8 | 5.2 | 1,400 | 26.9 | 470 | 3,400 | 5,300 | * |
| 5 | 8 | 12 | 10.9 | 7.6 | 7.5 | 47.1 | 410 | 5,200 | 3,900 | * |
| 6 | 8 | 12.7 | 9.75 | 7.1 | 18 | 264.2 | 362 | 5,900 | 7,050 | * |

*Not analyzed.

## GENERAL CHEMISTRY PARAMETERS (mg/l)

SAMPLE BATCH NO. 3
(Sampled 23 April 1980)

| Site No. | Dissolved Ortho-Phosphate | TP | $NH_3$-N | TKN | $NO_2$ | $NO_3$ | COD | Hardness | TDS | TSS | VSS | Cl | $SO_4$ | Total Alkalinity | Turbidity* (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.03 | 0.09 | <0.05 | 0.4 | <0.05 | 1.73 | 11. | 358. | 530. | 5. | 2. | 26. | 270. | 88. | 9. |
| 2 | 0.15 | 0.70 | 1.10 | 2.8 | 0.10 | 1.05 | 22. | 387. | 590. | 6. | 3. | 4. | 240. | 159. | 9. |
| 3 | 0.88 | 1.12 | 1.14 | 2.2 | 0.20 | 1.55 | 18. | 498. | 790. | 32. | 5. | 6. | 330. | 200. | 11. |
| 4 | 0.66 | 0.52 | 0.49 | 1.6 | 0.12 | 2.66 | 19. | 450. | 390. | 71. | 11. | 7. | 310. | 176. | 22. |
| 5 | 0.03 | 0.22 | <0.05 | 0.9 | <0.05 | 0.93 | 9. | 263. | 720. | 64. | 8. | 1. | 130. | 185. | 23. |
| 6 | 0.28 | 0.74 | 0.06 | 1.9 | 0.05 | 3.20 | 18. | 390. | 600. | 128. | 16. | 1. | 240. | 180. | 39. |
| Method Detection Limit | 0.02 | 0.02 | 0.05 | 0.2 | 0.05 | 0.05 | 5. | 1. | 20. | 2. | 2. | 1. | 10. | 1. | 1. |

*Turbidity in Nephelometric Turbidity Units (NTU).

## METALS (mg/l)

## SAMPLE BATCH NO. 3
(Sampled 23 April 1980)

| Site No. | As | Cd | Cu | Fe | Pb | Mn | Hg | Zn |
|---|---|---|---|---|---|---|---|---|
| 1 | <0.005 | 0.007 | <0.05 | 1.1 | <0.005 | 2.2 | <0.0005 | 0.01 |
| 2 | 0.006 | <0.005 | <0.05 | 1.2 | <0.005 | 1.3 | <0.0005 | <0.01 |
| 3 | <0.005 | <0.005 | <0.05 | 1.2 | 0.007 | 0.75 | <0.0005 | <0.01 |
| 4 | <0.005 | <0.005 | <0.05 | 2.2 | 0.007 | 0.69 | <0.0005 | <0.01 |
| 5 | 0.006 | 0.005 | <0.05 | 2.2 | <0.005 | 0.44 | <0.0005 | <0.01 |
| 6 | <0.005 | <0.005 | <0.05 | 4.0 | 0.008 | 0.72 | 0.0006 | <0.01 |
| Detection Limit | 0.005 | 0.005 | 0.05 | 0.5 | 0.005 | 0.05 | 0.0005 | 0.01 |

## PHYSICAL PARAMETERS

SAMPLE BATCH NO. 3
(Sampled 23 April 1980)

| Site No. | Air Temp (°C) | Water Temp (°C) | Dissolved Oxygen (mg/l) | pH | $CO_2$ (mg/l) | Est. Flow (cfs) | Specific Conductance (μmho) | Fecal Coliform (Colonies/100 mls) | Fecal Streptococci (Colonies/100 mls) | PCBs (μg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29.8 | 23.3 | 9.1 | 4.3 | <3,000 | 4.3 | 710 | 83 | 80 | |
| 2 | 25.8 | 23 | 14.8 | 4.7 | <3,000 | 7.0 | 850 | 3,650 | 1,210 | <0.5 |
| 3 | 29 | 21.5 | * | 5.0 | <3,000 | 22.9 | 1,050 | 170 | 245 | |
| 4 | 28 | 21.5 | 7.2 | 6.9 | 38 | 32.1 | 975 | 110 | 190 | <0.5 |
| 5 | 27.5 | 20.2 | 11.5 | 7.0 | 32 | 18.7 | 580 | 30 | 220 | |
| 6 | 20 | 19.5 | 11.2 | 5.5 | 1,100 | 63.2 | 850 | 110 | 350 | <0.5 |

*Data not available.

GENERAL CHEMISTRY PARAMETERS (mg/1)

SAMPLE BATCH NO. 4
(Sampled 7 May 1980)

| Site No. | Dissolved Ortho-Phosphate | TP | $NH_3$-N | TKN | $NO_2$ | $NO_3$ | COD | Hardness | TDS | TSS | VSS | Cl | $SO_4$ | Total Alkalinity | Turbidity* (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | <0.02 | 0.06 | 0.18 | 0.5 | 0.12 | 0.75 | 14. | 553. | 1180. | 6. | 4. | 26. | 750. | 0 | 7. |
| 2 | <0.02 | 0.10 | 1.97 | 6.0 | 0.14 | 0.20 | 25. | 549. | 1020. | 13. | 8. | 52. | 600. | 22. | 6. |
| 3 | 1.75 | 1.90 | 1.19 | 5.3 | 0.60 | 0.70 | 38. | 496. | 900. | 45. | 9. | 4. | 360. | 232. | 18. |
| 4 | 1.65 | 1.85 | 0.92 | 4.2 | 0.51 | 1.33 | 36. | 462. | 840. | 48. | 9. | 5. | 340. | 214. | 18. |
| 5 | 0.02 | 0.20 | <0.05 | 0.8 | 0.05 | 0.66 | 15. | 281. | 430. | 59. | 7. | 1. | 110. | 222. | 22. |
| 6 | 0.31 | 0.62 | 1.20 | 1.6 | 0.06 | 0.09 | 29. | 424. | 740. | 79. | 10. | 3. | 230. | 201. | 31. |
| Method Detection Limit | 0.02 | 0.05 | 0.05 | 0.2 | 0.95 | 0.05 | 5. | 1. | 20. | 2. | 2. | 1. | 10. | 1. | 1. |

*Turbidity in Nephelometric Turbidity Units (NTU).

METALS (mg/l)

SAMPLE BATCH NO. 4
(Sampled 7 May 1980)

| Site No. | As | Cd | Cu | Fe | Pb | Mn | Hg | Zn |
|---|---|---|---|---|---|---|---|---|
| 1 | <0.005 | 0.007 | <0.05 | 20.0 | <0.005 | 6.0 | <0.0005 | 1.1 |
| 2 | <0.005 | 0.006 | <0.05 | 5.0 | <0.005 | 4.7 | <0.0005 | 0.70 |
| 3 | <0.005 | <0.005 | <0.05 | 2.0 | 0.012 | 1.1 | <0.0005 | 0.08 |
| 4 | <0.005 | <0.005 | <0.05 | 1.7 | 0.008 | 1.3 | 0.0016 | 0.05 |
| 5 | <0.005 | <0.005 | <0.05 | 2.3 | <0.005 | 0.73 | <0.0005 | 0.05 |
| 6 | <0.005 | <0.005 | <0.05 | 2.8 | 0.007 | 0.98 | <0.0005 | 0.05 |
| Detection Limit | 0.005 | 0.005 | 0.05 | 0.5 | 0.005 | 0.05 | 0.0005 | 0.01 |

## PHYSICAL PARAMETERS

### SAMPLE BATCH NO. 4
(Sampled 7 May 1980)

| Site No. | Air Temp (°C) | Water Temp (°C) | Dissolved Oxygen (mg/l) | pH | $CO_2$ (mg/l) | Est. Flow (cfs) | Specific Conductance (μmho) | Fecal Coliform (Colonies/100 mls) | Fecal Streptococci (Colonies/100 mls) | PCBs (μg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * | 15.5 | 9.6 | 3.1** | * | 1.0 | 1,280 | < 1.0 | 22 | *** |
| 2 | * | 16 | 10.4 | 5.8** | * | 3.6 | 1,120 | 20 | 20 | *** |
| 3 | * | 16 | 6.6 | 7.1** | * | 10.7 | 1,090 | 260 | 550 | *** |
| 4 | * | 16.1 | 7.7 | 7.2** | * | 18.5 | 1,010 | 340 | 190 | *** |
| 5 | * | 15.8 | 8.5 | 7.2** | 24 | 8.0 | 610 | 270 | 265 | *** |
| 6 | * | 17 | 9.3 | 7.5** | 12 | 26.9 | 930 | 140 | 480 | *** |

*Data not available.

**pH measured in lab not more than six (6) hours after sampled.

***Not analyzed.

DATE
ILME
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