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THE HISTORY OF SEWAGE TREATMENT IN THE CITY OF BUFFALO, NEW YORK

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ABSTRACT: The development of sewage "treatment" in the City of Buffalo is best described as a series of improvements in disposal methods. From the 1800s, sewage disposal advanced from individuals dumping their own wastes, to a sewer system discharging directly to local waterways, to construction of a primary and secondary treatment plant in 1938. Waterborne disease outbreaks in Buffalo were endemic until sewage discharges were routed downstream of the city's water intakes. Prior to implementation of primary and secondary treatment in Buffalo, downstream neighbors experienced various problems related to untreated sewage in their drinking water. The city ignored their plight until a court order demanded the city treat its' sewage. Fortuitously, federal and state funding incentives coincided with the court order. The evolution of Buffalo's sewage treatment also is assessed in context of other programs in U.S. cities at the time.

INTRODUCTION

Sewage "treatment" in the city of Buffalo has progressed from direct discharge of untreated sanitary and industrial wastes into nearby bodies of water, to the establishment of a primary treatment plant and subsequently, a secondary treatment facility. Simply stated, primary treatment utilizes mechanical methods of purification while secondary treatment employs biological methods.

The primary objective of this study is to examine the evolution of sewage treatment in the city from the construction of the first sewers (1830s) through the completion of a secondary treatment plant (1979). The research focuses on sewage disposal methods, changes in the disposal methods through time and why the changes were made. Secondary objectives are to: 1) investigate the role of the Buffalo River in sewage disposal; 2) compare sewage treatment progress in Buffalo with contemporary programs at the national level; and 3) create a time series of maps that illustrate the city's progress in sewerage.

The research is significant because it provides a concise history of sewage treatment in Buffalo that can be used to illustrate national trends. In particular, many of the nation's industrial cities have experienced a similar course of events. Namely, settlement and growth followed by a continuous need for more efficient and sanitary methods of waste disposal (Tarr et al., 1980). In many instances, health considerations were the primary motivators for establishing and improving sewerage (Steele, 1866; Eddy, 1930; Tarr and McMichael, 1978).

Historically, city planning literature reveals an absence of sewerage planning (So, 1968; Scott, 1969; Melosi, 1980). Time horizon, which focuses on predicting the future implications of proposed actions, is an important part of planning and notably absent in regard to anticipating the negative effects of various methods of sewerage (McDowell, 1986). Sewer system planning most often has been considered an engineering problem (So, 1968). Typically, sewerage has been established and improved on an after-the-fact basis; primarily, meeting previously unmet needs such as large scale disposal (So, 1968).

PRE-SEWER DISPOSAL METHODS

Prior to the installation of Buffalo's first sewers in the 1830s, domestic waste disposal primarily was the responsibility of the individual. According to Sauer (1979), household waste was stored in cans behind residences, awaiting transfer to the nearest dumping site, most often a nearby vacant lot. This out-of-sight, out-of-mind attitude was prevalent in urban areas throughout the United States (Melosi, 1981).

Progress in domestic waste disposal evolved to include privy vaults and leaching cesspools (a stone lined hole in the ground that discharged slowly to the soil). The privy vaults basically were containment systems that had to be emptied periodically. The contents of the privy vaults were disposed of by various methods: dumped into nearby waterways; dumped on land outside the city; recycled on farmland for its water and nutrients; or, processed into fertilizer (Tarr and McMichael, 1978; Moffa, 1990). Both privy vaults and cesspools were located on individual residential lots and both subjected the immediate area to spillage, infiltration, general nuisance and health implications associated with these types of disposal.

Similarly, disposal of industrial wastes were the responsibility of individual firms. Industrial location was largely dependent on water, for both processing and transportation, therefore, many of Buffalo's industrial establishments were located on waterways during the pre-sewer time period (Sauer, 1979). In addition, the waterfront locations offered a convenient receptacle for disposal of industrial wastes - the water itself. Prior to the 1830s, the city of Buffalo did not have very many industries. Most were relatively small establishments and included tanning, lumber related trades and mills, grain milling and iron working (Holder, 1960).

Buffalo's pre-sewer disposal methods were adequate until their carrying capacities were exceeded. Population growth and concentration strained the disposal systems and made them an inefficient nuisance (Melosi, 1980). In summary, Buffalo's pre-sewer disposal methods adversely affected sanitary conditions on land as well as in its waterways (Steele, 1866; Sauer, 1979; Tarr et al., 1980).

EARLY SEWERAGE

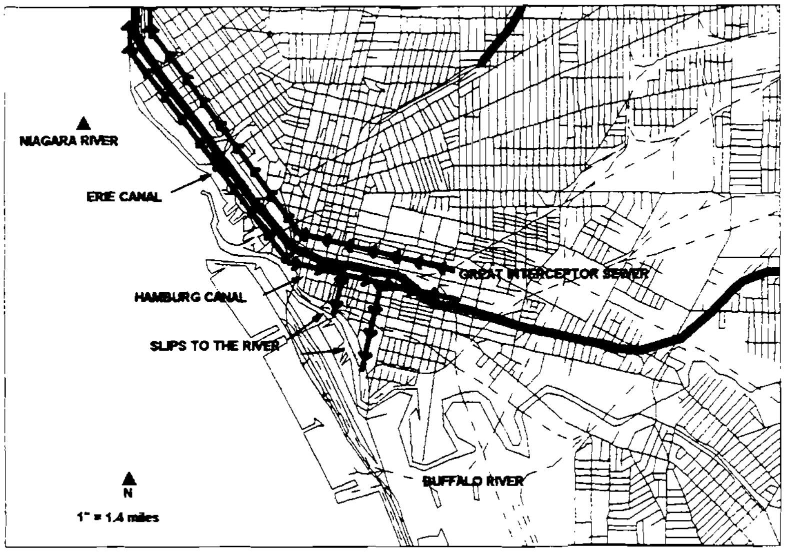
In the mid-1830s, Buffalo's first sewers were constructed along Ellicott and Oak Streets in the southern portion of the city. According to Steele (1866), the sewers were constructed from brick and wood; the bottom was a board and bricks jutted inward and up to enclose the line. Another line that Steele (1866) describes as the first great receiving sewer in Michigan Street (South Buffalo), was constructed in the late 1840's. This line, with lateral sewers joining it, transported waste to the Buffalo River where it was discharged, untreated.

Buffalo's Committee on Paving, Sewers and Lights established in 1847, issued a report in 1848 outlining the importance of a sewerage system to the health of the city. The committee recommended a complete system of underground drainage and developed a plan for the construction of principal sewer lines. The report also stated that the city's sewage disposal efforts lagged behind other large cities in the country and specifically cited Philadelphia, PA as a model example (Steele, 1866).

In 1883, the Great Interceptor Sewer was constructed along the northern side of the Buffalo River (see Figure 1). The main purpose of the sewer was to channel sanitary sewage to a point beyond the city's drinking water intake. Prior to construction of the sewer, human wastes were discharged upstream from the intake and were responsible for cholera epidemics (Sauer, 1979). The Great Interceptor also improved sanitary conditions in the neighborhoods it serviced. The line was routed north along the shores of the Niagara River to Black Rock, where it passed under the canal and discharged untreated sanitary and industrial waste to the Niagara River.

A primary objective of early sewerage was to remove domestic sewage from residential areas via underground drainage networks. Sewage treatment as it is known today was non-existent. In fact, the previously mentioned report by Buffalo's Committee on Paving, Sewers and Lights does not

Figure 1: The Great Interceptor Sewer (1883) and Canal Drainage into the Buffalo River (Sauer, 1979).



mention sewage treatment in the call for "a complete system of sewerage" (Steele, 1866). Most often, the sewers were routed to waterways in the city as dilution of the wastes by the water was believed to be a sufficient method of purification (Buffalo Sewer Authority, 1938; Melosi, 1980). As late as 1912, the National Association for Preventing the Pollution of Rivers and Waterways supported the disposal of sewage by dilution (Tarr et al., 1980). Many cities in the United States, including Boston, MA; Memphis, TN; New Orleans, LA; and Birmingham, AL, used dilution as a method of purification (Metcalfe and Eddy, 1928; Eddy, 1930; Linton, 1970).

Sauer (1979) states that all of the city's sewage went to three bodies of water in the city: the Buffalo River; the Erie Canal (which connected to the Buffalo River); or the Hamburg Canal (which connected to the Erie Canal. All three waterways ultimately discharge to the Niagara River (see Figure 1).

The city soon realized that the purifying capabilities of the waterways were being outstripped by the volume of waste produced by a growing population. Additionally, the direct discharge of untreated sewage fostered conflict between the city of Buffalo and downstream users in the U.S. and Canada. The first complaint concerning Buffalo's pollution of the Niagara River was noted in 1892 (Parran, 1935). Typhoid outbreaks as far away as Oswego, New York were attributed to the discharge of untreated sewage by the city (Buffalo Sewer Authority, 1938). Tonawanda, the city's closest downstream neighbor, was forced to use large quantities of chlorine in its water supply to prevent gastro-enteritis epidemics (Buffalo Evening News, 1933).

In 1909, the International Joint Commission (IJC) was formed between the United States and Canada to address issues concerning the use, obstruction or diversion of international waters (Clamen and Parsons, 1989). In 1912, the IJC met to address the problem of boundary water pollution and recommended that water from the Niagara River was unfit for drinking in an unpurified form. It also found the river to be totally unfit for domestic use and a serious hazard to riparians and bathers. In fact, the Niagara River was one of two boundary waters, the other being the Detroit River, characterized as having "perilous pollution...endangering the health and welfare of inhabitants in both the United States and Canada" (Chacko, 1968). The IJC report cited sewage discharges and direct industrial waste discharge as major sources to the boundary water.

The Niagara River was contaminated mainly from outfalls discharging to it and from the outflow of the Buffalo River. By the early 1930s, Buffalo's continued population and industrial growth had compounded the pollution problem. The polluted Buffalo River became a primary example of the effects of using water bodies as waste receptacles. As a focal point for water and rail transportation and an adequate source of process and cooling water, the river area attracted a multitude of industries. Shoreline industries freely discharged their wastes to the river; industries located farther inland discharged to the sewers that were routed to the river. In comparison with sewage discharges, which are mainly biological wastes, industrial discharges introduced more complex contaminants to the river, such as heavy metals, phenols, oils and chemicals (So, 1968). There were 78 outfalls discharging the city's sanitary and industrial waste to the Buffalo and Niagara Rivers by the 1930's (Parran, 1935). The city of Buffalo did not have any discharge points south of the Buffalo River (Greeley and Hansen, 1936).

A report to the Common Council by Public Works Commissioner George F. Fisk estimated the daily load of sewage and industrial wastes to the Buffalo River at 50,000,000 gallons (Buffalo Evening News, 1929). However, the State Health Department refused to intervene to eliminate industrial discharges until the city instituted measures to properly dispose of its sewage (Buffalo Evening News, 1929). By 1933, State Health Commissioner Thomas Parran demanded that the city stop polluting its water bodies with sewage and construct a sewage disposal facility (Buffalo Evening News, 1933). In 1935, the New York State Health Department, led by Parran, mandated the city of Buffalo to cease pollution of its waters. In response, the Buffalo Sewer Authority was established.

THE BUFFALO SEWER AUTHORITY AND THE BIRD ISLAND WASTEWATER TREATMENT PLANT

The Buffalo Sewer Authority (BSA) was established in 1935 by an Act of the New York State Legislature. It was defined as a public benefit corporation. Its responsibilities included halting New York originated pollution of the Niagara River and its tributaries. Both domestic sewage and industrial wastes were within the BSA's domain. The BSA accepted full responsibility for fulfilling the State Health Department's mandate and was authorized to borrow money, issue bonds and fix and collect rates and rentals (Buffalo Sewer Authority, 1938). The BSA secured a grant of $6.75 million from the federal Works Progress Administration (WPA) and an additional $8.25 million (at 4% interest) to construct a treatment plant.

Bird Island was chosen as the site for Buffalo's sewage treatment plant (see Figure 2). Construction of the Bird Island Wastewater Treatment Plant had two primary components: the construction of intercepting sewers, to collect the city's stormwater runoff and sanitary and industrial waste and transport it to Bird Island for treatment, and; the sewage treatment plant. Upon its completion on June 29, 1938, the plant employed the most modern treatment method at the time, primary treatment (Buffalo Sewer Authority, 1938). Primary sewage treatment involves the separation, purification and discharge of liquid waste and the incineration of solid waste, also known as sludge. Chlorination was the method of purification used by Buffalo's primary treatment plant. At the time of plant completion, 99% of Buffalo's sewage was liquid and the remaining 1% was in the form of sludge (Buffalo Sewer Authority, 1938).

The Bird Island Wastewater Treatment Plant had a design capacity of 540,000,000 gallons per day. The design capacity at that time was approximately four times the volume of normal dry weather flow, thus accounting for stormwater runoff (Buffalo Evening News, 1938). The design capacity of the treatment plant was based on population projections for approximately 15 years as the treatment works were considered to be easily expandable (Greeley and Hansen, 1936). Buffalo's chlorination system was, at that point in time, the largest in the world (Buffalo Sewer Authority, 1938). During construction of the plant, numerous engineers toured the site, including 135 sanitary engineers from Germany who came to the United States specifically to inspect it (Buffalo Sewer Authority, 1938).

Prior to completion of the sewage treatment plant, the Buffalo Sewer Authority was interested primarily in the construction process, mainly the interceptors and the plant. However, once the treatment plant was operational, the BSA assumed full responsibility for 754 miles of existing sewer lines. Many of the sewers were in poor condition or simply inadequate for the volume of sewage channeled. As a result, the BSA's operating budget was increased by $150,000 for 1938-39 to clean, repair and condition existing lines (Buffalo Sewer Authority, 1938). The design capacity for the new and reconditioned sewers were based on population projections for approximately 50 years (Greeley and Hansen, 1936).

The Bird Island Wastewater Treatment Plant alleviated bacteria problems in the Niagara and Buffalo Rivers. Approximately one year after plant operation began, bacteria levels in the Niagara River were reduced by 97 per cent. The remaining bacteria was blamed on industrial wastes flowing from the Buffalo River as industrial discharges continued from shoreline industries (Courier Express, 1939). The contributions from upstream sources (e.g. small towns such as Lancaster and East Aurora) were not recognized. It also must be noted that sewage discharges continued to impact water quality after the completion of the treatment plant. The City of Buffalo is serviced primarily by a combined sewer system. Simply stated, both sanitary flow and stormwater runoff are transported via the same pipe to the treatment plant. During large storm events, if the volume of combined flow is greater than the capacity of various pipes, the excess flow will be discharged untreated to a waterway. The points in the system that discharge the flow are called combined sewer outfalls (CSO's). Combined sewer outfalls have the potential to discharge industrial wastes, in addition to sewage related and street washoff contaminants. CSO's continue to have a negative impact on water quality (Pratt et al., 1995). Combined sewer systems were considered an acceptable method of collection in the early part of the century because it was thought the negative impact of the periodic overflows would be inconsequential once diluted by stormwater runoff and the receiving body of water (Metcalf and Eddy, 1928). More recently, it has been recognized that stormwater runoff can contribute contaminants at levels higher than sanitary flow alone (Goudie, 1986; Marsalek, 1990).

In 1942, the Federal Water Pollution Control Act (FWPCA) was enacted. Its goal was to make United States surface waters safe for fishing and swimming (Miller, 1991). The act was amended in 1956 to provide 30% grants for sewer plant construction. The 1960's ushered in greater public awareness of the pollution of United States waterbodies. The Federal Clean Water Act of 1966 and the New York State Pure Waters Bond Act (1965) provided additional funding for sewage treatment construction (Caruso, 1987). As a result, the Buffalo Sewer Authority began to upgrade the Bird Island Wastewater Treatment Plant to provide secondary treatment.

The key difference between primary and secondary treatment is primary treatment uses mechanical methods to remove pollutants from wastewater. Bar screens, grit chambers and settling tanks separate large solids and particles prior to disinfection of the remaining liquid. Secondary treatment utilizes bacteria to consume pollutants such as organic solids and can be four times more effective than primary treatment alone (BSA, undated; Linsley and Franzini, 1972; Water Environment Federation, 1993). Aeration, mixing oxygen with the wastewater, encourages the growth of certain bacteria. The Bird Island Secondary Treatment Plant uses the activated sludge method which mixes the wastewater with microorganisms and constant aeration. Sedimentation tanks separate the sludge for incineration while the liquid is disinfected and released as effluent to the Niagara River. Primary treatment methods precede secondary processes.

The BSA Secondary Treatment Plant project began in 1972 and was operational seven years later, in the fall of 1979. The secondary treatment plant is the largest in New York State and one of the ten largest in the U.S. (Frandina, BSA, personal communication).

TRUNK LINES AND INTERCEPTORS

The time series of maps (see Figures 2-5) trace the construction of trunk lines and intercepting sewers in the city. The trunk lines are sewers that are larger than five feet diameter. The sewer lines along each street, which receive residential and industrial waste, are routed to the trunk lines. The trunk lines connect to the interceptors which are the largest sewers. The interceptors carry sanitary and stormwater flow to the sewage treatment plant. The individual trunk lines are labeled on the maps. For each year, only the new constructions are identified. The most recent trunk line, the Seneca Street Extension, was completed in 1986 and is not pictured in the 1964 map. The city limits on each map correspond to the present boundaries; according to the *Atlas of the City of Buffalo, N.Y.* (1884), these boundaries are accurate for the years depicted.

Considering the age of Buffalo and its history of sewage treatment, it appears that settlement preceded the construction of the trunk lines. The *Illustrated Historical Atlas of Erie County, New York* (1880) reveals the vicinity of the Swan Street, Bird Avenue and Babcock Street trunk lines to be well populated prior to sewer construction, based on the presence of housing and other structures. The Babcock Street area is the most densely populated of the three.

The portion of the city surrounding the Bailey Avenue trunk line, constructed in 1889, is not notably populated in 1880. Buffalo's meat processing establishments, stockyards and related industries also are concentrated in that section of the city as early as 1880 (Rossi, 1993) and their presence would provide need for sewerage.

The *New Century Atlas of Greater Buffalo* (1915) also reveals well populated neighborhoods in the vicinity of the remaining trunk lines prior to sewer construction. The one exception is the eastern end of the Tonawanda Street and Hertel Avenue trunk line (1889) which appears relatively sparse in population. As indicated by the housing today, the eastern end of Hertel Avenue is a fairly affluent neighborhood and may explain why the trunk line preceded widespread settlement.

The trunk lines that were built prior to 1935, when the treatment plant was under construction, are within the immediate area of Buffalo's waterways. Obviously, the method of sewage disposal at that time, in conjunction with need and perhaps other factors, governed the location of the trunk lines. Where possible, the topography of Buffalo was utilized to eliminate the need for construction of pumping stations. In Figures 2 and 3, eight of the eleven trunk lines constructed followed the natural slope of the land toward a receiving body of water and thus, could depend on gravity to maintain the flow (United States Geological Survey, 1965).

Once the Bird Island Wastewater Treatment was operational, the newly constructed trunk lines were situated farther inland and need alone may have determined the locations. The majority of trunk line constructions in the 1930's, during plant construction (see Figure 4), apparently were necessary to bridge gaps in the system.

Finally, Figure 5 depicts the locations of Buffalo's intercepting sewers. All of the interceptors were constructed as part of the Bird Island project and thus, the locations were based on need. As the name suggests, the interceptors collect the flow from the trunk lines and transport it to the treatment plant. The South Interceptor, in conjunction with the Exchange Street Interceptor appear to follow the path of the former Great Interceptor (1883). The trunk lines present on the 1905 map (see Figure 3) determined the location of the intercepting sewers which carry flow to the treatment plant.

BUFFALO'S PLACE IN SEWAGE TREATMENT PROGRESS

Nationally, Buffalo's progress in establishing sewage treatment is governed by perception. On the one hand, the city may be considered a latecomer to sewage treatment. First, the pollution of the Niagara River caused international, as well as intrastate conflict for more than 40 years, from the first complaint noted in 1892 until the treatment plant was operational in 1938. Buffalo essentially

Figure 2: Trunk lines - 1886

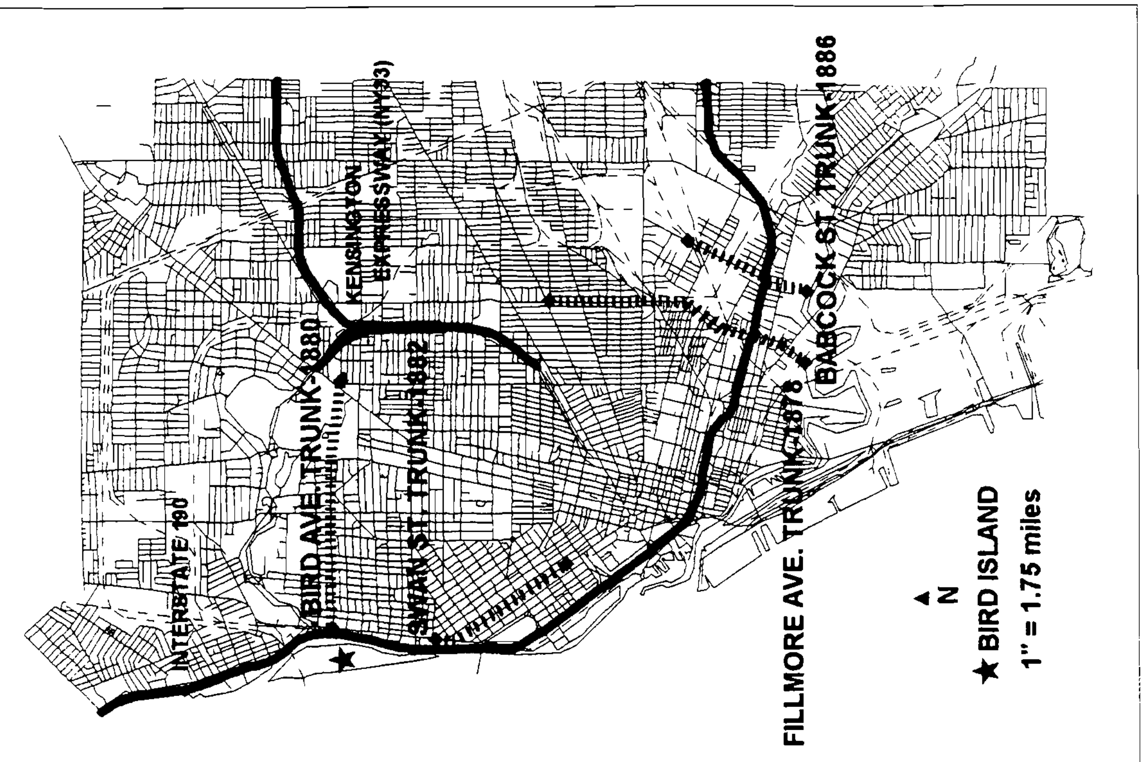


Figure 3: Trunk lines - 1905

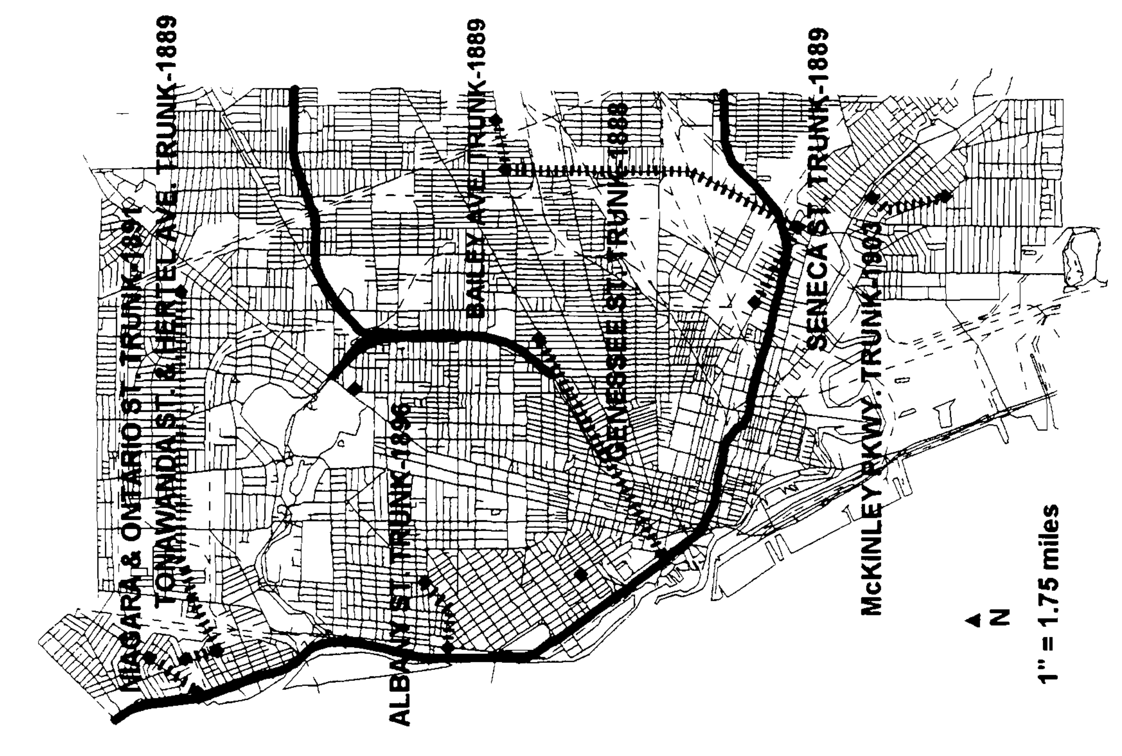


Figure 4: Trunk lines - 1964

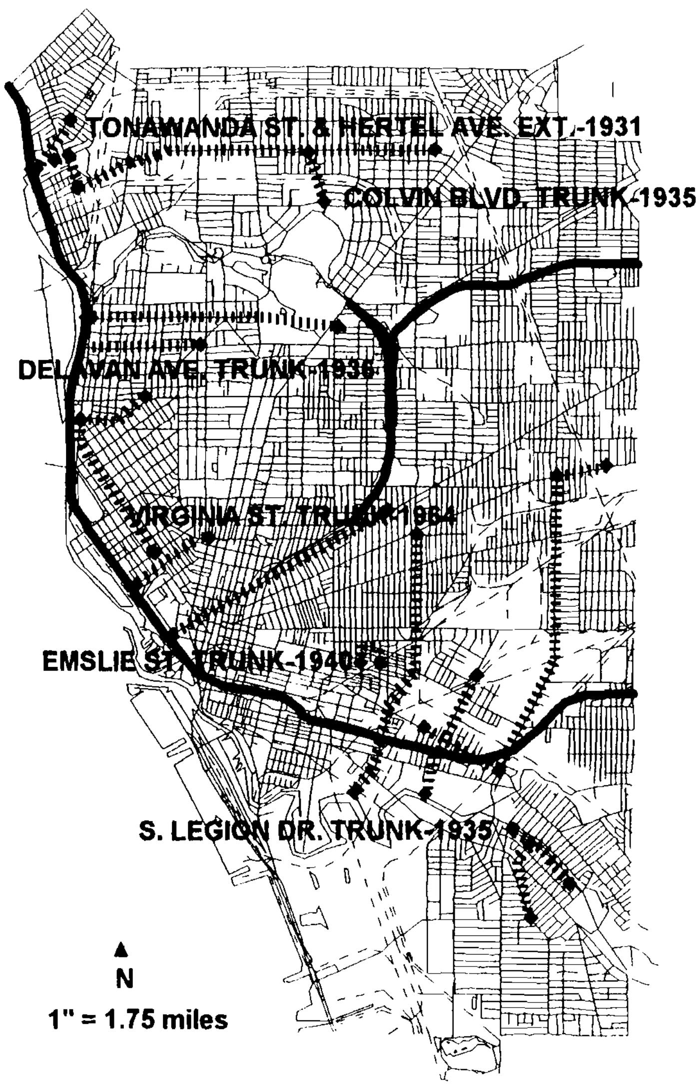
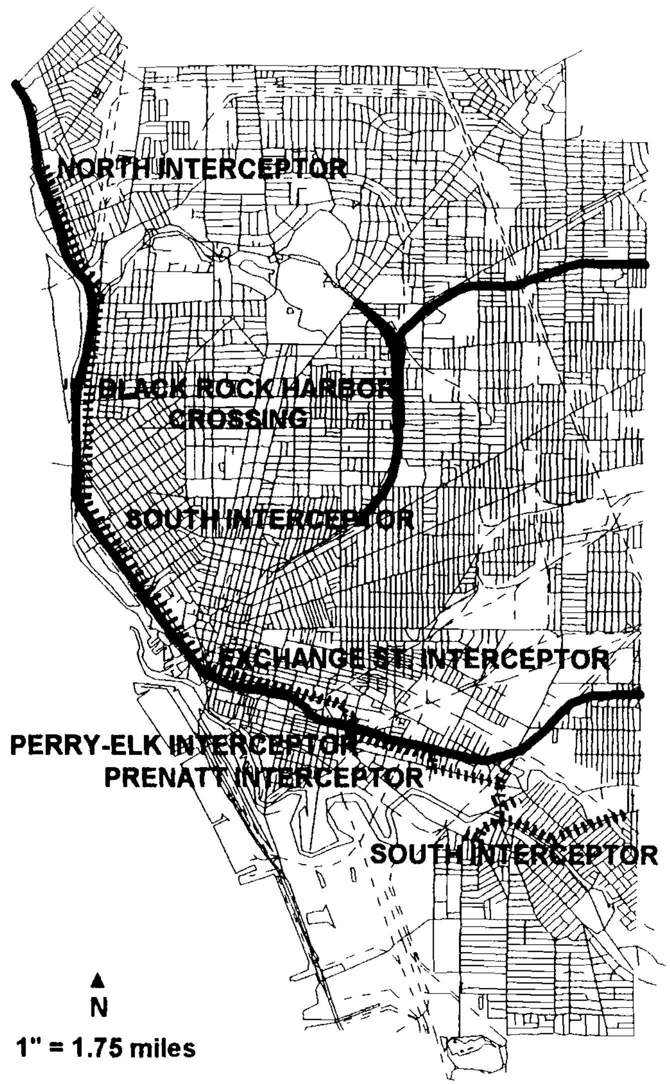


Figure 5: Interceptors - 1930's



ignored downstream water quality problems and instituted measures necessary to its own well being (e.g. moving its drinking water upstream from its discharge points). Second, by the 1890's the importance of clean water to health was realized (Pendleton, 1995) and yet, sewage discharge continued, at the expense of the city's downstream neighbors. Third, as early as 1910, sewage treatment plants were operational in several American cities including Columbus, OH, Plainfield, NJ and Reading, PA (Eddy, 1930). Massachusetts alone had four cities serviced by sewage treatment plants during the same time period (Clark, 1930; Eddy, 1930). Finally, the city was forced to construct sewage treatment works, via the New York State Health Department's mandate.

On the other hand, Buffalo's construction of sewage treatment works may be considered timely. First, as late as 1925, 80% of American cities with populations greater than 100,000 had no sewage treatment facilities (Linsley and Franzini, 1972). Second, 88% of those cities disposed their sewage by dilution (Metcalf and Eddy, 1928). Lastly, the funding provided by the Works Progress Administration resulted in the construction of sewage treatment facilities in many large American cities during the same time period. In summary, Buffalo's progress in sewage treatment may be considered average, at best.

CONCLUSIONS

In general, the evolution of sewage treatment in Buffalo followed a course of events similar to that of other American cities within the same time frame. It is best described as a series of improvements. Sewage disposal advanced from individuals dumping their own wastes to removing sewage from the immediate area and eventually to primary and secondary treatment. Population growth, coupled with area expansion, preceded the need for initiating sewerage (Steele, 1866). Through time, continued growth and expansion rendered past methods and improvements inadequate as well as unhealthy (Tarr and McMichael, 1978). The improvements made by the City of Buffalo seemed to be governed by necessity and in the case of the primary treatment plant, direct order from the state.

Both the Buffalo and Niagara Rivers have been designated Areas of Concern by the International Joint Commission due to general environmental impairments (IJC, 1989). The rivers have Remedial Action Plans (RAPs) that outline the impairments, sources, methods of remediation and hopes for future uses. Buffalo's history of sewage "treatment" is at least, partly to blame for the pollution of its two main waterways. Once again, funding will probably be Buffalo's greatest motivator for cleaning up its rivers.

Finally, it must be noted that sewage treatment in general, has progressed beyond secondary processes to include advanced (secondary) treatment and tertiary processes. If the past is any indication of the future, funding incentives and federal/state direction are prerequisite for further improvement in the city's treatment efforts.

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