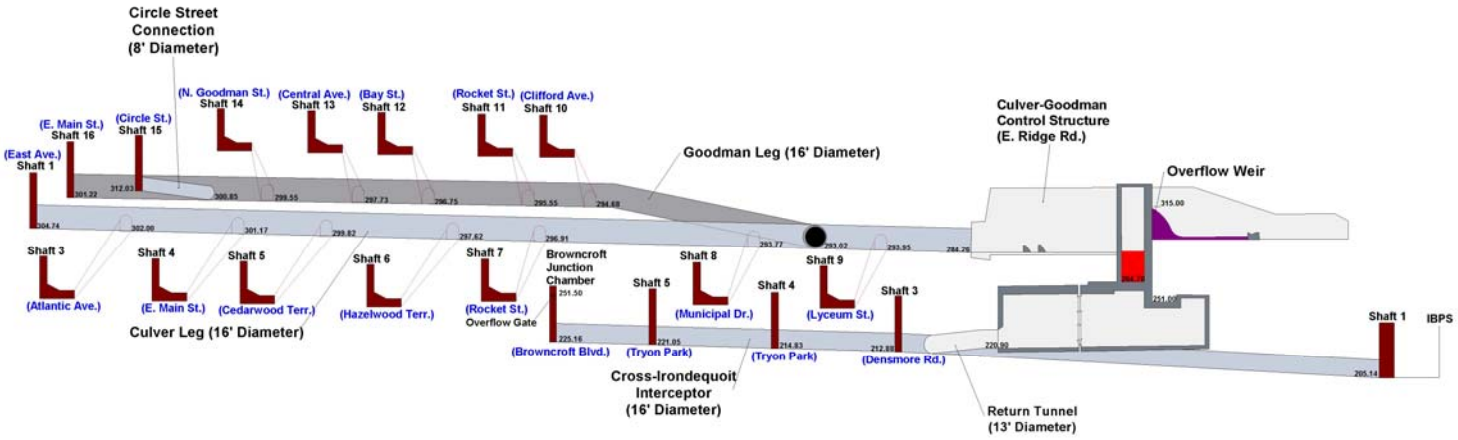
Wastewater: Collection and Treatment by Monroe County-Operated Facilities

East-side Deep Rock Tunnel System



Department of Environmental Services

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Wastewater: Collection and Treatment at Monroe County-Operated Facilities

Introduction

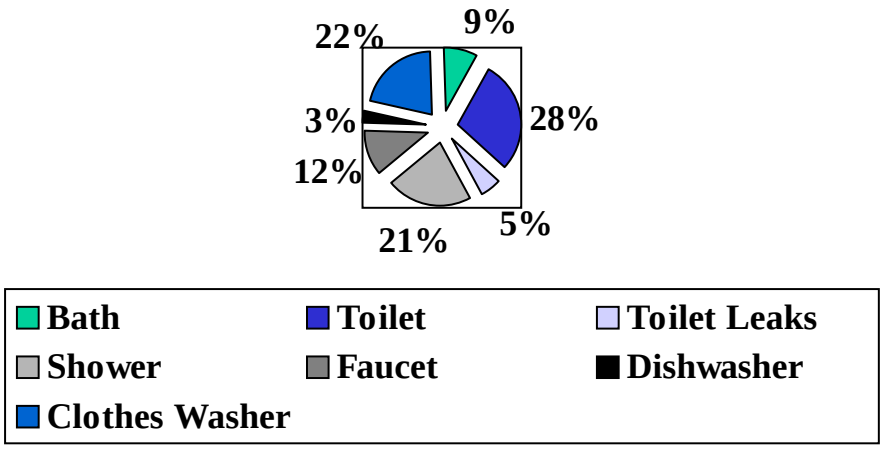
Water covers 71 percent of the earth's surface. We all want clean water—to drink, for recreation, and just to enjoy looking at. If water becomes polluted, its loses its value to us economically and aesthetically, and can become a threat to our health and to the survival of the creatures living in it and the wildlife that depends on it.

The Monroe County Department of Environmental Services (DES) works to keep not only the water environment clean, but also the land and air. This article will give a general overview of the major pollutants found in our waters, how they reach our treatment facilities, and what we do to eliminate or minimize them.

The DES's Division of Pure Waters' logo (right) shows its commitment to live up to its name. The division is dually tasked with trying to reduce the amount of pollutants entering the waste stream and, once they are in the water, removing them.

Although some kinds of water pollution can occur through natural processes, it is mostly a result of human activities. We use water daily in our homes and industries, about 100 gallons per day per person in the United States. The water we use is taken from lakes and rivers, and from underground (groundwater); and after we have used and contaminated it, most of it returns to these locations.

WHERE YOU USE WATER IN YOUR HOME



The used water of a community is called wastewater. If it is not treated before being discharged into waterways, serious pollution will result. Historically, it has taken humanity quite a bit of time to come to grips with this problem. Water pollution also occurs when rainwater runoff from urban and industrial areas and from agricultural land and mining operations makes its way back to receiving waters (river, lake or ocean) and into the ground. The photo at left depicts an overflow point of the Rochester City sewers into the Genesee River in the 1970s.

What are some different types of water pollution?

Some major types of water pollution include microbiological, chemical, oxygen depletion, nutrients and suspended matter.

Microbiological

Fish and shellfish can become contaminated with disease-causing (pathogenic) microorganisms and people who eat them can become ill. Some serious diseases like polio and cholera are waterborne. Pathogenic microorganisms like bacteria, viruses and protozoa can cause swimmers to get sick and beaches to close.

Chemical

A whole variety of chemicals from industry, such as metals and solvents, and even chemicals which are formed from the breakdown of natural wastes (ammonia, for instance) are poisonous to fish and other aquatic life. Pesticides used in agriculture and around the home are other types of toxic chemicals. Some of these can accumulate in fish and shellfish and poison people, animals, and birds that eat them.

Materials like detergent foam and oils float and spoil the appearance of a water body, as well as being toxic. Many chemical pollutants also have unpleasant odors. The Cuyahoga River, near Cleveland, Ohio, even caught fire several times because of flammable chemical wastes discharged into the water.

Oxygen-depleting Substances

Many wastes are biodegradable; that is, they can be broken down and used as food by microorganisms like bacteria. We tend to think of biodegradable wastes as being preferable to non-biodegradable ones, because they will be broken down and not remain in the environment for very long times. Too much biodegradable material, though, can cause the serious problem of oxygen depletion in receiving waters.

Like fish, aerobic bacteria that live in water use oxygen gas that is dissolved in the water when they consume their "food." (The oxygen in the water molecule itself (H_2O) is chemically bound, and is not available for breathing). Oxygen is not very soluble in water. Even when the water is saturated with dissolved oxygen, it contains 20,000 times less than the concentration that is present in air. If there is too much "food" in the water, the bacteria that are consuming it can easily use up all of the dissolved oxygen, leaving none for the fish, which can suffocate.

Once the oxygen is gone (depleted), other bacteria that do not need dissolved oxygen (anaerobic) take over. While aerobic microorganisms convert the nitrogen, sulfur, and carbon compounds that are present in the wastewater into odorless and relatively harmless oxygenated forms (like nitrates, sulfates and carbonates), these anaerobic microorganisms produce toxic and smelly ammonia, amines, and sulfides, and flammable methane (swamp gas). Add in the dead fish, and you see why we don't want large amounts of biodegradable materials entering lakes and streams.

Nutrients

The nutrients phosphorus and nitrogen are necessary for plant growth, and are plentiful in untreated wastewater.

Added to lakes and streams, they may cause a nuisance growth of aquatic weeds, as well as "blooms" of algae (microscopic plants). This can make a lake unsuitable for swimming and boating.

Algae and weeds die and become biodegradable material, which can cause oxygen depletion and suspended matter problems. If the water is used as a drinking water source, algae can clog filters and impart unpleasant tastes and odors to the finished water.

Suspended Matter

Some pollutants are dissolved in wastewater, meaning that the individual molecules or ions (electrically charged atoms or molecules) of the pollutant are mixed directly in between the molecules of water. Other pollutants referred to as particulate matter, consist of much larger (but still very small) particles which are suspended in the water. Although they may be kept in suspension by turbulence, once in the receiving water, they will eventually settle out and form silt or mud at the bottom. These sediments can decrease the depth of the body of water.

If there is a lot of biodegradable organic material in the sediment, it may become anaerobic and contribute to the problems mentioned above. Toxic materials can also accumulate in the sediment and affect the organisms that live there. Toxins can also build

up in fish that feed on them, and so be passed up the food chain, causing problems all along the way. Some of this particulate matter may be grease (or be coated with grease), which floats on the water creating an aesthetic nuisance.

How do we prevent water pollution?

To keep this used water from spoiling our water resources, pollutants must be removed from the water before it is discharged back into the environment. In Monroe County, the wastewater from homes, businesses and factories is collected by a system of underground pipes, or sewers, which carry it to wastewater treatment facilities (WWTF). Most of these are located near bodies of water into which the treated wastewater is discharged. Prior to 1970, there were approximately 40 WWTFs in Monroe County. Today, eight facilities remain, serving a population of over a half million.

Until 1998, Monroe County operated three WWTFs: Northwest Quadrant, Frank E. VanLare and Gates Chili Ogden. Gates-Chili-Ogden WWTF had a final discharge into the Genesee River. It was determined this point source could be eliminated by shutting down GCO and pumping the sewage flow to VanLare. (See appendix for plant diagrams)

A sewage pumping station was constructed on the grounds of the Gates Chili Ogden facility and the plant was decommissioned. The discharge from the pumping station is routed through the new Gates-Chili-Ogden force main to the southwest section of the Rochester, then on through downtown Rochester and north to VanLare—where it is treated.

Other wastewater treatment plants that discharge into the Genesee River include those from the villages of Scottsville and Honeoye Falls; and Kodak's King's Landing. Each of these facilities has a permit to discharge specific amounts of certain pollutants.

The county's VanLare and Northwest Quadrant plants are located on the south shore of Lake Ontario. VanLare dates back to 1916 and is the largest WWTF in the county. The operating permit for flow is 135 million gallons per day (mgd) with a capability of handling 660mgd during storm events. Northwest Quadrant is located in the town of Hilton and handles largely residential wastewater. NWQ has a permitted flow of 22mgd and handles 14mgd on average.

In the U.S., all such facilities must have a permit issued by the federal and/or state government, describing limits on the amounts of various pollutants that can be discharged. The U.S. Environmental Protection Agency (EPA) refers to these as National Pollutant Discharge Elimination System (NPDES) permits (New York State has State Pollutant Discharge Elimination System or SPDES). Both county-operated plants have these SPDES permits and are required to file monthly discharge monitoring reports (DMRs) to the state's Department of Environmental Conservation (DEC).

Some major industries and utilities (like Kodak and Rochester Gas and Electric) have their own sewer systems and/or treatment plants that can discharge directly into a waterway with a SPDES permit.

Even industries which are connected to municipal sewers may have to pretreat their wastewater before discharging, because of materials which can harm the sewers or the treatment plants—or may be a danger to the public or to people who work maintaining the sewer system.

In accordance with the Sewer Use Law of Monroe County, the Industrial Waste Control Section issues permits and conducts samples of industrial waste streams to ensure compliance with the law. The purposes of the Sewer Use Law are as follows:

- Control and regulate discharges into the county sanitary, storm and/or combined sewers and their tributaries;
- Prohibit excessive volumes of flow and the discharge of various listed substances/materials;
- Prohibit and/or regulate discharges (industrial or other) that would cost more to treat than normal sewage;
- Require the pretreatment of discharges if they could harm the sewer system, interfere with the treatment process or pass through the system untreated or partially treated thereby exceeding discharge limits;
- Protect public health and prevent nuisances;
- Provide cooperation between involved government agencies; and,
- Give the county the authority and procedure to make regulations, issue permits, conduct investigations, hold hearings, issue decisions, orders and opinions

Collection Systems (Sewers)

Some of the old brick arch work (Norton Street) in Rochester's combined sewer system.

Besides having a system of sewer pipes—called, for some reason, sanitary sewers—that carry wastewater to a treatment plant, cities and towns also need pipes to collect storm water. These are needed to prevent street flooding and usually lead directly to a waterway without any treatment. The runoff of pollutants from streets and yards into these storm sewers contain oil and other automotive wastes, which may contain toxic metals and organic compounds—as well as pesticides and nutrient-containing fertilizers from lawns and gardens, and pathogenic microorganisms from animal wastes. The EPA is currently addressing the problem of pollution from storm sewers.

In some local areas with separate sanitary and storm sewer systems (like the town of Greece), the flows to the treatment plants often increase greatly when it rains. This is due to cracks or separations in the pipes, which allow groundwater, and/or storm water from broken storm sewer pipes to infiltrate into the sanitary sewer—or from direct inflow

One of the overflow points into the Genesee River

of storm water into manholes and from illegal connections of roof drains and sump pumps in buildings.

This inflow and infiltration (I&I) can cause sewer overflow and backup during heavy rains. Additionally, all that clean rainwater is pumped to WWTFs where it must be chemically and biologically treated (with great expense) as if it were raw sewage. Monroe County DES actively works at trying to determine where points of I&I occur and halt them.

Portions of the city of Rochester's collection system date back to the 1800s when untreated waste and storm water ran into the same sewer lines and was discharged to receiving waters like Irondequoit Bay and the Genesee River. This is known as a combined sewer system.

During rainy periods, combined sewers cause two problems: overloading of the treatment plant with extra water, and contaminating waterways with untreated sewage from overflows.

Deep Rock Tunnel System (CSOAP)

To address this combined sewer overflow problem, Monroe County decided to construct a deep rock tunnel system that could capture and hold major storm runoff until it could be properly treated. This was called the Combined Sewer Overflow Abatement Program (CSOAP).

The Federal Construction Grants Program of 1980 gave the Monroe County Pure Waters District an opportunity to put an end to chronic overflow problems with its combined sewer system. There were close to 50 overflow points throughout the City of Rochester that directly entered the Genesee River and Irondequoit Bay.

The total cost of the CSOAP system was $514 million. Of this, seventy-five percent was paid by the federal grant program with New York State and Monroe County each contributing twelve and one half percent. The total local cost of the program to Monroe County was $64 million. (See appendix for tunnel system diagrams)

Actual construction on the tunnel system was started in 1982 and completed in 1991. Laser-guided tunnel boring machines, called moles, chewed tunnels anywhere from 10 to 16 feet in diameter—at an underground depth of between 85 and 200 feet. The $2.5 million moles were enormous pieces of equipment. They measured about 400 feet from cutter head to the end of its trailing equipment, where the smashed rock was loaded into rail cars. Approximately thirteen workers tended each mole.

The tunnel systems prevent overflows with a "catch and store" system. During wet weather events, the surface sewers still fill and over flow, but not to the Genesee River, Irondequoit Bay and the street. Instead, these overflows go through drop shafts into the CSOAP tunnel where the wastewater is stored and eventually conveyed to

VanLare for Treatment. Before the installation of the tunnel systems, there was an average of 30-40 overflow events per year. Overflows are now quite rare. Of the 50 original overflow sites, 35 were eliminated. In 2002, VanLare treated 1.2 billion gallons (an equivalent of over 91,000 above ground pools) of combined sewer overflow, that—in the past—would have gone directly into the Genesee River and Irondequoit Bay.

Today the sewer collection system operated by the Monroe County Department of Environmental Services consists of:

- 30 miles of deep rock tunnels
- 80 miles of interceptor sewers
- 1,100 miles of sanitary, storm and combined sewers
- 51 remote lift/pump stations to lift wastewater to a higher elevation to allow for gravity flow
- 15 tunnel facilities with flow control/diversion capabilities
- 25,000 catchbasins and 16,900 manholes

The head of a mole (showing its teeth) emerges from a tunnel.

The sewer system operated by Monroe County is spread over four sewer districts seen on the map at left: Northwest (yellow), Gates Chili Ogden (rust), Rochester (green), and Irondequoit Bay (blue).

How is Wastewater Treated to Remove Pollutants?

Once the wastewater arrives at Monroe County's two facilities, physics, chemistry, microbiology and engineering are all involved in purifying wastewater so that it can be safely returned to Lake Ontario.

VanLare and Northwest Quadrant are biological treatment plants. They use basically the same cleansing processes that naturally take place in lakes, rivers, etc. These facilities give cleansing reactions a place to occur under controlled conditions, so that they are completed before the water is discharged into the environment—Lake Ontario in this case.

At both facilities, chemical treatment—in the form of iron salts—is used for removal of the nutrient phosphorus by precipitation. Chlorine (in the form of sodium hypochlorite solution) is used for disinfecting, that is, killing harmful microorganisms before the final discharge of the wastewater. Chemical coagulants (polymers) are also used in sludge treatment to thicken the solids and promote the removal of water.

A typical treatment plant consists of a series of individual unit processes, with the output (effluent) of one process becoming the input (influent) of the next process. The first stages will usually be made up of physical processes that take out easily removable pollutants. After this, biological or chemical processes further treat the remaining pollutants by converting dissolved or colloidal impurities into a solid or gaseous form (so that they can be removed physically), or by converting them into safer, more desirable dissolved materials which remain in the water. The biosolids (sludge) which result from these processes form a side stream that must also be treated for disposal.

Treatment Process

What follows is the set of processes that occur once the wastewater enters the treatment facility. The time frames given for each process are for the VanLare facility and assume an average influent of 100mgd. The entire process, from water entering the plant until it is discharged, takes about 10 hours.

Preliminary treatment is used to remove large objects or abrasive material that might clog or damage equipment. These include bar screens and grit chambers. Bar screens simply catch large objects and rags, which are automatically raked off the screens. Grit chambers allow heavier materials, like sand and stones, to settle out, so that they will not cause abrasive wear on downstream equipment.

There are two types of grit removal systems at VanLare: aerated and non-aerated. The aerated system adds air bubbles to the wastewater on one side of a large rectangular chamber causing the wastewater to roil in a circular motion. This allows the heavier grit to settle to the bottom. The grit is removed from the chamber by a large screw drive system. The non-aerated system slows the influent in large rectangular tanks allowing the heavier grit to settle while leaving lighter organic material in suspension for further treatment. A submerged scraper removes grit from this chamber. The Northwest Quadrant plant uses aerated grit removal. The preliminary treatment process is completed

in about 15 minutes. The removed grit is trucked to the county's Mill Seat Landfill, located in the town of Riga, for disposal.

Primary settling basins/clarifiers are where the wastewater flow is slowed down for up to three hours. This allows organic suspended matter to either settle to the bottom or float to the surface. Most of this suspended matter has a density not much different from that of water, so it needs to be given enough time to separate. The tanks are designed with scrapers at the bottom to collect the settled sludge (biosolids) and direct it to an internal pit from which it can be pumped for further treatment—and skimmers at the surface, to collect the grease and plastics (scum) that floats to the top. This process eliminates about 30 percent of the wastewater's contaminants. The clarified water passes over teeth-like structures (weirs) and flows to the secondary treatment process.

Secondary treatment is a biological process (using bacteria and other microorganisms) that removes the majority of the remaining dissolved and colloidal organic matter. This biodegradation of the pollutants is allowed to take place in a location where plenty of air can be supplied to the microorganisms. This aerobic biological process promotes the formation of less offensive, oxidized products.

VanLare and Northwest Quadrant use a suspended growth biological treatment process known as the activated sludge system. This type of system consists of two parts—aeration tanks and a settling tanks/clarifiers. The aeration tank contains a "sludge" which is what could be best described as a mixed microbial culture, (mixed liquor) containing mostly bacteria, as well as protozoa, fungi, algae, etc. This sludge is constantly mixed and aerated by large mechanical aerators (propellers) on the surface of the tanks. The wastewater enters the tank from the primary clarifiers and mixes with the organisms. The organisms use the waste's organic compounds as nutrition to grow (numerically) and for respiration. The process can also be set up to provide biological removal of the nutrient phosphorus per EPA standards (see below).

After sufficient aeration time to reach the required level of treatment, the biological mixture is carried by the flow into the secondary clarifiers. An important condition for the success of this process is the formation of a type of culture which will flocculate (separate) naturally, producing a settling sludge (biosolids) and a reasonably clear upper (supernatant) layer of treated water. If the biosolids do not behave this way, too many solids will remain in the water leaving the clarifier, creating a poor quality effluent.

The biosolids collected at the bottom of the clarifiers are then recycled to the aeration tank to consume more organic material. The term "activated" sludge is used, because by the time the sludge is returned to the aeration tank, the microorganisms have been in an environment depleted of "food" for some time, and are in a "hungry," or activated state, eager to get busy biodegrading some more wastes. Since the amount of microorganisms, or biomass, increases as a result of this process, some must be removed on a regular basis for further treatment and disposal, adding to the solids already produced in primary treatment.

Nutrient removal refers to the treatment of the wastewater to take out phosphorus, which can cause nuisance growth of algae or weeds in Lake Ontario. Phosphorous removal is most commonly done at VanLare and Northwest Quadrant by chemical

precipitation with the iron compound ferrous chloride. The solids that are produced can be settled along with other sludge. Secondary treatment takes about 6.5 hours, after which 90 percent of the wastewater's original contaminants are removed.

An aerial view of the Frank E. VanLare Wastewater Treatment Facility

Disinfection, the final process before discharge, destroys harmful (pathogenic) microorganisms, i.e. disease-causing germs. The object is not to kill every living microorganism in the water—which would be sterilization—but to reduce the number of harmful ones to levels appropriate for deep discharge into Lake Ontario.

The most commonly used disinfectant is chlorine, which is supplied in the form of an alkaline solution called sodium hypochlorite. This is the same compound as common household chlorine bleach.

At Northwest Quadrant, the chlorine solution is added to the effluent just before it enters the final clarifiers. At VanLare, the chlorine solution is added to the effluent of the secondary treatment process as it enters a maze-like chlorine contact tank. The chlorinated effluent takes a 15-minute trip through the tank allowing the chlorine enough time to disinfect the effluent. By the time it is piped three miles into Lake Ontario and released at a depth of 120 feet, the level of chlorine in the effluent has dropped to negligible levels.

Biosolid (sludge) treatment

Ten hours of treatment has transformed the wastewater into a clean effluent, which has been discharged into Lake Ontario. What happens to the biosolids that were created along the way?

Biosolids from primary settling basins, called primary or "raw" sludge, is a noxious, smelly, gray-black, viscous liquid or semi-solid. It contains very high concentrations of bacteria and other microorganisms, many of them pathogenic, as well as large amounts of biodegradable organic material. Dissolved oxygen will be quickly consumed from the concentrated biosolids, and the foul and toxic results of anaerobic biodegradation (putrefaction) will be produced. The greasy floatable scum from primary treatment is another portion of this solid waste stream.

The secondary clarifiers produce a "secondary sludge," consisting largely of the microorganisms that have grown as a result of consuming the organic wastes in the activated sludge process. While not quite so objectionable, due to the biodegradation that has already taken place, the biosolids contain many pathogens and material that will decay and produce odors if not treated further. Both primary and secondary sludge is pumped to gravity sludge thickeners. As the biosolids settle, the supernatant is pumped to the head of the plant for re-treatment. The biosolids then leave the gravity thickeners and are combined in the day tanks (organic sludge holding tank, at Northwest Quadrant). These tanks give the biosolids from the various thickeners a uniform consistency. Chemical addition at this point reduces odors.

This liquid biosolid, which might contain 3 to 6 percent dry weight of solids, can be dewatered to form a drier sludge cake of 25 to 35 percent solids, which can be hauled as a solid rather than having to be handled as a liquid. Until 1999, the biosolids at VanLare were dewatered with belt filter presses. It was determined, however, that centrifugal dewatering would require less equipment maintenance and produce a drier sludge (up to 35 percent solids). Four centrifuges and associated equipment were installed and now produce drier biosolids. Chemical coagulants (polymers) are also added to the biosolids to aid in the release of water and help clump the solids.

Since the sewage entering the NWQ facility is primarily from residential areas, the resulting biosolids are relatively contaminant-free and have been used as an agricultural soil conditioner. Currently, however, all of NWQ's biosolids are dewatered, chemically treated and landfilled. VanLare's biosolds have a higher quantity of industrial contaminants and are not a candidate for any application other than landfilling and/or incineration.

Until all incineration was ended in 2005, these drier biosolids were delivered to the facility's multiple-hearth incinerators and required less energy to reduce to ash. The incinerators, equipped with odor reducing afterburners that operate at about 1230-1300^{0}F, eliminated all pathogens and reduced the biosolids volume by about 70 percent.

The 2005 construction of the Biosolds Off-Load Facility at VanLare achieved two goals: eliminate emission-producing incineration and ease biosolids transfer to the landfill where it would help convert garbage into renewable energy. The facility was created with four live bottom bins to hold dewatered biosolids, two drive-thru loading bays, and an automated weighing and loading system to fill the trailers. Each trailer

handles about 32 tons of biosolids with about 50 trailer loads going to landfills each week. A state-of-the-art odor control system is an integral part of this facility. Incineration now remains only as a backup disposal process.

Odor Control

In the handling and treatment of both wastewater and biosolids, a prime concern is odor control. In the sewers, prevention of anaerobic conditions and sulfide formation is an important consideration in preventing odors. If the wastewater is warm and the sewer flow is not rapid enough to aerate the water and scour the pipes, addition of chemicals such as nitrate, chlorine, hydrogen peroxide or iron compounds can be helpful. Untreated hydrogen sulfide gives off a powerful rotten egg smell and is also the major cause of sewer corrosion.

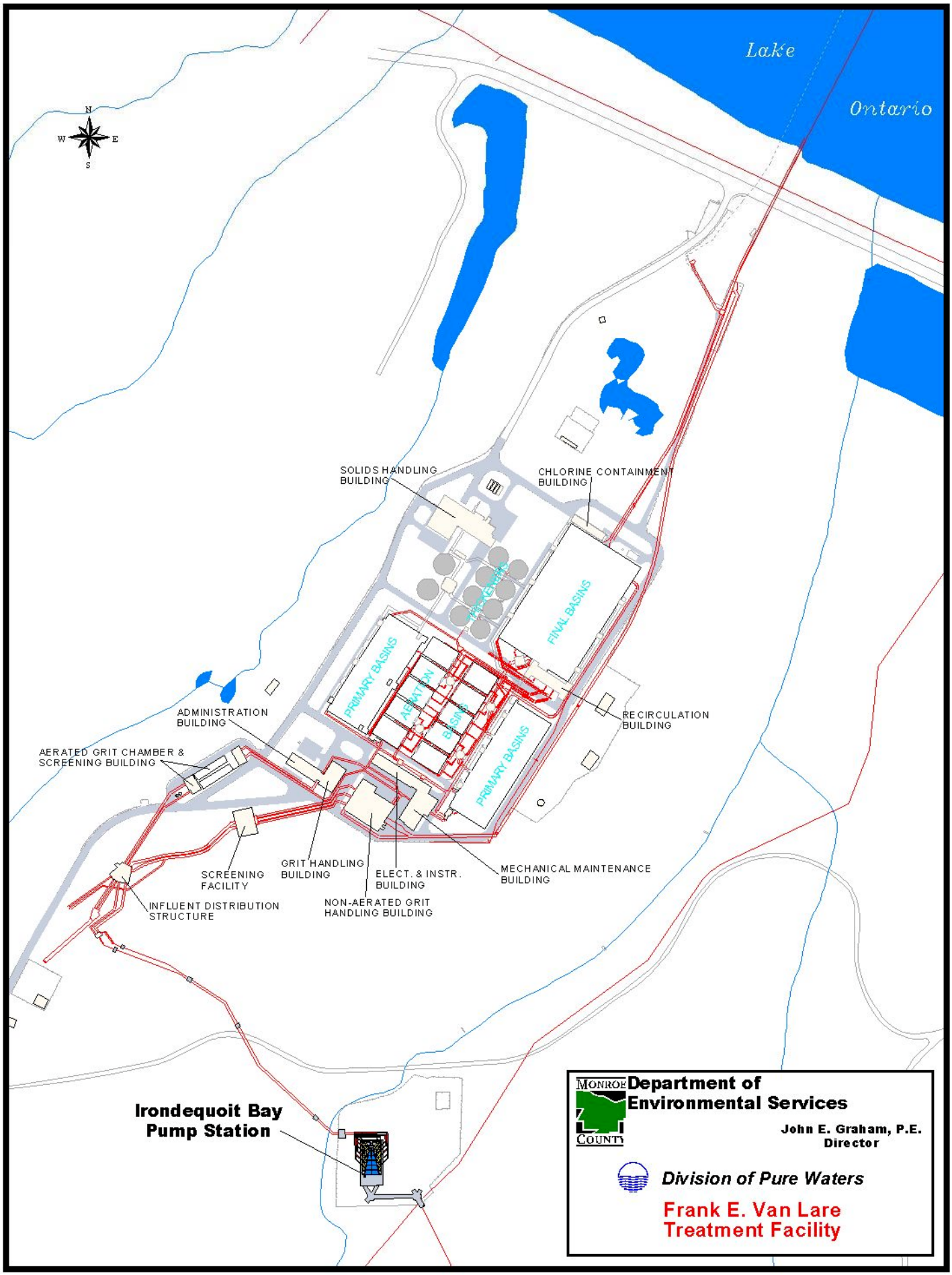
Odors are inevitable in various pump station and wastewater treatment plant processes. In processes where concentrated odors occur, they are ventilated through odor abatement systems like activated carbon beds or chemical scrubbers (often using hypochlorite solution). These systems greatly reduce nuisance odors released to the environment.

Waste-to-Watts

Biosolids from NWQ and VanLare wastewater treatment plants now provide a boost to area landfills. The mixing of garbage with moisture and microorganism-laden biosolids enhances the both decomposition and methane production. The gas is extracted and transported to the landfill gas energy facility through a series of wells and pipes. There the gas is dewatered, filtered, pressurized and piped to the generators, where the fuel turns the engines to produce electricity. Current Mill Seat Landfill gas profiles estimate that the landfill now produces enough methane gas to produce 3,200 kilowatts (kW) per hour of power (more than half of the electrical power used annually at the VanLare plant). With the additional biosolids, estimates indicate that methane gas production could support electric generation in the 6,000 to 8,000 kW range during the active period of the landfill.

Additional Resources

The Monroe County Department of Health has completed a county Environmental Report Card which includes key measurements describing the status of manmade and natural environments throughout Monroe County and the impacts of changes in environmental conditions on the health of living things. The report includes details on SPDES permit data, and water quality data for the Genesee River, Irondequoit Bay and the Rochester Embayment Area. This can be accessed on the Department of Health pages of the Monroe County website (www.monroecounty.gov). Further detailed information on wastewater treatment can be accessed at (www.geocities.com/flusch).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RECIRCULATION BUILDING
ADMINISTRATION BUILDING
AERATED GRIT CHAMBER & SCREENING BUILDING
SCREENING FACILITY
GRIT HANDLING BUILDING
ELECT. & INSTR. BUILDING
MECHANICAL MAINTENANCE BUILDING
INFLUENT DISTRIBUTION STRUCTURE
NON-AERATED GRIT HANDLING BUILDING
Irondequoit Bay Pump Station
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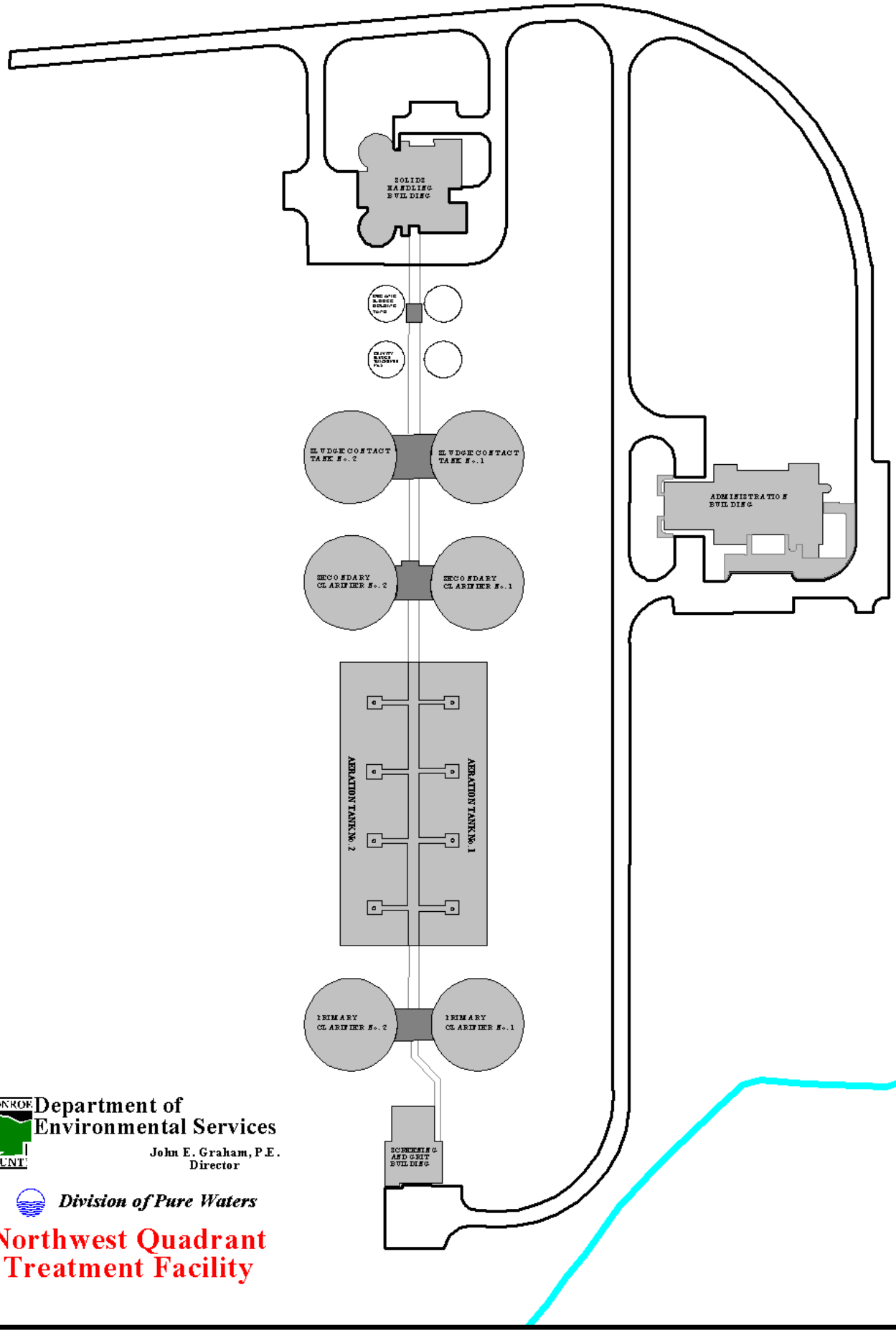

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Northwest Quadrant Treatment Facility

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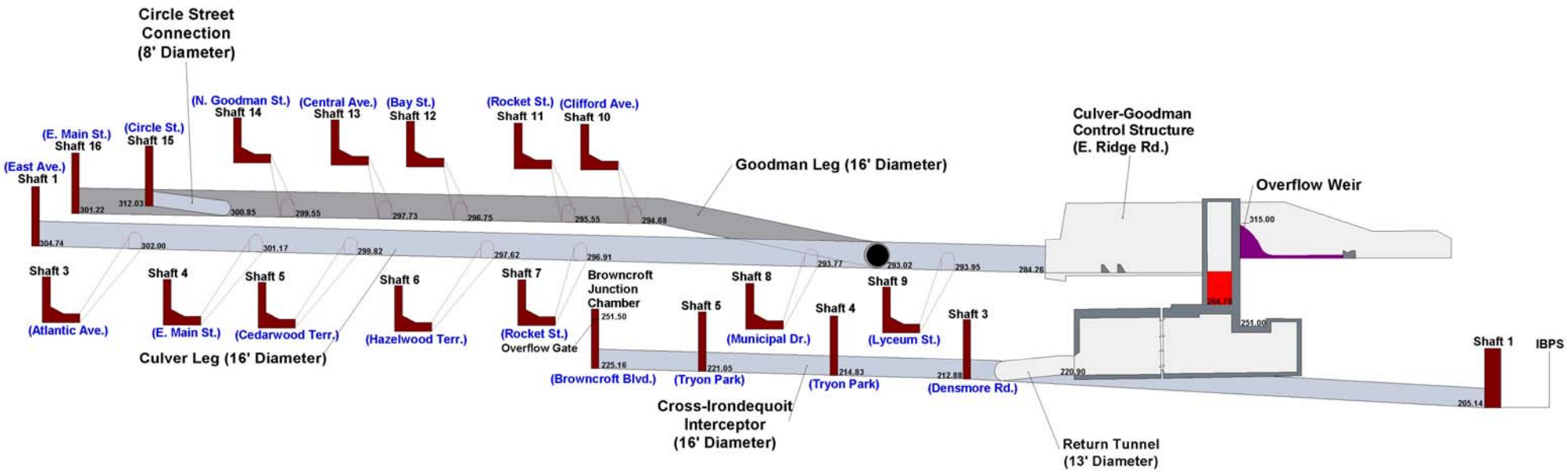
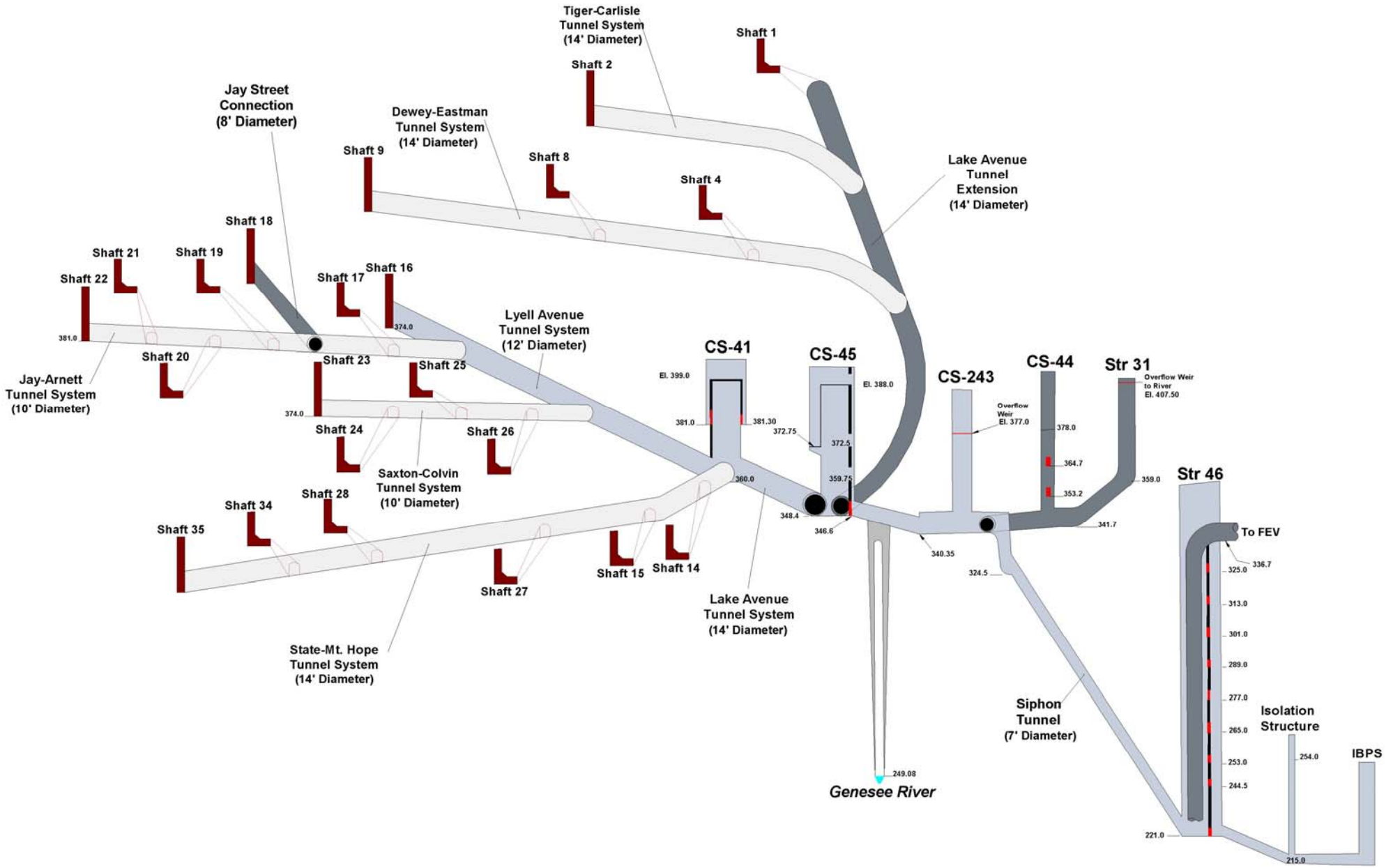
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