How Water in PHILADELPHIA is Treated and Distributed

1992

FACTS AND CHARTS

Abundant Water From Local Streams...

SOURCES AND DISTRIBUTION

Where does Philadelphia get its water?

The city pumps one-half of its water from the Delaware River, just above the outlet of Pennypack Creek. The other half is pumped from the Schuylkill River at two different locations: the Belmont Pumping Station on the west side, just below Columbia Avenue Bridge, and the Queen Lane Pumping Station on the east side, just below City Line Bridge. The Belmont Station pumps from the pool formed by the Fairmount Dam, while the Queen Lane Station draws water from the head of the same pool.

All sources are located within the city and, with minor exceptions, all service is within the city limits.

After treatment and filtration, the major part of the effluent (or output) of the Belmont and Queen Lane Plants is delivered through the distribution system by gravity. This is possible because these plants have filtered water basins with water level elevations of 239 and 216 feet respectively.

The other effluents from Belmont and Queen Lane—and all the effluent from the Baxter Plant—are pumped by stations located at, or near the plants, and some effluents are repumped at six booster stations. Pumping helps to maintain the gradients required for satisfactory pressures and good service at all points in the distribution system.

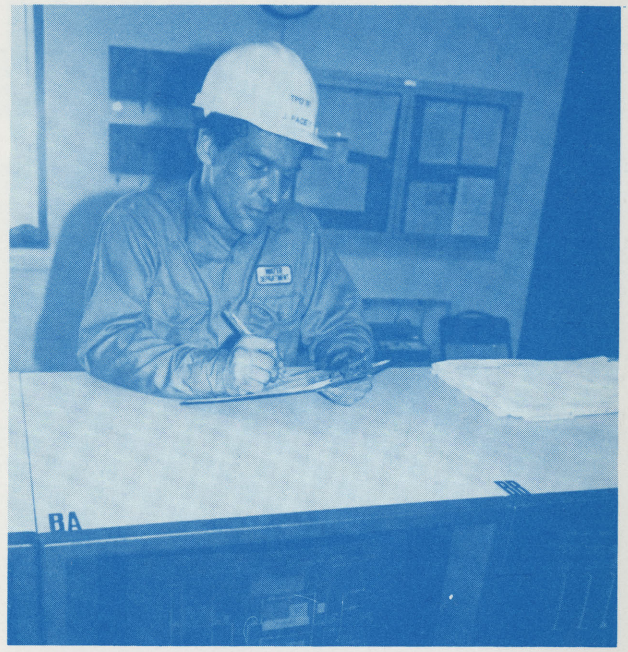
Normally about one-third of plant output is delivered by gravity and two-thirds is pumped. Of the latter, about 15% is repumped at the booster stations.

Because of differences in elevation among city neighborhoods (a difference of 450 feet, for example, between homes in Roxborough and those in South Philadelphia), the city is divided into ten pressure districts. The fact that Philadelphia takes its water from three different river sources also makes some of these districts necessary.

AREAS WHERE DELIVERED

Delaware water is delivered generally to those areas of the city east of Broad Street, while Schuylkill water reaches consumers west of Broad Street. There are some exceptions, however, to this pattern of distribution.

Thus Delaware water flows west of Broad Street to some neighborhoods south of Erie Avenue. It is also delivered to West Oak Lane and Chestnut Hill, and it may mix with Schuylkill water in the vicinity of East Park Reservoir before the latter water enters center city. Schuylkill water may also cross the Broad Street boundary: it serves the area bounded by Lehigh, Wyoming, and Kensington Avenue, and Roosevelt Boulevard.



Queen Lane's computerized automation system varies chemical feeds with changes in water flows, automatically backwashes filters and provides extensive alarm and monitoring capabilities.

Because of changes in consumer demands, and the need for occasional changes in plant operations, it is uncertain which of the river waters, or what combination of them, will be received in some areas along the north-south mid-axis of the city represented by Broad Street. West Philadelphia, however, receives only Schuylkill water.

The preceding is of particular interest to those who may be affected by changes in the mineral content of the water, since the Schuylkill water contains in solution about twice the amount present in Delaware water. In 1991, the average hardness of water delivered to distribution from the Baxter Plant on the Delaware averaged 78 parts per million; hardness of water from the plants on the Schuylkill averaged 130 parts per million.

The total population served is 1.74 million. To these customers the Water Department distributes an average of 349 million gallons daily.

In addition, the department delivers 17 million gallons of water daily to the Bucks County Water and Sewer Authority for distribution in lower Bucks County.

The distribution system contains 3,200 miles of pipes of various sizes, from three inches to seven feet nine inches in diameter. About 142 miles of this pipe are three feet or wider in diameter. There are 83,600 valves and over 27,700 fire hydrants.

Besides the regular distribution system, there is a high pressure fire system covering center city and that part of north central Philadelphia lying east of Broad Street and south of Lehigh Avenue. This is composed of 63 miles of mains, 1,900 valves, and 1073 hydrants, together with two pumping stations that deliver water at pressures up to 300 lbs. per sq. in. One station is located at Delaware Avenue and Race Street; the other at 7th Street and Lehigh Avenue.

MODE OF TREATMENT

Philadelphia's three water treatment plants are modern. The Baxter Plant was originally completed in 1959; the Belmont Plant in 1965; and the principal facilities of the Queen Lane Plant in stages — 1954, 1960, 1971. All three plants have been retrofitted for computer operation. The plants are of the rapid-sand filter type, and can be automatically or computer controlled.

Daily output of the water treatment plants, in millions of gallons daily, averaged as follows in fiscal 1991:

Belmont	**59.0**
Queen Lane	**99.3**
Baxter	**206.4**

Although there is some variation at the plants, the treatment process comprises of natural sedimentation, pre-chlorination, chemical treatment, flocculation, sedimentation, filtration, and post chemical treatment.

Natural sedimentation takes place in a large raw water reservior, where some suspended matter settles out as the water moves slowly through.

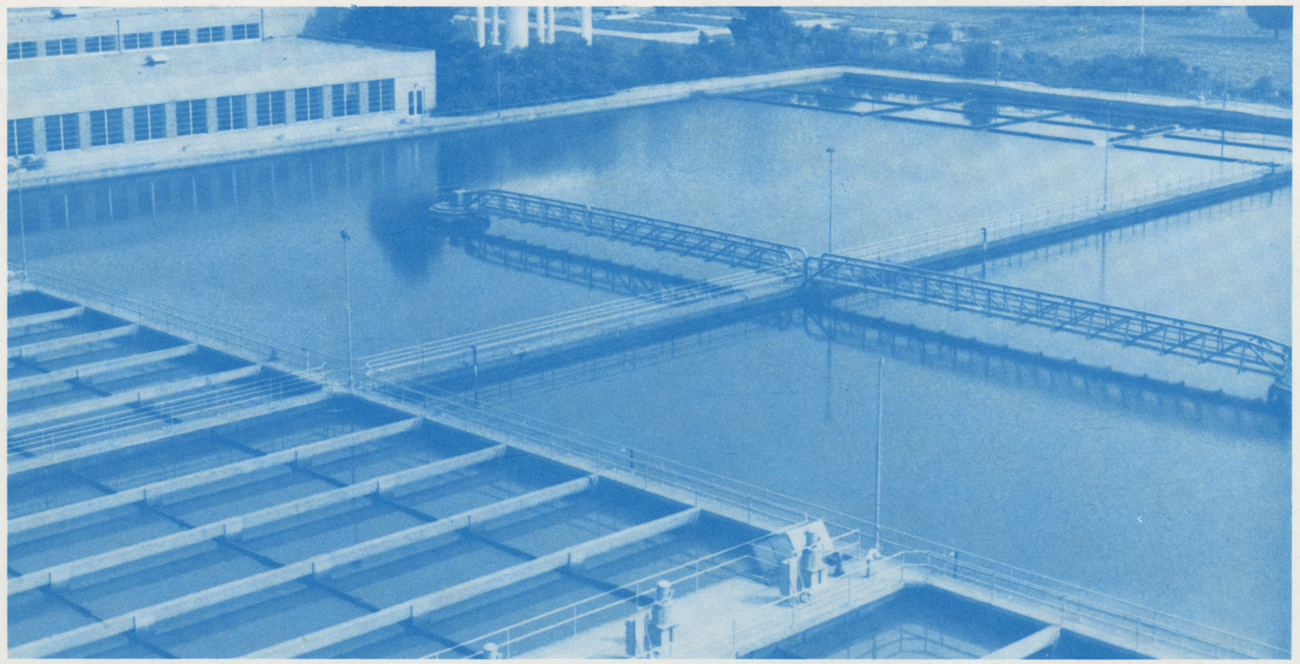
The second step in treatment is chlorination. The chlorine is added to the water to destroy taste and odor-producing materials which are chiefly organic matter. This may include the wastes of industries as well as those of natural origin.

The third step is injection of other chemicals into the raw water as it passes under a chemical or pre-treatment building. At this point, alum or ferric chloride may be added to promote the later formation of "floc," and chemicals such as carbon or sodium chlorite may be used to control taste and odor.

The fourth step is for the water to pass through small basins, where the chemicals and water are mixed for more than a half-hour by giant revolving paddles. The mixing causes the formation of "floc," tiny red or brown granules. The floc will enmesh suspended impurities in the water.

When necessary, lime is added to the water to neutralize acidity and create optimum conditions for the formation of floc.

Enmeshment of suspended particles by the floc takes place in large sedimentation basins to which the water next flows. In these basins the water remains quiescent for two to four hours, and the floc settles to the bottom, taking with it more than 90% of the suspended impurities. This prepares the water for filtration.



Water sparkles as it flows off the sedimentation basins at the Baxter Water Plant to enter the filter building (left background). The basins settle out 90% of the impurities in the water.

.....Treated In Modern Plants

.....One Of America's Purest Waters

The water is then filtered through beds of sand and gravel, which remove all particles that remain after the settling period.

As the final step in treatment, the chlorine content of the water is adjusted to ensure safety, and ammonia may be added to counteract chlorinous tastes and odors. At various steps in the treatment process, additional chemicals may be used, or the usual chemicals replaced by others. This is governed by the changes in the condition of the raw water supply.

To help prevent tooth decay in children, fluoride is also added to the water.

Because treatment steps differ slightly at the plants, the successive steps are summarized below:

BELMONT: (1) Settling by natural sedimentation for 22 hours (2) pre-chlorination, (3) application of chemicals—alum with lime for pH adjustment, (4) rapid mixing of chemicals with water, (5) slow mixing of chemicals to form "floc," (6) settling, (7) chlorination, (8) rapid sand filtration, (9) post treatment, including chlorination, zinc orthophosphate for corrosion control, fluoridation, and ammonia.

QUEEN LAND: (1) Settling for 20 hours, (2) pre-chlorination and fluoridation, (3) application of chemicals — ferric chloride, with lime for pH adjustment, and carbon, (4) rapid mixing of chemicals with water, (5) slow mixing of chemicals with water to form "floc," (6) settling, (7) chlorination, (8) rapid sand filtration, (9) post treatment, including zinc orthophosphate for corrosion control and ammonia.

BAXTER: (1) Settling by natural sedimentation, (2) chlorination, (3) application of chemicals — ferric chloride with lime for pH adjustment, chlorine, dioxide, and carbon, (4) rapid mixing of chemicals with water, (5) slow mixing of chemicals with water to form "floc," (6) settling, (7) chlorination to free chlorine residual, (8) rapid sand filtration, (9) post treatment, including chlorination, fluoridation, ammonia, and lime for corrosion control.

Water withdrawn from the East Park and Oak Lane reservoirs is rechlorinated before entering the distribution system. East Park water is treated with chlorine dioxide through the spring, summer and autumn to control algae.

QUALITY CONTROL: The Water Department guards the quality of its water from the river to the home faucet. Along the rivers, raw water samples are collected by boat. In the plants, laboratory personnel check the water at every treatment stage, and this is followed by regular sampling of 85 points in the distribution system. Laboratories make 180,000 wet chemical tests on water each year, and the equivalent of hundreds of thousands of other tests by electronic testing devices.

The city's drinking water, in its finished form, meets or surpasses all of the quality standards of the U.S. Environmental Protection Agency under the Safe Drinking Water Act.

Modern laboratories ensure pure, safe, and palatable drinking water. The Labs make 180,000 "wet chemical" tests and hundreds of thousands of instrumental tests on water samples yearly.

1801: Steam Pumps Supplied Water

Philadelphia's water system began with a bold experiment.

At a time when steam power was finding its first uses in America, the City Fathers opened two steam pumping stations in January, 1801. These water works represented the first large scale application of steam pumping to water service in this country.

The new system was the brain child of Benjamin Henry Latrobe, an immigrant British engineer, who later designed the Capitol in Washington.

One of Latrobe's stations was located just north of Chestnut Street near the Schuylkill River. The water flowed into a pit under the station, and a steam engine raised it about 40 feet into a brick conduit, which ran down Chestnut Street to Broad Street and then turned north to Centre (now Penn) Square.

The other station, situated in the middle of Centre Square where City Hall now stands, received the water and raised it by steam power to two wooden tanks that were 40 feet above the ground. these tanks, which held 17,660 gallons, were the city's only reservoir.

Labrobe's stations operated until 1815. The Centre Square buildings were taken down in 1829.

OLD FAIRMOUNT WATER WORKS

By 1812 the City Fathers had grown disgusted with the expense of keeping the wooden pumps running at Centre Square. Water service too was frequently interrupted by insufficient storage.

As a result, the City built new water works at "Fair Mount," which went into service on September 7, 1815. Water was raised to an earthen reservoir on the hill now occupied by the Museum of Art, from which it flowed by gravity to city houses.

At first, two steam engines were used to lift the water. Unfortunately, the boiler of one of the high pressure engines burst in 1818, and the City Fathers turned to much cheaper water-wheel power.

A dam was built across the Schuylkill River to form a fresh water pool, and new paddle wheels and pumps were installed just below the pool level. River water was conducted into a forebay on the back and east side of the mill buildings, and it was then led through flumes to turn the wheels.

The new water-driven works — the first of its type built for public water service in any large American city — went into operation July 1, 1822.

From the beginning of the Fairmount Station and through much of its subsequent evolution, Frederick Graff, eminent engineer, was the guiding spirit. His son, Frederick, Jr., carried on his work after his death in 1847.

The Centre Square Works was one of two steam-powered pumping stations opened by Philadelphia in 1801 to supply water.

As the city grew, additional paddle wheels were installed at Fairmount, and additional basins were created on the neighboring hill. By 1842, there were eight paddle wheels supplying water to four basins through double-acting force pumps which had been designed by Frederick Graff.

The first water turbine (a French invention by Fourneyron) was installed at Fairmount in 1851, and by 1871 all of the paddle wheels had been replaced by turbines. Fairmount Dam was rebuilt in 1842-43.

The Fairmount Station continued to supply portions of the city until March, 1911, when new filtration plants took over all water service.

19TH CENTURY PIPING

When the Centre Square Station went into service in 1801, Water flowed from it through wooden logs to reach center city homes. These logs were bored through the center, and joined end to end by iron bands and caulking.

The wooden mains, however, leaked badly and constantly, and by 1832, the city discontinued laying them. Up to that time it had laid 241,604 feet.

Cast iron mains gradually replaced the old logs. The first 400 feet of cast iron pipe was imported from England in 1817, and by 1852 the city proper had 440,403 feet of cast iron mains in service. By the 1850s wooden mains were no longer in use, although many of them were not actually removed from the ground.

Philadelphia's water system today has 3,200 miles of mains, most of them cast iron but with an increasing proportion of ductile iron and steel pipe. A few old mains laid in the 1830s and 1840s are still in service.

From Water Wheels And Wooden Mains

EARLY 20TH CENTURY FILTRATION

The chief method of purifying water in 19th century Philadelphia was to provide for quiet periods in the reservoirs. This allowed suspended materials to settle to the bottom.

As the century wore on, however, the water from the Delaware and Schuylkill rivers became increasingly polluted. Tastes and odors appeared, and the typhoid fever rate rose in the city.

Between 1858 and 1899, seven special studies were made of water sources and treatment. As a result of the 1899 report, the City Council authorized the construction of filtration plants.

Five new filtration plants — the biggest and finest "slow sand" plants in the world — went into service between 1902 and 1911. The new plants included extensive acreages of sand beds, where the river water was filtered. This filtration was preceded by cleansing in pre-filters of the coke or sponge type, and/or, later by settling in raw water basins.

Filtration of Philadelphia's water caused a marked drop in typhoid deaths. These quickly fell from an annual average of 60 per 100,000 residents to only one-fourth that number. With the introduction of chlorine treatment in 1913, typhoid was rapidly wiped out.

THE REBIRTH OF THE 1950S

As the years went by, the lack of public funds handicapped the city's water system. Its proud slow sand plants gradually deteriorated. Though a few rapid sand filters were introduced at the Queen Lane and Belmont Plants in the 1920s and other modifications were made, the plants were unable to keep up with growing water demands. This was also true of the old steam pumping stations.

The city's drinking water had become safe, but tastes and odors persisted. To correct this, activated carbon, ozone, chlorine dioxide, and other treatment chemicals were adopted in the late 1940s and early 1950s. There was an immediate improvement in water quality.

With the creation of a self-supporting Water Department in 1952, the long needed funds became available. The department began a $217 million construction program (1952-1976).

To provide better water and meet rising demand, the department built a network of modern treatment plants, pumping stations, covered reservoirs, and hundred of miles of new mains.

Notable were the treatment plants. Equipped with semi-automatic controls, the new (Baxter) Plant was the largest "push-button" rapid-sand plant in America when it was opened in 1959. Similar plants were completed in the 1960s at Queen Lane and Belmont.

During the 1950s, the last steam pumps were removed from pumping stations, and new electric pumps were installed.

LOAD CONTROL CENTER

Keeping watch over the distribution of water to Philadelphians is a modern system of electronic controls. The multi-million dollar system, known as the Load Control Center, was one of the first in this country when it was inaugurated in 1960.

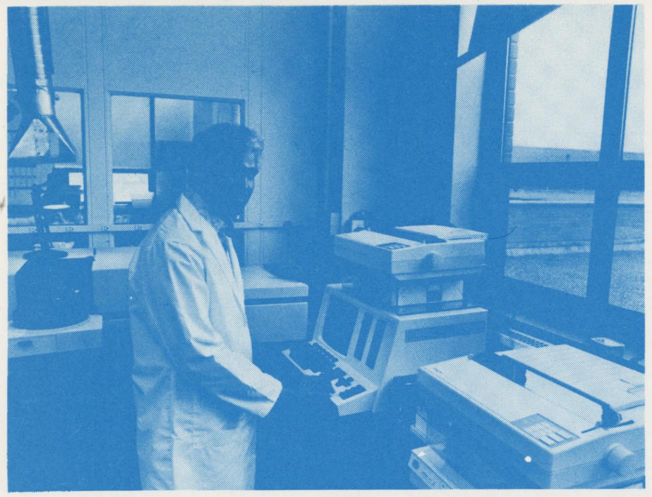
The high speed intelligence system constantly monitors water pressure, rates of flow, levels, etc. in water mains, reservoirs, and pumping stations throughout the City. Data is picked up by electronic sensing devices at 120 points in the water distribution grid and is relayed by a ring of seven microwave towers to the control center. Complex equipment then deciphers the incoming signals, translating them automatically into meaningful information on typewritten sheets and digital displays. In the near future, Load Control will feature a new Supervisory Control and Data Acquisition System (SCADA).

There are no operating personnel in any of the 16 pumping stations. By simply pushing a button, the operator at the control center can start or stop pumps, and open and close valves in the remotely located stations.

PROTECTING WATER QUALITY

In 1976, Philadelphia became the first American city to build a pilot plant to determine the best methods for removing trace organics, and tastes and odors from water. Located in the Baxter plant, the pilot facility used both regular treatment and non-conventional treatment such as carbon filters, ozone, polyelectrolytes, and macroreticular resins. A Trace Organics Laboratory was also built at Baxter to monitor the results of the tests.

To protect drinking water from taste and odor causing algae, the department began to cover its open reservoirs. In 1975-76, it placed floating covers on the north and south basins of the Oak Lane Reservoirs, and in 1992, the department will be completing the lining and covering of the north basins of the East Park Reservoirs. When completed, this will be one of the largest municipal lining/cover sites in the world.



The treatment of drinking water is an exacting process and Philadelphia's treatment plants take a number of precautions to make sure it is done right. There is a chemist working at each plant 24 hours a day. Every three hours, he or she tests the water at each stage of treatment. These tests allow the plant operators, also on staff 24 hours a day, to adjust their treatment to varying conditions.

WATER SYSTEM CAPACITIES — 1991

PLANT TREATMENT CAPACITIES

(in millions of gallons daily)

	RATED	PEAK RATE
BELMONT PLANT	78	123
QUEEN LANE PLANT	120	132
BAXTER PLANT	282	423

PLANT RETENTION CAPACITIES

(in millions of gallons)

		TOTAL
BELMONT PLANT:	Two 36-MG pre-sedimentation basins	72
	Four sedimentation basins	14.2
	Three filtered water basins	38.2
	Filtered water clear well	1.8
QUEEN LANE PLANT:	Pre-sedimentation basin	177
	Four 3-MG upper settling basins	12
	Four 3-MG lower settling basins	12
	Four filtered water basins	90
BAXTER PLANT:	Pre-sedimentation basin	176
	Four 10-MG sedimentation basins	40
	Five filtered water basins	193

OTHER RETENTION CAPACITIES

(in millions of gallons)

		TOTAL
UPPER ROXBOROUGH:	Filtered water basins	25.6
LOWER ROXBOROUGH:	Filtered water basins	3
COVERED RESERVOIRS:	East Park (filtered water)	677
	Oak Lane (filtered water)	70
STANDPIPES:	Two 5-MG Somerton tanks	10
	Two 5.5-MG Roxborough tanks	11
	Fox Chase tank	1.5

PUMPING STATION CAPACITIES

(in millions of gallons daily)

		TOTAL
RAW WATER:	Belmont Station (Schuylkill)	140
	Queen Lane Station (Schuylkill)	200
	Torresdale Station (Delaware)	480
FILTERED WATER:	1. Treated Schuylkill Water	
	Belmont High Service Station	42
	Chestnut Hill Booster Station	8.5
	East Park Booster Station	75
	Queen Lane High Service Station	77.5
	Roxborough High Service Station	45
	2. Treated Delaware Water	
	Fox Chase Booster Station	25.3
	Lardner's Point Station	240
	Oak Lane High Service Station	50
	Torresdale High and Low Service Station (200 MGD low, 80 MGD high)	263
	West Oak Lane Booster Station	27.5
HIGH PRESSURE:	Fairhill Station	21.6
	Race Street Station	21.6

(Each high pressure station can pump 15,000 gallons per minute)

NOTE: At each stage, the combined capacities of the water system facilities (whether treatment plants, reservoirs, or pumping stations) are much greater than average daily demand by consumers. This enables the Water Department to meet emergencies, to supply peak needs at certain hours or seasons, and to continue operation when some facilities have to be taken out of service.

....To An Automated Water System

WATER PRESSURE DISTRICTS

1. TORRESDALE H.S. — FOX CHASE
2. TORRESDALE L.S. DISTRICT — 85 P.S.I.
3. ROX. HI-SERVICE — WEST OAK LA. — CHESTNUT HILL
4. UPPER ROXBOROUGH GRAVITY
5. LOWER ROXBOROUGH GRAVITY DISTRICT
6. QUEEN LA. HIGH SERVICE — OAK LANE
7. LARDNER'S POINT — QUEEN LANE GRAV. DIST.
8. BELMONT H.S. DISTRICT
9. BELMONT GRAVITY
10. EAST PARK — LARDNER'S PT. DISTRICT

Note on Water Pressures: The normal range of water pressures, as received by customers, is shown on the map for each district. Thus 50 PSI—75 PSI (for District 1) denotes a pressure range of 50 to 75 pounds per square inch.

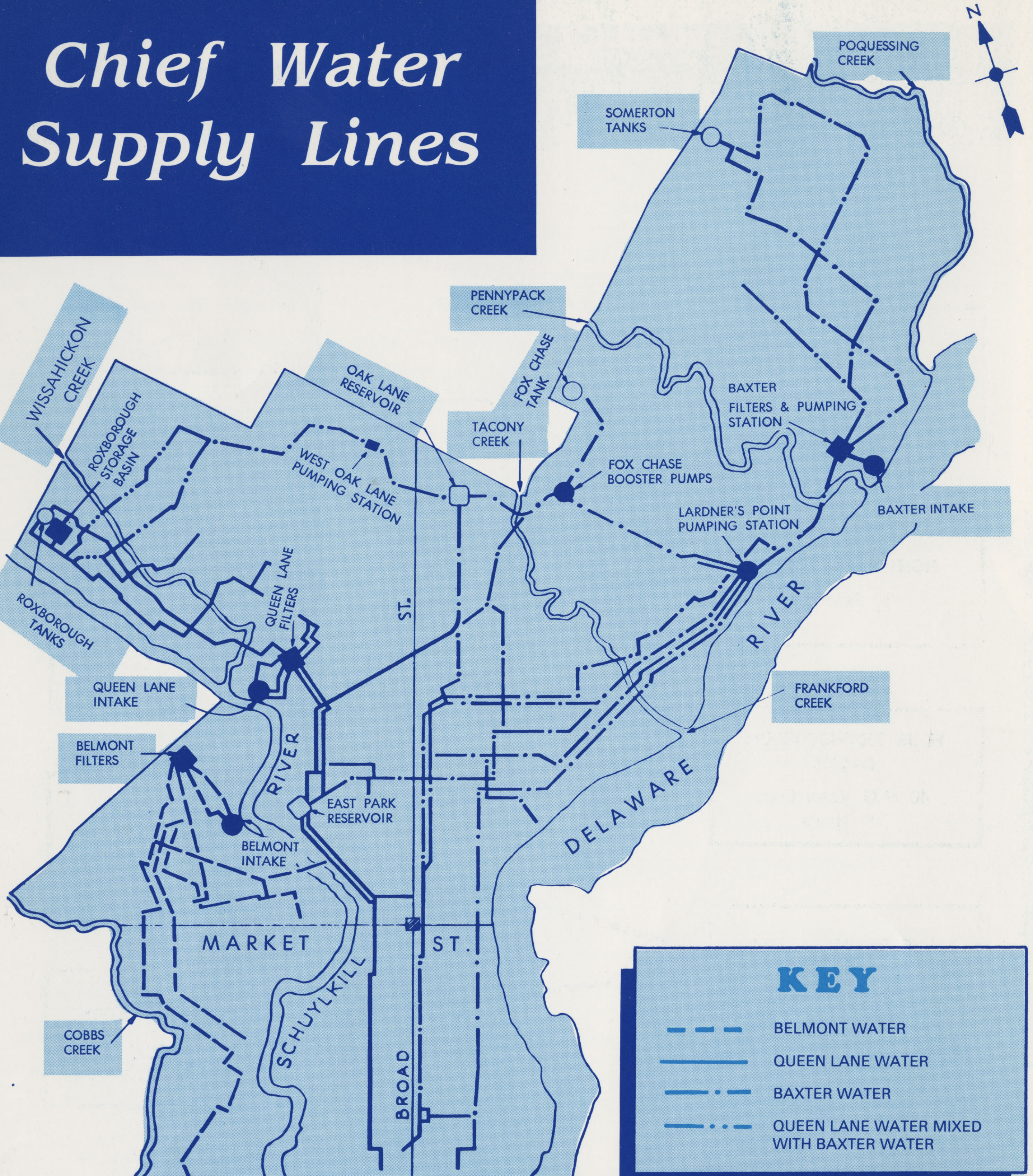
KEY

- ☐ Treatment Plants
- ★ River Water Pumping Stations
- ✪ Filtered Water Pumping Stations
- ☆ High Pressure Pumping Stations (for fire protection only)
- ◒ Tanks for Filtered Water
- ● Covered Reservoirs for Filtered Water

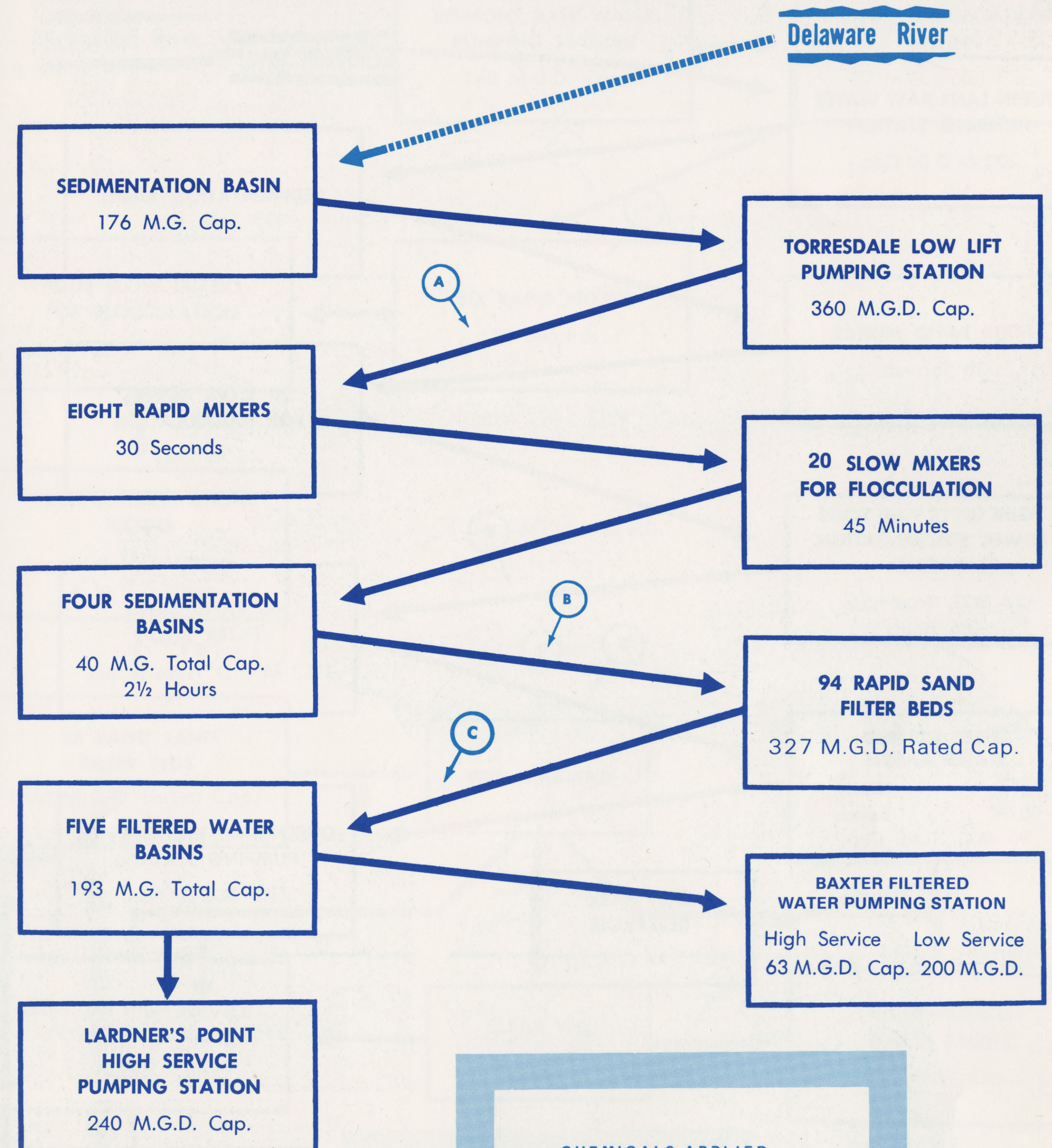
Note: There are also underground basins for filtered water at each treatment plant and in Upper Roxborough.

Philadelphia
Water Facilities & Water Pressure Districts

Chief Water Supply Lines



Baxter Water Treatment Plant



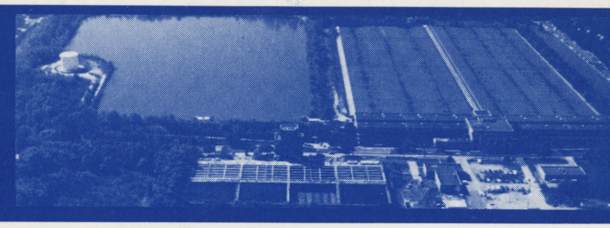
CHEMICALS APPLIED

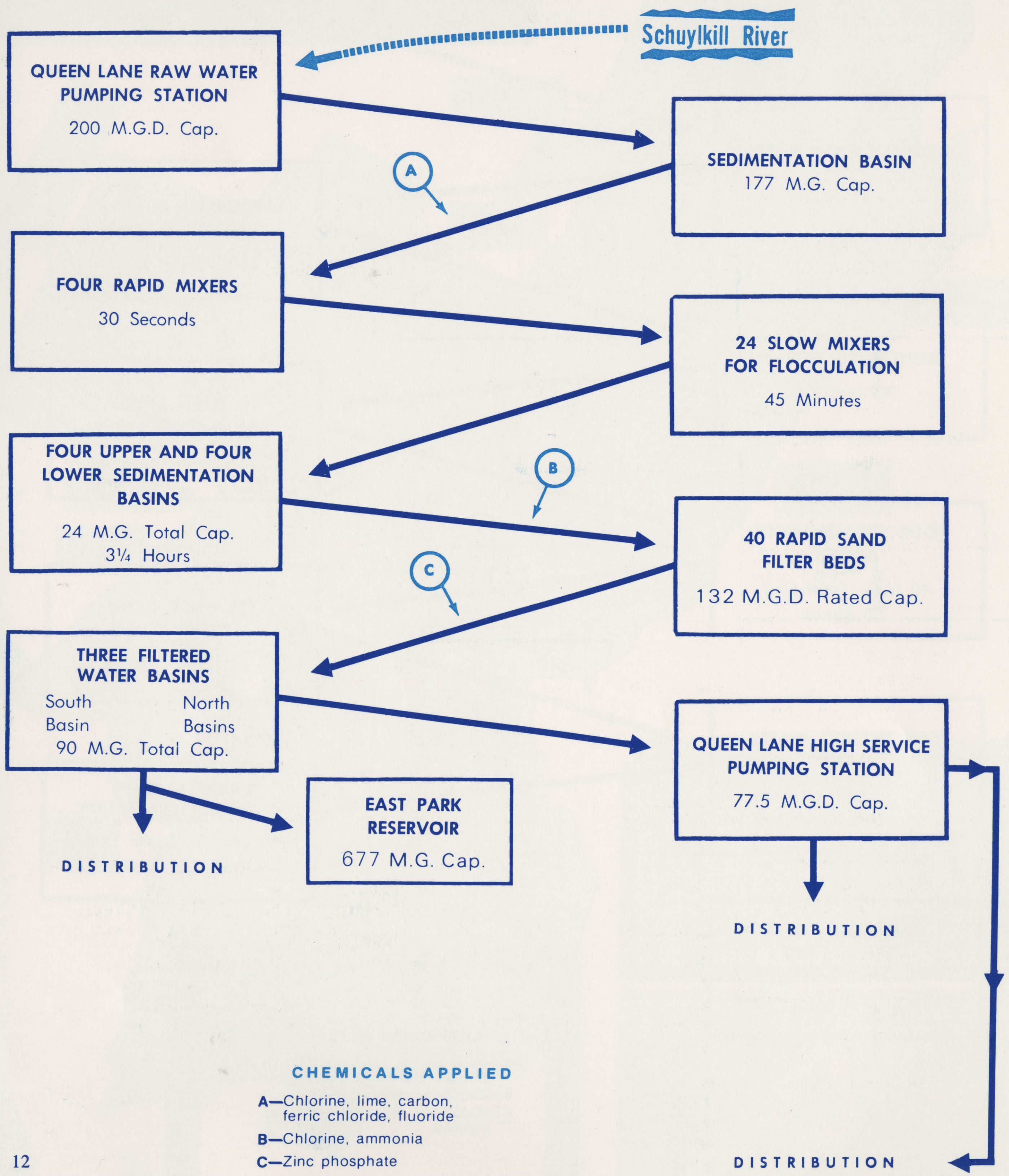
A—Ferric chloride, lime, carbon, chlorine, chlorine dioxide

B—Chlorine or chlorine dioxide

C—Fluoride, chlorine, chlorine dioxide, ammonia

Queen Lane Water Treatment Plant

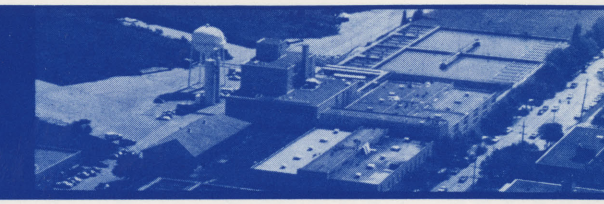


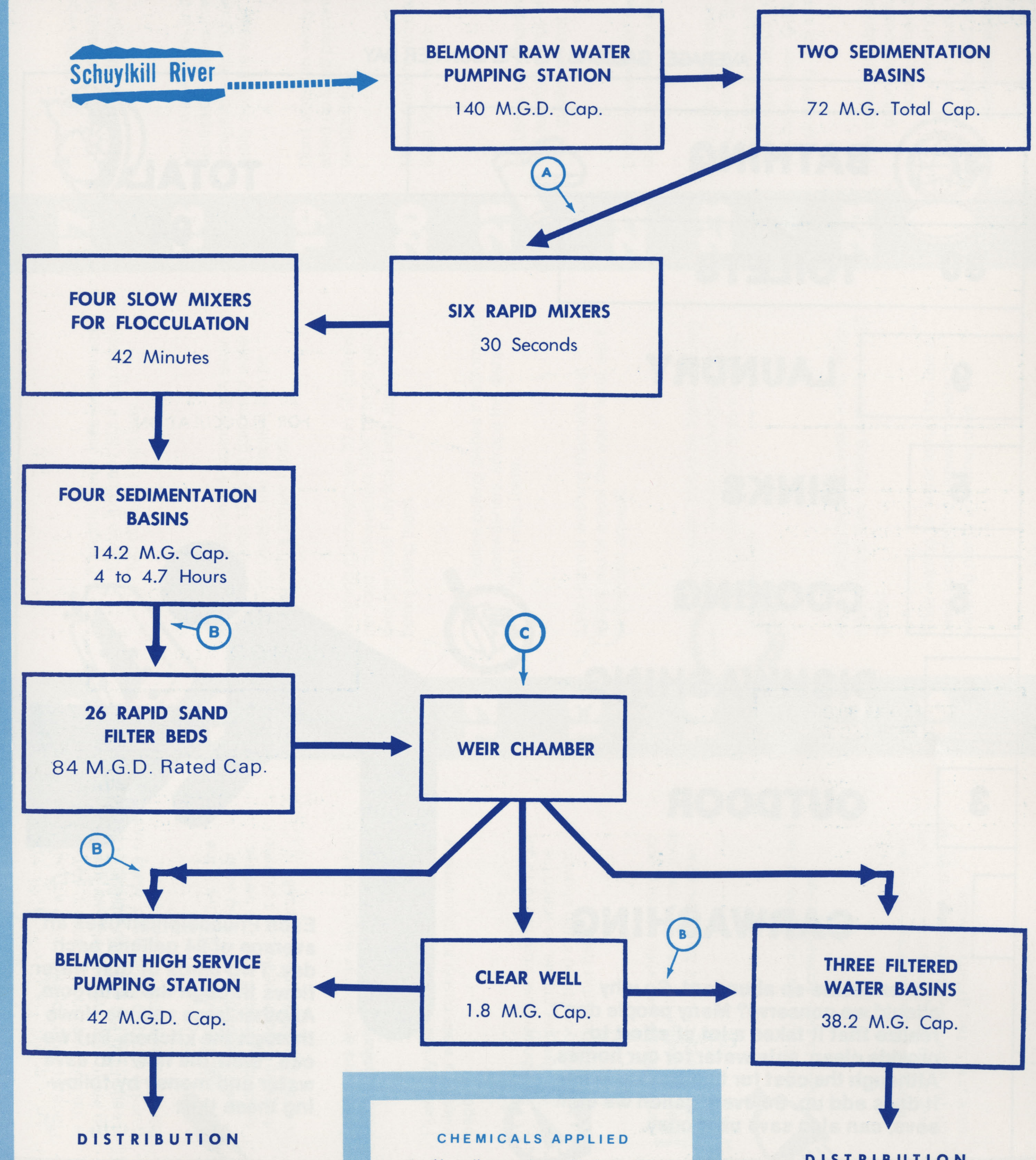


CHEMICALS APPLIED

A—Chlorine, lime, carbon, ferric chloride, fluoride
B—Chlorine, ammonia
C—Zinc phosphate

Belmont Water Treatment Plant





CHEMICALS APPLIED

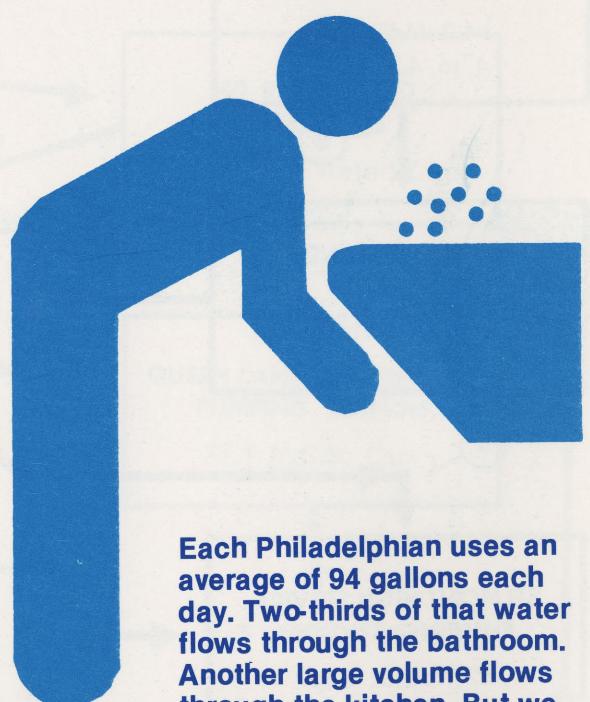
A—Alum, lime, carbon, chlorine, chlorine dioxide
B—Chlorine
C—Zinc phosphate, lime, fluoride, ammonia, chlorine, chlorine dioxide

HOME WATER USE

AVERAGE GALLONS PER PERSON PER DAY

37	BATHING
30	TOILETS
9	LAUNDRY
5	SINKS
5	COOKING
4	DISHWASHING
3	OUTDOOR
1	CARWASHING

TOTAL: 94



Water seems so abundant. So why should we conserve? Many people don't realize that it takes a lot of effort to provide clean, safe water for our homes. Although the cost for this service is low, it does add up. So every gallon we can save, can also save us money.

Each Philadelphian uses an average of 94 gallons each day. Two-thirds of that water flows through the bathroom. Another large volume flows through the kitchen. But we can "slow the flow" to save water and money by following these tips:

1 Place a plastic container filled with water in the toilet tank to help displace some of the five to seven gallons of water used in each flush. But don't use a brick; it can crumble and clog sewer pipes. Make sure the container doesn't block the float.

2 Place several drops of dye in the tank, but don't flush. If dyed water seeps into the bowl after five minutes, you have a hidden leak. Call a plumber, or make the simple repair yourself.

3 Toilet dams are another way to hold back several gallons from each flush.

4 Flush only when necessary. Don't use the toilet as a wastebasket for cigarettes or paper.

5 Showers use from five to 15 gallons per minute, so watch the time you spend in the shower. A kitchen timer helps.

6 Turn off the shower while lathering, and then resume for the rinse. You can even install a shut-off valve for this purpose.

7 Install flow restrictors in the shower-head to save additional water.

8 Shutting off the water while shaving will save two to four gallons of water. Turning off the water while brushing your teeth will save one to two gallons of water.

9 A short shower uses far less water than a tub bath. But if you take a tub bath, fill it half way.

10 Repair all leaks in the plumbing. A slow drip can waste 10 to 25 gallons of water a day. And usually, the problem can be solved with a simple repair.

11 Washing machines use 30 to 50 gallons per load; dishwashers use 16 to 20 gallons per load. Fully load both appliances before using them.

12 Before putting dishes in automatic dishwashers, scrape the dishes; don't rinse them.

13 If you have a washing machine that allows you to adjust the water level, set it for the right amount.

14 If you wash dishes by hand, use two basins, one for washing and one for rinsing, rather than a running faucet.

15 Keep a gallon bottle of water in the refrigerator, rather than running water for a cold glass.

16 While waiting for water to run hot, use a basin to catch the lukewarm water for watering plants and other uses.

17 Wash vegetables and fruits in a basin rather than under running water.

18 Don't water lawns and gardens more than necessary. Rather than follow a rigid schedule, watch for signs that the plants really need the water.

19 Don't water on windy or sunny days, when up to 50 percent of the water will evaporate.

20 Mulch gardens to retain moisture and keep down weeds.

21 Use a hand-held hose, with an automatic shut-off nozzle, for greater control.

22 Don't use water to "sweep" sidewalks and drives. A broom or rake works much better.

23 Use your water meter to detect hidden leaks in the house. Simply turn off all taps and water appliances. Then check the meter dial for about 15 minutes. If it moves, you have a leak. Go back and check the plumbing. Call a plumber for advice.

24 The meter can also show you how many gallons various fixtures use in your house. When a family member is in the shower, watch the meter for a minute. Or measure the water used in one cycle of the automatic washer.

Water is the lifeline of the Delaware Valley–

Don't Waste It!

Philadelphia
PWD
Water Department