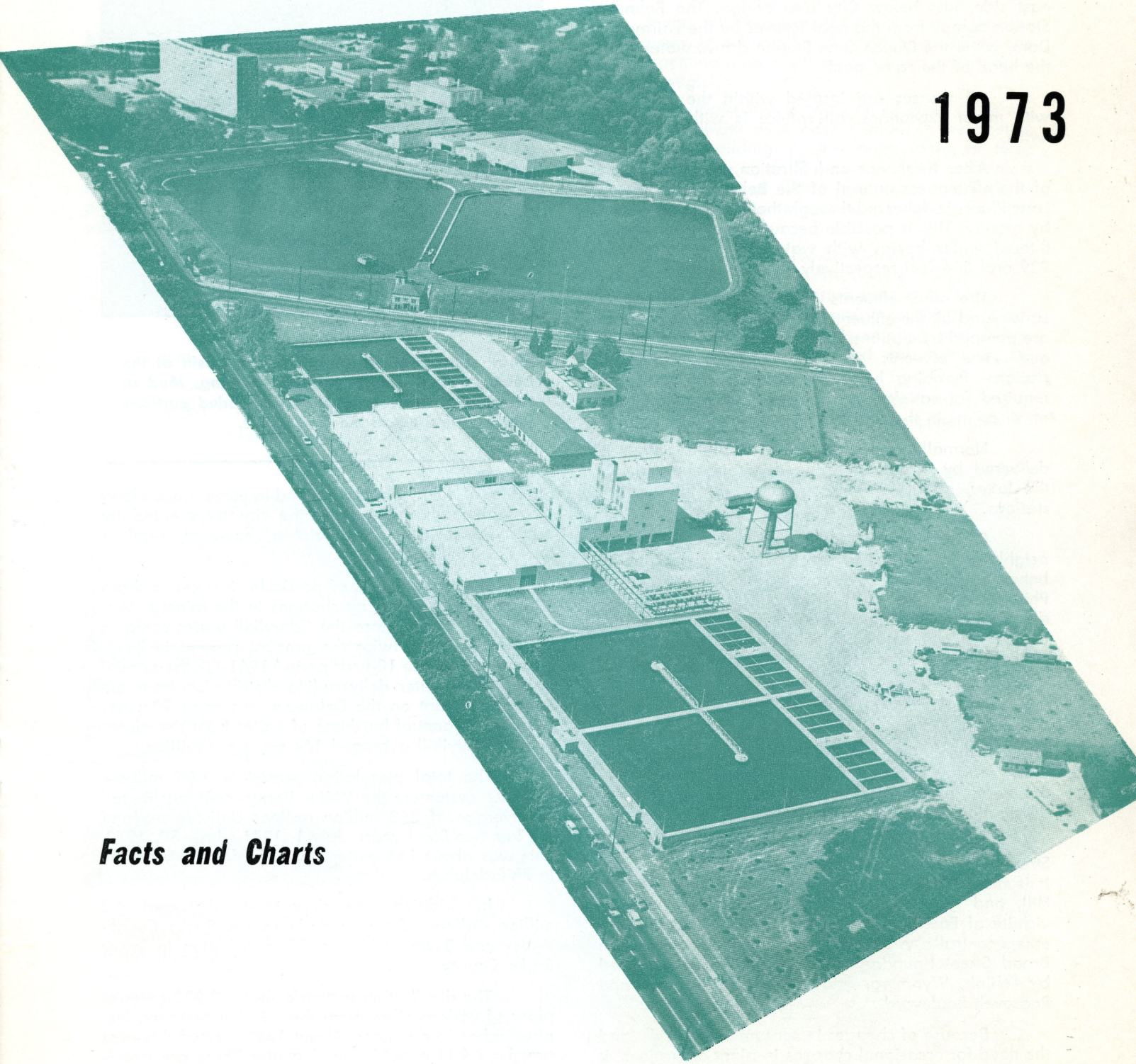
HOW WATER IN PHILADELPHIA IS TREATED AND DISTRIBUTED



1973

Facts and Charts

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 Torresdale 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.

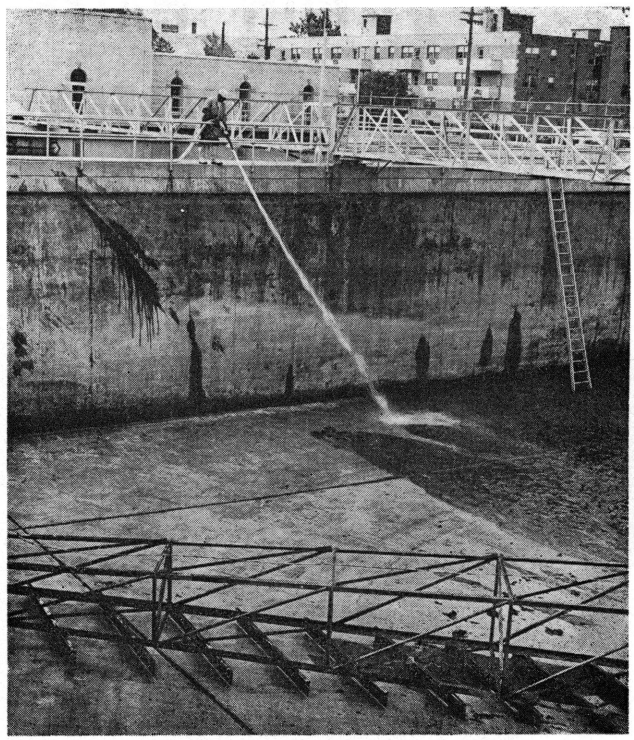
Because of differences in elevation among city neighborhoods (a difference of 450 feet, for example, between homes in Roxborough and those in South Philadelphia), the city is divided into ten pressure districts. The fact that Philadelphia takes its water from three different river sources also makes 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 central city. Schuylkill water may also cross the Broad Street boundary: it serves the area bounded by Lehigh, Wyoming, and Kensington Avenue, and Roosevelt Boulevard.

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.



Spring Cleaning: A sedimentation basin at the Belmont Plant gets a periodic cleaning. Mud at the bottom was formed from suspended particles which settled out of the river 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 the 10-year period 1961-70, the annual hardness of water delivered to distribution from the Torresdale Plant on the Delaware averaged 99 parts per million; annual hardness of water from the plants on the Schuylkill averaged 164 parts per million.

The total population served is 1.95 million. To these customers the Water Department distributed an average of 363 million gallons daily in each of the last two fiscal years, July 1, 1971 - June 30, 1973. This was about 186 gallons per day for every person in Philadelphia.

In addition, the department delivered 4.3 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 nearly 77,000 valves and over 25,000 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 1,050 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 comparatively new. The Torresdale Plant was completed in 1959; the Belmont Plant in 1965; and the principal facilities of the Queen Lane Plant in stages —1954, 1960, 1971. The plants are of the rapid-sand filter type, with automatic and semi-automatic controls. It is planned to bring all the plant treatment processes under computer control within the next few years.

Daily output of the water treatment plants, in millions of gallons daily, averaged as follows during the last two fiscal years:

	1972-73*	1971-72*
Belmont	64.7	61.8
Queen Lane	100.7	104.0
Torresdale	213.7	213.9

* July 1 of one year to June 30 of next

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

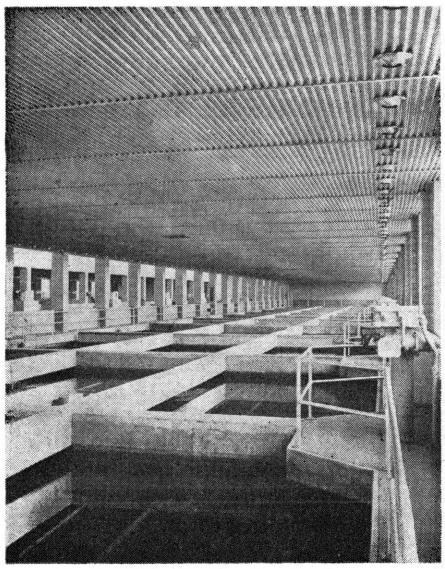
The first step in treatment is chlorination. The chlorine is added to the water to destroy taste-and odor-producing materials which are chiefly organic matter. This may include the wastes of industries as well as those of natural origin.

Initial chlorination takes place in a large raw-water reservoir, where the chlorine takes effect and some suspended matter settles out as the water moves slowly through.

The second 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 or ferrous 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 third step is for the chemical-laden 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 granules resembling snowflakes. 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.



Giant Water Tunnel: River water began flowing to the Queen Lane Plant through a new tunnel in May, 1973. The concrete-lined tunnel at right is 6,000 feet long and can carry up to 150 million gallons a day. The plant's filter beds are shown above.

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.

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) Pre-chlorination to free chlorine residual, (2) settling for 22 hours, (3) application of chemicals—chlorine or chlorine dioxide, alum with lime for pH adjustment, carbon, and ammonia, (4) rapid mixing of chemicals with water, (5) slow mixing of chemicals with water to form "floc," (6) settling, (7) rapid sand filtration, (8) post treatment, including chlorination, metaphosphate treatment, fluoridation, ammonia, and pH control with lime.

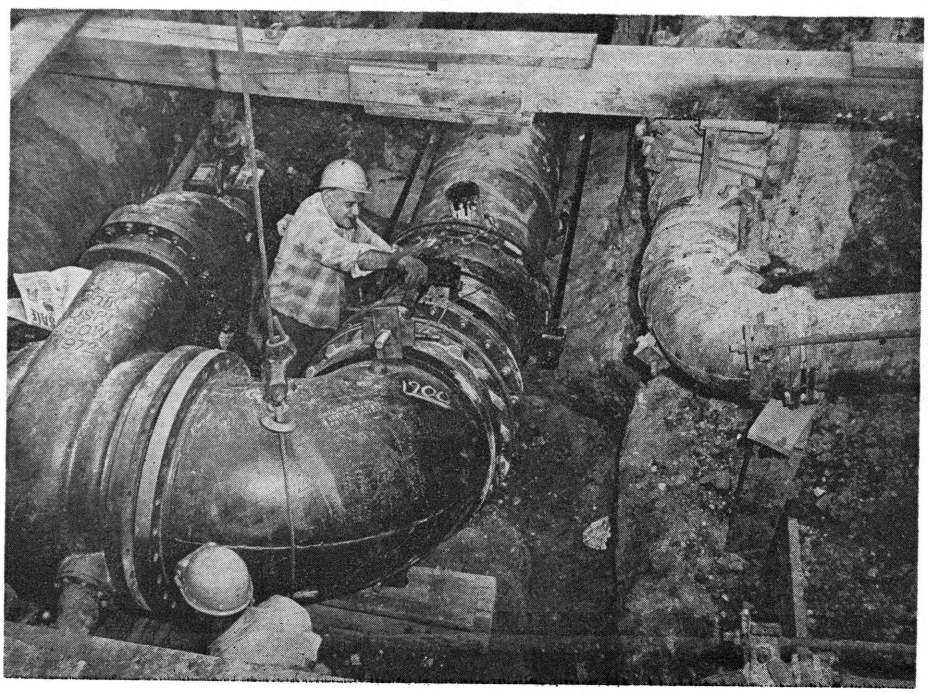
Queen Lane: (1) Pre-chlorination to free chlorine residual, (2) settling for 20 hours, (3) application of chemicals—chlorine, alum, with lime for pH adjustment, and carbon, (4) rapid mixing of chemicals with water, (5) slow mixing of chemicals with water to form "floc," (6) settling, (7) rapid sand filtration, (8) post treatment, including chlorination, fluoridation, caustic soda for pH control, and (for high service and Roxborough express water only) metaphosphate treatment.

Torresdale: (1) Pre-chlorination to free chlorine residual, or application of chlorine dioxide, (2) presedimentation, (3) application of chemicals—ferric chloride or ferrous chloride or alum, with lime for pH adjustment, chlorine or chlorine dioxide, and carbon, (4) rapid mixing of chemicals with water, (5) slow mixing of chemicals with water to form "floc," (6) settling, (7) rapid sand filtration, (8) post treatment, including chlorination and fluoridation; also pH adjustment with lime when required.

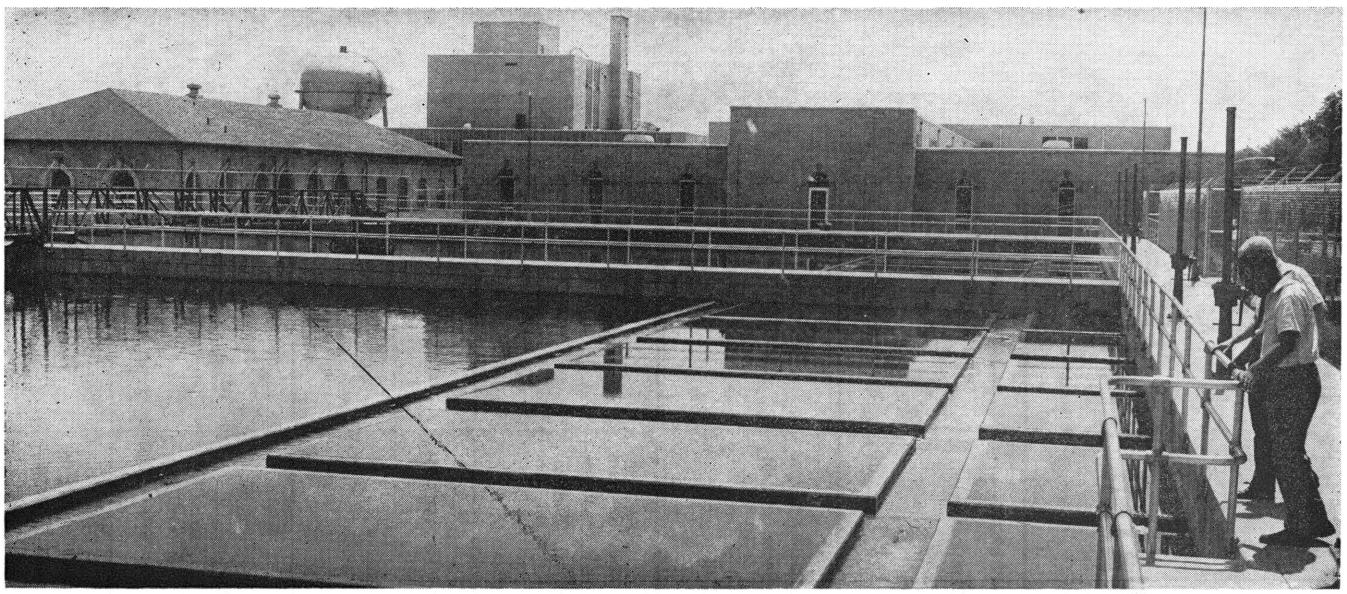
All water withdrawn from the East Park and Oak Lane Reservoirs is rechlorinated before entering the distribution system. Water at Oak Lane and East Park is treated with chlorine dioxide through the spring, summer and autumn to control algae.

Quality Control: The Water Department guards the quality of its water, from the river to the home faucet. Along the rivers, it maintains electronic monitoring stations and also collects river water samples 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 750,000 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. Public Health Service, and meets most of the very strict quality goals of the American Water Works Association. It is rated as one of the purest treated waters in America.



Water Distribution: Two million Philadelphians receive water through a network of 3,200 miles of mains. These mains range from three inches to nearly eight feet in diameter. At left, a huge valve has just been inserted into a main. The valve will make it possible to control flow through the main.



Belmont Water Treatment Plant

WATER SYSTEM CAPACITIES — 1973

PLANT TREATMENT CAPACITIES

(in millions of gallons daily)

	RATED	PEAK RATE
BELMONT PLANT	**78**	**108**
QUEEN LANE PLANT	**120**	**150**
TORRESDALE 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
TORRESDALE 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
OPEN 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)	360
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, 63 MGD high)	263
	West Oak Lane Booster Station	27.5
HIGH PRESSURE:	Fairhill Station	21.6
	Race Street Station	21.6

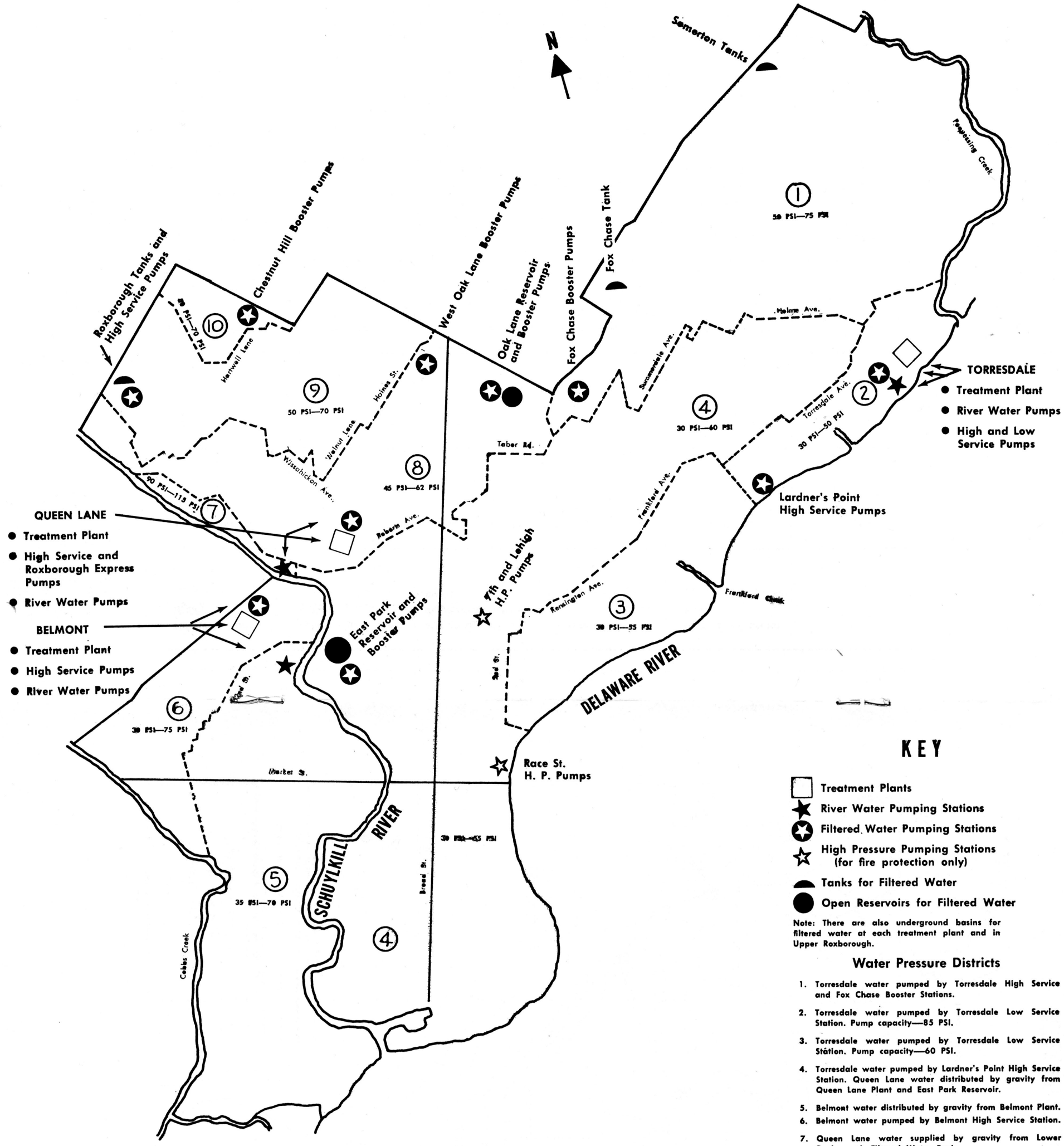
(Each high pressure station can pump 15,000 gallons per minute)

***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.*

CHEMICALS USED BY THE PHILADELPHIA WATER SYSTEM

CHEMICAL	STORAGE	FEED	POINTS OF APPLICATION	PURPOSE	MAXIMUM DOSAGES
Alum: Commercial aluminum sulphate $Al_2(SO_4)_3$ 18 H_2O	Dry in bulk, liquid in plastic or lead-lined tanks	Belt-type dry feed, rotodip, or pump and control valve	Inlet to rapid mix or mixing basin	Clarification	2.5 gpg
Lime: Oxide and hydrate CaO and $Ca(OH)_2$	Dry and bulk	Belt-type dry feed (slakers for the oxide) or pump and control valve	Inlet to rapid mixing basin or filter effluent	pH adjustment, also to increase alkalinity	2 gpg
Chlorine: Cl_2	150 - lb. cylinders, ton-cylinders, 55-ton R.R. tank cars	Commercial chlorinators with evaporators	Plant intake, rapid mix, or filter effluent	Taste and odor control (contact 16 to 20 hours), sterilization	16 ppm
Activated Carbon: C	Bags: also bulk truck or R.R. car to slurry	With slurry feeder pump or rotodip	Rapid mix or applied to filters	Taste and odor control	12 ppm
Hexametaphosphate: $(PO_3)_6$	Bags, 1½-ton unit hoppers	Solution tank and diaphragm feeder pump	Filter effluent	Reduce corrosion in distribution	1 ppm
Sodium Chlorite: $NaClO_2$	Liquid in stainless steel or rubber lined steel tanks	Solution tank and auxiliary tank to feeder pump	Plant intake, rapid mix, or filter effluent	Form chlorine dioxide for control of tastes, odors, or algae	1.5 ppm
Fluosilicic Acid: H_2SiF_6	Rubber - lined steel tanks	Measuring tank and diaphragm feeder pump	Filter effluent	Reduction of dental decay	1 ppm
Ferric Chloride: $FeCl_3$	Fiberglass-lined tanks	Rotodip liquid feed	Inlet to rapid mixing basin	Clarification	1 gpg
Ferrous Chloride: $FeCl_2$	Fiberglass - lined tanks	Rotodip liquid feed	Inlet to rapid mixing basin	Clarification	1 gpg
Ammonium Hydroxide: NH_4OH	Steel tanks	Diaphragm feeder pump	Inlet to rapid mix or mixing basin and filter effluent	Taste and odor control	1 ppm
Caustic Soda: Commercial Sodium Hydroxide NaOH	Steel tanks	Feeder pump	Filter effluent	pH adjustment	12 ppm
Sulfur Dioxide: SO_2	Ton cylinders	Commercial sulfunators	Rapid mix, filter effluent, basin effluent	Reduce chlorine residual	2 ppm

NOTE: gpg—grains per gallon; ppm—parts per million. One grain per gallon adds up to approximately 143 lbs. of chemical per million gallons of water while one part per million would result in 8.34 lbs. per million gallons.



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

Water Pressure Districts

1. Torresdale water pumped by Torresdale High Service and Fox Chase Booster Stations.
2. Torresdale water pumped by Torresdale Low Service Station. Pump capacity—85 PSI.
3. Torresdale water pumped by Torresdale Low Service Station. Pump capacity—60 PSI.
4. Torresdale water pumped by Lardner's Point High Service Station. Queen Lane water distributed by gravity from Queen Lane Plant and East Park Reservoir.
5. Belmont water distributed by gravity from Belmont Plant.
6. Belmont water pumped by Belmont High Service Station.
7. Queen Lane water supplied by gravity from Lower Roxborough Filtered Water Basin.
8. Queen Lane water pumped by Queen Lane High Service Station; also distributed by gravity from Upper Roxborough Filtered Water Basin. Torresdale water pumped by Oak Lane Booster Station.
9. Queen Lane water pumped by Roxborough High Service Station. Torresdale water pumped by West Oak Lane Station.
10. Either Torresdale or Queen Lane water pumped by Chestnut Hill Booster Station from April through November. At other times, the district is supplied directly by the Roxborough and West Oak Lane Stations.

Note on Water Pressures: The normal range of water pressures, as received by consumers, 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.*

Fig. 1

Philadelphia Water Facilities and Water Pressure Districts

Fig- 1-A

CHIEF WATER SUPPLY LINES

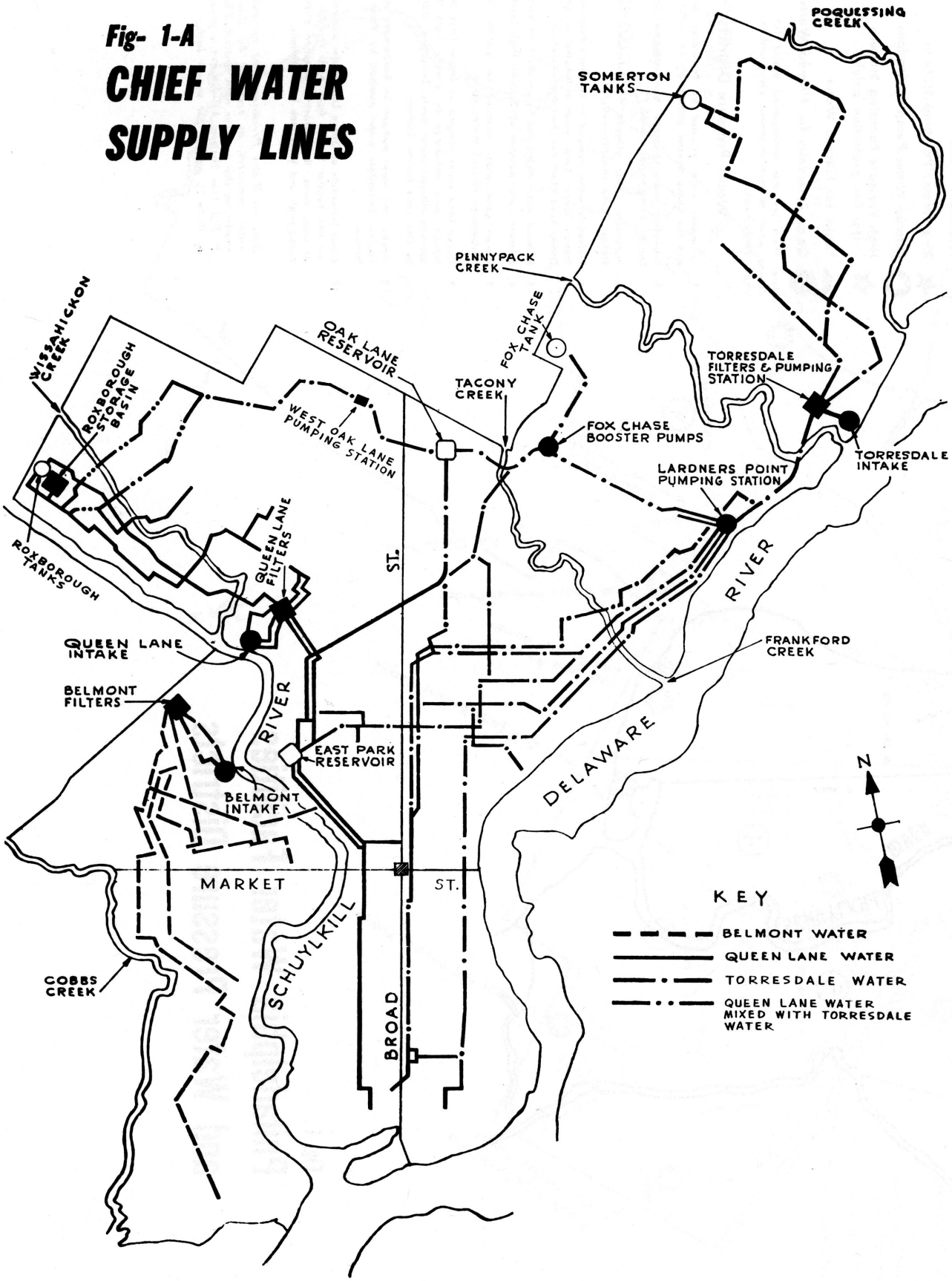
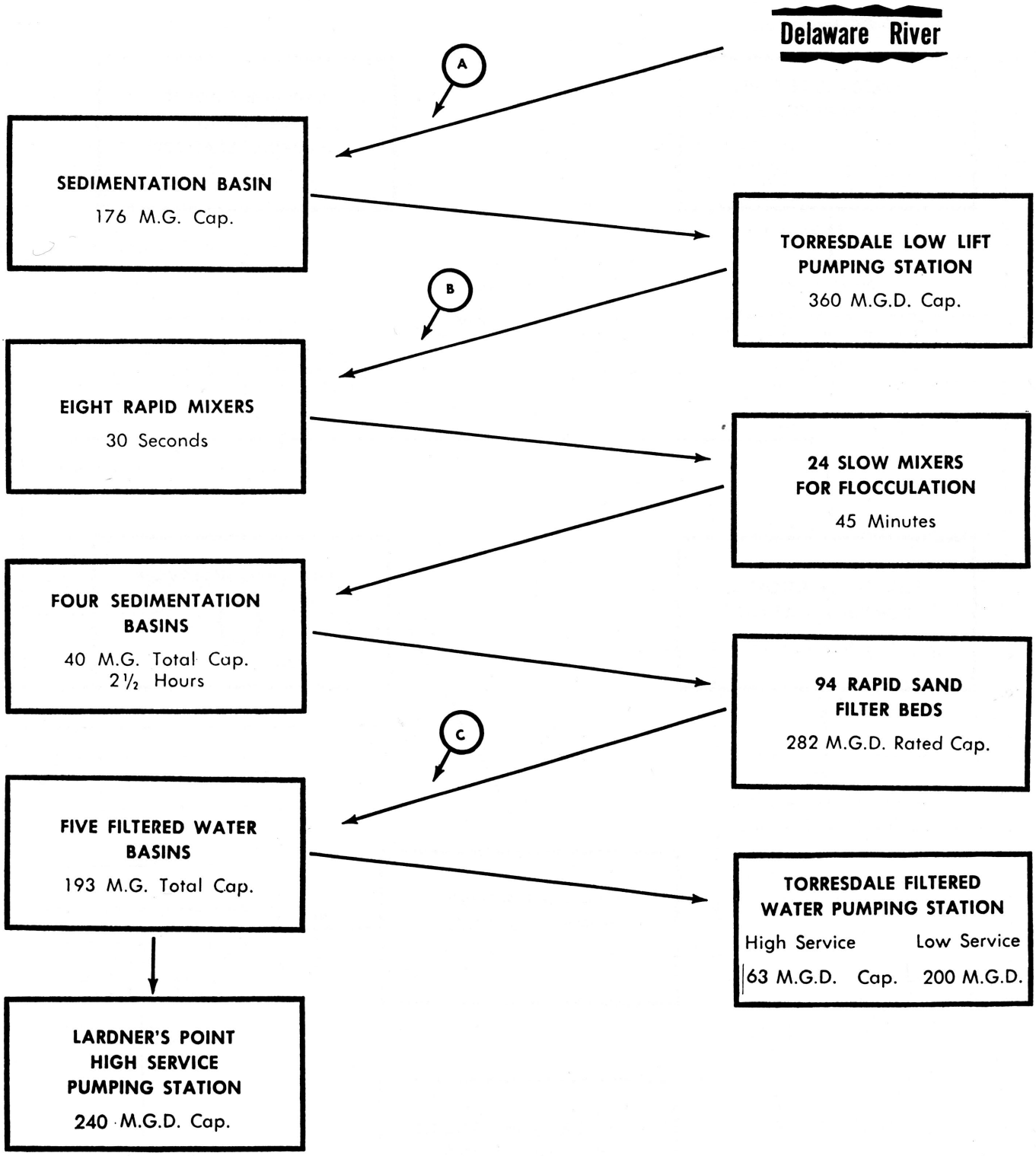


FIG. II-TORRESDALE WATER TREATMENT PLANT



Chemicals Applied

A—Chlorine or chlorine dioxide
B—Ferric or ferrous chloride, alum, lime, carbon, chlorine or chlorine dioxide
C—Lime, fluoride, chlorine or chlorine dioxide

FIG. II-A-DISTRIBUTION FROM TORRESDALE

TORRESDALE FILTERED WATER PUMPING STATION

High Service 63 M.G.D. Cap. Low Service 200 M.G.D.

DISTRIBUTION

High service pumps supply Pressure District 1 with average of 21 M.G.D. annually. Also supply 4.3 M.G.D. to Bucks County.

DISTRIBUTION

Low service pumps supply Pressure Districts 2, 3, and 4 with average of 35 to 40 M.G.D. annually.

LARDNER'S POINT HIGH SERVICE PUMPING STATION

240 M.G.D. Cap.

DISTRIBUTION

Supplies Pressure Districts 2, 3, and 4, and Fox Chase and Oak Lane Stations, with combined average of 145 M.G.D. annually.

FOX CHASE BOOSTER PUMPING STATION

25.3 M.G.D. Cap.

DISTRIBUTION

Supplies Pressure District 1 with average of 11 M.G.D. annually.

OAK LANE RESERVOIR

North Basin (A) South Basin

70 M.G. Total Cap.

OAK LANE BOOSTER PUMPING STATION

50 M.G.D. Cap.

DISTRIBUTION

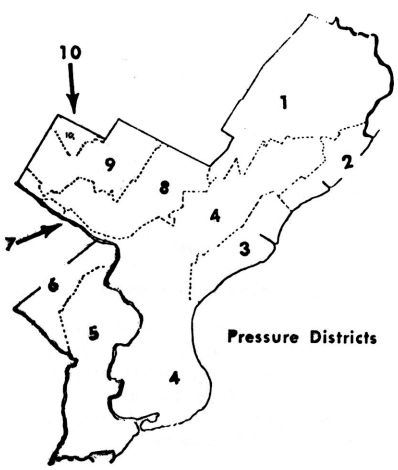
Supplies Pressure District 8 and West Oak Lane Station with combined average of 17 to 19 M.G.D. annually. Pressure District 8 is also supplied by Queen Lane H.S. Pumps and Upper Roxborough gravity.

WEST OAK LANE BOOSTER PUMPING STATION

27.5 M.G.D. Cap.

DISTRIBUTION

Supplies Pressure District 9, 10, with 8 to 9 M.G.D. annually.



Pressure Districts

▼ Chemicals Applied
Chlorine or chlorine dioxide

FIG. III-QUEEN LANE WATER TREATMENT PLANT

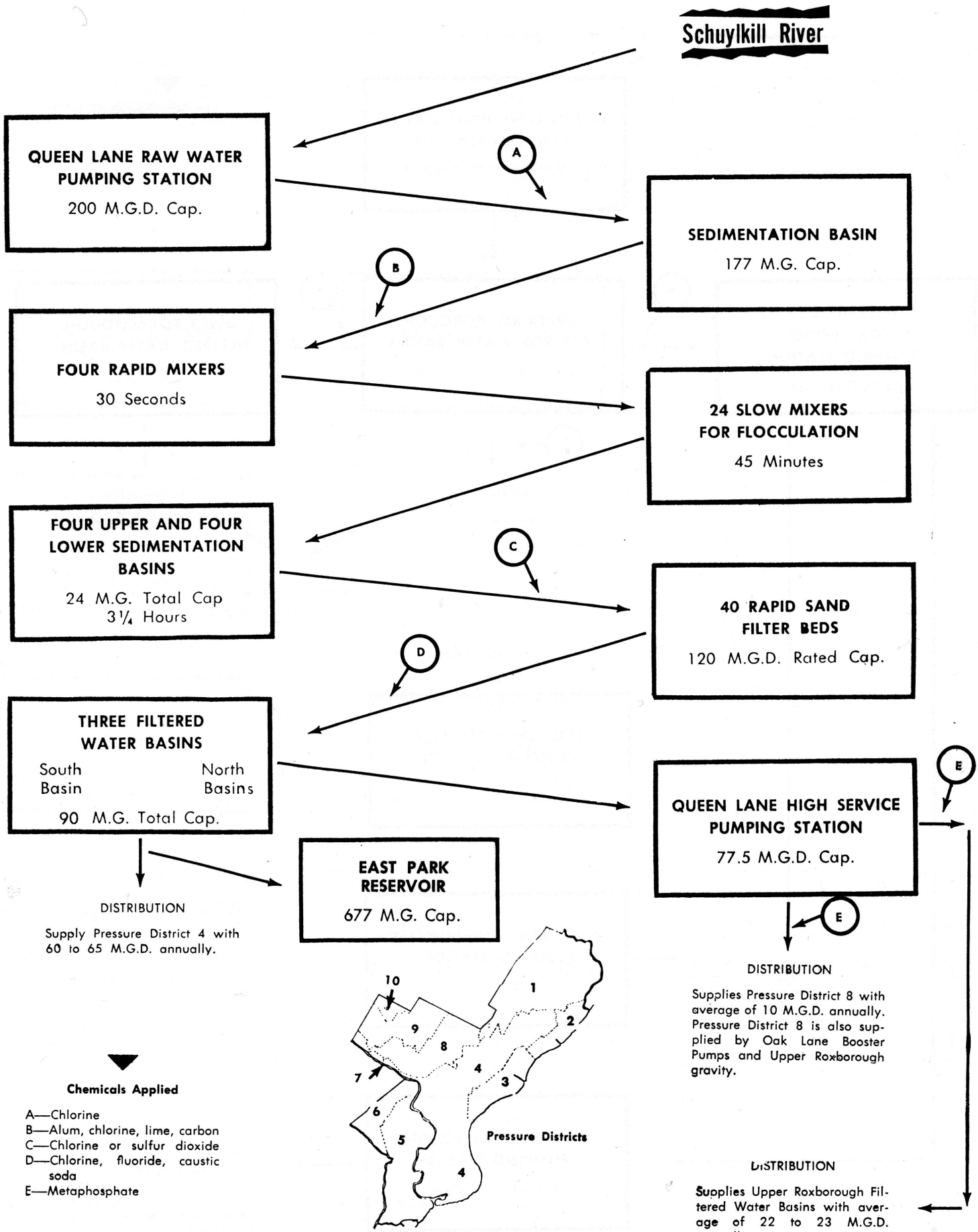


FIG. IV-DISTRIBUTION FROM ROXBOROUGH

QUEEN LANE HIGH SERVICE PUMPING STATION
77.5 M.G.D. Cap.

Chemicals Applied
A—Chlorine

ROXBOROUGH HIGH SERVICE PUMPING STATION
45 M.G.D. Cap.

A

UPPER ROXBOROUGH FILTERED WATER BASINS
25.6 M.G. Total Cap.

A

LOWER ROXBOROUGH FILTERED WATER BASIN
3 M.G. Cap.

A

DISTRIBUTION

To Pressure District 8 (also supplied by Queen Lane H.S. and Oak Lane Booster Pumps).

DISTRIBUTION

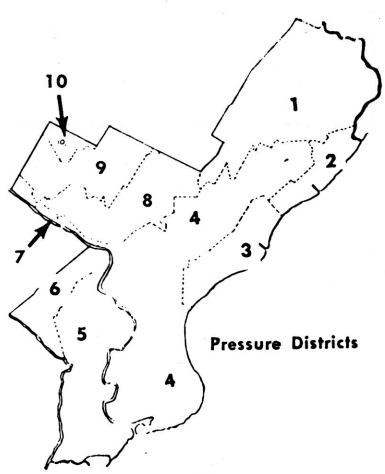
To Pressure District 7.

COMBINED DISTRIBUTION

Averages 12 M.G.D. annually.

Torresdale water

OAK LANE BOOSTER PUMPING STATION
50 M.G.D. Cap.



DISTRIBUTION

Supply average of 20 M.G.D. annually to Pressure Districts 9 and 10. About 8 to 9 M.G.D. of this is from West Oak Lane, and the rest from Roxborough Pumps.

WEST OAK LANE BOOSTER PUMPING STATION
27.5 M.G.D. Cap.

CHESTNUT HILL BOOSTER PUMPING STATION
8.5 M.G.D. Cap.

DISTRIBUTION

To Pressure District 10. No water has been distributed from the Chestnut Hill Station for several years. Station is used for stand-by.

FIG. V-BELMONT WATER TREATMENT PLANT

Schuylkill River

BELMONT RAW WATER PUMPING STATION
140 M.G.D. Cap.

A

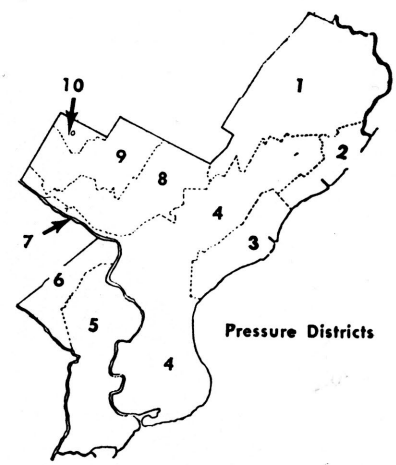
TWO SEDIMENTATION BASINS
72 M.G. Total Cap.

B

SIX RAPID MIXERS
30 Seconds

FOUR SLOW MIXERS FOR FLOCCULATION
42 Minutes

FOUR SEDIMENTATION BASINS
14.2 M.G. Cap.
-4 to 4.7 Hours



C

26 RAPID SAND FILTER BEDS
78 M.G.D. Rated Cap.

WEIR CHAMBER

BELMONT HIGH SERVICE PUMPING STATION
42 M.G.D. Cap.

CLEAR WELL
1.8 M.G. Cap.

THREE FILTERED WATER BASINS
38.2 M.G. Cap.

DISTRIBUTION

Supplies average of 13 to 14 M.G.D. to Pressure District 6 annually.

Chemicals Applied

A—Chlorine or chlorine dioxide
B—Alum, lime, carbon, ammonia, chlorine, or chlorine dioxide
C—Metaphosphate, lime, fluoride, ammonia, chlorine or chlorine dioxide

DISTRIBUTION

Supplies average of 50 M.G.D. to Pressure District 5 annually.

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