PAPER No. 393

Design Aspects of Municipal Water Supply Pilot Projects

By

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I. INTRODUCTION

A loan agreement was signed between the Government of Pakistan and US AID for 3.6 million dollars on 17-9-1964. Out of this amount, 2.15 million dollars were for commodity aid for the construction of municipal water supply systems in Sheikhupura, Gujranwala, Multan, Nawabshah and Hyderabad; and 1.45 million dollars were for consulting services. An agreement was signed between the Public Health Engineering Department (PHED) and an American Consulting Engineering Firm, Parsons Corporation, on 27-3-1965. According to the agreement, the consultants were required, besides other responsibilities, to evaluate the existing feasibility reports and, in conjunction with the PHED, to prepare design, drawings and specifications for the pilot projects. Location of the pilot projects is shown in Plate 1.

The Consultants, their Pakistani associates, and the PHED staff, all together known as the General Advisory Services for PHED, started work on the planning and design of the pilot projects in July, 1965. Since then, master plans for water supply of the project towns have been prepared and designs of the facilities needed to meet the immediate water supply needs in Sheikhupura, Gujranwala, and Multan have been finalized. The design of the Nawabshah Project, which also consists of the facilities needed to meet the immediate needs of the town, is also in final stages, except that the location of tubewells is not finally decided. Investigations are being carried out to find ground water of suitable quality as near the town of Nawabshah as possible. The design of a 5 mgd treatment plant to raise the capacity of the existing plant from 5 to 10 mgd and a one million gal. ground reservoir at Hyderabad has been finalized. These facilities have been designed independent of the master plan for water supply of Hyderabad, and are insufficient even to cater for the immediate needs of the city. Construction of the projects is well underway in Sheikhupura and Gujranwala, and is in the initial stages in Multan and Hyderabad. Construction of the Nawabshah Project is also expected to start in the near future.

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PLATE 1

GOVERNMENT OF WEST PAKISTAN

PUBLIC HEALTH ENGINEERING DEPARTMENT

GENERAL ADVISORY SERVICES

LOCATION MAP OF PILOT PROJECTS

The projects are being financed according to the following formula laid down by the Government :

1/3rd of the cost to be given as grant by the Government.

1/3rd of the cost to be given as interest-bearing loan by the Government.

The remaining 1/3rd of the cost would be contributed by the local bodies concerned from their own resources.

II. GENERAL DESIGN CRITERIA

A. Design Period

The projects have been planned for a design period of 25 years, *i.e.*, for the year 1990, except the Hyderabad Project which is an extension of the existing 5 mgd treatment plant to raise its capacity to 10 mgd. The construction of facilities is proposed in phases to meet the water requirements in the years 1970, 1975, and 1990.

B. Population

The populations for the future years 1970, 1975, and 1990 have been projected by the arithmetic, geometric and graphical methods and compared with the estimates made by the Town Planning Department. Generally the figures arrived at by the geometric method have been adopted for design purposes.

Areal distribution of population has been done on the basis of available data of existing population and using judgement as regards the future trend of areal distribution of population. In general, it is assumed that the density of population in the thickly populated central areas of the towns will not increase in the future. Projected population of the project towns (except Hyderabad) is assumed as follows :

	1970	1975	1990
Sheikhupura	55,000	66,000	110,000
Gujranwala	270,000	330,000	583,000
Multan	535,000	750,000	1,310,000
Nawabshah	60,000	72,000	114,000

C. Future Water Requirements

1. Per Capita Consumption—It is assumed that the average *per capita* consumption per day will be 40 gal. in 1975 and 50 gal. in 1990 in the larger cities, *viz.*, Gujranwala and Multan; and 35 gal. in 1975 and 45 gal. in 1990 in the smaller cities, *viz.*, Sheikhupura and Nawabshah.

The *per capita* consumption in districts of low population densities, where higher income group people generally live, is assumed to be higher than the average for the town. Similarly, the *per capita* consumption in districts of high population densities is assumed to be lower than the average for the town.

2. Industrial Demand—In general, it is assumed that larger industries will have their own arrangements for water supply. However, for small and medium-sized industries and commercial establishments, a nominal water demand of 1 to 5 gal. *per capita* per day is assumed.

3. Served Population—It is assumed that the served population in 1970, 1975, and 1990 will be 50%, 75%, and 90% of the projected population, respectively. In Multan, 90% of the population in the walled city area is assumed to be served from 1970 *through* 1990.

4. Unaccounted for Water—Unaccounted for water is that water which is supplied but not sold, measured, or otherwise accounted for. Wastage forms a major part of such water. The rate of unaccounted for water would have been expected to record a downward trend in the future due to better maintenance and management. However, considering that the systems will deteriorate with age, 30% (25% in case of Nawabshah) of water produced is assumed as unaccounted for, for all phases of construction up to 1990.

5. Average Total Water Production—Average total water production in mgd for the project towns (except Hyderabad) is estimated as follows :

	1970	1975	1990
Sheikhupura	1.37	2.56	6.64
Gujranwala	7.95	14.50	38.30
Multan	16.46	31.53	86.13
Nawabshah	2.30	4.33	9.23

6. Variations in Water Demand—There are no previous local records available to establish the relationship between the peak hour demand to the average hourly demand, and maximum day demand to the average daily demand. However, based on many considerations such as local conditions, seasonal variations, habits of the people, the following figures have been adopted for design purposes :

Maximum day demand	:	Average day demand ...	1.5 : 1.0
Peak hourly demand	:	Average hourly demand on maximum days ...	2.0 : 1.0

In Multan, peak hour demand in the walled city is assumed to be 1.5 times the maximum day demand. For industrial demand in Nawabshah it is assumed that the maximum day demand will be 1.2 times the average day demand and peak hour demand will be 1.4 times the average hourly demand *on maximum day.*

7. Maximum Day Demand—The maximum day demand in mgd for the project towns (except Hyderabad) is estimated as follows :

	1970	1975	1990
Sheikhupura	1.85	3.45	8.96
Gujranwala	11.90	21.80	57.30
Multan	24.69	47.29	129.20
Nawabshah	2.95	5.55	12.00

8. Peak Hourly Demand—The peak hour demand in mgd for the project towns (except Hyderabad) is estimated as follows :

	1970	1975	1990
Sheikhupura	3.29	6.14	15.94
Gujranwala	23.80	43.60	114.60
Multan	47.63	92.78	256.60
Nawabshah	4.87	9.04	20.13

9. Fire Demand—The design criteria for the project towns include provisions for meeting the following water demands :

(*a*) 400 gpm at the extremities of the town.
(*b*) 800 gpm (1200 gpm in Gujranwala) in the central, more densely populated areas of the town.

D. Water Quality

The municipal water supplies to consumers should be potable, *i.e.*, safe to drink, pleasant to the taste, and usable for domestic purposes. The water should be physically attractive, free of pathogenic organisms, and must not contain excessive amounts of offending chemical substances. For the project towns, the International Standards for Drinking Water (1963) suggested by World Health Organization have been adopted.

E. Source

The water sources available for use are ground water and surface water from rivers and canals.

The ground water is always cheaper for municipal use unless it is extremely deep or very bad in quality as it seldom needs any treatment other than sterilization. Sheikhupura, Gujranwala, and Multan are located in the Punjab plains, underlain with a depth of 1000 ft. or more of unconsolidated alluvium consisting mostly of medium to fine grained sand, forming an unconfined aquifer of practically unlimited capacity. The water quality is good and physical, chemical, and bacteriological tests indicate that the water is fit for human consumption under the WHO Standards for Drinking Water (1963). Deep tubewells have therefore been adopted as the source of supply for these towns.

The ground water quality in Nawabshah is on the borderline of WHO Standards as regards total dissolved solids. It is expected to deteriorate further with continuous withdrawal from tubewells. In the present phase of construction ground water will be used as the source of supply, but in the later phases, and, if necessary in the present phase also, provision will be made for treatment of canal water. The treated canal water will be mixed with the ground water in such proportions as to produce water of acceptable quality. Ground water will be used as far as possible so that the recurring cost of filtration and treatment is kept at a minimum. In Hyderabad the ground water is brackish. The River Indus and the canals offtaking from it at the G. M. Barrage are the only available source of supply.

F. Design and Construction of Tubewells

The installed tubewell capacity depends upon the operational storage capacity provided. The total capacity of tubewells provided in Multan is equal to the peak hour demand as no operational storage has been provided. In Gujranwala and Sheikhupura, the total capacity of tubewells provided is equal to 1.4 times the maximum day demand plus fire demand with 25% standby capacity. The tubewells at Gujranwala and Multan are designed for a capacity of 4 cusecs each, while those at Sheikhupura have a capacity of 2.5 cusecs each. The tubewells have been grouped in clusters at each well centre.

Reverse circulation rotary method of drilling tubewells has been adopted. Mild steel conductor pipes grouted in place have been provided to seal off the upper strata to minimise possibilities of pollution.

The strainer and blind pipe of fiberglass have been provided to guard against corrosion and incrustation. The wells have been kept sufficiently deep to accommodate the length of perforated casing or screen required to provide sufficient net area to assure that average velocity through the perforations would not exceed 0.125 ft. per sec. The width of slots is 3/32 in. and length $1\frac{3}{4}$ in. The total slot area is approximately 10 per cent of the total screen area.

A continuous gravel envelope of 6-in. thickness extending from the surface of the ground to the bottom of the hole is provided in all tubewells. The gravel packing consists of grain sizes ranging from coarse sand to ¼-in. gravel. Replacement of gravel after completion of a well would be accomplished through the use of conductor pipe. Cross section of a typical 4-cusec tubewell is shown in Plate 2.

The maximum permissible upward velocity in the strainer and blind pipe is 8 ft. per sec.

G. Pumps and Drive Units

Each of the tubewells has been provided with a vertical turbine pump. One tubewell at each well centre is equipped with a diesel engine drive. This will ensure the supply of water in case of power failure. Electric motors are provided at all remaining units.

H. Disinfection of Water Supply

Facilities are provided for adequate disinfection of all water supplies through the use of chlorine gas in metered amounts in the form of chlorine solution. The point of application is generally the rising main leading into the service reservoirs so as to provide a minimum of 20 min. time of detention prior to delivery to customers. A typical arrangement is shown in Plate 3. Free residential chlorine as measured in the mains at the extremities of system after chlorination is proposed to be not less than 0.1 to 0.2 ppm.

I. Storage

Total elevated storage consists of emergency storage and operational storage. In Sheikhupura and Gujranwala, an emergency storage equal to half an hour of maximum day demand is provided.

The operational storage capacity depends upon the installed tubewell capacity. In Gujranwala and Sheikhupura, operational storage capacity corresponding to a pumping capacity of 1.4 times the maximum day demand is provided. In Multan, because of the non-availability of land at suitable sites and the high cost of structurally elevated tanks, the provision of water storage facilities has not been found feasible. However, the alternate arrangement of providing area extra number of tubewells equal in capacity to maximum day peak hour demand and pumping direct into the distribution system has been made. During the peak hour all the tubewells would be in operation, but for the rest of the time only about half of them would be working and the remaining half would serve the purpose of standby or auxiliary tubewells to meet the emergency requirements.

PLATE 2.

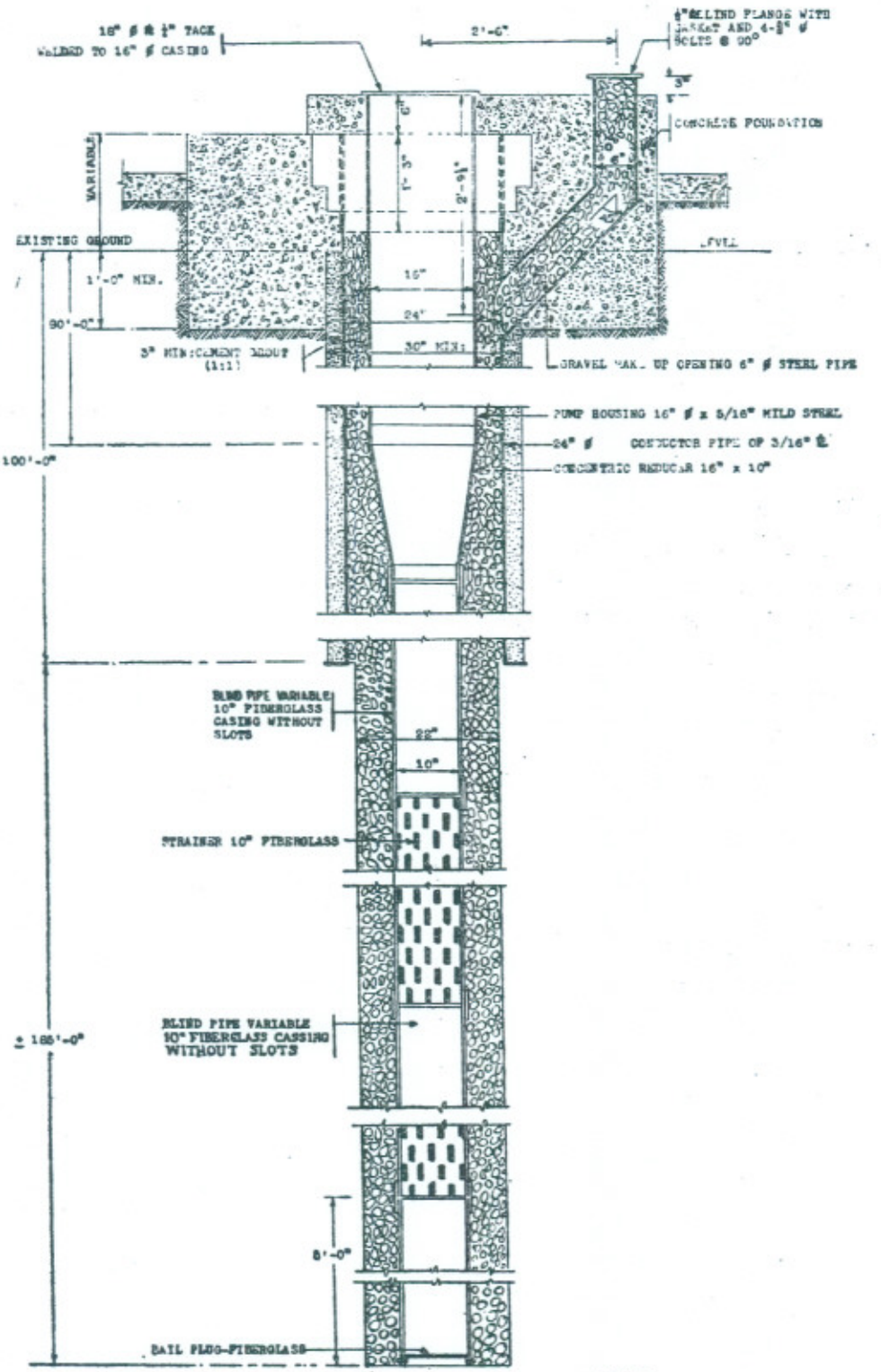
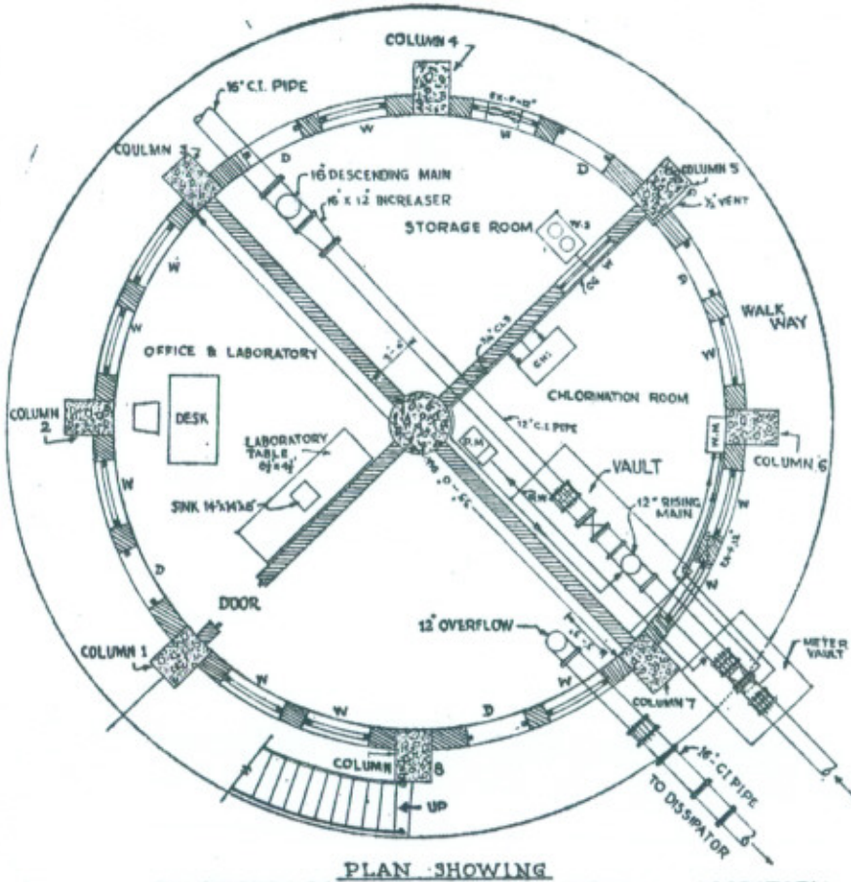
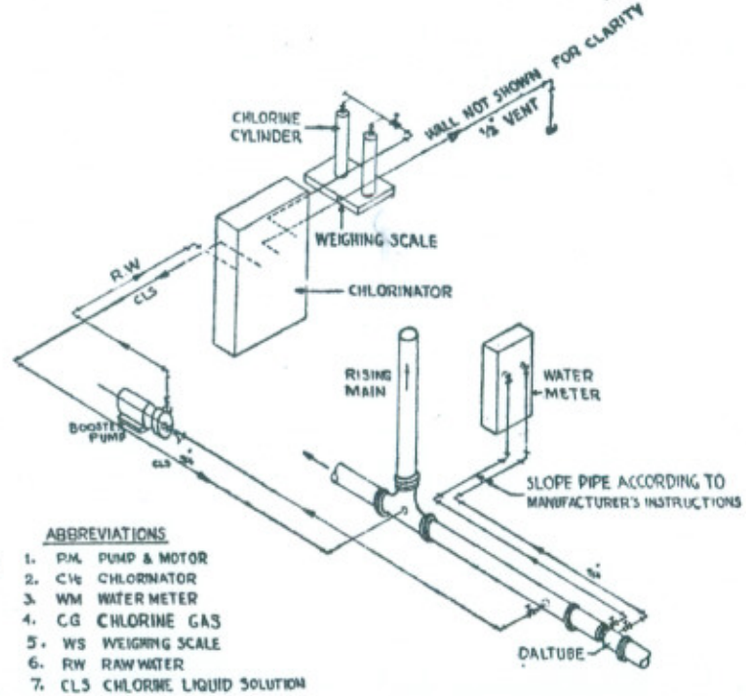


PLATE 2

SECTION OF A TYPICAL 4-CUSEC TUBEWELL



PLAN SHOWING
CHLORINATION ROOM, STORAGE ROOM, OFFICE & LABORATORY
AT THE BASE OF 1 LAC GALLON RESERVOIR (SHEIKHUPURA PROJECT)



ABBREVIATIONS

1. P.M. PUMP & MOTOR
2. C½ CHLORINATOR
3. WM WATER METER
4. C.G CHLORINE GAS
5. WS WEIGHING SCALE
6. RW RAW WATER
7. CLS CHLORINE LIQUID SOLUTION

ISOMETRIC VIEW OF
CHLORINATION INSTALLATION

PLATE 3

All overhead and ground reservoirs would be of reinforced concrete construction.

J. Distribution System

1. Hydraulic Design—Hydraulic design of the distribution grid is based upon a gradient of 2 to 3 ft. per 1000 ft. under conditions of maximum water demand. The maximum water demand is either the peak hour or the maximum day plus fire demand, with the larger of the two alternatives governing. It may be pointed out that in almost all cases the peak hour demand is more critical. Only during the analysis of smaller sub-areas within the distribution system does the maximum day plus fire demand become significant. Minimum size of distribution mains is 4 in.

A minimum terminal design pressure of 63 ft. is provided, which will be sufficient to supply water to the upper storey of 2-storey houses with adequate pressure.

2. Pipe Materials—The following pipe materials have been used :

(*a*) Cast iron pipe for rising main and other pipe in the vicinity of reservoirs and pump houses.

(*b*) Asbestos cement pipe for mains 4 to 16 in. in size.

(*c*) Prestressed concrete pipe for sizes larger than 16 in.

(*d*) Galvanized iron pipe for customer services.

3. Standardization of Pipe Diameters—Standard pipe diameters 4″, 6″, 8″, 10″, 12″, 16″, 18″, 21″, 24″, 27″, and 30″ have been used.

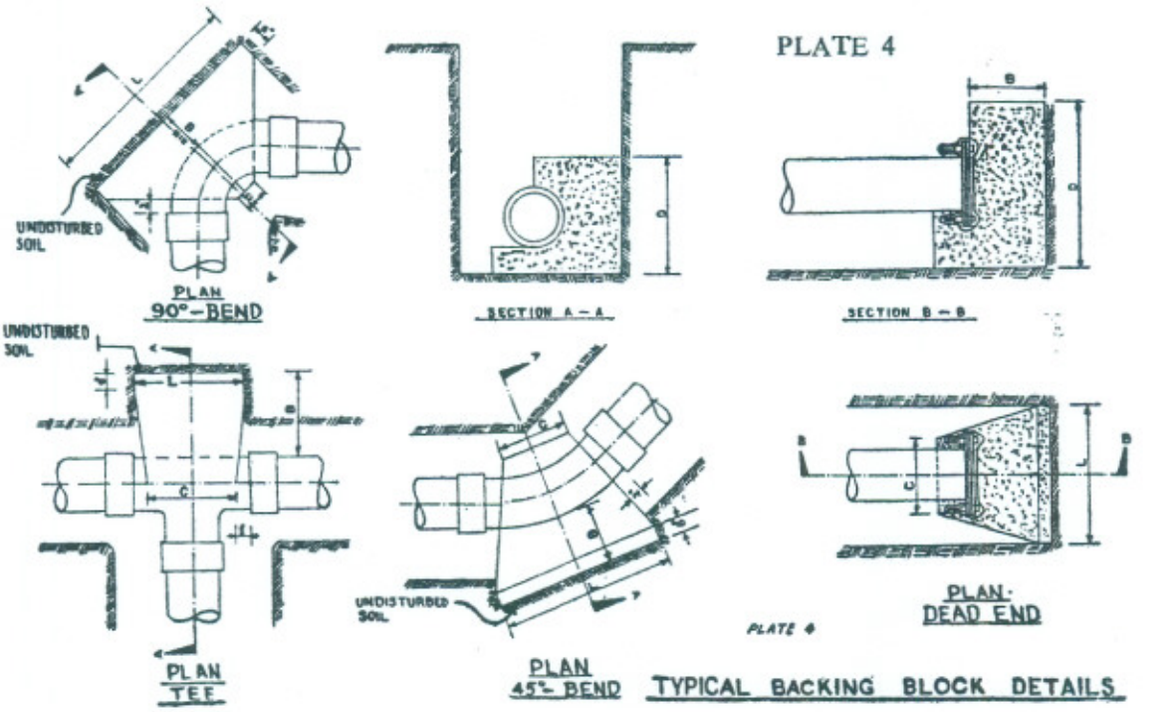
4. Fittings—Cast iron sluice valves are provided at spacing of about 1000 ft. on long mains and at the head of each branch main. Public stand-posts will be provided only on the recommendation of the Municipal authorities. Fire hydrants are provided at a distance of 500 ft. to 1000 ft.

5. Backing Blocks—The pressure of water in a water main exerts a thrust at each change of direction (bends, tees) and at each dead end. The thrust may be sufficient to unsettle the main and thereby move and open the joints. The effect of this thrust is encountered by providing concrete backing blocks at bends, tees, and dead ends. Typical details of backing blocks are shown in Plate 4.

6. Cover—A minimum cover of 2 ft. 6 in. over the pipe has been provided to avoid damage to the pipe due to traffic loads.

7. Service Connections—It has been found that the existing standard practice of providing ferrules for service connections causes too great a head

PLATE 4



TYPICAL BACKING BLOCK DETAILS

SCHEDULE OF BACKING BLOCK DIMENSIONS

DIA INCHES	AT TEES & DEAD ENDS				AT 90° BEND				AT 45° BEND			
	C	B	D	L	C	B	D	L	C	B	D	L
4	0-4	1-0	1-0	1-0	0-2	2-0	1-0	1-6	0-4	1-0	1-0	1-0
6	0-4	1-0	1-0	2-0	0-2	2-0	1-6	2-0	0-4	1-0	1-6	1-0
8	1-0	1-0	1-6	2-3	0-6	2-3	1-9	2-9	1-0	1-0	1-9	1-6
10	1-0	1-0	2-4	2-3	0-8	2-3	2-4	3-0	1-2	1-0	2-4	1-9
12	1-9	1-0	2-4	3-0	0-10	2-6	2-6	4-0	1-4	1-3	2-6	2-3
16	3-0	1-6	2-9	4-3	1-2	2-6	2-9	6-0	1-6	1-6	2-9	3-3
18	3-9	1-6	3-0	5-0	1-6	2-6	3-0	6-9	1-6	1-6	3-0	3-9
21	4-0	1-9	3-3	5-3	1-6	3-0	3-3	7-9	2-0	1-9	3-3	4-3
24	5-0	2-6	3-6	6-9	2-0	3-0	3-6	9-6	2-6	2-6	3-6	5-0
30	5-0	2-6	4-0	8-8	2-0	4-0	4-0	12-3	2-6	2-6	4-0	6-7

loss. The revised standards for service connection provide for the use of $\frac{3}{4}$-in. pipe and a full $\frac{3}{4}$-in. corporation cock.

K. Structures

The structures involved generally consist of brick masonry, plain cement concrete, and reinforced cement concrete.

Masonry used in the structures is generally of burnt bricks in 1 : 6 cement sand mortar.

Plain cement concrete Class C, with a minimum compressive strength of 2500 lb./sq. in. at 28 days, is generally used. The following classes of reinforced cement concrete are used in the structures :

Class	Min. compressive strength	Where used
A	5000 lb./sq. in. at 28 days	All water retaining structures
B	3500 lb./sq. in. at 28 days	All structures other than water retaining

III. BRIEF DESCRIPTIONS OF EACH PROJECT

A. Sheikhupura Project

1. Existing Water Supply—Up till 1964 there was no public water supply system in the town. Each dwelling had its own hand pump or an open dug well. Water through this source is not safe on account of contamination due to shallow depths. It was in 1962-63 that the Sheikhupura Water Supply Scheme estimated to cost Rs. 16.00 lac was prepared by PHED and approved by the Government. A part of the scheme was undertaken during 1963-64 before signing of the loan agreement with US AID and the appointment of consultants. An overhead reservoir of 50,000 gal. capacity, a tubewell of 1.9 cusecs capacity, and part of the distribution system were completed. Water is being supplied to more than 7000 persons through 350 private house connections and 4 public standposts.

2. Proposed Water Supply System—The system will ultimately (before 1990) have five well centres, each having an overhead reservoir of 1 lac gal. capacity and one or two tubewells of 2.5 or 4 cusecs capacity each. All the reservoirs will have a common elevation and will be connected to a common distribution grid. The height of the reservoirs is set at an elevation which will assure a terminal pressure of about 63 ft. even at the remotest corner of the service area.

At present only 3 tubewells of 2.5 cusecs capacity each will be constructed at 2 well centres and approximately 18 miles of pipe ranging in size from 4 in.

to 16 in. will be laid in practically every street and lane within the presently populated area. The existing overhead reservoir and tubewell have been incorporated in the proposed system, but will be retired from service by the year 1975 after completion of the second phase of the project. Only one reservoir of 1 lac gal. capacity will be constructed at one of the well centres. A building will be provided at the base of the reservoir to house the chlorination and metering equipment and a laboratory for testing (see Plate 3).

3. Financial Aspects—The estimated cost of the entire project (up to 1990) is approximately Rs. 116 lac. Out of this amount, about Rs. 36 lac will be spent on the construction of the present phase of the project, including the work already completed.

The flat rate customers in 1970, 1975, and 1990 are expected to be 4500, 8000, and 16500, respectively. The average monthly rates required to meet the maintenance and operation expenses of the system (excluding depreciation and debt service charges) vary from Rs. 4.30 per connection in 1970 to Rs. 5.00 per connection in the year 1990. The charges for metered service will vary from approximately Rs. 0.50 per 1000 gal. in 1970 to Rs. 0.70 per 1000 gal. in 1990.

B. Gujranwala Project

1. Existing Water Supply—A piped water supply is available in Model Town and Satellite Town on an intermittent basis without treatment. In remaining areas of the city most of the population takes water from open dug wells and hand pumps. In the absence of an efficient sewerage and drainage system, this shallow ground water is polluted and is a public health hazard as was proved by the outbreak of cholera epidemic in the year 1960.

2. Proposed Water Supply System—The system will ultimately (before 1990) have 11 well centres, with a total of 38 tubewells, each having an overhead reservoir of either 2 or 3 lac gal. capacity and 3 or 4 tubewells discharging 4 cusecs each. All the reservoirs will have a common elevation and will be connected to a common water distribution grid. The height of the reservoirs is set at such an elevation that it will ensure a terminal pressure of about 63 ft. even at the remotest corner of the served area.

At present only four reservoirs of 3 lac gal. capacity each and nine tubewells will be constructed at four centres, in addition to 4 tubewells of 1.5 cusecs capacity each already drilled at one of the well centres, and approximately 140 miles of pipe ranging in size from 4 in. to 27 in. will be laid in practically every street and lane within the presently populated area.

A building will be provided at the base of each reservoir to house the chlorination and metering equipment and a laboratory for testing.

3. Financial Aspects—The estimated cost of the three phases of construction is approximately Rs. 770 lac. Out of this amount, about Rs. 240 lac will be spent on the construction of the first (present) phase of the project.

The flat rate customers in 1970, 1975, and 1990 are expected to be 22,500, 41,500, and 87,500 respectively. The average monthly rates required to meet the maintenance and operation expenses of the system (excluding depreciation and debt service charges) vary from Rs. 3.80 per connection in 1970 to Rs. 4.60 per connection in the year 1990. The charges for metered service will vary from approximately Rs. 0.70 per 1000 gal. in 1970 to Rs. 1.00 per 1000 gal. in 1990.

C. Multan Project

1. Existing Water Supply—The city is partially served by piped water supply, and a major portion of the population obtains its water from hand pumps and open dug wells. Such water drawn from shallow depths is generally polluted and is likely to cause disease.

2. Proposed Water Supply System—When fully implemented (before 1990) the proposed system will comprise 24 well centres, with a total of 80 tubewells, each having 3 or 4 tubewells discharging 4 cusecs each.

In the present phase of construction 20 tubewells will be inastalled at 7 well centres and pipes ranging in size from 4 in. to 30 in. will be laid in practically every street and lane of the presently populated area. Proper structures will be constructed at each well centre to house the chlorination equipment, metering devices, and laboratory for testing.

3. Financial Aspects—The entire project (up to 1990) will cost approximately Rs. 1700 lac, out of which about Rs. 222 lac will be spent on the first (present) phase of construction.

The flat rate customers in 1970, 1975, and 1990 are expected to be 38,000, 78,000, and 83,000 respectively. The proposed monthly water rates required to meet the operation and maintenance cost, and depreciation and debt service charges (based on 6½% rate of interest and repayment in 10 equal annual instalments) are Rs. 8.00 per connection for houses built on plots of land measuring up to 1.5 kanals and Rs. 20.00 per connection for commercial establishments and houses built on plots of land measuring more than 1.5 kanals. The proposed charges for metered services are Re. 1.00 per 1000 gal. These rates are based on the latest analysis and it is expected that a similar pattern of water rates will be adopted for other projects.

D. Nawabshah Project

1. Existing Water Supply—There is no piped water supply system in the city. People meet their water requirements through shallow insanitary hand pumps, open wells, and ponds. These sources of supply are highly polluted and greatly affect the health of the people. Waters borne diseases are quite common.

2. Proposed Water Supply System—The planning and design of the project, and mainly the source of supply, have not been finalised as yet. Investigations are being carried out to find ground water of best possible quality as near the town of Nawabshah as possible. Purpose of these investigations is to utilize ground water as far as possible so that the recurring cost of filtration and treatment is avoided or kept at a minimum.

The project is being planned on the basis that combined canal and ground water sources may have to be used ultimately. The treated canal water will be mixed with ground water in such proportions as to produce water of acceptable quality. In the first phase, tubewells, distribution system (consisting of approximately 24 miles of pipe ranging in size from 4 in. to 16 in.), and ground and overhead storage reservoirs will be built to serve the needs of the present population of the town. If found necessary, a treatment plant will also be built. During the second and third phases, additional filter plants and tube-wells, and ground and overhead storage reservoirs will be constructed as per requirements of the respective phases.

3. Financial Aspects—It is estimated that the total cost of the three phases of construction up to 1990 will be about Rs. 180 lac. Out of this amount, approximately Rs. 62 lac will be spent on the construction of the first (present) phase of the project.

The flat rate customers in 1970, 1975, and 1990 are expected to be 5,000, 9,000, and 17,100 respectively. The average monthly rates required to meet the maintenance and operation expenses (excluding depreciation and debt service charges) vary from Rs. 7.00 per connection in 1970 to Rs. 9.50 per connection in the year 1990. The charges for metered services will be approxi-mately Rs. 1.25 per 1000 gal. from 1970 through 1990.

E. Hyderabad Project

1. Existing Water Supply—The old water supply system consists of a floating pontoon on the River Indus 3 miles downstream of the G. M. Barrage, with pumps and flexible pipe connection to a channel leading to storage and settling tanks of approximately 20 million gal. capacity. This system presently supplies 3.5 mgd unfiltered water to the old city.

The new water supply system was completed in 1962. It was the first phase of the 3-phase scheme for provision of 15 mgd of filtered water prepared in 1952. The water is withdrawn through an intake structure located at the left abutment of the G. M. Barrage. A delivery chamber receives pumped discharge from the intake well and discharges into a 30-in. steel gravity pipe line leading to the water treatment plant site. Raw water is conveyed from the delivery chamber to the hydraulic jump at the treatment plant site through a head portion of mild steel 30-in. diameter pipe 4,400 ft. in length and the tail portion of R.C.C. 48-in. pipe 4,220 ft. in length.

The intake works and the raw water transmission main have a capacity of 15 mgd. The treatment plant has a capacity of 5 mgd while the existing chemical feed arrangements are adequate for 15 mgd. The treatment plant has a circular flocculation sedimentation basin and 5 rapid sand filter units, both of "WABAG" patent. The backwashing of filter beds is done with the help of both air and water.

The filtered water is conveyed to the city by means of a 54-in. conduit of 15 mgd capacity. In the city the water is pumped into high service reservoirs and supplied through a distribution network of pipes.

2. Proposed Water Supply Facilities—The proposed immediate construction is actually the second phase of the scheme prepared in 1952. This includes a 5 mgd treatment plant to raise the capacity of the existing plant from 5 mgd to 10 mgd and a one million gal. ground reservoir at Fort Hill. These facilities are being provided independent of the master plan for water supply of Greater Hyderabad prepared by the General Advisory Services, and would partially meet the present water supply needs of the city. The proposed treatment plant has been so designed that its capacity could be raised from 5 mgd to 9 mgd by the provision of presedimentation basins. Thus, together with the existing plant, which can be overloaded to 6 mgd, the proposed plant will be adequate for 15 mgd, the ultimate plant capacity at this site. The present intake facilities, raw water transmission line, and chemical mixing arrangement by a hydraulic jump are sufficient to handle 15 mgd, and therefore the same have been utilised for the proposed treatment plant. The proposed improvements include the following :—

(*a*) *Intake*—At the existing intake two 5 mgd vertical turbine type pumps will be added, increasing the firm capacity to 15 mgd. Walls of the delivery chamber are to be raised by about 3 ft. to increase capacity of 30-in. raw water main to 15 mgd.

(*b*) *Treatment Plant*—The flow after the hydraulic jump is distributed into two units and connection for the proposed plant will be taken from the

existing 30-in. tee. The plan and sections of the treatment plant are shown in Plates 5 and 6.

Two rectangular flocculation basins, each 38′×45′×11′ deep, will be provided for slow mixing of the chemically treated raw water. At nominal flow of 5 mgd the detention time will be 68 min. (design criteria required a detention time of 60 min.) and at maximum flow of 9 mgd the detention time will eb 38 min. An oscillating paddle mechanism of the "walking beam" or "floscillator" type will be used for slow stirring in the flocculation basins.

Two rectangular sedimentation basins, each 150′×45′×11′ deep, separated from the flocculation basins by a baffle wall, will be provided. At nominal rate of flow the detention time will be 267 min. (design criteria required a detention period of 2-4 hr.) and at a maximum flow of 9 mgd it will be 199 min. The surface overflow rate at nominal flow will be 370 gal. per sq. ft. per day (design criteria required surface overflow rate of 375 gal. per sq. ft. per day) and at the maximum flow it will be 667 gal. per sq. ft. per day. Basin horizontal velocity will be 1 ft. per min. The weir overflow rate will be 14,300 gal. per ft. per day (design criteria required the weir overflow rate not to exceed 20,000 gal. per ft. per day). Circular mechanism will be used to keep the influent one third end of each sedimentation basin continuously cleaned of sludge. Hand cleaning will be required periodically to remove sludge from the remaining area of each basin beyond the influence of the cleaning mechanism. By-passes will be provided so that either or both basins may be taken out of service, if required.

Four rapid sand filter units each 30 ft. long and 21 ft. 11 in. wide, with a 2 ft. 6 in. wide gullet in the middle, will be provided. The rate of filtration at nominal flow will be 1.67 gallons per minute per sq. ft. A 30 in. sand depth with sand effective grain size of 0.45 to 0.55 and a uniformity coefficient of 1.5 to 1.7 will be used. Hard, round gravel will be used in sizes and depths shown below :

Size in inches	Depth of layer
No. 14 to No. 6	3″
$\frac{1}{8}$″ — $\frac{1}{4}$″	3″
$\frac{1}{4}$″ — $\frac{1}{2}$″	3″
$\frac{1}{2}$″ — $\frac{3}{4}$″	3″
$\frac{3}{4}$″ — $1\frac{1}{2}$″	5″
Total gravel depth:	17″

Rate-of-flow controllers will be provided to govern the rate of filtration for each filter unit. Discharge from the filter units will be directly into the clear water gravity conduit of 15 mgd capacity through a 30 in. diameter effluent pipe.

A filter bed surface wash arrangement is proposed to be provided to help the backwashing process. The rate of surface wash will be 3 gal. per min. per sq. ft. The backwash rate will be 15 gal. per min. per sq. ft. for 10 min. duration. Wash water troughs will be provided at 6 ft. centres so that wash water will not have to travel more than 3 ft. of horizontal distance to reach a trough. An elevated R.C.C. storage reservoir of 1 lac gal. capacity will be provided to supply water for washing the filters. Two pumps will be provided on the pump sump adjacent to the junction chamber on the 54-in. conduit to deliver water into this reservoir.

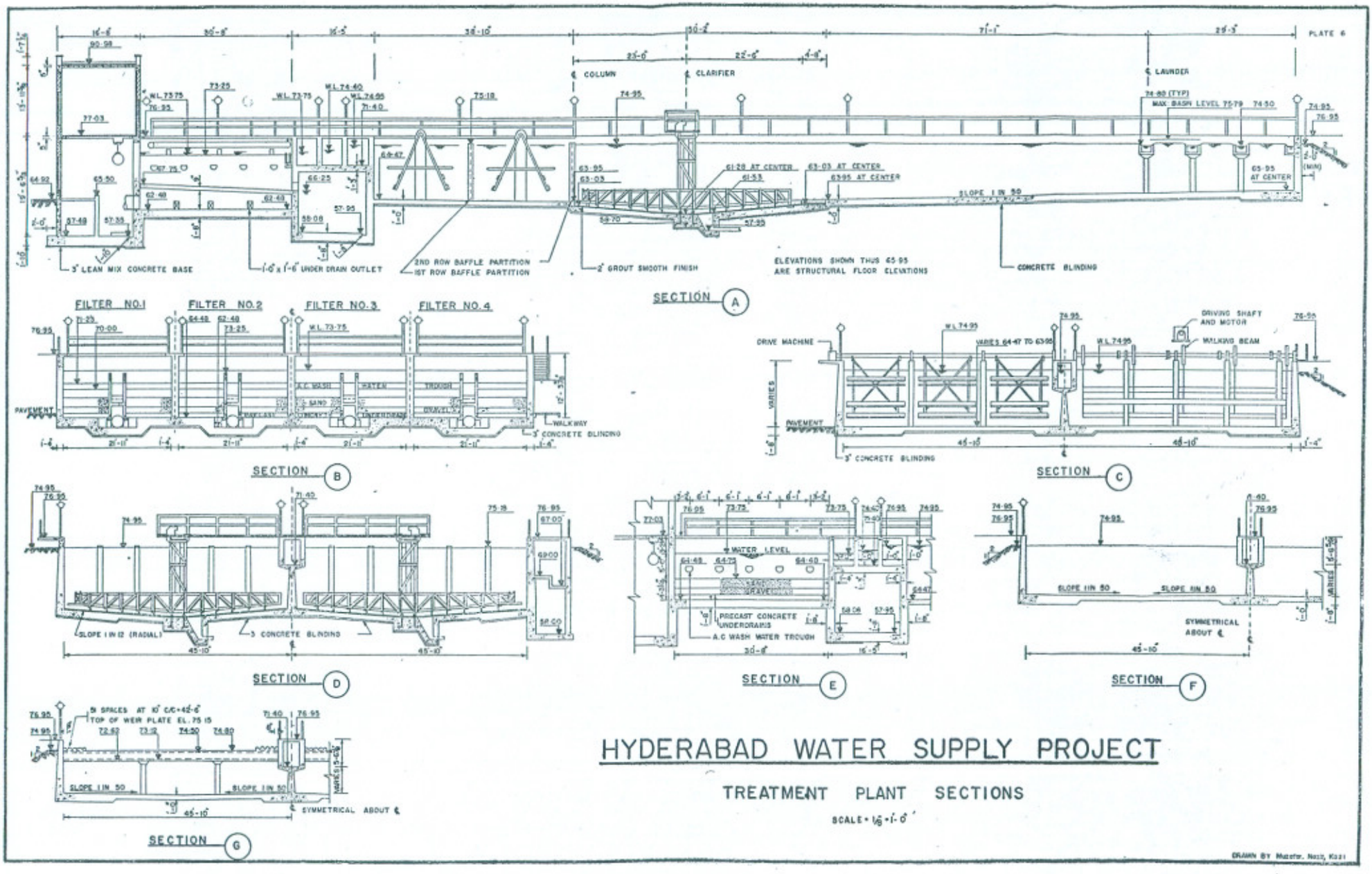
A small booster pump unit with pneumatic pressure tank will take water from the washwater supply and deliver the relatively small volume needed at suitable pressure for operation of hydraulic valves.

A new chlorination building is proposed to be constructed to house the chlorinators required for the treatment plant extension. It will also provide space for storage of chlorine.

(*c*) *Tulsidas Pumping Station*—A new sump will be provided at the end of the existing 54 in. gravity conduit. On this sump one 4-mgd and two 2-mgd vertical turbine type pumps will be installed, in addition to the existing pumps, increasing the station firm capacity to 9 mgd.

(*d*) *One Million Gallon Reservoir*—One million gal. capacity ground reservoir will be constructed at Fort Hill to act as a balancing reservoir.

3. Financial Aspects—The estimated cost of the project, including the construction of the treatment plant, a one million gal. ground reservoir at Fort Hill, improvements to intake structures, and modifications to Tulsidas Pumping Station, is Rs. 82.6 lac.

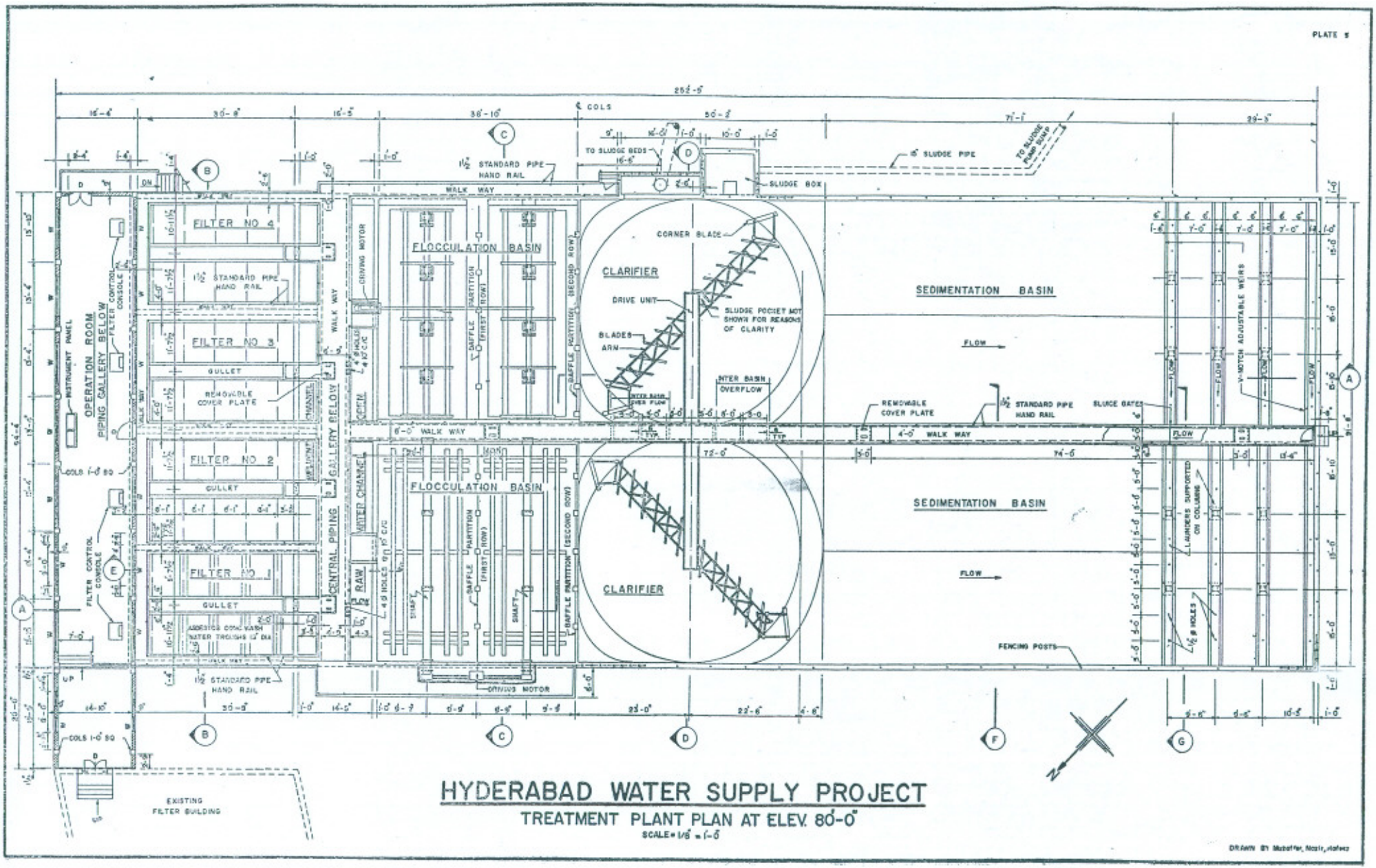


HYDERABAD WATER SUPPLY PROJECT

TREATMENT PLANT SECTIONS

SCALE = 1/8" - 1'-0"

DRAWN BY Muzafar, Nasir, Kazi



HYDERABAD WATER SUPPLY PROJECT

TREATMENT PLANT PLAN AT ELEV. 80'-0"

SCALE = 1/8" = 1'-0"

DRAWN BY Mabaffey, Mosier, Hafner