BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAH-508	2. SUBJECT CLASSIFICATION (695) AP12-0000-G584

3. TITLE AND SUBTITLE (240)

Rural irrigation works study final report; appendix B; operation and maintenance manual

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)

Engineering Consultants, Inc.; Planners. Engineers and Consultants, Ltd., Dacca

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1980	70p.	BG627.52.E57

9. REFERENCE ORGANIZATION (130)

EC

10. SUPPLEMENTARY NOTES (500)

(Prepared in cooperation with the joint venture firm, Planners, Engineers and Consultants, Ltd., Dacca)
(Final report consists of main report, v. 1-3; appendices, A-D; and executive summary: PN-AAH-503 - PN-AAH-510)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Irrigation
Water management
Irrigation canals
Maintenance
Manuals
Bangladesh
Tubewells
Cropping patterns

13. PROJECT NUMBER (150)

14. CONTRACT NO.(140) AID/SOD/PDC-C-0215

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

BG
G21.52
E51
APPENDIX B

PN-AAH-518

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

MINISTRY OF LOCAL GOVERNMENT, RURAL DEVELOPMENT AND COOPERATIVES

RURAL IRRIGATION WORKS STUDY
FINAL REPORT

APPENDIX B
OPERATION AND MAINTENANCE MANUAL

ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO, U.S.A.

PLANNERS, ENGINEERS AND CONSULTANTS LIMITED
DACCA, BANGLADESH

FEBRUARY 1980

TABLE OF CONTENTS

		Page
Appendix B:	Operation and Maintenance Manual	
Preface:	B-1	
Section 1:	The Distribution System	B-2
Section 2:	Low-lift Pumps: Operation, Maintenance and Costs	B-4
Section 3:	Deep Tube-wells: Operation, Maintenance and Costs	B-9
Section 4:	Pump Performance and Pumping Time	B-19
Section 5:	Cropping Patterns and Crop Water Requirements	B-20
Section 6:	Daily and Monthly Allocation of Water	B-24
Section 7:	Example of Irrigation Scheduling	B-27
Section 8:	Pump House Modification	B-30
Section 9:	Khal Maintenance Costs	B-31

LIST OF TABLES

Table No.	Table Title
	Appendix B
B-1	Lubricants Recommended by Manufacturers of Diesel Engines Used for LLP's
B-2	Lubricants Recommended by Manufacturers of Diesel Engines Used for DTW's
B-3	Lubricants Recommended by Manufacturers of Right Angle Gear Drives
B-4	Average Irrigation Requirements (Ia) for T. aman, in inches (Highland and Medium Highland)
B-5	Peak Irrigation Requirements (Ip) for T. aman, in inches (Highland and Medium Highland)
B-6	Average Irrigation Requirements (Ia) for Boro, in inches
B-7	Peak Irrigation Requirements (Ip) for Boro, in inches
B-8	Average Irrigation Requirements (Ia) for T. aus, in inches
B-9	Peak Irrigation Requirements (Ip) for T. aus, in inches
B-10	Average and Peak Irrigation Requirements (Ia and Ip) for Wheat, in inches
B-11	First Irrigation - January
B-12	Second Irrigation
B-13	Fifth Irrigation - February
B-14	Sixth Irrigation
B-15	Ninth Irrigation - March
B-16	Tenth Irrigation

LIST OF FIGURES

Figure No.	Figure Title
	Appendix B
B-1	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 1.5 cfs
B-2	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 1.6 cfs
B-3	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with an Irrigation Head of 1.7 cfs
B-4	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 1.8 cfs
B-5	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 1.9 cfs
B-6	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 2.0 cfs
B-7	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with an Irrigation Head of 2.2 cfs
B-8	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with an Irrigation Head of 2.4 cfs
B-9	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 2.6 cfs
B-10	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 2.8 cfs
B-11	Time Required To Deliver a Given Number of Inches of Water to a Given Number of Acres with a Head of 3.0 cfs

ABBREVIATIONS

BADC	=	Bangladesh Agricultural Development Corporation
B/C	=	Benefit-Cost Ratio
BRRI	=	Bangladesh Rice Research Institute
BSC	=	Bangladesh Shipping Corporation
BWDB	=	Bangladesh Water Development Board
CAD	=	Command Area Development
CARE	=	Cooperative of American Relief Everywhere
DEM	=	Directorate of Extension and Management
DTW	=	Deep Tube-Well
ECI	=	Engineering Consultants, Incorporated
FAO	=	Food and Agricultural Organization
GOB	=	Government of Bangladesh
HYV	=	High Yielding Variety
IRDP	=	Integrated Rural Development Program
KSS	=	Krishi Sambaya Samities (Agricultural Cooperative Society)
LLP	=	Low Lift Pump
MRD	=	Ministry of Local Government, Rural Development and Cooperatives
PEC	=	Planners, Engineers, and Consultants
RWP	=	Rural Works Program
SAE	=	Sub-Assistant Engineer, RWP
SDE	=	Sub-Divisional Engineer, RWP
STW	=	Shallow Tube-Well
TCCA	=	Thana Central Cooperative Association
TIP	=	Thana Irrigation Program
USAID	=	United States Agency for International Development
WAPDA	=	Water and Power Development Authority
WB	=	World Bank
XEN	=	Executive Engineer RWP

CURRENCY EQUIVALENTS

US $ 1 = Taka 15.00
Taka 1 = US $ .067

WEIGHTS AND MEASURES

1 acre (ac)	=	.405 hectare (ha)
1 bigha (bi)	=	.33 acre (ac)
1 sq mile	=	640 acres (ac)
1 maund (md)	=	82.28 pounds (lbs)
1 maund (md)	=	37.3 Kilograms (kg)
1 metric ton (ton)	=	26.8 maunds (md)
1 seer (sr)	=	2.06 pounds (lbs)
1 cubic foot per second (cusec)	=	0.283 cubic meters per second

GLOSSARY OF TERMS

Aman	=	Rice sown/planted during March to July/August and harvested in November or December.
Aus	=	Rice sown/planted during March and April and harvested in July and August. T. aus = transplanted aus; B. aus = broadcasted aus.
Beel	=	Marsh or lake; also spelled bill or bil.
Boro	=	Winter rice, planted during November and December and harvested during April to June.
Char	=	Newly formed sandy alluvial tract.
Drain	=	Canal to provide drainage or irrigation water.
Khal	=	Narrow natural channel of water.
Kharif	=	Summer season or rainy season.
Kutcha	=	Temporary, lower grade or dirt structures.
Paddy	=	Unhusked or rough rice (oryza sativa).
Pucca	=	Permanent, good quality structures.
Rabi	=	Winter season or dry season.
Thana	=	Political sub-division of a sub-division: police station or revenue unit.
Sub-Division	=	Political division of a district.

APPENDIX B

OPERATION AND MAINTENANCE MANUAL

PREFACE

This O & M Manual for the Rural Irrigation Works Study is prepared in DRAFT form for updating and expanding during the design and construction phase. One manual should be prepared for each sub-project as built.

The Manual primarily applies to sub-projects that use LLPs and DTWs as a source of water.

Section 1: The Distribution System

Simplified designs of on-farm water distribution systems have been adopted for LLPs and DTWs. These consist of a brick-lined canal (pucca drain) to handle the entire two-cusec pump flow, which can be delivered to any point within the system. At no place in the system is the flow divided. One turnout, generally located at the highest point, is provided for each three-to-five acre block of land enabling the cooperative distribution of water by the farmers within the block. Secondary ditches within each block may be advantageous, as would modest re-leveling of farm plots, but these operations will be the responsibility of the farmers. All the brick-lined canals of the distribution system are to be located on the boundaries between plots to create the least disrupt farming operations and to use the least land for the canal right-of-way. Two section designs offered in the Design Manual: a vertical, brick-wall rectangular section and a round-bottom section with sloping sides. Selection of the section to be used will be made at the time of project implementation.

Before construction of the distribution system is begun, the system must be carefully reviewed with the farmers--on the ground. Their understanding of the system and its operation must be ensured and their voluntary concurrence signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and canal and turnout locations will be made to meet actual field locations.

For this system, irrigation water will be scheduled for delivery by a roster posted at the pump house or other convenient location. The pump operator and lineman are responsible for the supply and timely delivery of water to the blocks. The delivery schedule and the water charges will be prepared by the water-user group management (cooperative).

Pump operation will be based on a twenty-hour day. This means that some irrigation will, of necessity, occur during darkness, resulting in reduced efficiency. Also, this will require readjustment of farmers' social activities and work schedules, but it is believed that such problems can be resolved. Distributing the water at night will almost certainly be easier than supplying the improved seeds, fertilizers, chemicals, fuel, and spare parts to them in the quantities and at the times required by the farmers.

A. Maintenance of Brick-Lined Canals

Most of the routine maintenance should be done by the water-user beneficiaries themselves. The following suggestions will help to prevent much major maintenance.

1. Keep both animals and people out of the brick-lined canals and off the bunds.
2. Repair cracks in the lining and turnouts quickly, before major damage occurs.
3. Keep all gates and slides clean and painted.
4. Sod the embankments with grass; keep the embankments maintained; and do not allow farmers to encroach on embankments.
5. Prevent canal overflow by stopping the pump. Overflow can cause major damage to the embankment.
6. Keep canals and turnouts free of weeds, trash, and sediment.
7. Do not allow bathing or washing of clothes in canals or weir boxes.

The water-users or the union council should appoint a committee at each sub-project to be responsible for emergency repairs, with support from the C.O. (Dev.).

Section 2: Low-lift Pumps: Operation, Maintenance, and Costs

A. LLP Operation

The LLP sub-projects may be operated in the same way as the DTW sub-projects. The two examples given in DTW Operation illustrate the methods of determining the irrigable acres, the rotation system and the irrigation schedule.

The DTW and LLP irrigation systems normally differ in that the LLP irrigates the lowest land, which has the lowest irrigation requirements. Rains are more liable to disrupt the schedule due to drainage into the lower land.

An irrigation schedule and a map of the command area, showing blocks, plots, and their acreages, should be conspicuously posted. The time of delivery to each block must be carefully kept by the operator.

The qualifications of the operator and his duties are the same as those for the DTW operator.

The duties and qualifications of the technician responsible for the technical services to the pump and engine are treated in Section 3.

Usually, LLP installations will be closer together than those of DTWs, enabling the technician to service more pumps per day. He should see each pump at 100-hour intervals (every five days), enabling him to supervise the lubricating oil change on each visit.

LLPs now used in Bangladesh are powered by at least twelve different models of diesel engines made by six different manufacturers, as follows:

Deutz - 210 D, FRL 912, F2L B12

Ruston - 2YWA, 1YWA

Slavia - IST 120

Kirlosker - RA2

Yanmar - TS 180C

GDR - IVD 8/8-25L,2VD 8/8-25VL, 4VD 8/8-25VL

With one exception, they are two cylinder, air-cooled diesel engines that drive a centrifugal water pump through a vibration damping coupling. They are mounted on a five foot metal frame with a two-wheeled trolley and are set up adjacent to the water source so that the suction hose will be as short as possible. As long as the pump is in good shape and the engine turns at the specified RPMs, they will deliver two cusecs.

B. LLP Maintenance

Daily servicing is the responsibility of the operator, who is generally an employee of the cooperative and under the manager's supervision.

The operator is responsibe for keeping a total record of the pump and its engine, including time on, time off, hours of operation, amount of fuel used, daily pump discharge rate, keeping the intake screen clean, etc.

He is also responsible for changing the water delivery from one block to another on schedule and keeping a record of the actual time the water flows to each block. The stop checks (the gates of the irrigation system), the engine, and its fuel and accessories are also in his care. With all these responsibilities he will need a helper during the irrigation season whose duties will be the same as those of the DTW operator, except for the pump and engine.

The technician's responsibilities are the same as those of the DTW technician's, with the exception that he should see each pump at 100-hour pumping intervals.

The TTDC workshop, backed by the Regional workshop, is charged with major maintenance and overhaul of LLPs. They are picked up in the field, replaced by an overhauled one, and brought back to the workshop.

In general, these shops are inadequate because they do not have enough transporcation, mechanics, work space, tools, spare parts, or convenient access to the spare parts depot (Dacca). As the pumps continue to age, the 50,000 or so now classed as operable will be rapidly reduced to half that number unless the thana workshops are immediately upgraded in all categories.

C. Low Lift Pump: O & M Cost

The cost of operating and maintaining a two-cusec LLP includes the cost of operating and maintaining the TTDC that services and repairs the pumps, as well as the Regional Work Shop's O & M because it also repairs and services the pumps.

Maintenance of the system will be insignificant; it would take a very large bullock to break a brick or two out of the vertical heavy walls. Erosion will be easily repaired with sand and cement by the operator's helper or any available mason.

Costs per hour, per acre-foot, and per acre will be calculated at the pump. The brick-lined canal, the turnouts, and the control stop checks are very efficient and water loss between the pump and the blocks, if any is little.

The estimates of the World Bank Report No. 1963-BD, 1978 have been updated as noted. It is assumed that the pump operates 1,000 hours per year at twelve hours per day.

1. Direct O & M Costs:

Direct O & M costs include the followig:

a) Diesel fuel at Tk 13.00 per gallon; consumption at 0.80 gallon per hour.

b) Lube oil at Tk 10.00 per gallon; consumption at 5.0 gallons per 200 hours.

c) Fuel and Lube filters at Tk 40.00 each; use at 2 each per 200 hours.

d) Spare parts at Tk 1,000 per 500 hours.

e) Operator's time at Tk 500 per month for 4 months.

f) Technician's time at Tk 40 per hour (1 visit of 3 hours each 100 hours).

2. Direct O & M Costs:

		Per hour for 1,000 hrs.
a)	Fuel	Tk 10.40
b)	Lube Oil	1.25
c)	Filters	.32
d)	Spare parts	2.00
e)	Operator time	2.00
f)	Technician's time	1.20
		17.17

3. Indirect O & M Costs: Estimated Indirect O & M Costs include the following:

		Per hour for 1,000 hours		
a)	BADC Staff (Annual for each pump)	1,200		
b)	Depreciation of Buildings	250		
c)	O & M of Workshop equipment	1,000		
		2,450	Tk	2,45
d)	TTDC Staff (Annual for each pump)	1,000		
e)	Depreciation of Buildings	250		
f)	O & M of Workshop equipment	1,000		
g)	Maintenance of structures at pump setting site	50		
		2,300		2,30

4. Capital Costs: Capital Costs include the following:

		Original	Annual	Per hour for 1,000 hours
a)	Engine	25,000	4,930	
b)	Pump and flex joint	10,000	1,972	
c)	Trolley (dolly)	1,725	275	
d)	Suction and discharge pipes	5,625	743	
e)	Other fittings	1,000	159	
		43,350	8,079	8,08

From the WB estimate: Assuming a 10% scrap value, a 12% annual interest rate and useful life of 7 years for engine and pump, 10 years for the dolley and fittings and 15 years for the pipe.

5. Summary of Costs: Total estimated LLP O & M costs are:

		Amount (tk)	100 hrs (Tk/hr)
a)	Direct O & M		17.17
b)	Overhead	4,750	
c)	Capital	8,079	
		12,829	

Tk 17.17/hour for 1000 hours, is eqivalent to Tk 8.59 per acre-inch, or Tk 103.08 per acre-foot.

6. Example

If the irrigation capacity is to be used on boro in the Chittagong District on high lowland, 37.9 inches will be needed with a maximum of 14.2 inches in March. If the pump runs twelve hours per day, March will require 360 hours of pump time, or 720 acre-inches of water. Then 720/14.2 = 51. Therefore 51 acres of boro may be planted.

With each of 51 acres requiring 37.9 inches, the crop will need 1,933 acre-inches, or 161 acre-feet, for a total cost of Tk 16,596 and a per-acre acre cost of Tk 325.41. Adding to this the annualized and overhead costs gives a total cost of Tk 29,425, or Tk 576.96/acre (16,596 + 12,829 = 29,425).

7. Example:

To figure annual equivalent capital cost for pump and similar equipment:

a) Reduce original cost by salvage value.

25,000 - (.10 x 25,000) = 22,500

2. Amortize at 12% interest rate for useful life.

22,500 x .219118 (capital recovery factor for seven years) = 4,930. This figure is the annual cost.

Section 3: Deep Tube-wells: Operation, Maintenance, and Costs

A. DTW Operation

Operation and servicing of DTWs is the responsibility of the cooperative manager. The pump operator, hired by the cooperative, does the actual fueling, changing of oil, servicing of the air cleaner and filter, cleaning of the unit. The TTDC is responsible for training the pump operator.

The operator must be able to read and write so that he can record the servicing of the engine and fuel and oil consumed and can log the water delivered to each block which becomes the bsis for each farmer's water charge.

Generally, he is also responsible for changing the water from one block to another in accordance with the published irrigation schedule. (The operator, however, does not make the schedule.) Because the pump will be running twenty hours a day, he will need a helper during the irrigation season to assist in switching the water delivery from block

to block.

The operator is responsible for the safekeeping of check-stops with which direct the water from one block to the next, and for their storage in the pump house when not in use. For repair purposes, boards, nails, the rubber edging material, saw, and hammer should be supplied by the cooperative manager.

The manager will no doubt delegate the repair of the brick-lined canal and turnouts to the operator if no mason is available. The operator will need the necessary tools, the brick, sand, and cement. All cracks in the lining should be periodically cleaned and pointed.

B. DTW Maintenance

1. Engines: There are two makes of diesel engines used to power DTW's. The MWM for Morten-Worke Monnheim AG, and the 3YWA or Ruston 3YWA for Dorman Diesels Ltd. There are two sizes of the MWM, the D327-2, a two-cylinder, 20 HP engine, and the D327-3, a three-cylinder, 25 HP engine. Both run at 1,500 RPM. The 3YWA is a three-cylinder, 20 HP engine and operates at 2,000 R.P.M.

All the engines drive a well head gear box with a gear ratio of either 3:4 or 1:1, via a clutch through a two-U-joint drive line.

2. Operator's Daily Maintenance

a) Add clean fuel.
b) Check oil level in crankcase. Fill to full mark.
c) Check oil in air cleaner. Clean and refill when dirty.
d) See that all air screens are clean.
e) Wipe down engine. Keep pump, engine and pump house clean.

3. Starting the Engine

a) Disengage clutch.

b) Move decompression lever/levers to "start" position.

c) Crank the engine as fast as possible. Keep cranking and release the decompression lever/levers while still cranking.

d) Let it run three minutes.

e) Fill the water tank that lubricates the upper bearing.

f) Engage the clutch forcefully but rapidly.

Stopping the Engine

a) Disengage clutch.

b) Set throttle to idle.

c) Let engine run for four minutes.

d) Move throttle lever to "stop" position.

e) Wipe the engine clean.

Operator's Periodic Maintenance

a) Change crankcase oil every 100 hours with the best diesel lube oil that can be found.

b) Change lubricating oil filter every 200 hours.

c) Lightly lubricate external control connections.

6. Technician: Many maintenance procedures are beyond the capability of the operator and will, therefore, require trained technicians with special tools. These men and their training are the responsibility of BADC, through its regional workshops or the TTDC. To provide the technicians with transportation to as many DTW installations as possible, a motorcycle with adequate carrying compartments for tools, fuel filters, grease gun, etc. should be furnished.

One technician may be expected to service about two wells per day, depending upon travel. Each technician's route and the number of wells to be serviced should be adjusted so that he checks each installation at about 200 to 250 pumping hour intervals. At twenty hours per day, his schedule could take ten to fourteen days, servicing from 20 to 25 pumps. If the pumping day is shorter, he could service more. The technician's record of all services performed in the log book will become a part of the complete and permanent log of the well that is maintained at TTDC.

7. Training the Technician: The technician must be well trained in mechanics. His permanent employment will be efficiently used because he will return to the Thana repair shop at the end of the irrigation season and serve as an instructor at the Training Center or as a mechanic.

8. Technician's Duties:

a) Remove air cooling compartment cover and clean out accumulated dirt or debris twice a year.

b) See that the cooling fan guard is free of trash.

c) Check oil level of injection pump.

d) If it is time for an oil change, clean the strainer in the sump and clean the filter guaze, if any, and see that a new oil filter element is installed every 200 hours of operation or every other oil change.

e) Check V-belt tension of the MWM and set for proper deflection.

f) Clean fuel filter bowl and replace cartridge at 500 hour intervals or sooner.

g) Check both intake and exhaust valve clearance and reset once per year.

h) Check all head bolts with a torque wrench once per year.

i) Change oil in injector pump and governor once per year.

j) Remove injectors and test spray once per year.

k) Grease the clutch throwout bearing once per year on MWM engines and at 2000 hour intervals on the Ruston.

l) Check engine speed with a techometer and reset governor when necessary.

m) The technician will decide when the engine needs a complete overhaul. He will arrange for a new one or a rebuilt one to be installed and the old one returned to the shop for overhaul.

9. Technician's Non-Engine Service:

a) Grease the U-joints of the drive line twice per year.

b) Check the gear oil level in the well head gear box and see that the operator drains off the water and replaces the oil when the irrigation season is over.

10. Engine Replacement: If the engine breaks down, immediate replacement is mandatory. The Thana Training and Development Center should have rebuilt engines for this purpose.

The importance of time to water-users, with their large investment in crops necessitatese a special, all-terrain vehicle, one with very wide flotation tires that is able to cross rice paddies in deep water without damaging the crop. A boom and draw, strong enough to pull the well and place the engine, is essential. Each TTDC needs at least one mobile crane-draw works rig. The boom or tower can be hydraulically operated while the draw works may be cable operated.

11. Well and Pump: Because the pumps deteriorate from use and age, they also require repair. One Thana in the Dacca District reported that about one out of every ten pumps brokedown during the 1978 season. Well-pulling equipment sometimes includes a pipe tripod and chain block that is carried to the well in pieces and assembled. The liner, shaft, and bowls are then pulled by manual power.

Quick repair is crucial to farmers because the significant costs of HYV seed, planting, fertilizer, pesticide, and irrigation water can cause a catastrophic loss of crop.

The ability of the TTDC to repair wells quickly is dependent upon their availability of equipment, trained men, and spare parts which is, in turn, dependent upon the coordinated efforts of the purchasing, storage, and distribution systems of the Ministry.

12. Clutch: Each make of DTW Diesel engine has a different type of clutch, each requiring different servicing.

The MWM air-cooled engines, types D327-2 and D327-3, have conax clutches. They are serviced with a Zerk grease gun through a single Zerk fitting on the top of the clutch housing. This clutch should have two shots of grease at least once per year or at 2,000-hour intervals.

The Ruston 3YWA air-cooled engines have pressure plate clutches. They are serviced with a Zerk grease gun by removing the clutch inspection plate and giving the Zerk fitting on the clutch spider two shots of grease at 200-hour intervals.

Shell greases, "livonia" or "Alvania", are available and are recommended for the Ruston and MWM engines.

13. Gear Drive: Three makes of DTW right angle gear drives are used by BADC. The gear ratio is either 1:1 or 3:4 and the pumps are designed to run at 2,000 RPM whereas some engines run at 2,000 and others at 1,500 RPM.

The three makes are:

a) Amarillo Right Angle Gear Drives, made by the Amarillo Gear Company, Amarillo, Texas.

b) U.S. Hollowshaft Right Angle Gear Drives, made by Emerson Electric Company, Connecticut, USA.

c) Rotos Right Angle Gear Drives, made by Rotos Pompe of Millana, Italy.

All the drives are lubricated with SAE 90 gear oil, the level of which should be checked daily while the pump is stopped. There is a small glass window to check circulation when the pump is running.

The oil should be changed each year at the end of the irrigation season always with the same brand of gear oil. If it is necessary to change brands, the old oil must be drained completely and the sump rinsed with a flushing oil before refilling. It is best to change oil while the gear box is hot.

Before starting the pump, at the beginning of the irrigation season, the drain plug should be unscrewed just enough to allow accumulated water to drain out.

C. Deep Tube Well - O & M Costs

The estimated cost of operating and maintaining a two cusec DTW includes the capital cost of the operator's quarters and at the TTDC shops. Costs per hour and per acre-foot for both 1,000- and 2,000-hour operation as well as costs per acre are calculated.

Estimates taken from World Bank Report No. 1963-BD, 1978, are updated as follows:

1. Direct O & M Costs:

a) Diesel fuel at Tk 13.00 per gallon, consumption at 1 gallon per hour.

b) Lube oil at Tk 50.00 per gallon, consumption at 6.5 gallons per 200 hours.

c) Gear oil at Tk 50.00 per gallon; consumption at 1.5 gallons per 2,000 hours.

d) Fuel and Lube oil filters at Tk 40.00 each; use 2-each per 200 hours.

e) Spare parts at Tk 2,000/600 hours.

f) Operator's time at Tk 500 per month for 176 hours per month.

g) Helper's time at 300 per month for 176 hours per month.

h) Technician's time at Tk 40 per hour (3 visits, 4 hours each) per 600 hours.

2. Direct O & M Costs

		Per hour 1,000 hrs.	Per hour 2,000 hrs.
a)	Fuel	13.00	13.00
b)	Lube	1.63	1.63
c)	Gear oil	.38	.38
d)	Filters	.40	.40
e)	Spare parts	3.33	3.33
f)	Operator	2.80	1.40
g)	Helper	1.10	.55
h)	Technician	1.25	2.50
		23.89	23.19

3. Estimated Indirect or Overhead Costs: 1-7 year life at 12% annual interest rate on the updated cost; 2-10 year life at 12% annual interest rate on the updated cost; 3.4.5.6.20 year life at 12% annual interest rate on the updated cost; Salvage value, 10 percent of items 1, 2, 5, and 6.

		Taka		
			Per hour 1,000 hrs	Per hour 2,000 hrs
1)	BADC Staff (Annual for each well)	3,000		
2)	Depreciation of building "	300		
3)	O & M of equipment and workshop "	1,000		
		4,300	4.30	2.15
4)	TTDC STaff (Annual for each well)	2,000		
5)	Depreciation of building "	300		
6)	O & M of equipment and workshop "	1,000		
		3,300	3.30	1.65
			7.60	3.80

4. Capital Costs: (World Bank 1978 estimates were doubled)

		Taka			
		Total	Annual	Per hour 1,000 hrs	Per hour 2,000 hrs
1)	Engine	36,800	7,258		
2)	Pump and Gear head	48,000	7,646		
3)	Construction and drilling	81,250	10,877		
4)	Casing, liner, shaft, etc.	47,500	6,359		
5)	Pump house	20,000	2,410		
6)	Operators house	12,000	1,446		
		245,500	35,996	36.00	18.69

For each DTW sub-project the construction of the distribution system has to be added as a capital cost.

5. Summary of Costs:

		Annual Tk	100 hrs Tk/hr	200 hrs Tk/hr
a)	Direct O & M		23.89	23.19
b)	Overhead	7,600		
c)	Capital	35,996		
		43,596		

Tk 23.89 per hour is equivalent to Tk 11.95 per acre-inch, or Tk 143.40 per acre-foot, for 1,000 hours of operation.

Tk 23.19 per hour is equivalent to Tk 11.60 per acre-inch, or Tk 139.20 per acre-foot, for 2,000 hours of operation.

4. Example

At twenty hours of operation per day, the pump will produce 1,200 acre-inches, or 100 acre-feet, in thirty days. This production will be used in one thirdy-day period during the crop's growing season. It determines the area that may be planted. If the sub-project is in the Dacca District on high lowland, 15.1 inches are necessary for boro in March, allowing eighty acres to be planted. The average irrigation requirement of boro in the Dacca District is 39.7 inches and 39.7 inches on eighty acres is 3,176 acre-inches, or 264.67 acre-feet.

A two-cusec DTW operating 1,000 hours will produce 166.66 acre-feet; operating 2,000 hours will produce 333.33 acre-feet. To determine the cost of producing 264.67 acre-feet:

166.66 acre-feet at Tk 143.40 per acre foot
264.67 acre-feet at Tk 140.93 per acre-foot
333.33 acre-feet at Tk 139.20 per acre-foot

Therefore, the total direct cost to irrigate eighty acres of boro in the Dacca district amounts to Tk 37,300, or Tk 466.75 per acre. Adding to this the annualized and overhead cost gives a total cost of Tk 80,896, or Tk 1011.2 per acre (37,300 + 43,596 = 80,896).

Generalizing: Cost per acre-foot is given by:

$$Y = 147.60 - .0252\ (X)$$

where Y = Cost of 1 acre-foot

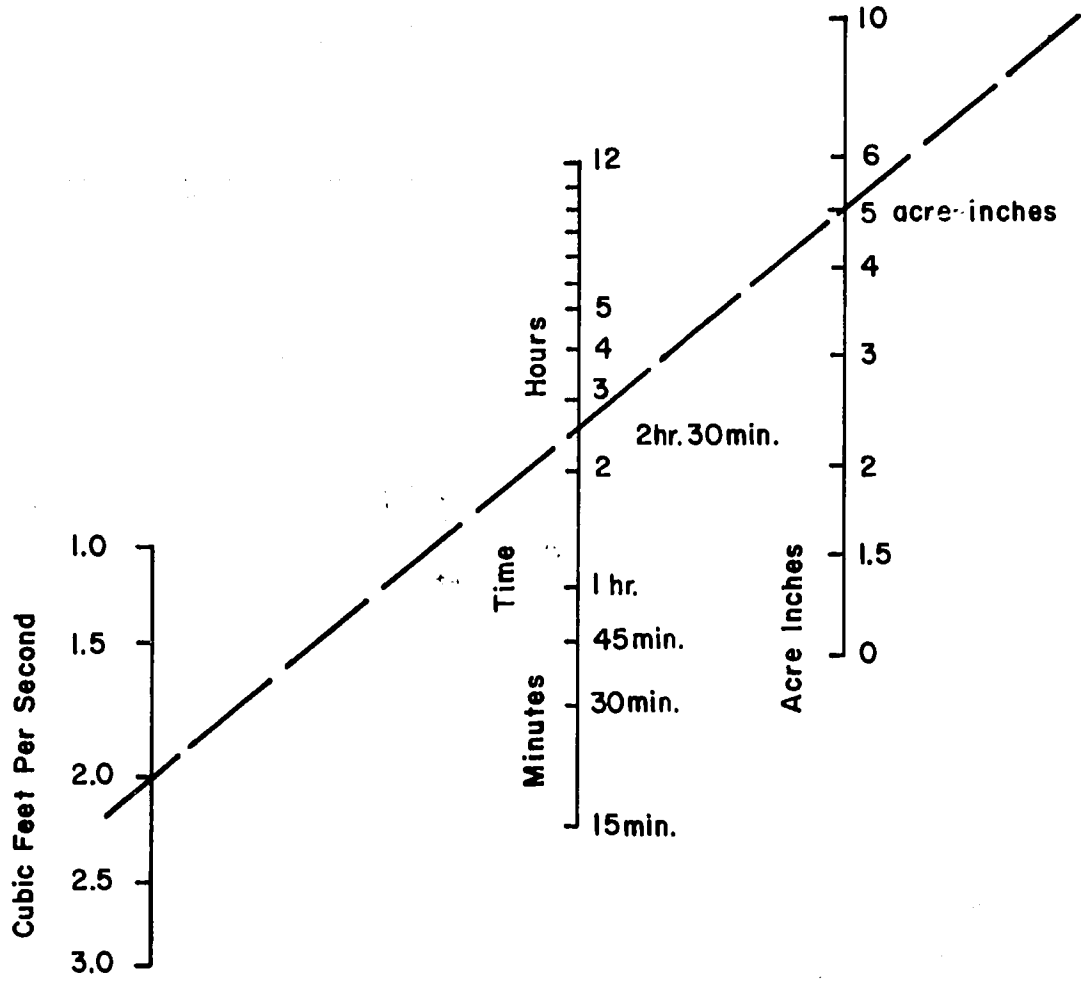
X = Water required in acre-feet.

Section 4: Pump Performance and Pumping Time

To find the time needed to put given acre-inches on one acre with a given rate of flow, use a straight edge between the two outside scales of Figure B-Ex-1 on the following pate. This line's intersection with the middle scale will show thetime.

Example: A two-cusec pump will require about 2 hours and 30 minutes to put five acre-inches on one acre of land.

FIGURE B - Ex - 1


Cubic Feet Per Second
1.0
1.5
2.0
2.5
3.0
Time
Hours
12
5
4
3
2
1 hr.
45min.
30min.
15min.
Minutes
2hr. 30min.
Acre Inches
10
6
5 acre-inches
4
3
2
1.5
0

Section 5: Cropping Patterns and Crop Water Requirements

A. Design Criteria

The water required for a peak irrigation period of less than one month is often used for design to ensure the availability of adequate water. This was not done because (1) water is limiting rather than land and a too conservative estimate of its availability would unduly decrease irrigated acreage; (2) the crop calendars show only average dates whereas planting and harvesting times actually occur over a period of about one month. during which large amounts of water are required; (3) given a twenty hour per day pump operation, there could be an increase of 4/24 x 100 = 17 percent in operating time, if necessary, during periods of peak water use.

the cropping pattern for a project is determined, the peak irrigation requirements can be used to determine the command areas by the following procedure:

1) Show recommended crops and type of land (highland, lowland, etc.) on the sub-project map.
2) Planimeter the area available for each crop.
3) Tablulate peak monthly water requirements for the crops, using appropriate values of Ip from Table B-5, B-7 and B-9.
4) On the basis of cropping priorities, determine the acreage that can be grown of each crop and the total command area. This is illustrated by the example below. While laying out the irrigation distribution ditches and irrigation blocks for the sub-projects, adjustment of crop areas may be necessary due to physical constraints.

Example

Location: Rangpur District

Area available for crops:

Wheat	-	180 acres on medium highland
Boro	-	20 acres on high lowland
T. aus	-	180 acres on medium highland, following wheat
T. aus	-	20 acres on high lowland, following boro
T. aman	-	180 acres on medium highland (same land as wheat)

Boro acreage could be increased by putting it on medium highland in place of wheat, but priority was given to wheat for this example on the medium highland.

Peak irrigation requirements:

As per step 3, tabulate peak irrigation requirements from Tables B-2, B-4, B-6 and B-7.

				T. aus	
	T. aman	Wheat	Boro	Following Wheat	Following Boro
Oct	6.9				
Nov	4.2				
Dec		2.7	5.0		
Jan		5.3	9.3		
Feb		7.7	11.6		
Mar		5.3	14.2	4.5	
Apr			4.9	16.3	7.0

Cropping priorities:

For this example it is assumed that the first priority is to grow boro followed by T. aus on the twenty acres of high lowland. Crop acreages and command area calculations are as follows:

The acreage of T. aus on medium highland can be calculated by using the data for May from the table (Note: approximate operating hours per month = (30 days) (20 hours/day) = 600 hours.):

$$\frac{(1.8\ \text{ac-in/hr})(600\ \text{hr})-(20\ \text{ac})(4.9\ \text{in})-(60\ \text{ac})(7\ \text{in})}{16.3\ \text{in}} = 51.7\ \text{acres}$$

(1.8 ac-in/hr is the pump capacity; one ac-in/hr is approximately equal to one cfs.)

From the table it is obvious that the maximum wheat acreage must be determined from the data for either February or March:

February: $$\frac{(1.8\ \text{ac-in/hr})(600\ \text{hrs})-(20\ \text{ac})(11.6\ \text{in})}{7.7\ \text{in}} = 110.1\ \text{ac}$$

March: $$\frac{(1.8\ \text{ac-in/hr})(600\ \text{hrs})-(20\ \text{ac})(14.2\ \text{in})-(51.7\ \text{ac})(4.5\ \text{in})}{5.3\ \text{in}}$$

$$= 106.3\ \text{ac}$$

These calculations show that the peak irrigation requirements in March govern wheat acreage and that the maximum wheat acreage that should be grown is 106.3 acres. Therefore, the total command area is:

Wheat	-	106.3 ac
Boro	-	20.0 ac
Total		126.3 ac

To see whether T. aman can be planted on the 106.3 acres of medium highland that will be included in the command area, the following calculation is made for possible T. aman acreage.

October: $$\frac{(1.8 \text{ ac-in/hr})(600 \text{ hrs})}{6.9 \text{ in}} = 156.5 \text{ ac}$$

This shows that enough water is available for 106.3 acres of T. aman.

Summary of acreages:

Wheat	-	106.3 ac
Boro	-	20.0 ac
T. aus following wheat	-	51.7 ac
T. aus following boro	-	20.0 ac
T. aman	-	107.4 ac
Total command area	-	126.3 ac

Operation costs:

The above acreages can be used to calculate operation costs by using the total average irrigation requirements (Ia) from Tables B-4, B-6, B-8, and B-10 as follows: 47 and 49 as follows:

	Area (Acres)	Ia (inches)	Total Water Required (acre-inches)
Wheat	106.3	18.6	1977
Boro	20.0	39.2	784
T. aus following wheat	51.7	15.6	807
T. aus following boro	20.0	5.0	100
T. aman	106.3	3.9	415
Total			4083

The total water required can then be multiplied by the appropriate unit costs.

Section 6: Daily and Monthly Allocation of Water (7-day rotation)

A. Determining the time required to deliver each block's daily and monthly allocation with a seven-day rotation: December

The water requirement for wheat is 3.0 inches whereas that for boro is about 7.0 inches. Because these are comparatively small allocations, it will be best to operate the pump on a demand basis. Land preparation water for the boro crop may exceed the 7.0 inches if it is a dry year. In any case, when supplying this requirement it would be prudent to run the pump continuously until each block is satisfied.

In the interest of good management, a record of the delivery time to each block should be faithfully kept.

B. The January Requirement

The water requirement for wheat is 7.5 inches for 30 days, 0.25 inch for one day, or 1.75 inches for seven days, which is below the guide line of a minimum two-inch delivery.

In order to meet this problem, the entire allotment should be delivered to half the blocks of wheat on alternate weeks. This will change the seven-day rotation to rotation days, which will more closely conform to the present practice of four irrigations for the wheat crop and change the delivery to 3.5 inches.

The water requirement for boro is 12.7 inches for 30 days, .423 inch per day, or 2.96 inches for seven days.

C. The January Rotation and Time of Delivery

The first and second irrigations (see Tables B-11 and B-12) in January may be scheduled as illustrated. The third irrigation will be the same as the first, and the fourth will be the same as the second.

D. The January Time of Delivery

The hours of delivery are found by multiplying each block acreage by the seven day water requirement and dividing by the pump capacity.

The hours of delivery may be graphically found, with a little interpolation, using Figure B-4. Figures B-1 through B-10 appy to flows from 1.5 to 3.0 cfs. The time of delivery may also be found by using the nomograph, Figure B-Ex-1 in Section 4, which shows the time necessary for delivery to one acre. This number, multiplied by the block acreage, will yield the time of delivery for the block.

The single block irrigation on the seventh day of the January rotation opens the possibility of advancing that block's time to the sixth day, if desired.

E. Rain Interruptions of the Schedule in January

The water requirement for boro during January is 0.42 inch per day. The wheat requirement is less. Therefore, a rain of 0.42 inch in one day will allow the schedule to be set back one day. This presents no problem for the rotation. The pump is merely not operated the next day. The following day the rotation schedule is resumed where it was stopped.

A rain of less than 0.42 inch will benefit both crops and may be enough for one day's wheat requirement but, in general, it will be advantageous to ignore the smaller rains. A little deficit in January can be made up on the seventh day of the rotation but adequate water will pay off when growing HYV rice.

More rain (say 0.8 inch, for example) will allow the pump to be shut off for more (two in this example) days. Obviously, rain guage is needed; any straight sided vessel will suffice, as will a guage in a closed paddy. The manager must be alert to the benefits of a guage.

F. The February Requirement

The water requirements for wheat is 8.7 inches February: 0.29 inch per day, 2.03 inches for seven days, or 4.06 inches for fourteen days.

Is is necessary to decide whether to keep the fourteen-day rotation or to abandon it. It will take between 7.75 and 9.0 hours to deliver the 4.06 inches to a block. It will take between 6.4 hours and 7.5 hours to deliver 3.29 inches to the boro blocks.

Because the entire 140 hours of pumping time is to be used, the times the blocks require should fit into the operating day. If they don't, the water can be turned into the same block the next day in order to deliver its full quota.

For this example, use the less efficient method of turning the water into the same block twice. It may not please the farmers but it makes a fair schedule. It is illustrated on the first and second days of the fifth and sixth irrigations (see Tables B-13 and B-14).

The water requirement for boro is 14.1 inches, 0.47 inch per day, or 3.29 inches for seven days.

G. The February Rotation and Times of Delivery

The fifth and sixth irrigation may be scheduled as illustrated. The over-run on the third day of the sixth irrigation may be compensated for by subtracting fifteen minutes from each block.

The seventh irrigation will be the same as the fifth, and the eighth the same as the sixth.

Rainfall may be compensated for as it was in January, but the daily requirement raises to 0.47 inch.

H. The March Requirement

The water requirement for wheat is 5.2 inches, 0.173 inches per day, and 2.43 inches for fourteen days.

The water requirement for boro is 16 inches, 0.53 inch per day, or 3.73 for seven days.

I. The March Rotation and Times of Delivery

The ninth and tenth irrigations may be scheduled as outlined (see Tables B-15 and B-16).

The eleventh irrigation will be the same as the ninth and the twelfth and the same as the tenth.

Rainfall may be compensated for as before, but the daily requirement increases to 0.53 inch for boro. Less than that (0.2 inch for example) could be enough to suspend irrigating the wheat entirely if is comes in the later part of the month.

J. The April Requirement

Because there is no water requirement for wheat, and the boro requirement is minimal, about 5.2 inches, it will be best to go on a demand basis during the last week in March. In this way some aus, tobacco, or vegetables may receive some water also.

Section 7: Example of Irrigation Scheduling

TABLE B-Ex-1

FIRST IRRIGATION

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Boro Blocks		#10-#14	#15-#19	#20-#24	#25-#29	#30-#33	#34-#37
Wheat Blocks	#1-#5						
Blocks' Delivery Time (hrs:mins)	#1- 3:10 #2- 3:20 #3- 3:30 #4- 3:30 #5- 3:10	#10- 3:30 #11- 3:40 #12- 3:30 #13- 3:30 #14- 3:40	#15- 3:40 #16- 3:40 #17- 3:20 #18- 3:20 #19- 3:40	#20- 3:40 #21-3:30 #22- 3:20 #23- 3:50 #24- 3:30	#25- 3:50 #26- 3:30 #27- 3:20 #28- 3:30 #29- 3:40	#30- 4:00 #31- 3:00 #32- 3:30 #33- 3:30	#34- 3:40 #35- 3:30 #36- 3:30 #37- 3:30
Daily Total	15:40	17:30	17:50	17:50	17:50	14:00	15:10

SECOND IRRIGATION

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Boro Blocks		#10-#14	#15-#19	#20-#24	#25-#29	#30-#33	#34-#37
Wheat Blocks	#6-#9						
Blocks' Delivery Time	#6- 3:10 #7- 3:20 #8- 3:30 #9- 3:30	The boro delivery schedule will be the same as the first week's schedule.					
Daily Total	13:30	17:50	17:30	17:50	17:50	14:00	15:10
							113:40

TABLE B-Ex-3

FIFTH IRRIGATION

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Boro Blocks		#10 - #14	#15 - #19	#20 - #24	#25 - #29	#30 - #33	#34 - #37
Wheat Blocks	#1 - #5						
Blocks' Delivery Time	#1- 4:30	#10- 4:10	#15- 4:30	#20- 4:20	#25- 4:30	#30- 4:40	#34- 4:00
	#2- 4:40	#11- 4:30	#16- 4:00	#21- 4:00	#26- 4:00	#31- 3:40	#35- 4:00
	#3- 5:00	#12- 4:00	#17- 4:00	#22- 3:50	#27- 3:50	#32- 4:00	#36- 4:30
	#4- 5:00	#13- 4:00	#18- 4:00	#23- 4:30	#28- 4:10	#33- 4:10	#37- 4:10
	#5- 4:30	#14- 4:20	#19- 4:30	#24- 4:10	#29- 4:20		
Daily Total	22:40	21:00	21:00	20:50	20:50	16:30	16:40
							139:50

TABLE B-Ex-4

SIXTH IRRIGATION

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Boro Blocks		#10 - #14	#15 - #19	#20 - #24	#25 - #29	#30 - #33	#34 - #37
Wheat Blocks	#6 - #9						
Blocks' Delivery Time	#6- 4:30	The boro delivery schedule will be the same as the fifth week schedule.					
	#7- 4:50						
	#8- 5:00						
	#9- 5:00						
Daily Total	19:20	21:00	21:00	20:50	20:50	16:30	16:30
							136:30

Section 8: Pump House Modification

Existing pump houses, in general, are too small and under-ventilated when a diesel engine is the power source. Every successful well will have to be pulled for repairs sooner or later. A four-foot-by-four-foot hole in the roof over the well can be used for this purpose as well as for improved ventilation. It then becomes possible to move the power source onto its base and easily remove it. With the roof off the well, the pulling and replacing of the pump and liner also become much easier and, therefore, more efficient. This procedure presupposes a mobile lifting boom but it could also be used to move the four-foot-by-four-foot cover.

A standard-size pump house for all DTW pumps should be ten feet by twelve feet inside with ten feet of head room in the middle.

In diesel engine installation the engine cooling air should be exhausted to the outside, just as the combustion gasses are.

The seven-gallon fuel tanks for the engines are inadequate because they must be filled three times per day in order to operate twency hours. A thirty-gallon tank should be mounted to the wall above the engine. This will require a hand pump to put the fuel up into the permanently mounted fuel tank. Because clean fuel provides added life to an engine, it is suggested that two fuel filters be put in the line between the elevated tank and the injection pump.

In order to guard the installation, it is recommended that the pump house should have an adjoining room for living quarters. The addition could use one wall of the pump house as its own fourth wall with doors and windows be added at the discretion of the cooperative's officers. The operator would then have living quarters, which could be considered as part of his compensation and which would eventually amortize the capital investment.

Section 9: Khal Maintenance Costs

The approximate cost of moving 100 cubic feet of earth 100 feet is Tk 20.

The rate of sediment deposition in a khal is directly related to the soil type, crops, rainfall, size of watershed, and amount of suspended material in the water supply.

Assuming an average rate of deposition of one-half the winter season's high water mark in ten years, and an original depth of five feet, there would be about 2.5 feet of sedimentation in the tenth year.

With an average bottom width of ten feet and a length of one mile with 1:1 side slopes, the average khal excavation will require the removal of about 31 cubic feet per linear foot of length.

At 20 Tk per 100 cubic feet, the cost per running foot is equal to Tk 6.20, or Tk 32,748. Therefore the cost of re-excavating a mile of khal is equal to Tk 3,275 per year.

TABLE B-1 LUBRICANTS RECOMMENDED BY MANUFACTURERS OF DIESEL ENGINES USED FOR LIP'S

SL. NO.	TYPE OF ENGINE	LUBRICANT RECOMMENDED BY MANUFACTURER	EQUIVALENT LUBRICANT LOCALLY AVAILABLE & ITS PRESENT PRICE
1.	Deutz: F1L - 210D	at 41°F to 86°F SAE 30	CASTROL CRI 30 @ Tk 46.91/IG in non-returnable drums of 45 gallons ex MI Chittagong/up country depot HD-30 @ 49.91/IG Rotella 30 @ 46.91/IG Date: 18.10.79 Price may go up by 40% to 50% in near future
2.	F1L 208D (i)	at 77°F and above SAE 40	
3.	Deutz F2L 912	Above 68°F SAE 30	
4.	F2L 912W (i)	Below 68°F SAE 20W/20	
5.	Detuz: F1L 812 (i)	HD - Oil	
6.	F2L 812		
7.	Ruston: 2YWA	Above 40°F upto 85°F SAE 20	
8.	1YWA	Over 85°F SAE 30	
9.	Slavia: 1ST 120	For Winter :- * Shell Oil Rotella 30 Shell Oil Rotella T 30 Shell Oil Rimula 30 For Summer :- ** Shell Oil Rotella 40 Shell Oil Rotella T 40 Shell Oil Rimula 40 Rinsing Oils :- Shell Oil Vitrea 27 (Viscosity Approx. 21CST)	
10.	2ST 120 (i)		
11.	Kirlosker : RA2	Above 41° upto 50°F Rotella 20 Between 50°F upto 76°F Rotella 30 Above 76°F Rotella 40 Flushing Oil - Shell Donex Flushing Oil	

* Winter of Czechoslovakia ** Summer of Czechoslovakia

TABLE B-1 (continued)

12.	Yanmar: TS 180 (for 2 cusec pump)		Below 50°F	50°-68°F	68°-95°F	Above 95°F	CASTROL CRI 30 ..... HD-30 ..... Rotella-30 .....
		Shell Talona	10W	20	30 & 40	50	
		Shell Rimula	20/20W	20/20W	30 & 40	-	
			(Not used by BADC)				
13.	GDR : 1VD8/8 - 2SL 2VD8/8 - 2SVL 4VD8/8 - 2SVL		Above 32°F		Above 86°F		
			SAE 20		SAE 30		
			Rotella & Talona of Shell				

Flushing Oil

Jamuna Flushing Oil @ Tk. 34.02 per gallon
Meghna Flushing Oil @ Tk. 37.03 " "
BOC Flushing Oil @ Tk. 34.02 " "
Any one of the flusing oils may be used.

TABLE B-2

LUBRICANTS RECOMMENDED BY MANUFACTURERS OF DESEL ENGINES USED FOR DTW'S

SL. NO.	TYPE OF ENGINE		LUBRICANT RECOMMENDED BY MANUFACTURER		EQUIVALENT LUBRICANT LOCALLY AVAILABLE & ITS PRESENT PRICE.
1.	MTM Diesel:	D327-2	From 32°F to 86°F	SAE 20	CASTROL GTX - 30 @ 46.91/IG HD-30 @ 49.91/IG ROTELLA 30 @ 46.91/IG Date: 18.10.79 Price may go up by 40% to 50% in the near future
2.		D327-3	Above 86°F	SAE 30	
3.	Ruston :	3YJA	Above 40°F upto 85°F	SAE 20	
			Over 85°F	SAE 30	

Flushing Oil:

Jamuna Flushing Oil @ Tk. 34.02/IG

Meghna Flushing Oil @ Tk. 37.03/IG

BOC Flushing Oil @ Tk. 34.03/IG

Any of the flushing oils may be used

TABLE B-3

LUBRICANTS RECOMMENDED BY MANUFACTURERS OF RIGHT ANGLE GEAR DRIVES

SL. NO.	TYPE OF GEAR DRIVE	LUBRICANT RECOMMENDED BY MANUFACTURER	EQUIVALENT LUBRICANT LOCALLY AVAILABLE & ITS PRESENT PRICE
1.	AMARILLO	High grade Turbine Oil. Viscosity 500 SUV at 100°F (500 Sayholt Universal Second at 100°F)	— CASTROL HYSPIN 175 @ Tk. 40.60/IG — — Hytrco-65 @ 74.16/IG — — Shell Tellus Oil 41 @ Tk. 40.60/IG — Date: 18.10.79 Price may go up by 40% - 50% in near future
2.	HOLLOSHAFT	Turbine Oils, Viscosity of 400-500 SSU Seconds at 100°F.	
3.	ROPOS	SAE 40 E/50°c.	

Flushing Oil :

Jamuna Flushing Oil @ Tk. 34.02 per gallon

Meghna Flushing Oil @ Tk. 37.03 " "

BOC Flushing Oil @ Tk. 34.02 " "

Any one of the above mentioned flushing oils may be used.

TABLE B-4

AVERAGE IRRIGATION REQUIREMENTS (Ia) FOR T. AMAN,

IN INCHES (HIGHLAND AND MEDIUM HIGHLAND)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Re .86	P .86	Ia	ETc-Re .86	P .86	Ia
Chittagong						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	1.7	.6[1]	2.3	2.6	1.8[1]	4.4
Total			2.3			4.4
Dacca & Tangail						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.7	1.0[1]	3.7	4.0	2.9[1]	6.9
Total			3.7			6.9
Khulna						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	1.6	1.7[1]	3.3	1.9	1.9[1]	3.8
Nov	2.7	1.2	3.9	3.8	3.5	7.3
Total			7.2			11.1

(continued)

TABLE B-4

(continued)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Re / .86	P / .86	Ia	ETc-Re / .86	P / .86	Ia
Rajshahi						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.8	1.0[1]	3.8	4.0	3.0[1]	7.0
Total			3.8			7.0
Rangpur						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.8	1.1[1]	3.9	4.0	3.2[1]	7.2
Total			3.9			7.2

[1] $\frac{ETc-Re}{ETc} \times \frac{P \text{ for entire month}}{.86}$

TABLE B-5

PEAK IRRIGATION REQUIREMENTS (Ip) FOR T. AMAN,

IN INCHES (HIGHLAND AND MEDIUM HIGHLAND)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Rd .86	P .86	Ip	ETc-Rd .86	P .86	Ip
Chittagong						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.8	1.0[1]	3.8	4.1	2.8[1]	6.9
Dacca & Tangail						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	2.7	3.2[1]	5.9	2.9	3.4[1]	6.3
Nov	2.8	1.2	4.0	4.2	3.5	7.7
Khulna						
Aug	.0	.0	.0	.0	.0	.0
Sep	.2	.2[1]	.4	.3	.3[1]	.6
Oct	.7	7.0	9.7	2.9	7.0	9.9
Nov	3.5	1.2	4.7	5.1	3.5	8.6
Rajshahi						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	4.5	5.0[1]	9.5	4.8	5.0[1]	9.8
Nov	3.3	1.2	4.5	4.7	3.5	8.2

(continued)

TABLE B-5
(continued)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Rd / .86	P / .86	Ip	ETc-Rd / .86	P / .86	Ip
Rangpur						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	3.3	3.6[1]	6.9	3.5	3.8[1]	7.3
Nov	3.0	1.2	4.2	4.3	3.5	7.8

[1] $\frac{\text{ETc Rd}}{\text{ETc}} \times \frac{\text{P for entire month}}{.86}$

TABLE B-6

AVERAGE IRRIGATION REQUIREMENTS (Ia) FOR BORO, IN INCHES

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Re .86	La	P .86	Ia	ETc-Re .86	La	P .86	Ia	ETc-Re .86	La	P .86	Ia
Chittagong												
Dec		5.0		5.0		3.0		3.0				
Jan	5.2		7.0	12.2	5.2		5.2	10.4	2.7	.0	1.7	4.4
Feb	6.0		7.0	13.0	6.0		5.2	11.2	5.7		3.5	9.2
Mar	6.6		7.0	13.6	6.6		5.2	11.8	7.2		3.5	10.7
Apr	1.5		1.2	2.7	1.5		.0	1.5	3.1		.6	3.7
May									.0		.0	
Total				46.5				37.9				28.0
Dacca & Tangail												
Dec		5.0		5.0		3.0		3.0				
Jan		4.7	7.0	11.7	4.7		5.2	9.9	2.4	.0	1.7	3.9
Feb		5.9	7.0	12.9	5.9		5.2	11.1	5.7		3.5	9.2
Mar		8.3	7.0	15.3	8.3		5.2	13.5	8.8		3.5	12.3
Apr		2.2	7.0	3.4	2.2		.0	2.2	4.2		.6	4.8
May									.0		.0	
Total				48.3				39.7				30.2
Khulna												
Dec		5.0		5.0		3.0		3.0				
Jan	5.3		7.0	12.3	5.3		5.2	10.5	2.7	.0	1.7	4.4
Feb	6.9		7.0	13.9	6.9		5.2	12.1	6.5		3.5	10.0
Mar	8.1		7.0	15.3	8.1		5.2	13.1	8.7		3.5	12.2
Apr	3.1		1.2	4.3	3.1		.0	3.1	5.3		.6	5.9
May									.1		.0	.1
Total				50.8				42.0				32.6

(continued)

TABLE B-6

(continued)

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia
Rajshahi												
Dec		5.0		5.0		3.0		3.0				
Jan	4.4		7.0	11.4	4.4		5.2	9.6	2.3	.0	1.7	4.0
Feb	6.4		7.0	13.4	6.4		5.2	11.6	6.0		3.5	9.5
Mar	8.1		7.0	15.1	8.1		5.2	13.3	8.7		3.5	12.2
Apr	4.0		1.2	5.2	4.0		.0	4.0	6.6		.6	7.2
May									.2			.2
Total				50.1				41.5				33.1
Rangpur												
Dec		5.0		5.0		3.0		3.0				
Jan	3.6		7.0	10.6	3.6		5.2	8.8	2.0	.0	1.7	3.7
Feb	5.7		7.0	12.7	5.7		5.2	10.9	5.5		3.5	9.0
Mar	7.8		7.0	14.8	7.8		5.2	13.0	8.4		3.5	11.9
Apr	3		1.2	4.7	3.5		.0	3.5	5.9		.6	6.5
May									.0		.0	.0
Total				47.8				39.2				31.1

TABLE B-7

PEAK IRRIGATION REQUIREMENTS (Ip) FOR BORO, IN INCHES

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Rd/.86	Lp	P/.86	Ip	ETc-Rd/.86	Lp	P/.86	Ip	ETc-Rd/.86	Lp	P/.86	Ip
Chittagong												
Dec		7.0		7.0		5.0		5.0				
Jan	5.7		7.0	12.7	5.7		5.2	10.9	2.9	2.0	1.7	6.6
Feb	7.1		7.0	14.1	7.1		5.2	12.3	6.7		3.5	10.2
Mar	9.0		7.0	16.0	9.0		5.2	14.2	9.5		3.5	13.0
Apr	4.4		1.2	5.6	4.4		.0	4.4	7.4		.6	8.0
May									.2		.0	.2
Dacca & Tangail												
Dec		7.0		7.0		5.0		5.0				
Jan	5.1		7.0	12.1	5.1		5.2	10.3	2.7	2.0	1.7	6.4
Feb	6.7		7.0	13.7	6.7		5.2	11.9	6.5		3.5	10.0
Mar	9.9		6.0	16.9	9.9		5.2	15.1	10.5		3.5	14.0
Apr	4.0		1.2	5.2	4.0		.0	4.0	6.7		.6	.3
May									.3		.0	.3
Khulna												
Dec		7.0		7.0		5.0		5.0				
Jan	5.9		7.0	12.9	5.9		5.2	11.1	3.0	2.0	1.7	6.7
Feb	7.9		7.0	14.9	7.9		5.2	13.1	7.6		3.5	11.1
Mar	9.7		7.0	16.7	9.7		5.2	14.9	10.2		3.5	13.7
Apr	4.8		1.2	6.0	4.8		.0	4.8	7.8		.6	8.4
May									.6		.0	.6

(continued)

TABLE B-7

(Continued)

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Rd / .86	Lp	P / .86	Ip	ETc-Rd / .86	Lp	P / .86	Ip	ETc-Rd / .86	Lp	P / .86	Ip
Rajshahi												
Dec		7.0		7.0		5.0		5.0				
Jan	4.9		7.0	11.9	4.9		5.2	10.1	2.6	2.0	1.7	6.3
Feb	7.3		7.0	14.3	7.3		5.2	12.5	7.0		3.5	10.5
Mar	10.1		7.0	17.1	10.1		5.2	15.3	10.7		3.5	14.2
Apr	5.8		1.2	7.0	5.8		.0	5.8	9.5		.6	10.1
May									1.0		.0	1.0
Rangpur												
Dec		7.0		7.0		5.0		5.0				
Jan	4.1		7.0	11.1	4.1		5.2	9.3	2.2	2.0	1.7	5.9
Feb	6.4		7.0	13.4	6.4		5.2	11.6	6.2		3.5	9.7
Mar	9.0		7.0	16.0	9.0		5.2	14.2	9.5		3.5	13.9
Apr	4.9		1.2	6.1	4.9		.0	4.9	8.3		.6	8.9
May									.0		.0	.0

TABLE B-8

AVERAGE IRRIGATION REQUIREMENTS (Ia) FOR T. AUS, IN INCHES

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern Medium Highland				Boro-Based Cropping Pattern High Lowland			
	ETc-Re .86	La	P .86	Ia	ETc-Re .86	La	P .86	Ia	ETc-Re .86	La	P .86	Ia
Chittagong												
Mar		3.5		3.5								
Apr	2.8	3.5	1.9[1]	8.2		6.0		6.0		5.0		5.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0		.0		.0	.0
Total				11.7					6.0			5.0
Dacca & Tangail												
Mar		3.5		3.5								
Apr	3.5	3.5	2.2[1]	9.2	.0	6.0		6.0		5.0	.0	5.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				12.7				6.0				5.0
Khulna												
Mar		3.5		3.5								
Apr	4.7	3.5	5.8	14.0		7.0		6.0		5.0		5.0
May	1.7		1.2[1]	2.9	1.6		1.1	2.7	1.6		.8[1]	2.4
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				20.4				8.7				7.4

(continued)

TABLE B-8

(continued)

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern Medium Highland				Boro-Based Cropping Pattern High Lowland			
	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia
Rajshahi												
Mar		3.5		3.5								
Apr	5.8	3.5	5.8	15.1		6.0		6.0		5.0		5.0
May	2.8		1.8[1]	4.6	2.7		1.7	4.4	2.7		1.3[1]	4.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				23.2				10.4				9.0
Rangpur												
Mar		3.5		3.5								
Apr	5.1	3.5	3.5[1]	12.1		6.0		6.0		5.0		5.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				15.6				6.0				5.0

[1] $\frac{ETc-Re}{ETc} \times \frac{P \text{ for entire month}}{.86}$

TABLE B-9

PEAK IRRIGATION REQUIREMENTS (Ip) FOR T. AUS, IN INCHES

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern							
					Medium Highland				High Lowland			
	ETc-Rd / .86	Lp	P / .86	Ip	ETc-Rd / .86	Lp	P / .86	Lp	ETc-Re / .86	Lp	P / .86	Ip
Chittagong												
Mar		4.5		4.5								
Apr	6.7	4.5	5.8	17.0		8.0		8.0		7.0		7.0
May	2.3		1.6 [1]	3.9	2.2		1.5 [1]	3.7	2.2		1.1 [1]	3.3
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0	.0	.0	.0	.0		.0	.0	.0		.0	.0
Dacca & Tangail												
Mar		4.5		4.5								
Apr	5.7	4.5	5.8	16.0		8.0		8.0		7.0	.0	7.0
May	3.3		2.1 [1]	5.4	3.0		2.0 [1]	5.0	3.0		1.5 [1]	4.5
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Khulna												
Mar		4.5		4.5								
Apr	6.6	4.5	5.8	16.9		8.0		8.0		7.0		7.0
May	5.0	4.5	3.4 [1]	8.4	4.9		3.4 [1]	8.3	4.9		2.5 [1]	7.4
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0

(continued)

TABLE B-9

(continued)

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern							
					Medium Highland				High Lowland			
	ETc-Re / .86	Lp	P / .86	Ip	ETc-Re / .86	Lp	P / .86	Ip	ETc-Re / .86	Lp	P / .86	Ip
Rajshahi												
Mar		4.5		4.5								
Apr	7.0	4.5	4.8	[1] 16.3		8.0		8.0		7.0		7.0
May	7.4	4.5	4.7	[1] 12.1	7.3		4.7	12.0	7.3		3.5	[1] 10.8
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Rangpur												
Mar		4.5		4.5								
Apr	7.0	4.5	4.8	[1] 16.3		8.0		8.0		7.0		7.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				15.6				6.0				5.0

[1] $\frac{ETc-Rd}{ETc} \times \frac{P \text{ for entire month}}{.86}$

TABLE B-10

AVERAGE AND PEAK IRRIGATION REQUIREMENTS (Ia AND Ip)
FOR WHEAT, IN INCHES

DISTRICT	Ia $(\frac{ETc-Re}{.60})$	Ip $(\frac{ETc-Rd}{.60})$
Chittagong		
Dec	2.8	3.0
Jan	7.2	7.5
Feb	7.2	8.7
Mar	3.2	5.2
Total	20.4	
Dacca & Tangail		
Dec	3.0	3.2
Jan	6.3	6.8
Feb	7.2	8.2
Mar	4.2	5.5
Total	20.7	
Khulna		
Dec	3.5	3.5
Jan	7.2	7.8
Feb	8.2	9.3
Mar	4.0	5.7
Total	22.9	
Rajshahi		
Dec	3.2	3.2
Jan	5.8	6.3
Feb	7.7	8.7
Mar	4.3	6.0
Total	21.0	

(continued)

TABLE B-10

(continued)

DISTRICT	Ia $(\frac{ETc-Re}{.60})$	Ip $(\frac{ETc-Re}{.60})$
Rangpur		
Dec	2.7	2.7
Jan	4.8	5.3
Feb	6.8	7.7
Mar	4.3	5.3
Total	18.6	

TABLE B-11

FIRST IRRIGATION - JANUARY

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Wheat Blocks	#1 - #3	#4 - #6	#7				
Boro Blocks			#15 - #16	#17 - #19	#20 - #22	#23 - #25	#26
Blocks' Delivery Time	#1- 7:00 #2- 7:20 #3- 7:40	#4- 7:10 #5- 6:50 #6- 7:20	#7- 7:20 #15- 6:00 #16- 6:00	#17- 6:50 #18- 5:50 #19- 6:20	#20- 6:30 #21- 6:00 #22- 5:50	#23- 6:40 #24- 6:00 #25- 6:00	#26- 6:00
Daily Total	22:00	21:20	19:20	19:00	18:40	18:40	6:00 125:00

TABLE B-12

SECOND IRRIGATION

Wheat Blocks	#8 - #10	#11 - #13	#14				
Boro Blocks			#15 - #16	#17 - #19	#20 - #22	#23 - #25	#26
Blocks' Delivery Time	#8- 7:50 #9- 7:40 #10- 7:20	#11- 7:10 #13- 7:50 #13- 7:50	#14- 7:40	The boro schedule is the same as the first irrigation			
Daily Total	22:50	22:00	19:40	19:00	18:20	18:40	6:00 126:20

TABLE B-13

FIFTH IRRIGATION - FEBRUARY

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Wheat Blocks	#1 - #3	#3 - #5	#6 - #7				
Boro Blocks			#15	#16 - #18	#19 - #21	#22 - #24	#25 - #26
Blocks'	#1- 8:00	#3- 4:00	#6- 8:30	#16- 6:50	#19- 7:00	#22- 6:20	#25- 6:40
Delivery	#2- 8:30	#4- 8:20	#7- 8;30	#17- 7:30	#20- 7:10	#23- 7:20	#26- 6:50
Time	#3- 4:40	#5- 7:50	#15- 6:40	#18- 6:20	#21- 6:40	#24- 6:50	
Daily Total	21:10	20:10	21:40	20:40	20:50	20:30	13:30
							138:30

TABLE B-14

SIXTH IRRIGATION

Wheat Blocks	#8 - #10	#11 - #12	#13 - #14				
Boro Blocks			#15	#16 - #18	#19 - #21	#22 - #24	#25 - #26
Blocks'	#8- 9:00	#10- 4:00	#13- 9:00	The boro schedule will be the same as the fifth irrigation.			
Delivery	#9- 8:40	#11- 8:20	#14- 8:40				
Time	#10- 4:30	#12- 8:00	#15- 6:40				
Daily Total	22:10	20:20	24:20	20:40	20:50	20:30	13:30
							142:20

TABLE B-15

NINTH IRRIGATION - MARCH

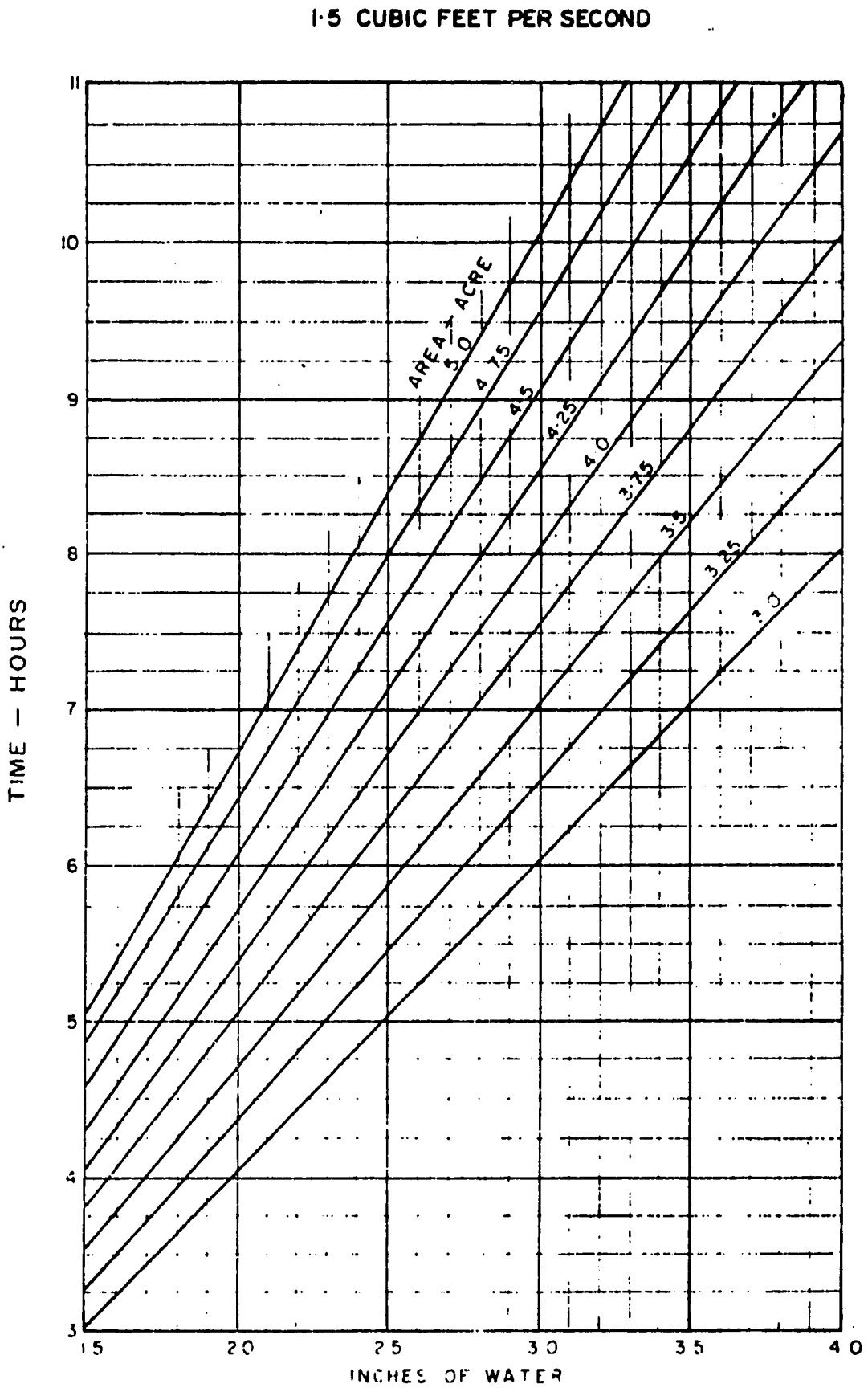
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
Wheat Blocks	#1 - #4	#5 - #7					
Boro Blocks		#15	#16 - #18	#19 - #20	#21 - #22	#23 - #24	#25 - #26
Blocks' Delivery Time	#1- 4:50 #2- 5:10 #3- 5:20 #4- 5:00	#5- 4:50 #6- 5:10 #7- 5:10 #15- 7:30	#16- 7:40 #17- 8:30 #18- 7:20	#19- 8:00 #20- 8:00	#21- 7:30 #22- 7:20	#23 8:20 #24 7:40	#25- 7:30 #26- 7:40
Daily Total	20:20	22:40	23:30	16:00	14:50	16:00	15:10 128:30

TABLE B-16

TENTH IRRIGATION

Wheat Blocks	#8 - #11	#12 - #14					
Boro Blocks		#15	#16 - #18	#19 - #20	#21 - #22	#23 - #24	#25 - #26
Blocks' Delivery Time	#8- 5:30 #9- 5:30 #10- 5:10 #11- 5:00	#12- 4:50 #13- 4:50 #14- 5:20 #15- 7:30	The boro schedule is the same as the ninth irrigation.				
Daily Total	21:00	22:30	23:30	16:00	14:50	16:00	15:10 129:00

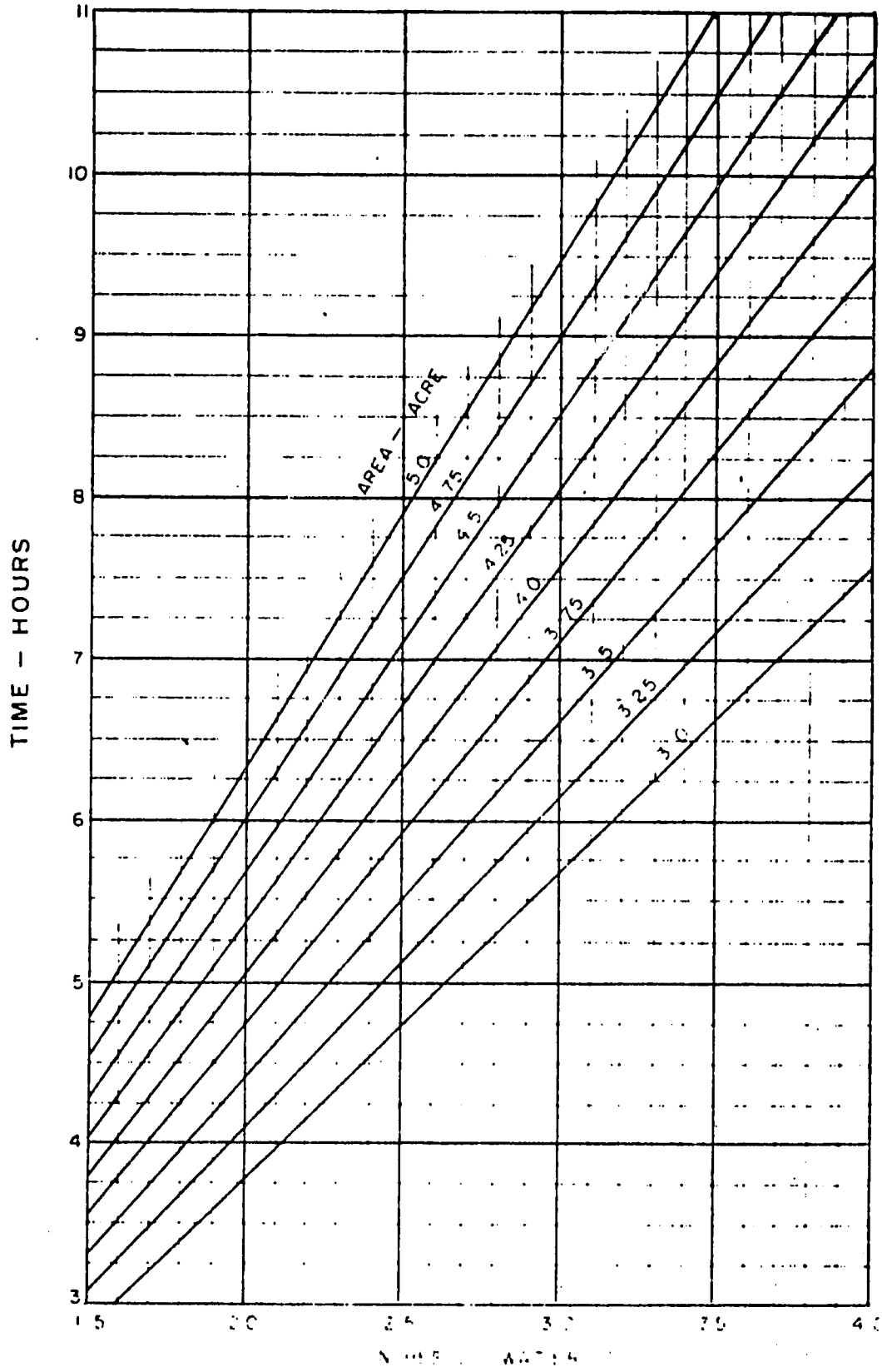
Figure B-1



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 1·5 CFS

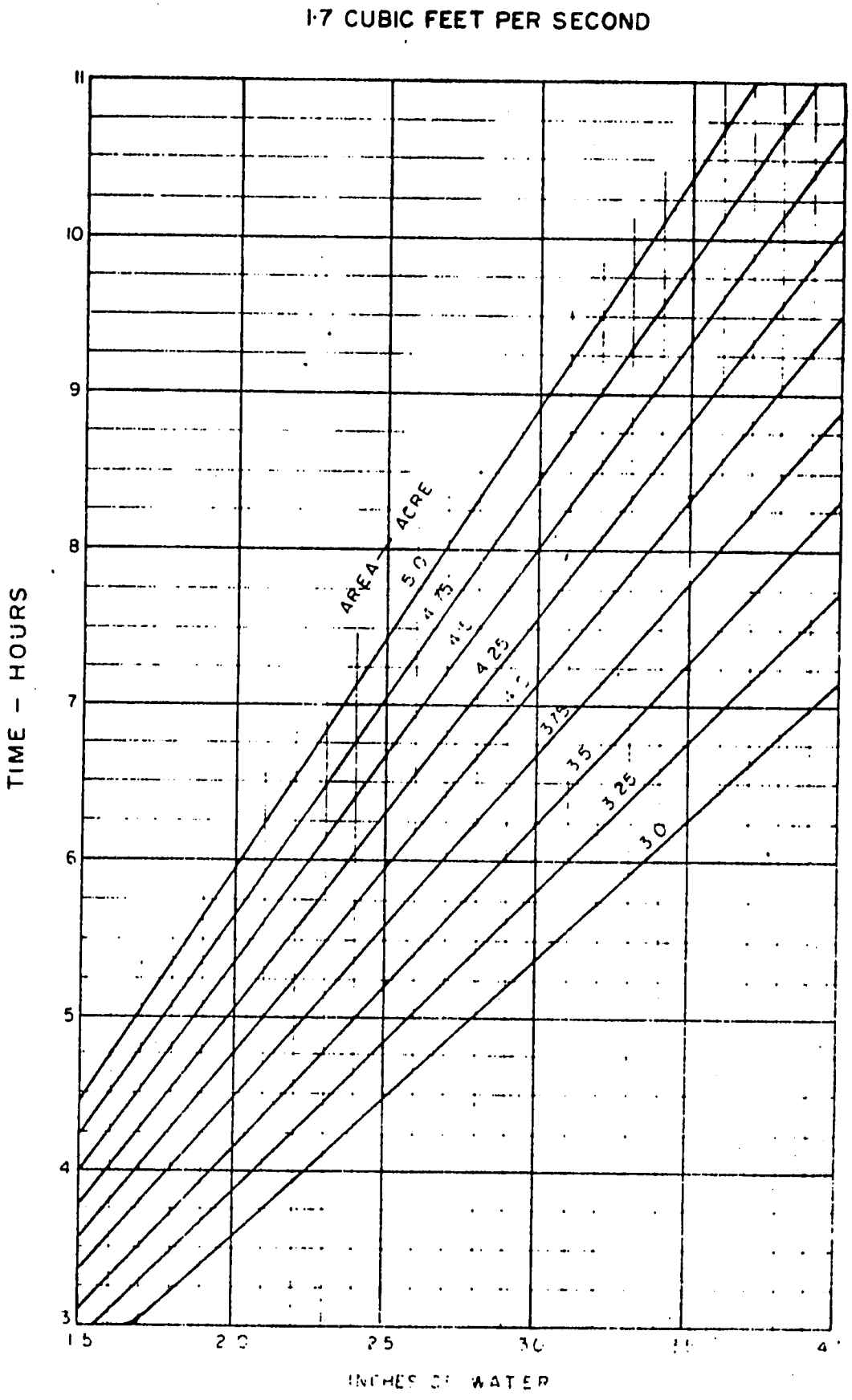
Figure B-2

1·6 CUBIC FEET PER SECOND



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 1 6 CFS.

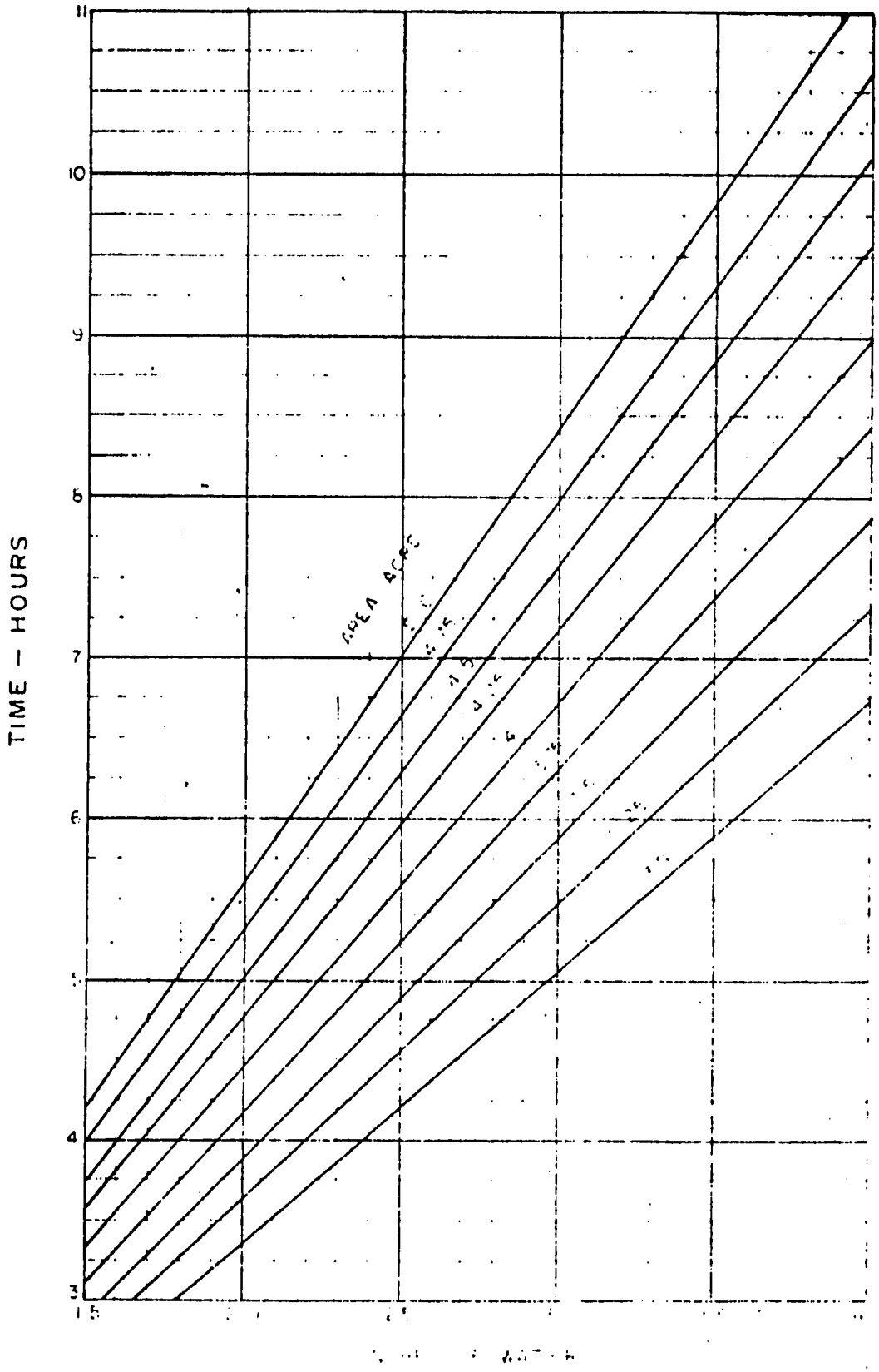
Figure B-3



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH AN IRRIGATION HEAD OF 1·7 CFS.

Figure B-4

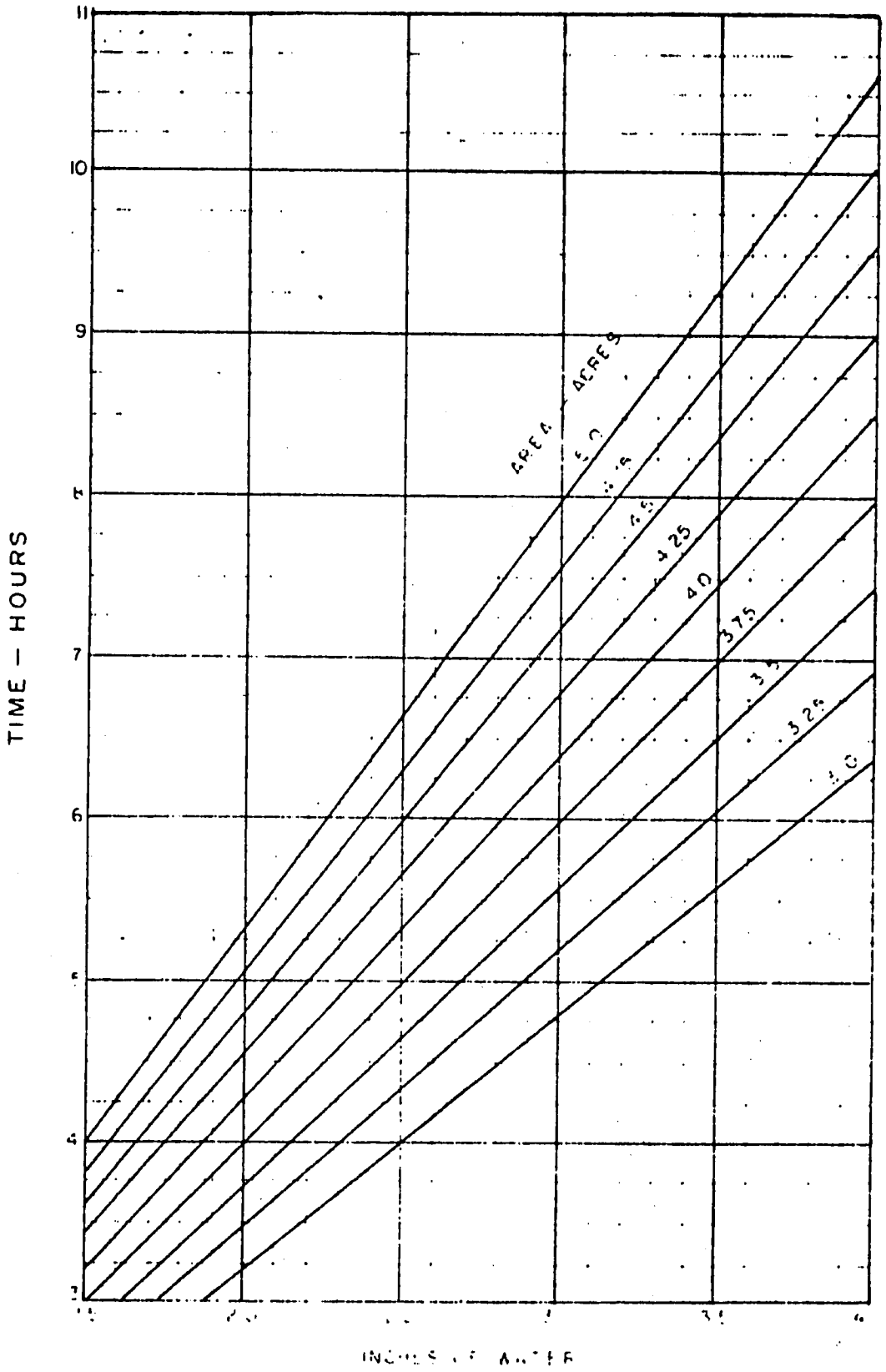
1·8 CUBIC FEET PER SECOND



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 1·8 CFS

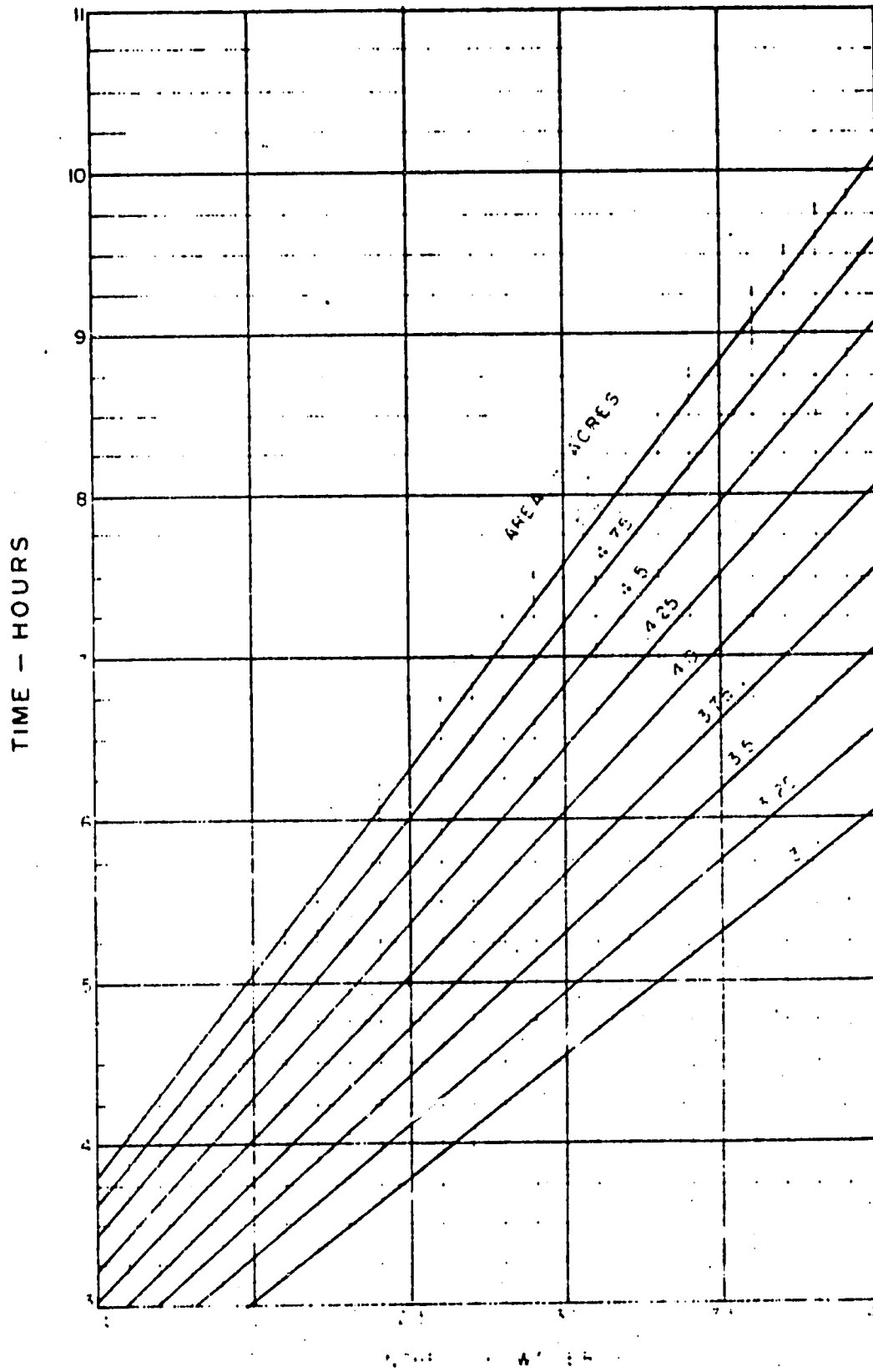
Figure B-5

1·9 CUBIC FEET PER SECOND

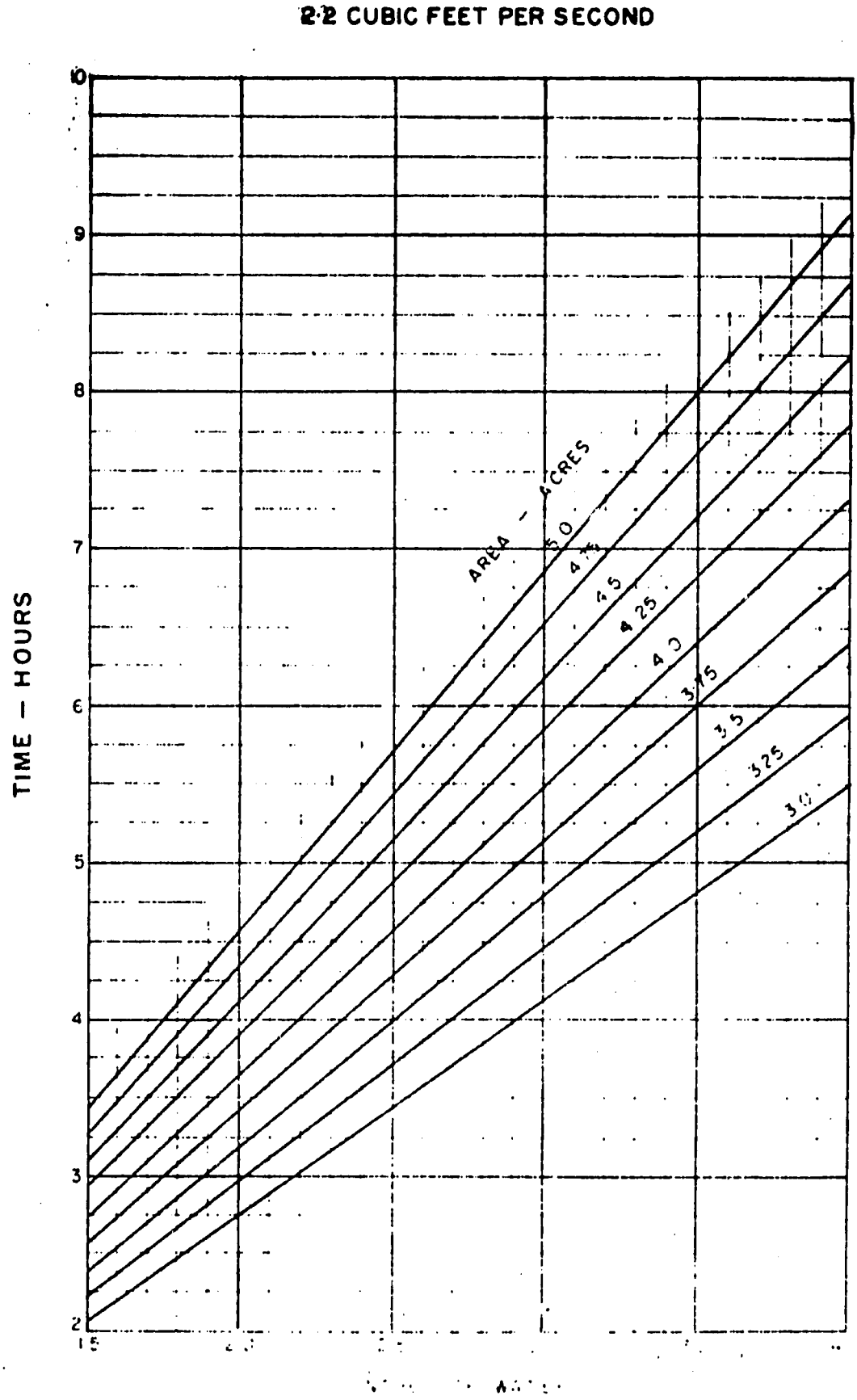


TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 1·9 CFS.

2·0 CUBIC FEET PER SECOND

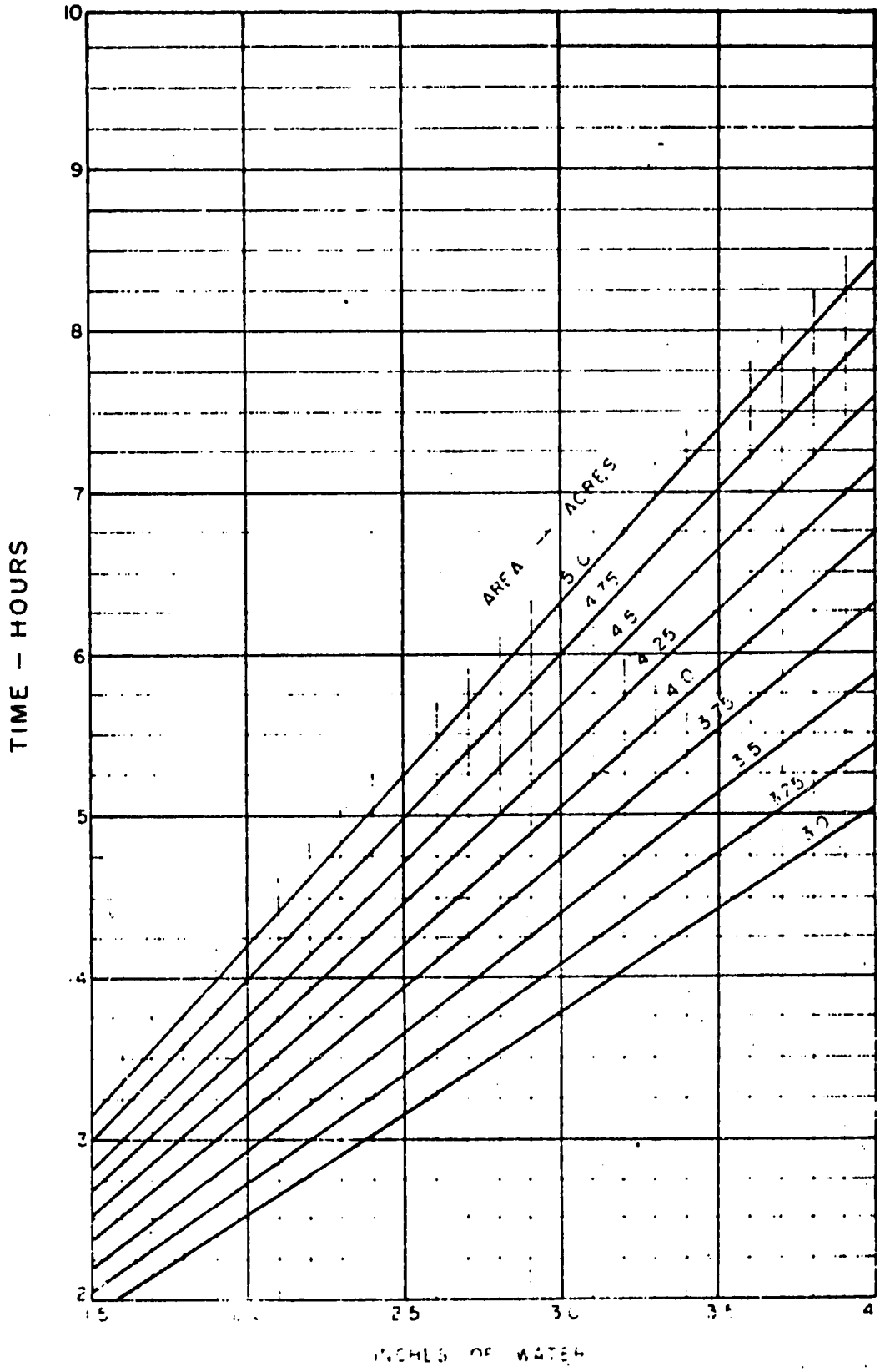


TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 2.0 CFS



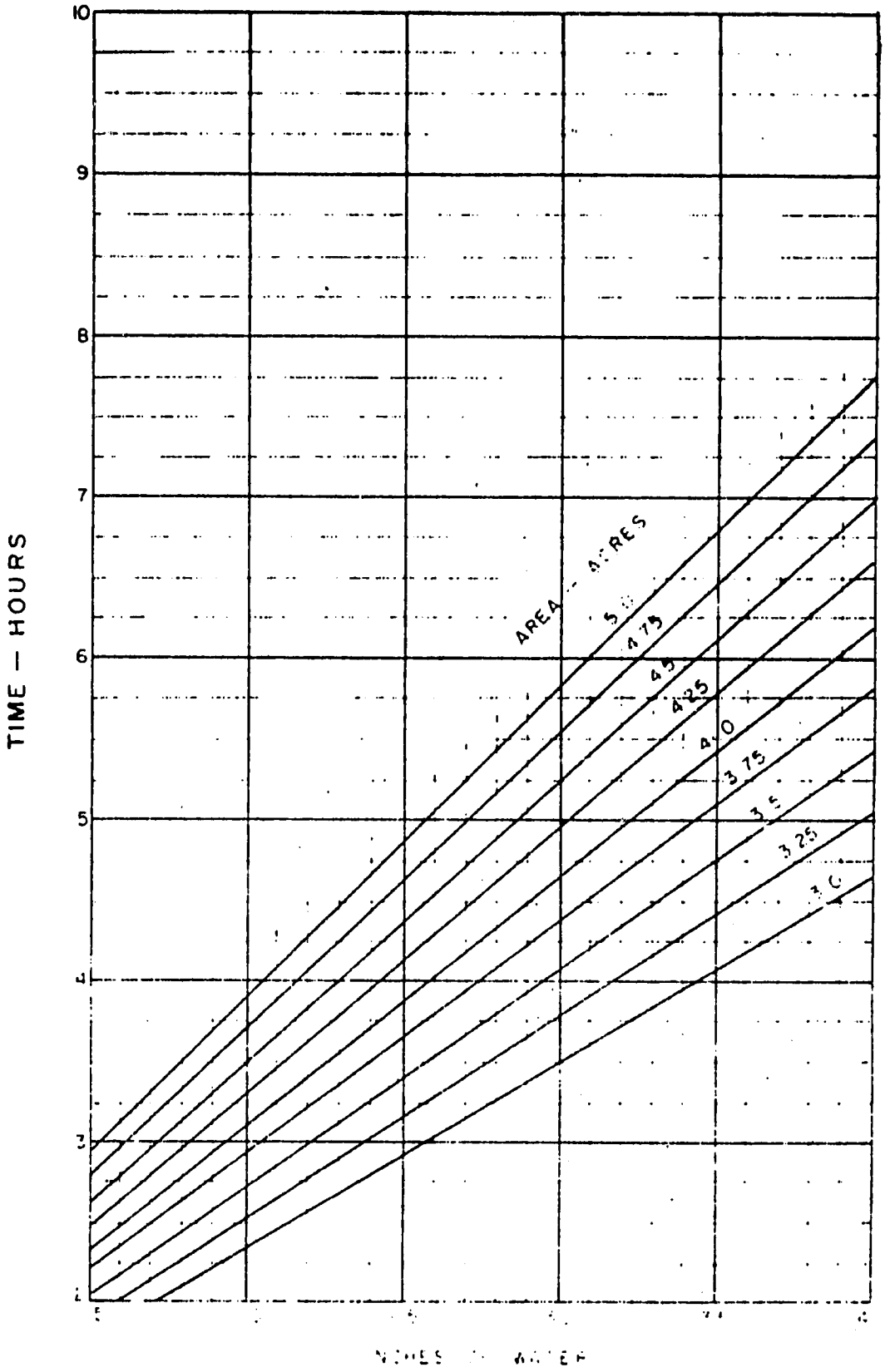
TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH AN IRRIGATION HEAD OF 2.2 CFS.

2·4 CUBIC FEET PER SECOND



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH AN IRRIGATION HEAD OF 2·4 CFS.

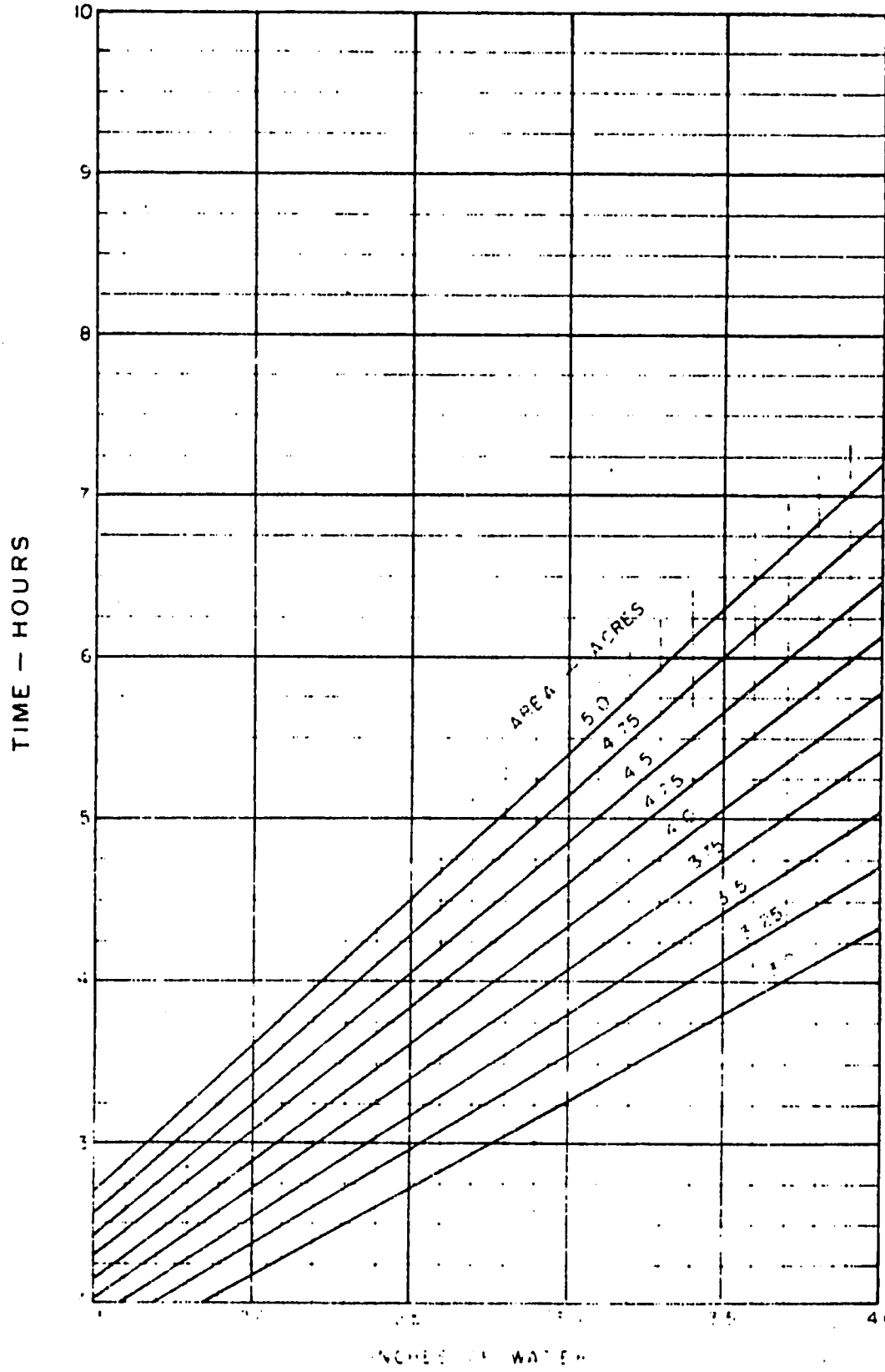
2·6 CUBIC FEET PER SECOND



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 2·6 CFS

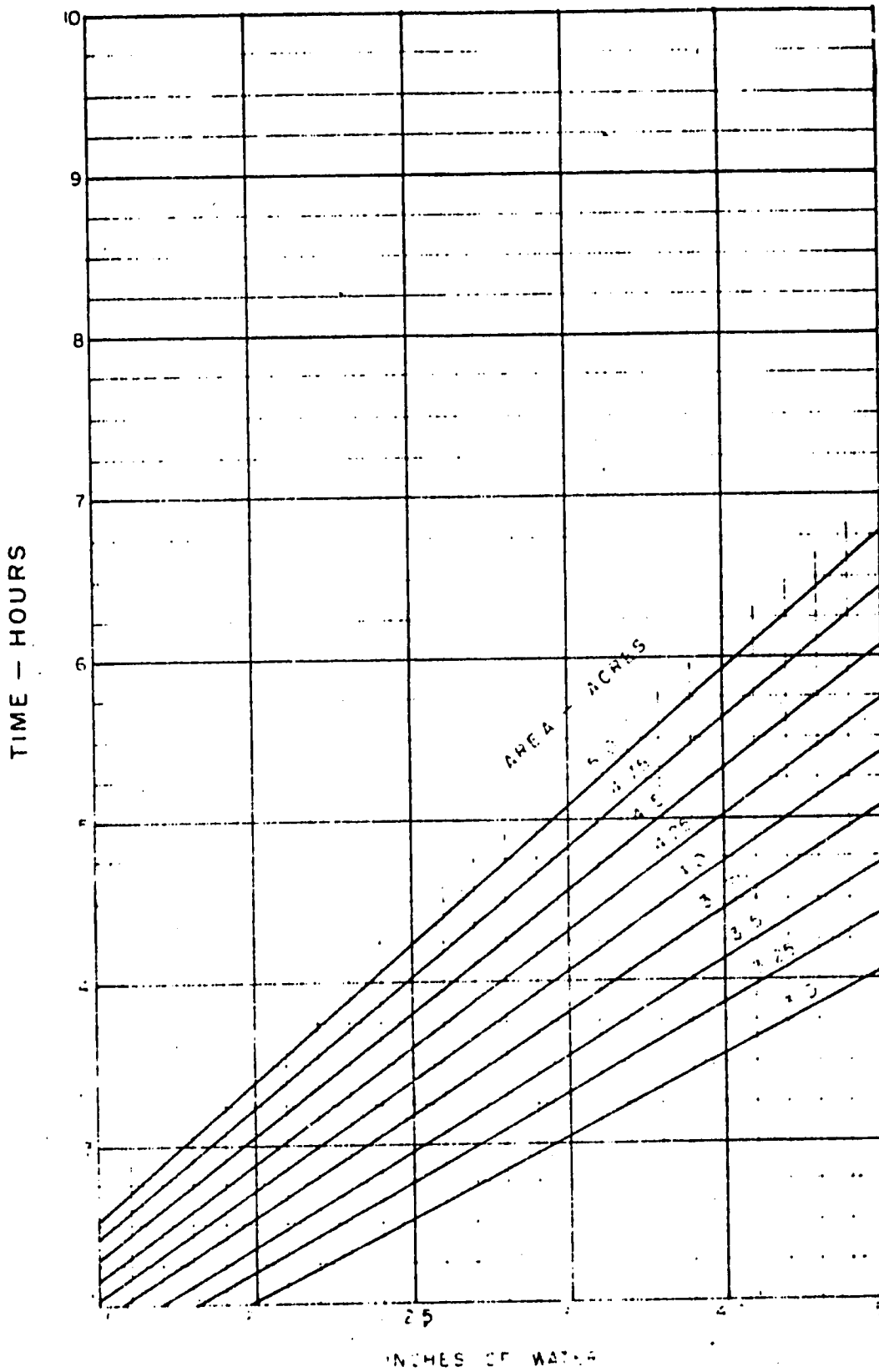
Figure B-10

2·8 CUBIC FEET PER SECOND



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 2 8 CFS

3·0 CUBIC FEET PER SECOND



TIME REQUIRED TO DELIVER A GIVEN NUMBER OF INCHES OF WATER TO A GIVEN NUMBER OF ACRES WITH A HEAD OF 3·0 CFS