APPENDIX II

UPGRADING OF THE MAFRAQ WASTEWATER TREATMENT PLANT

CONCEPTUAL DESIGN CALCULATIONS

REMOVAL EFFICIENCIES
&
COMPARSION WITH SIMILAR TREATMENT PLANTS

(DRARGA, MORROCO)

Stearns & Wheler Companies

IRG / USAID — Client
40295.30.1/10 — Date / Job No.
MAFRAQ. CONCEPTUAL DESIGN AR. — Subject
Comp. By / Checked By

THE FOLLOWING REMOVAL EFFICIENCIES ARE CONSIDERED APPLICABLE FOR THIS FACILITY:

1) SEDIMENTATION / THICKENING TANKS

PRELIMINARY DESIGN SUMMARY

Number of Units:	Two (2)			
Design Flow/Unit:	3275	m^3/d	600.8	gpm
Hyd. Loading Rate at Design Flow:	1.22	m/hr	0.5	gpm/ft^2
Max Flow/Unit:	6500	m^3/d	1192	gpm
Hyd. Loading Rate at Max Flow:	1.22	m/hr	0.5	gpm/ft^2
Design Efficiency Factor:	80%		80%	
Effective Settling Area/Unit:	221.74	m^2	2387	ft^2
Number of Plates/Unit:	130		130	
Perpendicular Plate Spacing:	76.2	mm	3	inches
Plate Width:	1.22	m	4	feet
Plate Length:	3.05	m	10	feet
Plate Material:	FRP			
Tank Material:	Steel (painted)			
Model Number:	DRH-2387-130-410x3			
Approx. Unit Dimensions:	8.3 m x 4.3 m x 8.5 m		27' L x 14' W x 28' T	

- TSS REMOVAL = 70% (TYPICAL REMOVAL EFFICIENCY FOR PRIMARY)

IN MAFRAQ THE INFLUENT TSS LEVELS ARE ALSO HIGHER THAN THE TYPICAL JORDANIAN TSS. BECAUSE OF THE LONG GRAVITY SEWER

- BOD REMOVAL = 50% TYPICAL REMOVAL EFF. FOR PRIMARY SETTLING RECEIVING HIGH PARTICULATE BOD (REFERENCE: MAFRAQ FESIBILITY STUDY).
- TN REMOVAL = 15% TYPICAL REMOVAL EFFICIENCY FOR PRIMARY

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IRG/USAID — Client
40295, 21.17.00 — Date / Job No.
MAFRAQ. CONCEPTUAL DESIGN. — Subject
A.K. — Comp. By
Checked By

COMPARISON OF THE REMOVAL EFFICIENCIES THROUGH ALL TREATMENT UNITS – MAFRAQ VS DRARGA (MOROCCO).

DRARGA → PARAMETER MAFRAQ →	AN OR SDT	DN OR PDN	AS B	FL	RSF TF RSF	CU(RB) RB	BS TOTAL MP
BoD	43%	39%	–	–	70%	20% – 16%	95%
	50%	40%	54%	33%	40%		
CoD	38%	38%	–	–	66%	16%	94.4%
TSS	57%	86%	[illegible]	–	89%	0	96%
VSS	48%	–	–	–	91%	0	97.6%
NH_3	40%	[illegible]	–	–	75%	95%	99%
TKN	45%	41%	[illegible]	–	0	98%	99%
TN	45%	50%	–	–	0	99.3%	99.3%
NO_x	–	100%	–	–	0	99%	99.7%
P_T	–	32%	–	–	–		

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Subject	**Comp. By**	**Checked By**
MAFRAQ, CONCEPTUAL DESIGN	AK	

COMPARISON WITH DRARGA, MOROCCO
OPERATIONAL DATA FROM DEC 2004
T° OF THE WASTEWATER = 14°C.

1) ANAEROBIC REACTOR LOADING = 430 $\frac{g.BOD}{m^3.D}$
(V = 1,800 m^3)

Note: In Mafraq we proposed the elimination of the anaerobic reactors, because the influent sewer line is very long and the biodegradation of the organic material is very advanced

2.) DENITRIFICATION FILTERS = 0.05 kg $NO_x/m^3/D$.
(V = 1,572 m^3)

Note: In Mafraq we proposed a fluidized-type denitrification reactor to allow higher denitrification in smaller volumes (reduced cost. too).
In Drarga the denitrification is divided between the DN & RB.
The same strategy shall be implemented during the detailed design.

3.) RSF = HYDRAULIC LOADING RATE = 0.23 m/day
(A = 15,600 m^2) height of water / dose = 0.23 cm/dose.
Q_R = 1.8. Q_{2010}

Note: The size of the filters in MAFRAQ is determined based on a split of 50% Q_R between DENIT REACTOR and RB!

4) Constructed Wetlands - Reed beds
(A = 10,000 m^2)
NO_x load = 81 kg N/ha.
TN load = 276 kg/ha

SEDIMENTATION/THICKENING TANKS

Stearns & Wheler Companies

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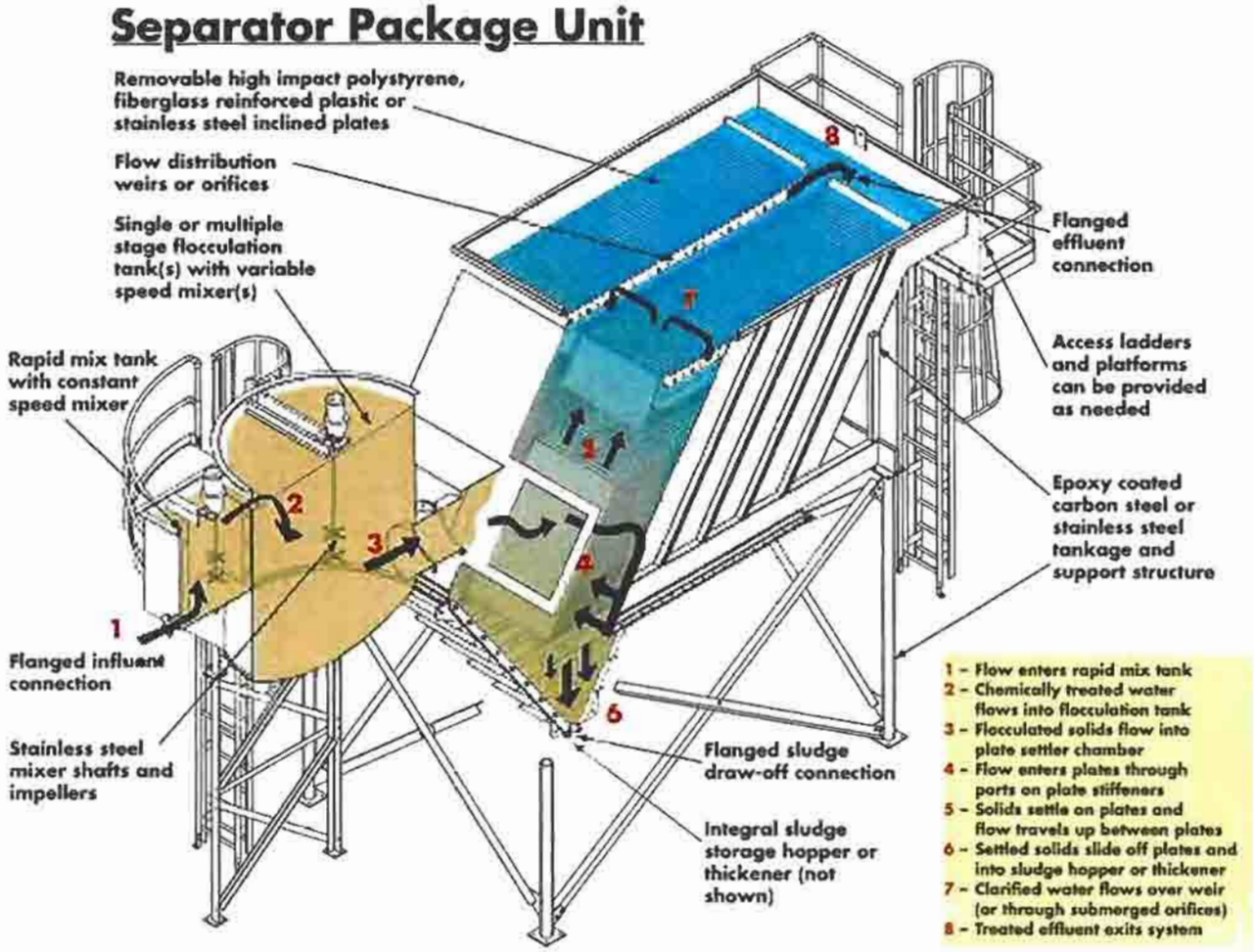
MAPRAQ Conceptual Design — Subject

AK — Comp. By / Checked By

Typical Zimpro® Inclined Plate Separator Package Unit



CAN HAVE chemical ADDITION UNIT (NOT INSTALLED NOW BUT PIPING PROVIDED TO DO SO)

NOTE!
DURING THE DETAILED DESIGN PROVISIONS SHOULD BE MADE TO ENSURE ADEQUATE CLEANING OF THE PLATES (WEEKLY, MONTHLY, ETC) → PROVIDE NON POTABLE WATER STATIONS

HYDRAULIC PROFILE DESIGN

Stearns & Wheler Companies

Client	Date	Job No.
IRG/USMD	40295, 21, 1700	

Subject	Comp. By	Checked By
MAFRAQ, Conceptual report	AK	

HYDRAULIC PROFILE.

(A) Guiding principles for the profile

1) The only way to reuse the existing structures (waste stabilization ponds) is with influent pumping station.

Lifting the design peak flow of 13,000 m³/D to an elevation ≡ to the feed to the sedimentation/thickening tanks provides gravity flow to all subsequent units.

2.) The water elevation in all existing ponds is taken from the "as-built drawings" OF MAFRAQ WSP.

3.) The location of the RSF and RB (beside the existing ponds) is selected based on the given rock elevations in the 200 B soil study. During the detailed design study the proposed elevations of the RSF and the RB should be reevaluated and repositioned if additional soil borings shows higher rock elevations.

4). DURING THE DETAILED DESIGN AND BASED ON additional, more detailed site survey, a gravity plant option schould be evaluated.

The proposed approach is described on the next page

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MAFRAQ - CONCEPTUAL DESIGN — Client
Date — Job No. 40295; 21,17
SEDIMENTATION / THICKENING TANKS RK. — Subject
Comp. By — Checked By

1. The Sedimentation / Thickening Tanks would rely on the lamella settling principle (WAJ EXPRESSED CONCERNS IF WE USE LARGER, NON RAKED SETTLING TANKS).

2. THE UNITS ARE DESIGNED FOR AN AVERAGE Q = 6,550 m³/d & PEAK Q = 13,000 m³/day

3.

Number of Units:	Two (2)			
Design Flow/Unit:	3275	m^3/d	600.8	gpm
Hyd. Loading Rate at Design Flow:	1.22	m/hr	0.5	gpm/ft^2
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Perpendicular Plate Spacing:	76.2	mm	3	inches
Plate Width:	1.22	m	4	feet
Plate Length:	3.05	m	10	feet
Plate Material:	FRP			
Tank Material:	Steel (painted)			
Model Number:	DRH-2387-130-410x3			
Approx. Unit Dimensions:	8.3 m x 4.3 m x 8.5 m		27' L x 14' W x 28' T	

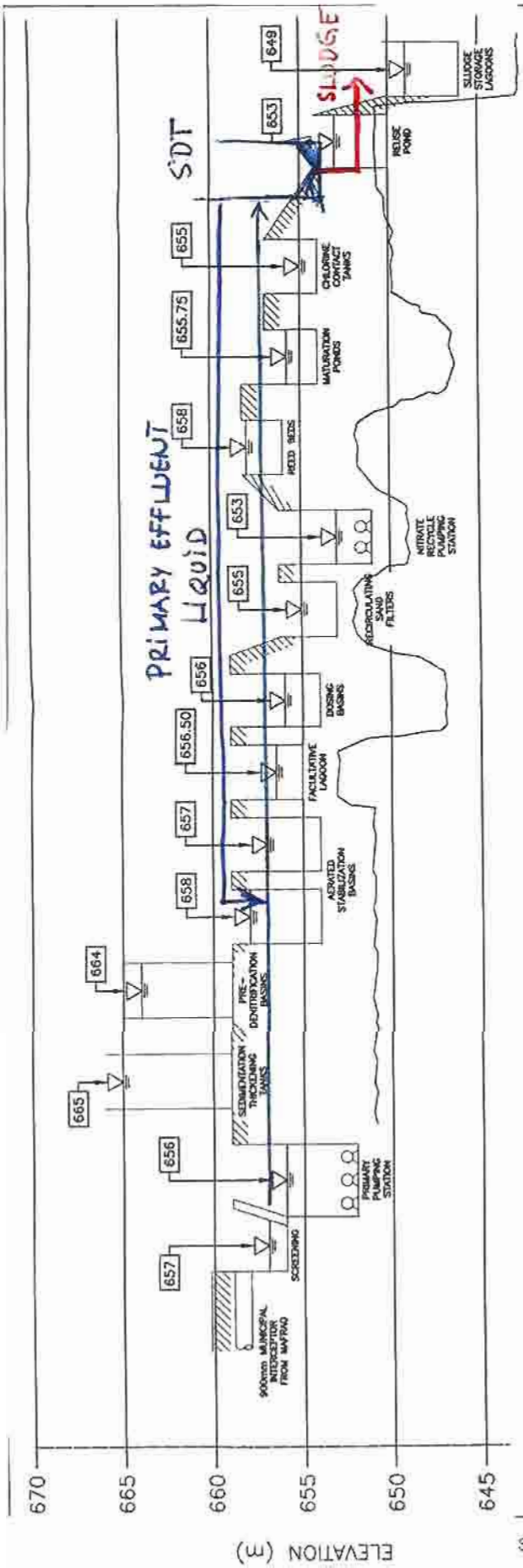
4. REQUIRED AREA OF THE UNITS
- MAX FLOW = 13,000 m³/D (546 m³/HR)
- AVERAGE DESIGN FLOW / UNIT = 6,550 m³/D. (273 m³/h)
- LOADING / UNIT = 1.22 m³/m²/HR.

REQUIRED UNIT DIMENSIONS
8.3m x 4.3m x 8.5m (H)
↓ LENGTH ↓ WIDTH

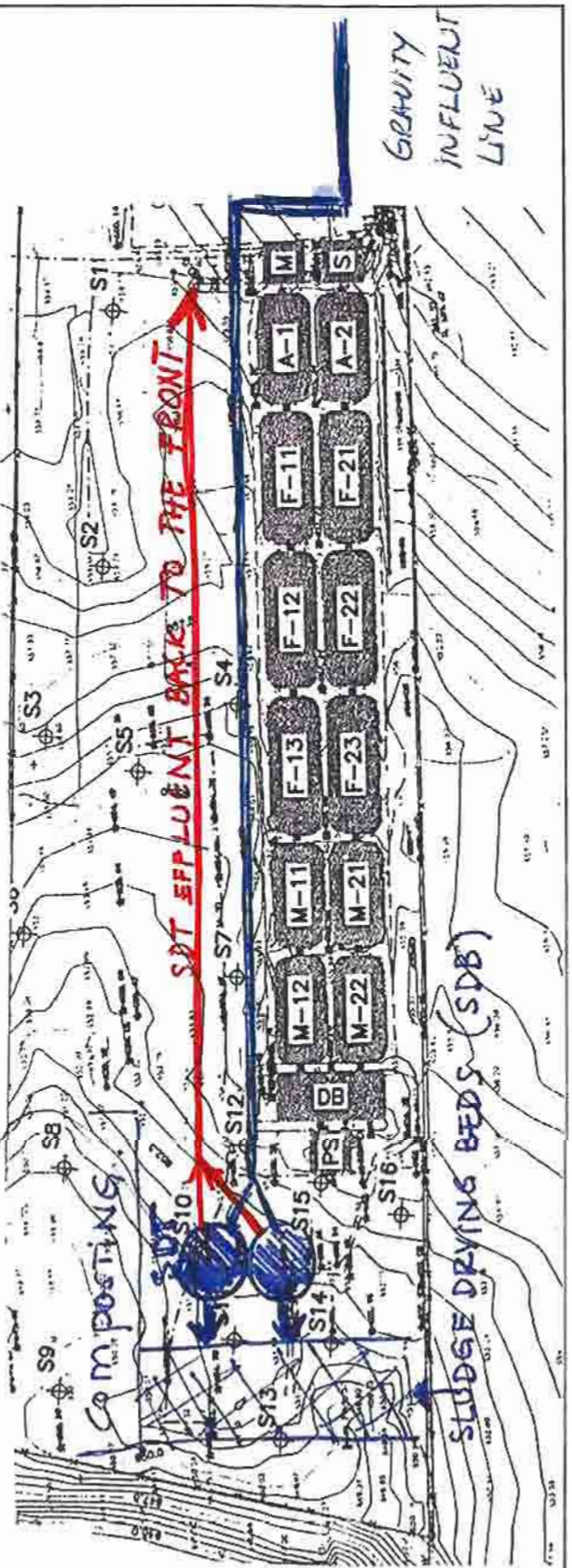
Stearns & Wheler Companies

Client	Date	Job No.
IRG / USAID	40295.21.1700	

Subject	Comp. By	Checked By
MAFRAQ, CONCEPTUAL DESIGN	AK	



SLUDGE CAN BE REMOVED HYDRAUSTATICALLY FROM THE SDT TANKS. IF WE CAN RECIRCULATE THE SDT IN THE BACK.



(*)

SLUDGE PRODUCTION

&

MASS BALANCE

Stearns & Wheler Companies

MAFRAQ - IRG / USAID 40295

Date Job No.

AK

Subject Comp. By Checked By

CONCEPTUAL DESIGN

DESIGN CRITERIA

Q_{ave} = 6,550 m³/day

Q_{max} = 13,000 m³/day

BOD = 4,740 kg/day (724 mg/l)

TKN = 800 kg/day

TSS = 4,740 kg/d. (724 mg/l)

① Sludge production

TSS removal by the lamella settling system → How much is settleable?

Let's assume I will remove 70% of the TSS load to the plant

$TSS_{removed}$ = 3,318 kg/d.

approximate solids concentration ~ 5%

$$V_{solids} = \frac{3{,}318 \text{ kg/d}}{\underset{\%\text{solids}}{0.05} \times \underset{(SG)}{1.03}} = 64{,}427 \text{ l or } \sim 65 \text{ m}^3/\text{day}$$

We propose to use the aerobic sludge

stabilization, because the VSS content is very high.

Design of stabilization basin

VSS loading = 1.6 to 4.8 $\frac{kg\ VSS}{m^3 \cdot d}$.

. Approximately 80% of the removed solids are volatile →

∴ 3318 kg TSS × 0.8 = 2654 kg

#1 $V_{aerobic\ digestion} = \frac{2654}{3.2\ kg\ VSS/m^3} = 829\ m^3$

#2 V designed as gravity thickeners

$= \frac{3318\ kg}{25 \sim 50\ g/m^2\text{-}day} = 66\ m^2$

Not applicable for this case.

Design #1 ⇒ V = 829 m^3 which is equivalent to ~ 13 day HRT.

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Client: MAFRAQ - USAID/IRG
Subject: CONCEPTUAL DESIGN
Date
Job No.: 40295.
Comp. By
Checked By

T° in Jordan → 20°C.

∴ VSS reduction of ± 35 to 50% could be achieved.

The principal OBJECTIVES of sludge stabilization are to reduce pathogens, eliminate offensive odors, and control the potential for putrefaction of organic matter.

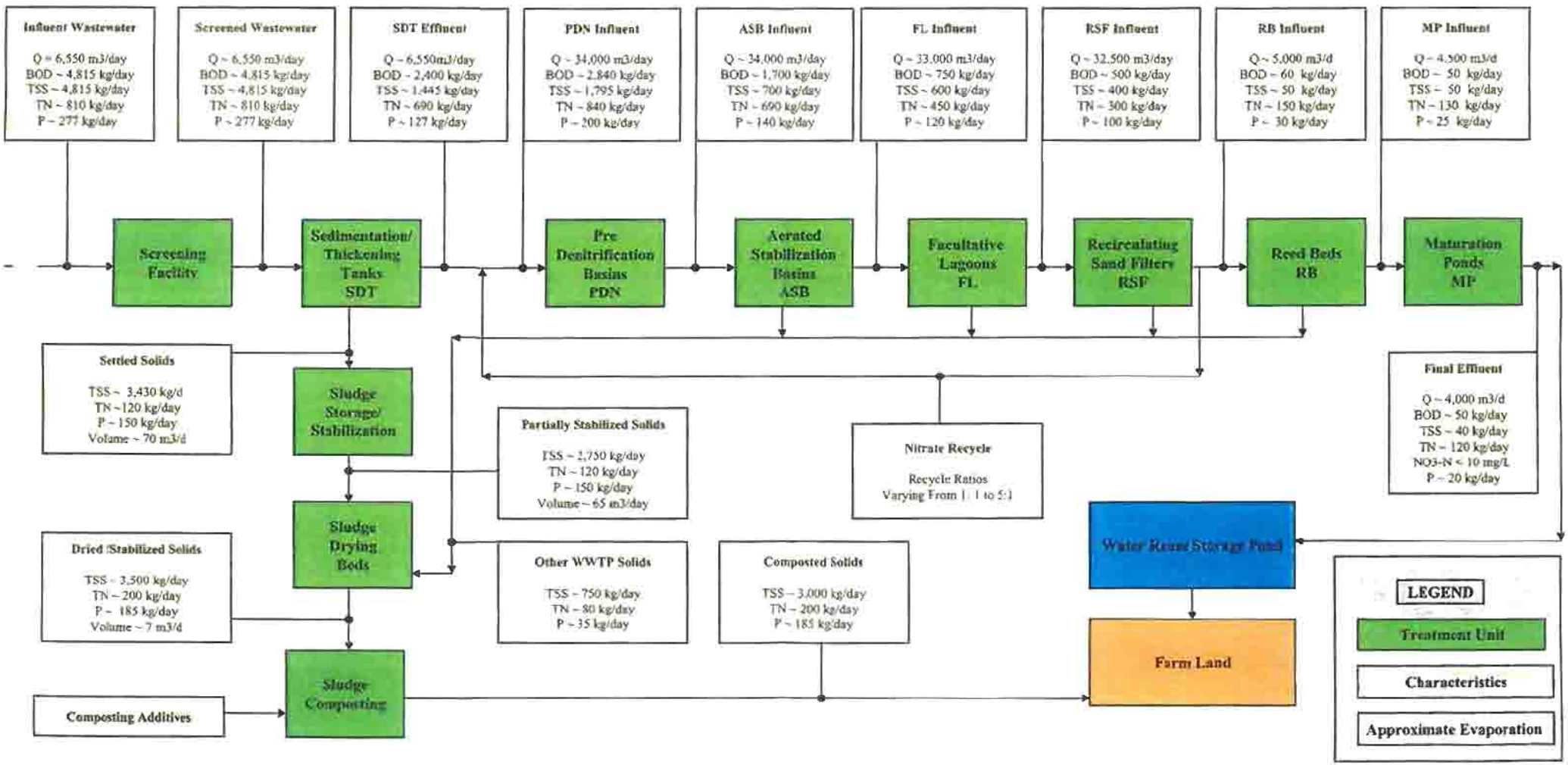
What about chemical stabilization ?? { No, too costly in Jordan

Primary sludge → Thickening → stabilization → dewatering.

↓

can be composting

Figure 4
MAFRAQ WASTEWATER TREATMENT PLANT
Mass Balance Diagram
Maximum Design Conditions (2025)



SCREENING

&

SEPTAGE RECEIVING STATION

Stearns & Wheler Companies

Client: MAFRAQ - CONCEPTUAL DESIGN

Date | Job No.

Subject: INFLUENT SCREENS.

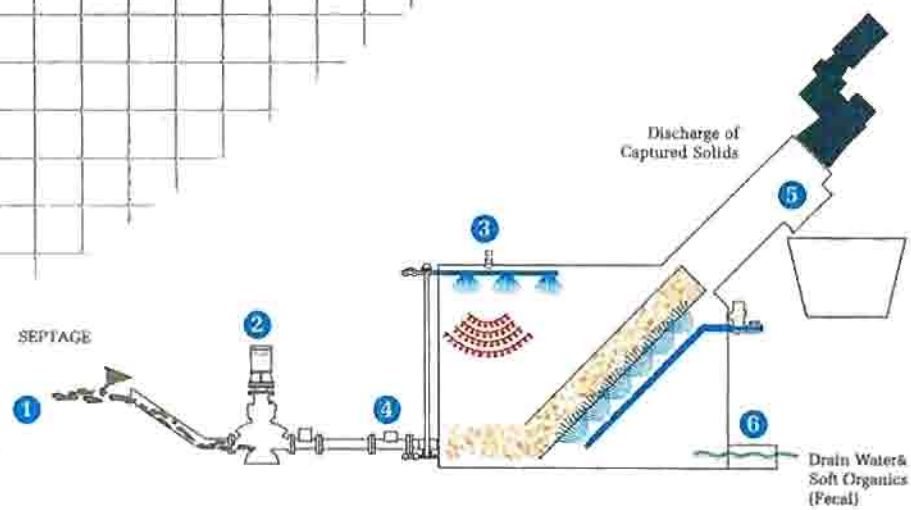
Comp. By | Checked By

SEPTAGE RECEIVING STATION.

Possible options

1) Built in place (detailed design to compare with

2) Option 2 ↓



Model	Screen Dia.	HP (kW)	Screenings Capacity	Max. Flow
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: Grinder 30004T-1204 uses standard 4kW motor.

SEPTAGE RECEIVING SYSTEM

HONEY MONSTER™

The Septage Receiving System is based on proven Auger Monster technology, which allows cleaner handling of septage truck waste through separation of solids. The unique combination of grinding, washing and dewatering septage waste can be accomplished in approximately 5 to 15 minutes for a typical septage truck.

An optional metering and billing control system is available for monitoring septage flow and providing accurate billing information to septage haulers and to the plant. The system is based on a card reader or digital key pad for security, in combination with a flow meter and valve.

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Client | Date | Job No.

Subject | Comp. By | Checked By

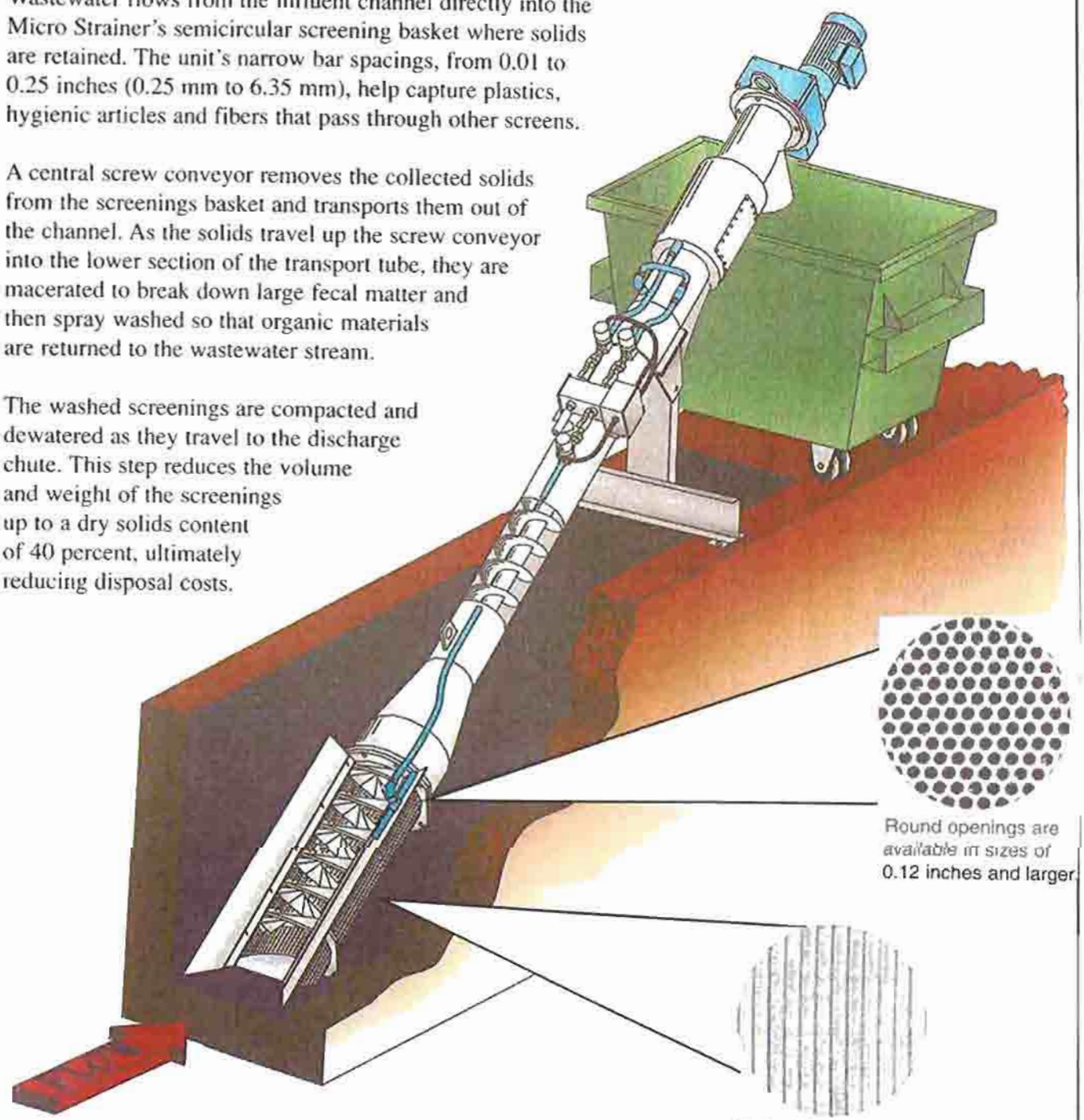
SCREENING (OPTION 1) OR Conventional screen

Removes Solids Efficiently and Cleanly

Wastewater flows from the influent channel directly into the Micro Strainer's semicircular screening basket where solids are retained. The unit's narrow bar spacings, from 0.01 to 0.25 inches (0.25 mm to 6.35 mm), help capture plastics, hygienic articles and fibers that pass through other screens.

A central screw conveyor removes the collected solids from the screenings basket and transports them out of the channel. As the solids travel up the screw conveyor into the lower section of the transport tube, they are macerated to break down large fecal matter and then spray washed so that organic materials are returned to the wastewater stream.

The washed screenings are compacted and dewatered as they travel to the discharge chute. This step reduces the volume and weight of the screenings up to a dry solids content of 40 percent, ultimately reducing disposal costs.



NOTE: DETAILED DESIGN FOR Q_{peak} = 13,300 m^3/D.

WET WEATHER (HIGH FLOW)

STORAGE BASIN

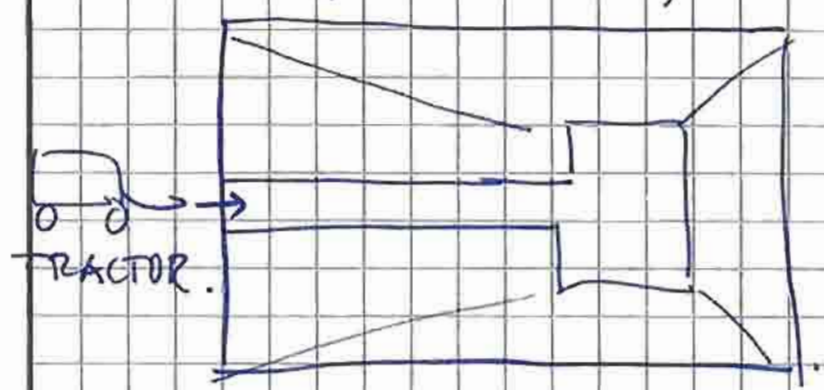
Stearns & Wheler Companies

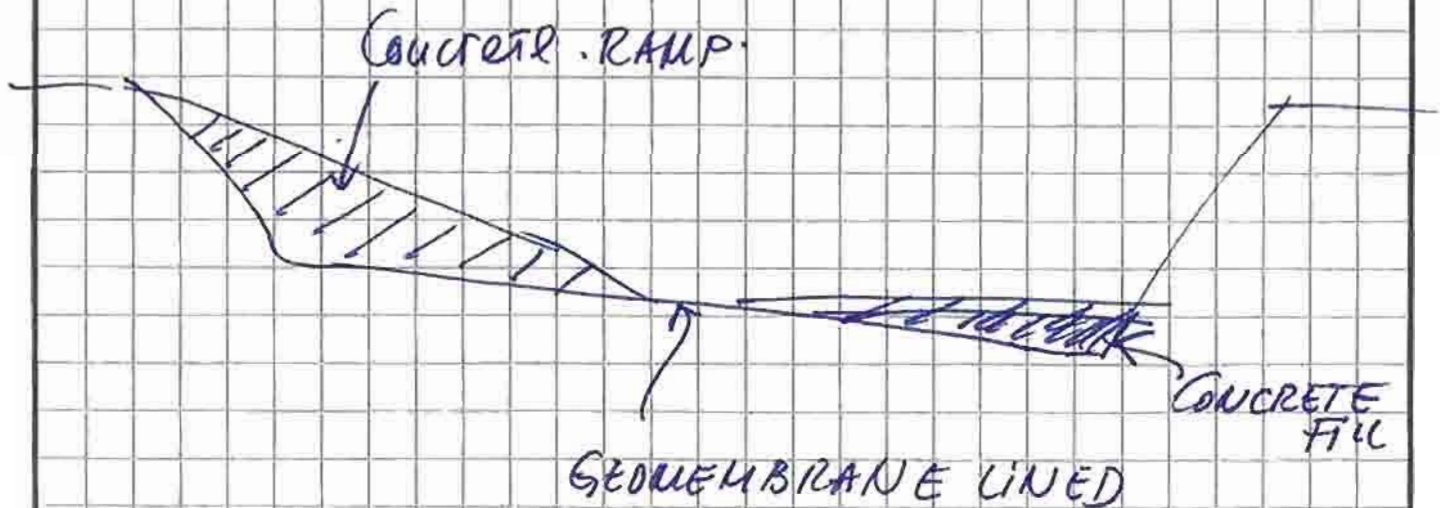
Client: MAFRAQ - CONCEPTUAL DESIGN | Date | Job No.

Subject: WET WEATHER STORAGE BASIN | Comp. By | Checked By

In Amman SE,W designed an earthen basin like the sketch shown on this page.

- ramp could allow truck to go in the basin
- During the detailed design the supernatant flow by gravity back to the headworks should be examined.





INFLUENT PUMPING STATION

CONCEPTUAL DESIGN

Stearns & Wheler Companies

Client: MAFRAQ - CONCEPTUAL DESIGN

Subject: INFLUENT PUMPING STATION

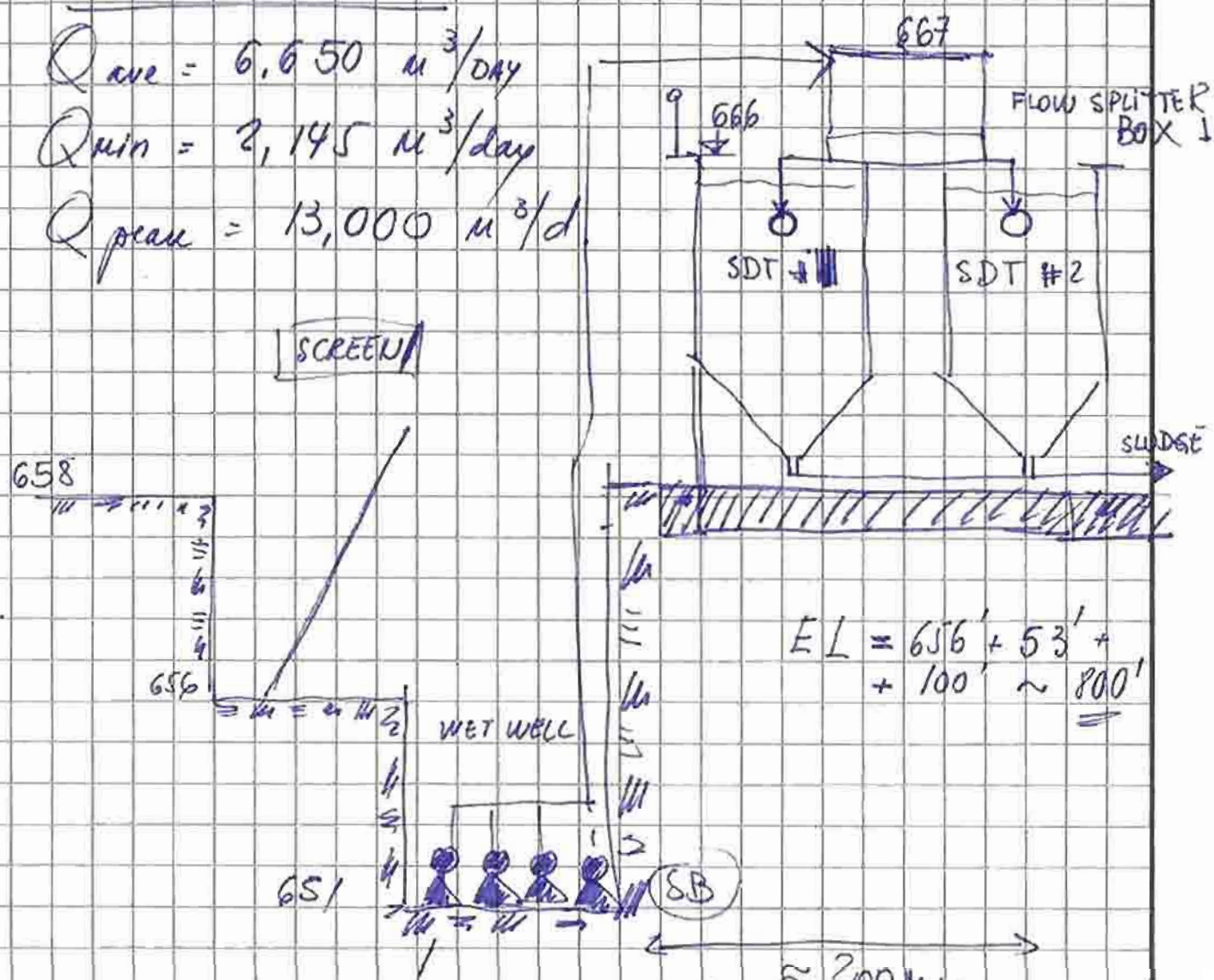
Date | Job No. | Comp. By: AK | Checked By

DESIGN CRITERIA

$Q_{ave} = 6,650\ m^3/DAY$

$Q_{min} = 2,145\ m^3/day$

$Q_{peak} = 13,000\ m^3/d$



$EL = 656' + 53' + 100' \sim 800'$

$Q_1 = Q_2 = Q_3 = Q_4 = 4,360\ m^3$ (800 gpm).

$TDH = 16m + \Delta h = \sim 53' + \frac{0.188}{100} \times 800$

pumps = 2, 400 gpm. // $= \frac{0.188'}{100\ ft}$

$TDH \sim 65'$ $Q = 800$ gpm.

Sheet 1 of ___

Stearns & Wheler Companies

MAFRAQ CONCEPTUAL DESIGN 40295.21.170

Client: RAW SEWAGE | Date | Job No.

Subject: PUMPING STATION | Comp. By | Checked By

→ Pump Selection - MOTOR 20 HP.

GOULDS
model HS : - 1180 RPM.
size 4 x 4 x 12
impeller diam. 5600630 AA

~ BHP ≈ KW - (20 KW)

Pump Capacity

Q each ~ 3,028 l/min.
Total Dynamic head ~ 19.8 m.
Max sphere passage (mm) = 10/6
Motor & Pump weight = 293 kg.
Motor size = 20 KW
pump speed = 1180 rpm.
Working pressure. 690 kPa.
Suction pipe connection = 100 mm.
Discharge:

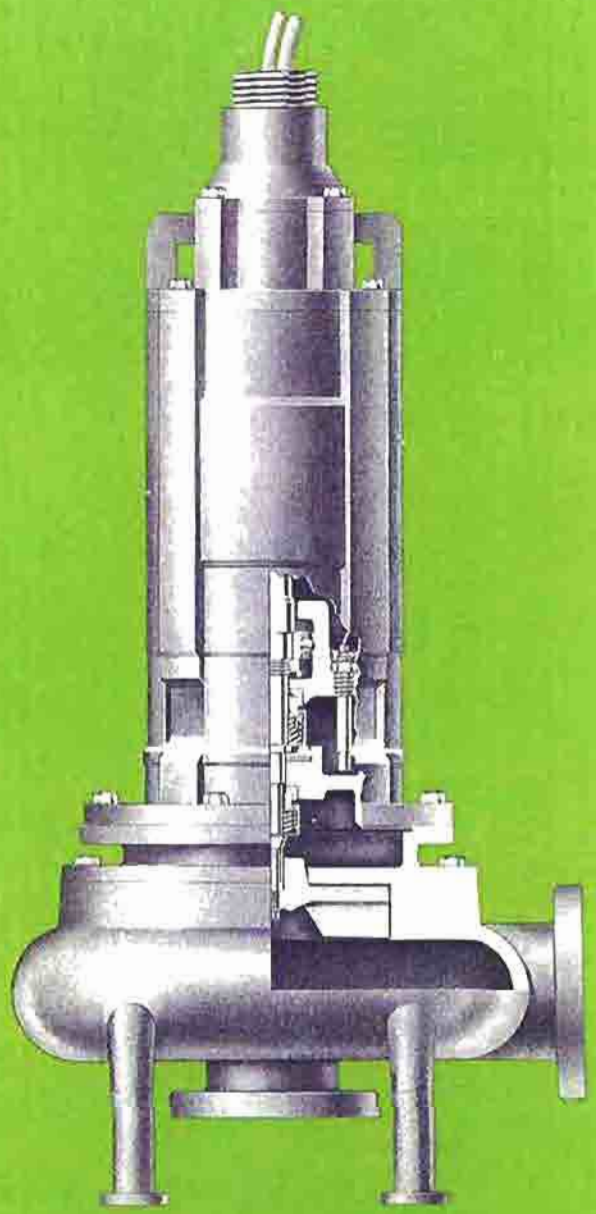
Common discharge pipe

500 m.

P1 P2 P3 P4 Sheet 2 of 2 stand by

Goulds/Morris Model HSUL

Submersible Hydro-Solids Pumps



The Model HSUL handles any solid—maximum solid size equals suction/discharge size. Versatile mounting allows pump to stand or be mounted on optional slide rail assembly.

Designed to Pump Large Solids and Fibrous Materials

- Capacities to 2000 GPM (455 m³/h)
- Heads to 140 feet (43 m)
- Temperatures to 140°F (60°C)
- Solids to 6 inches (15 mm)

Design Features

Recessed Impeller

Permanently Lubricated Bearings

Automatic Reset Thermostats in Motor

Motor Protected from Liquid

Available in Cast Iron or HC600
(Stainless Steel Components Available)

Optional Slide Rail Assembly

Optional Special Insulation to 194°F (90°C)

Stainless Steel Hardware

Carbon vs Ceramic Tandem Seals Standard
(Special Purpose Seals Available)

25 ft. Neoprene-Jacketed Cables

Services

General Service Sumps

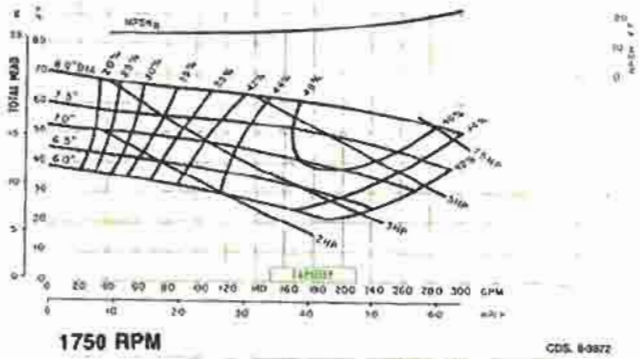
Wastewater Treatment Plants

Coal Power Plants

Sewage Lift Stations

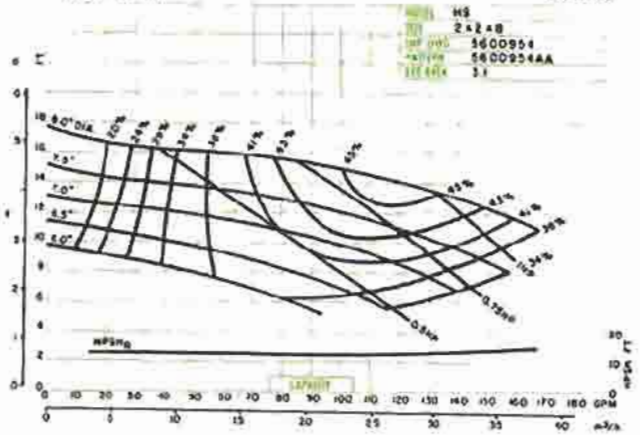
Industrial Wastes

Performance Curves Model HSUL



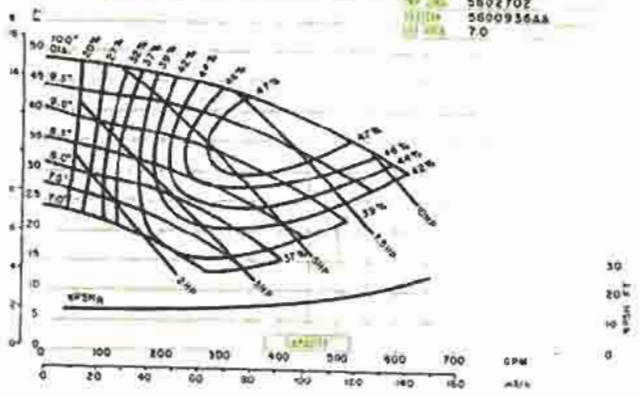
1750 RPM

CDS: B-9872



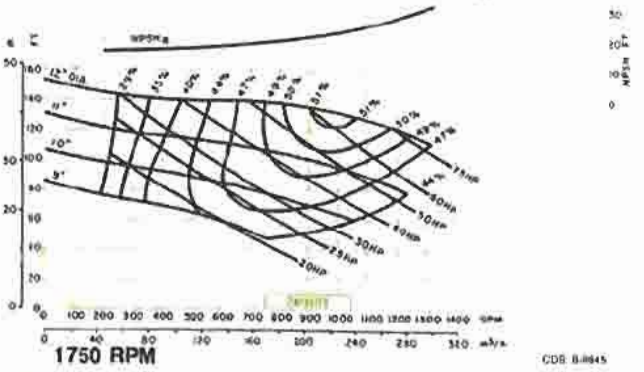
880 RPM

CDS: B-9876



1180 RPM

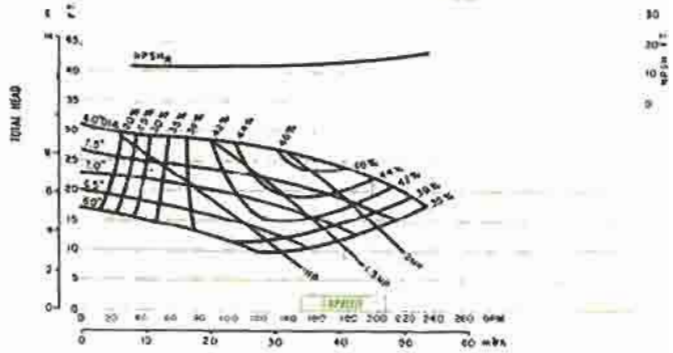
CDS: B-9841



1750 RPM

CDS: B-9845

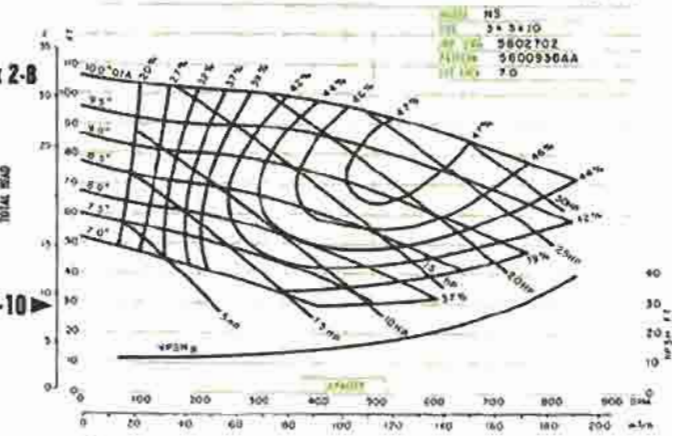
2 x 2-8



1180 RPM

CDS: B-9873

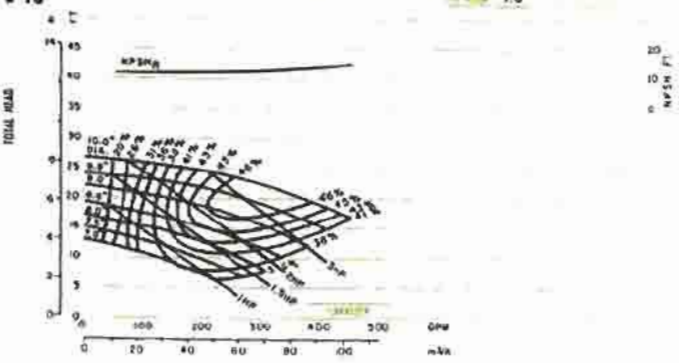
◄2 x 2-8 / 3 x 3-10►



1750 RPM

CDS: B-9843

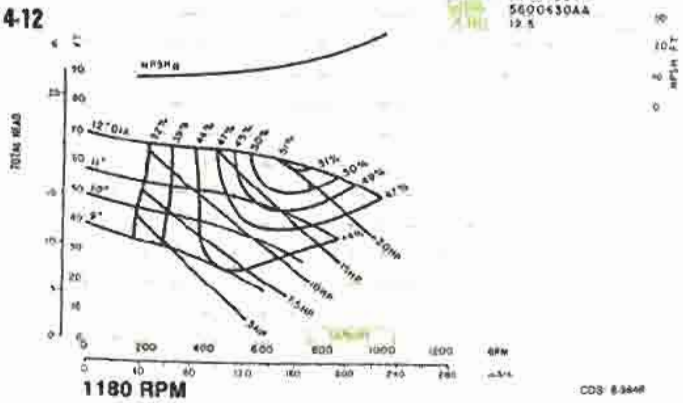
3 x 3-10



880 RPM

CDS: B-9879

4 x 4-12

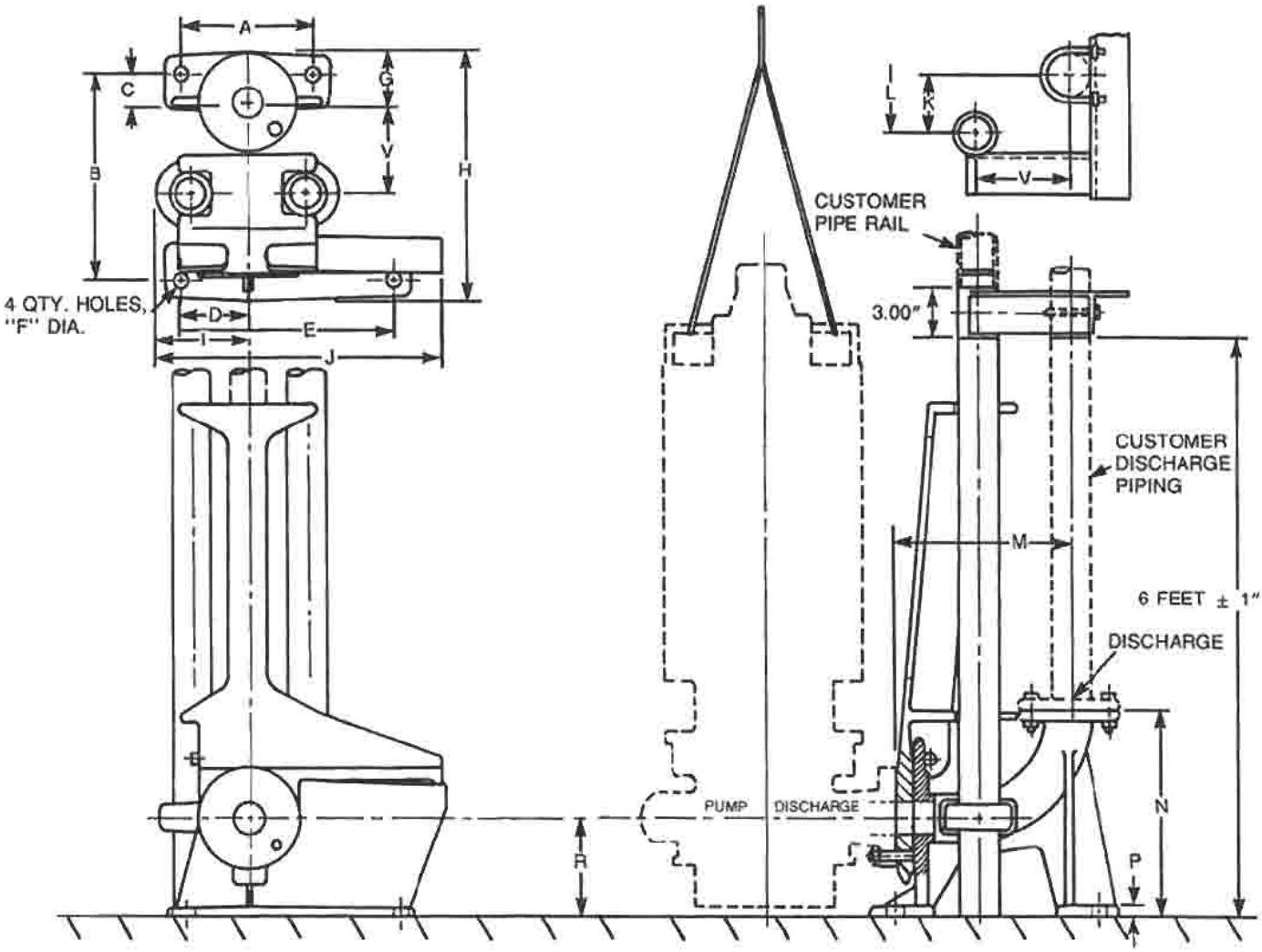


1180 RPM

CDS: B-9848

Dimensions Slide Rail System

All dimensions in inches.

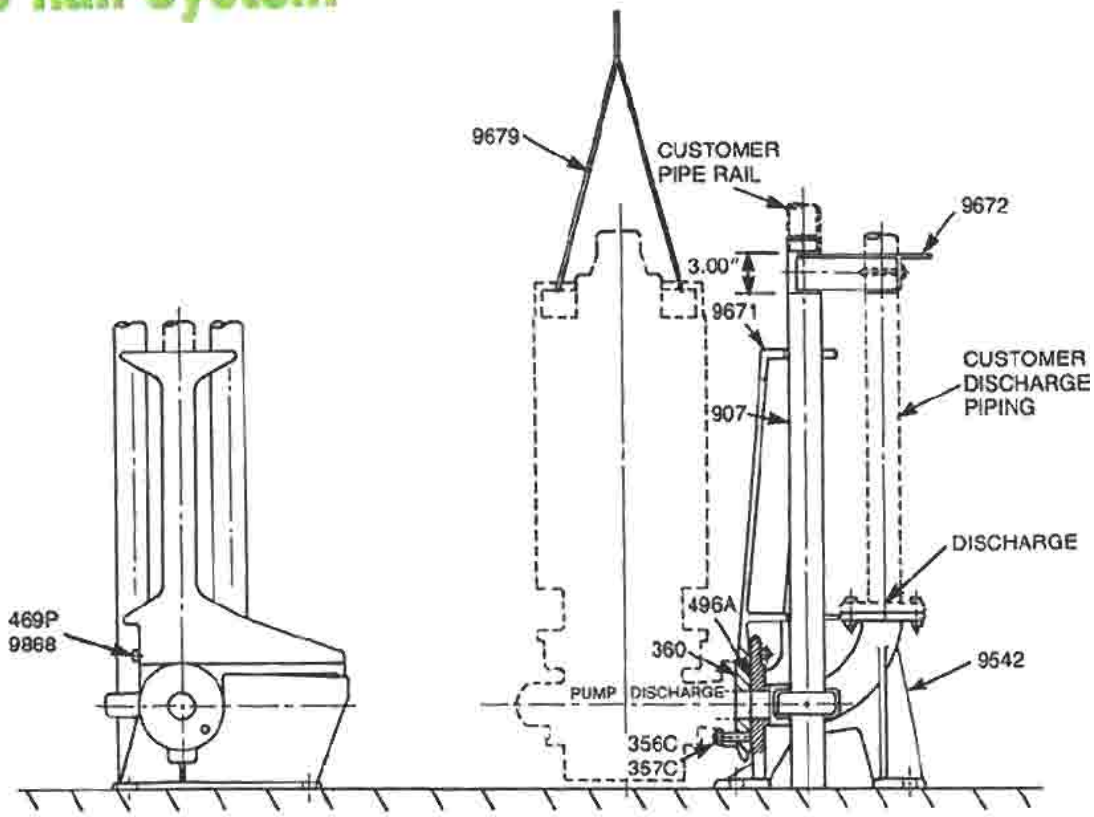


DIMENSIONS																	
SIZE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	R	V
2"	8	11.25	1.75	4.0	13	.75	3.0	14.8	5.5	18	3.5	7	9.5	12.5	.50	6.0	5.5
3"	9.5	15.00	2.50	4.8	15	.75	3.8	17.5	6.0	20	4.0	8	11.0	15.5	.50	7.8	6.5
4"	10	17.00	3.00	5.0	16.5	1.0	4.5	20.0	6.8	22	4.8	9.5	12.25	18.0	.62	9.0	7.5
6"	13	21.38	3.75	6.5	21.5	1.0	5.5	24.9	8.0	27	6.0	12	15.25	23.5	.62	12.0	9.5
8"	15	25.88	4.75	7.5	25	1.25	6.8	29.9	9.0	31	7.0	14	18.0	28.5	.75	13.5	11.5
10"	18	31.12	6.00	9.0	29	1.25	8.0	35.2	10.0	35	8.0	16	21.0	33.0	.75	16.0	13.8

NOTES:

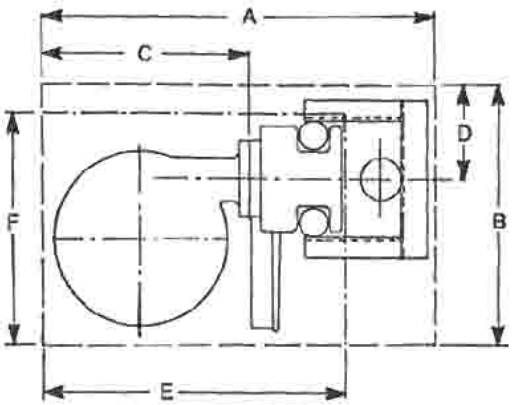
1. Discharge flange drilling conforms to class 150 ANSI.
2. Rail pipe is available in pairs of 6 foot lengths and must be cut as necessary by customer to fit installation pipe is 2" schedule 40. Allow 3" for each rail bracket used. One pair furnished standard.
3. One rail bracket assembly is required with every rail pipe pair. One included as standard.
4. This drawing shows slide rail system only. See the pump dimension print for pump and motor dimensions.

Slide Rail System



Parts List and Materials of Construction

Item	Part Name	Material		
		Cast Iron	HC600 Hardened	316SS
356C	Stud	18-8SS	18-8SS	316SS
357C	Hex Nut	18-8SS	18-8SS	316SS
360	Gasket	Rubber	Rubber	Rubber
469P	Cotter Pin	18-8SS	18-8SS	316SS
496C	O-ring	Buna-N	Buna-N	Buna-N
907	Pipe Rail, Pair	Steel	Steel	316SS
9542	Elbow Base	CI	HC600-HT	316SS
9671	Guide Bracket	CI	HC600-HT	316SS
9672	Rail Bracket Assy	Steel	Steel	316SS
9679	Lift Cable Assy	18-8SS	18-8SS	316SS
9868	Hinge Pin	Steel	Steel	316SS



MIN. PIT SIZE

PUMP SIZE	A	B	C	D
2x2-8	30.00	21.50	15.00	8.50
3x3-10	38.00	25.00	20.00	9.00
4x4-12	42.00	27.00	22.00	10.00
6x6-12	49.00	31.00	25.00	11.00
6x6-18	54.50	35.00	30.50	11.00

MIN. COVER OPENING

PUMP SIZE	E	F
2x2-8	23.00	18.00
3x3-10	29.00	21.00
4x4-12	31.00	23.00
6x6-12	36.00	27.00
6x6-18	41.00	31.00