Water and wastewater system

CT 263

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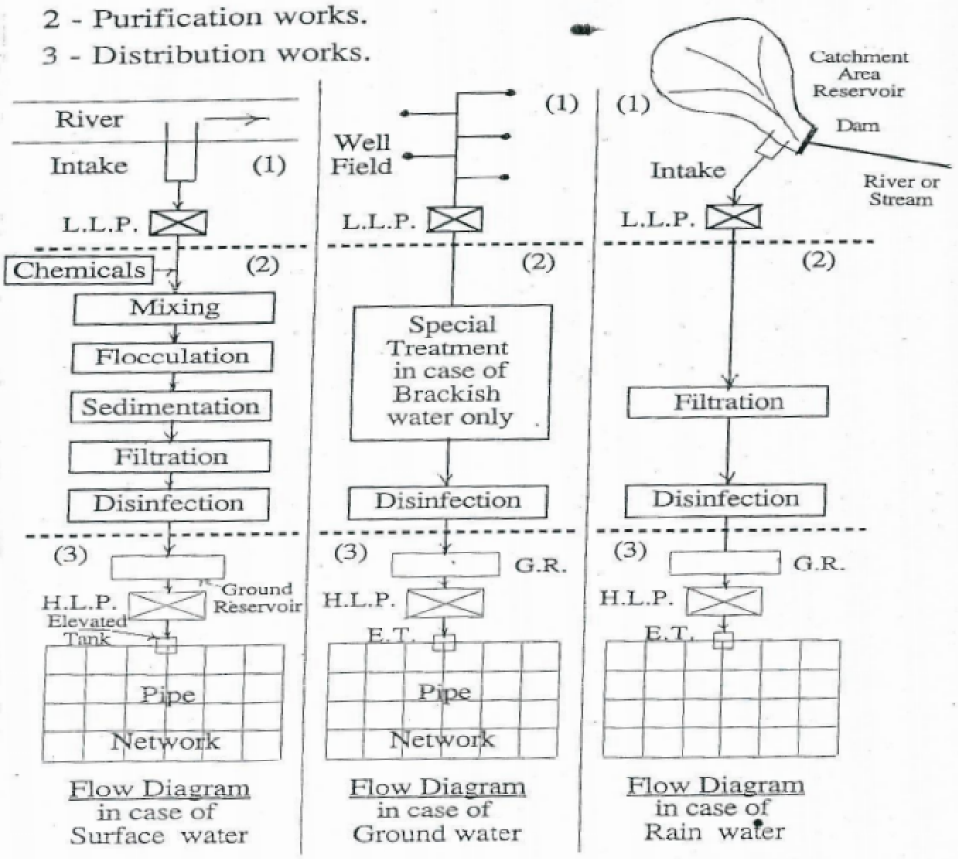
WATER SUPPLY WORKS

Water supply works consist of three main stages :

1 - Collection works

2 - Purification works.

3 - Distribution works.



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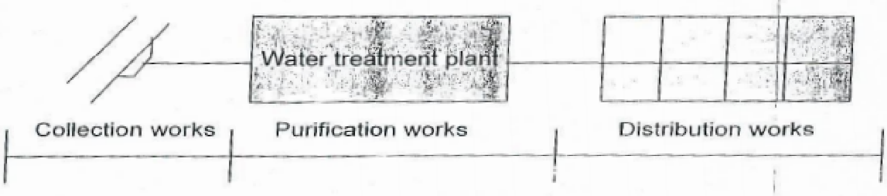
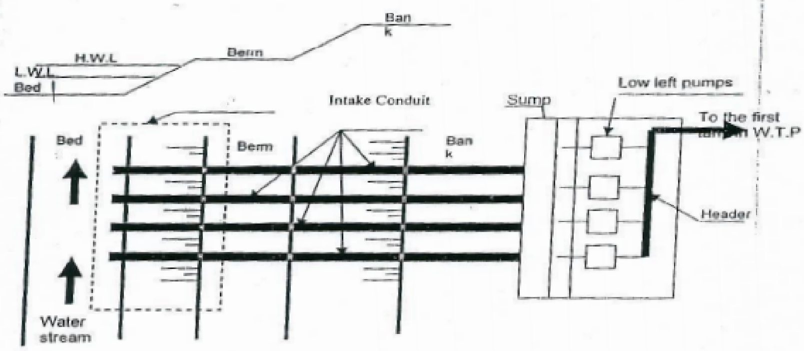


Collection works for surface water
Collection works consists of:

1- Intake and intake conduit.
2- Sump.
3- Low left pumps.



1) **Collection works for surface water**

Intake structure

Purpose

1- collection of water
2- protection of the embankment side slopes from failure & with stand dead load , live load and traffic load
3- preventing clogging of intake pipe

Types of intake:

a) Pipe intake
b) Tower intake
c) Shore intake
d) Submerged intake

w 60m

d 6m

DWL 2m

a) Pipe intake

- deep stream
- very wide stream
- High fluctuation in w.L.
- There may be pollution on shore
- navigable stream

• تصل الماسورة حتى 1/3 عرض النهر للابتعاد عن التلوث الموجود على الشاطىء
• تحمل الماسورة بواسطة trusses محمولة على piles
• يتم عمل شبكات بين piles المحيطة بالمأخذ لمنع دخول الشوائب
• منسوب المأخذ تحت منسوب سطح الماء 0.5متر
• أقصى مسافة بين pipe c.L & inlet c.L لا تزيد عن 7 متر
• تستخدم مواسير ductile iron or steel

b) Tower intake

- The same conditions as pipe intake but width is not wide enough for pipe intake

Tower intake is used in special cases:

1. insufficient wide for pipe intake to allow navigation
2. wide fluctuation in w.L
3. draw down of water from lake , dams & reservoirs

c) Shore intake:

• يستخدم الهدار لمنع وصول الشوائب إلى الماسورة
• يستخدم الحائط الساند لمنع جوانب المجرى المائي من الإنهيار
• تستخدم الماسورة cast iron حتى قطر 90 سم
• كلما زاد القطر يفضل استخدام خرسانة

Cases to use shore intake "مهمة جداً"

- Narrow & shallow stream
- pollution on surface
- navigable
- small fluctuation in W.L

Purpose of bar screen:

To avoid any strange bodies to pass with water

d) Submerged intake

Cases to use:

- Wide & shallow or narrow & deep
- pollution on shore & surface
- navigable (with conditions)

Factors affecting the choice of type &location of intake:

a) For type:

1. Dimension of stream (depth – wide)
2. Navigation
3. Pollution
4. Fluctuation of water level

b) For location:

1. Up stream the city to avoid pollution from city
2. on straight reach of the stream to avoid silting & scouring around the intake
3. Restricted area taken around the intake structure 150m before it & 50m after it to avoid direct pollution.

Intake conduit :

Purpose: الماء الخام

To transmit raw water from source to L.L.P

Design criteria of intake conduit

1- The conduit can be designed according to

$$Q_{max} = A \times v = n(\pi \Phi^2/4)\, v \quad m^3/sec$$

2- v = Velocity of flow $\geq$ 0.6 m /sec → self-cleaning velocity
$\leq$ 1.5 m/sec → non-scouring velocity

• سرعة ترسيب الرمل 0.3 م/ث

3-no. of pipes $\geq$ 2

4- friction loss = $h_f = 4fLv^2 / (2g\varnothing)$

Where:

F = coefficient of friction = 0.008 – 0.01 (taken 0.008)
L = length (m)
= (30-70) m → (shore & submerged)
= (150-200) → pipe intake
V = actual velocity in the conduit
g = 9.81

5- $Q_{design} = Q_{max\ monthly} = 1.4 Q_{av}$
$Q_{min} = 0.5\, Q_{max\ monthly} = 0.7\, Q_{av}$

n	Q
2	< 1
3	1 → 1.5
4	1.5 → 2
e	> 2

2) $v_{min} = Q_{min} / (n \pi Ø^2/4) > 0.6$ m/sec

If $v_{min} < 0.6$ → close one pipe

Then:

$v_{min} = Q_{min} / ((n-1) \pi Ø^2/4) > 0.6$ m/sec

3) $v_{max\ max} = Q_{max\ monthly} / ((n-1) \pi Ø^2/4) \leq 2.5$ m/sec emergency case - where if one pipe is broken.

Low lift pump:

a) sump (wet well):

Purpose

To distribute raw water uniformly on the total number of pumps

Design criteria:

1 – volume = the max. of → $Q_{max\ monthly} \times 2$ minutes → take the bigger.

→ $Q_{min} \times 5$ minutes

$= L \times S \times d$

Where :

L → length of sump = n_t of pump X x ⟶ (1.5 → 3.4)

S → width of sump = (1 -3)m

d → water depth in the sump ≥ (L.w.L – h_f – B.L + 0.5)m

n → number of pump

x → spacing between pumps (1.5-3.0)m

Checks:

The horizontal cross section area of sump (A)

A ≥ 5 vertical cross section of intake conduits

$S \times L \geq 5 [n \pi Ø^2/4]$

b) Low lift pump:

Purpose

To raise raw water from the source to the level of first unit in water treatment unit

Design criteria:

1- $H_{total} = H_{static} + H_{dynamic}$

H_{static} = G.L + 5 m – L.w.L

$H_{dynamic} = h_f + h_s$

h_s = (10-20)% h_f OR (1.0 -2.0)m

2- $Q_{design} = Q_{max\ monthly}$

$Q_{min} = 0.5\ Q_{max\ monthly} = 0.7\ Q_{av}$

3- $HP_{max} = w\ Q_{max}\ H_T / (75\ \eta_1 \eta_2)$

Where:
$W \rightarrow$ density of water = 1000 kg / m^3
$\eta_1 \rightarrow$ pump efficiency = (70 – 80) % كفاءة المضخة
$\eta_2 \rightarrow$ motor efficiency = (80 – 90)% // الموتور
usually $\eta_1\eta_2 = 0.6$

4- $n_{working} \geq 2$ $n_t \leq 10$

5- for each type of pumps (1 - 2) reserve

6- $Q_{reserve} / Q_{working}$ = (50 – 150)%

- عند أختيار الطلمبات يفضل اختيار أقل عدد من الطلمبات الكبيرة حتى تقل مساحة عنبر الطلمبات
- يفضل اختيار الطلمبات من نفس النوع تقريبا

Example:
A water treatment plant feeds a city of pop 194000 C & annual average water consumption 190 L/C/d
Design collection works of this plant if the source is narrow &shallow with the following data
HWL=7 m
LWL =6 m
Berm level=8 m
Bed level=1m

Sol^n
I) intake
Shore intake

II) intake conduit:
Q_{av} = pop x w.c
= 194000 x 190 / (24 x 60 x 60) = 426.6 L/s = 0.4266 m^3 / sec

$Q_{des.} = Q_{max\ monthly} = 1.4\ Q_{av} = 1.4 \times 0.4266 = 0.6\ m^3$ / sec

$Q_{min} = 0.7\ Q_{av} = 0.7 \times 0.4266 = 0.3\ m^3$ / sec

Assume v = 1 m/s

$Q_{des} = A\ V = n\ \pi Ø^2/4 \times V = 0.6\ m^2$

Assume $n = 3 \rightarrow Ø = 0.5046\ m \approx 0.5$

Checks.
For Φ = 500 mm, n= 3, a= 0.196 m^2

1) $v_{act} = Q_{des}/(n\ a) = 0.6/(3 \times 0.196) = 1.02$ m/sec > 0.6 m/sec, < 1.5 m/sec → safe

2) $v_{min} = Q_{min}/(n\ a) = 0.3/(3 \times 0.196) = 0.51$ m/sec < 0.6 m/sec → unsafe
→ close one pipe

$v_{min} = Q_{min}/((n-1)a) = 0.3/(2 \times 0.196) = 0.77$ m/sec → safe

3) $v_{max\ max} = Q_{des}/((n-1)\ a) = 0.6/(2 \times 0.196) = 1.53 < 2.5$ m/sec → safe

This case is emergency case (one pipe is out of order)

assume L = 70 m

$h_f = 4fLv_{act}^2/(2g\varnothing) = 4 \times 0.008 \times 70 \times 1.02^2/(2 \times 9.81 \times 0.5)$
$= 0.24$ m

III) L.L.P:

Use 2 working pumps each of 300 l / sec with Qmax
1 x 300 L/sec with Q min
2 x 300 L/sec stand by
$n_t = 2+2 = 4$

$H_T = (8+5) - 6 + 0.24\ (1 + 0.02) = 7.24$ m

HP = 1000 x 0.6 x 7.24 / (75 x 0.6) = 96.53

IV) Sump :
$V1 = Q_{max\ monthly} \times 2 = 0.6 \times 2 \times 60 = 72\ m^3$
$V2 = Q_{min} \times 5 = 0.3 \times 5 \times 60 = 90\ m^3$

→ Volume of sump = 90 m^3 = L x S x d
$L = n_t * x$

→ Assume X = 2 m → L = 4 x 2 = 8 m
→ Assume S = 2 m → 90 = 8 x 2 x d → d = 5.625

d_{min} = (L.w.L – h_f) – B.L + 0.5 = 6 – 0.24 – 1 + 0.5 = 5.26 m → safe-

<u>If unsafe</u>
Ass d=dmin
$S = V / (L \times d_{min})$ & check S = (1 – 3) m

Example:

ni φ

Design the intake conduit of the collection works sewing a city of pop = 200,000 capita & average w.c of 265 l/c/d.

Given:
p= 200,000 C
W.C = 265 l/c/d

Req.
Design of intake conduits

Sol^{n}
$Q_{a.v}$ = pop * w.c = (200,000x265)/ (1000x24x60x60) = 0.62 m^3/sec
$Q_{design} = Q_{max\ monthly} = 1.4\ Q_{av} = 0.868\ m^3/sec$
$Q_{min} = 0.5\ Q_{max} = 0.434\ m^3/sec$

For conduit:
$Q_{des} = n(\pi\Phi^2/4)\ v$
ass v = 1.2 m/sec, n = 2

Φ= 0.679 m=679 mm
Take Φ= 700 mm
n = 2 pipes

$a_{1p} = \pi(0.70)^2/4 = 0.385 m^2$

Checks
For Φ = 700 mm, n= 2, a= 0.385 m^2

1) $v_{act} = Q_{max}/ (n\ a)$ = 0.368/(2x 0.385) = 1.13 m/sec > 0.6 m/sec, < 1.5 m/sec safe

2) $v_{min} = Q_{min}/ (n\ a)$ = 0.434/(2x 0.385) = 0.56 m/sec < 0.6 m/sec-- unsafe

so that close one pipe at min flow
$v_{min} = Q_{min}/ (1*0.385)$ = 1.13 m/sec > 0.6 m/sec .... safe.

3) $v_{max\ max} = Q_{max}/ ((n-1)\ a)$ = 0.868/(1x0.385) = 2.25 < 2.5 m/sec----- safe
This case is emergency case (one pipe is out of order)

Example.

$n_{mm} = 3$ if given present & Future

It is required to design the intake conduits for collection works for a city within the following data:

Current pop = 200,000 c
Annual rate of increase of pop.= 2%
Design period = 40 year.
Max monthly water consumption = 200 l/c/d & is constant with project period.
Summer

Given:

Current pop = 200,000 c, r = 2% , D.P = 40 years, $q_{max\ monthly}$ = 200 l/c/d& is constant.

Req:

n,-Φ of intake conduits.

Sol^n:

For future:

$P_{40} = 200,000(1+2/100)^{40} = 441,610$ c

$Q_{m\,m} = 441,610*200/(1000*86400) = 1.022\ m^3/sec$

$Q_{min} = 1/2\ Q_{m\,m} = 0.511\ m^3/sec$

So $Q_{max} = (\pi\Phi^2/4)\ vxn$, ass n = 3, v = 1.2 m/sec

So Φ = 0.601 m → Φ = 600 mm, a = 0.283 m²

Check for future

1) $v_{act} = 1.022/(3X\ 0.283) = 1.2$ m/sec > 0.6 m/sec, < 1.5 m/sec .... Safe

2) $v_{min} = 0.511/(3X\ 0.283) = 0.602$ m/sec > 0.6 m/sec ....Safe

$(n-1)$

2) $v_{max\ max} = 1.022/(2X\ 0.283) = 1.81$ m/sec < 2.5m/sec .... Safe

Check for present

Q_{max} = 200,000x200/(1000x86400 s/d) = 0.463 m^3/sec
Q_{min} = 0.2315 m^3/sec

1) v_{act} = 0.463/(3x 0.283) = 0.54 m/sec < 0.6 m/sec unsafe
so use 2 pipe at present.

$v_{act\ 2p}$ = 0.463 / (2x 0.283) = 0.82 m/sec — > 0.6 m/sec, < 1.5 m/sec ……… Safe

2) v_{min2p} = 0.2315 / (2x 0.283) = 0.41 m/sec < 0.6m/sec unsafe

use one pipe only at present min flow.

So $v_{min\ 1p}$ = Q_{min}/ A = 0.2315 / (1x 0.283) = 0.82 m/sec > 0.6m/sec ……Safe

Here no need for check $v_{max\ max}$———— why?

لأنه توجد هناك ماسورتان قطعتانه وبذلك في حالة حدوث Vmax max تم تحكم

Example

An existing W.T.P. with 4 intake conduits each of Φ = 500 mm & 6 LLP Q_3
(4working + 2 stand by) each of 300 l/s

1) Determine the max pop. To be served by this plant if the current av. w.c = 150 l/c/d
2) If the annual rate of increase for pop. = 2% per year & for w.c. = 0.2% per year, find the additional no. of conduits and pumps with the same dimensions & capacity to serve this city for 20 years,

Given
n = 4   Φ = 500 mm
no of working pumps=4 (300 l/s)
no of standby pumps=2
r = 2 %
av. w.c = 150 l/c/d   r' = 0.2 %

if given intake conduit n & Φ
∴ there's Q_1 & Q_2
... also L.L.P ... be
... for L.L.P.

Req
P max existing

Sol.

$Q_{max\,1} = 1.5 \times 4\pi(0.5)^2/4 = 1.178\ m^3/sec.$

$Q_{max\,2} = 2.5 \times 3\pi(0.5)^2/4 = 1.473\ m^3/sec.$ الأصغر

$Q_{max\,3} = n\,w \times q_{1pump} = 4 \times 0.3 = 1.2\ m^3/sec.$

-- $Q_{max} = 1.178\ m^3/sec = Q_{max\ future}$

$= 1.4 \times p \times av.wc/(1000 \times 24 \times 60 \times 60)$

P_{max} served =484663 c

so $P_f = 484663\ (1 + 2/100)^{\Delta t} = 720184$ c

$w.c_f = 150\ (1 + 0.2/100)^{\Delta t} = 156.1$ l/c/d

$Q_{max\,f} = 1.4 \times p \times wc = 1.4 \times 720184 \times 156.1/(1000 \times 24 \times 60 \times 60) = 1.823$ m^3/sec

$\Delta Q = 1.823 - 1.178 = 0.645\ m^3/sec$

n add = $0.645 / (\pi (0.5)^2/4) \times 1.5 = 2.19$----n add=3 Φ 500 mm
n add pumps = 0.645 x1000/300=2.15→n add = 3 pumps

Example:

An existing W.T.P is fed by 3 intake conduits each of Φ = 500 mm.
Find the max served population if the max. W.C = 250 l/c/d.

Given:

n= 3 Φ = 500mm max. W.C=250l/c/d r=2% D.P=20 years

Req.:

P_{max}.

Sol.

assume v =1.5 m/s

$Q_1 = n(\pi\Phi^2/4)\,v = 3\,(\pi \times 0.5^2/4) \times 1.5 = 0.884\ m^3/sec.$

$Q_2 = (n-1)\,(\pi\Phi^2/4)\,v_{mm} = (3-1)\,(\pi \times 0.5^2/4) \times 2.5 = 0.982\ m^3/sec$

Take $Q_d = Q_1 = 0.884\ m^3/sec.$

Q_d = max w.c x pop.
0.884 = pop. X 250 / (1000 x24 x 60 x 60)
pop. = 305511 C.

Example:

Find the design period for a W.T.P serving 400,000 C with 3 intake conduits each of 800mm. geometric coefficient 0.01. max daily water consumption 360 l/c/d.

Given:

P=400,000 C , n=3 , Φ=800mm , Kg=0.01 , max daily W.C=360l/c/d

Req.:

D.P

Solution:

$Q_{max1} = n(\pi\Phi^2/4)\ v_{max} = 3\ (\pi \times 0.8^2/4) \times 1.5 = 2.26\ m^3/sec$

$Q_{max2} = (n-1)(\pi\Phi^2/4)\ v_{maxmax} = (3-1)\ (\pi \times 0.8^2/4) \times 2.5 = 2.5\ m^3/sec$

$Q_f = Q_{max1} = 2.26\ m^3/sec$

av W.C = max daily W.C / 1.8 = 360 / 1.8 = 200 l/c/d

$Q_f = 1.4\ P_f \times$ av W.C / (1000 x 24 x 60 x 60)

$2.26 = 1.4\ P_f \times 200 / (1000 \times 24 \times 60 \times 60) \rightarrow P_f = 697372$ C

$\ln P_f = \ln P_p + K_g\ \Delta t$

$\ln 697372 = \ln 400000 + 0.01\ \Delta t \rightarrow \Delta t = 55.6$ years

Example:

Find the design period for 4 intake conduits each of Φ = 600 mm serving the increased pop. At rate = 2% per year if the current pop. = 100,000 C ,av W.C = 200 l/c/d (const. with D.P)

Given:

n=4 , Φ = 600 mm , r = 2% , P_p = 100,000 C , av W.C = 200 l/c/d (const. with D.P)

Req.:

D.P

Solution:

$Q_{av\,p} = P_p \times$ av. W.C = 100000 x200 / 1000 = 20000 m^3 /day

$Q_{max\,f\,1} = n(\pi\Phi^2/4)\ v_{max} = 4(\pi \times 0.6^2/4) \times 1.5 = 1.7\ m^3/sec$

$Q_{max\,f\,2} = (n-1)(\pi\Phi^2/4)\ v_{maxmax} = (4-1)\ (\pi \times 0.6^2/4) \times 2.5 = 2.12\ m^3/sec$

$Q_{max\,f} = Q_{max\,f\,1} = 1.7\ m^3/sec \rightarrow Q_{av\,p} = Q_{max\,f}/1.4 = 1.214\ m^3/sec$

$= 1.214 \times 24 \times 60 \times 60 = 104889.6\ m^3/day$

$W.C \times P_f = W.C \times P_p(1+r/100)^{\wedge}\Delta t$

$Q_{av\,f} = Q_{av\,p}(1+r/100)^{\wedge}\Delta t$

$104889.6 = 20000\ (1+2/100)^{\wedge}\Delta t \rightarrow \Delta t = 83.6$ years

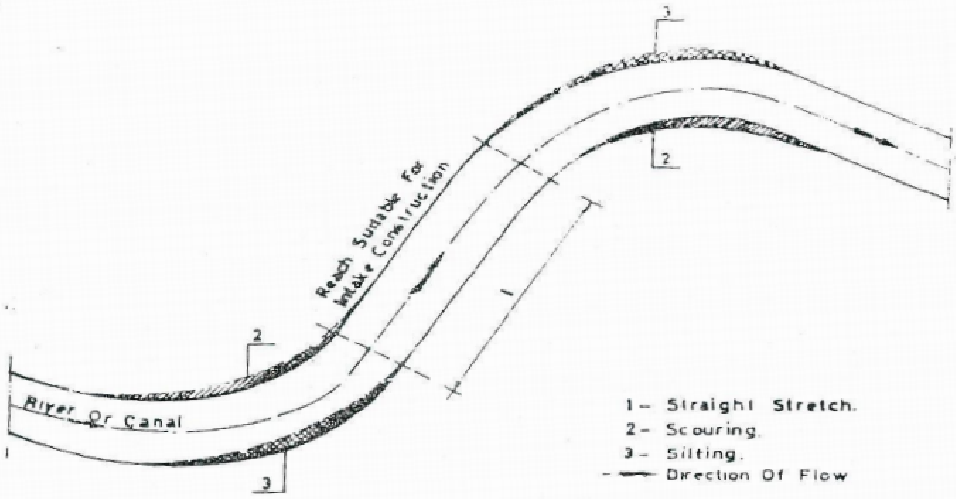


FIG. (22) <u>LOCATION OF INTAKE ON WATER STREAM</u>

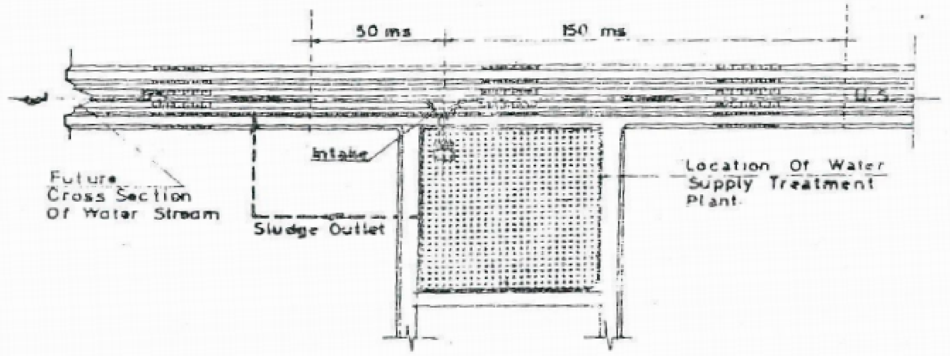


FIG. (23) PROHIBITED AREA FROM USE ROUND

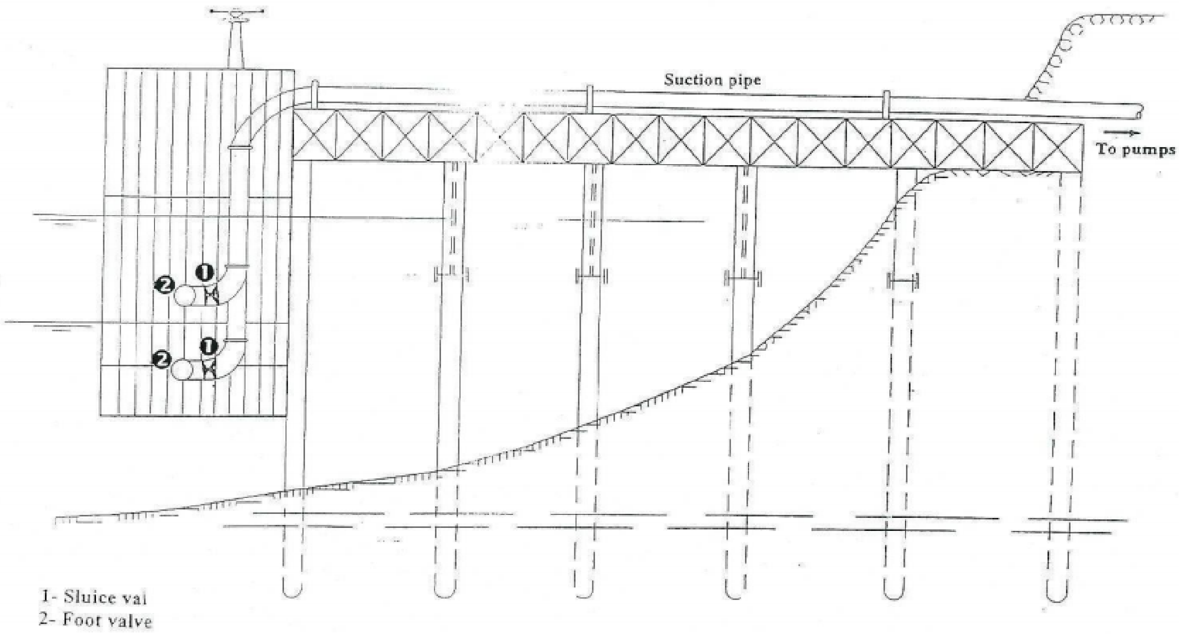


Figure (3-2): Typical pipe intake

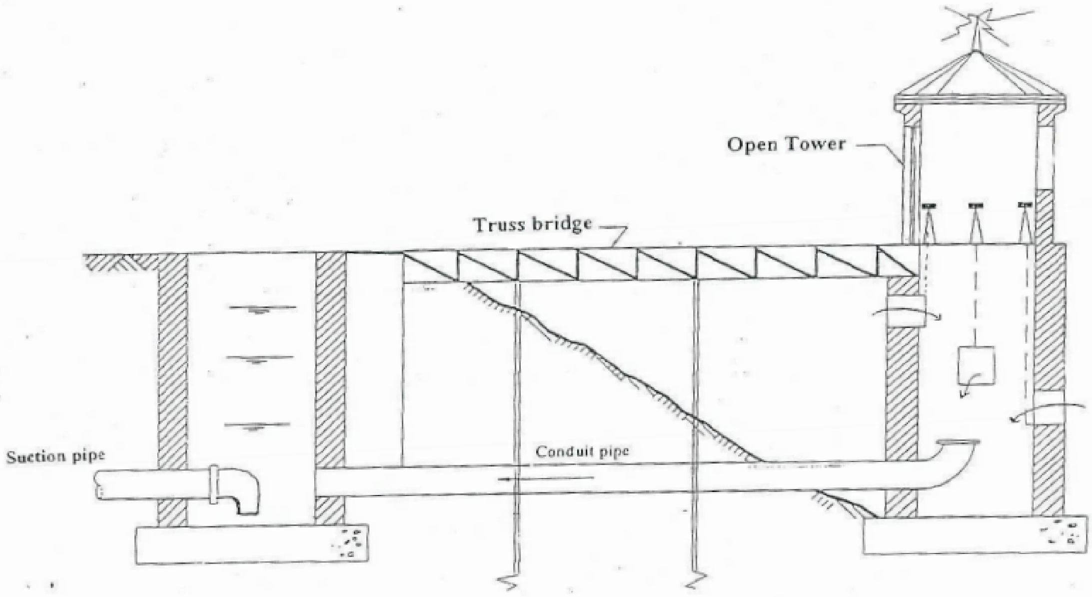


Figure (3-4): Typical tower intake

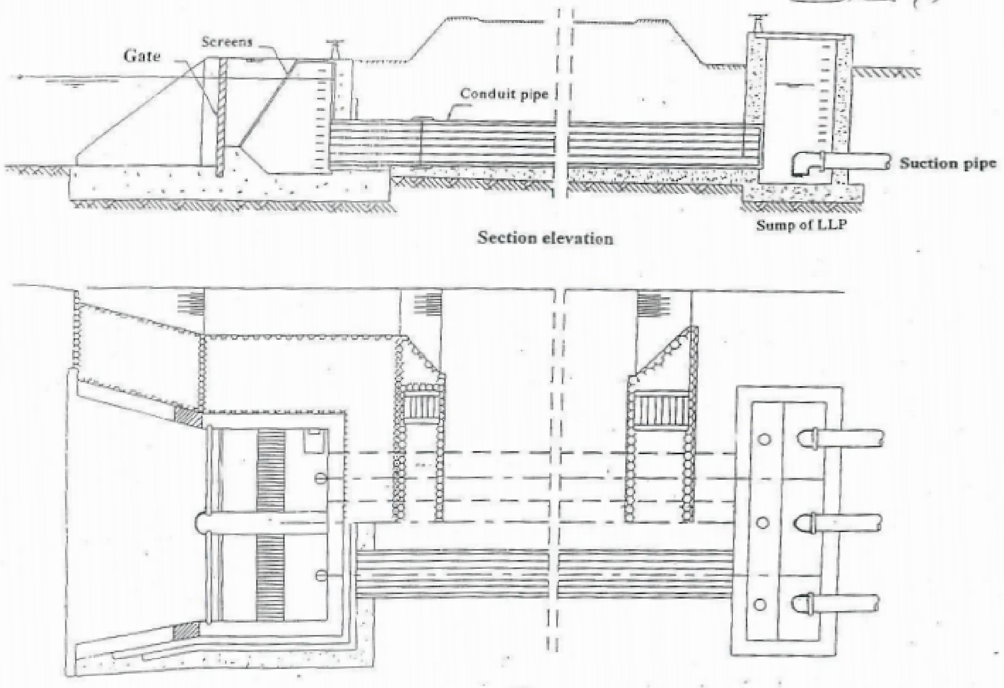
Shore Intake

21-9-2010

أنظمة مياه

Canon

د/ مساري



Typical shore intake

(72)

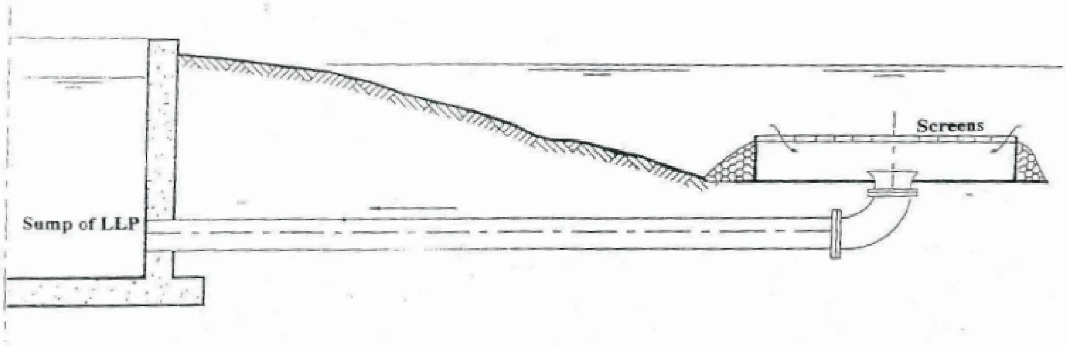


Figure (3-3): Typical submerged intake