Cranfield UNIVERSITY

SUMPS AND INTAKES

Dr Hoi Yeung

PUMP SUMPS AND INTAKES

1. GENERAL

Considerable time and effort is expended during the design stage of major pumping stations to ensure the hydraulic conditions at the pump inlet are satisfactory. The pump performance is dependent on the flow conditions as they are presented to the pump and they must satisfy the requirements for proper approach conditions.

There is very little published information on the general hydraulic requirements for pump sumps. Although there are papers describing specific pumping stations the main references available to the designer are:-

1. *The Hydraulic Design of Pump Sumps and Intakes*; MJ Prosser, BHRA/CIRIA, 1977

2. *Swirling Flow Problems at Intakes*; IAHR Hydraulic Structures Design Manual No 1, 1987

3. *Pump Intake Design*; American National Standards Institute (ANSI), 1998

4. *Design Recommendations for Pump Stations with Large Centrifugal Wastewater Pumps*, ITT Flygt Ltd.

KSB also have useful design guidance as do other pump manufacturers.

The ANSI standard on Pump Intake Design is the main reference and it sets out both good and bad practice and gives acceptance criteria for model testing.

2. HYDRAULIC REQUIREMENTS

The main requirements, as they affect the pump performance, relate to the flow conditions approaching the pumps.

- No or little pre-swirl of the flow into pumps
- No vortices present around the pump intakes
- No air carried through to the pumps
- In sewage/ drainage stations – sediment deposition is minimised and the material is carried through and into the pumps
- In sewage and drainage pumping stations there should be no build up of floating solids or potential for ragging
- Similarly the potential for grease build up is minimised

2.1 Effect of pre-swirl on pump performance

Swirl or 'pre-swirl' is the mass rotation of the flow entering the pump. This is considered to be the rotation set up in the sump by the hydraulics of the sump and not by the action of the pump impeller – hence the use of the expression 'pre-swirl'

The degree of swirl is indicated by the angle of the spiral that the flow makes as it enters the suction face of the pump

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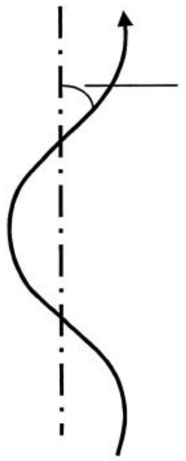


Pumps are designed to accept flow entering the volute axially. Any deviation away from that ideal affects the pump performance. Swirl or 'pre-swirl' entering the pipe thus presents the flow at a less than optimum angle to the impeller blades.

If the pre-swirl is in the opposite direction to the rotation of the pump impeller then the effect is to increase the developed head and the absorbed power thus typically the efficiency will be reduced. In an extreme case potential motor overload could result. If the pre-swirl is in the same direction as the pump impeller then there is a reduction in the flow and again in the efficiency. Cavitation can result leading to damage to the impeller and uneven loads on the bearings with premature wear.

Most manufacturers will accept pre-swirl of up to 5^0 and this is set out in the ANSI guide as the relevant acceptance criteria for a model test.

In a model the swirl is measured with a freely rotating vane located at the critical section – for a submersible pump at the throat of bellmouth intake; for a dry well pump with suction pipework, the relevant section is at the suction face of the pump. It can be shown that the swirl angle is the inverse tangent of the tangential velocity (measured by the rotation speed of the vane) and the axial velocity (calculated from the known flow rate and the area of the section).

Achieving a swirl angle of 5^0 or less for all normal operating flow conditions in a sump and the various combinations of operating pumps, is a major reason for undertaking model testing. As will be discussed later, any sump where the flow enters eccentrically to the axes of the pumps, is likely to have problems of excessive swirl.

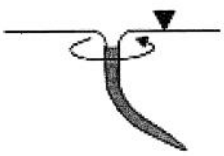
2.2 Effect of vortices on pump performance

Whereas swirl is a function of the mass rotation of the flow entering the pump intake as a result of the flow conditions in the sump, vorticity is a local phenomenon of intense rotation of the fluid. They can have a significant effect on the pump performance with adverse shock loadings on the impeller leading to vibration and damage to the bearings.

Vortices may originate at the surface of the flow or be attached to the walls or floor close to the pump intake – submerged vortices. They can be classed as follows:-

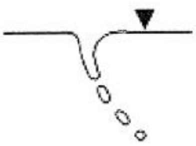
Type 1: surface swirl

Type 2: surface dimple; coherent swirl

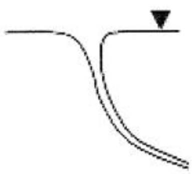


Type 3: dye core to intake; coherent swirl throughout water column

Type 4: vortex pulling in floating trash but not air



Type 5: vortex pulling air bubbles to intake



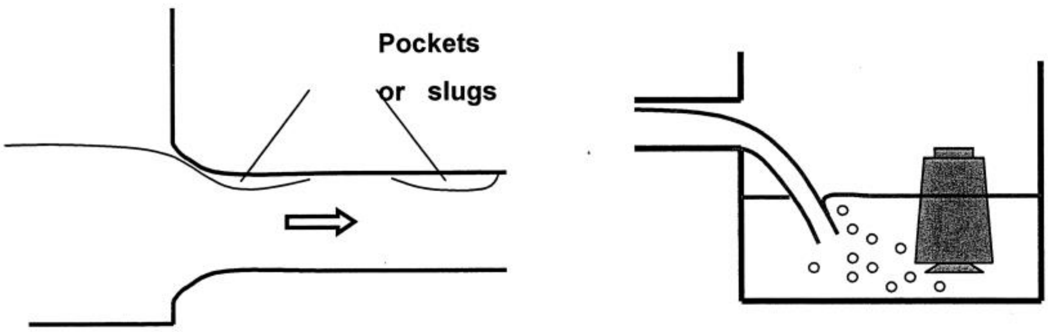
Type 6: full air core to intake

Strong vortices of types 4, 5 and 6 must be eliminated and again this is an important aspect of any model testing. Ideally, all vorticity should be designed out but the ANSI standard states that the acceptance criterion should be:-

"Free surface and sub-surface vortices must be less severe than vortices with a (dye) core (free-surface vortices of Type 3 and sub-surface vortices of Type 2)"

2.3 Effects of air on pump performance

Air can be entrained in the flow as a result of gulping, of plunging flow into the sump, by air-entraining surface vortices or air pulled out of solution by the low pressures at the centre of submerged vortices. Even small amounts of air can lead to a significant reduction in discharge and loss of efficiency. For example a 3% air content in the flow entering a centrifugal pump could result in a 15% drop in efficiency, though such figures do depend on the particular pump. As indicated above, however, air-cored vortices must be eliminated and should not be a source of air entering the pump.



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It must be remembered that air properties and bubble sizes are not scaled down in a physical model. Thus the entrainment process at full scale is more intense and more air is entrained. It is also the case that release of air in the prototype is less easy than in the model. The rise velocity of typical air bubbles is the same at both scales and at full scale there is relatively further to travel. Thus air bubbles will be carried further towards the pump at full scale.

2.4 Sediment movement

In sewage and drainage pumping stations there is the added complication of sediment carried by the inflow. Sewage pumps are or can be designed to cope with some concentration of sediment in the flow and the objective of the design of the station is almost always to ensure that sediment is passed forward to the pumps and on down the system to the grit removal facilities further downstream. The sump is not the place for allowing sediment to deposit and build up: any deposits of sediment become consolidated with the build up of biological slimes and become a matrix for septicity.

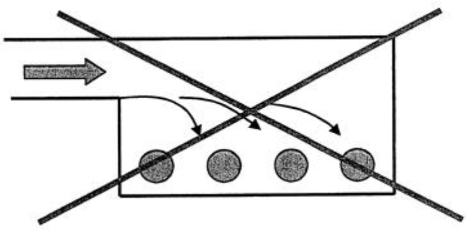
The object of the sump design must therefore be to avoid areas of slow moving flow where sediment could settle and to keep the material moving towards the pumps. Some degree of turbulence in the sump is thus beneficial and one criterion that has been suggested is that the size of the sump of a sewage pumping station should be based on a loading of 35 to 45 l/s per square metre of sump area. Thus, for example, a pumping station passing a flow of 1 m^3/s should have a sump plan area of between 22 and 28 m^2.

Other issues with sewage pumping such as the avoidance of the build up of a floating mat of material in the sump are best approached through operation of the station rather than trying to build facilities to prevent or remove such material.

3. EXAMPLES OF GOOD AND BAD DESIGN

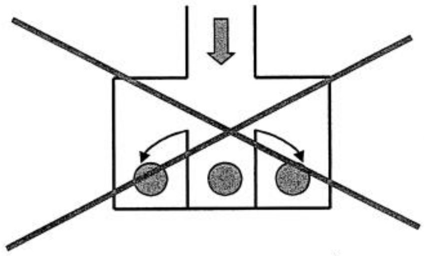
3.1 Swirl

Swirl is generated by eccentricity in the flow approaching the pumps. Thus any sump layout in which a strong flow has to turn in to approach the pump is likely to lead to swirl. The two examples overleaf illustrate this problem.



SIDE ENTRY

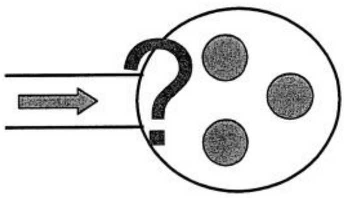
Strong asymmetry. Swirl into pumps inevitable



ABRUPT EXPANSION INTO SHORT BAYS

Flow to outer pumps highly asymmetric

In both cases the flow is directed eccentrically to the pumps and string swirl will result. It should be noted that even the ANSI guidelines recommend arrangements that will lead to swirl. Consider the example below:-



ANSI Recommended design but strong asymmetry to outer two pumps and swirl inevitable!

The incoming flow is aimed at the central pump and swirl on that unit may be low but the flow is directed past the outer two pumps and they will both inevitably suffer from swirl. Some loss of performance may be acceptable for a small installation but, for a larger station where pump efficiency and performance is important, such an arrangement would not be desirable.

In summary, any installation where there is a strong eccentricity in the flow approaching the pumps may lead to unacceptable swirl, and even where the incoming flow is directed straight at or close to the pump, problems of swirl may exist. A good hydraulic design is one in which the flow approaches the pumps smoothly and uniformly at moderate velocity.

Prosser in the earlier CIRIA manual recommends ways of spreading and straightening the flow and similar recommendations are given in the ANSI standard:-

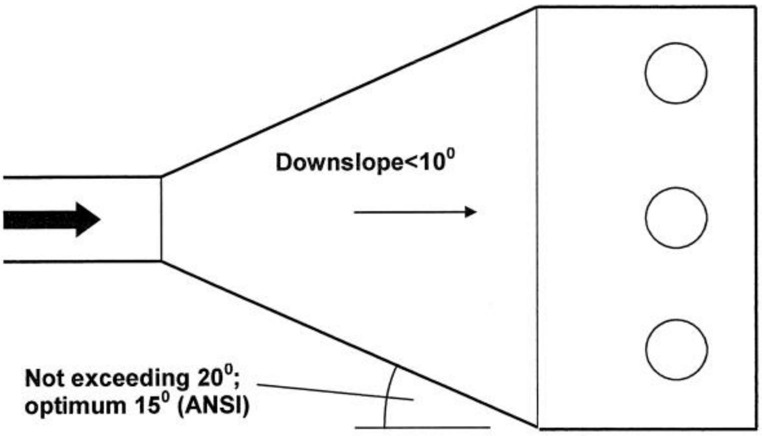


Figure 3.1 Gentle expansion from inlet to pumps

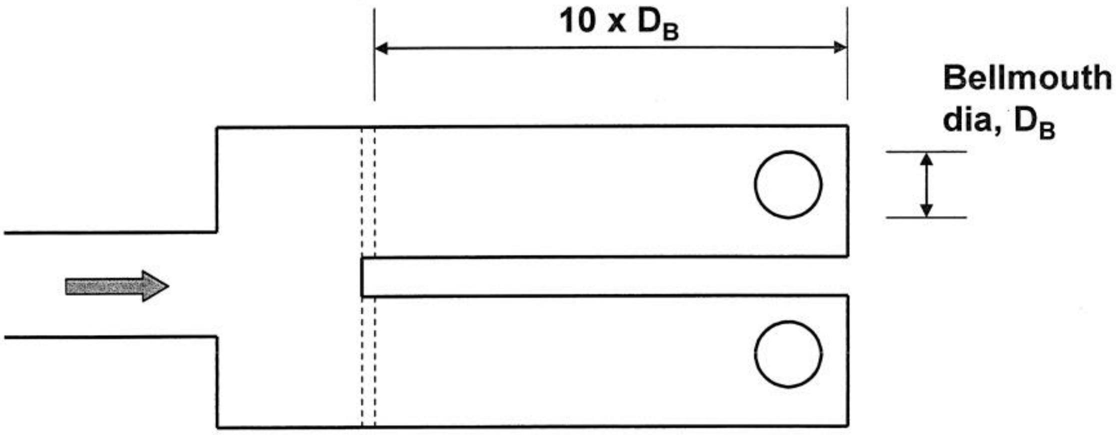


Figure 3.2 Long individual bays

However, both these approaches lead to large structures and may be impracticable if space is limited. It should also be noted that even these suggested designs do not always reduce swirl to within the required limits.

More commonly these days is the use of baffles to reduce the energy of the incoming flow and to spread the flow laterally. Figure 3.3 shows the basic concept.

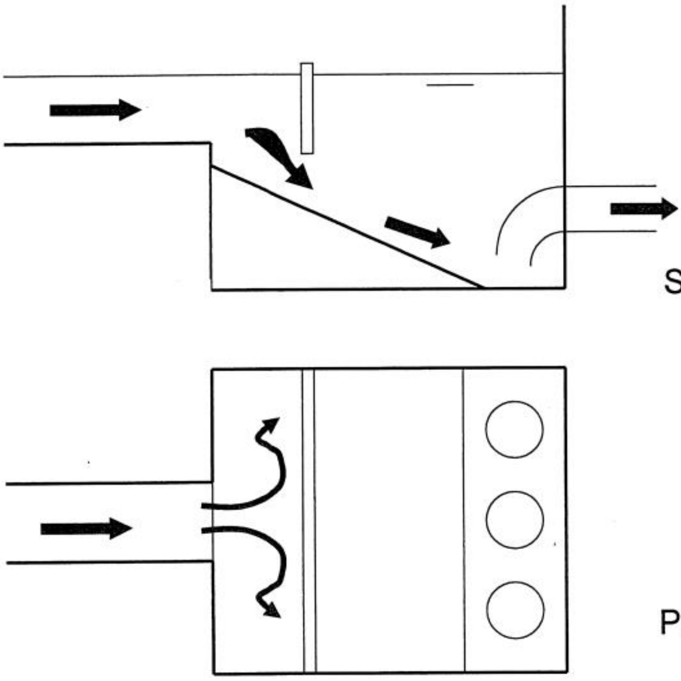
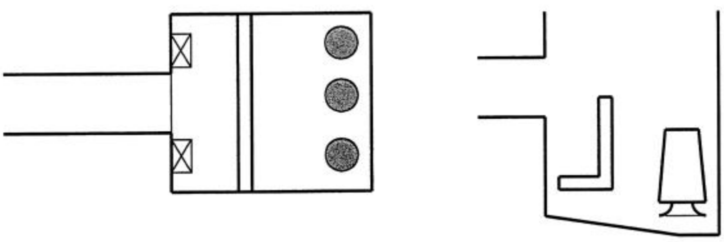


Figure 3.3 Use of an inlet baffle to spread the flow

Such an arrangement can work well but the baffle arrangement developed by Flygt Pumps seems to work even better:-



Baffle walls now very common and work well. (Flygt standard designs)

Figure 3.4 L shaped baffle/ inlet channel

The development of the baffle into an inlet channel has a number of advantages:-

- The energy dissipation of the incoming flow is held within the inlet channel.
- The flow is directed back towards the upstream wall where it passes through floor openings into the main sump spreading out as it hits the wall and floor
- No strong jets are directed towards the pumps
- Much of the air entrained by the flow plunging into the sump is released in the inlet channel and any that does pass through into the sump has an opportunity to be released from the more gentle flow conditions approaching the pump

Where possible, the design of small and medium sized installations should be standardised as much as possible. The use of designs such as those developed by Flygt and other pump manufacturers have been proved to work and if a new station is designed along the same principles then there should be no need or model tests.

For large stations it is usually sensible to model test them. Even then the use of the same principles of design should be followed. Figure 3.5 shows a larger station designed to the same concepts.

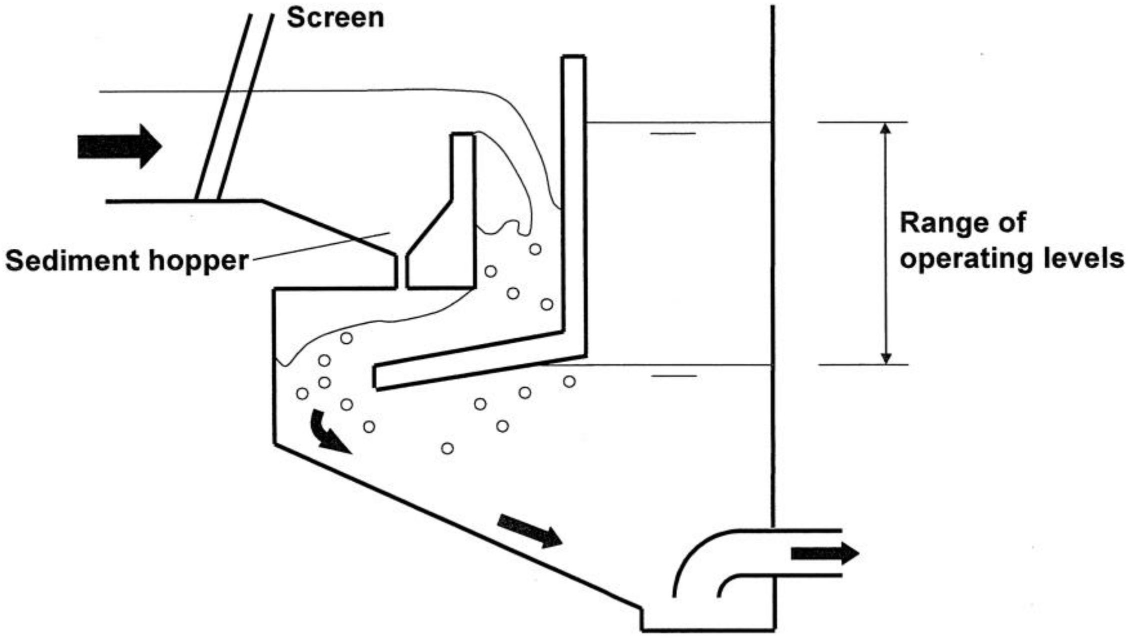


Figure 3.5 Example of larger pumping station with baffled inlet

This station was model tested and the L-shaped baffle worked well both in dissipating the energy of the plunging flow and in developing smooth uniform flow approaching the pumps. The conditions in the main sump allowed air to rise up to the water surface in the main sump and be released. This is a sewage pumping station and screening was carried out in the inlet channel. To maintain adequate depth through the screen a weir wall was included at the entry to the sump and, as this would have interfered with the movement of sediment, a conical hopper was included in the floor of the inlet channel to allow the sediment to pass on into the main sump and down the steep benching to the pumps. The model testing confirmed that the design worked well and very few details needed to be modified.

3.2 Vorticity

Whereas the likelihood of swirl is relatively easy to predict, the likely presence or otherwise of vortices around the pump intakes is much more difficult to predict and is one of the main reasons for carrying out physical model tests. It appears that the formation of vortices is due much more to the details of benching and obstructions around the pump intake such as flow separation from the end of a short dividing wall between pumps. A high swirl angle may be indicative of vortex activity but that is not essential and vortices may form in what would be considered a good sump design.

Submergence may help to reduce the risk of vorticity. The CIRIA report suggests a minimum submergence, S, above the bellmouth of 1.5 times the bellmouth diameter but that criterion has been superseded by others which take into account the velocity of the flow entering the intake. The ANSI guide suggests using the following criterion:-

$$S/D_b \geq 1 + 2.3F_b$$

where D_b is the bellmouth diameter and $F_b = V_b/(g.D_b)^{0.5}$. V_b is the average velocity through the plane of the bellmouth

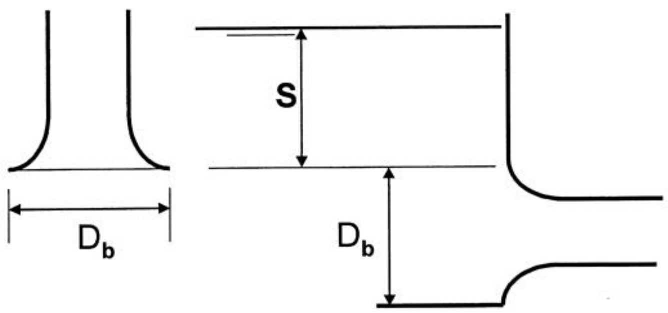
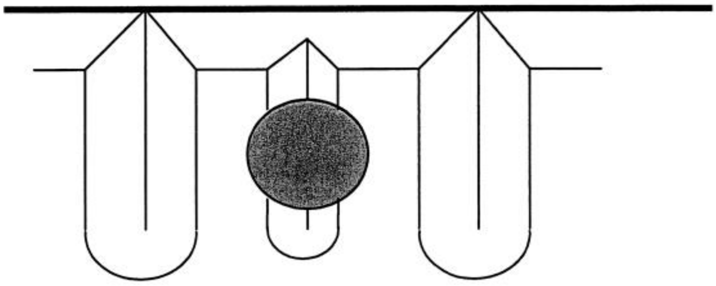


Figure 3.6 Intake Submergence

It should be noted that this criterion should reduce the risk of surface vorticity in a well designed sump. It will not solve the problems in a badly designed one.

Provided the swirl angles are within acceptable limits, the provision of benching around the pump intake does appear to reduce the risk of vorticity. Figure 3.7 shows typical details comprising a straightening vane under the pump or intake bellmouth – this greatly reduces swirl as well – and the construction of sloping benching between the pumps. This is preferred to the provision of short walls which can give rise to more problems than they solve.



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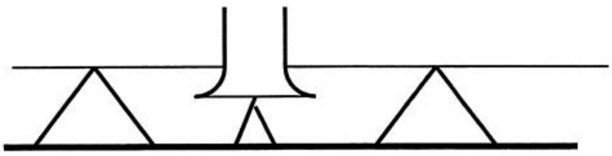

Side

Figure 3.7 Benching details around pump intake to reduce risk of vortices

3.3 Air entrainment

The problems of air entrainment have been discussed earlier. Significant volumes of air must not be carried through to the pumps and any air reaching the pumps in a physical model is an indication that there may be problems at full scale.

In particular flow plunging into a sump will entrain air and if the flow is directed at the pumps then it is likely that air will be carried into the intake. Again it should be noted that the ANSI document shows sump layouts for small pumping installations where this may well occur. It must be avoided in larger more important stations.

The use of a sump inlet channel as discussed above and shown in Figure 3.8 below is one solution to the air problem. Although there may be high turbulence and air entrainment occurring with the flow plunging into that channel, much of the air is released before the flow passes into the main sump and the more quiescent flow approaching the pumps gives the opportunity for air to escape before the pump intakes.

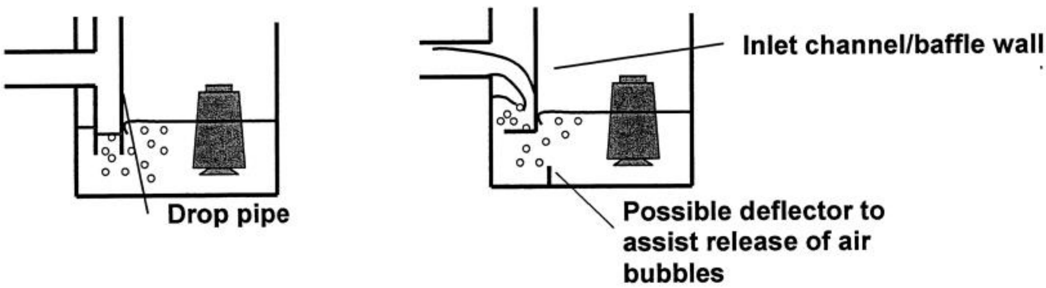

Figure 3.9 Possible solutions to air problems

3.4 Sedimentation and ragging

Sediment is present in both sewage and drainage flows and may be present in raw water. If so the pumping station needs to be designed to avoid that sediment being deposited and building up in the sump. Sediment deposits can change the flow patterns in the sump, can act as a trap for rags and other material, which when released could block the pumps, and, most importantly, can provide a matrix for the growth of biological slimes and septicity with potential water quality issues. If heavy loads are expected then the pumps must be designed and chosen to cater for that material. In particular if heavy ragging loads are expected then the type of impeller needs careful consideration and there designs with single

The main requirement is to keep the sediment and rags moving through the station and to avoid areas within the sump of slow moving or stagnant flow. A degree of turbulence in the sump is beneficial to keep sediment moving but excessive turbulence may have other effects such as reducing the release of air bubbles. One criterion that has been suggested for sizing a sewage pumping station sump is that the 'loading' should be in the range of 35 to 45 l/s per square metre of sump area. (Thus, for example, a station passing a flow of 1 m^3/s would have a sump area of between 22 and 28 m^2).

4. MODELLING

4.1 The need for modelling

The flow in a pumping station is highly complicated and three-dimensional. Until relatively recently the only way to understand that flow pattern was to build a physical model of the sump and observe the flow in the model. That still remains a powerful tool and is the only way that the fine details of the flow, in particular the formation and strength of vortices can be properly assessed. For large important pumping stations, which tend to be individually designed, the construction of a physical model to identify any problems and to enable solutions to be developed must be recommended.

For small pumping stations there is a lot of experience and standard designs have been developed. Wherever possible such designs should be adopted and there should be no need of modelling of every installation.

That also applies to medium sized stations. If a standard tested design can be employed then modelling may be unnecessary. If it has to be a unique one-off design then modelling may be necessary. There is however an alternative to physical modelling in such cases. Computational Fluid Dynamics, CFD, is now being used to simulate the flows in pumping stations and may be a feasible option for such stations. It can certainly model the overall hydraulic flow patterns but the technique does have limitations. As yet it cannot properly simulate the fine scale vortices that are picked up in a physical model. That is partly the size of the grids used in the models and partly lack of basic understanding of the structures within fine vortices. However, there is an argument that as CFD can model the overall hydraulics and the important feature of swirl entering the pumps and as the likely requirement for controlling vorticity is known to be benching around the pumps, then CFD can provide a reasonable solution. It does not yet provide full confidence that vortices can be picked up, and for that reason should not replace physical modelling on large important installations but it does enable a reasonable solution to be developed. Both in terms of programme time and cost CFD has significant benefits.

4.2 Physical modelling: scaling

Physical models of pumping station sumps are modelled to a true scale – i.e. none of the three dimensions are distorted. They are operated on the basis of Froudian scale similarity.

The Froude no is defined as

$$Fr = V/(g.d)^{0.5}$$

Where V is a representative velocity and D a representative length (in an open channel V would be the average velocity and d the depth of flow). The Froude number represents the ratio between inertial and gravitational forces acting on the fluid. These are the two main forces involved in flows around a hydraulic structure thus if the model is operated at the same Froude no as the full scale installation, the prototype, then the flow patterns in model and prototype should be the same.

Thus $V_M/(gd_M)^{0.5} = V_P/(Gd_P)^{0.5}$ where suffices M and P refer to model and prototype respectively

And hence $V_M/V_P = (D_M/D_P)^{0.5}$

D_M/D_P is the scale ratio $= 1:S$

Thus $V_M/V_P = 1/\sqrt{S}$

i.e. if the scale is say 1:9 then the velocities in the model are 1/3 of those at full scale.

It can also be shown in a similar way that the ratio of flows, $Q_M/Q_P = 1/S^{2.5}$

While the flows and velocities can be scaled accurately in this way, there are other phenomena that do not scale in the same way:-

- Air entrainment and release as discussed earlier
- Sediment transport. Using a light weight, plastic, material settlement of sediment can be modelled but accurate representation of the transport of sediment cannot be simulated.
- Viscosity and surface tension are the same in model and prototype. Provided, the model scale is large enough the effects of these is generally small. It is generally accepted that a Reynold's number (a measure of the influence of viscosity) of greater than 3×10^4 ensures reasonable representation of swirl and vorticity.

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Pump Sumps and Intakes

Hoi Yeung
h.yeung@cranfield.ac.uk

www.cranfield.ac.uk

Cranfield UNIVERSITY
Process Systems Engineering

Pumping Station 1 – Potable Water Transfer Station

Sumps and Intakes

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Pumping Station 2 – Combined Sewage Pumping Station

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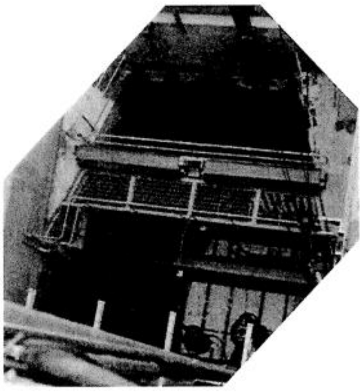

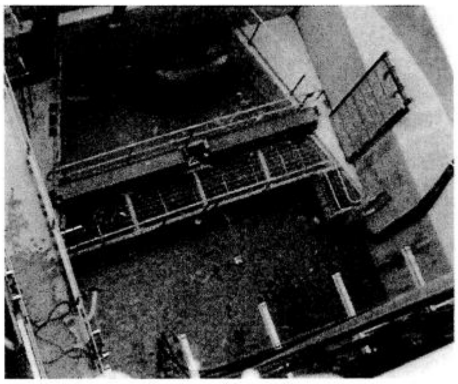

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Pumping Station 3 – Dry Well

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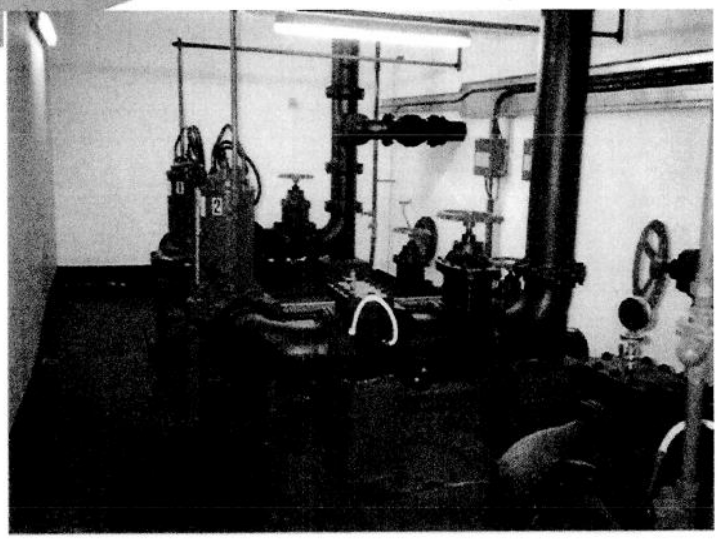

Sumps and Intakes

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Pumping Station 4 – Small Sewage Station

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Intake Hydraulic Design - for Efficient Operation of the Pumps

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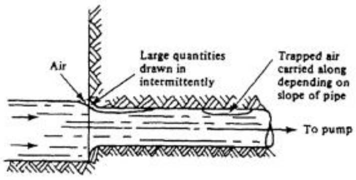
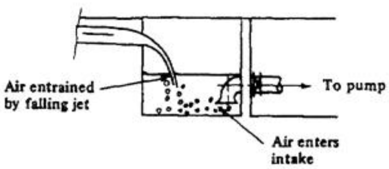
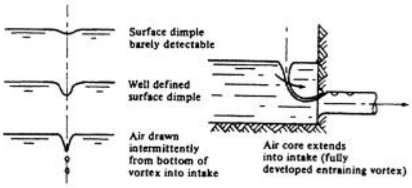
- Adequate volume for control of pumps
- Adequate NPSH
- No or little pre-swirl of the flow into pumps
- No vortices present around the pump intakes
- No air carried through to the pumps
- In sewage/ drainage stations –
  - sediment deposition is minimised and the material is carried through and into the pumps
  - no build up of floating solids or potential for ragging
  - potential for grease build up is minimised

Undesirable conditions - air

- Reduction of discharge, head, efficiency
- Vibration, damage
- ~7-10% air leading to air lock

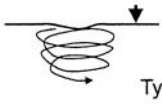




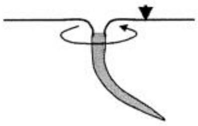


Surface Vortices Classification

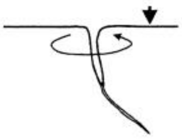
Type 1: surface swirl



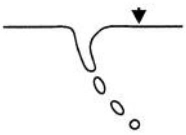
Type 2: surface dimple; coherent swirl



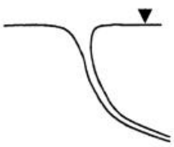
Type 3: dye core to intake; coherent swirl throughout water column



Type 4: vortex pulling in floating trash but not air



Type 5: vortex pulling air bubbles to intake



Type 6: full air core to intake

Submergence to minimise surface vortices

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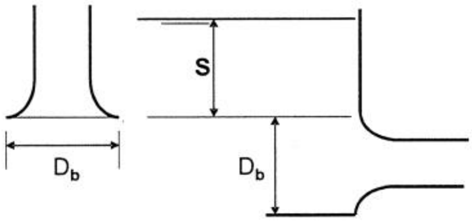
One way of reducing swirl and possibly vorticity is to increase the depth of submergence above the intake:-



ANSI recommendation is that $S/D_b \geq 1 + 2.3F_b$ where D_b is the bellmouth diameter and $F_b = V_b/(g.D_b)^{0.5}$. $V_b = Q/(\Pi D^2/4)$.

BUT this criterion applies to a well designed sump. It won't solve the problems of a poor one!

Air Movement and mitigation

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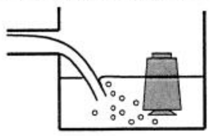
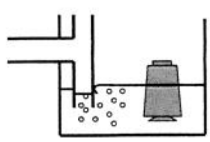
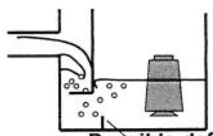
- **Avoid plunging flow onto or near to pumps:-**



Remember: Compared to model tests, more air is entrained in full size installation and is less easily released.

- **If flow dropping into sump then possibly use drop pipe or baffle wall and encourage air movement to surface before reaching pump:-**





Possible deflector to encourage upward movement of bubbles

Arrangement to minimise air

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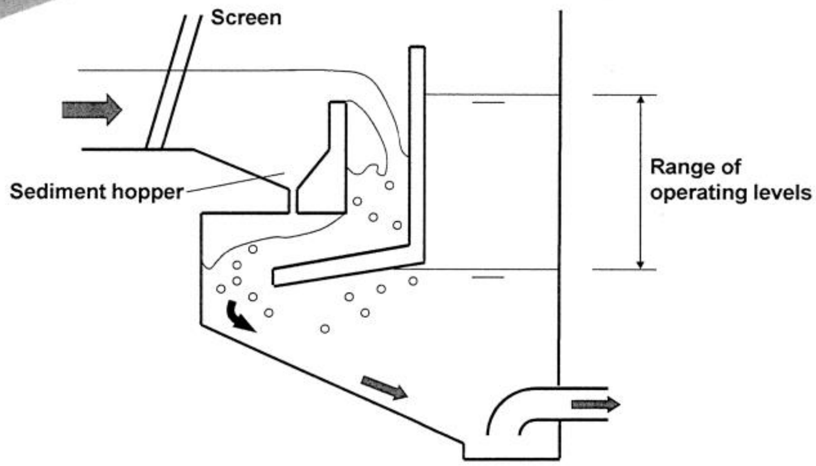

Undesirable conditions - Swirl

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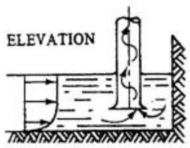
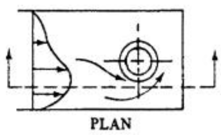
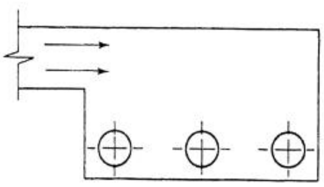
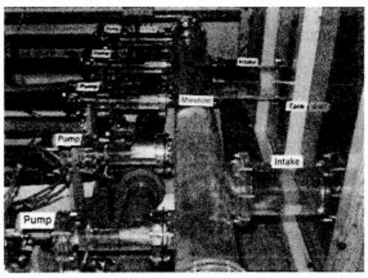
- Swirl leads to flow breakdown and thus loss performance
- Bulk swirl intensifies approaching the intake
- 5 deg (?) at pump inlet









Swirl (pre-swirl)

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Swirl or 'pre-swirl' refers to the mass rotation of the flow as it approaches the pump.

Most pumps are designed for flow to approach the impellor at right angles.
Pre-swirl opposing the impellor rotation increases the head, the absorbed power and reduces the efficiency. Extra loads on the pump impeller and bearings. In extreme cases motor overload could result.

Pre-swirl in the direction of the pump impeller then there is likely to be a reduction of flow, efficiency and power. Cavitation and excessive bearing wear may result

Most manufacturers accept a value of no more than 5 degrees in line with the ANSI recommendations.

Undesirable conditions - Turbulence

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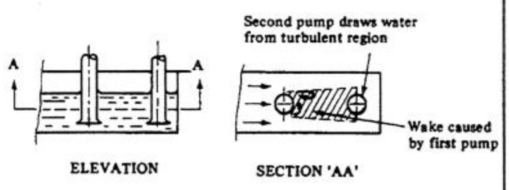
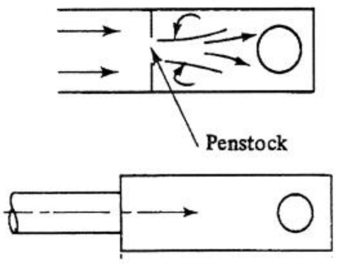
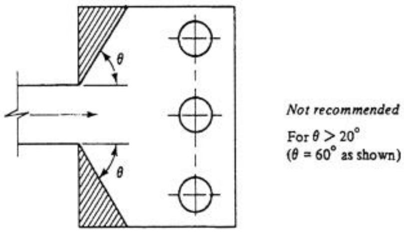
- Large scale turbulence
- High velocity jet







Undesirable conditions - Vortices

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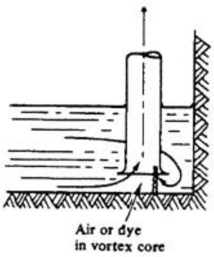
- Air, cavitation
- Fluctuating load



Vortices I

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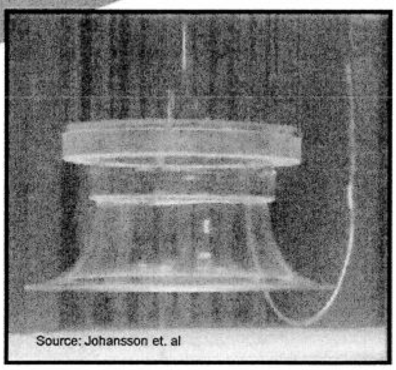
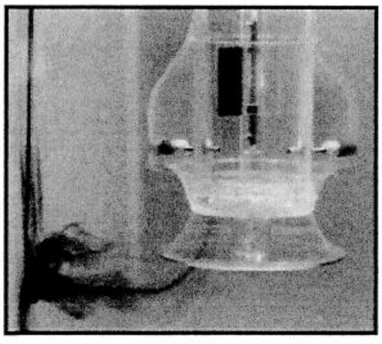
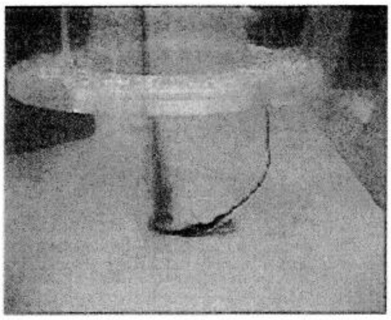


Air–cored surface vortex

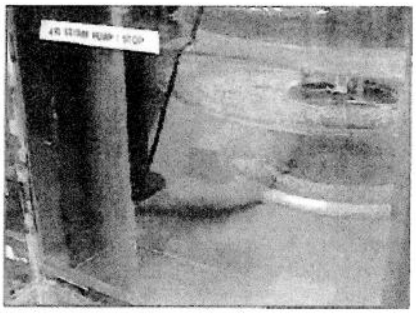


Vortex attached to side wall of sump

Vortices II



Vortex attached to floor of sump



Vortex attached to side wall of sump

Vortices

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Vortices must be differentiated from swirl. They are local tight swirling flow with high rotation. They may be originated from the water surface in the sump or be attached to the walls or floor.

If they enter the pump intake they can put high uneven loads on the pump impeller and not only reduce the pump efficiency but damage the pump bearings.

Strong surface vortices may even entrain a core of air and carry that down into the pump.

Weak vortices may be tolerable but string vortices must be eliminated.

Undesirable conditions - Stagnant region

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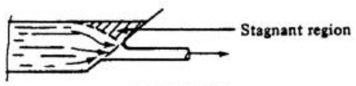
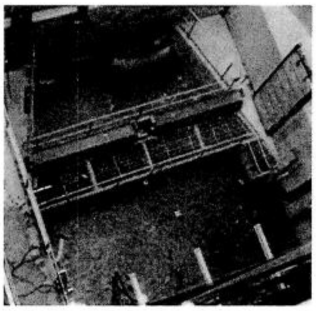
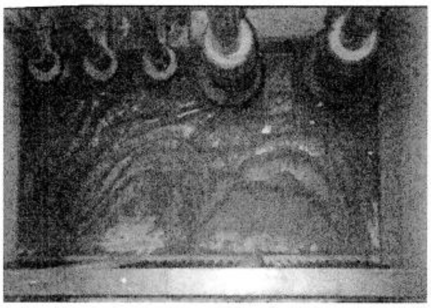
- Sediments, floats, grease, septicity







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Good sump design 1

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- Maximum sump inlet velocity (1-1.2m/s) else baffle plate
- Energy dissipated before final approach to pump
- Average velocity in sump low (0.3m/s for clean water, 0.7m/s for sewage)
- No obstruction or streamlined
- Divergence < 20 deg
- Slope < 10deg for clean water
  45-60 deg for sewage

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Good sump design 2

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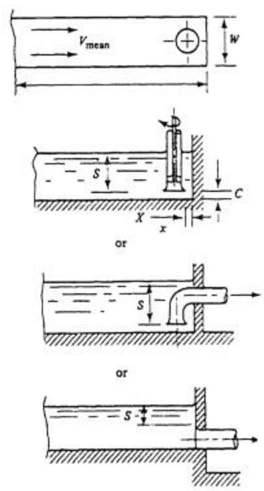
- Adequate submergence and clearance

Clearance from sump floor C = 0.5 D
Proximity to rear wall X = 0.25D
Width between pump bay W= 2 – 3 D

Divergence < 20deg
Downslope < 10 deg (clean sump only)



Good sump design 3

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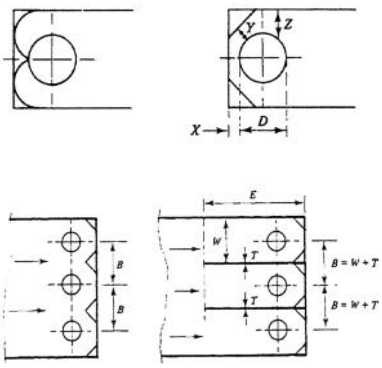
- Corners filled in to minimise stagnant region
- Suction not too small compared with the size of sump or partition



B = Pump spacing
W = Width between splitters
T = thickness of splitters
E = Length of splitters

Possible solutions – long approach bays

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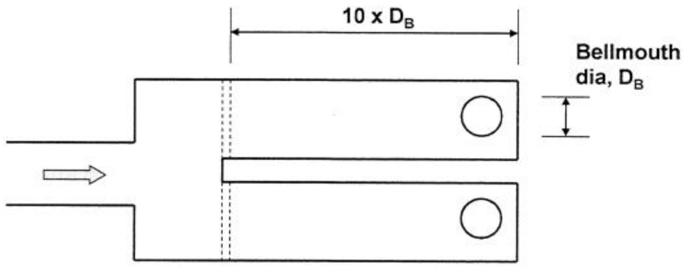

Possible solutions – gradual expansion

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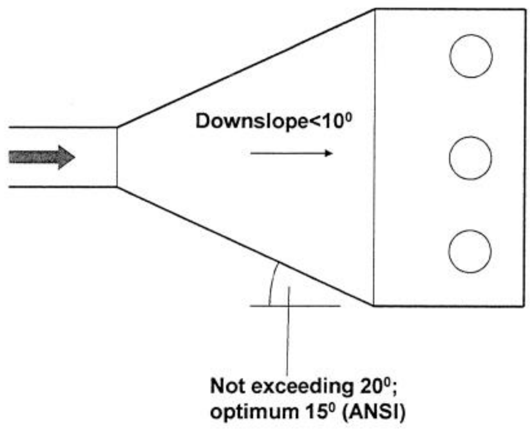

Another possible solution – a baffle across the incoming flow

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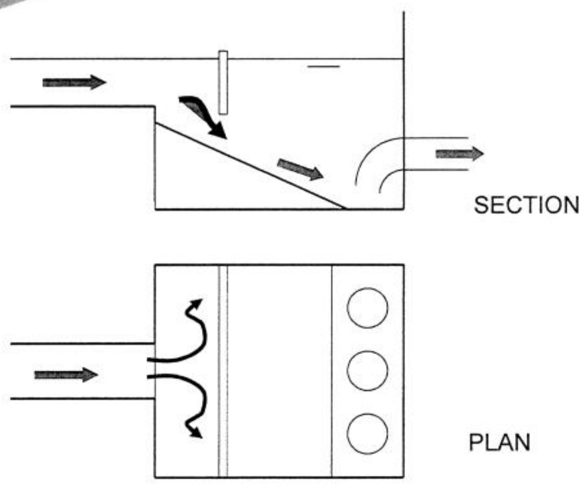

Possible solution – energy dissipation and flow conditioning

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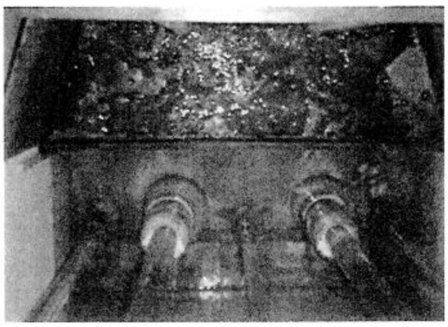
Stage reduction of turbulence using:

- Energy dissipation blocks
- Curtain wall (watch out for scum)

Benching (to reduce discontinuity)



Possible solution – flow splitter/straightener

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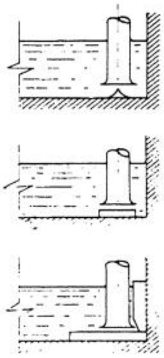
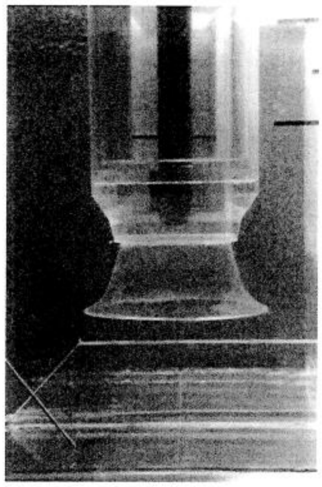
- Flow splitter to reduce swirl and vortex





Possible solution - Benching

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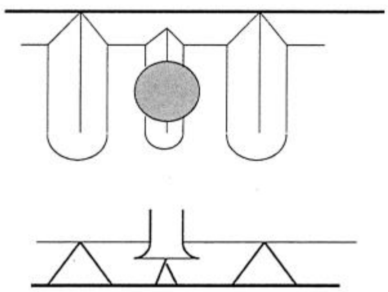

Vortices generally can be eliminated by careful design of benching and flow straighteners around intake but likely to need physical model tests to identify and for benching design.

Look out for RAGS!

Most pump manufacturers have developed their own details which will work in a well designed sump.

Example I

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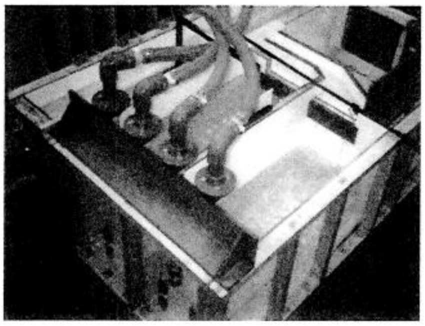

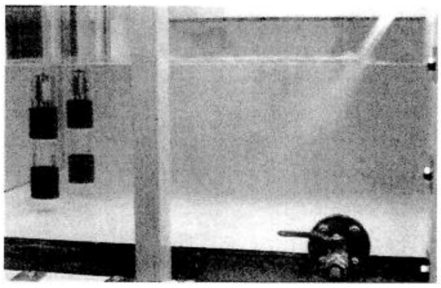

Example II

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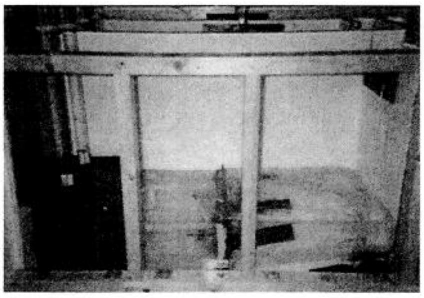
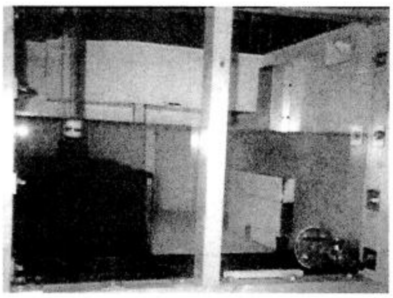
Divide into bays
Baffle to contain air and disturbance





Pump Sumps and Intakes

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A lot of time and effort is expended on designing and model testing pump sumps.

Why?

What are we concerned about?

Pump Sumps and Intakes

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Needs to ensure

- **Efficient operation of the pumps**
- **No air carried into the pumps**
- **NPSH requirements met**
- **In sewage and drainage stations, good screening conditions**
- **Sediment carried through to the pumps**

Theory of model tests

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- Physical versus Computational

Physical model testing
- Geometric similarity
- Froude scale (consideration to Reynolds number)
- Scale effects (bubble, vortex, sediments)

Dynamic Similarity 1

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Force on a bubble

$$F = f(d, u, \rho_w, \rho_a, \mu, \sigma, k, g)$$

$$\frac{F}{\frac{1}{2}\rho u^2} = f_1\left(\frac{\rho_w u d}{\mu}, \frac{\rho_a}{\rho_w}, \frac{\rho_w u^2}{\sigma}, \frac{u}{\sqrt{k/\rho}}, \frac{u}{\sqrt{gd}}\right)$$

Force coefficient = f (Reynolds number, density ratio, Weber number, Mach number, Froude number)

Dynamic Similarity 2

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Hydraulic model

Height need to be modelled (flow over weir, height change due to area change)

$$\frac{h_m}{h_p} = \frac{u_m^2}{u_p^2}$$

$$u_m = \frac{1}{\sqrt{s}} u_p$$

Froude scale

Fr model = Fr prototype

$$Q_m = \frac{1}{s^{5/2}} Q_p$$

$$t_m = s^{1/2} t_p$$

Hydraulic modelling

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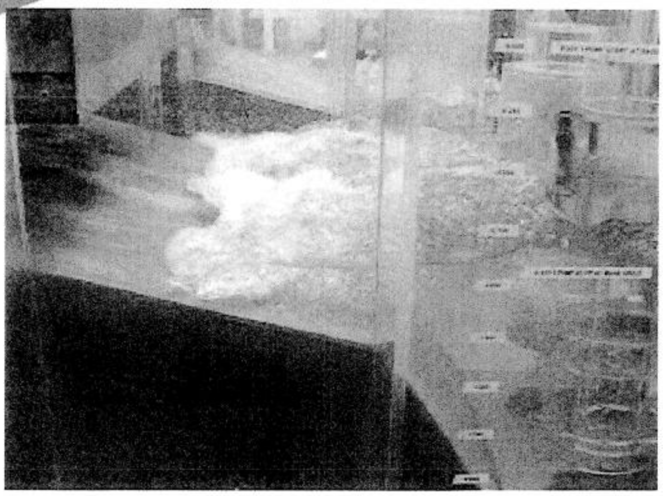

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Hydraulic modelling

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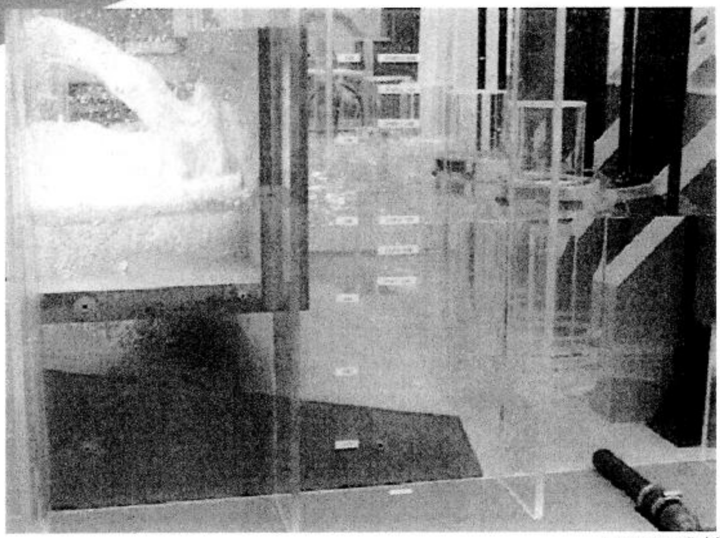

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Hydraulic Modelling - Scale Effects

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• Viscosity	Re > 10 times critical Re, model pump diameter >25mm
• Surface tension	not reliable model weir height <10mm
• Aeration/bubbles	under estimate quantity, entrainment and overestimate release
• Sediment	use graded and different density particles
• Geometry	use smooth construction material
• Vortex behaviour	under estimate (use higher flow), scale model >1:10, test using 1.5 Froude velocity

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CFD modelling

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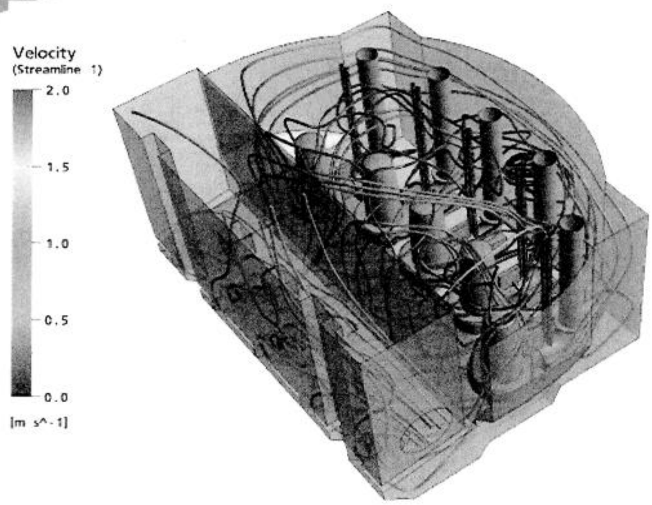

CFD modelling

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Computational Fluid Dynamics is used in many high technology industries such as aero-space, turbine and jet engine design, combustion thermodynamics and Formula 1 racing car design.

Flow space is divided up into small elements and then solves the energy and mass conservation equation.

It is used in the water industry, particularly in the design of process units within a treatment works where it is important to ensure good hydraulic performance.

It is beginning to be used for pumping station design but cannot yet model the fine structures of vortices.

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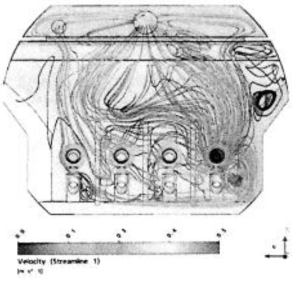
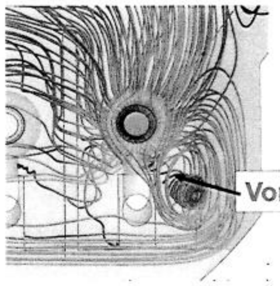
- Bottom water level below minimum submergence criteria.
- Potential for vortex formation:
  large unrestricted space in back area (>>0.75D) and side clearance greater than (>0.5D)





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CFD modelling

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- With the right boundary conditions CFD can model the general flow patterns in the sump and can predict the swirl into the pumps with reasonable accuracy.
- For critical major stations physical modelling is still the best approach. For smaller stations, particularly if of fairly standard design, then CFD offers a much cheaper and quicker analysis though with greater risk of vortices being present at full scale.

Sumps and Intakes

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Hydraulic model test

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- When?
- Cost?
- Timing?

- When beyond present knowledge (cannot copy previous design)
- Worth while when cost of model test comparable with cost of the sump
- Consulting engineer - before pump selected
- Contractor - too late

What is Wrong

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