Construction Dewatering

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Outline

- Dewatering – What & Why
- Consequences - Improper Dewatering
- Design Considerations
- Methods of Ground water Control
What is Water Table?

- Most people know that the "water table" has something to do with ground water.
- The word table provides an image of a flat surface, like a tabletop, and it is commonly assumed that when a well is drilled it strikes water once it reaches below the water table.

© American Ground Water Trust
What is Water Table?

- Ground water is sub-surface water, but not all sub-surface water is ground water.
- The upper surface of ground water is the water table. Below this surface, all the pore spaces and cracks in sediments and rocks are completely filled (saturated) with water. These saturated layers, known as the saturated zone (or the phreatic zone), are where ground water occurs. Strictly speaking only water found in the saturated zone is ground water.
WATER TABLE LOCATION
**HVORSLEV’S METHOD**

**DETERMINATION OF GROUND WATER LEVEL BY HVORSLEV’S METHOD**

- Borehole observation is the simplest technique.
- Boreholes drilled during a subsurface investigation can be kept open for 24 hours.
- The level of water is normally determined by lowering a tape with a float or by an electrical switching device, which is, actuated on contact with water.
HVORSLEV’S METHOD cont...

• In a cohesive soil stratum, the stabilization of water table may take time.
• In such situations, the location may be ascertained by adopting the extrapolation method.
• In this case, a plot of water level versus time is made and the groundwater level is estimated by extrapolating the curve until it becomes parallel to the time axis. If several levels are noted at equal time intervals the following computational method is used.
Rising water level method - by Hvorslev

- This method is also referred to as the *time lag method or computational method*.
- It consists of bailing the water out of the casing and then observing the rate of rise of water level in the casing at intervals of time until the rise in water level becomes negligible.
- The rate is observed by measuring the elapsed time and the depth of the water surface below the top of the casing.
• The intervals at which the readings are required will vary somewhat with the permeability of the soil.
• In no case should the elapsed time for the readings be less than 5 minutes.
• In freely draining materials such as sands, gravels etc., the interval of time between successive readings may not exceed 1 to 2 hours.
• But in soils of low permeability such as fine sand, silts and clays, the intervals may rise from 12 to 24 hours, and it may take a few days to determine the stabilized water level.
HVORSLEV’S METHOD cont...

Here, $h_1 \neq h_2 \neq h_3$

$\Delta T_1 = \Delta T_2 = \Delta T_3$

$3^{rd}$ day

$2^{nd}$ day

$1^{st}$ day

0 day
• Let the time be \( t_0 \) when the water table level was at depth \( H_0 \) below the normal water table level (Ref Fig).

• Let the successive rise in water levels be \( h_1 \), \( h_2 \), \( h_3 \) etc., at times \( t_1 \), \( t_2 \), \( t_3 \) respectively, wherein the difference in time \( (t_1 - t_0) \), \( (t_2 - t_1) \), \( (t_3 - t_2) \), etc., is kept constant.
Let \((t_1 - t_o) = (t_2 - t_1) = (t_3 - t_2)\) etc = \(\Delta t\)

Now, from Fig.
\[H_0 - H_1 = h_1\]
\[H_1 - H_2 = h_2\]
\[H_2 - H_3 = h_3\]
The depths $H_o$, $H_2$, $H_3$ of the water level in the casing from the normal water table level can be computed as follows:

$$H_o = \frac{h_1^2}{h_1 - h_2}$$

$$H_2 = \frac{h_2^2}{h_1 - h_2}$$

$$H_3 = \frac{h_3^2}{h_2 - h_3}$$
Let the corresponding depths of water table level below the ground surface be \( h_{w1} \), \( h_{w2} \), \( h_{w3} \) etc.

Now we have

\[
\begin{align*}
  h_{w1} &= H_w - H_o \\
  h_{w2} &= H_w - (h_1 + h_2) - H_2 \\
  h_{w3} &= H_w - (h_1 + h_2 + h_3) - H_3
\end{align*}
\]

Where, \( H_w \) is the depth of water level in the casing from the ground surface at the start of the test.

Normally \( h_{w1} = h_{w2} = h_{w3} \); if not an average value gives \( h_w \), the depth of ground water table.
Example

Numerical Example

# Establish the location of ground water in a clayey stratum. Water in the borehole was bailed out to a depth of 10.5 m below ground surface, and the rise of water was recorded at 24 hour intervals as follows:

\[h_1 = 0.63 \text{ m} \ , \ h_2 = 0.57 \text{ m} , \ h_3 = 0.51 \text{ m}\]
Example . . .

Data:
\( H_w = 10.5 \text{ m} \)
\( \Delta t = 24 \text{ hrs} \)
\( h_1 = 0.63 \text{ m} \), \( h_2 = 0.57 \text{ m} \), \( h_3 = 0.51 \text{ m} \)

\[
H_o = \frac{h_1^2}{h_1 - h_2} = \frac{0.63^2}{(0.63 - 0.57)} = 6.615 \text{ m}
\]

\[
H_2 = \frac{h_2^2}{h_1 - h_2} = \frac{0.57^2}{(0.63 - 0.57)} = 5.415 \text{ m}
\]

\[
H_3 = \frac{h_3^2}{h_2 - h_3} = \frac{0.51^2}{(0.57 - 0.51)} = 4.335 \text{ m}
\]
Example . . .

1\textsuperscript{st} day $h_{w1}$

\[ h_{w1} = H_w - H_o \]
\[ = 10.5 - 6.615 \]
\[ = 3.885 \text{ m} \]

2\textsuperscript{nd} day $h_{w2}$

\[ h_{w2} = H_w - (h_1 + h_2) - H_2 \]
\[ = 10.5 - (0.63 + 0.57) - 5.415 \]
\[ = 3.885 \text{ m} \]

3\textsuperscript{rd} day $h_{w3}$

\[ h_{w3} = H_w - (h_1 + h_2 + h_3) - H_3 \]
\[ = 10.5 - (0.63 + 0.57 + 0.51) - 4.335 \]
\[ = 4.455 \text{ m} \]

Average depth of G.W.L $h_w = (h_{w1} + h_{w2} + h_{w3})/3 = 4.075 \text{ m}$
CONTROL OF GROUND WATER
Purpose

• The purpose is to control the surface and subsurface hydrologic environment in such a way as to permit the structure to be constructed “in the dry.”

• Dewatering means “the separation of water from the soil,” or perhaps “taking the water out of the particular construction problem completely.”

• This leads to concepts like pre-drainage of soil, control of ground water, and even the improvement of physical properties of soil.
Purpose

During construction stage

- Provide a dry excavation and permit construction to proceed efficiently
- Reduce lateral loads on sheeting and bracing in excavations
- Stabilize “quick” bottom conditions and prevent heaving and piping
- Improve supporting characteristics of foundation materials
- Increase stability of excavation slopes and side-hill fills
- Cut off capillary rise and prevent piping and frost heaving in pavements
- Reduce air pressure in tunneling operations
Purpose

Post construction stage

- Reduce or eliminate uplift pressures on bottom slabs and permit economics from the reduction of slab thicknesses from basements, buried structures, canal linings, spillways, dry docks, etc.
- Provide for dry basements
- Reduce lateral pressures on retaining structures
- Control embankment seepage in all dams
- Control seepage and pore pressures beneath pavements, side-hill fills, and cut slopes.
Methods

- Exclusion Techniques
- Dewatering Techniques
Methods . . . .

- **Exclusion Techniques**

- Methods in which a very low-permeability discrete wall or barrier is physically inserted or constructed in the ground (sheet-piling and diaphragm walls)

- Methods which reduce the permeability of the in situ ground (grouting methods and artificial ground-freezing)

- Methods which use a fluid pressure in confined chambers such as tunnels to counterbalance groundwater pressures (compressed air and earth pressure balance tunnel-boring machines)
Dewatering Techniques

There are several methods commonly used to drain or dewater a construction site:

- Gravity flow
- Pumping and Vacuum
- Electro-Osmosis.
Methods

Exclusion Techniques
Exclusion Techniques

Cutoff walls penetrate into a very low-permeability stratum.
Exclusion Techniques . . . .

Cutoff walls used in combination with dewatering methods
Cutoff walls used with a horizontal barrier to seal the base.
Exclusion Techniques . . .

- **Displacement barriers**
  - Steel sheet-piling
  - Vibrated beam wall

- **Excavated barriers**
  - Slurry trench wall using cement-bentonite or soil-bentonite
  - Concrete diaphragm walls
  - Bored pile walls (secant and contiguous)
Exclusion Techniques . . . .

- **Injection barriers**
  - Permeation and rock grouting using cement based grouts, chemical and solution grouts
  - Jet grouting
  - Mix-in-place walls

- **Thermal barriers**
  - Artificial ground-freezing using brine or liquid nitrogen

- **Tunneling methods**
  - Compressed air
  - EPB TBM
Dewatering Techniques
Dewatering

Gravity Flow Method

Through Channels and ditches

- This is the less costly method.
- The site is drained through channels placed at intervals, that permit the water to flow away from the high points.
- This method has been used for thousands of years.
- It has the disadvantage of requiring a long time to properly drain the land.
Dewatering . . . .

**Pumping and Vacuum Method**

- This method is more expensive than gravity, but is faster in results.
- It requires pumps that suck the water out of the soil and remove it to a distant place or river or lake.
Dewatering . . .

*Electro-Osmosis*

Through use of Cathodes and Anodes with passage of Electrical current

- This method is most expensive
- It is only effective method of dewatering in deep clay soils.
Dewatering - Open Excavation by Ditch and Sump
Dewatering . . . .

Open sump and Ditches
Dewatering . . . .

Open sump and Ditches
CASE STUDY-1
No. 65, PUTANNA ROAD, GANDHIBAZAAR, BANGALORE
Proposed Construction of Stilt +4 storied Commercial complex

Results of Geotechnical Investigation done on 18-05-2008:

- Water Table between 0.6 m to 1.0 m below the EGL during the period of investigation
- Loose brownish sandy in the top 2.0 m to 3.6 m below the existing ground level in various boreholes
- N-value at depth of 3.0 m below the ground level is observed to quite low.

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<th>Recorded N-value</th>
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Case Study - Commercial complex

Excavation for placing isolated footing for a column
Pump being positioned for dewatering to create dry condition for placing concrete footing
Case Study - Commercial complex

Dewatering from the pit in progress
Case Study - Commercial complex

Closer view of the pump used for Dewatering
Case Study - Commercial complex

View of the Dewatering almost nearing completion
Case Study - Commercial complex

Mucking process after Dewatering
Case Study - Commercial complex

Temporary Supporting to adjacent building at the place of Dewatering
Case Study - Commercial complex

Concreting of footing is complete. Reinforcement cage of the column in view.
Case Study - Commercial complex

Dewatering in process before concreting of column
Case Study - Commercial complex

Concreting of column completed
Case Study - Commercial complex

View of Form work being removed after concrete of column has attained strength.
Case Study - Commercial complex

Dewatering in progress for back filling the soil to cover the column.
Case Study - Commercial complex

View of the adjacent columns after successful concreting of footing and part of the columns with soil being filled back to cover the columns.
Case Study - Commercial complex

Getting ready for Dewatering to construct next column footing
CASE STUDY-2

LIC OF INDIA, JEEVAN BHEEMA NAGAR, BANGALORE
Case Study - LIC of India

Proposed Residential Quarters for Employees of LIC of India

View of Construction activity for placing footing
Case Study - LIC of India

Proposed Residential Quarters for Employees of LIC of India

Results of Geotechnical Investigation done on 15-05-2008:
- Water Table between 2.0 to 3.0 m below the EGL during the period of investigation
- Filled up soil for a depth of 2.4 to 3.0 m.
- N-value below the natural ground level is observed to be quite good.

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<td>300</td>
</tr>
<tr>
<td>3.0</td>
<td>350</td>
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</table>
Case Study - LIC of India

View of Construction workers try remove soil to make way for water movement away from concreted footing.
Case Study - LIC of India

View of the footing with severe cracks at the corners.
Case Study - LIC of India

Closer view of the footing with severe cracks at the corners.
Case Study - LIC of India

View of the workers preparing to cast new footing.
Case Study - LIC of India

View of the site with liquefied soil
Case Study - LIC of India

View of Concrete blocks being stacked to observe whether the liquefied soil can bear the load.
Case Study - LIC of India

A view of the construction site
Lessons learnt from the Case Studies

- Importance of a proper Geotechnical Investigation
- Need for a suitable arrangement for dewatering when water table is present within the depth of placing foundation
Advantages of Open Sump and Ditches

- Widely used method
- Most economical method for installation and maintenance
- Can be applied for most soil and rock conditions
- Most appropriate method in situation where boulders or massive obstructions are met with in the ground

Greatest depth to which the water table can be lowered by this method is about 8 m below the pump
Disadvantages of Open Sump and Ditches

- Ground water flows towards the excavation with high head or a steep slope and hence there is a risk of collapse of sides.

- In open or timbered excavations there is risk of instability of the base due to upward seepage towards pumping sump.
Small pipes, 50-80 mm in diameter, connected to screens at the bottom and to a vacuum header pipe at the surface constitute a well point system.
Details of Well points

- Small well-screens of sizes of 50 to 80 mm in diameter and 0.3 to 1 m length.
- Either made with brass or stainless-steel screens
- Made with either closed ends or self jetting types
- Plastic (nylon mesh screens surrounding flexible riser pipes)

Well point system used in situations requiring long period presence ground (e.g., for dewatering dry dock excavation).
Installed well-point
Well Point Dewatering system

• A well point system consists of a number of well points spaced along a trench or around an excavation site.

• These well points in turn are all connected to a common header that are attached to one or more wellpoint pumps.
Well Points connected to a Header pipe
Typical Well Point System

- To pump
- Static water level
- Riser pipe
- Johnson well point
- Ground water
- Water-bearing stratum
Well Point System
Closed ring installation

✓ The closed ring installation for bulk excavation is to be carried out, with the surface header pipe forming a closed ring around the excavation. The well points are spaced around the header pipe and the pump set draws from the header to discharge the ground water away from the excavation site. In areas where the table has to be lowered further than average 6 meters drainable by one closed ring system, several stages may be installed. The primary excavation is made to the new water table level achieved by the first well-point system, then the second ring system drops the table further to allow the excavation work to continue.
Progressive line installation

✓ For trenching work, the progressive line installation is used. Depending on the composition of the ground, one row of well-points along one side of the trench is usually enough to obtain the correct drawdown the whole excavation area. Should the ground water consist of impervious strata or about the invert, it may be necessary to install well-points along both sides of the trench.

The installation is carried out on a progressive basis. As each section of the trench work is completed and backfilled, so the well-points can be withdrawn and replaced ahead of the workings to allow the ground to be prepared for the next section of the trench.

The pump sets and surface run header pipes are also designed for quick and smooth transfer of operations.
A wellpoint pump is a combination of two pumps, one of which pumps water from the header and the other of which is a vacuum pump to remove air which enters the system.

Control of air is important, as excessive air causes cavitations, which reduces pump efficiency.
Well Point Pump
• Wellpoint assemblies are made up of a wellpoint, screen, riser pipe, and flexible hose swinger and joint with tuning.
• These are generally installed by jetting.
Jetting In

With the exception of the tube well – where the hole is bored – well-points are generally placed in the soil by using a high pressure water jet.

The high pressure water is supplied from a special pump jetting pump and fed through either a self jetting well-point or a special jetting tube if disposable well-point units are being used.

Works guided by skilled operators, high pressure jetting places the well-points quickly and accurately in the right place and at the right depth.

Where subsoil conditions don't allow well-points to be jetted into place, the bore is drilled, and then the well-point placed in.
Installing the well-point
Single Stage Well Point System

![Diagram of Single Stage Well Point System](image)

- Original water table
- Symmetrical
- Lowered water table
- Well point
- Header pipe to pump
- Risers @ 2' to 5' centers
Single Stage Well Point System

- Water Table
- Sandy Loam
- Clay
- Silty Sand
- Fine Sand
- Gravely Sand
- Griffin Wellpoint
- Groundwater Drawdown
- Depressed Groundwater Table
Greater lifts are possible by lowering the water in two or more stages.
Multi - Stage Well Point System
Well point systems are frequently the most logical and economical choice for dewatering construction sites where the required lowering of ground water level is approximately 6 m (20 feet) or less. However, greater lifts are possible by lowering the water in two or more stages.

The 20-foot lift restriction results from the fact that the water is lifted by difference between ambient air pressure and the lowered pressure created by the pump.
Dewatering the construction site for the new Doha International Airport.
Spacing of well point system

- Depends on the permeability of the soil.
- Availability of time to effect the drawdown

General guidelines

- In fine to coarse sands or sandy gravels – 0.75 to 1 m is satisfactory
- Silty sands of fairly low permeability – 1.5 m is suitable
- In highly permeable coarse gravels – as close as 0.3 m centres

In a typical system, well points are spaced at intervals of from 3 to 10 feet.
Well Point Spacing

Typical Well Point Spacing in Granular Soils

Groundwater lowering, ft

Spacing of wellpoints, ft

Poles

Gravel

Very fine gravel

Coarse sand

Medium sand

Fine sand

NAVFAC (1982)
Well Point Spacing

Typical Well Point Spacing in Stratified soils

NAVFAC (1982)
A Typical Well point system unit

- In general a well pointing equipment comprises 50 to 60 well points to a single 150 or 200 mm pump with a separate Jetting pump.

- The well point pump has an air/water separator and a vacuum pump as well as the normal centrifugal pump.
Suitability of well point system

- Practical and effective under most soil and hydrological conditions.
- Suitable in shallow aquifers where the water level needs to be lowered no more than 15 or 20 feet.
- Site is accessible
- Most effective in sands and sandy gravels of moderate permeability
Situations where other systems of dewatering are preferred to Well point system

- where water levels must be lowered greater distance than can be practically handled by the well point systems
- where greater quantities of water must be moved than is practical with well points
- where the close spacing of well points and the existence of the above-ground header might physically interfere with construction operations.
Capacity of well point system

**General**
- Depending on their diameter and other physical characteristics, each well point can draw from 0.1 to 25 gallons and more per minute.
- Total systems can have capacities exceeding 20,000 gallons per minute.

**Typical**
- The capacity of a single well point with a 50 mm riser is about 10 litres/min.

**Gallon** is a measure of capacity equal to eight pints and equivalent to 4.55 litres (British); equivalent to 3.79 litres (U.S); used for liquids.
Design considerations of well-point system

When designing a well point system, it is necessary to give first consideration to the physical conditions of the site to be dewatered.

The physical layout
Adjacent areas
Soil conditions
Permeability of the soil
The amount of water to be pumped
Depth to imperviousness
Stratification
Advantages of well point system

- Installation is very rapid
- Requires reasonably simple and less costly equipment
- Water is filtered and carries little or no soil particles.
- There is less danger of subsidence of the surrounding ground than with open-sump pumping.
Limitations of well point system

- A lowering of about 6 m (20 ft) below pump level is generally possible beyond which excessive air shall be drawn into the system through the joints in the pipes, valves, etc., resulting in the loss of pumping efficiency.

- If the ground is consisting mainly of large gravel, stiff clay or soil containing cobbles or boulders it is not possible to install well points.
DEEP-WELL DEWATERING
Deep well systems consist of one or more individual wells, each of which has its own submersible pump at the bottom of the well shaft. Such systems are particularly suitable where large volumes of water in highly permeable sand and gravel areas permitting rapid recharging of ground water from surrounding areas exist.
A typical deep well consists of a drilled hole within which is a lower screened casing which admits water to the pump; an upper casing which prevents soil from reaching the pump and, within the casing, the pump and its discharge pipe.
The discharge pipe supports the pump to which it is attached. Electrical wiring for the pump motor runs between the discharge pipe and the casing. The space between the drilled hole and the casing is normally packed with filter material (for example, coarse sand and/or gravel) to minimize the pumping of solid material from the soil surrounding the well.
Spacing of Deep well point system

- Normally, individual wells are spaced at an approximate distance of 50 feet apart.

- However, depending upon soil conditions and the dewatering plan the spacing may need to be just a few feet apart.
Individual well capacities are from 21 to 3,000 gallons per minute and with total systems the capacities can be as high as 60,000 gallons per minute.

Deep well pumps can lift water 100 feet or more in a single stage and the variation of the typical deep well system is a pressure within an aquifer.

Deep well points require no pump as the water is forced to the surface by its own pressure. To boost the water flow a vacuum pump is frequently used.
Deep wells are often sealed to prevent intake of air or water from higher aquifers.
Although deep wells are often more expensive to install and maintain, in many applications they can be the most economical choice.
Design considerations of Deep well-point system

- The soil investigation report
- The grain size analysis and permeability tests
- The hydrology of the area
- The topography
- The space limitations of the site and surrounding structure.
- The projected method of excavation and shoring if any
- The construction schedule
VACUUM DEWATERING
OR
EJECTOR/EDUCTOR
DEWATERING SYSTEMS
Ejector/Eductor dewatering systems are employed to control pore pressures.

To lower groundwater levels to provide stable working conditions in excavations.

They are particularly suited to operating in fine soil conditions.
SITUATIONS NEEDING EJECTOR DEWATERING SYSTEMS

Robert's diagram
Eductor systems are able to extract groundwater and generate a high vacuum at the base of wells up to 50 m deep and of as little as 50 mm diameter.

Vacuum drainage can provide dramatic improvement in the stability of silty fine sands and laminated silts and clays by the control of excess pore pressures.

Eductor wells have been successfully installed in raking boreholes to dewater beneath inaccessible areas such as railway lines and canals.
Supply pumps at ground level feed high-pressure water to each ejector well head via a supply main. The supply flow passes down the well and through a nozzle and venturi in the ejector. The flow of water through the nozzle generates a vacuum in the well and draws in groundwater. The supply flow and extracted groundwater mix, return to the surface and feed back to the pumping station via a return main.
The return flow is used to prime the supply pumps and the excess water extracted is discharged by overflow from the priming tank. A single pumping station can be used to operate up to about 75 ejector wells installed in an appropriate array around the works.
Eductor Dewatering system
Eductor Dewatering system
Eductor dewatering system

- They are flexible in level and layout
- Stable in operation
- Able to run dry without damage
- Not limited by depth. Also effective to greater depths
- Best in low-yielding wells
- Energy intensive
- Venturi in base of well creates vacuum
Electro-Osmosis

Through use of Cathodes and Anodes with passage of Electrical current

Only effective method of dewatering in deep clay soils.
Electro-osmosis is the movement of water (and whatever is contained in the water) through a porous media by applying a direct current (DC) field.
Principle of Electro-Osmosis
When electrodes are placed across a clay mass and a direct current is applied, water in the clay pore space is transported to the cathodically charged electrode by electro-osmosis.

Electro-osmotic transport of water through a clay is a result of diffuse double layer cations in the clay pores being attracted to a negatively charged electrode or cathode.

As these cations move toward the cathode, they bring with them water molecules that clump around the cations as a consequence of their dipolar nature.
In addition, the frictional drag of these molecules as they move through the clay pores help transport additional water to the cathode.

The macroscopic effect is a reduction of water content at the anode and an increase in water content of the clay at the cathode.

In particular, free water appears at the interface between the clay and the cathode surface.

This excess of free water at the cathode has lubricating effects.
Effectiveness of Electro-osmosis

Electro-osmosis provides two benefits when properly applied

- First, electro-osmosis provides uniform pore water movement in most types of soil. Since the boundary layer movement towards the cathode provides the motive force for the bulk pore water, the size of the pore is not important.
- Unlike hydraulic conductivity, electro-osmotic flow rate is NOT sensitive to pore size. Electro-osmotic flow rate is primarily a function of applied voltage. The electro-osmotic permeability for any soil at 20°C is around $1 \times 10^{-5} \text{ cm/s}$ at 1 volt/cm.
- The entire soil mass between the electrodes is basically treated equally.

This is why electro-osmosis is so effective in clayey and heterogeneous soils.
Some Applications and Precautions in Construction Dewatering and its control
DEEP DEWATERING

Fig. 1

Deepwell dewatering system

Highrise building

Plaza level

Discharge line to stormwater

Basement 1

Original water table

Basement 2

Lift overrun

Depressed water level

Filtered deepwall

Pumpset
Permanent Groundwater Control System

Diagram showing the components of a permanent groundwater control system, including impervious and pervious backfill, initial water table, gravity flow, blanket drains, sump and pump, piezometers, relief wells, and artesian flow.
Deep Wells with Auxiliary Vacuum System

[Diagram of deep well with auxiliary vacuum system]

- **Discharge Header**
- **Vacuum Header**
- **Initial Water Table**
- **Silty Sand**
- **Weathered Sandstone**
- **Silt**
- **Sandstone**
- **Submersible Pump**
- **Well Screen**

See detail above.
Buoyancy Effects on Underground Structure

Structure bearing pressure

Uplift pressure = \( h \gamma_w \)
Recharge Groundwater to Prevent Settlement
Sand Drains for Dewatering A Slope
Grout Curtain or Cutoff Trench around An Excavation
Video
Thank you