Grate hydraulics

In typical conditions, a trench drain reaches hydraulic capacity before the grate. When there are concentrated flows running down a steep slope for example, the grate may not be capable of capturing all the flow, even if the trench is correctly sized.

Correctly located drains position grates in the direct path of surface runoff. A grate has a finite capacity to capture the surface run-off from the catchment area. When the grate's hydraulic capacity has exceeded, bypass occurs.

A grate's hydraulic performance can be greatly influenced by subtle changes in the design of the grate and catchment characteristics.

When liquid moves over a grate, the following two scenarios may occur:

- **Weir** occurs when liquid depths are minimal and the speed of liquid is high.
- **Drowned orifice** occurs when there is an accumulation of liquid above the grate.

Drains positioned in sag or valley locations allow for more liquid to accumulate. This gives rise to higher flow rates due to the increased pressure of the liquid depth being pushed through the grate openings.

Hydraulic performance is affected by the characteristics of the grate and catchment.

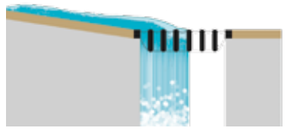
1. Grate characteristics

- Intake area.
- Width of grate.
- Design features such as the direction of bars, slots and slip resistance features.

2. Catchment characteristics

- Catchment slope determines the liquid velocity.
- Catchment roughness determines the liquid velocity and head of liquid.
- Flow direction – one direction requires a barrier drain, two or more directions requires a sag or valley drain.
- Type of liquid.
- Debris within the liquid.

No bypass



100% Capture
All the liquid flows through the grate opening.

Bypass

Less than 100% Capture
Bypass occurs when not all of the liquid flows through the grate openings.
Reasons for bypass include:

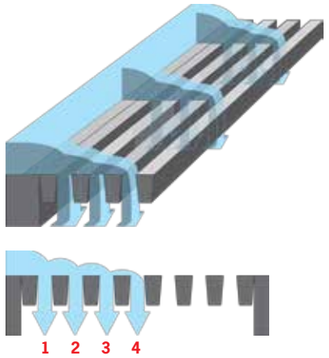
- Not enough grate open area.
- Too much runoff.
- Too much slope perpendicular to grate.

Types of inlet grates

Grate with longitudinal openings

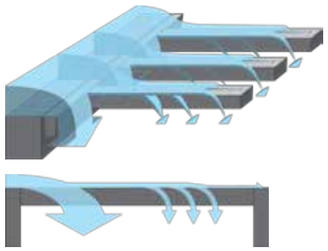
When comparing grates of equal intake area and width, grates with longitudinal openings offer the highest water intake and the maximum flow evacuation. See image below.

- Four bars interrupt and slow down the flow before a weir is produced.
- Slots 1, 2 and 3 are drowned orifices.
- Slot 4 acts as a weir.



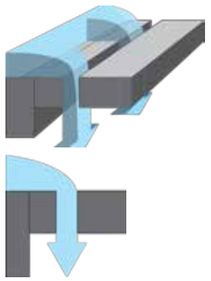
Grate with transverse openings

When comparing grates of equal intake area and width, grates with transverse openings offer moderate water intake. The bars create a bridge across both sides of the drain with minimal flow interruption, this can result in early (low volume) bypass.



Grate with a slot opening

When comparing grates of equal intake area and width, grates with slot openings provide minimal flow interruption as a weir is produced. The water intake is the lowest and the minimal depth above the slot will have negligable drowned orifice effect.



Note: Designers need to be aware of the trade-off between small inlets for heel safety and large inlets for optimum grate hydraulics. For more information, see page 115.

ACO Technical Services – Modelling grate hydraulics

Grate intake experiments

Due to the complex nature of fluids in relation to grate inlet hydraulics, testing is the only way to accurately predict how a grate will intercept surface water run-off.

ACO commissioned the UNSW Water Research Laboratory to research and test grate hydraulics. Three studies were carried out in 1998, 2004 and 2016 to investigate the water intake performance of ACO grates.

The tests were carried out under varying flow rates and catchment approach slopes. Each grate was tested until bypass occurred, which is the point where liquids pass across the grate.

The hydraulic grate test results enable ACO to accurately recommend grates for specific projects based on their catchment hydraulics.

Grate intake calculator

Grate Intake Calculator (GIC) provides valuable information on the performance of a grate during design conditions.

To generate results from the **'GIC'** program the following information is required:

- Preferred grate type.
- Length of grate (metres).
- Length and width of catchment area (metres).
- Position of trench in catchment area.
- Surrounding pavement material for example concrete or asphalt.
- Rainfall intensity in (mm/hr).
- Crossfall perpendicular to the trench drain (%).

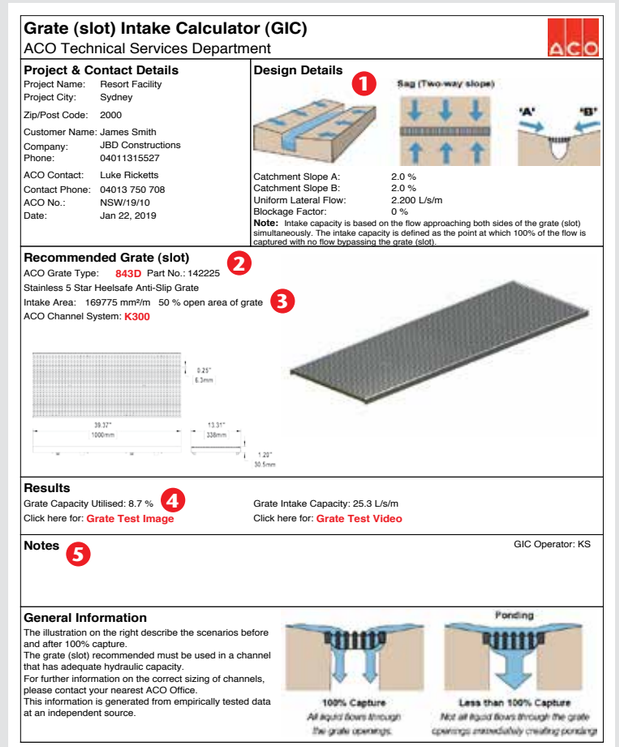
Grate analysis results

ACO's grate analysis program calulates the following information.

Key

1. Catchment design and hydraulics.
2. Recommended grate information.
3. Total intake area per metre of trench run.
4. Hydraulic utilisation of the grate – 100% indicates that all the grate intake capacity is used.
5. Additional notes relating to the grates performance.

For a quick result, an online version of the **'GIC'** program is available.



Grate (slot) Intake Calculator (GIC)
ACO Technical Services Department

Project & Contact Details
Project Name: Resort Facility
Project City: Sydney
Zip/Post Code: 2000
Customer Name: James Smith
Company: JBD Constructions
Phone: 04011315527
ACO Contact: Luke Ricketts
Contact Phone: 04013 750 708
ACO No.: NSW/19/10
Date: Jan 22, 2019

Design Details 1
Sag (Two-way slope)
Catchment Slope A: 2.0 %
Catchment Slope B: 2.0 %
Uniform Lateral Flow: 2.200 L/s/m
Blockage Factor: 0 %
Note: Intake capacity is based on the flow approaching both sides of the grate (slot) simultaneously. The intake capacity is defined as the point at which 100% of the flow is captured with no flow bypassing the grate (slot).

Recommended Grate (slot) 2
ACO Grate Type: 843D Part No.: 142225
Stainless 5 Star Heelsafe Anti-Slip Grate
Intake Area: 169775 mm²/m 50 % open area of grate 3
ACO Channel System: K300

Results
Grate Capacity Utilised: 8.7 % 4
Click here for: Grate Test Image
Grate Intake Capacity: 25.3 L/s/m
Click here for: Grate Test Video

Notes 5
GIC Operator: KS

General Information
The illustration on the right describe the scenarios before and after 100% capture.
The grate (slot) recommended must be used in a channel that has adequate hydraulic capacity.
For further information on the correct sizing of channels, please contact your nearest ACO Office.
This information is generated from empirically tested data at an independent source.

Ponding
100% Capture
All liquid flows through the grate openings.
Less than 100% Capture
Not all liquid flows through the grate openings immediately creating ponding.

Grate Intake Calculator (GIC)

Every grate on the ACO Drain website has a link to the **'GIC'** program.

Go to **www.acodrain.com.au**

Click the symbol to go to the **'GIC'** input page.