Max Q

Technical Bulletin No 2

CHILD SAFETY OF INLETS

INTRODUCTION
Many Queensland inlets have extended kerb openings on to channels large enough to carry a child – see photos 1&2. Qudm 2007 permits opening heights to 125mm a dimension based on voluntary entry and exclusion by head size. Technical Note 7.05.1 stresses that this does not cover the risk for small children entering the inlet, involuntarily, feet first. In such a case the child may be trapped in the opening or swept through into the stormwater system.

CHILD SAFE OPENING
For a child safe inlet, Qudm requires a 90mm[1] opening to exclude the torso of a 2 year old child. Max Q has adopted 90mm as the opening size for its Kerbway inlets and 100mm (3 year old child) for Drainway Plus and Stormway inlet systems. Such openings, which are detailed on the Engineering Drawings, were incorporated in all modelling used to determine inlet capture design curves in calibration by the University of South Australia. The magnitude of the forces at play in engineering terms, on a child fallen into the kerb side flow path, are examined in the sections which follow.

FLOW FORCES ON A CHILD
The Bridge Code calculates drag forces on a partially or fully submerged object as:

$F = 0.5\ C\ V^2\ A$, where:

F = Force in kN

C = 2.2

V = Velocity of flow m/s.

+A = Area m^2

If end on, a child is represented by a rectangle 0.3m x 0.12m, the force on a child stationary in the flow = $4V^2$ kg, from 8 to 95kg as set out in Table 1. The side on to the flow force, would be more than three times these amounts.

FLOW VELOCITY AT INLETS
For an allowable DV≤0.6, Qudm 1992, Chart A2-4, tabulates average roadway velocities for flows up to 140mm kerb height ranging from 1.2m/s at 1% grade to 4.0 m/s at 12% grade. Higher velocities occur in the channel and adjacent 0.5m of pavement, the flow section in which a child would be carried. There, velocities calculated using the Izzard Equation (Techical Bulletin No 6) are 1.4m/s at 1% grade and 4.9m/s at 12% grade.

1. A child may pass through or be wedged in a 125mm high kerb opening
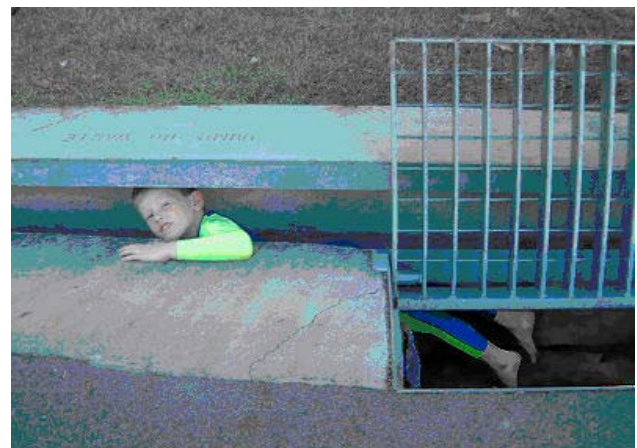
2. Children fit into the 225mm wide inlet channel

3. Manning grate with 100mm kerb inlet

FORCES ON A CHILD

End on forces on a child striving to remain stationary in the flow are shown in the last row of Table 1, to be read from the top down. They are large compared with weights of children, shown in Table 2.

TABLE 1

Description		Forces on a child at increasing road grades Q_2 flows to top of mountable kerb = 3.3m wide on 1:30 X-fall pavement			
		1%	4%	8%	12%
Allowable roadway flow	L/s	274	548	775	950
Ave full width velocity	m/s	1.2	2.3	3.3	4.0
Average DxV	m2/s	0.16	0.33	0.46	0.57
Flow to lip + 0.5m	L/s	153	306	433	530
Type A 2400 inlet capture	L/s	200	256	278	250
Type A 4800 inlet capture	L/s	264	339	400	400
Ave lip + 0.5 velocity	m/s	1.4	2.8	4.0	4.9
Force on child	kg	8	32	64	95

The obstruction is envisaged as having K=2.2 (Bridge Code) so that Force kg = 0.5 x 2.2 x 0.3 x 0.12 x V^2 = 4 x V^2

Table 1 is based on Qudm Q_2 (once in 2 year) flows, which apply to any particular location. Across a city or large town such flows and larger should be expected in many locations in any particular year.

WEIGHT AND HEIGHT OF THE CHILD

Weights of children, for comparison with the forces on a child ranging from 8kg to 95 kg as shown in Table 1, are set out in Table 2.

TABLE 2

Boys 10 percentile Height and Weight					
Age	m	kg	Age	m	kg
2	0.82	11	8	1.20	21
3	0.91	13	9	1.25	23
4	0.98	14	10	1.30	25
5	1.04	16	11	1.35	28
6	1.10	17	12	1.40	31
7	1.15	19	13	1.46	35
Adapted from Hamill PVV: NCHS growth curves for children. DHEW 78-1650					

Comparing child weight with the forces at play, it is evident even older children may lose control and be swept along at Q_2 flows. Two instances, one tragic, the other fortunate are described below.

SOUTHPORT SCHOOL

An unfortunate occurrence in school grounds at Southport Queensland, in February 2003, is a reminder of how easily tragedy may occur. The incident did not involve a kerb inlet but the approach flow in which the victim was playing was that beside normal mountable kerb. The child, small for his 11 years, was carried by the flow head first into a 375mm diameter pipe. The site of the tragedy before a grill was installed over the pipe entrance is shown in Photograph 4.

4. Mountable kerb directing flow to pipe entrance

RESIDENTIAL STREET
This November 2004 photo followed a call by the boy's mother to Brisbane's Sunday Mail, telling of the five year old playing in a kerb side flow. The SM photographer captured the boy in a carefully managed replay in what was by then a much-reduced flow. The mother was reported as saying "I thought there might be a big drain down the road and as soon as I saw him I was yelling at him to get out". Tragedy, which may easily have been the result, was averted. Both the mother and the newspaper saw the similarities with the Southport conditions.

5. Child playing in the channel flow

KERB OPENING EFFECT ON CAPTURE
Child safety should not be compromised in the name of inlet efficiency but the effect on capture of reducing kerb opening height has to be considered. This is discussed in more detail in Technical Bulletin No 1 but the following examples show capture need not be sacrificed. Firstly, test data for kerb-in-line inlets show capture for inlets with Manning 850 x 510 longitudinal bar grates and 90mm kerb openings is comparable with capture for the 930 x 676 BCC transverse bar grated inlets with 125mm kerb opening. Secondly, for lip-in-line inlets assessed on a capture for length of inlet basis, Drainway Plus inlets (610 x 610 grates) and Stormway inlets (850 x 510 grates) with 100mm kerb openings compare favourably with IPWEA and BCC inlets (930 x 676 grate) with 125mm kerb openings.

CONCLUSION
Children exposed to Qudm Q_2 (1:2 Yr) kerb side flows and even those of lesser magnitude are at risk of being swept along towards a stormwater inlet. In such instances Max Q and Drainway Plus inlets calibhrated for capture at kerb openings of 90/100mm, as shown on the Engineering Drawings, provide an important level of protection for children over those with 125mm openings, without sacrificing capture.

(1) Qudm has adapted the 90mm dimension from *AS 4685.1 – Playground Equipment – General Safety Requirements* which in turn has borrowed from the *US* publication, *Handbook For Public Playground Safety* by the *US Consumer Product Safety Commission* which requires a maximum slot width of 3½" = 89mm. The 90mm opening is designed to exclude entry of a 2 year old child, in playground conditions. Although there is the added risk that force will be applied, it is considered that 100mm openings that exclude entry of a 3 year old child (Table 3) would be satisfactory for kerb inlets,

TABLE 3

Age years	2	3	4	5	6	7	8	9	10
Height m	0.82	0.91	0.98	1.05	1.1	1.15	1.2	1.25	1.3
Body Size mm	89	99	106	114	119	125	130	136	141
Adapted from Hamill PVV:NCHS growth curves for children. DHEW 78-1605									