Concrete Pipes

Humes™

BUILD ON OUR EXPERTISE

CONTENTS

A. INTRODUCTION

General

Humes Pty Limited is the leading manufacturer of steel reinforced concrete pipes and associated precast products in Australia.

Available in a wide range of diameters, lengths and with varying strengths, Humes concrete pipes have a proven track record and are custom designed for users applications including drainage, sewage, water supply and irrigation.

Concrete Pipes provides the information necessary to specify Humes concrete pipes for all of these applications in the one easy-to-use publication.

Specification of Humes concrete pipes has also beensimplified with the inclusion of a Pipe Design Request Sheet on page 48 of Concrete Pipes. Please copy the sheet and complete the necessary information, then fax or mail to your nearest Humes office for the fastest possible service.

Manufacturing

Humes steel reinforced concrete pipes are made from coarse and fine aggregates, cement and hard drawn deformed steel reinforcement.

They are manufactured and factory tested for quality to Australian Standard AS 4058-1992 "Precast concrete pipes (pressure and non-pressure)". Pipes can also be custom made and tested to meet specific customer requirements.

Generally Humes concrete pipes up to 2100mm nominal diameter (DN2100) are centrifugally cast using the Humespun process invented in 1910 in Australia by Walter Hume. In use throughout the world, the Humespun process of centrifugal casting produces strong and durable concrete pipes.

Humes concrete pipes larger than DN2100 arevertically cast in steel moulds using high frequency vibration which produces concrete pipes with characteristics compatible with those of centrifugally spun pipes.

The manufacture of centrifugally spun pipes.

The ideal pipe material for, handling peak flows, highabrasion resistance and impermeability of concrete makes steel reinforced concrete pipe the most appropriateselection for specifying pipes whilst a range of natural characteristics further enhance its performance. These include an indefinite increase in strength in the presence of moisture and autogenous healing of cracks.

Joint Types

Humes concrete pipes are manufactured with two basic joint types - Flush Joint and Rubber Ring Joint.

Flush Joint in pipes provide an interlocking joint and allows for a small degree of flexibility in the pipeline alignment. Rubber Ring Joint in pipes, either belled socket or in-wall joint depending on the diameter of the pipe and its application, are designed to accommodate change in pipeline alignment and settlement in a pipeline while maintaining a watertight joint.

Further information on the joints specific to pipe application types is provided in each of the following sections.

Pipes manufactured in 1920 at Loveday S.A. have been exhumed and reused in a culvert at the Gurra Road Project in S.A. in 2000.

Durability

For most common installations, the service life of concrete pipe is virtually unlimited. The longevity of steel reinforced concrete pipe provides Asset Managers with a resource having low maintenance in service and the ability to recycle into other projects when exhumed. Some of the Roman aqueducts are still in use after 2000 years and samples from the first known concrete pipes in the US, laid in 1842, showed it to be in excellent condition after more than 140 years.

Of the 350 million kilometres plus of reinforced concrete pipe that has been laid in Australia, the number of pipelines which have suffered from durability problems has been extremely small and confined mainly to unprotected pipe being used in aggressive conditions.

Advances in technology and processes such as the use of Humes Plastiline for sewer pipes and astringent inhouse quality control systems ensures concrete will continue to be the most durable material for pipes.

Size Class (DN)

Humes standard range of concrete pipes are available in diameters from 225mm (DN225) up to 2100mm (DN2100).

Diameters outside this standard range and up to DN3600 are also available. Special project pipes are also available for all sizes when required or where specified.

Humes concrete pipes are typically manufactured in nominal 2.44m lengths to optimise transport and handling. Other lengths, longer or shorter can be manufactured on request.

Comprehensive tables listing the availability of Size Classes (DN) are provided in each section.

Load Class

Humes steel reinforced concrete pipes are available in Standard-Strength (Class 2-4) and Super-Strength (Class 6-10) Load Classes.

The numeric classification system adopted to identify the load carrying capacity of concrete pipes is based on any particular pipe class being able to carry approximately the same proportionate height of fill. Thus a Class 10 pipe can carry five times the height of fill of a Class 2 pipe in any size, under the same installation conditions.

See Section B: Test Load Data for further information on the range and test loads.

The required strength of a concrete pipe depends on both the load to be carried by the installed pipe and the supporting ground installation conditions. The load transmitted onto the pipe depends on the height and type of fill material. Also, when installed in a trench, the width of the trench at the top of the pipe is important. Generally the wider the trench, the greater the load for any height of fill over the pipe.

The load class for concrete pipes can be determined by consulting the Australian Standard AS3725-1989 "Loads on Buried Concrete Pipes" which provides methods for determining the installed load on concrete pipes from the earth fill over the pipes as well as any induced live (vehicle) load effects.

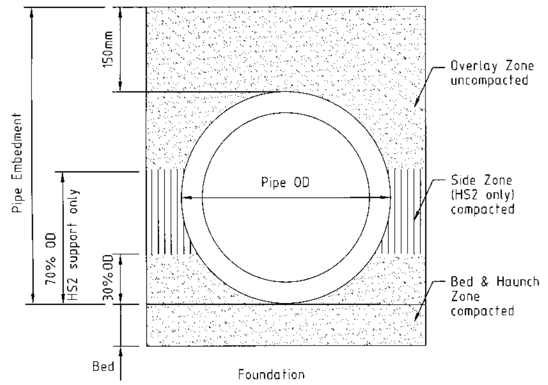
The standard also provides a range of recommended Bedding Support Type installations. The range varies from no support to haunch support to haunch and side support.

Routine testing of pipes to validate Load Class compliance.

For the majority of pipe installations, Humes Standard-Strength (Class 2-4) concrete pipes, used inconjunction with type H2 or type HS2 Bedding Support, are suitable (see Figure A1).

The letter 'H' in the terminology indicates haunch support only. 'HS' indicates both haunch and side support. The numerals after 'H' and 'HS' indicate the level of support in the material used.

Design Tables A1 & A2 for Bedding Type H2 and HS2 are provided for ease of specifying concrete pipes within a limited range of stated conditions. Figure A2 compares the results for a sample pipe installation using both Type H and Type HS Bedding Supports. Similarly, for embankment installation, Table A5 is provided.



Where specified, compaction to be 60% Density Index or 90% max. Dry density for standard com-

Figure A1, Type H2 and Type HS2 Bedding Supports

Size Class (DN)	Load Class						Installation Quantities		Trench Width (m)
	2	3	4	6	8	10	Bed Haunch	Overlay	
225	3.6	5.4	9.0				0.180	0.495	1.00
300	2.9	4.8	18.0				0.195	0.525	1.00
375	2.5	5.2	25.0				0.220	0.580	1.05
450	2.4	5.0	25.0				0.265	0.665	1.15
525	2.5	5.5	25.0				0.300	0.765	1.25
600	2.8	6.2	25.0				0.325	0.815	1.30
675	2.8	6.2	25.0				0.370	0.910	1.40
750	2.8	6.1	15.0		>25m		0.420	1.010	1.50
825	3.1	6.5	16.0				0.450	1.065	1.55
900	3.0	6.2	12.5				0.500	1.170	1.65
1050	3.1	6.1	12.0				0.585	1.325	1.80
1200	2.9	5.5	9.6				0.700	1.555	2.00
1350	2.9	5.4	9.0				0.910	1.730	2.15
1500	2.8	5.1	8.2				1.050	1.990	2.35
1650	2.6	4.7	7.2	17.0			1.240	2.350	2.60
1800	2.5	4.4	6.6	13.6			1.450	2.735	2.85
1950	2.5	4.2	6.2	11.9	25.0		1.665	3.150	3.10
2100	2.5	4.0	5.9	10.9	20.0		1.915	3.570	3.35

Table A1, Maximum Fill Height (m) & Installation Quantities (cu.m/lin.m) for Bedding Type H2 for Trench Installation, Clayey Sand Soil
Note : Installation quantities based on assumption of 10% bulking.

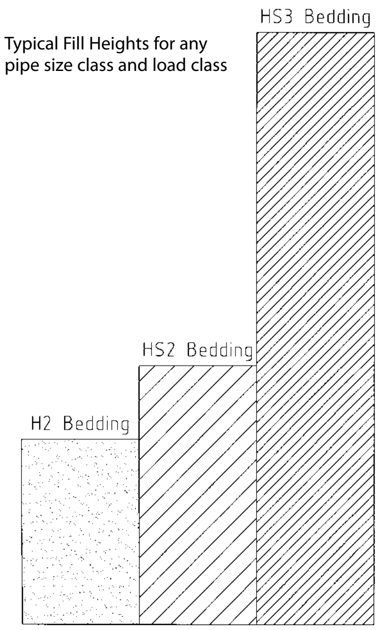


Figure A2, Comparative Fill Heights of Standard-Strength Concrete Pipes

Bedding prepared, pipes laid ready to receive back fill.

Size Class (DN)	Load Class					Installation Quantities			Trench Width (m)
	2	3	4	6	8	Bed Haunch	Side Support	Overlay	
225	5.2	7.8				0.180	0.095	0.400	1.00
300	4.1	10.8				0.195	0.105	0.420	1.00
375	3.7	15.0				0.220	0.125	0.455	1.05
450	3.6	11.0				0.265	0.145	0.520	1.15
525	3.6	11.5				0.300	0.185	0.580	1.25
600	4.1	14.8				0.325	0.195	0.625	1.30
675	4.2	13.0				0.370	0.225	0.685	1.40
750	4.1	11.0		>25m		0.420	0.250	0.760	1.50
825	4.5	12.0				0.450	0.265	0.800	1.55
900	4.3	10.7				0.500	0.305	0.870	1.65
1050	4.4	10.0				0.585	0.345	0.985	1.80
1200	4.0	8.2	22.0			0.700	0.410	1.150	2.00
1350	4.0	8.0	16.5			0.910	0.450	1.280	2.15
1500	3.8	7.3	13.3			1.050	0.530	1.460	2.35
1650	3.5	6.5	10.8			1.240	0.655	1.700	2.60
1800	3.3	6.0	9.5	25.0		1.450	0.790	1.950	2.85
1950	3.2	5.7	8.6	20.0		1.665	0.935	2.215	3.10
2100	3.1	5.4	8.1	17.0		1.915	1.080	2.490	3.35

Table A2, Maximum Fill Height (m) & Installation Quantities (cu.m/lin. m) for Bedding Type HS2 for Trench Installation, Clayey Sand Soil
Note : Installation quantities based on assumption of 10% bulking.

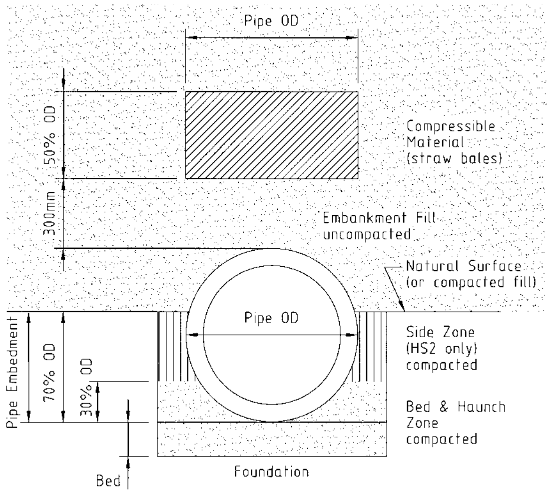
In large fill situations, a combination of Standard-Strength concrete pipes and Type HS3 Bedding Support* canprovide the most appropriate solution. Table A3 provides details for such an installation.

*Type HS3 Bedding Support is similar to that required by a flex-ible pipe installation.

Size Class (DN)	Load Class				
	2	3	4	6	
225	8.2	12.4	16.6	-	1.00
300	6.8	10.4	13.6	20.4	1.00
450	6.0	9.2	12.2	18.2	1.15
600	6.2	9.2	12.4	18.6	1.30
750	6.2	9.2	12.2	18.4	1.50
900	5.8	8.8	11.8	17.6	1.65
1050	5.8	8.6	11.6	17.2	1.80
1200	5.6	8.4	11.2	16.8	2.00
1350	5.4	8.2	10.8	16.4	2.15
1500	5.2	7.8	10.4	16.0	2.35
1650	5.2	7.8	10.4	15.6	2.60
1800	5.0	7.6	10.2	15.2	2.85
1950	4.8	7.4	9.8	14.6	3.10
2100	4.8	7.2	9.6	14.4	3.35

Table A3, Maximum Fill Height (m), Embankment Conditions (p=0.3), Bedding Type HS3, Clayey Sand Soil
* Width for Quantities as for HS2, Table A2

When pipelines carry high fill embankments (in excess of5 metres) over the top of the pipe, an Induced Trench installation system as illustrated in Figure A3 might beconsidered. Advantages of this system in high fillembankments include a possible reduction of the pipe Load Class and/or reduced Bedding Support, or an increase in the height of fill for a chosen pipe Load Class and Bedding Support Installation.



Where specified, compaction to be 60% Density Index or 90% max. Dry density for standard com-

Figure A3, Induced Trench Installation & Bedding Type HS2

Table A4 presents Induced Trench conditions for a limited range of pipes combined with type HS2 Bedding Support and indicates the advantages (see Figure A3 also).

In all cases, the most appropriate installation can be obtained by matching pipe Load Class and the Bedding Support Type. The maximum effect of varying the Bedding Support Type is that the required strength of a pipe can be reduced to as much as one quarter of the calculated inservice loading.

This allows the designer to choose the most economic combination of pipe strength and pipe installation.

The Concrete Pipe Association of Australasia software "Concrete Pipe Selector, Version 4.0 " is recommended.

Size Class (DN)	Load Class		
	3	4	6
1200	10.0	13.4	20.0
1500	9.5	12.8	19.2
1800	9.2	12.3	16.0
2100	8.7	11.6	17.4

Table A4, Max. Fill Height (m) for Induced Trench & Bedding Type HS2, Embankment Conditions (p=0.3), Clayey Sand Soil

Hydraulics

To establish the flow rates for the various types of concrete pipes, Manning's formula should be used for short run culvert and drainage applications, while the Colebrook-White formula should be used for long run drainage, gravity sewer lines and all pressure pipe applications.

The Concrete Pipe Association of Australasia publication "Hydraulics of Precast Concrete Conduits" isrecommended.

Comprehensive details on the hydraulics for the different pipe types are provided in each section.

Size Class (DN)	Load Class											
	2		3		4		6		8		10	
	H2	HS2	H2	HS2	H2	HS2	H2	HS2	H2	HS2	H2	HS2
225	3.6	5.2	5.4	7.8	7.2	10.4	-	-	-	-	-	-
300	3.0	4.2	4.6	6.4	6.0	8.4	9.0	12.6	12.0	17.0	15.0	21.2
375	2.8	3.8	4.2	6.0	5.4	7.8	8.2	11.8	11.0	15.6	13.8	19.6
450	2.6	3.8	4.0	5.8	5.4	7.6	8.2	11.4	10.8	15.4	13.6	19.2
525	2.8	3.8	4.2	5.8	5.4	7.8	8.2	11.6	11.0	15.4	13.8	19.4
600	2.8	3.8	4.0	5.8	5.4	7.8	8.2	11.6	11.0	15.4	13.8	19.4
675	2.6	3.8	4.0	5.8	5.4	7.6	8.2	11.6	10.8	15.4	13.6	19.2
750	2.6	3.8	4.0	5.8	5.4	7.6	8.2	11.6	10.8	15.4	13.6	19.2
825	2.6	3.6	4.0	5.6	5.2	7.4	7.8	11.0	10.4	14.6	13.0	18.4
900	2.6	3.6	4.0	5.6	5.2	7.4	7.8	11.0	10.4	14.6	13.0	18.4
1050	2.6	3.6	3.8	5.4	5.0	7.2	7.6	10.8	10.2	14.4	12.8	17.8
1200	2.6	3.4	3.8	5.2	5.0	7.0	7.4	10.4	9.8	14.0	12.4	17.4
1350	2.6	3.4	3.6	5.0	4.8	6.8	7.2	10.2	9.6	13.6	12.0	17.0
1500	2.6	3.2	3.6	5.0	4.6	6.6	7.0	9.8	9.4	13.2	11.6	16.4
1650	2.6	3.2	3.6	4.8	4.6	6.4	7.0	9.8	9.4	13.0	11.6	16.2
1800	2.6	3.2	3.8	4.8	4.6	6.4	6.8	9.6	9.0	12.8	11.4	15.8
1950	2.6	3.2	3.6	4.6	4.6	6.2	6.6	9.2	8.8	12.2	10.8	15.2
2100	2.6	3.2	3.8	4.6	4.6	6.0	6.4	9.0	8.6	12.0	10.8	15.0

Table A5, Max. Fill Heights (m), Embankment Conditions, Bedding Support Types H2 (p=0.7) & HS2 (p=0.3), Clayey Sand Soil

Designing concrete pipe for varied uses is made simpler with the advent of computer design application programs.Humes Technical (Design) Services have a range of programs suitable for most designer purposes which can be used to evaluate pipe performance and allows the designer to investigate various concrete pipeline alternatives, including pipe selection, installation specification and pipeline hydraulics. Further information on services available and details on the programs can be obtained by contacting your local Humes office.

B. TEST LOAD DATA

Table B1 : Test Loads in kiloNewtons / metre length
Standard Strength: Class 2 - Class 4
Super-Strength: Class 6 - Class 10
Standard Range: DN225 - DN2100
Note : Intermediate strength classes are specified by linear interpolation between values and Humes can advise onindividual applications.

Steel Reinforced Concrete Pipes are manufactured and proof tested to Australian Standards requirements. The Australian Standard AS 4058-1992 provides levels of proof test loads for concrete pipes and sample pipes taken for routine quality assurance during normal production which ensures the pipes' strength. Test load requirements for all Humes concrete pipes are given below.

Load Class	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10		Load Class
Size Class (DN)	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Size Class (DN)
225	14	21	21	32	28	42	-	-	-	-	-	-	225
300	15	23	23	34	30	45	45	56	60	75	75	94	300
375	17	26	26	39	34	51	51	64	68	85	85	106	375
450	20	30	30	45	40	60	60	75	80	100	100	125	450
525	23	35	35	52	46	69	69	86	92	115	115	144	525
600	26	39	39	59	52	78	78	98	104	130	130	163	600
675	29	44	44	66	58	87	87	109	116	145	145	182	675
750	32	48	48	72	64	96	96	120	128	160	160	200	750
825	35	52	52	78	69	104	104	130	138	173	173	217	825
900	37	56	56	84	74	111	111	139	148	185	185	231	900
1050	42	63	63	95	84	126	126	158	168	210	210	263	1050
1200	46	69	69	104	92	138	138	173	184	230	230	288	1200
1350	50	75	75	113	100	150	150	188	200	250	250	313	1350
1500	54	81	81	122	108	162	162	203	216	270	270	338	1500
1650	58	87	87	131	116	174	174	218	232	290	290	363	1650
1800	62	93	93	139	124	186	186	233	248	310	310	388	1800
1950	66	99	99	149	132	198	198	248	264	330	330	413	1950
2100	70	105	105	158	140	210	210	263	280	350	350	438	2100
2250	74	111	111	167	148	222	222	278	296	370	370	463	2250
2400	78	117	117	176	156	234	234	293	312	390	390	488	2400
2700	86	129	129	194	172	258	258	323	344	430	430	538	2700
3000	94	141	141	212	188	282	282	353	376	470	470	588	3000
3300	102	153	153	230	204	306	-	-	-	-	-	-	3300
3600	110	165	165	248	220	330	-	-	-	-	-	-	3600

C. CONCRETE CULVERT PIPES

Humes can provide a comprehensive range of steel reinforced concrete culvert pipes in diameters from 225mm up to 3600mm (standard range DN225 - DN 2100).

They are available with two basic joint types - Flush Joint (FJ) and Rubber Ring Joint (RRJ).

Flush Joint (FJ)

FJ pipes with External Bands (EB) are recommended for normal culvert conditions. They provide an interlocking joint between pipes, as shown in Figure C1, and give a true and positive alignment along the length of the pipeline.

When EB bands are used in conjunction with FJ culvert pipes, they provide a soil-tight joint along the pipeline and prevent loss of bedding material into the pipe. Groundwater infiltration may occur however, when the groundwater level is significantly above the pipeline obvert (approx. 3m).FJ pipes fitted with EB bands allow a small degree of flexibility for the bedding-in of the pipeline during natural processes of consolidation.

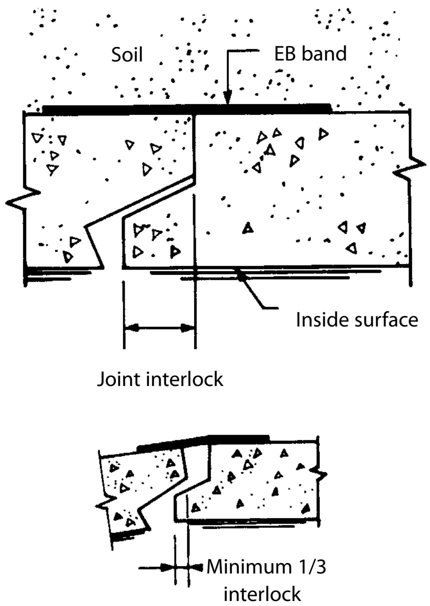


Figure C1, Flush Joint Profile

Rubber Ring Joint (RRJ)

RRJ pipes are also suitable for culvert applications and are most effective when differential ground settlement is anticipated or if a pipeline is expected to flow full under outlet control conditions with a significant hydraulic pressure head.

See Section D, Concrete Stormwater Pipes for further details.

Size Class (DN)

See Table C3 on page 13 for details of Flush Joint Pipes.

Load Class

Humes concrete culvert pipes are available in Standard-Strength (Class 2-4) and Super-Strength (Class 6-10) Load Classes.

The most appropriate culvert installation can be obtained by matching both pipe Load Class and the Bedding Support Type. For the majority of installations, Standard-Strength concrete culvert pipes used in conjunction with type H2 or type HS2 Bedding Support, are suitable.

For large fill situations, a combination of Super-Strength pipes and type HS3 Bedding Support can provide the most appropriate and economical solution.

Further information on the Load Class of concrete pipes can be obtained by referring to Section A : Introduction.

Hydraulics

The size of overland flows is determined from hydrological data and by the design service life of the pipeline.

"Australian Rainfall and Run-off", a publication of the Institution of Engineers, Australia and/or "Hydraulics of Precast Concrete Conduits", published by the Concrete Pipe Association of Australasia, provides the information for determining the peak flow in the pipeline.

The most commonly used formula to determine overland flow rates is the Rational Formula: $Q = 2.78\ CIA$ (litres/sec). Where :

C is the coefficient of run-off, typically 0.7 to 0.9
I is rainfall intensity (mm/hr)
A is the catchment area in hectares

See Table C1 for common values of rainfall intensity (I) for a sample of design situations.

Location	Storm	Intensity mm/hr for Design Life 10 yrs	50 yrs	Location	Storm	Intensity mm/hr for Design Life 10 yrs	50 yrs
Adelaide	30 mins	40	55	Hobart	30 mins	35	45
	1 hr	25	35		1 hr	20	32
	2 hr	15	22		2 hr	13	18
Brisbane	30 mins	90	120	Melbourne	30 mins	45	65
	1 hr	60	75		1 hr	30	40
	2 hr	37	50		2 hr	18	25
Canberra	30 mins	50	70	Perth	30 mins	40	50
	1 hr	30	40		1 hr	25	30
	2 hr	20	25		2 hr	15	18
Darwin	30 mins	115	135	Sydney	30 mins	75	100
	1 hr	75	90		1 hr	60	75
	2 hr	45	55		2 hr	38	55

Table C1, Rainfall Intensity Levels from "Australian Rainfall & Run-off"

The hydraulic evaluation of culvert pipes is based on Manning's formula and the recommended value of Manning's 'n' for concrete pipe is 0.013 for field conditions. Laboratory testing has produced values of less than 0.011.

The flow condition in a culvert is expressed as either inlet control or outlet control. It is essential that the designer investigate both states of flow and adopt the morerestrictive flow condition for design.

Inlet control

Inlet control conditions shown in Figure C2 exist in a pipeline where the capacity of the pipeline is limited by the ability of upstream flow to easily enter the pipeline, a common situation in coastal Australia where short culvert lengths on steep grades are used. The flow under inlet control conditions can be either inlet submerged or unsubmerged.

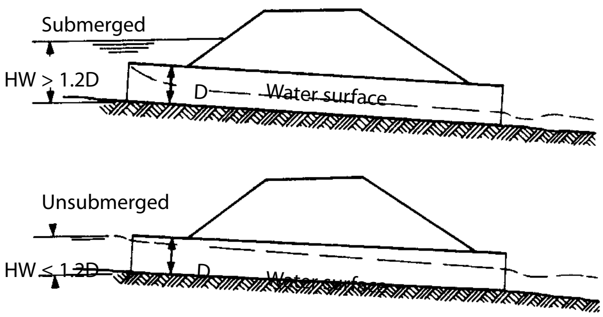


Figure C2, Inlet Control

A typical multi-channel culvert during construction.

Outlet control

Where culverts are laid on flat grades and empty below the downstream water level, the culvert typically operates with outlet control conditions as shown in Figure C3.

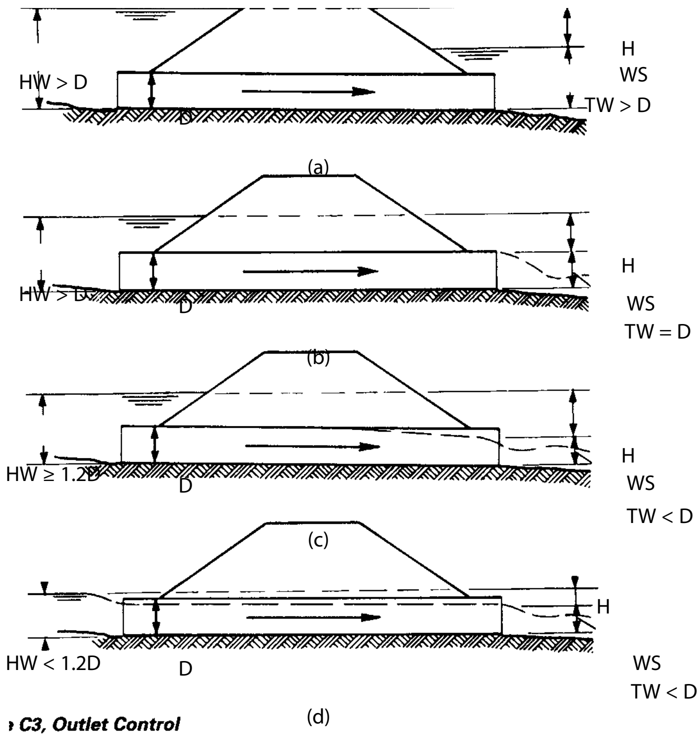
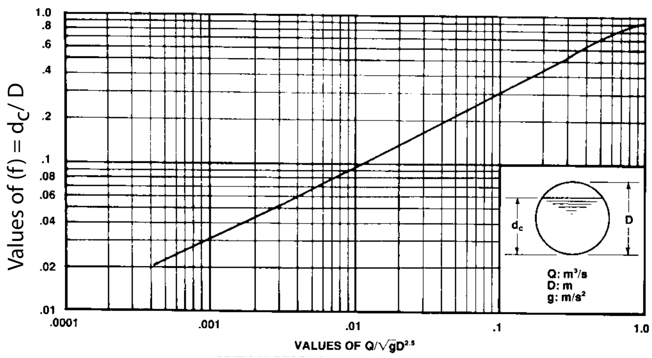


Figure C3, Outlet Control

When operating under outlet control conditions, the culvert pipe may flow full or part-full depending on the tailwater depth.

Where the tailwater depth is greater than the pipe diameter, the pipe will typically flow full. Where the tailwater depth is less than the pipe diameter, the design tailwater depth should be taken as the greater of the actual tailwater depth or (dc + D)/2 where dc is the critical depth for the actual flow discharge, see Figure C4.



Values of (f) = $Q/\sqrt{g}\,D^{2.5}$

eg. D = 1.2m ∴ (f) = 0.557

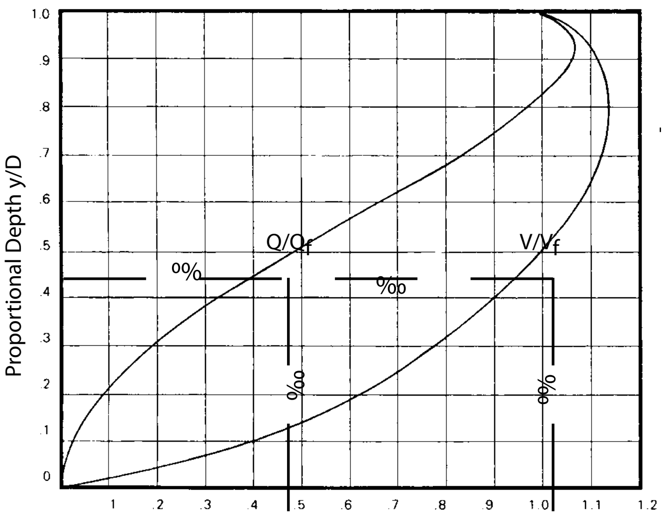
Q = 2.75 cumecs $d_c/D = 0.75$

$d_c = 0.90$m

Figure C4, Critical Depth Relationships

The design charts (Figures C7 & C8) for pipe culvert inlet and outlet conditions allow quick and easy answers for the designer when evaluating maximum discharge conditions at maximum headwater. For a lesser discharge, Figure C5 can be used to determine flow characteristics.

Where inlet flow conditions exist in a culvert, the flow capacity of the pipeline is independent of the pipe surface roughness (Manning's 'n').



Proportional Discharge Q/Q_f and Proportional Velocity V/V_f

Q = Part-full Velocity	eg. D = 1200mm	$V/V_f = 0.97$
Q_f = Full flow Discharge	$Q_f = 6.0$ cumecs	V= 5.0m/sec
V = Part-full Velocity	$V_f = 5.2$m/sec	y/D = 0.46
V_f = Full flow Discharge	Q = 2.75 cumecs	y = 0.55m
	$\therefore$ $Q/Q_f = 0.46$	

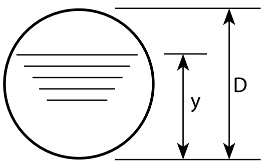


Figure C5, Flow Relationships

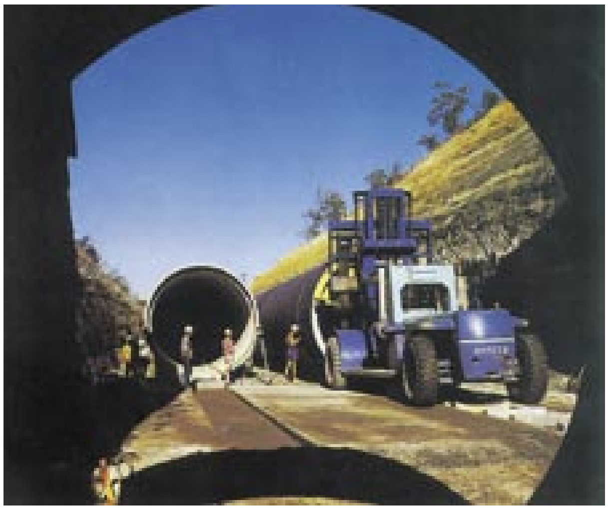
The pipeline flow capacity for inlet control conditions is dependent on the ratio of headwater depth to culvertdiameter and the inlet geometry type. Outlet controlconditions operating in a culvert determine the pipeline flow capacity by the effects of pipe surface roughness (Manning's 'n'), pipeline length and slope and inlet geometry type. Use of the flow chart in determining flow conditions is illustrated in the example given beneath the charts.

Installation

Humes culvert pipes above DN525 are normally supplied with elliptical grid reinforcement, unless a circular grid is specifically requested. Elliptical grid reinforced pipes must be laid with the word "TOP" at the crown (or invert) of the pipe and within 10° each side of the vertical centreline. To simplify handling, lifting holes are generally provided in the top of all FJ pipes and FJ splays above DN 525.

See Section J : Handling and Installation for further details.

Installing sewer pipes, note trench shoring equipment (Oxley Creek - Brisbane).



3600mm diameter pipes being installed at Prospect Dam - NSW.

Other Culvert Products

Humes manufactures a wide range of associated components to provide the complete culvert pipeline solution. These include :

- Headwalls - These are used where the hydraulic design requires improved inlet and outlet flow conditions.

- FJ Splay pipes - These permit curves in pipeline alignment without the usual problems of hydraulic head loss (turbulence) that can result from a rapid change in the direction of the flow at a sharp bend. Details are given for the minimum radius of curved alignment. See Table C2 and Figure C6 for minimum radius using double ended splays and preferred radius using single ended splays. EB bands can also be used with FJ Splays. For lesser radii, FJ bend pipes may be supplied.

Precast concrete Headwalls for Rubber Ring Joint Pipes.

Notes :

1. The number of splay pipes required is determined from the deflection angle and the centreline radius. This information should be given when ordering splay pipes.Humes Engineers will calculate the optimum number of splay pipes required.

2. The curve "hand" is described as when lookingdownstream in the direction of the flow.

Size Class (mm)	Centerline Radius (m)	
	minimum	preferred
600	4.0	11.5
675	4.3	11.8
750	4.6	12.2
825	4.9	12.4
900	5.2	12.6
1050	5.8	13.0
1200	6.4	13.4
1350	7.0	13.7
1500	7.7	14.0
1650	8.4	14.4
1800	9.2	15.0
1950	10.0	15.9
2100	10.8	16.7

Table C2, Radius of Curved Alignment

Multiple Barrel Splay Pipes (EB Joint).

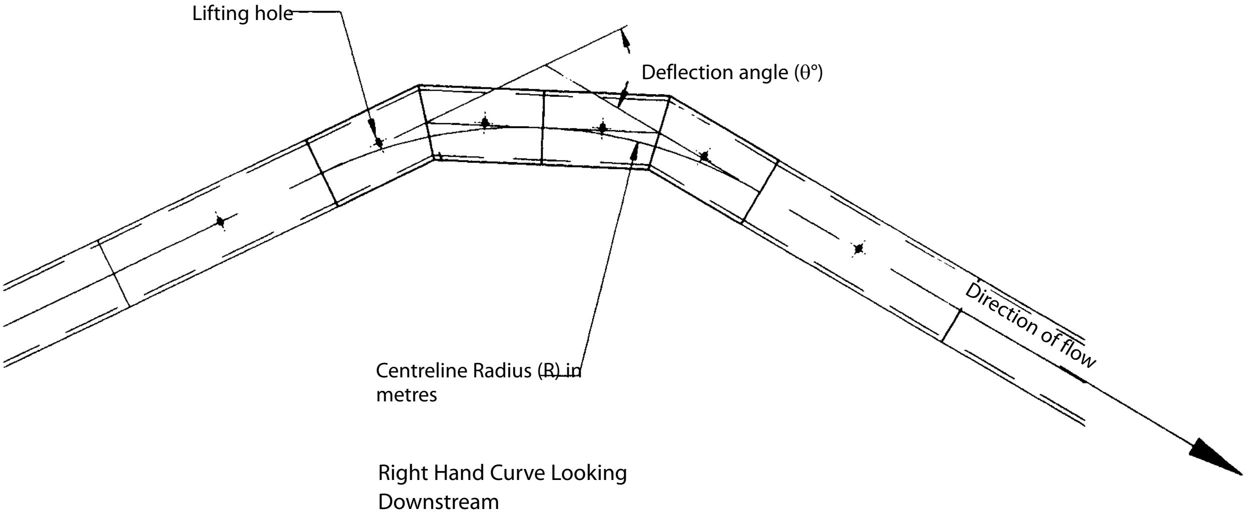
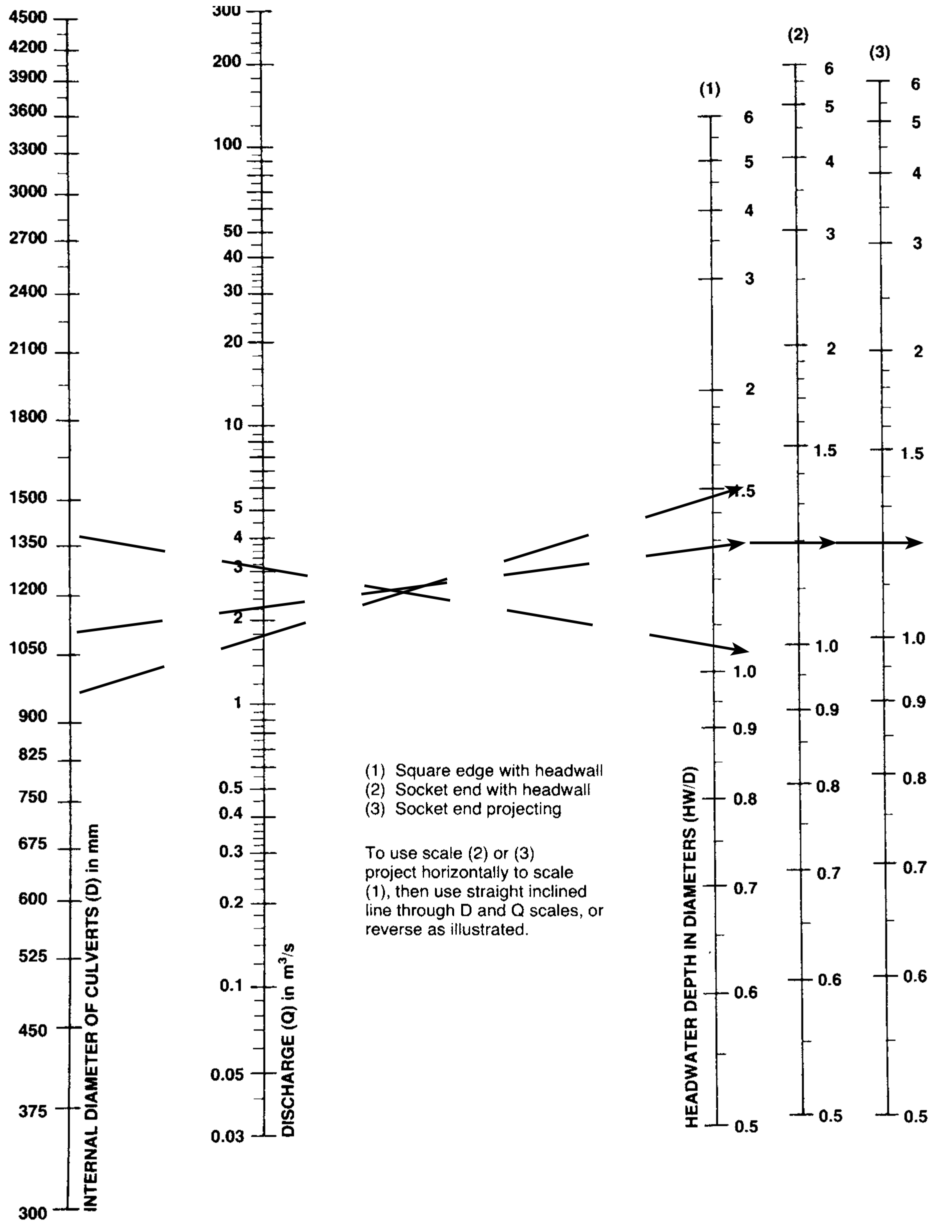


Figure C6, Flush Joint Splays in Curved pipeline Alignment (single ended splay)



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS
WITH INLET CONTROL

Figure C7, Flow Relationships for Inlet Control in Culverts

Culvert Pipe Example

A culvert is to be laid under a proposed road embankment. From the catchment physical data and hydraulic information, the designer has determined a peak flow discharge of 5.5 cumecs (5500 litres/sec) passing through the culvert pipeline. The roadway alignment establishes the embankment height at 2.0m above existing ground surface and the culvert is to be laid at natural ground level. To avoid flooding the roadway pavement, the maximum upstream flood level is to be 300mm below roadway level and from downstream flow restrictions, the estimated tailwater level is 1.0m above the natural ground surface. The width of the roadway formation including embankment slope is to be 50m over which the natural ground surface falls 500mm. The culvert is to be constructed with headwalls.

From the information,

Max Headwater HW = 1.70m, Max Tailwater TW = 1.00m
Pipe culvert length = 50m,
Pipe culvert slope = 500mm in 50m (1 in 100)

Assume inlet Control Conditions

Since max headwater is 1.7m try 1500mm diameter FJ pipe
HW/D = 1.7/1.5 = 1.13

From inlet condition Figure C7 using 'square edge with headwall';
Q = 4.1 cumecs < Q required

Try twin 1050mm FJ pipe
HW/D = 1.7/1.05 = 1.62

From inlet condition Figure C7 using 'square edge with headwall';
Q = 2.2 cumecs < Q required (=5.50/2)

Try twin 1200mm diameter FJ pipe
HW/D = 1.7/1.2 = 1.42

continued next page

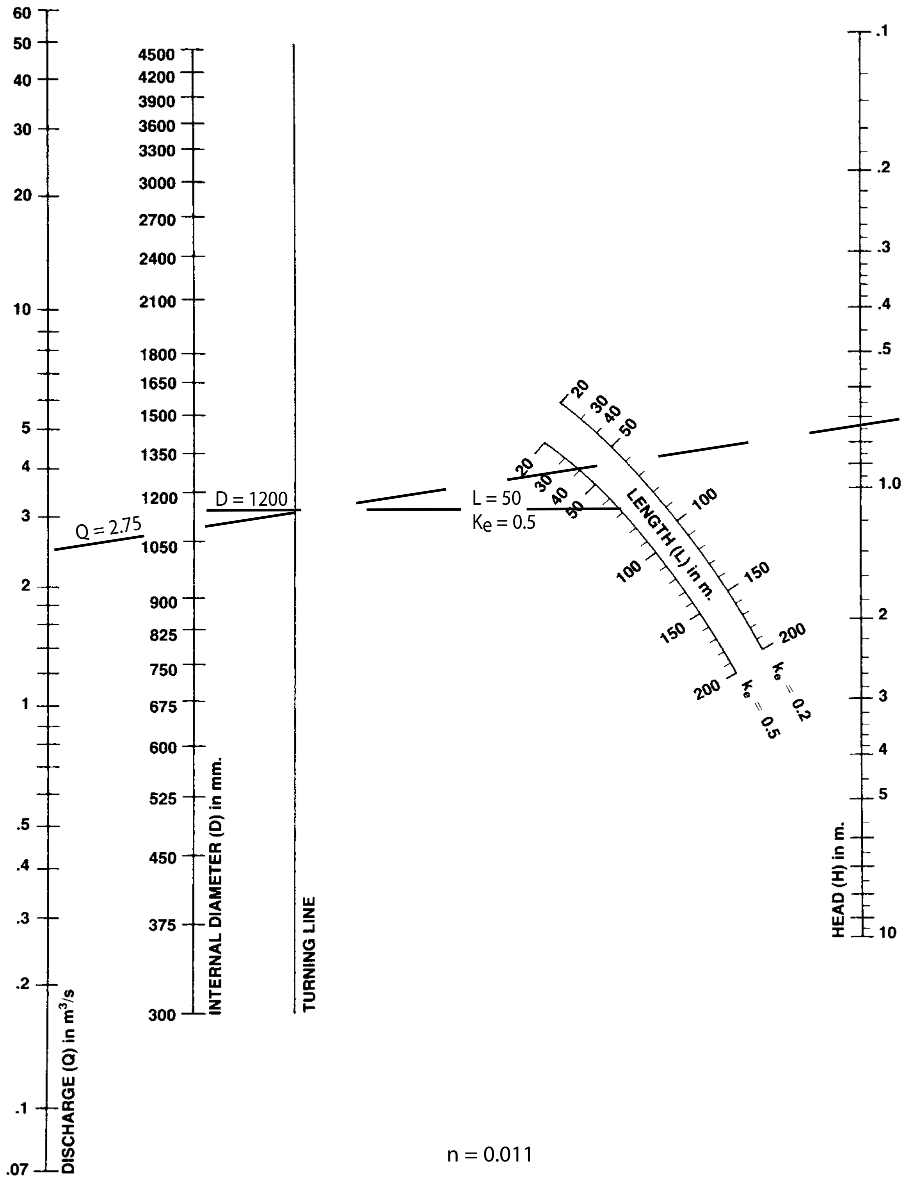


Figure C8, Flow Relationships for Outlet Control in Culverts

Culvert Pipe Example continued

From inlet condition chart using 'square edge with headwall' (i.e. k_e = 0.5);
Q = 3.0 cumecs > Q required

From inlet control conditions for Q=2.75 cumecs
HW/D = 1.25
Therefore HW = 1.5m
Check for outlet control conditions

Proposed 2/1200 mm diameter pipes from inlet conditions

Determine critical flow depth (dc)

$Q/\sqrt{g} / D2.5 = 2.75/\ \sqrt{9.81} / 1.2^{2.5} = 0.557$
from Figure C4, Page 12, dc/D = 0.75
dc = 0.90m
(dc + D) / 2 = (0.9 + 1.2) / 2 = 1.05 > TW (=1.0m)
then adopt TW = 1.05m

From outlet condition chart, for Q = 2.75 cumecs, H = 0.65m then
HW = (dc + D) / 2 + H - fall = 1.05 + 0.65 - 0.5 =1.20m

Since for inlet conditions HW (=1.50m) is greater than for outlet conditions, then inlet control governs.

Determine Flow Velocity

Hydraulic grade = (1.5+0.5-1.0) in 50m i.e. 0.02

Adopt ks = 0.6, from Figure D4, Page 18

Vf = 5.2 m/sec, Qf = 6.0 cumecs
from Figure C5, Page 9

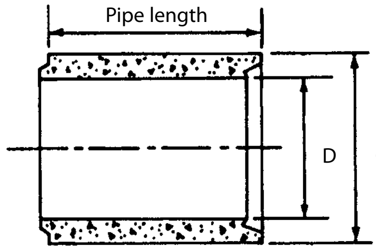
Q / Qf = 2.75 / 6.0 = 0.46 therefore V / Vf = 0.97
Therefore V = 5.0 m/sec
also Y/D = 0.46 therefore Y = 0.55m < dc (=0.90m)

Since the flow depth is less than the critical depth, a hydraulic jump may occur at the culvert outlet if the downstream channel flow is not supercritical. Erosion protection at the culvert outlet may be necessary.

FLUSH JOINT PIPES
DN225 - DN3600

Table C3 : Actual Internal Diameter D (mm), Outside Diameter OD (mm) and Pipe Mass (kg)

Standard-Strength: Class 2 - Class 4
Super-Strength: Class 6 - Class 10
Standard Range: DN225 - DN2100
Pipe Length (nom): 2.44m except where indicated*.
Other lengths are available on request.



Flush Joint Pipe

Note : Pipe mass based on concrete density of 2500kg/m^3

Load Class	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10		Load Class
Size Class (DN)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	Pipe OD (mm)
225	229	125	229	125	229	130							279
300	300	205	300	205	300	210	290	235	280	260	268	295	362
375	375	280	375	285	375	290	363	330	355	360	343	395	445
450	450	400	450	405	450	415	444	445	438	465	418	545	534
525	534	465	518	545	502	625	502	625	502	630	486	705	616
600	610	565	600	625	586	705	586	710	570	800	554	885	698
675	685	690	679	735	661	850	661	860	637	1005	615	1135	781
750	762	815	756	865	730	1045	730	1055	714	1170	682	1385	864
825	838	945	832	1000	806	1205	806	1215	782	1400	754	1605	946
900	915	1090	903	1200	883	1370	883	1390	851	1655	795	2085	1029
1050	1066	1420	1054	1550	1026	1830	1026	1855	966	2430	926	2775	1194
1200	1219	1775	1207	1925	1179	2245	1171	2355	1109	3045	1059	3580	1359
1350	1372	2165	1360	2340	1332	2700	1292	3230	1242	3830	1202	4335	1524
1500	1524	2405	1504	2710	1468	3245	1424	3860	1374	4590	1324	5230	1676
1650	1676	2885	1656	3220	1620	3820	1576	4495	1516	5450	1476	6065	1842
1800	1828	3375	1808	3745	1772	4400	1718	5295	1668	6200	1628	6855	2006
1950	1994	4200	1982	4515	1944	5225	1904	5980	1834	7340	1794	8040	2198
2100	2160	5215	2136	5655	2110	6205	2050	7535	1990	8715	1960	9335	2388
2250*	2250	8140											2530
			2250	8775	2250	9165							2550
							2250	14195					2718
									2250	15050			2742
											2250	18640	2850
2400*	2438	8795											2718
			2438	9640									2742
					2438	10850							2768
							2438	20620	2438	20715	2438	20855	3060
2700*	2700	11460	2700	11585									3030
					2700	13115							3060
							2700	21250	2700	21340	2700	21490	3410
3000*	3060	13750											3410
			3060	15835	3060	16510							3460
							3060	32700	3060	32800	3060	32950	4010
3300	3300	21110	3300	21240	3300	21350							3900

D. CONCRETE STORMWATER PIPES

Humes can provide a comprehensive range of steel reinforced concrete stormwater pipes indiameters from DN225 to DN3600 (standard range DN225 to DN2100).

Rubber Ring Joint (RRJ) pipes are recommended for stormwater drainage systems, although Flush Joint (FJ) pipes can also be used under some circumstances.

RRJ pipes up to DN1800 are supplied with a belled socket joint, while those larger than DN1800 aresupplied with an in-wall joint (see Figures D1 & D2)

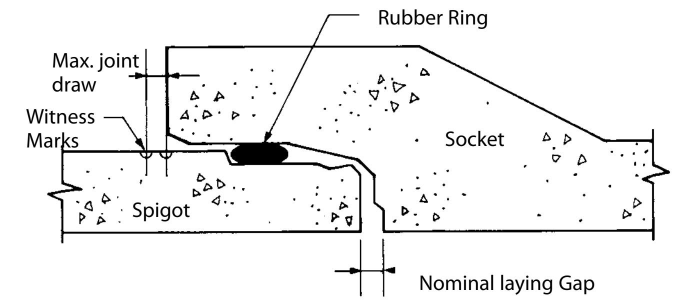


Figure D1, RRJ Pipe with Belled Socket Joint

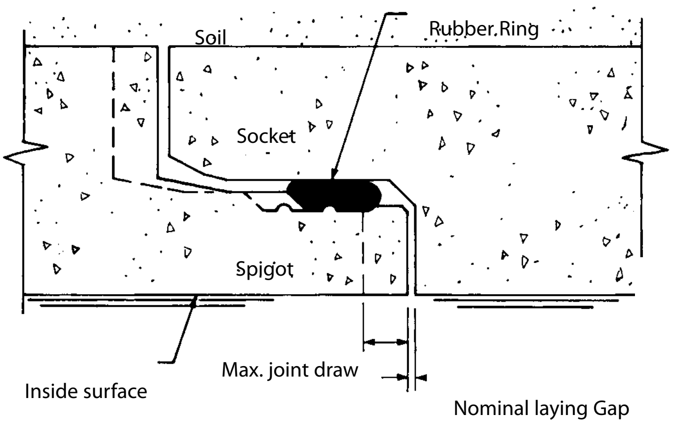


Figure D2, RRJ Pipe with In-wall (Skid) Joint

Rubber Ring Joint (RRJ)

Rubber Ring Joints provide concrete pipes with a high degree of flexibility to accommodate ground settlement or deflections.

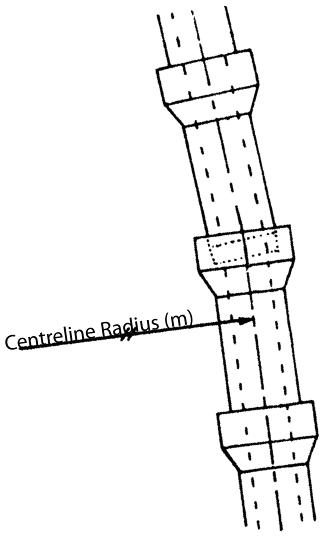
The RRJ profile is designed for ease of installation, and allows curved alignment adjustments while maintaining a watertight joint capable of withstanding the common levels of hydraulic head occurring in a storm water pipeline.

Table D1 presents the minimum radius for curves in the pipeline for the standard range of pipes. Details on other sizes can be obtained by contacting Humes.

Size Class (DN)

See Tables D2 & D3 on pages 15 & 16 for details.

Rubber Ring Joint drainage pipes - note the trench construction to ensure a stable worksite.



Size Class (DN)	Radius (metres)
300	70
375	70
450	105
525	135
600	150
675	170
750	230
825	275
900	170
1050	230
1200	240
1350	275
1500	230
1650	275
1800	85
1950	230
2100	170

Table D1, Minimum Centreline Radius Based on sizes available in most locations

RUBBER RING JOINT PIPES
DN225 - DN1800

Table D2 : Actual Internal Diameter D (mm),
Socket Dimensions (A,G & H),
Outside Diameter OD (mm) and Pipe Mass (kg).

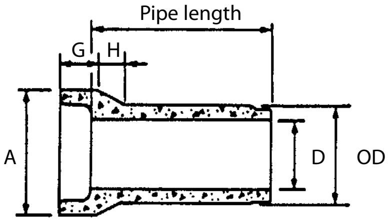
Standard-Strength: Class 2 - Class 4
Super-Strength : Class 6 - Class 10
Standard Range: DN225 - DN1800
Pipe Length:(nom) 2.44m.
Pipes available in most areas indicated by bold type.
Other lengths are available on request.

Note : Pipe mass based on concrete density of 2500kg/m^3

For most Size Classes of Rubber Ring Joint Pipe, thestandard size is complemented by alternatives.

These additional sizes have restricted availability and Humes should be consulted by the designer to confirm their supply status.

Rubber Ring Belled Socket Joint Pipe



Load Class	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10		Socket Dimensions (A,G & H)			Load Class
Size Class (DN)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	A (mm)	G (mm)	H (mm)	Pipe OD (mm)
225	229	110	229	110	229	110							362	89	83	279
	229	135	229	140	229	140							368	108	95	293
225	229	220	229	220	229	220							394	114	114	305
	229	240	229	240	229	240							406	114	114	311
300	300	220	300	220	300	240	290	250	280	280	268	310	451	76	89	362
	304	280	304	280	304	280	304	285	298	305	284	340	470	114	114	381
	300	370	300	375	300	375	300	375	300	380	300	380	508	114	114	400
375	375	305	375	310	375	315	365	345	351	395	343	420	540	80	95	445
	381	340	381	345	381	345	375	370	361	425	357	430	546	114	114	457
	380	545	380	545	380	545	380	545	380	545	380	550	622	121	133	496
450	450	435 4	50	440	450	450	444	480	438	500	418	580	622	114	114	534
	450	605	450	610	450	615	450	615	450	615	444	640	694	147	116	560
	457	800	457	805	457	805	457	805	457	810	457	810	749	133	190	597
525	534	515	534	595	502	675	502	680	502	685	486	755	711	133	133	616
	534	650	534	650	534	655	534	665	524	715	510	785	762	133	133	636
	530	880	530	880	530	880	530	890	530	895	530	895	822	140	133	666
600	610	625	610	685	586	765	586	770	570	860	554	945	797	133	133	698
	610	815	610	820	610	820	610	830	600	895	578	1015	851	133	133	724
	610	1130	610	1135	610	1135	610	1140	610	1145	610	1150	932	143	152	762
675	685	760	685	805	661	920	661	930	645	1030	615	1205	886	133	133	781
	680	845	680	855	680	860	670	930	648	1070	616	1255	915	176	113	784
	680	1175	680	1180	680	1185	680	1190	680	1200	656	1350	988	196	146	820
750	760	940	760	985	736	1170	728	1125	712	1290	680	1500	997	143	152	864
	750	955	750	1000	750	1010	734	1125	710	1295	680	1485	996	196	118	680
	762	1145	762	1150	762	1160	762	1170	738	1340	706	1560	1033	143	152	890
	762	1380	762	1385	762	1390	762	1395	762	1405	762	1630	1084	143	152	914
825	838	1050	838	1105	806	1305	806	1320	782	1500	748	1745	1064	146	146	946
	830	1200	830	1210	830	1215	814	1350	782	1590	750	1825	1098	196	128	950
	838	1410	838	1420	838	1425	838	1445	814	1635	782	1875	1149	171	149	978
900	910	1415	910	1425	898	1535	898	1555	862	1850	800	2335	1197	152	152	1042
	900	1425	900	1435	900	1445	884	1595	852	1855	790	2335	1190	215	138	1040
	915	2030	915	2035	915	2040 9	15	2055	915	2075	851	2600	1302	178	259	1093
1050	1070	1895	1070	1910	1050	2115	1038	2250	990	2725	950	3075	1391	171	149	1220
	1050	1790	1050	1800	1050	1820	1018	2140	960	2695	920	3035	1364	215	151	1190
	1066	2335	1066	2345	1066	2355	1066	2380	1010	2930	966	3340	1454	178	259	1244
1200	1220	2175	1220	2195	1187	2555	1180	2695	1120	3360	1070	3905	1543	171	149	1372
	1200	2190	1200	2210	1194	2300	1160	2685	1090	3435	1040	3970	1540	215	165	1350
	1200	3275	1200	3290	1200	3300	1200	3325	1160	3775	1110	4345	1670	210	215	1420
1350	1370	2460	1370	2610	1330	2995	1300	3400	1240	4115	1200	4630	1695	171	149	1524
	1350	2690	1350	2715	1344	2810	1286	3555	1230	4210	1190	4720	1710	230	170	1514
1500	1524	3550	1524	3575	1504	3905	1460	4515	1404	5335	1354	5990	1937	194	292	1714
1650	1676	3890	1676	3925	1644	4470	1606	5065	1546	6045	1486	6915	2089	194	292	1866
1800	1828	4450	1828	4495	1796	5085	1748	5900	1668	7285	1608	8220	2267	194	203	2032

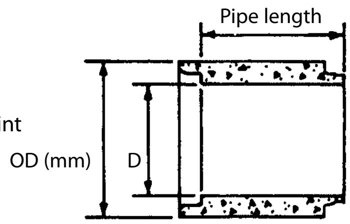
RUBBER RING IN-WALL JOINT PIPES DN1200 - DN3600

Note : Pipe mass based on concrete density of 2500kg/m^3

Table D3 : Actual Internal Diameter D (mm), Outside Diameter OD (mm) and Pipe Mass (kg)

Standard-Strength: Class 2 - Class 4
Super-Strength: Class 6 - Class 10
Standard Range: DN1200 - DN3600
Pipe Length (nom): 3.0m except where indicated* is 2.44m
Other lengths are available.

Rubber Ring In-wall Joint Pipe

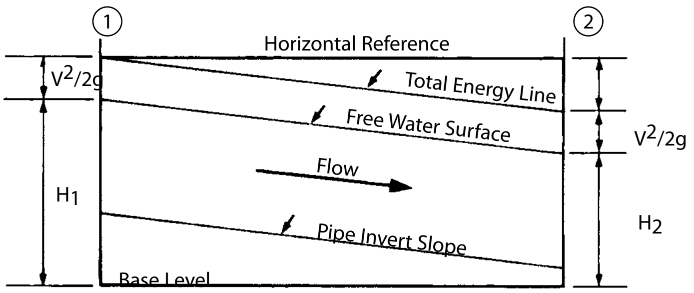


Load Class	Class 2		Class 3		Class 4		Load Class
Size Class (DN)	D (mm)	Mass (kg)	D (mm)	Mass (kg)	D (mm)	Mass (kg)	Size Class OD (mm)
1200*	1280	2985	1280	3005	1280	3025	1500
1950*	1950	5515	1950	5540	1950	5580	2220
2100*	2100	6340	2100	6370	2100	6415	2388
2250	2250	8795	2250	8880			2550
					2250	11925	2650
2400	2438	9575	2438	9660			2742
					2438	10895	2768
2700	2700	11505	2700	11590			3030
					2700	13175	3060
3000	3060	13795	3060	15875			3410
					3060	16585	3460
3300*	3300	21110	3300	21240	3300	21350	3900
3600*	3600	20165	3600	20220	3600	20320	4130

Load Class	Class 6		Class 8		Class 10		Load Class
Size Class (DN)	D (mm)	Mass (kg)	D (mm)	Mass (kg)	D (mm)	Mass (kg)	Size Class (DN)
1200*	1260	3285	1240	3545	1200	4015	1500
1950*	1894	6715	1830	7850	1780	8760	2220
2100*	2068	7265	2000	8585	1920	10055	2388
2250	2250	12120					2550
			2250	15050			2742
					2250	18640	2850
2400	2438	20620	2438	20715	2438	20855	3060
2700*	2700	21250	2700	21340	2700	21490	3410
3000*	3060	32700	3060	32800	3060	32950	4010

Hydraulics

Generally, a stormwater pipeline system is designed so that the hydraulic gradeline is at or below the level of the line joining the upstream and downstream manhole surfacelevels as shown in Figure D3.



$$H_1 + V^2/2g = H_2\ V^2/2g + H_{friction}$$

Figure D3, Uniform Flow Conditions

The loss of energy head in the pipeline is the aggregate of elevation, exit velocity and friction head losses. Of these, normally only elevation and friction head losses are major considerations.

The flow of water in a stormwater pipeline operating full or with minor energy head is determined from the hydraulic gradient in the pipeline.

For determining head loss in a stormwater pipeline, the Colebrook-White formula is recommended and a roughness height (k_s) of 0.6mm is likewise recommended.

Figure D4 gives the capacity and flow velocity of a pipeline flowing with an established hydraulic grade. Alternatively, available energy head can be used to determine the required pipe size for a given flow discharge.

Figure C5 on page 9 for part-full flows is given in Section C, Concrete Culvert Pipes and can be used to determine part-flow depth, velocity and discharge in a pipeline.

Although a value of k_s = 0.6mm is recommended, where the stormwater system is located in a fully developed urban environment, this reasonably conservative value, which is determined from the combined effects of pipe surface and solid material carried in the flow, may be reduced to 0.15mm, considerably increasing the flow capacity where appropriate (see Figure D5).

Use of the flow chart in determining flow conditions is illustrated in the example given beneath the charts.

Load Class

Humes concrete stormwater pipes are available in Standard-Strength (Class 2-4) and Super-Strength (Class 6-10) Load Classes.

The most appropriate stormwater pipe installation can be obtained by matching both pipe Load Class and the Bedding Support Type. For the majority of installations, Standard-Strength concrete stormwater pipes used in conjunction with Type H2 or Type HS2 Bedding Support, are suitable.

For large fill situations, a combination of Super-Strength pipes and Type HS3 Bedding Support can provide the most appropriate and economical solution.

Further information on the Load Class of concrete pipes can be obtained by referring to Section A, Introduction.

Installation

All Humes RRJ belled socket pipes are supplied with laying witness marks indicated in the RRJ profile for easy control of the deflected joint.

Note, Humes concrete stormwater pipes are normally supplied with elliptical grid reinforcement, unless a circular grid is specifically requested. Elliptical grid reinforced pipes must be laid with the word "TOP" at the crown (or invert) of the pipe and within 10° each side of the vertical centreline.

To simplify handling, lifting anchors can be provided if requested in heavy large size RRJ pipes, and for RRJ pipes DN1800 and over, Humes provides a special rubber ring lubricant to assist joining.

See Section J: Handling and Installation for further details.

Large diameter Rubber Ring Joint Pipe installation at Goolwa - S.A.

Other Stormwater Products

Humes manufactures a wide range of associated components to provide the complete stormwater drainage system.

These include precast manholes, drop inlets, side entry pits, bends, tees and junctions, as well as stormwater pits.

With the ever increasing need to responsibly manage a healthy environment, Humes have developed atechnically advanced portfolio of stormwater quality management products.

Humeceptor non-scouring sediment and oil interceptor targets priority fine sediments, which transport nutrients and toxicants, close to where they are generated, protecting local creeks, wetland habitats and wildlife as well as downstream rivers, bays and oceans. Humeceptor is proven to capture as much as 90% of ALL sediment (including the material less than 100 microns which is of most concern), 97.8% of free oils and significant quantities of other materials lighter than water (eg. cigarette butts, polyester beads, plastic food wrappers etc)

Humegard in-line gross pollutant traps been designed to trap a range of gross pollutants including plastics, aluminum, waxed packaging, drink containers, cigarette buttts, syringes, polystyrene, paper and coarser-grained sediment (150 microns+). Laboratory and field testing has proven capture rates up to 100% for gross pollutants prior to by-pass and up to 85% on an annualised basis, allowing for periods of high flow by-pass.

k_s=0.6mm

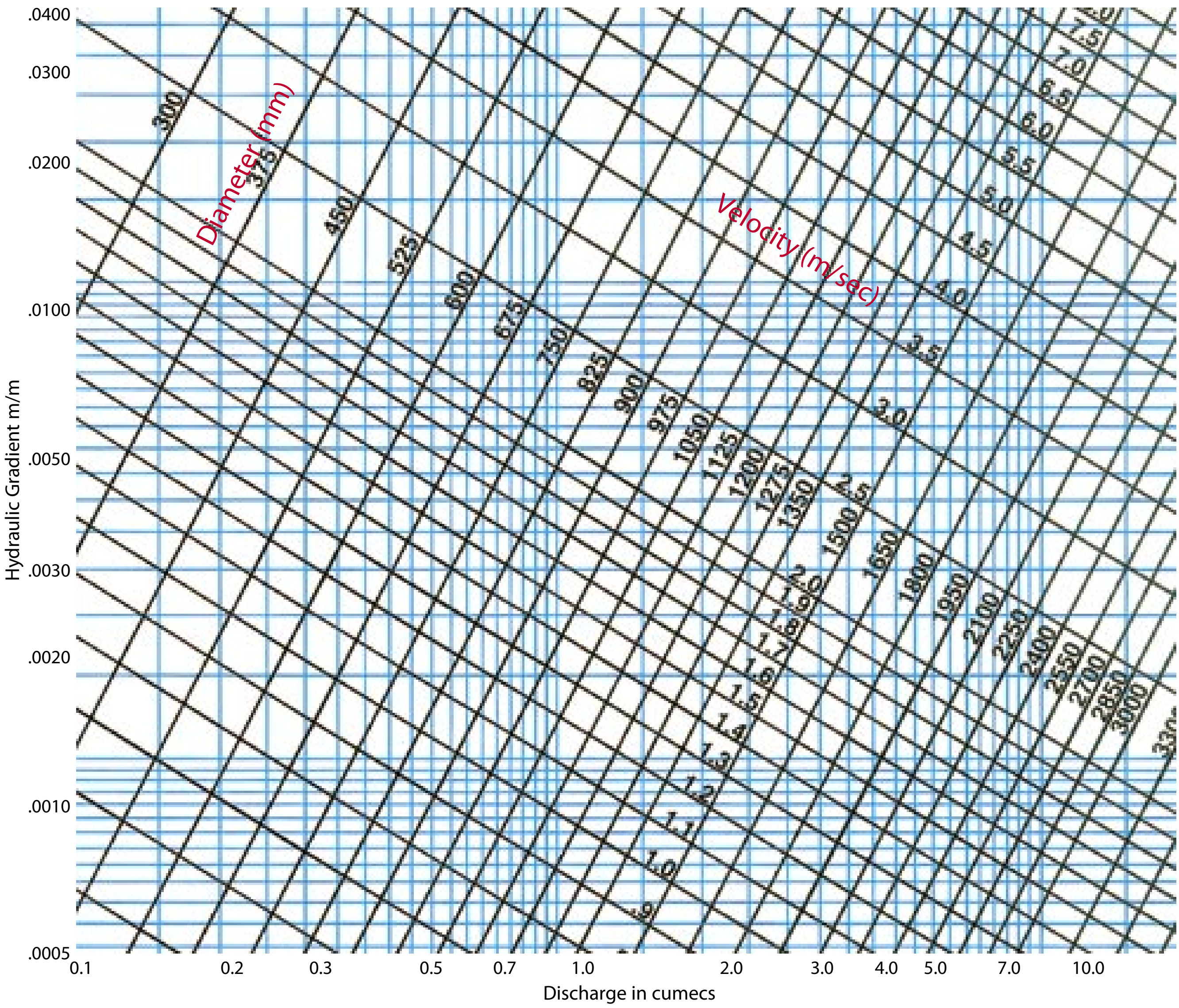


Figure D4, Full Flow Conditions Colebrook-White Formula k_s=0.6mm

Stormwater Pipe Example

A stormwater drainage pipeline is proposed to service a new industrial development in Sydney. The new pipeline is to connect into an existing system at an existing downstream manhole. The total catchment area of 4 hectares is to be sealed with an estimated coefficient of run off 0.9. The estimated time for the total catchment to be contributing to the outflow discharge is 30 minutes. The pipeline length is 80 metres and a minimum 600mm dia pipe is specified for maintenance. A minimum design life of 50 years is required.

From Table C1, Page 7,
I_{50} = 100mm/hr for 30 min storm duration

Q = 2.78 x 0.9 x 100 x 4 = 1.0 cumec

From Figure D4 for 1.0 cumec and 600mm dia pipe,

Hf = .021 x 80 = 1.68m

Vf = 3.55m/sec

Hv = V^2 / 2g = 0.64m
An evaluation of the existing system confirms the total energy head at the downstream pit to be 0.5m.

k_s=0.15mm

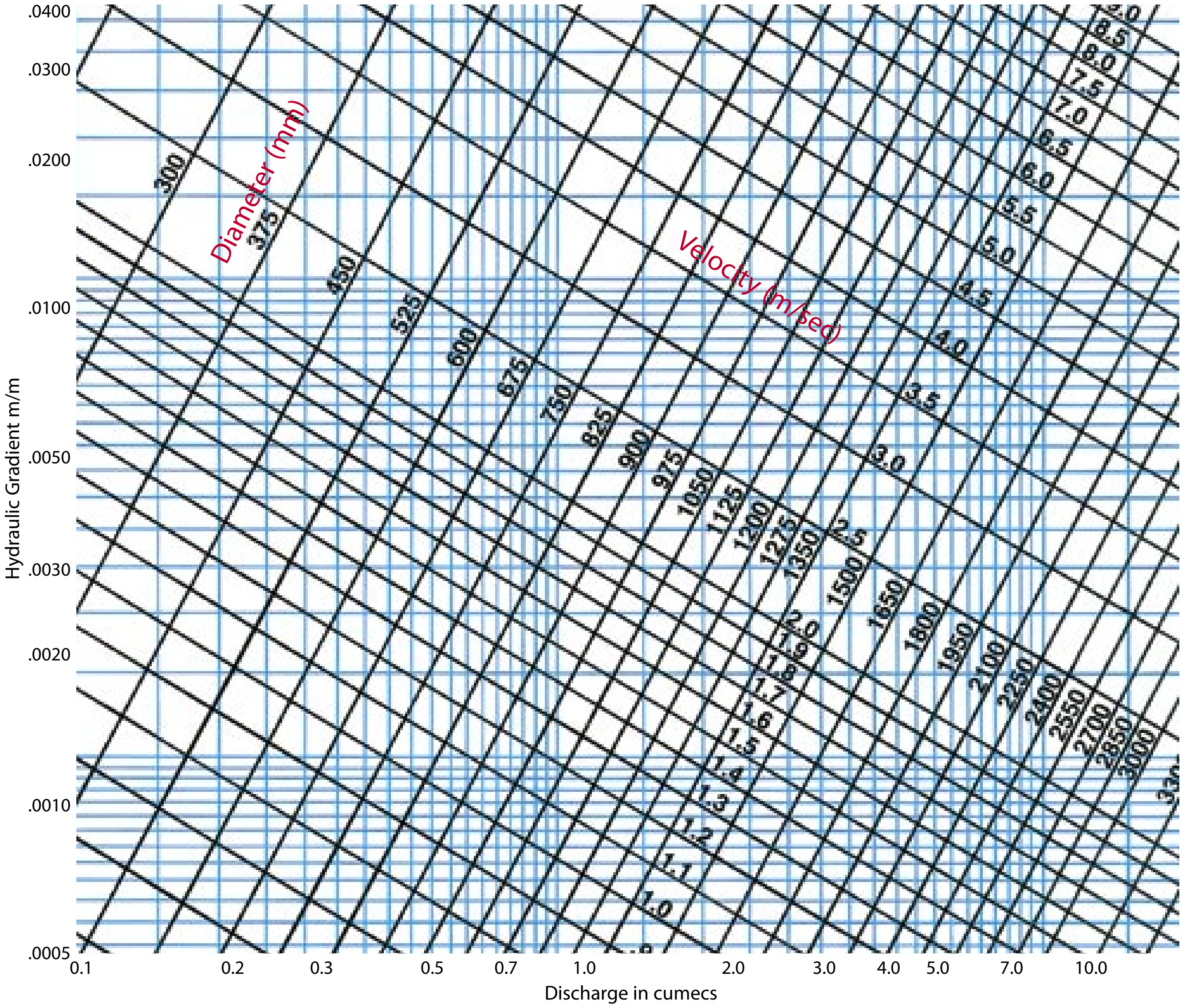


Figure D5, Full Flow Conditions Colebrook-White Formula k_s=0.15mm

Total energy head at upstream end of new pipeline is

HT = Hf + Hv + H d/s
= 1.68 + 0.64 + 0.5 = 2.82m

The pipeline upstream invert level to be a minimum 2.82m below finished surface level.

Alternatively, a 750mm dia pipe and 1.0 cumec

Hf = 0.0068 x 80 = 0.54m
Vf = 2.3m/sec
Hv = 2.3^2 / 2g

At upstream end of new pipeline

HT = 0.54 + 0.27 + 0.5
= 1.31m

NOTE : The existing system should be analysed to determine the hydraulic effect on the system due to the new pipeline addition. A longitudinal profile of the total stormwater system's hydraulic effects is recommended.

E. CONCRETE SEWERAGE PIPES

Humes can provide a comprehensive range of steel reinforced concrete sewerage pipes in diameters from 225mm to 3600mm (standard range DN225-DN2100).

Rubber Ring Joint (RRJ) pipes are recommended for sewerage applications.

RRJ pipes up to DN1800 are supplied with a belled socket joint, while those larger than DN1800 aresupplied with an in-wall joint (see Figures D1 & D2 on page 14).

Sewerage Pipes

In conjunction with sewerage system designers, Humes engineers have developed a range of concrete sewerage pipes to economically minimise or eliminatenoxious gas effects which can exist in sewer pipeline systems.

Humes has available proven design methods which can assist the systems designer to investigate thepossibility of sulphide build-up in the system.

Where the system design cannot avoid sulphide generation, Humes manufactures a number of sewerage pipes incorporating special features.

These include:

Plastiline™ sheeting - A chemically inert material, developed by Humes research scientists, is mechanically fixed to the pipes internal surface during the manufacturing process, as shown in Figure E1, to give complete protection against chemical attack on the pipe surface.

The sheeting need only be applied to the pipe's internal surface above the low flow level during normal operating conditions.

Calcareous aggregate - This provides added protection by inhibiting the progress of chemical attack and is used in either the concrete cover to reinforcement or the sacrificial layer.

Sacrificial layer concrete - An internal surface layer of concrete additional to the normal 10mm cover to reinforcement in concrete pipe, as shown in Figure E1.

The sacrificial layer is designed to gradually chemically corrode during the life of the pipe.Humes' Engineers can determine the required thickness by analysis of the system. The corrosion process leaves the pipe structurally sound at the end of its design life, making it possible for the service life of the pipeline to be reassessed and possibly extended.

Additional cover to reinforcement - The extra cover gives added protection where the systems designer has little or no information to carry out a detailed pipe-system analysis.

A summary of these various treatments follows and provides a set of general guidelines.

When in doubt, the designer should contact Humes for a specific analysis of the pipeline's operating conditions.

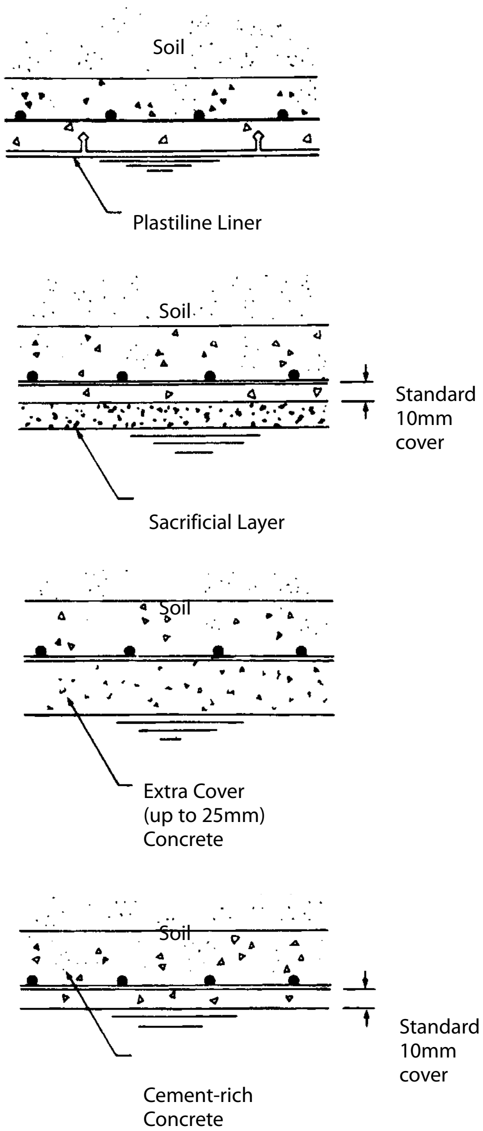


Figure E1, Sewer Pipe Types

2250mm diameter Plastiline™ Pipes in Western Australia.

Summary of Pipe Types

Type 1: Standard Sewer Pipe

With a minimum cementitious content of 400 kg/cu m, standard sewer pipes are adequate for most properly designed sewer systems.

Type 2: Extra cover to reinforcement

The cover to reinforcement can be increased from 10mm in standard sewer pipes to up to 25mm. Commonly specified for sewer systems with insufficient data on future flowcharacteristics.

Will lengthen life by up to 2 times.

Type 3: Sacrificial layer

Typically 5-15mm thick, sacrificial layers are suitable when future flow forecast data is available.

Will lengthen life by up to 3 times.

Type 4: Calcareous aggregate

Used with Type 2 or Type 3 to further increase resistance to corrosion.

Will lengthen life by up to 5 times.

Type 5: Plastiline™

Inert liner which provides fail-safe approach in highly aggressive environments.

Ensures minimum 120 year life.

Rubber Ring Joint (RRJ)

Humes RRJ pipes are designed to provide a waterproof seal against infiltration in to the system and exfiltration of sewerage into groundwater.

The joint seal is designed against a minimum 9m head (90KPa), internal and external, and the joint configuration allows for watertightness to be maintained even when normal settlements cause joint deflections in the pipeline. Pipeline installers can use this joint deflection to maintain line and level of the pipeline.

See Table D1 on page 14 for details of the minimum radius for RRJ pipelines.

Humes RRJ pipes used in sewerage pipelines are supplied with natural rubber rings with root inhibitor which prevents vegetation roots from entering the system.

Plastiline™ installed in pipe at moulding stage.

Size Class (DN)

RRJ pipes with Plastiline Sheeting are readily available in sizes of DN600 and above. However, Plastiline pipes can be supplied in sizes down to DN300.

Where corrosion protection is added to the pipe in the form of a sacrificial layer or extra cover, the internal bore of the pipe is reduced and designers need to include thisreduction in the waterway area in their hydraulic design.

The diameter reduction is generally 20mm to 40mm, depending on the system and its design life requirements.

See Tables D2 & D3 on pages 15 & 16 for details of Size Class (DN) availability.

A sewerage pipe (Plastiline™) installation in Western Australia.

Load Class

Humes concrete sewerage pipes are available in Standard-Strength (Class 2-4) and Super-Strength (Class 6-10) Load Classes.

The most appropriate pipeline installation can be obtained by matching both pipe Load Class and the Bedding Support Type.

For the majority of installations, Standard-Strength concrete sewerage pipes used in conjunction with Type H2 or Type HS2 Bedding Support, are suitable.

For large fill situations, a combination of Super-Strength pipes and Type HS3 Bedding Support can provide the most appropriate and economical solution.

Further information on the Load Class of concrete pipes can be obtained by referring to Section A, Introduction.

Hydraulics

The hydraulic design for each section of the sewage pipeline system investigates both peak and minimum flows in the line.

Peak flows in the system determine the pipe size, the pipe size should then be checked to ensure that at minimum flows the sewage flow velocity does not fall below the self-cleansing velocity.

Gravity flows in a sewage pipeline between manholes are designed hydraulically by considering pipe friction losses and any flow disturbance losses at inlets, outlets, bends and junctions in the pipeline.

Losses due to flow disturbances should be minimal since the designer should eliminate these as part of the campaign against hydrogen sulphide generation.

Frictional losses along the pipeline are based on the Colebrook-White formula, using a recommended roughness height k_s value of 1.5mm (see Figure E2). This chart also indicates minimum velocities for slime control and the self-cleansing velocities.

The flow discharge and velocity given is for the pipeline running full. The values can be adjusted for a pipelinerunning part-full by referring to Figure C5 on page 9 for part-full flow conditions.

Class 4 Pipes with Sacrificial Layer.

Installation

All Humes RRJ pipes are supplied with laying witness marks indicated in the RRJ profile for easy control of the deflected joint (see Figure D1, Page 14).

Humes concrete sewerage pipes are normally supplied with elliptical grid reinforcement, unless a circular grid is specifically requested.

Elliptical grid reinforced pipes must be laid with the word "TOP" at the crown (or invert) of the pipe and within 10° each side of the vertical centreline.

To simplify handling, lifting anchors can be provided if requested in heavy large size RRJ pipes and for RRJ pipes DN1800 and over, Humes provides a special rubber ring lubricant to assist jointing.

See Section J, Handling and Installation for further details.

Sewerage pipe (Plastiline™) during installation.

Associated Products

Humes manufactures the entire range of products for a sewage reticulation system including precast manhole systems with a range of precast shape bases, pipe tees and junctions and short length pipes.

Wedge ring manholes provide a seal against groundwater infiltration and can accommodate normal joint deflections caused by ground consolidation. Precast concrete pumpwells are also available in a range of sizes up to DN3600 and are specifically designed for sewerage applications.

Vacuum testing of Access Chamber.

A precast pump station.

Cylindrical Capacity (Litres) based on flush joint pipe, Load Class 2.

DN mm	Length of Pipe (metres)														
	0.2	0.4	0.6	0.8	1.0	1.2	1.22	1.4	1.6	1.8	1.83	2.0	2.2	2.4	2.44
300	15	29	44	58	73	87	89	102	116	131	133	145	160	174	177
375	23	47	68	91	114	137	139	160	182	205	209	228	251	274	278
450	33	66	98	131	164	197	200	230	262	295	300	328	361	394	400
525	45	90	134	179	224	269	273	314	358	403	410	448	493	538	547
600	59	117	175	234	292	351	357	409	468	526	535	585	643	701	713
675	74	147	221	295	369	442	450	516	590	663	676	737	811	885	899
750	91	182	274	365	456	547	556	639	730	821	835	912	1003	1095	1113
825	110	221	331	441	552	662	673	772	883	993	1009	1103	1213	1324	1346
900	131	263	394	525	657	788	801	919	1050	1182	1202	1313	1445	1576	1602
1050	179	358	536	715	894	1073	1090	1251	1430	1608	1636	1788	1966	2145	2180
1200	234	467	701	934	1168	1401	1425	1635	1869	2102	2137	2336	2569	2802	2849
1350	295	591	887	1182	1478	1773	1803	2069	2364	2660	2704	2955	3251	3546	3605
1500	365	730	1094	1459	1824	2189	2225	2554	2919	3283	3338	3648	4013	4378	4451
1650	441	883	1324	1766	2207	2649	2693	3090	3532	3973	4039	4414	4856	5297	5386
1800	525	1051	1576	2101	2627	3152	3205	3677	4203	4728	4807	5254	5779	6304	6409
1950	617	1233	1850	2466	3083	3699	3761	4317	4933	5549	5632	6166	6782	7399	7522
2100	715	1430	2145	2860	3575	4290	4362	5005	5721	6436	6543	7151	7866	8581	8724

k_S=1.5mm

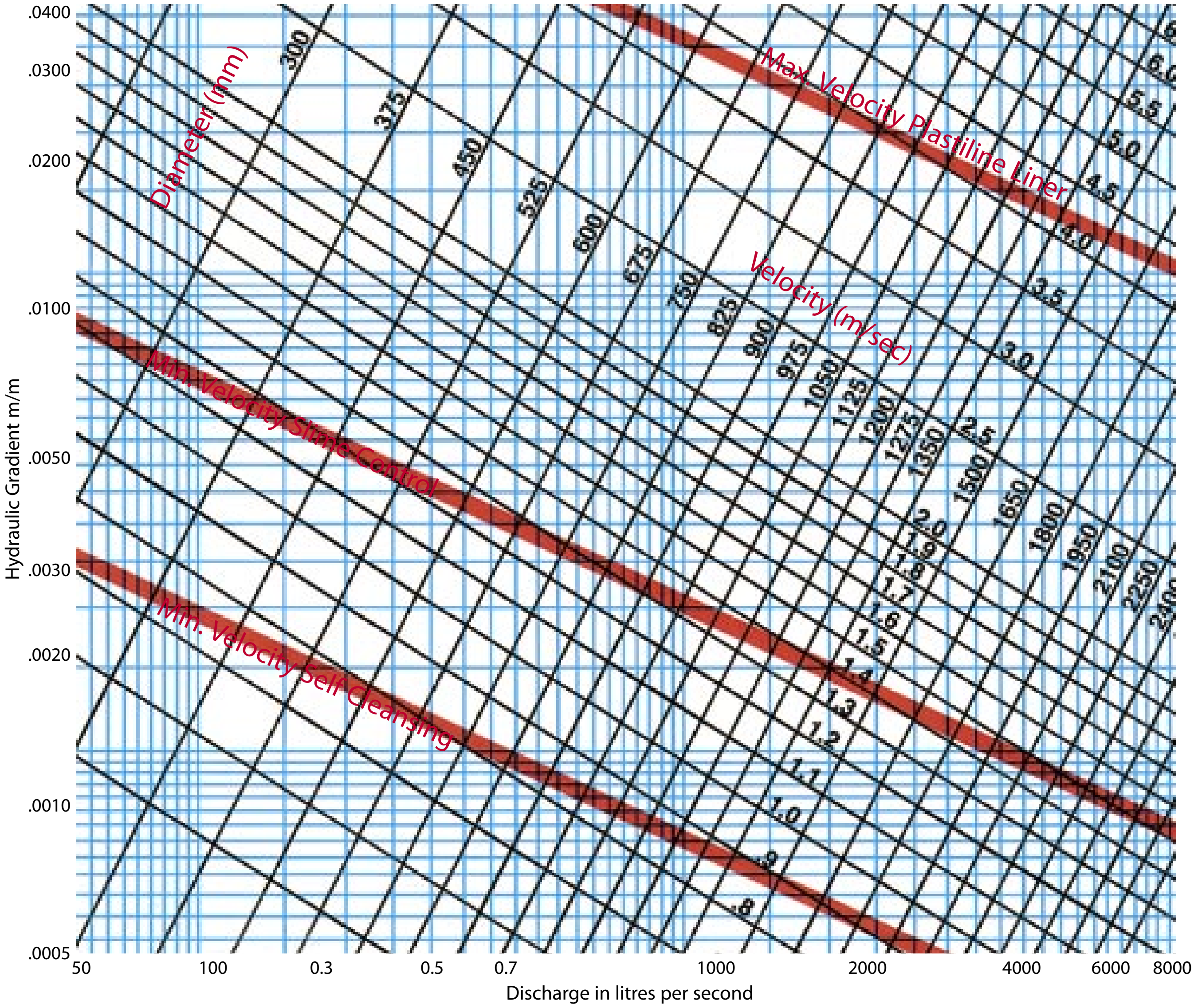


Figure E2, Full Flow Conditions Colebrook-White Formula k_S=1.5mm

Sewerage Pipe Example

A gravity sewer main is proposed to serve a new residential development. The development is for medium density population over an area of 500 ha.

For medium density residential, adopt average dry weather flow, 0.2 litres/sec/ha

therefore average dry weather flow

= 0.2 x 500 = 100 l/sec

For peak wet weather flow, adopt a factor of 2.5 on average dry weather flow. Also, for new residential development, add an allowance of 0.6 litres/sec/ha for infiltration.

Therefore peak wet weather flow = (100 x 2.5) + (0.6 x 500) = 550 l/sec

During the developmental stage of the new estate, a period of low density population will exist. For this period, adopt low density flow of 0.13 litres/sec/ha

Therefore minimum short-term dry weather flow = 0.13 x 500 = 65 l/sec

Summary design parameters

Minimum average dry weather flow 65 l/sec
Average dry weather flow 100 l/sec
Peak wet weather flow 550 l/sec

For concrete pipe with sewage flows k_S = 1.5 mm is recommended.

From Figure E2, for peak wet weather flow 550 l/sec, try DN525 pipe.

Hydraulic gradient (s) = 0.0155
Full flow velocity (Vf) = 2.5m/sec
Minimum velocity slime control = 1.22m/sec
Minimum velocity self cleansing = 0.78m/sec

Adopt pipe grade 1 in 75 (0.013) for DN525.

Average dry weather flow velocity
Q/Qf = 100/550 = 0.18

From Figure C5, Page 9, V/Vf = 0.75
therefore V = 1.88m/sec > minimum velocity slime control

Minimum average dry weather flow velocity
Q/Qf = 65/550 = 0.12

From Figure C5, Page 9, V/Vf = 0.68
V = 1.70m/sec > minimum velocity slime control

Adopt DN525 on grade 1 in 75

F. CONCRETE PRESSURE PIPES

Humes can provide a comprehensive range of steel reinforced concrete pressure pipes in diameters from 225mm to 3600mm (standard range DN300-DN1800).

Rubber Ring Joint (RRJ) pipes are recommended for all concrete pressure pipe applications.

RRJ pipes up to DN1800 diameter are supplied with a belled socket joint, while those larger than DN1800 are supplied with an in-wall joint (see Figures D1 and D2 on page 14).

Joint Type

Rubber Ring Joints provide concrete pipes with a high degree of flexibility to accommodate ground settlement or deflections. The RRJ profile is designed for ease of installation, and allows curved alignments or alignment adjustments while maintaining a pressure tight joint seal. Table F1 presents the maximum joint deflections possible for the standard range of pressure pipes. See also Figure F1.

Witness marks are provided to indicate both nominal laying gap and maximum joint deflection.

Where fittings are included in the pipe system, thrust blocks should be provided to prevent lateral or longitudinal movement and separation in the adjacent pipe joint. The magnitude of the thrust force is dependent on the pressure in the pipeline and the deflected angle or restriction to flow.

The design of reinforced concrete pressure pipe systems as described in the Concrete Pipe Association of Australasia publication, "Hydraulics of Precast Concrete Conduits", is recommended to specifiers and designers.

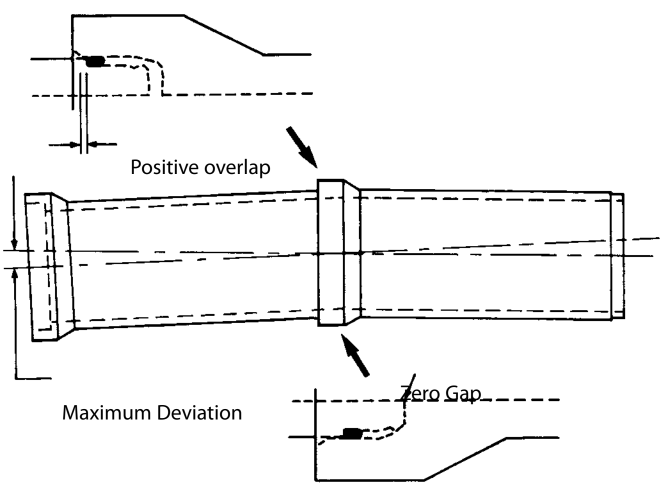


Figure J12, Deflected Joint Details

Figure F1, Deflected Joint Details

Size Class (DN)	Pipe (mould) size (mm) ID x wall	Max. joint deflection degrees
300	304 x 38	1.7
	300 x 50	1.6
375	367 x 34	1.7
	381 x 38	1.5
	380 x 58	1.3
450	446 x 36	1.2
	450 x 42	1.3
	450 x 55	1.6
	457 x 70	1.4
525	534 x 41	1.0
	534 x 51	0.8
	530 x 68	1.3
600	610 x 44	0.9
	610 x 57	0.8
	610 x 76	0.8
675	685 x 48	0.8
	680 x 52	1.2
	680 x 70	1.2
750	760 x 52	0.6
	750 x 55	1.2
	762 x 64	0.7
	762 x 76	0.7
825	838 x 54	0.5
	830 x 60	1.2
	838 x 70	0.7
900	910 x 66	0.8
	900 x 65	1.2
	915 x 89	0.7
1050	1050 x 70	1.1
	1070 x 75	0.6
	1066 x 89	0.6
1200	1200 x 75	1.0
	1200 x 110	1.0
1350	1370 x 77	0.5
	1350 x 82	0.9
1500	1524 x 95	0.6
1650	1676 x 95	0.5
1800	1828 x 102	1.6

Table F1, Pressure Pipe Maximum Joint Deflections - Pipes available in most areas indicated by bold type.

Size Class (DN)

The size class for reinforced concrete pressure pipeswill depend on hydraulic calculations for pressure and discharge.

Humes standard range of reinforced concretepressure pipes are from DN300 to DN1800 diameter (see Tables F2 & F3). Pipe sizes are also available below DN300 diameter and, for these diameters, reduced lengths of 1.22 metres are normally recommended. Pipe diameters above DN1800 can be supplied where required for special projects.

Load/Pressure Class

Reinforced concrete pressure pipes are designed for the combined effects of external load and internal pressure when operating in service. Australian Standard AS 4058 - 1992 "Precast concrete pipes (pressure and non-pressure)" gives a minimum requirement for factory test pressure of 120% of working pressure in the pipeline. Working pressure when specified should include all effects as well as any dynamic surge pressures in the pipeline.

To simulate the combined effects of load and pressure, the corresponding test load for a pressure pipe with a minimum factory test pressure of 120% working pressure is increased above the normal calculated non-pressure value by as much as 182% by the application of the quadratic parabola,

$$T = \frac{W}{F}\left(\frac{P_t}{P_t - P_w}\right)^{1/3}$$

T = test load
W/F = calculated test load
Pt = test pressure
Pw = working pressure

The combination of test pressure and test load can be most economically specified when a balanced condition of their effects is considered in the design. The table for thebalanced conditions of maximum allowable fill height for maximum test pressure is given in Table F4 for stated design and installation conditions.

For the majority of installations, concrete pressure pipes can be installed using Type H2 Bedding Support.

See Section A: Introduction, for further information on the design and installation of concrete pipes.

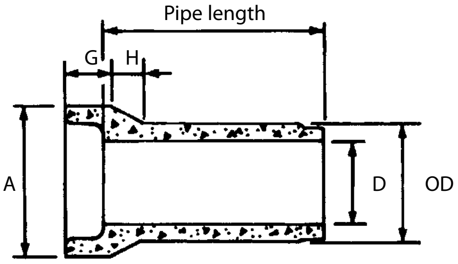


Figure F2, Rubber Ring Belled Socket Joint Pipe

Size Class (DN)	Pipe OD	Socket Dimensions		
		A	G	H
300	380	470	127	77
	400	508	114	114
375	435	516	106	70
	457	546	127	76
	496	622	121	133
450	518	603	127	74
	534	622	127	76
	560	694	147	116
	597	749	113	190
525	616	711	147	82
	636	762	147	109
	666	822	140	135
600	698	797	147	82
	724	851	143	109
	762	932	147	152
675	781	886	176	90
	784	915	196	113
	820	988	143	146
750	864	997	196	152
	860	996	143	118
	890	1034	143	152
	914	1084	146	152
825	946	1064	196	146
	950	1098	196	128
	978	1149	152	149
900	1042	1197	215	152
	1030	1190	196	138
	1093	1302	215	182
1050	1190	1364	196	151
	1220	1391	196	149
	1244	1454	215	182
1200	1350	1540	210	165
	1420	1670	171	215
1350	1524	1695	230	149
	1514	1710	230	170
1500	1714	1937	230	193
1650	1866	2089	230	193
1800	2032	2267	230	204

Table F2, Pressure Pipe Standard Class Range Dimensions - Pipes available in most areas indicated by bold type.

Size Class (DN)	Pressure Class (kPa)					Pipe OD	Pipe Mass 2.44m long
	200	300	400	500	700		
	Internal Diameter (mm) x Wall Thickness (mm)						
300	304 x 38	304 x 38	304 x 38	304 x 38		280	285
					300 x 50	400	390
375	367 x 34	367 x 34	367 x 34	367 x 34		435	300
			381 x 38	381 x 38		457	355
					380 x 58	496	565
450	446 x 36	446 x 36	446 x 36			518	385
			450 x 42			534	450
				450 x 55		560	625
					457 x 70	597	840
525	534 x 41	534 x 41	534 x 41			616	530
				534 x 51		636	680
					530 x 68	666	930
600	610 x 44	610 x 44	610 x 44			698	645
				610 x 57		724	915
					600 x 81	762	1250
675	685 x 48	685 x 48				781	780
			680 x 52			784	880
				680 x 70		820	1225
750	760 x 52	760 x 52				864	960
			762 x 64			890	1195
				762 x 76		914	1290
825	838 x 54	838 x 54				946	1075
			830 x 60			950	1295
				826 x 76		978	1580
900	910 x 66	910 x 66	910 x 66			1042	1470
				899 x 97		1093	2255
1050	1050 x 70	1050 x 70				1190	1840
			1050 x 85			1220	2180
				1050 x 97		1244	2610
1200	1200 x 75	1200 x 75				1350	2260
			1200 x 110	1200 x 110		1420	3435
1350	1370 x 77	1370 x 77				1524	2540
			1326 x 94			1514	3130
1500	1524 x 95	1524 x 95				1714	3655
			1500 x 107			1714	4070
1650	1676 x 95	1676 x 95				1866	4020
1800	1828 x 102	1828 x 102				2032	4600

Table F3, Pressure Pipe Standard Class Range - Pipes available in most areas indicated by bold type. Other Pressure Classes are also available. Note: Pipe mass based on concrete density of 2500kg/m^3

Size Class (DN)	Actual Size D x wall (mm)	Maximum Test Pressure (kPa)	Maximum Fill Height (m)	Size Class (DN)	Actual Size D x wall (mm)	Maximum Test Pressure (kPa)	Maximum Fill Height (m)
300	304 x 38	650	>25		730 x 65	525	8.0
	298 x 41	700	>25		726 x 64	475	7.0
	300 x 50	975	>25		750 x 70	550	19.0
	294 x 53	1050	>25		762 x 76	575	>25
375	367 x 34	550	4.0		750 x 82	625	>25
	357 x 39	575	4.0	825	838 x 54	350	3.5
	381 x 38	525	5.0		832 x 57	400	3.5
	375 x 41	550	7.5		830 x 60	425	4.0
	380 x 58	900	>25		806 x 72	525	15.0
	370 x 63	975	>25		838 x 70	475	8.0
450	446 x 36	450	3.0		814 x 82	600	>25
	436 x 41	475	5.0	900	910 x 66	425	4.5
	450 x 42	450	4.5		898 x 72	475	7.5
	450 x 55	700	>25		900 x 65	425	4.0
	430 x 65	875	>25		880 x 75	500	9.0
	457 x 70	900	>25		915 x 89	575	>25
525	534 x 41	450	4.0	1050	1050 x 70	375	3.5
	518 x 49	550	9.0 1		1018 x 86	500	7.5
	534 x 51	525	9.0		070 x 75	400	4.0
	514 x 61	700	>25		1058 x 81	450	5.0
	530 x 68	750	>25		1066 x 89	475	9.0
	514 x 76	800	>25		1050 x 97	525	>25
600	610 x 44	425	4.0	1200	1200 x 75	350	3.0
	594 x 52	475	5.0		1168 x 91	450	6.5
	610 x 57	550	10.0		1200 x 110	525	10.0
	598 x 63	625	>25		1180 x 120	600	17.0
	610 x 76	725	>25	1350	1370 x 77	325	2.5
	598 x 82	800	>25		1360 x 82	350	3.0
675	685 x 48	400	4.0		1350 x 82	350	3.0
	673 x 54	475	5.0		1326 x 94	400	4.5
	680 x 52	425	4.5	1500	1524 x 95	350	2.75
	656 x 64	575	13.0		1508 x 103	400	4.75
	680 x 70	600	>25	1650	1676 x 95	325	2.5
	660 x 80	700	>25		1652 x 107	375	3.0
750	760 x 52	350	3.5	1800	1828 x 102	325	2.5
	736 x 64	500	6.0		1812 x 110	350	2.5
	750 x 55	400	4.0				

Assumed conditions:
1. Minimum trench width
2. Soil mass 18 kN/m^3
3. Bedding type H2
4. Test pressure = 1.2 working pressure

Table F4, Pressure Pipe Actual Size, Test Pressure & Fill Height

Hydraulics

Reinforced concrete pressure pipes are designed for the maximum operating discharge rate in the pipeline. There are two design types of pressure pipelines, the gravitypressure pipeline and the pumped pressure pipeline.

Gravity pressure pipelines utilise the static head over the length of the pipeline to provide discharge and the pipes used are designed to a minimum factory test pressure of 120% working pressure, or working pressure plus 15 metres head, whichever is greater.

Gravity pressure mains are an hydraulically 'soft' system, rarely incurring the effects of waterhammer.

Pumped pressure pipelines are susceptible to waterhammer effects if the system is not designed and operated to eliminate its occurrence, possibly leading to an hydraulically 'hard' system.

Waterhammer effects and their analysis require a detailed knowledge of the operating conditions within the system and its geometry.

Waterhammer in a pressure pipe system, which can be as high as 100 times the flow velocity head at shutdown in the pipeline, is typically caused by either rapid valve closure or uncontrolled pump operation, either at start-up or breakdown. When no waterhammer analysis is carried out, pumped pressure pipelines are tested to a pressure 1.5 times working pressure, or working pressure plus 15m head, whichever is greater.

However, in a reinforced concrete pipeline subjected to unforeseen operations, the pipes are ductile in nature and any surges in the line which could result in cracked pipes will not cause the system to become unserviceable.

A reinforced concrete pipe, overloaded with passingpressure surges, will expand and some minor cracks may result.

So long as the reinforcing steel stress level is not exceeded, the pipe will return to its original state after the pressure surge passes, reducing cracking and after a short time, the cracks will re-seal under the natural action of the concrete's unique autogenous healing process. During this time it may be necessary to reduce the pipeline working pressure.

The working pressure in a pipe to provide the specified discharge is determined from the sum of the elevation (static lift) between pipeline inlet and outlet and head (pressure) losses along the pipeline caused by pipe and fluid friction effects and exit velocity head loss.

Exit velocity head losses are commonly small in contrast to pipe and fluid friction head losses and, in most cases, can be disregarded.

Similarly, losses through bends and fittings, which are determined as a proportion of the velocity head, are also small and can be similarly disregarded in mostcircumstances after checking.

The Concrete Pipe Association of Australasia brochure "Hydraulics of Precast Conduits" is an excellent reference for quantifying the magnitude of these losses where considered appropriate.

Establishing the magnitude of friction head losses alongthe pipeline is carried out by using the Colebrook-White equation, adopting recommended values for pipe surface roughness height (k_s) depending on the fluid type.

For clean water in a water supply pipeline, the value of pipe surface roughness (k_s) 0.06mm is appropriate.

However, where in doubt or where a significant number of fittings are in the pipeline, a more conservative value of (k_s) 0.15mm is recommended.

Design charts (Figure D5 and Figure F1) based on thesurface roughness values of 0.15mm and 0.06mm are given on pages 19 & 32.

For sewer rising mains, a value of 0.6mm is recommended and the appropriate chart (Figure D4) is also provided on page 18.

The charts provide the slope of the hydraulic gradient for a required discharge flow rate in the pipeline and the friction head losses in the pipeline can be determined by applying this value over the line's entire length.

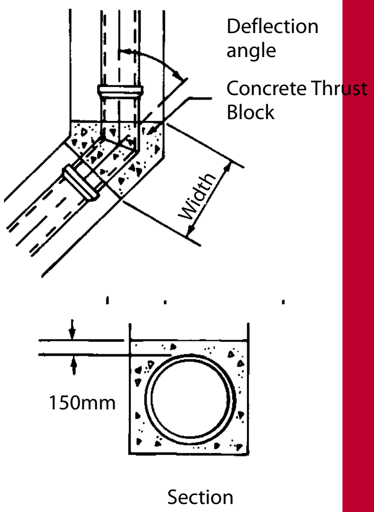
Where a pressure pipeline has a change in horizontal or vertical alignment, or where bends, reducers, tees or valves are fitted within the pipe system, unbalanced forces at the change in flow direction need to be resisted by fitting thrust blocks along the pipeline.

The magnitude of the thrust force is determined by geometrics and the size of the thrust block is found by adopting a value for the passive resistance of the soil in the trench walls, typically 100 kN/m^2.

Table F5 provides typical values of thrust block sizes based on stated conditions.

Size Class (DN)	Width (mm) (per 10m head per 15˚ deflection	
Soil Bearing (Kpa)	100	250
300	100	50
375	100	50
450	125	75
525	150	75
600	175	100
675	185	100
750	200	100
825	200	100
900	250	125
1050	275	150
1200	300	150
1350	325	150
1500	350	175
1650	375	175
1800	425	200

Table F5, Pressure Pipe Thrust Block Size for Horizontal Bends



Concrete strength 25 MPa

Other Pressure Pipe Products

Reinforced concrete pressure pipes can be manufactured with bends, reducers and cast-in mild steel, cast iron or plastic fittings, where required by the system designer.

Typical arrangements are shown below.

Single mitre bend.

Cement lined mild steel off takes.

Mild steel adaptor for 2100mm diameter skid ring joint pipe.

Socket to spigot reducer.

Air valve on 2700mm diameter skid ring joint pipe.

Field Hydrostatic Testing

Before delivery to site, every Humes pressure pipe is hydrostatically tested to the specified test pressure. Consequently, field pressure testing should not be specified for the purpose of reassessing individual pipe performance.

However, the manner in which the pipes have been handled on site and the conditions to which they have been subjected prior to and during laying may require that the test be applied to "prove" the pipeline installation. The purpose of specifying a field hydrostatic test is solely to reveal the existence of inadequate laying procedures.

It is strongly recommended that the specified site test pressure be not greater than the sustained working pressure to which the pipeline will be subjected inservice.

When a field test is to be applied, preconditioning of the pipeline is essential to give meaningful results.

The pipeline should be allowed to stand under 50 kPa hydrostatic pressure at the highest point in the line for such time as is necessary to allow natural absorption of water into the concrete.

The time taken for this to occur will depend on the moisture condition of the pipes, as well as the ambient site conditions.

Some lines will need no more than 24 hours, others may need weeks. Subsequently, pressurisation should be carried out slowly, initially at 50 kPa increments per hour.

Once the test pressure has been reached, and providing no major faults have appeared, the loss of water should be measured at hourly intervals over a period of three hours.

If measurements show a steadily decreasing loss rate, equilibrium has not been achieved and it may be necessary to allow a further period of preconditioning before attempting further measurements. A test result is considered satisfactory when the amount of water lost in one hour does not exceed the amount defined by theformula given.

$Q_L = N.D.(TP)^{1/2} / 70$

Q_L is leakage in litres per hour

N is number of joints in the section of line under test

D is diameter of pipe in metres

TP is specified site test pressure in kiloPascals

Remember, correct laying procedures and proper supervision during installation are a better solution to providing evidence of good installation. See Section J, Handling & Installation.

Field testing of pipes - Brisbane.

Routine Hydrostatic testing of 2250mm diameter Plastiline™ pipes at Humes Welshpool Plant in Western Australia.

k_S=0.06mm

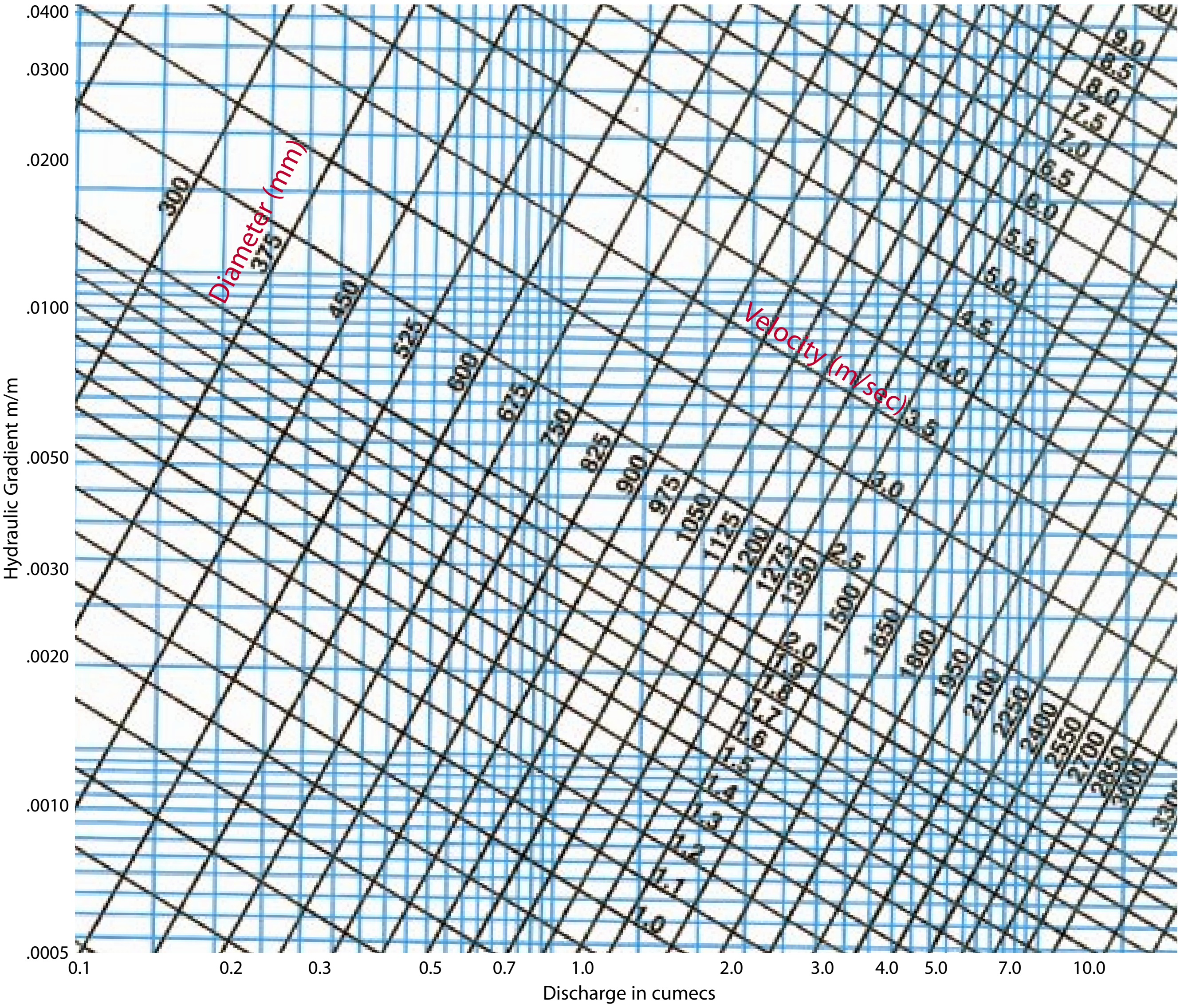


Figure F3, Full Flow Conditions Colebrook-White Formula k_S=0.06mm

Pressure Pipe Example

A pressure pipeline is to be designed for transferring raw sewage from a central collection pump station within the city built up area to a proposed sewage treatment plant at the city boundary.

The length of the pipeline is to be 5km and the pipeline route is to include five 90° horizontal bends and three 60° horizontal bends.

The elevation difference between the pump station and thetreatment plant is a rise of 5 metres.

An estimated maximum discharge rate based on the pumpcharacteristics is 500 litres/second.

The system is to be designed for an estimated 15 metres of waterhammer and a maximum velocity of 2.0m/sec.

The pipeline is to follow natural surface with a nominal 1.0 metre cover to top of the pipe.

From Figure D4, Page 18

k_S = 0.6mm for pumped sewerage flows with 500 l/sec and maximum velocity nominal 2.0m/sec.

Choose a DN600 pipe,

Vf = 1.8m/sec

Hydraulic gradient = 0.0055

Friction head loss = 0.0055 x 5000 = 27.5m

For 90° and 60° bends adopt velocity head coefficients 1.27 and 0.16 (refer CPAA "Hydraulics of Precast Concrete Conduits")

Exit velocity head = $1.8^2/2g$ = 0.165m

Head loss at bends

= (5 x 1.27 x 0.165) + (3x 0.16 x 0.165) = 1.127m

Total Head

Static lift = 5m
Friction head = 27.5m
Velocity head = 0.165m
Head loss at bends = 1.127m
Total = 33.792m

Include waterhammer allowance = 15 metres

Working head in pipeline = 48.8m

Pipe test pressure for pumped pipeline is 1.5 times working pressure:

Test Pressure = 1.5 x 9.81 x 48.8 = 718 kPa

Using the Concrete Pipe Association of Australasia "Pipe Selection and Installation" manual and the parabolic formula given on page 29, a Load Class 2 pipe is adequate for 1 metre cover with type H2 installation.

Specify a DN600 reinforced concrete pressure pipe class 2/718.

G. CONCRETE IRRIGATION PIPES

Humes can provide a selected range of steelreinforced concrete irrigation pipes in diameters from DN300 to DN750.

Rubber Ring Joint (RRJ) pipes are recommended for most irrigation applications where a pressure tight joint seal is required.

Applications

Humes range of small diameter reinforced concrete irrigation pipes are easily transported and laid using farm machinery equipment and can be relocated around the property to meet changing irrigation requirements without the need for special pipelaying skills.

Concrete irrigation pipe systems have reducedmaintenance requirements and enhance property values.

Joint Type

Rubber Ring Joints (RRJ) are designed to provide a joint seal capable of resisting pressures far in excess of those normally operating in most irrigation systems.

Maximum deviations in alignment are given in Table G1 (refer also to Figure G1). Deflections may be the result of pipeline settlements or included during laying to provide a change in pipeline alignment.

Witness marks are provided to indicate both nominal laying gap and maximum joint deflection.

For DN375 and DN450, the pipe joint has been designed to be compatible with standard cast iron fittings. For other size classes, this requirement has not been considered necessary since custom made fittings are normally specified.

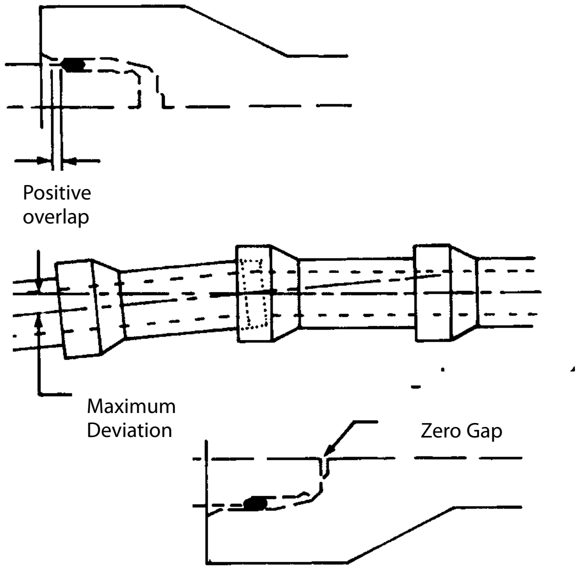


Figure G1, Deflected Pipeline Alignment

Size (DN)	Max Deviation (mm) for Pipe length 2.44 (m)
300	63
375	72
450	51
525	46
600	40
675	36
750	29

Table G1, Maximum Joint Deviations

Size Class (DN)

Reinforced concrete irrigation pipes are manufactured in diameters from DN300 to DN750 as shown in Table G2 (refer Figure G2). Beyond this range, Humes reinforced pressure pipes as detailed in Section F, Concrete Pressure Pipes can be used to give an increased choice to the pipeline designer. The size class of pipe required is determined from the irrigation supply requirements of the planned farm crop yield.

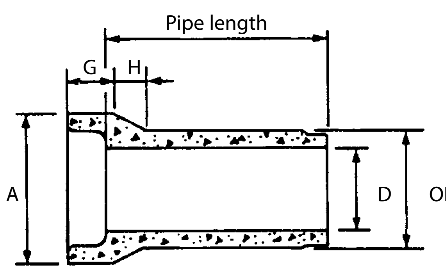


Figure G2, Pipe Dimensions

Size (DN)	D	OD	A	G	H	Mass per Pipe Length 2.44 (m)
300	300	362	451	107	89	220
375	367	435	516	106	70	300
450	446	518	603	127	74	385
525	534	616	711	147	133	530
600	610	698	797	147	133	645
675	685	781	886	147	133	780
750	760	864	997	143	152	960

Table G2, Pipe Dimensions (mm) and Masses (kg)
Note: Pipe mass based on concrete density of $2500kg/m^3$

Load/Pressure Class

The Load Class of a reinforced concrete irrigation pipe is normally Class 2, since most pressure pipelines follow the ground's natural surface and are laid at a minimum depth of around 1 metre. The Pressure Class of irrigation pipes is determined from the irrigation requirements and is usually up to a maximum of 500 kPa Pressure Class (415 kPa working). More commonly, a reinforced concrete irrigation pipe Pressure Class 200 kPa is required. Table G3 presents Standard Pressure Classes as a guide. Other intermediate Pressure Classes are also available when required.

Size Class (DN)	Pressure Class (kPa)		
	200	300	500
	Internal diameter (mm) x Wall Thickness (mm)		
300	300 x 31	–	–
375	367 x 34	367 x 34	367 x 34
450	446 x 36	446 x 36	440 x 39
525	534 x 41	534 x 41	534 x 41
600	610 x 44	610 x 44	–
675	685 x 48	685 x 48	–
750	760 x 52	760 x 52	–

Table G3, Standard Pressure Classes

Hydraulics

The hydraulic flow requirements of the reinforced concrete irrigation system is used to determine the Size Class required. The hydraulic pressure to provide the required flow discharge in the pipeline is determined from the sum of the elevation difference between the supply point and receiving discharge point, and frictional losses along the pipeline caused by flows along the pipe's surface. Table G4 presents Head Loss based on the surface texture common to concrete pipe for irrigation water (k_s = 0.15mm).

Size Class (DN)	Discharge* litres/second						
	10	50	100	250	500	750	1000
300	–	0.016	0.055	0.36	–	–	–
375	–	0.0053	0.019	0.15	0.5	–	–
450	–	0.0022	0.0077	0.047	0.2	0.45	0.8
525	–	0.001	0.0035	0.025	0.065	0.15	0.25
600	–	–	0.0015	0.010	0.035	0.075	0.13
675	–	–	0.001	0.0055	0.020	0.045	0.075
750	–	–	–	0.0030	0.012	0.025	0.045

Table G4, Head Loss in metres per 10m Length of Pipeline * See Page 35 for Conversions

Note: Values are for clean water (ks = 0.15mm)
Values to right of red line have pumped velocity > 3.0m/sec and scour may occur in the channel at the outlet.

Irrigation Pipe Example

A pumped irrigation pipeline is proposed to supply water from the river on a farm up to a storage dam for crop irrigation. The distance from the river to the dam is 1500 metres and the river is approximately 18 metres below the dam.

The dam is to be used to irrigate 1 hectare of cotton fields at a frequency of 50mm every 10 days.

Quantity of water required every 10 days is:

10,000 x 0.005 = 500 m3 = 500,000 litres

If the maximum economic pipeline operation is for the pump to run continuously for not less than 2 hours to refill the dam prior to irrigation then the maximum pumping rate required is 250,000 litres/hour ie. 70 litres/sec.

Adopt a pump rate of 50 litres/sec ie 180,000 litres/hour. The time to refill the dam is (500,000/180,000) 2 hours 50 mins. From the table of head loss per 10m of pipeline:

Total head loss due to friction in the pipeline, for say DN375 diameter pipe, is 0.0053 x 1500/10 = 0.795m

Working head in the pipeline is then;
static head plus friction head losses = 18 + 0.795 = 18.8m

Working pressure in pipeline = 18.8 x 9.81 = 184.4 kPa

For pumped pressure pipeline Test Pressure is 1.5 times working pressure, or working pressure plus 150 kPa whichever the greater.

Therefore, Test Pressure = 184.8 + 150 = 334.4 kPa

Specify 335 kPa test pressure ie. class 2/335 irrigation pipe.

Cylindrical Capacity (Litres) based on flush joint pipe, Load Class 2.

DN mm	Length of Pipe (metres)														
	0.2	0.4	0.6	0.8	1.0	1.2	1.22	1.4	1.6	1.8	1.83	2.0	2.2	2.4	2.44
300	15	29	44	58	73	87	89	102	116	131	133	145	160	174	177
375	23	47	68	91	114	137	139	160	182	205	209	228	251	274	278
450	33	66	98	131	164	197	200	230	262	295	300	328	361	394	400
525	45	90	134	179	224	269	273	314	358	403	410	448	493	538	547
600	59	117	175	234	292	351	357	409	468	526	535	585	643	701	713
675	74	147	221	295	369	442	450	516	590	663	676	737	811	885	899
750	91	182	274	365	456	547	556	639	730	821	835	912	1003	1095	1113

IMPERIAL AND METRIC EQUIVALENTS

Length	1 mm	= 0.039370 in	1 in	= 25.4 mm
	1 m	= 3.28084 ft	1 ft	= 0.3048 m
	1 km	= 0.621371 miles	1 mile	= 1.609344 km
Area	1 cm^2	= 0.1550 in^2	1 in^2	= 6.4516 cm^2
	1 m^2	= 10.7639 ft^2	1 ft^2	= 0.0929063 m^2
	1 ha	= 2.47105 acres	1 acre	= 0.404686 ha
Volume	1 m^3	= 35.3147 ft^3	1 ft^3	= 0.0283168 m^3
Liquid	1 litre	= 0.0353147 ft^3	1 ft^3	= 28.3168 litres
Measure		= 0.219969 imp gal	1 imp gal	= 4.54609 litres
		= 0.2642 US gals	1 US gal	= 3.785 litres
	1 megalitre	= 0.08104 acre ft	1 acre ft	= 1.234 megalitres
Velocity	1 m/sec	= 3.28084 ft/sec	1 ft/sec	= 0.3048 m/sec
	1 kph	= 0.621371 mph	1 mph	= 1.609344 kph

Mass	1 gram	= 0.035274 oz	1 oz	= 28.3495 grams
	1 kg	= 2.20462 lb	1 lb	= 0.45359 kg
	1 tonne	= 0.984207 tons	1 ton	= 1.01605 tonnes
		= 1.102312 US tons	1 US ton	= 0.90718 tonnes
Volumetric	1 litre/sec	= 13.19814 imp	1 imp	= 0.075768
Flow Rate		gal/min	gal/min	litres/sec
		= 0.0353147 cusecs	1 cusec	= 0.0283168 cumecs
Force	1 kN	= 224.809 lbf	1 lbf	= 0.004448 kN
		= 0.100361 tonf	1 tonf	= 9.96402 kN
Pressure	1 MPa	= 0.064749 $tonf/in^2$	1 $tonf/in^2$	= 15.4443 MPa
and Stress	1 kPa	= 0.145038 lbf/in^2	1 lbf/in^2	= 6.89476 kPa
		= 0.3346 ft head	1 ft head	= 2.989 kPa

NOTES

H. CONCRETE JACKING PIPES

Humes can provide a standard range of steelreinforced concrete jacking pipes in diameters from DN300 to DN900 for short length installations (less than 30m) and from DN900 to DN3000 for larger distances. Sizes outside this common range can also be supplied where required.

Butt Joint (BJ) pipes are commonly used for short length culvert and stormwater applications, while Rubber Ring (Skid) Joint pipes are recommended for sewerage or pressure applications.

Jacking Applications

Pipe jacking is a pipe installation method which allowsreinforced concrete pipes to be installed as an underground pipeline without digging a trench from the ground surface (see Figure H1).

Jacking reinforced concrete pipe has been seen as a major development in pipelaying techniques, particularly for laying concrete pipes beneath existing road or rail embankments or other situations where trenching would causeinterference to existing services or surface structures. Pipeline sections jacked up to 100 metres long have become increasingly common in stormwater and sewerage systems since pipe jacking methods were first used in Australia in the early seventies.

Other alternative methods have also been used for trenchless installation of small diameter concrete pipes. These include, but are not necessarily restricted to, boring, ramming and tunnelling techniques.

Auger boring is generally used for short drives where a horizontal auger is used to drill a hole into which theconcrete pipe is then pushed.

Pipe ramming is the process of pushing small diameter concrete pipe into undisturbed ground using the pipe's leading edge as a cutter. The loosened spoil material in the laid pipeline is then 'mucked' out by screw conveyor.

Micro-tunnelling is the most accurate method for trenchless installation of small sized pipes. A remote controlled steerable tunnel boring machine is fitted to the first (lead) pipe which is then pushed into the ground ahead of the remaining (trailing) pipeline.

Man entry pipe jacking methods are, however, the most common and cost-efficient in Australia and apply to pipelines greater than DN900 or, preferably, DN1200. The pipes are jacked into the hole excavated immediately ahead of the progressing pipeline installation.

A typical jacking pipe installlation, note air ducting and rail transport of spoil mat.

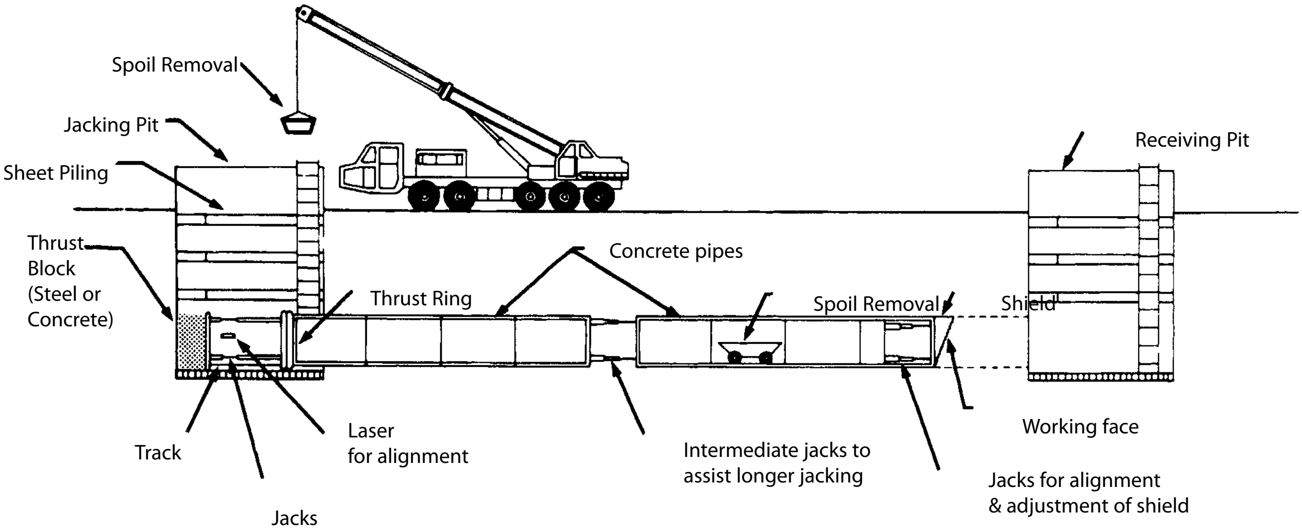


Figure H1, Typical Pipe Jacking Set-Up (for pipes larger than 900 mm diameter)

Pipe Types

Humes supplies reinforced concrete jacking pipes to withstand the highest levels of thrust needed to push the pipeline lengths into the undisturbed ground.

The type of pipes selected will depend on the end use.

For short lengths in a culvert or stormwater system, a Butt Joint (BJ) pipe is generally satisfactory (see Figure H2). For sewerage systems, a rubber ring joint pipe with an in-wall joint seal is recommended (see Figure H3 and H4).

BJ pipes are supplied with steel locating bands and, when also requested, a compressible timber joint packer touniformly spread the jacking loads during installation. SJ and SCJ jacking pipes can likewise be supplied with a compressible joint packer if requested.

The jacking pipe joint design must withstand the combined effects of axial thrust and horizontal or vertical deflection at the joint in the pipeline during installation. Table H1 provides details of maximum joint deflection for thecorresponding maximum thrust in the pipeline.

In some cases, particularly in small diametermicro-tunnelling where the pipe joint is required to be arubber ring for watertightness, the rubber ring seal is formed against a steel collar (SCJ) cast onto the pipe, as shown in Figure H4.

Steel Collar Joint pipes are also recommended for large diameter (>DN1800) pipe and long (>50m) jacking lengths to provide joint flexibility and provide a sealed joint where bentonite injection is used to reduce pipe / soil friction.

Where the sealed joint is formed against the steel band, it is necessary that the joint's service life be at least the equivalent of the concrete pipe. Reinforced concretejacking pipe with this type of sealed joint can be custom designed by Humes engineers.

To achieve and maintain the joint's watertightness, importantly for sewer systems, stainless steel type SS304 is recommended for use as the steel collar band.

The design of the pipe joint can be checked by referring to the Concrete Pipe Association of Australasia's brochure, "Pipe Jacking".

Humes technical representatives should be consulted about the most appropriate choice of pipe type when planning the final pipe jacking project.

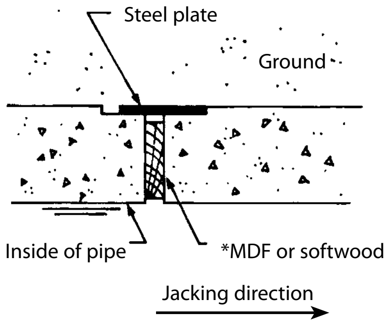
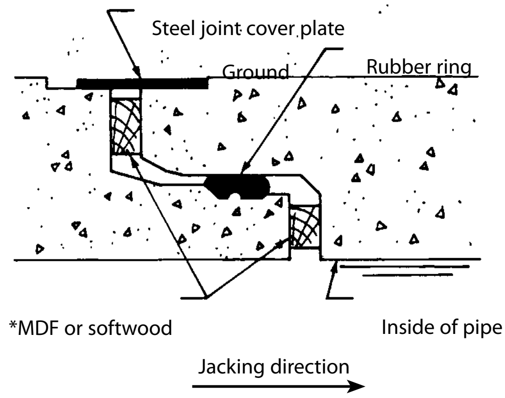


Figure H2, Butt Joint Profile
*medium density fibreboard



re H3. Joint Profile Rubber Ring
Figure H3, Joint Profile Rubber (Skid) Ring

Size Class (DN)	Jacked distance (metres)				
	15	20	25	50	100
300	20/0.50	30/0.40	30/0.40	> CLASS 4 REQUIRED	
375	30/0.35	30/0.35	40/0.30		
450	30/1.05	40/0.60	50/0.50	90/0.30	
525	30/1.60	40/1.70	50/1.25	100/0.45	200/0.30
600	40/1.15	50/1.40	60/1.05	120/0.40	230/0.25
750	50/1.25	60/0.95	70/0.75	140/0.50	280/0.25
900			90/0.95	170/0.50	330/0.20
1050				200/0.55	390/0.25
1200				220/0.70	440/0.25
1350				250/0.80	490/0.30
1500				270/0.60	540/0.25
1650				300/0.60	590/0.30
1800		< CLASS 3 REQUIRED		330/0.65	650/0.30
1950					710/0.45
2100					770/0.45
2250					820/0.50
2400					880/0.50
2700					980/0.60
3000					1100/0.70

Table H1, Maximum Jacking Force (tonnes)/Maximum Joint Deflection (degrees)
Class 4 pipes bold type, Class 3 pipes plain type.
Assumed Conditions: Soil Type Clayey Sand, 2.4 m long butt joint pipe.

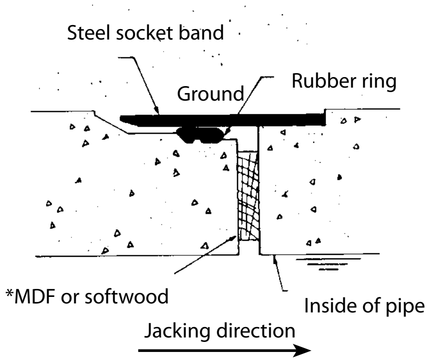


Figure H4, Joint Profile Steel Collar Joint (SCJ)
*medium density fibreboard

Size Class (DN)

The size class of reinforced concrete jacking pipes is determined from in-service conditions of the pipeline.

Conventional pipe jacking techniques require a minimum pipe size of DN900 or, preferably, DN1200 for long lengths.

Pipes below this minimum size can be jacked successfully to maximum lengths of 30 metres, typically the length required under road or rail embankments.

Longer lengths of small diameter jacking pipes can be installed, however, micro-tunnelling techniques may be required.Humes can supply specially designed pipes to suit most micro-tunnelling requirements.

The diameters of Humes jacking pipes range in size from DN300 to DN900 for short length pipe installations (less than 30 metres) and from DN900 up to DN3000 for longer distances. See Table H2 for dimensions of Humes range of Jacking Pipes.

	Size Class (DN)	Pipe D (mm)		Pipe OD (mm)	Pipe Mass (kg) (2.4m)	
		Class 3	Class 4		Class 3	Class 4
Butt or Steel Collar Joint Pipes						
Standard Range (BJ or SCJ)	300	300	300	362	205	210
Standard Range (BJ or SCJ)	375	375	375	445	285	290
Standard Range (BJ or SCJ)	450	450	450	534	405	415
Standard Range (BJ or SCJ)	525	518	502	616	545	625
Standard Range (BJ or SCJ)	600	600	586	698	635	715
Standard Range (BJ or SCJ)	750	756	730	864	875	1065
Standard Range (BJ or SCJ)	900	903	883	1029	1225	1400
Standard Range (BJ or SCJ)	1050	1054	1026	1194	1595	1865
Standard Range (BJ or SCJ)	1200	1207	1179	1359	1975	2290
Standard Range (BJ or SCJ)	1350	1360	1332	1524	2400	2760
Standard Range (BJ or SCJ)	1500	1504	1468	1676	2790	3285
Standard Range (BJ or SCJ)	1650	1656	1620	1842	3335	3890
Standard Range (BJ or SCJ)	1800	1808	1772	2006	3870	4485
Standard Range (BJ or SCJ)	1950	1982	1944	2198	4610	5325
Standard Range (BJ or SCJ)	2100	2136	2110	2388	5765	6315
	2250	2250	2250	2550	7200	7460
	2400	2438	2438	2768	8580	8800
	2700	2700	2700	3060	10315	10620
	3000	3060	3060	3460	13055	13450
Rubber Ring Joint Pipes (sealed joint)						
Std Range (SJ)	1200	1200	1200	1500	3955	3980
Std Range (SJ)	1950	1894	1870	2220	6575	7035
Std Range (SJ)	2100	20690	2040	2388	7180	7610
	2400	2438	2438	2768	8580	8800
	2700	2700	2700	3060	10315	10620
	3000	3060	3060	3460	13055	13450

Table H2, Reinforced Concrete Jacking Pipes Class 3 and Class 4
Note: Pipe mass based on concrete density of 2500kg/m^3

Load Class

Jacking techniques in many instances require pipes to withstand substantial installation loads, so that a minimum Class 3 'Standard-Strength' pipe is used to ensure a trouble-free installation.

Most jacking pipe installations have non-critical external vertical loads applied since the pipe is installed underground into undisturbed ground where the ground's natural cohesion provides arching over the pipe.

Australian Standard (AS3725-1989) gives the method for determining vertical loads on jacking pipes. Where thecalculation includes the effects of arching, reasonably extensive soil investigations should be carried out,particularly in long lengths of pipeline greater than30 metres where soil type could be expected to vary. Where extensive over-excavation is encountered caused by instability at the jacking face, cement mortar grouting of the annulus between the pipe and ground should becarried out.

The jacking installation results in a recommended bedding factor of between 2 and 3 being used to determine the specified pipe class. The higher value is recommended where the annulus between pipe and ground is grouted. See Table H3 for maximum depths to top of the pipe for a jacked pipeline in assumed ground conditions.

Size Class (DN)	Class 3	Class 4
300		
450		
525		
600	> 25 metres	
750		
900		
1050		
1200		
1350	15.0	
1500	11.0	
1650	9.5	
1800	8.5	19.0
1950	7.5	13.5
2100	7.30	11.5
2250	6.5	11.0
2400	6.0	10.0
2700	6.0	9.0
3000	5.5	8.5

Table H3, Reinforced Concrete Jacking Pipe - Maximum Depth to Top of Pipe
Notes: Assumes Excavation width
B = (OD + 100)mm
Soil Mass 18kN/cubic metre
Bedding Factor 2.0
Soil Cohesion c=0kPa

Hydraulics

Whether the jacking pipes are used in culvert, stormwater, sewerage or pressure applications, the same hydraulic design methods used for trenched pipe apply. The relevant information is provided in each of these respective sections: Section C, Concrete Culvert Pipes (page 7); Section D, Concrete Stormwater Pipes (page 14); Section E, Concrete Sewerage Pipes (page 20); and Section F, Concrete Pressure Pipes (page 25).

Installation

When analysing the pipe and the pipeline for installation stresses, it should be noted that maximum calculated forces usually only occur in the pipeline just prior to completion of jacking.

Reinforced concrete jacking pipes are generallymanufactured with circular grid reinforcements to allow for possible pipe rotation during jacking. They can also be supplied with lubrication points cast into the pipe barrel for bentonite injection to minimise ground skin friction during jacked movements.

The recommended number and location of these points is shown in Figure H5. Their inclusion may be considered as an added insurance against possible delays in the jacking operation due to tight ground conditions or at start up after extended work breaks.

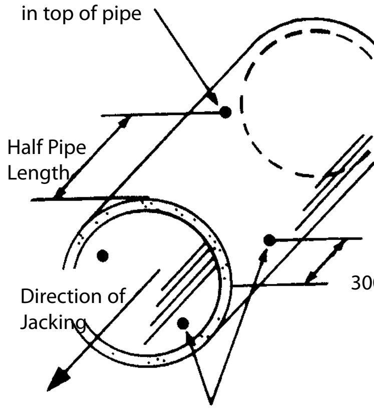


Figure H5, Lubrication Points

Stormwater pipes, jacking pit showing muck cart rail, air ducting and pipe joint type.

Jacking shield on lead pipe.

J. HANDLING AND INSTALLATION

Placing Your Order

When ordering, the following basic information helps us quickly meet your requirements.

Give the details of the delivery address and unloading, the specific pipe details, diameter, type, class, quantities and delivery schedules. Any other particular pipe or delivery requirements. List any other requirements ie. fittings or associated products. If necessary specification type or application type details if you require verification of product suitability. Also include any testing or special inspection requirements.

Written instructions are usually the best instructions. The Pipe Design Request Sheet on the inside back cover of Concrete Pipes should be followed when giving written instructions for ordering the pipe.

Arriving at the Site

When stacking on site, all pipes with "Top" should always be stored with the "Top" mark facing upwards. Take extra care when pipes are double stacked.

If pipes are to be stored on the job for a period of months, orientating them east to west, when possible, will reduce the sun's effects on the barrel of the pipes. This, although not essential, will help to protect their good quality until installed below ground level.

Handling On-Site

When installing Rubber Ring Joint (RRJ) pipes, minimise the rubber rings' exposure to direct sunlight. Rubber rings are best stored inside the pipe barrel and left in hessian bags when supplied. EB bands when supplied with Flush Joint (FJ) pipes should also be stored inside the pipe.

Rolling rubber rings do not need to be lubricated as they rely on the natural effects of rubber on concrete to roll. Ensure the spigot end is clean.

Rubber rings and EB bands should be fitted to the pipe's spigot at the ground surface before lowering the pipe into the trench. The rubber ring is fitted into the groove on the spigot as shown in Figure J1 and should be checked to ensure that the ring has no twists around its circumference. This guarantees uniform rolling when jointing.

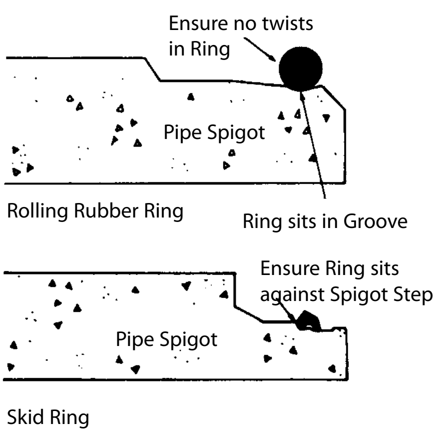


Figure J1, Fitting Rubber Ring

Concrete pipe being loaded onto truck for delivery to site.

If the pipes are joined and excessive "springback" is experienced in the joint, then the joint should be pulled open and the rubber ring again fitted onto the spigot, ensuring that no twists occur around its circumference.

It's a good idea to stack pipes on timber bearers at one-third points along the barrel for easy access when fitting lifting equipment.

All pipes should be chocked to prevent movement when stacked.

RRJ pipes can be supplied with lifting devices if requested for handling and laying, however, more commonly suitable lifting straps or chains are used for handling the pipes. Where chains are used, take care to minimise damage to the pipe and bedding when removing the chains afterplacing the pipe.

Humes Rubber Ring Lubricant is supplied with all skid ring joint pipes. The lubricant is a special mix of soft soap solution (see Figure J2). NEVER use petroleum products, (e.g. grease) as a substitute lubricant.

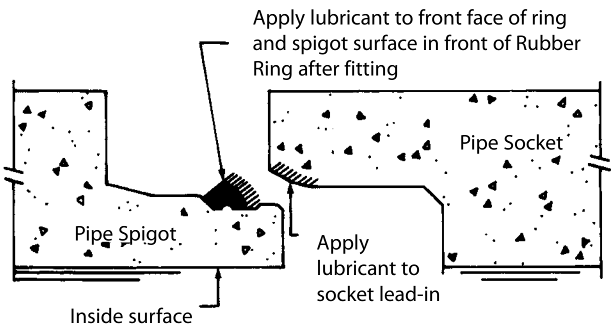


Figure J2, Skid Joint Lubrication

Flush joint (FJ) pipes are generally supplied with lifting holes and plugs are provided which should be secured after laying. Lifting equipment should be sized so as not to damage the pipe (see Figure J3) and certified for the pipe load.

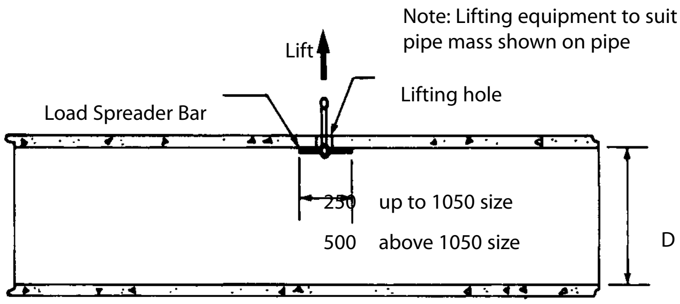


Figure J3, Lifting Equipment

Figure J3, Lifting Equipment

A trench installation for a rural culvert.

Digging the Trench

Remember, all trenches, deep or shallow, can be death traps.

Excavated material should be placed far enough from the top of the trench to allow sufficient clearance for installation operations and to minimise the danger of rocks or lumps rolling back into the trench.

The pipe designer has specified the pipe strength class based on a maximum trench width at the top of the pipe. The width of the trench nominated by the specifier should not be exceeded without first checking with the pipeline designer.

Trench walls may be battered or benched above the top of pipe without affecting the pipe design strength class(see Figure J4).

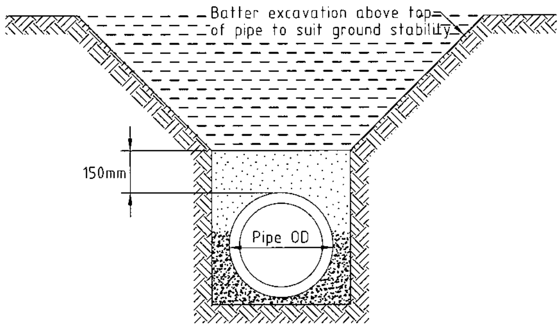


Figure J4, Trench Profile

Where the pipe is to be laid at natural surface level and the more severe loading from an embankment condition causes a high pipe class to be specified, a trench condition can be constructed by placing and compacting to 95% Modified Maximum Dry Density fill material up to the level of the top of pipe and then excavating the trench into the placed fill as shown in Figure J5.

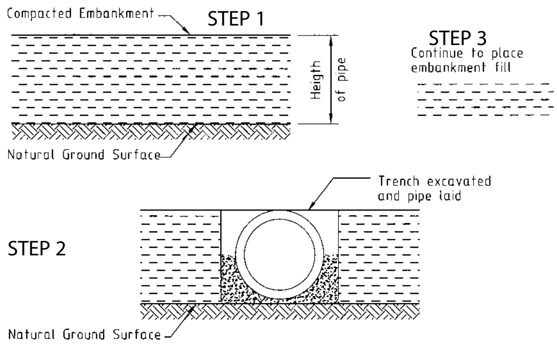


Figure J5, Stages for Trench in Embankment

Where an "Induced Trench" has been specified it is essential that the compressible material width be at least the width of the excavated trench as shown in Figure A3 on page 5. The compressible material must be confined within a trench either in natural ground or excavated in placed and compacted fill material.

The Pipeline Foundation

The foundation for a pipeline at the trench invert under the pipes provides stability and uniformity along the pipeline. Hard or soft spots in the foundation under the pipeline should be removed and replaced with compacted granular material to give uniform support to the pipe (see Figure J6).

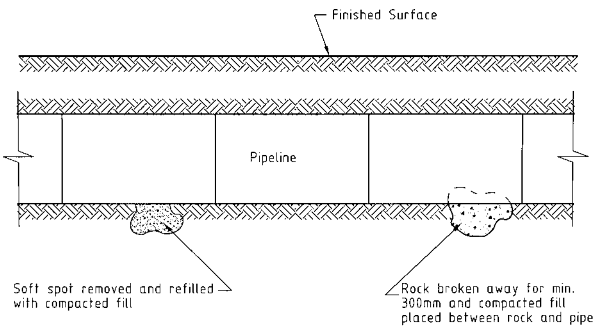


Figure J6, Trench Foundation Conditions

Placing the Bed

Concrete pipes are placed on a prepared flat bed. Shaped bedding is not necessary for concrete pipe. Bed material is spread across the full trench width to the depth required and compacted to prevent settlement of the pipeline. Bed material should be granular and fall within the specified size limits give in Table J1.

Sieve Size (mm)	Weight passing (%)
19.0	100
2.36	100 to 50
0.60	90 to 20
0.30	60 to 10
0.15	25 to 0
0.075*	10 to 0

Table J1, Grading Limits for Select Fill in Bed and Haunch Zones *To have low plasticity

In many instances, the pipe mass is sufficient to compact the bed under the pipe after an allowance of extra depth of loose bed material is made to accommodate settlement during natural compaction. Bed material each side of the pipe should be compacted to give a good stable support to the embedment soil profile higher up in the installation. Remember to dig out chases for rubber ring joint sockets as shown in Figure J7.

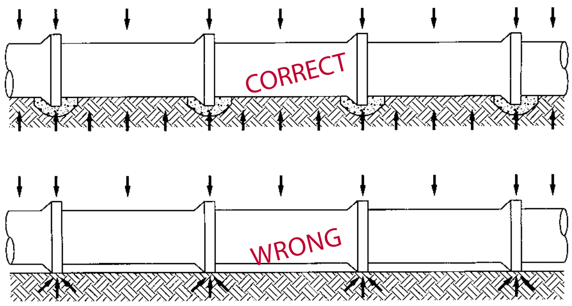


Figure J7, Trench Foundation Preparation

Preparing the bedding to accommodate the socket.

Jointing the Pipes

When joining RRJ pipes there is a "nominal" recommended joint laying gap and a maximum laying gap, as shown in Table J2 and Figure J8.

The jointing load required for RRJ pipes increases as the pipe diameter increases. Generally speaking, pipes less than DN450 can be readily pushed home without using leverage tools.

	Size Class (DN)	Nominal	Maximum
Belled Socket Joint	100	3	5
	150	3	5
	225	3	5
	300	3	10
	375	5	12
	450	5	12
	525	5	12
	600	5	12
	675	5	12
	750	8	12
	825	8	10
	900	8	15
	1050	10	15
	1200	10	20
	1350	10	15
	1500	10	18
	1650	10	18
	1800	10	55
In-wall Joint	1950	10	25
	2100	10	33
	2250	10	36
	2400	10	37
	2700	15	44
	3000	15	48

Table J2, Laying Gaps (mm)

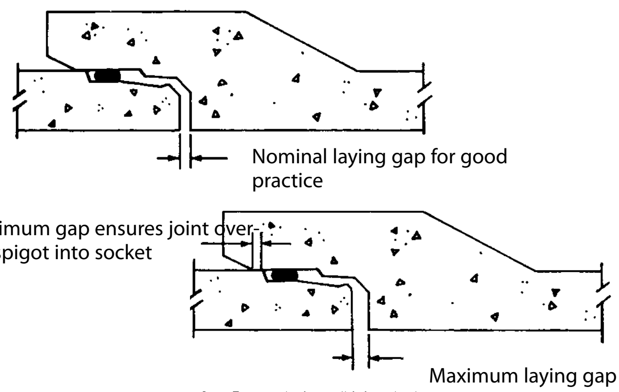


Figure J8, Rubber Ring Joint Laying Gaps n.b. In-wall joint similar

Pipes larger than DN450 and up to DN1200 can be pushed home using simple leverage tools combined with the slung pipe mass as shown in Figure J9.

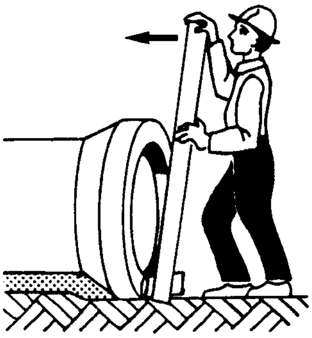


Figure J9, Jointing Small Diameter Pipes

Pipes larger than DN1200 require jointing by use of a come-along or by a winch and rope to the slung pipe from the laid pipeline. The jointing load is resisted by a "dead man" timber located upstream in the pipeline as shown in Figure J10.

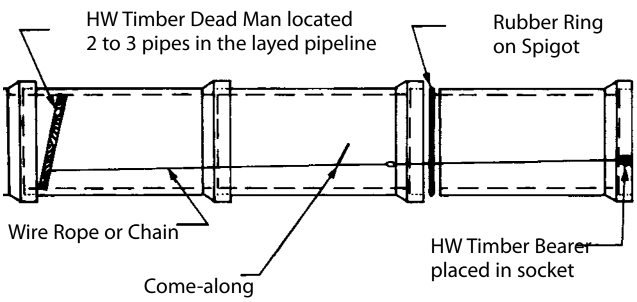


Figure J10, Jointing Large Diameter Pipes

Jointing of large diameter sewerage pipes at Oxley Creek Brisbane.

Multiple 1350 diameter Rubber Ring Joint stormwater pipes - Rocklea Markets Brisbane.

Approximate jointing loads are given in Table J3 forstandard RRJ pipes.

Where lifting devices are fitted for handling, these are used to make the jointing operation quick and easy.

Flush joint pipes are easily jointed without effort, but always ensure that the joints interlock is properly made.

Size Class (mm)	Jointing Load (kg)*
300	110-140
375	150-170
450	180-250
525	250-290
600	300-380
675	320-400
750	420-470
825	500-590
900	570-660
1050	700-770
1200	810-850
1350	900-980
1500	1000-1200
1650	1200-1350
1800	1600-1700
1950	1600-1800
2100	1700-1850

Table J3, Table of Jointing Loads - Standard Range
*Note: The lower figure is the most commonly achieved in practice.

Laying the Pipe

EB bands when fitted to flush joint pipes are "flipped" into position across the joint after settling the pipe in place on the prepared bed.

For RRJ pipes less than DN1800, a laying gap is indicated on the outside of the pipe by a series of witness marks (see Figure J11) which show that the joint has been pushed fully "home", thus ensuring proper jointing.

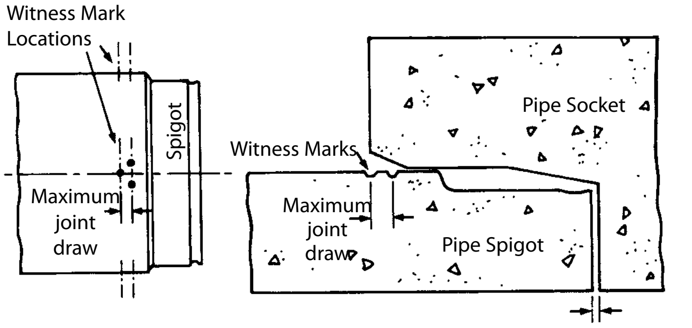


Figure J11, Rubber Ring Joint Witness Marks

RRJ pipes laid around a curve where the joint is to be deflected, should firstly be pushed fully home (zero laying gap) and then the pipe levered at the opposite end to produce the required deflection as shown in Figure J12.

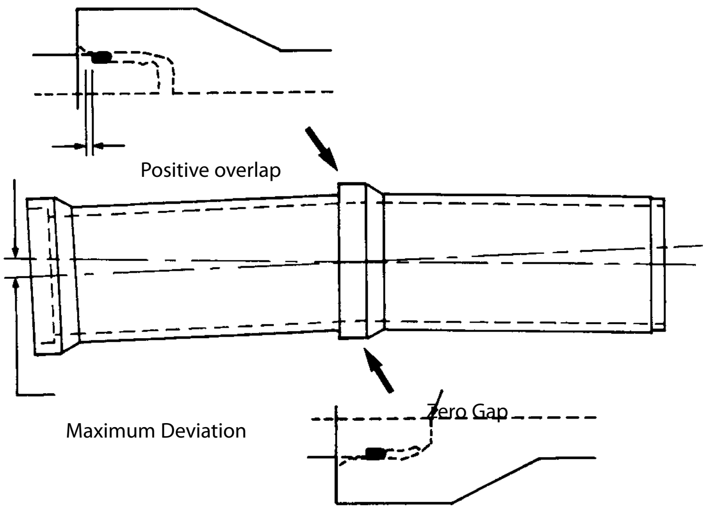


Figure J12, Deflected Joint Details

The recommended procedure for laying pipe is to fit the spigot into the socket. In this orientation, joints are restrained from opening as a result of pipe movement during pipeline settling. Laying in this manner protectssurfaces inside the pipe socket from the entry of bedmaterial which may occur if jointed socket onto spigot. Even so, if adequate precautions are taken, there is no reason why concrete pipes cannot be jointed and laid in the reverse manner.

Preparing the bedding at the socket end of the pipe to be joined.

Bedding the Pipe

Pipe embedment is the general name given to the soilprofile around the installed pipe and includes the bed zone, where required, and overlay zone as shown in Figure J13. Pipe bedding refers to the bed and haunch zones which provide the underlying support to the pipe.

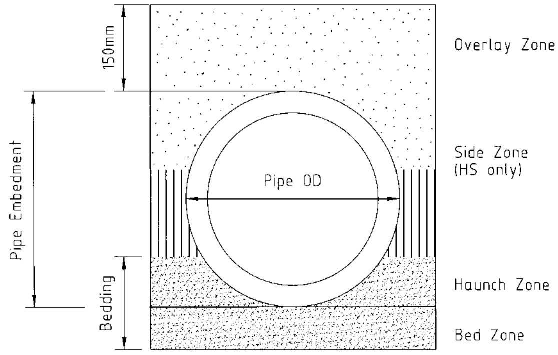


Figure J13, Pipe Embedment Profile

The four most important points when bedding and backfilling around reinforced concrete pipes are:

- Avoid damaging the pipes by excessive impact from heavy compaction equipment. Keep large rocks (greater than 300mm) and other such hard objects out of the fill adjacent to the pipes.
- Bring up the haunch and side zones on both sides of the pipe, so that the difference between the level of the material never exceeds two compaction layer thicknesses. This ensures that the pipes will not be eased slightly out of alignment.
- Avoid running heavy construction equipment over the pipes until a sufficient cushion of material has been placed, approximately 300mm for normal equipment.
- When using vibrating compaction equipment, allow a 500mm cushion of material over the pipe or alternatively turn off the vibration until this level is reached.

Compacting of fill material is a critical part of the installation

Large vibrating rollers should always be checked for their effects.Humes engineers can provide guidance.

The "Haunch Zone" in both "H" and "HS" type installations is essential to support the lower portion of the pipe. Voids in the haunch zone under the pipe should not exist as they may cause instability in the embedment compaction.

The "Side Zone" compaction in HS Type installations is important in supplying side support to laterally resist the load on the pipe.

When installing pipes in HS type installations, it is a requirement that the trench side walls also have sufficient strength to carry the load shed from the pipe and through the side zone material. Visual inspection of the physical nature of the exposed surface is usually sufficient to determine if this condition is achievable, however, when in doubt, Humes engineers can provide guidelines and recommendations.

The range of recommended concrete pipe installations varies from that which requires the least amount of work, "Type U", through to the installation containing the greatest amount of preparation and supervision, the "Type HS3" installation.

"Type U" support shown in Figure J14 is an uncontrolled pipe installation and only requires that there should be no unevenness in support under the pipe. In many instances, the inbuilt strength of reinforced concrete pipe allows this very inexpensive method to be used. Where the pipeline is to be subjected to vehicle loads, this type of installation is not recommended.

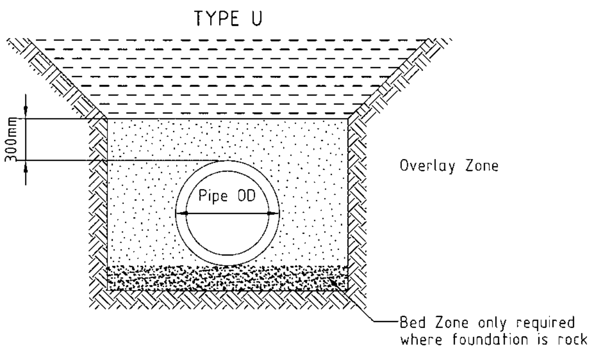


Figure J14, Type U Support

"Type H" support involves the selection and compaction, not only of the bed material, but also the haunch material as illustrated in Figure J15.

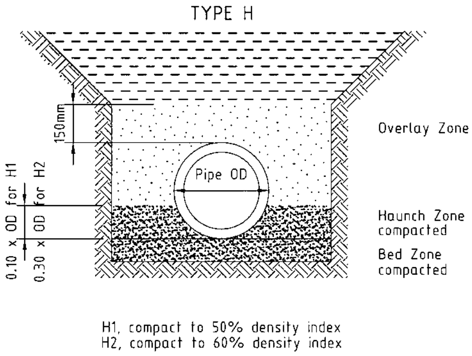


Figure J15, Type H Support

Selection of the bed and haunch material to be used should be made to suit the grading limits described in Table J1 on page 42.

These grading limits have been derived from experience, of both stability of the compaction after installation and ease of compaction during placement.

Where material outside this requirement is to be used, the pipe strength required should be increased by 10%. However, this may well be within the specified pipe strength.

The depth of the Haunch Zone and the degree ofcompaction is dependent on the type of support specified, either H1 or H2.

The measurement of compaction given "Density Index", relates to the non-cohesive material specified. If a cohesive material outside the grading limits and containing significant amounts of clay and silt is to be used, then "Maximum Dry Density" for standard compaction is used to describe the degree of compaction.

Table J4 presents a table of equivalent support stiffness.

Standard Compaction Max. Dry Density	Density Index
95%	70%
90%	60%
85%	50%

Table J4, Equivalent Compaction Stiffness

Note that standard compaction is appropriately specified for trench earthworks.

After placement of the haunch material, ordinary fill material can be used in the Overlay Zone around the pipe. This material only requires that no stones be greater than 150mm and no specific compaction level is needed.

The third type of bedding support available is the "HS Type", which specifies both haunch and side support, as indicated in Figure J16.

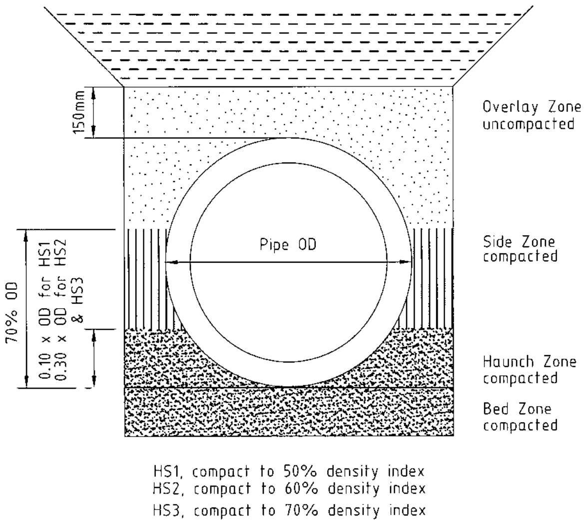


Figure J16, Type HS Support

This type of installation is an extension of the haunch type support and includes a Side Zone with material meeting the requirements given in Table J5. Similar to the haunch material specification, local material outside this range may be used with a subsequent 10% increase in pipe strength necessary.

Sieve Size (mm)	Weight passing (%)
75.0	100
9.5	100 to 50
2.36	100 to 30
0.60	50 to 15
0.075	25 to 0

Table J5, Grading Limits for Select Fill in Side Zones

Depth of placement and compaction of both this side zone material and the haunch zone material lower down in the soil profile, is dependent on the type of support specified, HS1, HS2 or HS3.

Narrow trenches can cause difficulty in working andcompacting the bedding to the required levels which must be achieved to give the assumed support for the pipe.

This is particularly important for Type HS3 Support where significant levels of side support are assumed.

Remember, if the width of the trench is increased during installation, this will cause an increase in the load on the pipe.

The trench width however, may be increased by benching or battering above the level of the top of the pipe as shown in Figure J17.

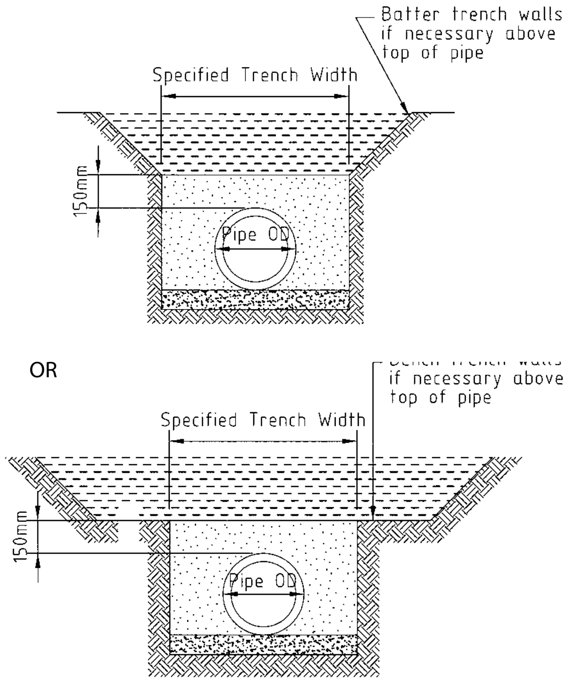


Figure J17, Trench Profile Above Pipe Installation

All recommendations for pipe embedment materials specification and compaction and comments on installation support effects are based on Australian Standard AS3725 "Loads on Buried Concrete Pipes".

Index

Pipe Design Request Sheet

Client: ______________________

Project: ______________________

Design required for ⃞ Estimate ⃞ Tender

Pipe Usage (tick)

- ⃞ Culvert & Stormwater
  - ⃞ Flush Joint ⃞ Pressure
- ⃞ Sewerage
  - ⃞ Gravity ⃞ Pressure
- ⃞ Jacking
  - ⃞ Unsealed Joint ⃞ Sealed Joint
- ⃞ Pressure & Irrigation
- ⃞ Other: ______________________

⃞ Load Class specified

Size Class	Load Class	Unit Length (m)	Total Length (m)

⃞ Determine Load Class

Size Class	Trench Width (m)	Fill Height (m)	Unit Length (m)	Total Length (m)

Installation Condition ⃞ Trench ⃞ Embankment

Installation Type ⃞ Type H2 ⃞ Type HS2 ⃞ Type HS3 ⃞ Other: ______________________

Soil Type ⃞ Sand & gravel ⃞ Clayey Sand ⃞ Wet Clay

Live Loads

⃞ None ⃞ Austroads

⃞ Other: ______________________

Pressure Class (if applicable)

Test Pressure

⃞ kPa ________ ⃞ Calculate

State Working Pressure kPa (including Water Hammer)

Line is: ⃞ Gravity ⃞ Pumped

Standard ⃞ AS 4058-1992

⃞ Other: ______________________

Special requirements

Cement Type: ______________________

Reinforcement Cover: ______________________

Reo. Grid type: ______________________

Sacrificial Layer: ______________________

Calcareous Aggregates: ______________________

Minimum Bore: ______________________

Other: ______________________

"Plastiline" Lining (if applicable)

Degree of Lining ⃞ 359 ⃞ 330 ⃞ 300 ⃞ 270 ⃞ Other:

Design required by: ______________________

Tender closing date: ______________________

Name: ______________________

Location: ______________________

Phone: ______________________

Fax: ______________________

Signature: Date: ______________ ________

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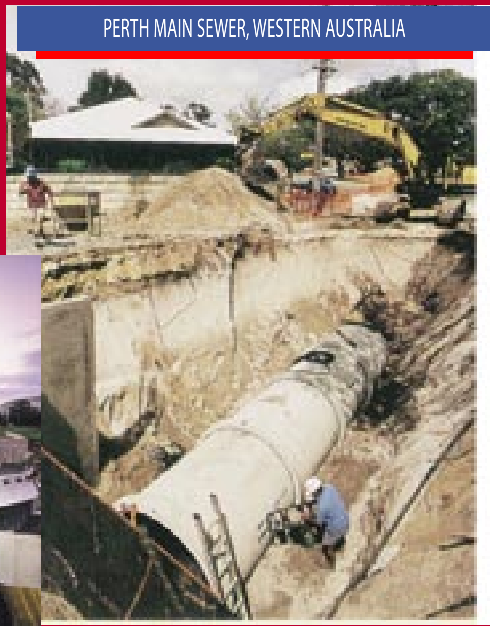
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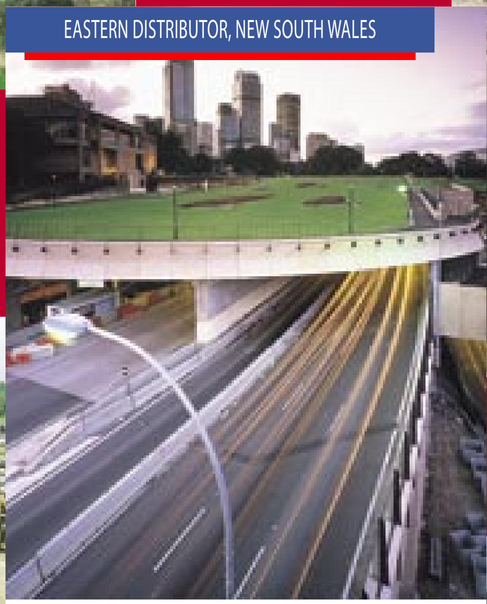
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