Depth of Bury Tables

A. General

The depth of bury tables on the following pages are based upon the design methodology from the various pipe material associations' design manuals. In order to develop the allowable depth of bury tables, numerous assumptions, including site characteristics and construction methods, were required for each pipe material. In general, when assumptions were required, the values that would provide more conservative results were selected.

For site conditions that differ from the assumptions used for the following tables, a separate calculation should be made with values appropriate to the specific conditions at the proposed project. In order to assist with the lengthy equations involved in some of the pipe design methods, SUDAS has developed a number of spreadsheets that will calculate the allowable depth of bury based upon site conditions entered by the user. These spreadsheets are available on the SUDAS website at iowasudas.org. The spreadsheets follow the design methodology of each pipe material association's design manual. Before using the spreadsheets, the designer should have a thorough understanding of the limitations of each design method.

B. Rigid Pipe Assumptions

The depth of bury calculations for clay pipe were done in accordance with the National Clay Pipe Institute's *Clay Pipe Engineering Manual*. The depth of bury calculations for concrete pipe were done in accordance with the ACPA *Concrete Pipe Design Manual*, utilizing the Marston-Spangler design method. The results of the depth of bury calculations for concrete and clay pipe indicated in Tables 9B-5.01 through 9B-5.05 were developed with the following assumptions:

- Saturated clay backfill – $k\mu'$=0.110
- Unit weight of backfill = 120 lb/ft^3
- $D_{0.01}$ pipe strength with a factor of safety of 1.0 (concrete pipe only)
- A minimum trench width of 54 inches (this is the smallest excavator bucket commonly used by some contractors).
- An HS-20 live load applied in an unpaved condition. If the pipe will not be subjected to live load, the minimum depth of bury does not apply.
- Maximum allowable depth of bury was cut off at 40 feet. Calculated values may exceed this depth, but were not shown. For depths greater than 40 feet, an independent analysis should be done using values for actual site conditions.

Table 9B-5.01: Allowable Depth of Bury for Class III (2000D) RCP

Pipe Diameter (inches)	Bedding Class (feet)				
	R-1	*R-2*	*R-3 and R-4*		
			$A_s=0.0\%$	*$A_s=0.4\%$*	*$A_s=1.0\%$*
12	2 to 7	1 to 10	1 to 15	1 to 19	1 to 27
15	2 to 8	1 to 10	1 to 16	1 to 19	1 to 27
18	1 to 8	1 to 11	1 to 16	1 to 20	1 to 40
21	1 to 8	1 to 11	1 to 18	1 to 26	1 to 40
24	1 to 8	1 to 12	1 to 23	1 to 36	1 to 40
27	1 to 10	1 to 15	1 to 30	1 to 40	1 to 40
30	1 to 11	1 to 15	1 to 29	1 to 40	1 to 40
33	1 to 11	1 to 15	1 to 28	1 to 40	1 to 40
36	1 to 11	1 to 15	1 to 27	1 to 40	1 to 40
42	1 to 11	1 to 15	1 to 26	1 to 38	1 to 40
48	1 to 11	1 to 15	1 to 26	1 to 36	1 to 40
54	1 to 11	1 to 15	1 to 25	1 to 34	1 to 40
60	1 to 11	1 to 15	1 to 25	1 to 33	1 to 40
66	1 to 11	1 to 15	1 to 24	1 to 32	1 to 40
72	1 to 11	1 to 15	1 to 24	1 to 32	1 to 40

Table 9B-5.02: Allowable Depth of Bury for Class IV (3000D) RCP

Pipe Diameter (inches)	Bedding Class (feet)				
	R-1	*R-2*	*R-3 and R-4*		
			$A_s=0.0\%$	*$A_s=0.4\%$*	*$A_s=1.0\%$*
12	1 to 12	1 to 15	1 to 23	1 to 28	1 to 40
15	1 to 12	1 to 16	1 to 23	1 to 30	1 to 40
18	1 to 13	1 to 16	1 to 29	1 to 40	1 to 40
21	1 to 13	1 to 18	1 to 40	1 to 40	1 to 40
24	1 to 16	1 to 23	1 to 40	1 to 40	1 to 40
27	1 to 19	1 to 30	1 to 40	1 to 40	1 to 40
30	1 to 19	1 to 29	1 to 40	1 to 40	1 to 40
33	1 to 19	1 to 28	1 to 40	1 to 40	1 to 40
36	1 to 19	1 to 28	1 to 40	1 to 40	1 to 40
42	1 to 18	1 to 27	1 to 40	1 to 40	1 to 40
48	1 to 18	1 to 26	1 to 40	1 to 40	1 to 40
54	1 to 18	1 to 25	1 to 40	1 to 40	1 to 40
60	1 to 18	1 to 25	1 to 40	1 to 40	1 to 40
66	1 to 18	1 to 25	1 to 40	1 to 40	1 to 40
72	1 to 18	1 to 24	1 to 40	1 to 40	1 to 40

Table 9B-5.03: Allowable Depth of Bury for Class V (3750D) RCP

Pipe Diameter (inches)	Bedding Class (feet)				
	R-1	*R-2*	*R-3 & R-4*		
			$A_s=0.0\%$	$A_s=0.4\%$	$A_s=1.0\%$
12	1 to 18	1 to 23	1 to 35	1 to 40	1 to 40
15	1 to 19	1 to 24	1 to 40	1 to 40	1 to 40
18	1 to 19	1 to 30	1 to 40	1 to 40	1 to 40
21	1 to 25	1 to 40	1 to 40	1 to 40	1 to 40
24	1 to 34	1 to 40	1 to 40	1 to 40	1 to 40
27	1 to 40	1 to 40	1 to 40	1 to 40	1 to 40
30	1 to 40	1 to 40	1 to 40	1 to 40	1 to 40
33	1 to 40	1 to 40	1 to 40	1 to 40	1 to 40
36	1 to 40	1 to 40	1 to 40	1 to 40	1 to 40
42	1 to 37	1 to 40	1 to 40	1 to 40	1 to 40
48	1 to 35	1 to 40	1 to 40	1 to 40	1 to 40
54	1 to 33	1 to 40	1 to 40	1 to 40	1 to 40
60	1 to 32	1 to 40	1 to 40	1 to 40	1 to 40
66	1 to 31	1 to 40	1 to 40	1 to 40	1 to 40
72	1 to 31	1 to 40	1 to 40	1 to 40	1 to 40

Table 9B-5.04: Allowable Depth of Bury for Reinforced Concrete Arch Pipe

Pipe Size (inches)	Equivalent Diameter (inches)	Pipe Class A-III (feet)	Pipe Class A-IV (feet)
18 by 11	15	2 to 11	2 to 16
22 by 13	18	2 to 11	1 to 20
26 by 15	21	2 to 14	1 to 27
29 by 18	24	2 to 15	1 to 31
36 by 22	30	1 to 15	1 to 29
44 by 27	36	1 to 15	1 to 28
51 by 31	42	1 to 15	1 to 27
58 by 36	48	1 to 15	1 to 26
65 by 40	54	1 to 15	1 to 26
73 by 45	60	1 to 15	1 to 25
88 by 54	72	1 to 15	1 to 25

Table 9B-5.05: Allowable Depth of Bury for Extra Strength VCP

Pipe Diameter (inches)	Bedding Class (feet)				
	R-1	**R-2**	**R-3 & R-4**		
			A$_s$=0.0%	*A$_s$=0.4%*	*A$_s$=1.0%*
6	1 to 25	1 to 30	1 to 30	1to 30	1 to 30
8	1 to 20	1 to 26	1 to 30	1 to 30	1 to 30
10	1 to 18	1 to 23	1 to 30	1 to 30	1 to 30
12	1 to 16	1 to 20	1 to 30	1 to 30	1 to 30
15	1 to 15	1 to 19	1 to 28	1 to 30	1 to 30
18	1 to 14	1 to 18	1 to 30	1 to 30	1 to 30
21	1 to 15	1 to 22	1 to 30	1 to 30	1 to 30
24	1 to 18	1 to 28	1 to 30	1 to 30	1 to 30
27	1 to 20	1 to 30	1 to 30	1 to 30	1 to 30
30	1 to 19	1 to 29	1 to 30	1 to 30	1 to 30
33	1 to 20	1 to 30	1 to 30	1 to 30	1 to 30
36	1 to 20	1 to 30	1 to 30	1 to 30	1 to 30
39	1 to 19	1 to 29	1 to 30	1 to 30	1 to 30
42	1 to 18	1 to 26	1 to 30	1 to 30	1 to 30

C. Flexible Pipe Assumptions

The depth of bury calculations for PVC pipe were done in accordance with the Uni-Bell PVC Pipe Association's *Handbook of PVC Pipe: Design and Construction*. The depth of bury calculations for HDPE pipe were done according to the Plastic Pipe Institute's: *The Complete Corrugated Polyethylene Pipe Design Manual and Installation Guide*. The AASHTO design method was used for the determination of live load for both materials. The results of the depth of bury calculations for PVC and HDPE pipe indicated in Tables 9B-5.06, 9B-5.07, and 9B-5.08 were developed with the following assumptions:

1. **PVC Assumptions:**
    - Unit weight of backfill is 120 lb/ft^3
    - Prism load for backfill
    - Deflection lag factor (D$_L$) of 0.1
    - Modulus of soil reaction (E') of 0 psi, 1000, lb/in^2, and 1000 lb/in^2 for pipe classes F-1, F-2, and F-3 respectively.
    - An HS-20 live load applied in an unpaved condition. If the pipe will not be subjected to live load, the minimum depth of bury does not apply.
    - Maximum allowable pipe deflection of 5%. A value of 3% is used for design based upon the published deflection accuracy of $\pm$ 2% for dumped crushed rock bedding.
    - Maximum allowable depth of bury was cut off at 40 feet. Calculated values may exceed this depth, but were not shown. For depths greater than 40 feet, an independent analysis should be done using values for actual site conditions.

2. **HDPE Assumptions:**
    - Unit weight of backfill is 120 lb/ft^3
    - Prism load for backfill
    - Water table 2 feet below ground surface
    - Deflection lag factor (D$_L$) of 0.1
    - Crushed rock bedding with a 1,000 lb/in^2 modulus of soil reaction (E')

- An HS-20 live load applied in an unpaved condition. If the pipe will not be subjected to live load, the minimum depth of bury does not apply; however sufficient cover should be provided to protect the pipe from damage by ultraviolet radiation or maintenance equipment.
- Maximum allowable pipe deflection of 5%
- Pipe also checked for wall thrust, critical buckling pressure, bending stress, and bending strain.

Table 9B-5.06: Allowable Depth of Bury for Gravity Flow PVC Pipe - Bedding Class F-2 or F-3

Pipe Diameter (inches)	ASTM (feet)					
	D 3034 Solid Wall		*F 679 Solid Wall*	*F 949 Corrugated Exterior*	*F 1803 Closed Profile*	*D 2680 Composite*
	SDR 26	*SDR 35*	*SDR 35*			
8	2 to 28	2 to 24	---	2 to 24	---	2 to 32
10	2 to 28	2 to 24	---	2 to 24	---	2 to 32
12	2 to 28	2 to 24	---	2 to 24	---	2 to 32
15	2 to 28	2 to 24	---	2 to 24	---	2 to 32
18	---	---	2 to 24	2 to 24	---	---
21	---	---	2 to 24	2 to 24	2 to 24	---
24	---	---	2 to 24	2 to 24	2 to 24	---
27	---	---	2 to 24	---	2 to 24	---
30	---	---	2 to 24	2 to 24	2 to 24	---
33	---	---	2 to 24	---	---	---
36	---	---	2 to 24	2 to 24	2 to 24	---
42	---	---	2 to 24	---	2 to 24	---
48	---	---	2 to 24	---	2 to 24	---
54	---	---	---	---	2 to 24	---
60	---	---	---	---	2 to 24	---

Table 9B-5.07: Allowable Depth of Bury for AWWA C900/C905 PVC Pressure Pipe

Pipe Diameter (inches)	Bedding Class (feet)		
	P-1	*P-2*	*P-3*
4	2 to 19	2 to 40	2 to 40
6	2 to 19	2 to 40	2 to 40
8	2 to 19	2 to 40	2 to 40
10	2 to 19	2 to 40	2 to 40
12	2 to 19	2 to 40	2 to 40
14	2 to 19	2 to 40	2 to 40
16	2 to 19	2 to 40	2 to 40
18	2 to 19	2 to 40	2 to 40
20	2 to 19	2 to 40	2 to 40
24	2 to 19	2 to 40	2 to 40

Table 9B-5.08: Allowable Depth of Bury for HDPE Pipe - Bedding Class F-2 or F-3

Pipe Diameter (inches)	AASHTO M 294 (feet)
6	2 to 8
8	2 to 8
10	1 to 9
12	2 to 8
15	1 to 9
18	1 to 9
24	1 to 9
30	1 to 9
36	1 to 9
42	1 to 8
48	1 to 8
54	1 to 8
60	1 to 8

3. **Polypropylene Assumptions:** The depth of bury calculations for polypropylene pipe were completed in accordance with the AASHTO LRFD Bridge Design Specifications, Sixth Edition. Most of the design criteria are as noted below and the remaining load factors and modifiers are as specified in AASHTO.
   - General Design Criteria
     - Design Interval: 50 years
     - Live load applied per NCHRP 647 (checked against AASHTO LRFD)
     - Deflection limit: $\Delta_A = 5\%$
   - Site Assumptions:
     - Clay soils
     - Groundwater assumed 2 feet below ground surface
     - Unit weight of wet soil: $g_s = 120$ pcf
     - Void ratio of soil: $e = 1.9$ (soft, slightly organic clay)
   - Installation Properties
     - Soil compaction: 90% (note: 95% is required by the specs, but a lower value was used for design to recognize the fact that trench compaction is difficult to achieve and sometimes lacking).
     - Pipe Embedment Material: Crushed stone envelope
     - Pipe Embedment Material Compaction: Dumped condition
     - Bedding coefficient = $K_B = 0.100$
     - Deflection lag factor: $D_L = 1.5$
   - AASHTO Load Factors & Modifiers
     - Factor for uncertainty in groundwater: $K_{wa} = 1.0$
     - Installation Factor: $K_{gE} = 1.5$
     - Coefficient for Variation of Thrust: $K_2 = 1.0$ (at springline)
     - Load Factor for vertical earth pressure: $g_{EV} = 1.3$

Table 9B-5.09: Allowable Depth of Bury for Polypropylene Pipe

Pipe Diameter (inches)	ASTM F 2736 (feet)	ASTM F 2764 (feet)
12	24	---
15	25	---
18	22	---
24	20	---
30	22	22
36	---	21
42[1]	---	22
48[1]	---	23
54[1]	---	21
60[1]	---	21

[1] Storm Sewer only.
Minimum depth of cover for all diameters 12 to 54 inches is 1 foot. Minimum cover for 60 inch pipe is 2 feet.

D. Ductile Iron Pipe Assumptions

The depth of bury calculations for ductile iron were done according to the DIPRA publication "Design of Ductile Iron Pipe." The results of the depth of bury calculations for ductile iron pipe indicated in Table 9B-5.09 were developed with the following assumptions:

- Unit weight of backfill is 120 lb/ft^3
- Prism load for backfill
- An HS-20 live load applied for all conditions
- Live load impact factor of 1.5
- Bedding classes P-1, P-2, and P-3 follow DIPRA laying conditions Type 2, Type 4, and Type 5, respectively.
- Maximum allowable pipe deflection of 3%
- 48,000 psi ring bending stress limit.
- Maximum allowable depth of bury was cut off at 40 feet. Calculated values may exceed this depth, but were not shown. For depths greater than 40 feet, an independent analysis should be done using values for actual site conditions.

Table 9B-5.10: Allowable Depth of Bury for Ductile Iron Pipe (Thickness Class 52)

Pipe Diameter (inches)	Bedding Class (feet)		
	P-1	*P-2*	*P-3*
4	2.5 to 40	2.5 to 40	2.5 to 40
6	2.5 to 40	2.5 to 40	2.5 to 40
8	2.5 to 40	2.5 to 40	2.5 to 40
10	2.5 to 36	2.5 to 40	2.5 to 40
12	2.5 to 31	2.5 to 40	2.5 to 40
14	2.5 to 26	2.5 to 40	2.5 to 40
16	2.5 to 23	2.5 to 37	2.5 to 40
18	2.5 to 20	2.5 to 34	2.5 to 40
20	2.5 to 18	2.5 to 32	2.5 to 40
24	2.5 to 16	2.5 to 29	2.5 to 38
30	2.5 to 13	2.5 to 23	2.5 to 31
36	2.5 to 13	2.5 to 22	2.5 to 30
42	2.5 to 13	2.5 to 21	2.5 to 29
48	2.5 to 13	2.5 to 19	2.5 to 27
54	2.5 to 13	2.5 to 19	2.5 to 27