

## MN6-3 Conduit Materials

### 6-3.1 Corrugated Metal Pipe

#### Watertightness:

- H = 5 feet or less - use standard riveted annular or helical lock-seam CMP
- H = 5 to 10 feet - use caulked seam riveted annular CMP or standard helical lock-seam CMP
- H = 10 to 25 feet - riveted annular CMP must be close riveted and have caulked seams. Helical lock-seam pipe must be gasketed
- H = More than 25 feet - use of CMP is not permitted unless approved by the State Conservation Engineer for a specific location

Where H is the total available head in feet, or the difference in elevation between design water surface in the pool to a point 0.6D up from outlet invert or the tailwater level, whichever is higher.

Riveting: Standard single riveted pipe is used for pipes less than 36 inches in diameter. Double riveted pipe is required for pipes greater than 36 inches in diameter, but can be requested for smaller pipe sizes. Rivets shall be placed in each corrugation.

Rivet spacing for close riveted pipe shall not exceed 3 inches, except that 12 rivets are sufficient for 12 inch diameter pipe.

Refer to Figure 6-3.1 for riveting details.

Connecting bands: Connecting bands of the "watertight" type are used whenever the head (H) is more than 5 ft. Standard connecting bands may be used when the head is less than 5 ft.

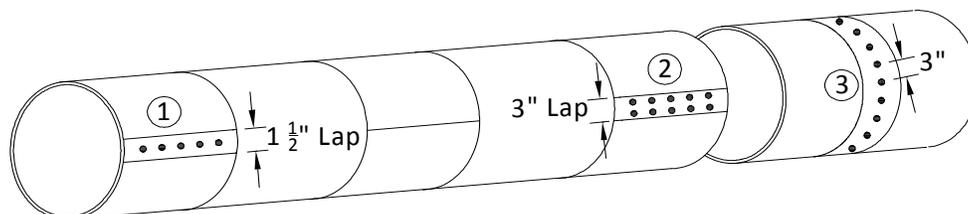
Connecting bands may be two gauges lighter than the gauge of the corrugated metal conduit barrel, or at least 1/2 the thickness of the conduit barrel gauge. In no case should the connecting band be less than 16 gauge.

Camber: Camber should be provided at uniform intervals along the conduit barrel for pipes placed on yielding foundations. The minimum amount provided should be 2% of the height of fill above the conduit. This amount is in addition to the conduit elevation determination based upon a uniform slope. When necessary, the area engineer will provide a procedure for determining camber.

Fabrication: Fabrication and other material requirements shall meet the requirements of NRCS National Material specification (551), Coated Corrugated Steel Pipe or Material Specification (552), Aluminum Corrugated Pipe.

Coatings: Aluminized coating should be provided as needed whenever corrosive conditions exist, such as when the saturated soil resistivity is less than 4,000 ohms-cm or the pH is lower than 5.

Figure 6-3.1 Riveting Details



- ① Standard Single Riveted Pipe. Use for pipes less than 36 inches in diameter. Rivet in each corrugation
- ② Double Riveted Pipe. Required for pipes greater than 36 inches in diameter, but can be requested for smaller sized pipes. Rivet in each corrugation
- ③ Close Riveted Pipe. Rivet spacing shall not exceed 3 inches except that 12 rivets are sufficient on 12-inch pipe.

Table 6-3.1 Minimum Gauge for Corrugated Metal Pipe

| Nominal Gauge <sup>2/</sup>        | 16    | 14    | 12    | 10    | 8     |
|------------------------------------|-------|-------|-------|-------|-------|
| Aluminum, Fed. Spec. WW-P-402      |       |       |       |       |       |
| Specified Thickness (in)           | 0.060 | 0.075 | 0.105 | 0.135 | 0.164 |
| Tolerance under <sup>1/</sup> (in) | 0.007 | 0.007 | 0.008 | 0.009 | 0.009 |

|                                    |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|
| Iron or Steel, Fed. Spec. WW-P-405 |       |       |       |       |       |
| Specified thickness (in)           | 0.064 | 0.079 | 0.109 | 0.138 | 0.168 |
| Tolerance under <sup>1/</sup> (in) | 0.007 | 0.007 | 0.012 | 0.012 | 0.012 |

<sup>1/</sup> No limit on over thickness.

<sup>2/</sup> For informational purposes only.

**Thickness:** Pipe thickness and nominal gauge for corrugated metal pipes should be according to Table 3 in Minnesota Conservation Practice Standard (378), Pond, and Table 6-3.1.

**Cathodic Protection:** Cathodic protection shall be provided for coated welded steel and galvanized corrugated metal pipe where the need and importance of the structure warrant. Cathodic protection shall meet the requirements of National Conservation Practice Standard (430), Irrigation Pipeline. Additional criteria for the design of cathodic protection systems can also be found in Design Note 12, Control of Underground Corrosion.

**Aluminum pipe:** Aluminum pipe should be used according to the limitations given in the National Engineering Manual, Part 543.01.

### 6-3.2 Rigid Pipe

**Reinforced concrete (rigid) pipe and connections** should be designed to withstand the external and internal pressures to which it will be subjected and still maintain watertightness.

**Strength:** Rigid pipe may require concrete bedding or a concrete cradle to provide necessary support to the conduit. Appropriate cradles and strength of pipe should be determined from drawing 3-N-46473.

#### Joins:

H = 20' or more – use vulcanized endless rubber gasket

H = < 20' – use recommendations of manufacturer for watertight connection.

Where H is the total available head in feet, or the difference in elevation between design water surface in the pool to a point 0.6D up from outlet invert or the tailwater level, whichever is higher.

All joints should be articulated. Articulation should be continuous through the cradle or bedding when the respective thickness beneath the conduit is greater than 4 inches.

**Camber:** Camber should be provided for conduits placed on yielding foundations at each interior joint along the conduit. The minimum amount provided should be 2% of the height of fill above the conduit.

**Conduit Discharge Velocity:** The riser should have a smooth elbow and a detailed check should be made of spillway pressures (negative and positive) whenever velocities of flow through the conduit approach 35 ft/sec. Special inlet designs should be developed when the pressures developed are less than atmospheric (generally  $V > 35$  ft/sec.)

### 6-3.3 Flexible Pipe

The material in this section is intended for low hazard dams 35 feet or less in effective height. Additional criteria for the design of flexible pipes are provided in the National Engineering Handbook, Part 636, Chapter 52, Structural Design of Flexible Conduits.

**Camber:** should be provided on yielding foundations at uniform intervals along the conduit barrel. The minimum amount provided should be 2% of the height of fill above the conduit. This amount will be in addition to the conduit elevation determination based upon a uniform slope. When necessary, the area engineer will provide a procedure for determining camber.

**Auxiliary structures and appurtenances:** Plastic pipe will not be exposed to the surface where it can be damaged by sunlight, fire, ice, etc., unless made of ultraviolet resistant materials and protected by coating or shielding as necessary. The inlets and

outlets shall be structurally sound and made from materials compatible with the pipe (such as metal or concrete). Connections of plastic pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the plastic.

Joints: All plastic pipe joints are to be watertight by the use of elastomeric (rubber gasket) joints meeting extensibility requirements calculated according to Technical Release No. 18. Where plastic pipe is joined by other materials, the joints shall be made watertight by gaskets or caulking capable of withstanding external and internal pressures.

Capacity: A typical Mannings “n” value for plastic pipe is 0.010. Full pipe flow capacity using this value can be determined using the table provided in Exhibit 6-3.2.

Strength: The pipe should be capable of withstanding the external loading without yielding, buckling, or cracking. Pipe strength should not be less than that of the grades indicated in Table 6-3.3 for plastic pipe.

Table 6-3.3 Acceptable PVC Pipe for Use in Earth Dams.

| Nominal Pipe Size (in) | Schedule for Standard Dimension Ratio (SDR) | Maximum Depth of Fill Over Pipe (ft) |
|------------------------|---|--------------------------------------|
| 4 or less              | Schedule 40                                 | 15                                   |
|                        | Schedule 80                                 | 20                                   |
|                        | SDR 26                                      | 10                                   |
| 6, 8, 10, 12           | Schedule 40                                 | 10                                   |
|                        | Schedule 80                                 | 15                                   |
|                        | SDR 26                                      | 10                                   |

<sup>1</sup> Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM-D-1785 or ASTM-D-2241.

Exhibit 6-3.1 NEH Section 5, ES-97 Hydraulics: Flow Areas in Circular Conduits for Various Depths of Flow

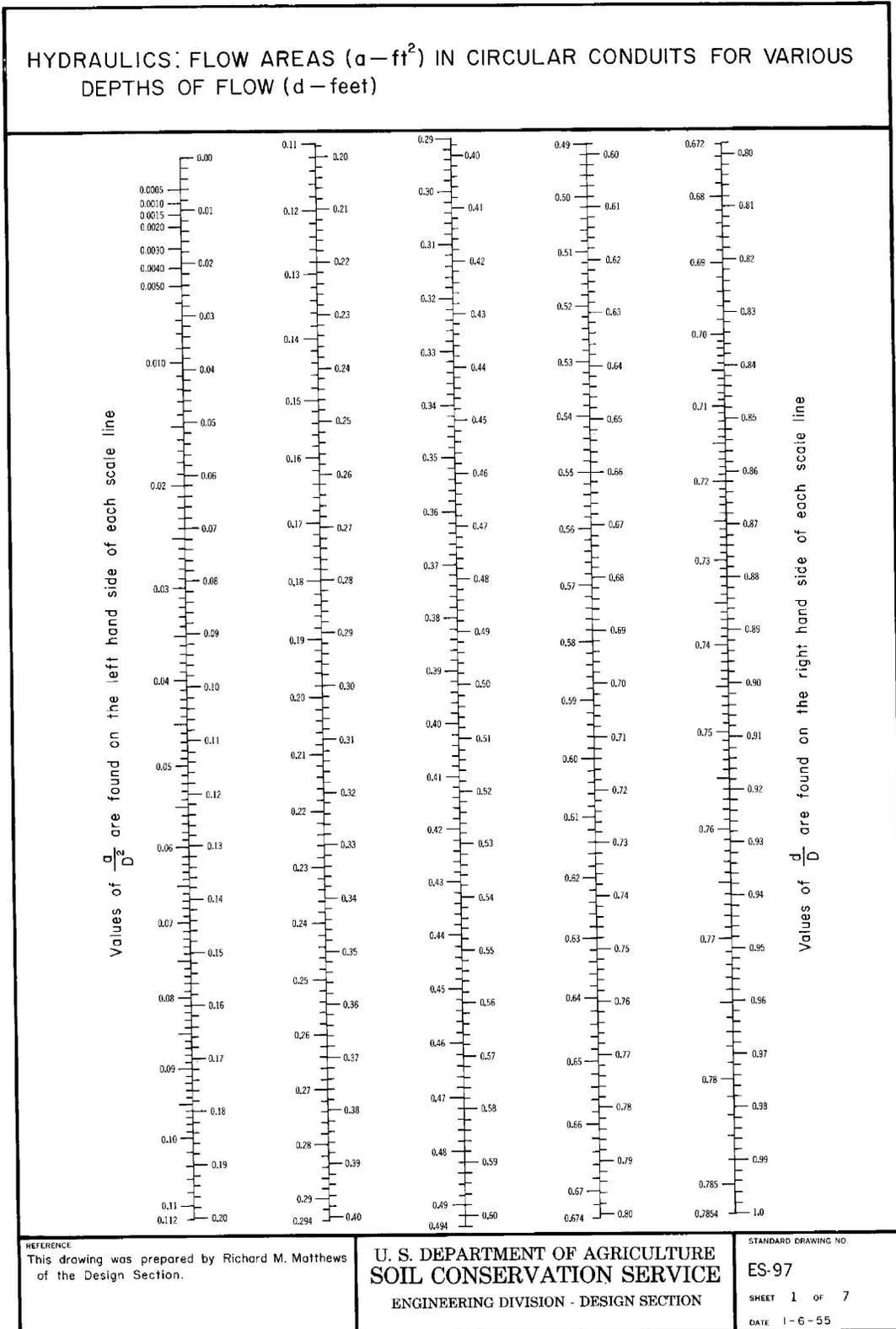


Exhibit 6-3.2 Head Discharge Table for PVC Pipe, Full Pipe Flow Condition

| Dia. | Length (feet) | Head in Feet |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|------|---------------|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|      |               | 6.0          | 7.0  | 8.0  | 9.0  | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 18.0 | 19.0 | 20.0 | 21.0 |
| 6    | 50            | 1.85         | 2.00 | 2.14 | 2.27 | 2.39 | 2.51 | 2.62 | 2.73 | 2.83 | 2.93 | 3.03 | 3.12 | 3.21 | 3.30 | 3.39 | 3.47 |
|      | 60            | 1.76         | 1.90 | 2.03 | 2.16 | 2.27 | 2.39 | 2.49 | 2.59 | 2.69 | 2.79 | 2.88 | 2.97 | 3.05 | 3.14 | 3.22 | 3.30 |
|      | 70            | 1.68         | 1.82 | 1.94 | 2.06 | 2.17 | 2.28 | 2.38 | 2.48 | 2.57 | 2.66 | 2.75 | 2.83 | 2.91 | 2.99 | 3.07 | 3.15 |
|      | 80            | 1.61         | 1.74 | 1.86 | 1.97 | 2.08 | 2.18 | 2.28 | 2.37 | 2.46 | 2.55 | 2.63 | 2.71 | 2.79 | 2.87 | 2.94 | 3.02 |
|      | 90            | 1.55         | 1.67 | 1.79 | 1.90 | 2.00 | 2.10 | 2.19 | 2.28 | 2.37 | 2.45 | 2.53 | 2.61 | 2.68 | 2.76 | 2.83 | 2.90 |
|      | 100           | 1.49         | 1.61 | 1.73 | 1.83 | 1.93 | 2.02 | 2.11 | 2.20 | 2.28 | 2.36 | 2.44 | 2.52 | 2.59 | 2.66 | 2.73 | 2.80 |
|      | 110           | 1.45         | 1.56 | 1.67 | 1.77 | 1.87 | 1.96 | 2.04 | 2.13 | 2.21 | 2.29 | 2.36 | 2.43 | 2.50 | 2.57 | 2.64 | 2.70 |
|      | 120           | 1.40         | 1.51 | 1.62 | 1.71 | 1.81 | 1.90 | 1.98 | 2.06 | 2.14 | 2.21 | 2.29 | 2.36 | 2.43 | 2.49 | 2.56 | 2.62 |
| 8    | 50            | 3.62         | 3.91 | 4.18 | 4.44 | 4.68 | 4.90 | 5.12 | 5.33 | 5.53 | 5.73 | 5.91 | 6.10 | 6.27 | 6.44 | 6.61 | 6.78 |
|      | 60            | 3.47         | 3.75 | 4.01 | 4.25 | 4.48 | 4.70 | 4.91 | 5.11 | 5.30 | 5.49 | 5.67 | 5.84 | 6.01 | 6.18 | 6.34 | 6.49 |
|      | 70            | 3.34         | 3.61 | 3.85 | 4.09 | 4.31 | 4.52 | 4.72 | 4.91 | 5.10 | 5.28 | 5.45 | 5.62 | 5.78 | 5.94 | 6.09 | 6.24 |
|      | 80            | 3.22         | 3.48 | 3.72 | 3.94 | 4.16 | 4.36 | 4.55 | 4.74 | 4.92 | 5.09 | 5.26 | 5.42 | 5.58 | 5.73 | 5.88 | 6.02 |
|      | 90            | 3.11         | 3.36 | 3.59 | 3.81 | 4.02 | 4.21 | 4.40 | 4.58 | 4.75 | 4.92 | 5.08 | 5.24 | 5.39 | 5.54 | 5.68 | 5.82 |
|      | 100           | 3.01         | 3.26 | 3.48 | 3.69 | 3.89 | 4.08 | 4.26 | 4.44 | 4.61 | 4.77 | 4.92 | 5.08 | 5.22 | 5.37 | 5.50 | 5.64 |
|      | 110           | 2.93         | 3.16 | 3.38 | 3.58 | 3.78 | 3.96 | 4.14 | 4.31 | 4.47 | 4.63 | 4.78 | 4.93 | 5.07 | 5.21 | 5.34 | 5.48 |
|      | 120           | 2.85         | 3.07 | 3.29 | 3.48 | 3.67 | 3.85 | 4.02 | 4.19 | 4.35 | 4.50 | 4.65 | 4.79 | 4.93 | 5.06 | 5.19 | 5.32 |
| 10   | 50            | 6.01         | 6.49 | 6.94 | 7.36 | 7.76 | 8.14 | 8.50 | 8.85 | 9.18 | 9.51 | 9.8  | 10.1 | 10.4 | 10.7 | 11.0 | 11.2 |
|      | 60            | 5.80         | 6.26 | 6.70 | 7.10 | 7.49 | 7.85 | 8.20 | 8.54 | 8.86 | 9.17 | 9.47 | 9.8  | 10.0 | 10.3 | 10.6 | 10.9 |
|      | 70            | 5.61         | 6.06 | 6.48 | 6.87 | 7.24 | 7.60 | 7.93 | 8.26 | 8.57 | 8.87 | 9.16 | 9.44 | 9.7  | 10.0 | 10.2 | 10.5 |
|      | 80            | 5.44         | 5.87 | 6.28 | 6.66 | 7.02 | 7.36 | 7.69 | 8.00 | 8.30 | 8.60 | 8.88 | 9.15 | 9.42 | 9.7  | 9.9  | 10.2 |
|      | 90            | 5.28         | 5.70 | 6.10 | 6.47 | 6.81 | 7.15 | 7.47 | 7.77 | 8.06 | 8.35 | 8.62 | 8.89 | 9.14 | 9.39 | 9.6  | 9.9  |
|      | 100           | 5.13         | 5.55 | 5.93 | 6.29 | 6.63 | 6.95 | 7.26 | 7.56 | 7.84 | 8.12 | 8.38 | 8.64 | 8.89 | 9.14 | 9.37 | 9.6  |
|      | 110           | 5.00         | 5.40 | 5.77 | 6.12 | 6.46 | 6.77 | 7.07 | 7.36 | 7.64 | 7.91 | 8.17 | 8.42 | 8.66 | 8.90 | 9.13 | 9.35 |
|      | 120           | 4.88         | 5.27 | 5.63 | 5.97 | 6.30 | 6.60 | 6.90 | 7.18 | 7.45 | 7.71 | 7.96 | 8.21 | 8.45 | 8.68 | 8.90 | 9.12 |
| 12   | 50            | 9.03         | 9.7  | 10.4 | 11.1 | 11.7 | 12.2 | 12.8 | 13.3 | 13.8 | 14.3 | 14.7 | 15.2 | 15.6 | 16.1 | 16.5 | 16.9 |
|      | 60            | 8.75         | 9.45 | 10.1 | 10.7 | 11.3 | 11.9 | 12.4 | 12.9 | 13.4 | 13.8 | 14.3 | 14.7 | 15.2 | 15.6 | 16.0 | 16.4 |
|      | 70            | 8.50         | 9.18 | 9.8  | 10.4 | 11.0 | 11.5 | 12.0 | 12.5 | 13.0 | 13.4 | 13.9 | 14.3 | 14.7 | 15.1 | 15.5 | 15.9 |
|      | 80            | 8.27         | 8.94 | 9.55 | 10.1 | 10.7 | 11.2 | 11.7 | 12.2 | 12.6 | 13.1 | 13.5 | 13.9 | 14.3 | 14.7 | 15.1 | 15.5 |
|      | 90            | 8.06         | 8.71 | 9.31 | 9.9  | 10.4 | 10.9 | 11.4 | 11.9 | 12.3 | 12.7 | 13.2 | 13.6 | 14.0 | 14.3 | 14.7 | 15.1 |
|      | 100           | 7.87         | 8.50 | 9.08 | 9.6  | 10.2 | 10.7 | 11.1 | 11.6 | 12.0 | 12.4 | 12.8 | 13.2 | 13.6 | 14.0 | 14.4 | 14.7 |
|      | 110           | 7.68         | 8.30 | 8.87 | 9.41 | 9.9  | 10.4 | 10.9 | 11.3 | 11.7 | 12.1 | 12.5 | 12.9 | 13.3 | 13.7 | 14.0 | 14.4 |
|      | 120           | 7.51         | 8.12 | 8.68 | 9.20 | 9.7  | 10.2 | 10.6 | 11.1 | 11.5 | 11.9 | 12.3 | 12.6 | 13.0 | 13.4 | 13.7 | 14.1 |

Assume:  $n = 0.010$   
 $K_e + K_b = 1$

$$Q = A \sqrt{\frac{2gh}{1 + K_e + K_b + K_p L}}$$

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