



Detention Pond Outlet is Dual 48-inch Pipes. According to the chart below, the flow area of 2-48" RCP is roughly 24 sqft. The closest equivalent box size for a 24 sqft opening is a 66" RCP or 5x5' RCB. A 66" RCP was used for the length and depth of the riprap. The width dimension used was taken from the 48" RCP multiplied by 2.

ROCK LINING FOR CULVERT OUTLETS				
CULVERT SIZE - DIA (IN.)	MINIMUM DEPTH AND LENGTH (FT.)	MINIMUM ROCK LINING (CULVERT DIA.)	ROCK EQUIVALENT PIPE ARCH CULVERT (APPROX.)	EQUIVALENT CONCRETE BOX CULVERT (APPROX.)
18	1 X 4	12	2	2' X 1 1/2'
24	1 X 6	14	3	2' X 2'
30	1 X 7	16	4	2' X 2'
36	1.5 X 9	18	9	3' X 2'
42	2 X 10	20	15	3' X 3'
48	2 X 12	20	18	4' X 3'
54	2 X 13.5	22	22	4' X 4'
60	2 X 15	25	28	5' X 4'
66	2 X 18	25	33	5' X 5'
72	2 X 20	30	44	5' X 6'
84	2.5 X 25	35	81	6' X 6'
96	2.5 X 30	40	111	7' X 7'
108	3 X 32	40	142	8' X 8'

Depth: 2 Feet
Width: 24 Feet
Length: 25 Feet
Unit Weight = 165 pcf
D100 = 24 Inches
D50 = 15 Inches
D30 = 12 Inches
D15 = 10 Inches

$$D\% = \left[\frac{6W}{\pi Y_s} \right]^{1/3}$$

$$D_{150} = \frac{(86)(6)}{3.14(165)} = 0.99675$$

0.998 Ft.

STATE OF MISSOURI
DIVISION OF HIGHWAYS
DESIGN DIVISION
PROJECT NUMBER
R-5039
PROFESSIONAL ENGINEER

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
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**ROCK LINING
FOR CULVERT OUTLET**

DATE EFFECTIVE: 10/01/1981
DATE PREPARED: 8/21/2009

609.70C

SHEET NO.
1 OF 1

Table 3-1
Gradations for Riprap Placement in the Dry, Low-Turbulence Zones

Limits of Stone Weight, lb¹, for Percent Lighter by Weight

D ₁₀₀ (max) in. Stone Weight, No. 10, 10 Percent Lighter by Weight								
100		50		15		D ₃₀ (min) ft	D ₉₀ (min) ft	
Max	Min	Max ²	Min	Max ²	Min			
Specific Weight = 155 pcf								
9	34	14	10	7	5	2	0.37	0.53 *
12	81	32	24	16	12	5	0.48	0.70
15	159	63	47	32	23	10	0.61	0.88
18	274	110	81	55	41	17	0.73	1.06
21	435	174	129	87	64	27	0.85	1.23
24	649	260	192	130	96	41	0.97	1.40
27	924	370	274	185	137	58	1.10	1.59
30	1,268	507	376	254	188	79	1.22	1.77
33	1,688	675	500	338	250	105	1.34	1.94
36	2,191	877	649	438	325	137	1.46	2.11
42	3,480	1,392	1,031	696	516	217	1.70	2.47
48	5,194	2,078	1,539	1,039	769	325	1.95	2.82
54	7,396	2,958	2,191	1,479	1,096	462	2.19	3.17
Specific Weight = 165 pcf								
9	36	15	11	7	5	2	0.37	0.53 *
12	86	35	26	17	13	5	0.48	0.70
15	169	67	50	34	25	11	0.61	0.88
18	292	117	86	58	43	18	0.73	1.06
21	463	185	137	93	69	29	0.85	1.23
24	691	276	205	138	102	43	0.97	1.40
27	984	394	292	197	146	62	1.10	1.59
30	1,350	540	400	270	200	84	1.22	1.77
33	1,797	719	532	359	266	112	1.34	1.96
36	2,331	933	691	467	346	146	1.46	2.11
42	3,704	1,482	1,098	741	549	232	1.70	2.47
48	5,529	2,212	1,638	1,106	819	346	1.95	2.82
54	7,873	3,149	2,335	1,575	1,168	492	2.19	3.17
Specific Weight = 175 pcf								
9	39	15	11	8	6	2	0.37	0.53 *
12	92	37	27	18	14	5	0.48	0.70
15	179	72	53	36	27	11	0.61	0.88
18	309	124	92	62	46	19	0.73	1.06
21	491	196	146	98	73	31	0.85	1.23
24	733	293	217	147	109	46	0.97	1.40
27	1,044	417	309	209	155	65	1.10	1.59
30	1,432	573	424	286	212	89	1.22	1.77
33	1,906	762	565	381	282	119	1.34	1.94
36	2,474	990	733	495	367	155	1.46	2.11
42	3,929	1,571	1,164	786	582	246	1.70	2.47
48	5,864	2,346	1,738	1,173	869	367	1.95	2.82
54	8,350	3,340	2,474	1,670	1,237	522	2.19	3.17

Notes:

1. Stone weight limit data from ETL 1110-2-120 (HQUSACE, 1971 (14 May), "Additional Guidance for Riprap Channel Protection, Ch 1," US Government Printing Office, Washington, DC). Relationship between diameter and weight is based on the shape of a sphere.
2. The maximum limits at the W₅₀ and W₁₅ sizes can be increased as in the Lower Mississippi Valley Division Standardized Gradations shown in Appendix F.

Screen Captures of MoDOT Specification Manual

SECTION 609.70 ROCK LINING.

609.70.1 Description. This work shall consist of constructing rock lining at the locations shown on the plans or as directed by the engineer.

609.70.2 Material. The material for rock lining shall be in accordance with Sec 611.30 for Type 2 Rock Blanket.

609.70.3 Construction Requirements. The rock lining material shall be placed by dumping and left in a rough condition to the approximate shape of the channel bottom.

609.70.4 Method of Measurement. Final measurement of the completed rock lining will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. Where required, measurement will be made to the nearest cubic yard of material in place in the completed rock lining. The revision or correction will be computed and added to or deducted from the contract quantity.

609.70.5 Basis of Payment. The accepted quantity of rock lining, complete in place, will be paid for at the contract unit price. No direct payment will be made for any excavation required to place the rock lining.

SECTION 611.30 ROCK BLANKET

611.30.1 Description. This work shall consist of constructing a protective blanket of rock or broken concrete on slopes or stream banks.

611.30.2 Material. The material for rock blanket shall be durable stone or broken concrete containing a combined total of no more than 10 percent of soil, sand, shale or non-durable rock. The material shall contain a large percentage of pieces as large as the thickness of the blanket will permit, with enough smaller pieces of various sizes to fill the larger voids. For Type 1 Rock Blanket, at least 40 percent of the mass shall be of pieces having a volume of one cubic foot or more. For Type 2 Rock Blanket, at least 60 percent of the mass shall be of pieces having a volume of one cubic foot or more. Acceptance of quality and size of material will be made by visual inspection at the job site.