Culvert Sizing Evaluation
Mines Road Bridge (No. 26) Lowell, VT

An Hydrology and Hydraulic (H&H) Study completed by the Vermont Agency of Transportation (VOAT) on 16 July selected the following design flow rates:

- Q25 – 320 Cubic Feet per Second (CFS) – *Design Flow Standard for Town Highways*
- Q100 - 480 CFS – Check Flow

VAOT concluded that the existing structure (72-inch diameter corrugated metal pipe) was hydraulically inadequate because the Headwater Depth (HW) to culvert diameter/rise (D) ratios "exceeded allowable values *and* water overtops the roadway below the Q25 design flow".

The VAOT noted when sizing structures, they attempt to select structures that meet the hydraulic standards, fit the natural channel width, the roadway grade and other site conditions. Using those criteria, VAOT concluded that a 14ft. wide by 6 ft high concrete box culvert with bed retention sills should be installed with the culvert invert buried 12 inches below the stream bed *or any similar structure with a minimum clear span of 14ft. and at least 70 square feet of waterway area.*

FEMA's reimbursement for replacement culverts and bridges is limited to an in-kind replacement structure that meets that is sized appropriately to meet the VAOT hydraulic design standards. While changes to design for the purposes constructability may be considered eligible, as of the date of this analysis, FEMA does not recognize upgrades to structures in Vermont that include the burial of the culvert inverts, resizing to accommodate the bankfull width of the stream or upgrading to open-bottomed culverts as being an eligible standards for the purposes of reimbursement.

FEMA evaluated the culvert sizing at this site using the attached nomographs from the Federal highway Administration publication *Hydraulic Design of Highway Culverts (Rev. May 2005)* to estimate costs associated with an appropriately sized, in-kind, replacement culvert based on the design flow standard for town highways (Q25) as well as on pertinent VOAT design guidance (VOAT Hydraulics Manual, 1998, Pg 6-6) as follows:

1. *For culverts up to and including 900 mm (36 inches) in rise, the allowable headwater should be no greater than 1.5 times the diameter at the design frequency (HWID<I.5);*

2. *For culverts greater than 900 mm (36 inches) in rise, the allowable headwater should be no greater than 1.2 times the diameter at the design frequency (HW ID< 1.2);*

This evaluation concludes that the following *in-kind* replacement structures are appropriately sized to accept the Q25 and meet VAOT limits for headwater depths:

- A 78-inch diameter CMP installed with the invert at the stream bed surface;
- An elliptical CMP installed with the invert at the stream bed surface and an equivalent open area of at least 37 SF; and,
- A CMP Arch Culvert with a span of 98 inches and a rise of 69-inches or with similar dimensions and an equivalent cross-sectional area.

This sizing cost evaluation assumes that each installation includes a headwall at the structure entrance.

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Evaluation assumes a structure with headwall at entrance.

Q100 = 480 cfs

78-inch diameter for Q25 = 320 cfs

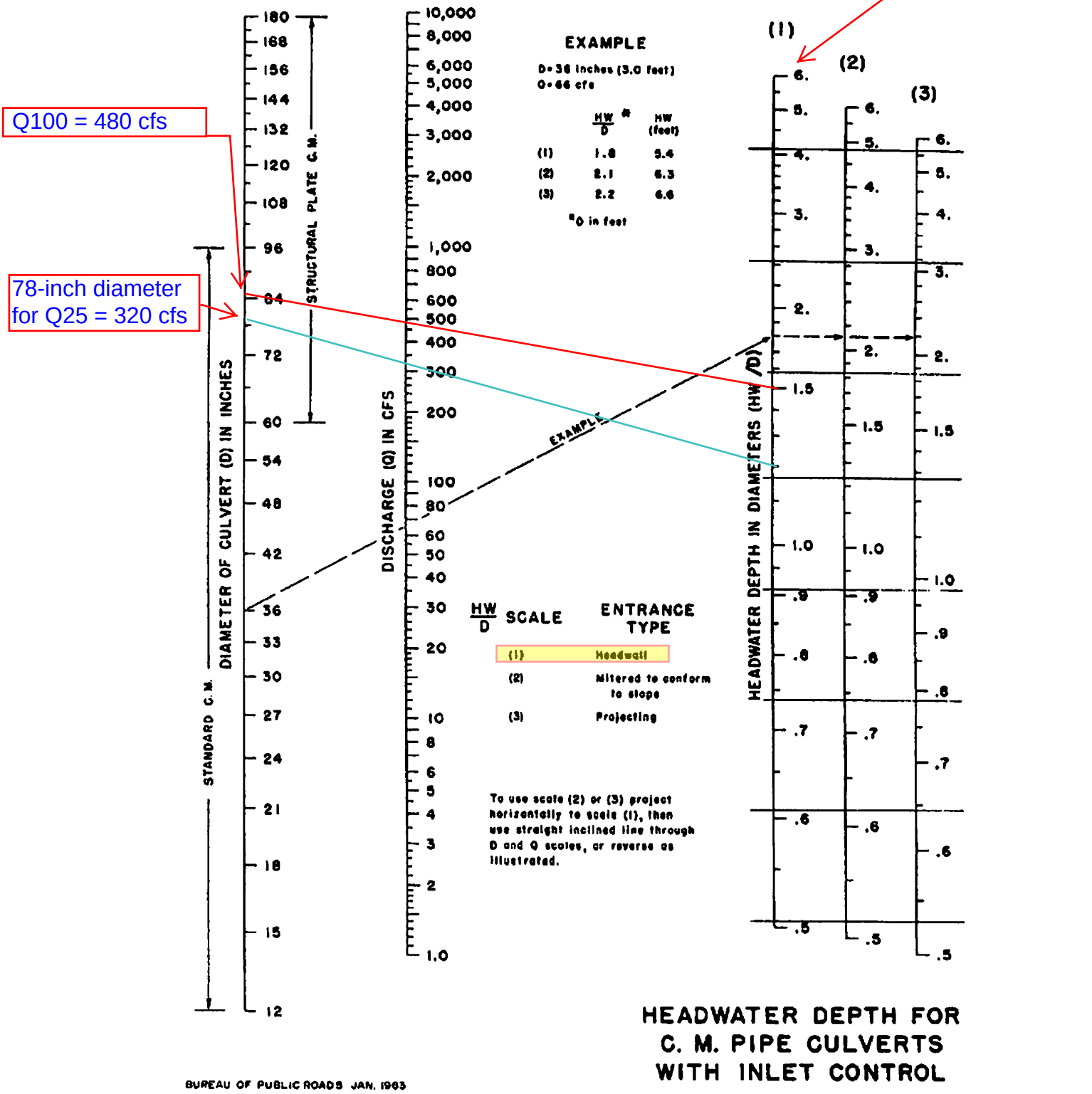

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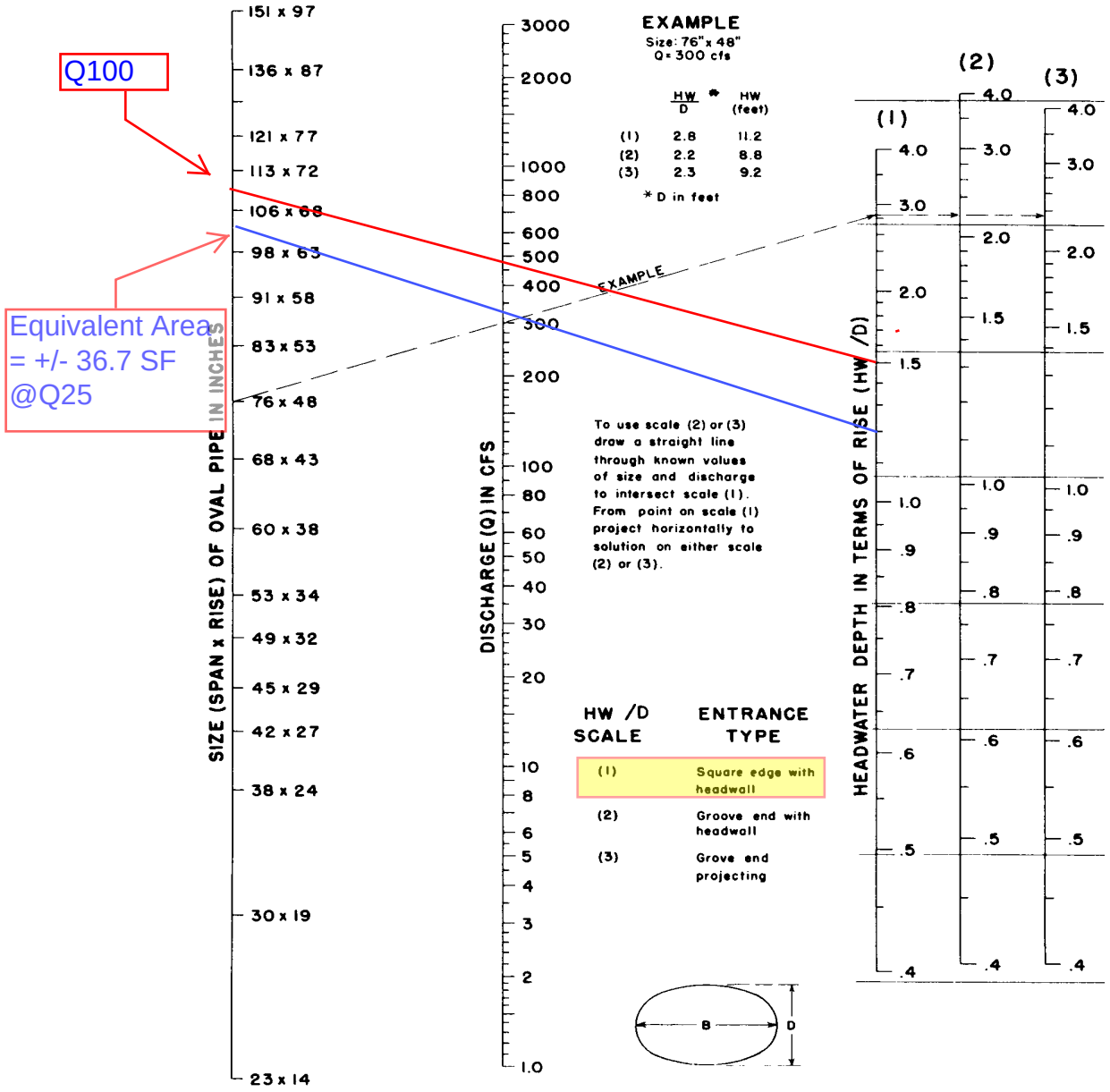
CHART 29B



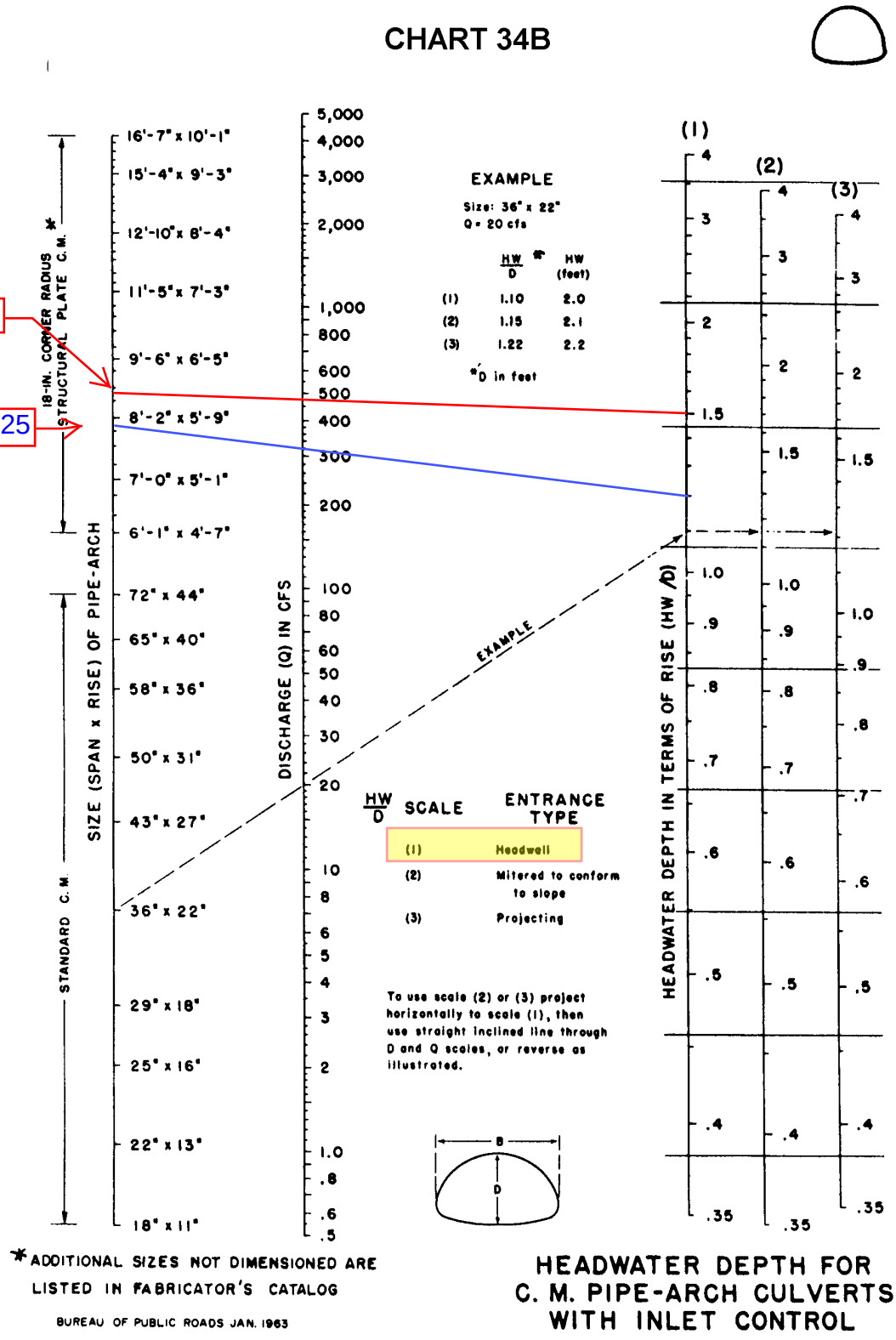
HEADWATER DEPTH FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS HORIZONTAL
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Note: This nomograph was used in the absence of one for an elliptically CMP. This substitution is considered sufficiently accurate for conceptual design and cost estimating purposes. Sizing could vary from final design phase sizing.

Q100

98-in by 69-in for Q25



*ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

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HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL