Appendix H

C-Factor Projections

This section was written as an appendix to the CWMP report *Task C: Water Supply and Service Management Plan*.

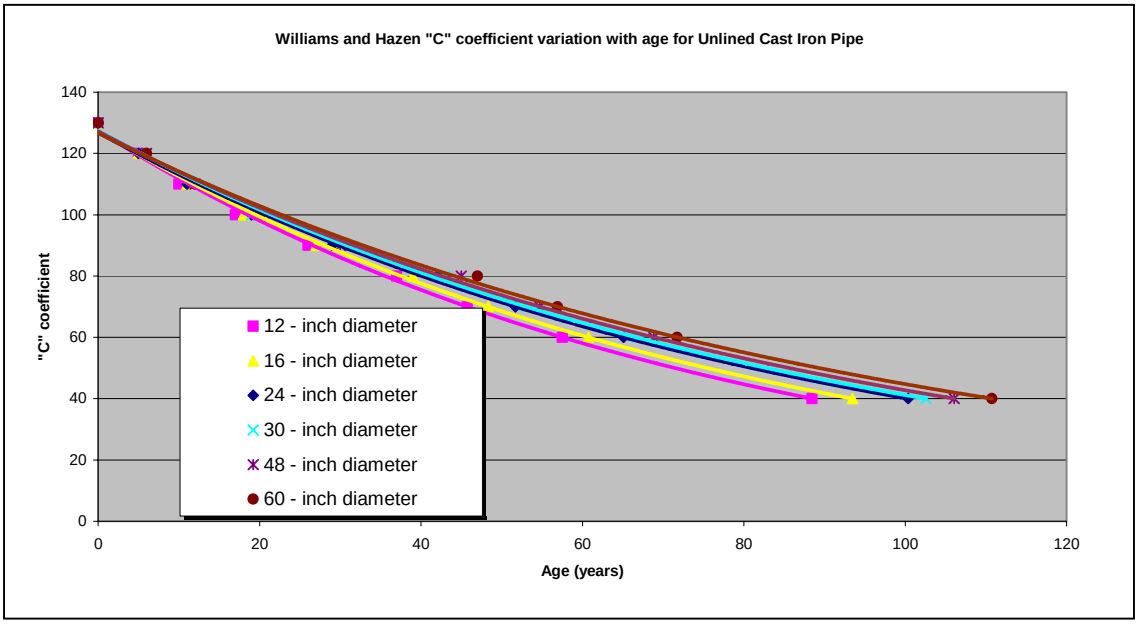
1. Goal

The main purpose of this report is to define the methodologies used to determine C-factors for each of the pipe materials present in the current DWSD system. Pipe friction factors were adjusted in the model to represent the effect of aging over the planning horizon. The adjustments were made to account for increase in resistance to flow caused by corrosion as a pipe ages. The CWMP report *Task C: Renewal and Replacement Program* provides C-factor aging curves for each of the pipe materials; cast iron, lined steel, unlined steel, ductile iron, and concrete. These curves were developed based on actual field testing data from DWSD's system and other published information.

2. Cast Iron Pipes

In conjunction with the Comprehensive Water Master Plan, a study was performed to develop estimated C-factor values over the next 50 years at 10 (ten) year intervals for the years 2010, 2020, 2030, 2040, and 2050 with respect to the size, age, and material of construction of the transmission mains. In general, the study involved researching the available literature on variation of C-factor with age for different types of materials of construction and determining which method of C-factor estimation was best suited for the DWSD system. On completion of the study, the project team concluded that the C-factor variation with age for unlined cast iron pipe be determined as per the hydraulic tables presented by Williams and Hazen for cast iron pipes. C-factor roughness coefficients were decreased for each decade model to simulate the aging of the pipes by using the 2000 CWMP model C-factors as a base and then decreasing their values based on the aging curves established for each pipe diameter. Figure 1 depicts the aging C-factor curves for various sized cast iron pipes.

FIGURE 1 - WILLIAMS AND HAZEN C FACTOR VARIATION CURVES



3. Lined Steel, Unlined Steel, Duct Iron and Concrete Pipes

In general, the base C-factors for the lined and unlined steel, duct iron, and concrete pipes were derived from the DWSD Contract CS-1171 report *Water Quality Model of the DWSD Transmission System* completed in 1997. In this model C-factors were assigned on the basis of pipe material and age or from results of flow tests. These factors were calibrated to determine the best-fit correlation between wall decay (k_w) and C-factor for the DWSD system. These C-factors were then compared and updated based on the recent calibration data collected for DWSD CS-1332, City of Detroit Hydraulic and Water Quality Model and field testing from the summer of 2003. The pipe C-factors which were updated to reflect the recent data are listed below in Table H-1.

The C-factors for steel, concrete and ductile iron pipes were modified based on linear regression results of the available C- factor data. The Year 2000 C-factor was assumed to be the same as the original calibrated model C-factors (*Water Quality Model of the DWSD Transmission System*—1997). These C-factors were then aged, or decreased, by 2.5 for each decade. A C-factor of 130 was used for all new concrete, steel and ductile iron pipes and their relative C-factors were then decreased by 2.5 per decade.

TABLE H-1
C-factors Updated to Reflect 2003 Detroit Model Data

Pipe ID #	Material	Detroit Model 2003 C-Factors	Detroit Model 1997 C-Factors
119	Concrete	110	90
132	Concrete	110	75
203	Concrete	100	80
244	Steel	110	65
261	Concrete	110	90
264	Concrete	110	70
302	Concrete	115	75
305	Concrete	115	75
310	Steel	115	100
318	Steel	115	85
320	Concrete	110	90
325	Concrete	115	75
326	Concrete	115	75
392	Concrete	115	70
407	Steel	100	70
408	Steel	100	70
410	Steel	100	75
411	Steel	100	80
466	Concrete	115	90
510	Steel	110	95
641	Concrete	110	60
659	Concrete	115	70
664	Concrete	115	75
665	Concrete	115	80
899	Steel	100	70
914	Steel	120	80
919	Concrete	115	70
924	Concrete	125	70
1400	Concrete	110	100