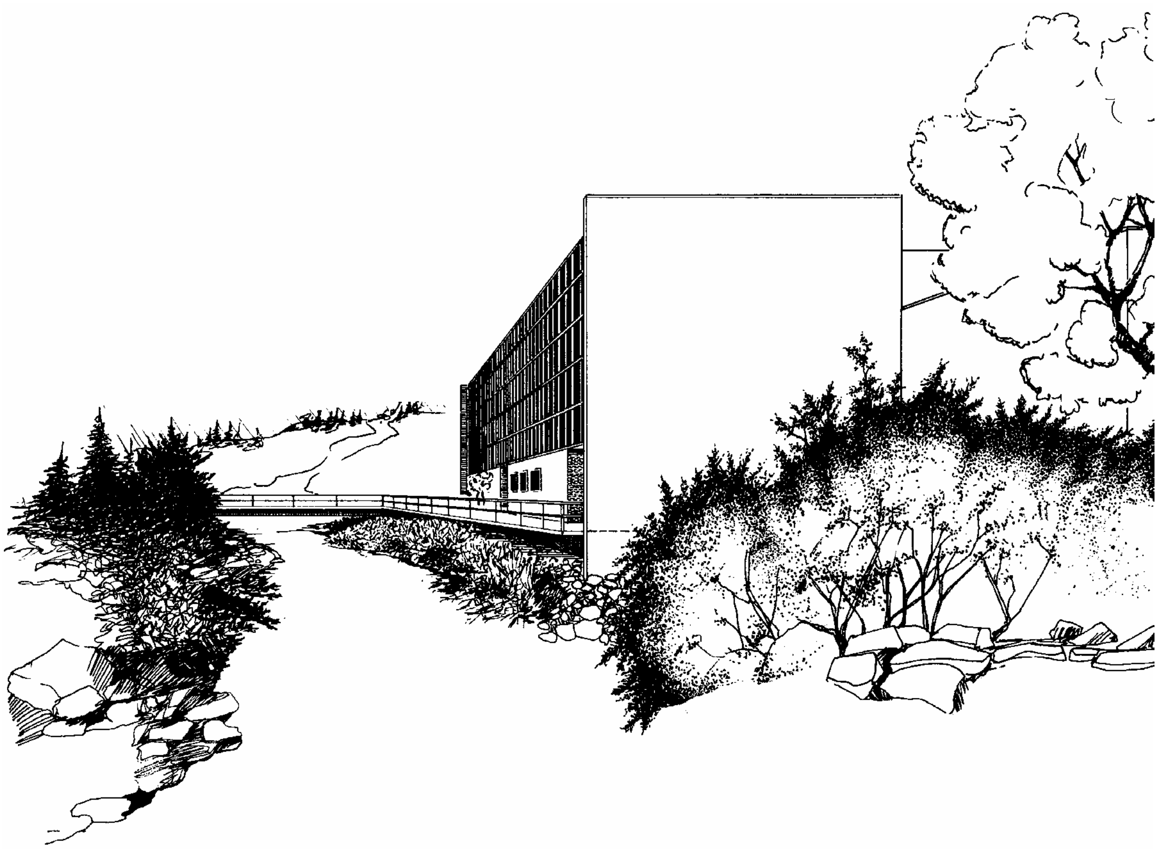
FRICTION TESTS ON 48-INCH POLYURETHANE-LINED STEEL PIPE

Prepared for

Northwest Pipe Company

May 2007



UTAH WATER RESEARCH LABORATORY

Utah State University
Logan, Utah

Report No. 1773

FRICTION TESTS ON 48-INCH POLYURETHANE-LINED STEEL PIPE

Submitted to:

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INTRODUCTION

Utah State University was contracted by Northwest Pipe Company to perform a friction flow test at the Utah Water Research Laboratory (UWRL) in Logan, Utah on 48-inch polyurethane-lined steel pipe. Five lengths of pipe (each 45 feet long) were shipped to the UWRL for the hydraulic test. Cold water tests were performed to determine the pipe roughness coefficient (Hazen Williams C value) over a full range of flow rates. Jeff Gardener and Bruce Vanderploeg of Northwest Pipe Company witnessed the tests.

EXPERIMENT SETUP

In addition to the test pipe, Northwest Pipe Company also shipped pipe components to aid in the experimental setup of the test. These included two transition pipe spools (welded in place) so that the laboratory's pipe could be mated to the test pipe. The pipe transitions were necessary so that the farthest upstream pipe section and the farthest downstream pipe section could be connected to the laboratory 48-inch steel pipe. The transition pieces were necessary because the O.D. of the test pipe was 49.75 inches and the O.D. of the laboratory approach piping was 48 inches. Also shipped were 15 wood cradles that were used to support the pipe along its length (three per pipe length), threaded rod, nuts and bolts, that were used to tie each bell and spigot joint together, and gaskets that were installed in each bell prior to assembly. Each pipe joint was restrained with threaded rod to keep the joints from moving. Northwest Pipe Company prepared the pipe with steel gussets; so that each pipe joint could be restrained on each side of the pipe (at the spring line).

The 48-inch test setup was assembled in the UWRL 6 x 8 x 500-ft concrete laboratory channel with the bells of the pipe facing downstream. Dresser couplings were used to connect the upstream and downstream adapter spools to the laboratory pipe. Figure 1 is a photograph of the 48-inch pipe being installed in the concrete channel. Figure 2 shows details of the pipe setup as provided by Northwest Pipe Company.

Pressure taps were installed 7.5 feet upstream (approximately two diameters) of the first 45-ft test pipe and 11 feet downstream (nearly three diameters) of the last 45-ft test pipe in the 48-inch laboratory pipe. A pressure tap was located on each side of the pipe at the spring line at each location. Pressure tubing was collared together at each location a brought to a central location where the differential pressure could be measured using a Rosemount pressure transducer. The pressure taps consisted of a square-edged 1/8-inch hole with a NPT fitting welded to the outside of the pipe. Pressure differential instrumentation was also connected to the laboratory 48-inch master venturi meter for flow measurements.

Figure 1. Installation of 48-inch Polyurethane-Lined Steel Pipe Test Setup

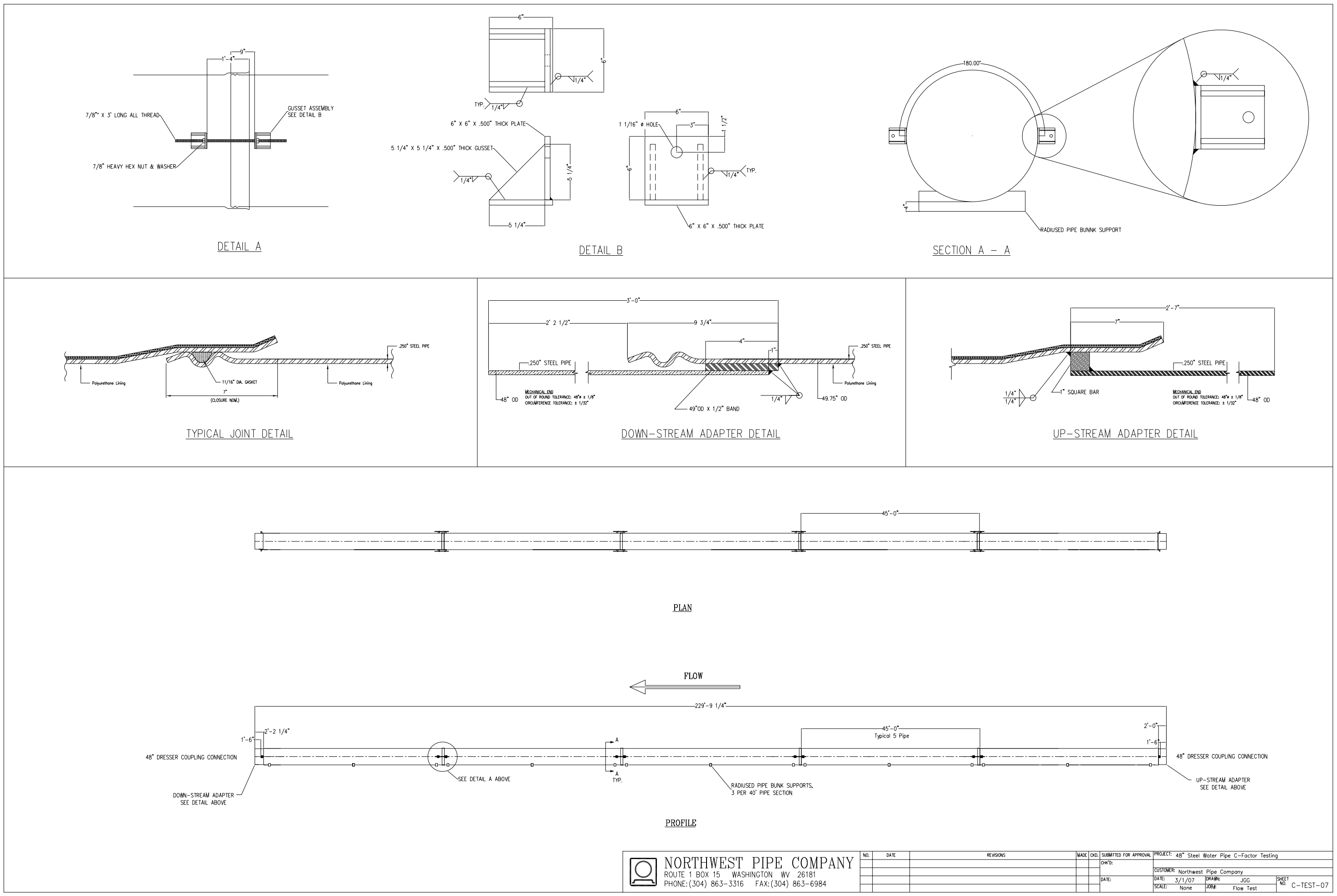

Figure 2. Test Setup Details

TEST PROCEDURE

Water was supplied to the test line from a reservoir near the hydraulics laboratory. The flow rate through the pipe and differential pressure across the pipe were measured for each run. The water temperature was also measured. Differential pressure measurements were taken from the pressure taps that were installed upstream and downstream of the test pipe section.

All flow measurements were made using the laboratory 48-inch master venturi meter. The venturi meter is regularly calibrated and is traceable to the National Institute of Standards and Technology. Discharge was controlled using a 48-inch valve downstream of the test section.

Test pipe head loss differentials were measured using a Rosemount differential transmitter. The Rosemount transmitter was carefully zeroed at a no flow condition prior to any data collection and periodically during the test series. The transmitter output was averaged during each individual run using an averaging Fluke volt/amp meter. Appropriate ranges were set on the transmitter to minimize uncertainties as the pipe differentials changed. Measurements were immediately fed into a computer to display deviations in test results before any flow change was made. Twelve data points were collected during the test series.

For each desired flow setting, laboratory conditions maintained a constant flow through the pipe during the run period. Each averaging period took about 5 minutes, which was long enough to record the actual flow rate through the master venturi meter and to record the average milliamp output from the pipe differential.

The inside diameter of the test pipe was found to be 49.25 inches. The inside diameter of the laboratory pipe (in which the pressure taps were installed) on the upstream and downstream ends of the test sections was 47.25 inches. Since the pressure differential measurements were in pipe having a different inside surface roughness and a different inside diameter than the test pipe, adjustments to the differential reading were made for each run to account for the small amount of head loss occurring between the upstream pressure tap location and the upstream edge of the test pipe (7.5 feet of 47.25-inch ID pipe) and between the downstream edge of the test pipe and the downstream pressure taps (11 feet of 47.25-inch ID pipe). For completeness, the energy loss associated with friction and velocity head changes through these reaches of the measurement length were subtracted from each actual differential reading for each run to provide a net energy loss for the test pipe only.

RESULTS

Table 1 summarizes the test results. Figure 3 is a plot of the data in terms of the Darcy f friction coefficient. Figure 4 is a plot of the data in terms of the Manning's "n" friction coefficient. Figure 5 is a plot of the data in terms of the Hazen Williams C friction coefficient.

Table 1. Utah Water Research Laboratory Pipe Friction Data

Manufacturer:	Northwest Pipe Company
Calibration Date:	5/17/2007
Calibration Location:	48-inch pipe channel

Nominal Pipe dia=	48-Inch
Steel Pipe Dia @ US piezo=	47.2500
Steel Pipe Dia @ DS piezo=	47.2500
Test Pipe I.D. =	49.2500
Pipe area (ft^2) =	13.2294
Water Temp. (F) =	46.5
Unit Weight(pcf) =	62.20
Kin. Visc. (ft^2/s) =	1.51E-05

Pipe Setup

Upstream:	64.5ft of 48-inch steel pipe upstream of test section
Downstream:	41ft of 48-inch steel pipe downstream of test section
Length between piezos (ft)=	241.58
Length from US tap to US end of test pipe (ft)=	7.50
Length from DS end of test pipe to DS tap (ft)=	11.00

Calibration Performed by: Steven Barfuss, Zac Sharp
Witnessed by: Jeff Gardner, Bruce Vanderploeg

Run No.	Flow (cfs)	Velocity (fps)	Inlet Reynolds Number	Pipe Friction Loss DP in H20	DP ft	DP psi	Darcy f	Manning's n	HW C
1	2	3	4	5	6	7	8	9	10
1	29.2	2.20	601,099	0.6872	0.0573	0.0248	0.0129	0.01056	149.29
2	59.5	4.49	1,225,334	2.5799	0.2150	0.0932	0.0116	0.01003	148.97
3	78.7	5.95	1,621,254	4.3107	0.3592	0.1557	0.0111	0.00980	149.38
4	94.4	7.13	1,944,657	6.0785	0.5065	0.2196	0.0109	0.00970	148.83
5	112.4	8.49	2,315,549	8.3767	0.6981	0.3026	0.0106	0.00957	149.04
6	130.0	9.83	2,678,895	10.9397	0.9116	0.3952	0.0103	0.00945	149.28
7	148.6	11.23	3,062,062	14.0432	1.1703	0.5073	0.0101	0.00937	149.10
8	164.1	12.40	3,381,651	16.8834	1.4070	0.6099	0.0100	0.00930	149.08
9	179.3	13.55	3,694,714	19.8773	1.6564	0.7180	0.0099	0.00924	149.13
10	188.1	14.22	3,876,055	21.7761	1.8147	0.7866	0.0098	0.00921	148.93
11	212.2	16.04	4,373,428	27.3007	2.2751	0.9862	0.0097	0.00914	148.73
12	221.8	16.77	4,570,535	29.5711	2.4643	1.0682	0.0096	0.00911	148.87

Average C coefficient : **149.05**

Certified by:

Steven L. Barfuss P.E.
Research Assistant Professor

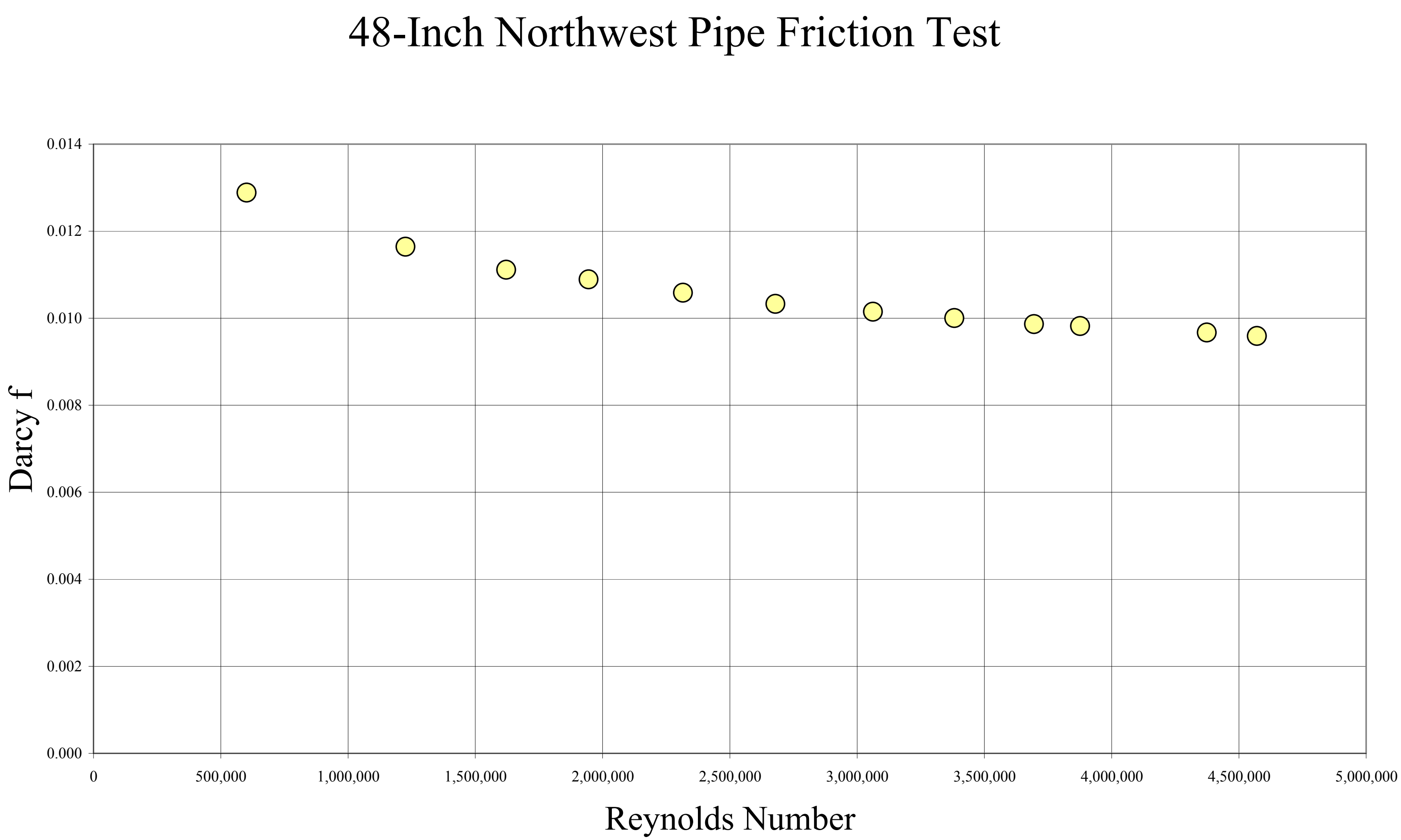

Figure 3. Friction Coefficient Data (Darcy f)

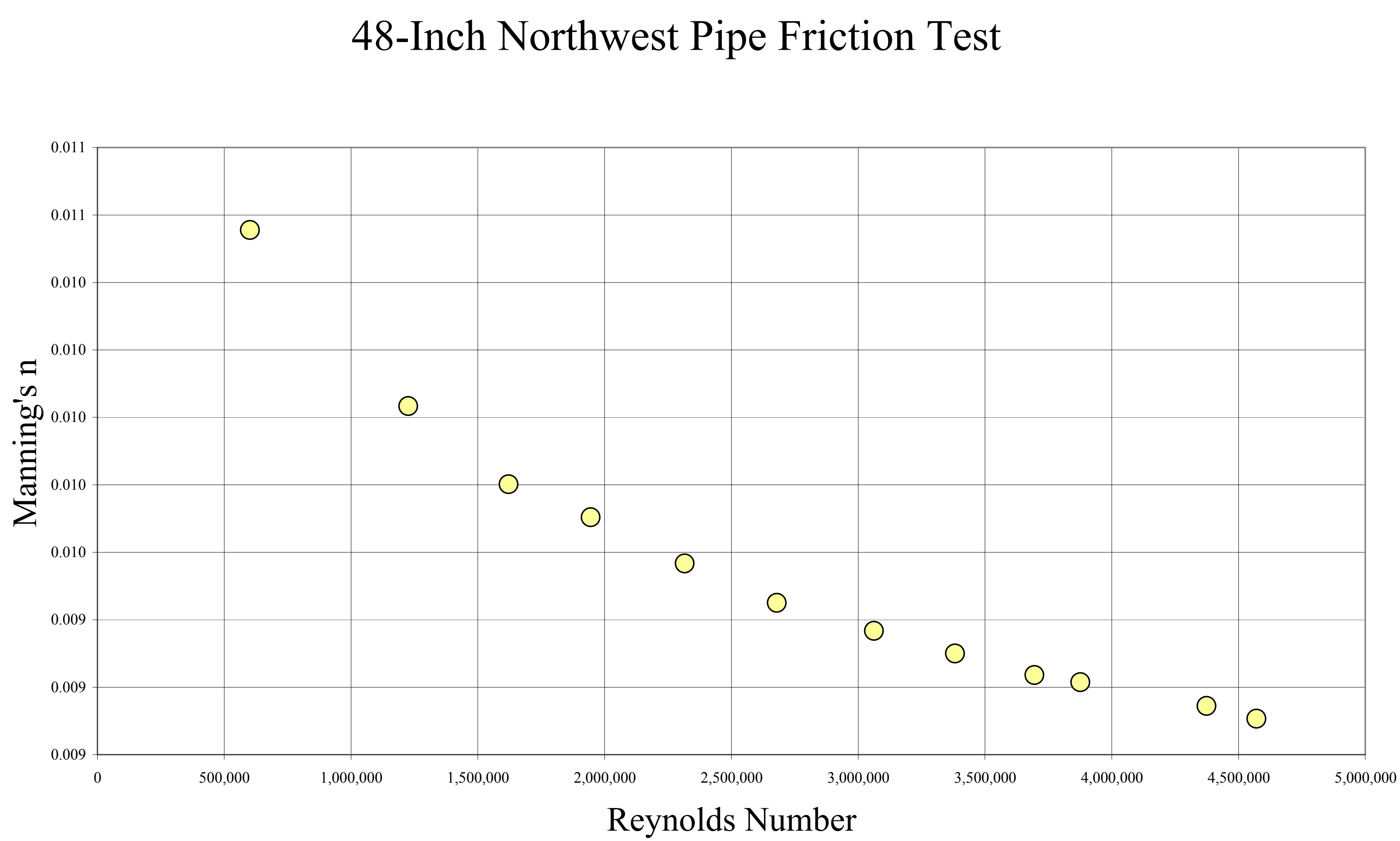

Figure 4. Friction Coefficient Data (Manning’s n)

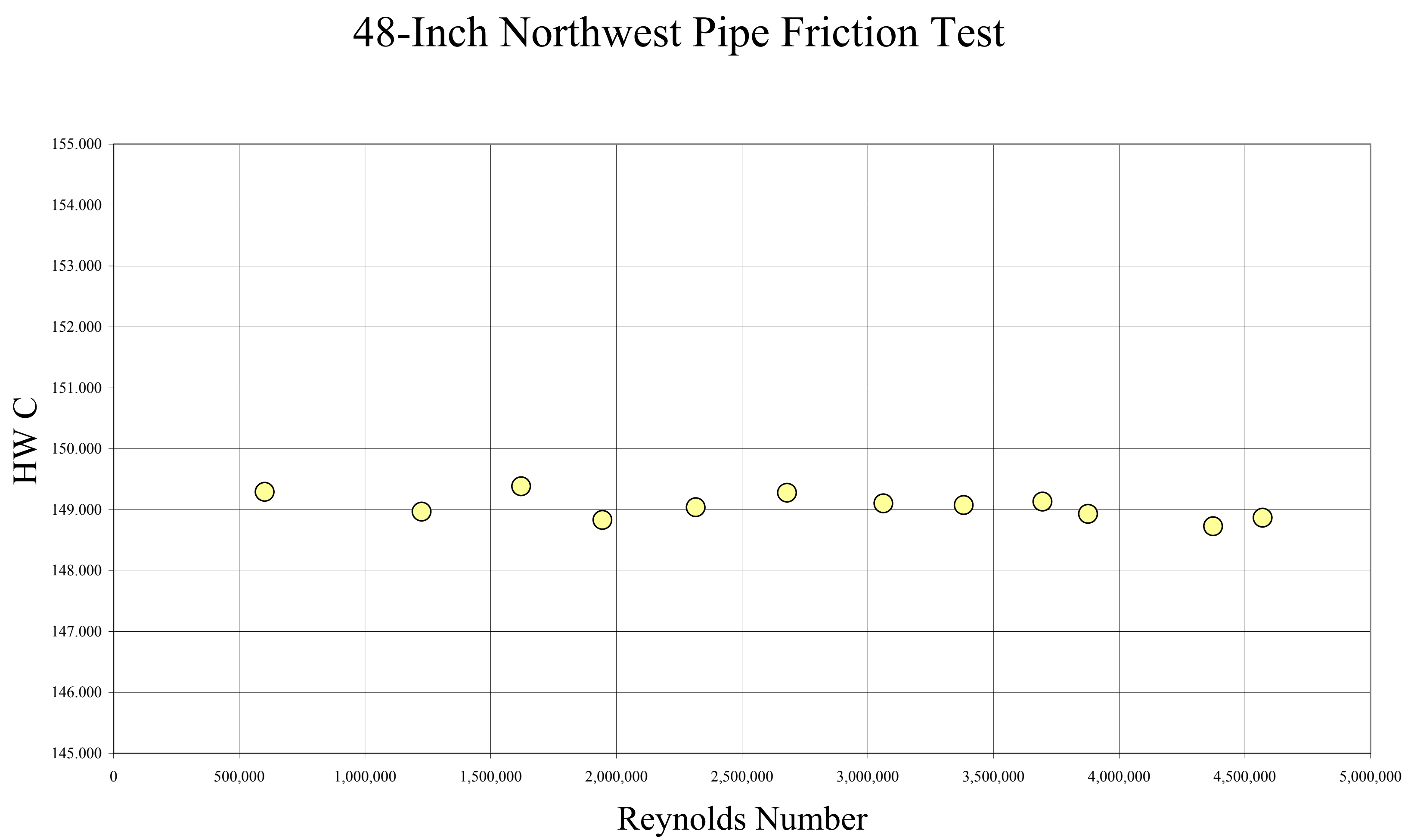

Figure 5. Friction Coefficient Data (Hazen Williams C)