FLOW RATING ANALYSIS FOR PUMP STATION G508

By
Sheng Yue & Emile Damisse

November 2011

SFWMD-HIST-024

Hydro Data Management Section
Operation & Infrastructure Bureau
South Florida Water Management District

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ACKNOWLEDGEMENT

The authors wish to express their appreciation to Matthew Alexander for collecting the pump performance curve and pump design information for this rating analysis.

DEFINITIONS

Acronyms

TDH	Total dynamic head
TSH	Total static head
SFWMD	South Florida Water Management District
STA	Stormwater treatment area

EXECUTIVE SUMMARY

Pump Station G508 consists of four diesel main inflow pumps each with capacity of 470 cfs, two electric low inflow pumps each with capacity of 110 cfs, and three electric seepage pumps each with capacity of 25 cfs.. This report summarizes a preliminary flow rating analysis for each type of pump at Pump Station G508 based on their corresponding pump performance curve. The developed rating equations will be used to compute flows through the pump station.

1.0 INTRODUCTION

1.1 Background

Pump Station G508 is the Compartment C build-out inflow pump station. The station is located just southeast of Structure G406. Pump Station G508 consists of three types of pumps: 4 diesel main inflow pumps each with capacity of 470 cfs, two electric low inflow pumps each with capacity of 110 cfs, and three electric seepage pumps each with capacity of 25 cfs. **Figure 1** shows the location of Pump Station G508.

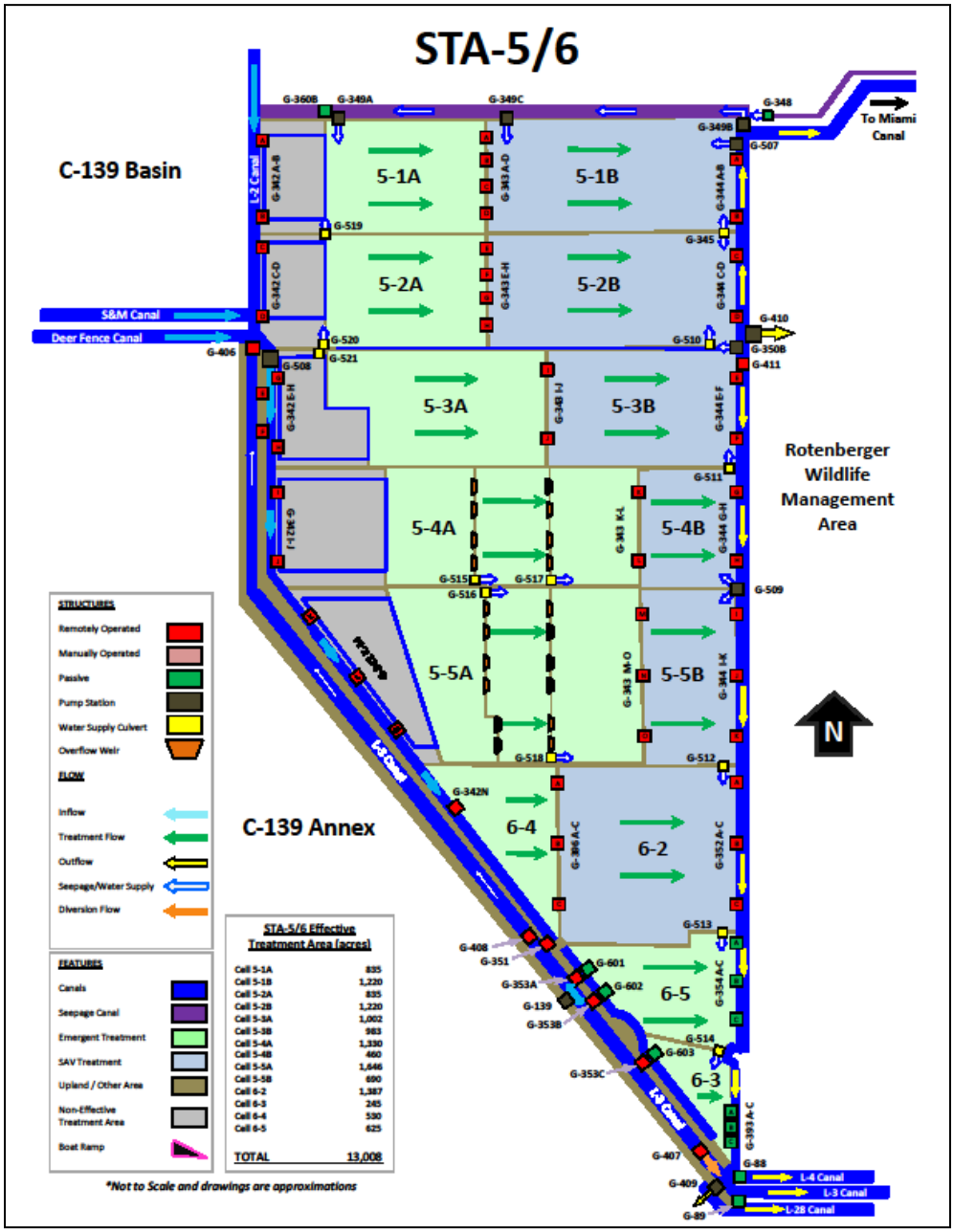

Figure 1. Location map for Compartment C and Pump Station G508

1.2 Objectives and Scope

We will conduct a preliminary rating analysis to develop a flow rating equation for each type of pump at Pump Station G508 to compute flows through the pump station.

2.0 STATION DESIGN

Pump Station G508 consists of four diesel main inflow pumps each with capacity of 470 cfs, two electric low inflow pumps each with capacity of 110 cfs, and three electric seepage pumps each with capacity of 25 cfs. **Table 1** presents more detailed description of the station. **Figure 2** illustrates the plan view of the pump station, and **Figure 3a** through **3c** show the profile view of main inflow pump, low inflow pump, and seepage pump, respectively.

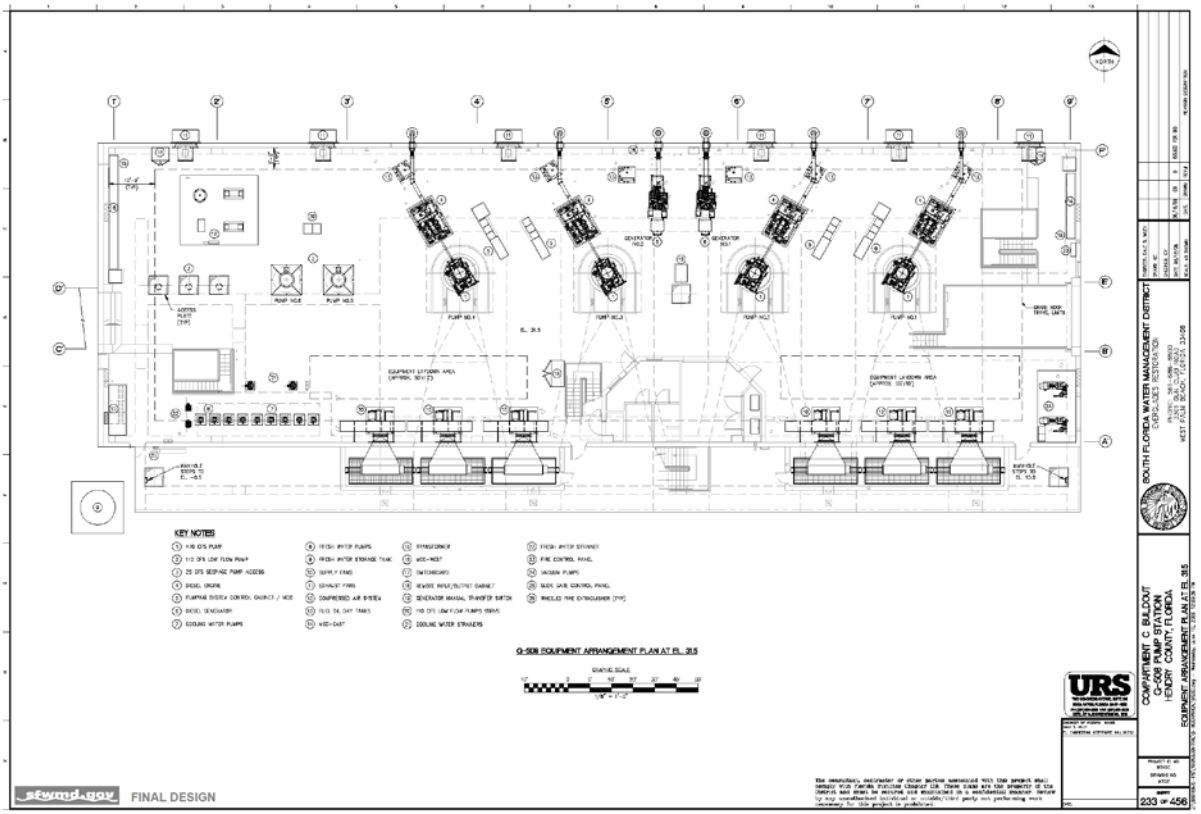

Figure 2. Plan view of Pump Station G508

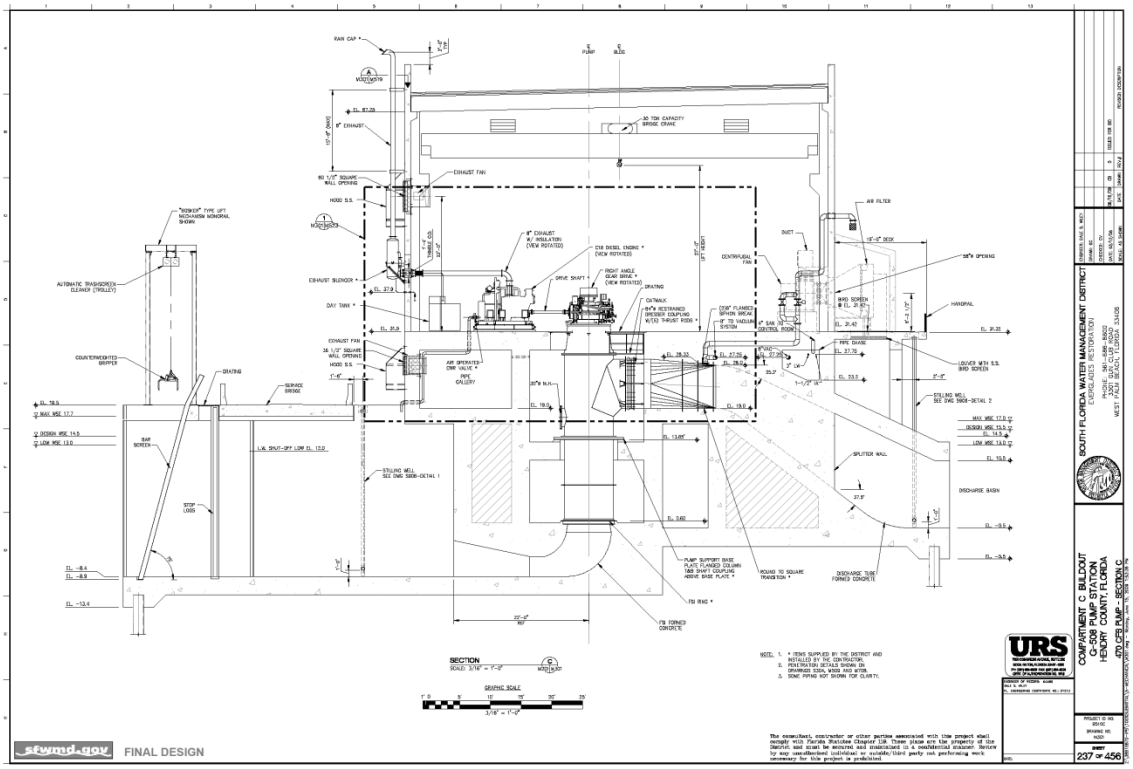

Figure 3a. Profile view of G508 main inflow pump – 470 cfs

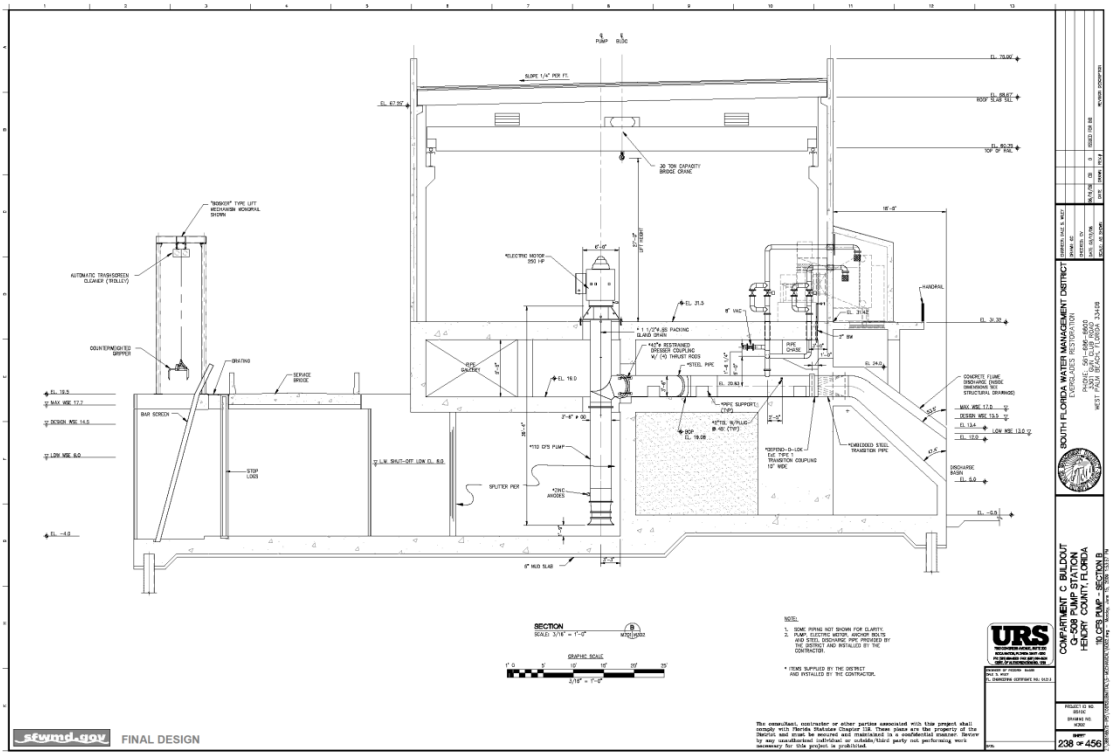

Figure 3b. Profile view of G508 low inflow pump – 110 cfs

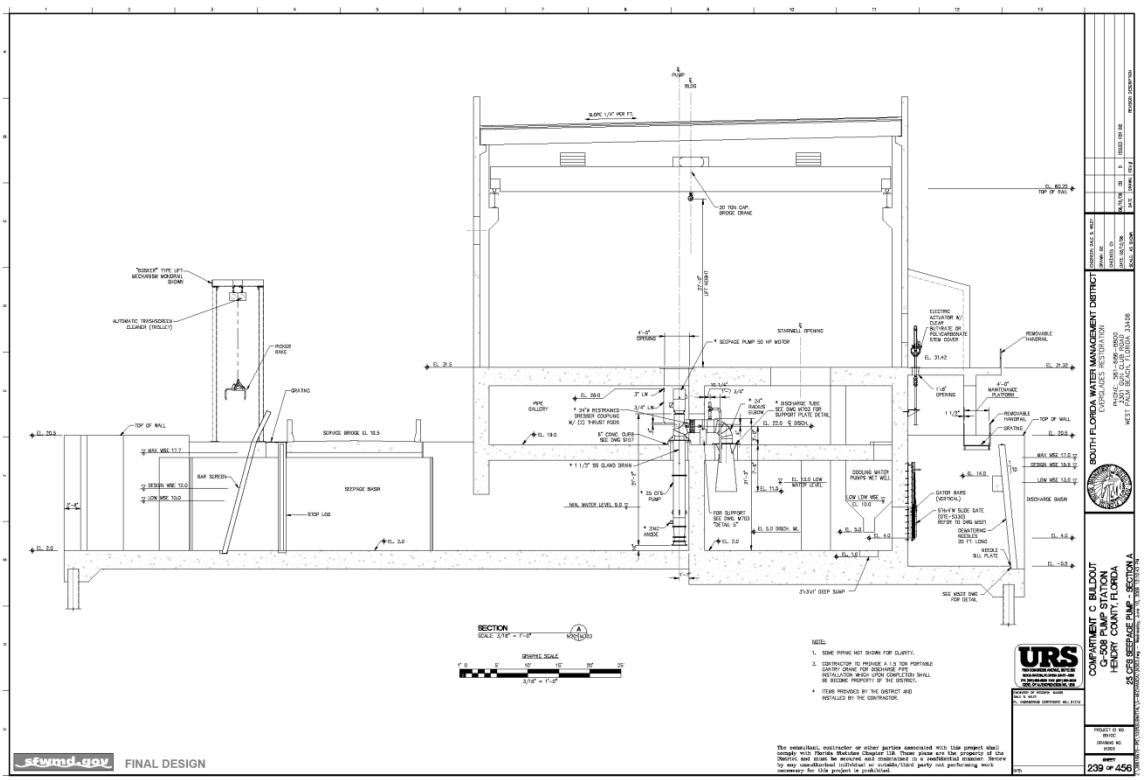

Figure 3c. Profile view of G508 seepage pump – 25 cfs

Table 1. Description for Pump Station G508

Pump Type	ITEM	Description
Diesel main inflow pump	Number of pumps	4
	Design pump capacity	470 cfs
	Engine motor horsepower	556 Hp
	Design engine speed	1640 rpm
	Pump impeller speed	145 rpm
	Propeller Diameter	80.7 in
	Discharge pump diameter	96 in
Electric low inflow pump	Number of pumps	2
	Design pump capacity	110 cfs
	Engine motor horsepower	250 Hp
	Design engine speed	440 rpm
	Pump impeller speed	440 rpm
	Propeller Diameter	34 in
	Discharge pump diameter	42 in
Electric seepage pump	Number of pumps	3
	Design pump capacity	25 cfs
	Engine motor horsepower	50 Hp
	Design engine speed	880 rpm
	Pump impeller speed	880 rpm
	Propeller Diameter	16.5 in
	Discharge pump diameter	24 in

The pump station is designed with both manual and remote operation of these pumping units. Remote operation is from the SFWMD's operations control center in West Palm Beach. Telemetry control for remote operation and real-time status is available. Headwater and tailwater data are also available to the remote operators, while headwater and tailwater staff gauges are available for manual/local operation.

2.1. Pump Performance Curves for G508

The manufacturer provides the pump performance curves for these three types of the pumps at Pump Station G508, as shown in **Figure 4** through **Figure 6.**

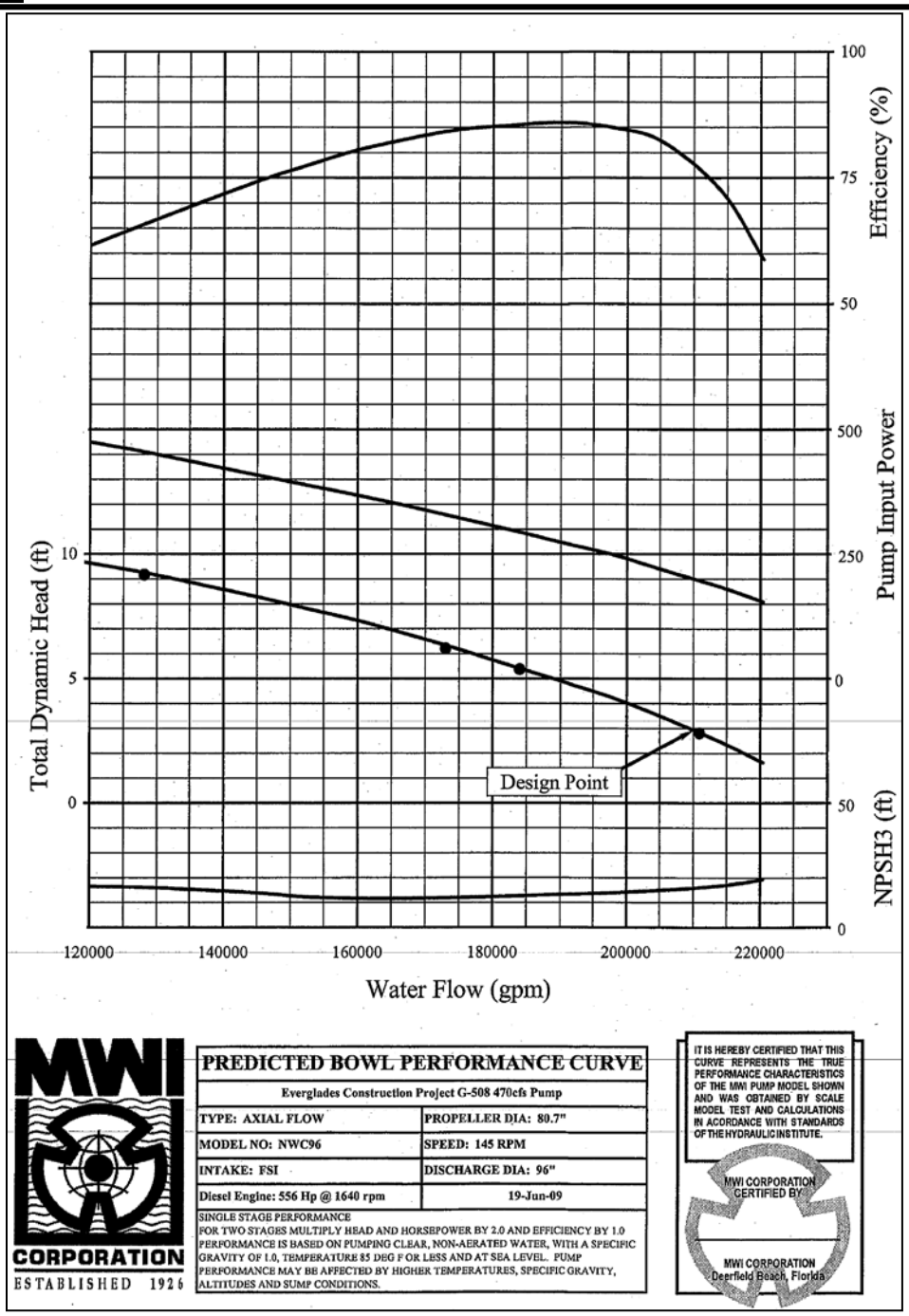

Figure 4. Pump performance curve for G508 diesel main inflow pump of 470 cfs

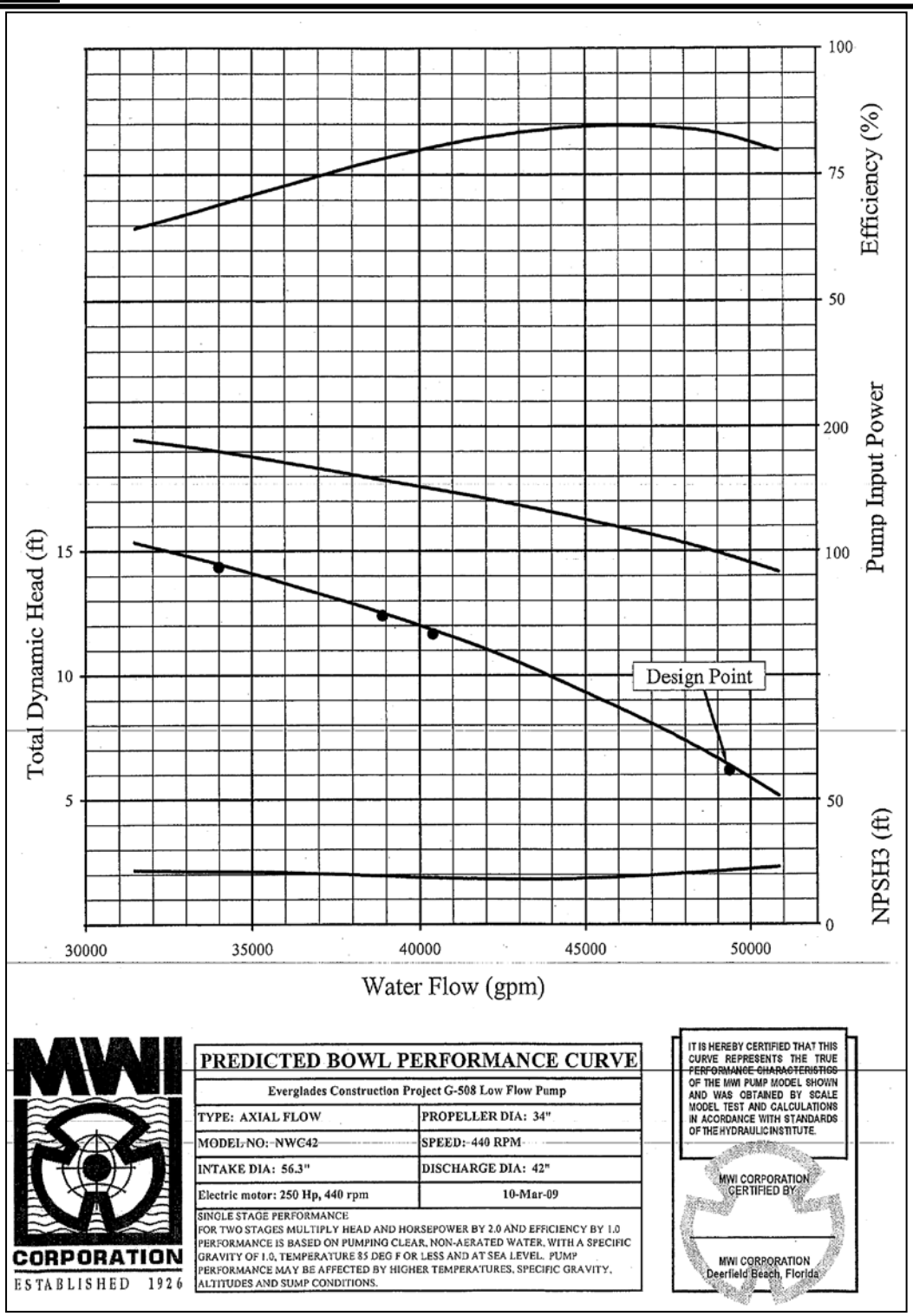

Figure 5. Pump performance curve for G508 electric low inflow pump of 110 cfs

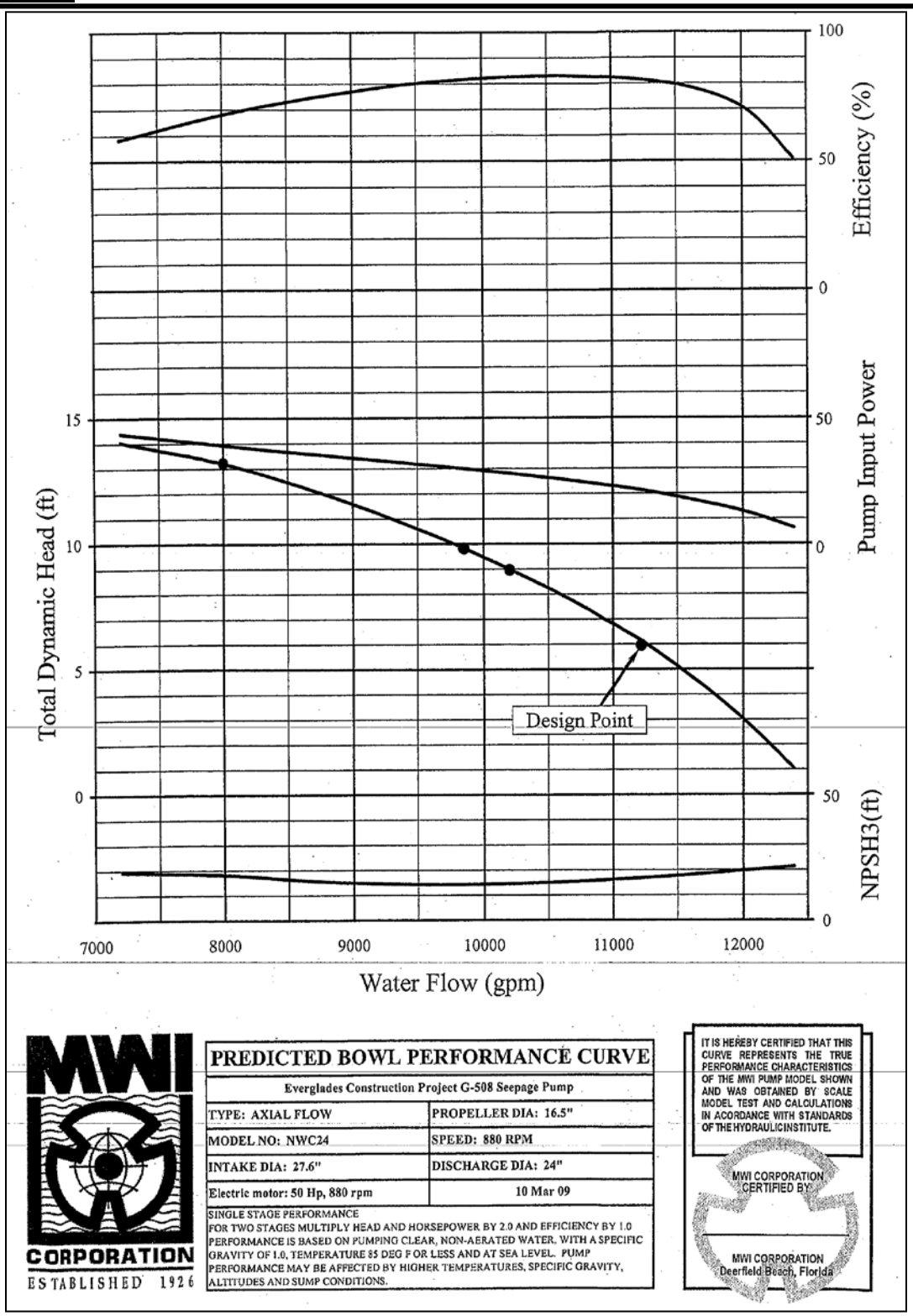

Figure 6. Pump performance curve for G508 electric seepage pump of 25 cfs

3.0 RATING ANALYSIS

We will develop a Case 8 flow rating equation for each type of pump at Pump Station G508, based on the factory pump performance curve. Case 8 rating equation is developed by dimensional analysis and the pump affinity laws, which is the conventional rating equation representing all the possible cases, as documented in Damisse (2001) and Imru and Wang (2003). Equation below shows the Case 8 flow rating equation.

$$Q = A\left(\frac{N}{No}\right) + BH^{C}\left(\frac{No}{N}\right)^{2C-1} \quad (1)$$

$$H = \max\{CL, TW\} - HW \quad (2)$$

Where

Q:	Discharge in cfs;
H:	Total static head (TSH);
N:	Pump engine speed in rpm;
No:	Design pump engine speed in rpm;
A, *B* and *C*:	Regression coefficients determined through regression analysis (A > 0, B < 0, and C > 1.0).
CL:	Discharge pipe outlet centerline elevation;
TW:	Tailwater elevation;
HW:	Headwater elevation.

The *H* versus *Q* relationship can be estimated by subtracting the total head losses through the intake and discharge works from total dynamic head (TDH) on the pump performance curve. We will then conduct a non-linear regression analysis using SAS NLIN function to determine the coefficients in the above equation.

We computed TSH by subtracting total head loss from TDH. The total head loss includes friction loss and minor losses, which were computed based on the loss coefficients provided by the pump manufacturer. **Table 2** through **Table 4** presents TDH, total head loss, and TSH vs. *Q* values corresponding to diesel main inflow pump of 470 cfs, electric low inflow pump of 110 cfs, and electric seepage pump of 25 cfs, respectively. **Table 5** provides the flow rating equation coefficients of Eq. (1) corresponding to each type of the pump, which were estimated by nonlinear regression analysis. **Figure 7** illustrates the developed rating curve for G508 diesel main inflow pump of 470 cfs, **Figure 8** for G508 electric low inflow pump of 110 cfs, and **Figure 9** for G508 electric seepage pump of 25 cfs. These diagrams illustrate that the rating curves from the developed rating equation fits the TSH well.

Table 2. TDH, Head Loss, TSH and Discharge Relations for G508 Diesel Main Inflow Pump - 470 cfs

Flow Rate (gpm)	Flow Rate (cfs)	TDH (ft)	Head Loss (ft)	TSH (ft)
120000	267.370	9.60	0.588	9.012
125000	278.510	9.38	0.639	8.741
130000	289.650	9.14	0.691	8.449
135000	300.791	8.86	0.745	8.115
140000	311.931	8.60	0.801	7.799
145000	323.072	8.30	0.860	7.440
150000	334.212	7.96	0.920	7.040
155000	345.352	7.64	0.982	6.658
160000	356.493	7.34	1.047	6.293
165000	367.633	6.98	1.113	5.867
170000	378.774	6.59	1.182	5.408
175000	389.914	6.19	1.252	4.938
180000	401.054	5.74	1.325	4.415
185000	412.195	5.38	1.399	3.981
190000	423.335	4.90	1.476	3.424
195000	434.476	4.48	1.555	2.925
200000	445.616	4.00	1.635	2.365
205000	456.756	3.50	1.718	1.782
210000	467.897	2.90	1.803	1.097
215000	479.037	2.36	1.890	0.470

Table 3. TDH, Head Loss, TSH and Discharge Relations for G508 Electric Low Inflow Pump -110 cfs

Flow Rate (gpm)	Flow Rate (cfs)	TDH (ft)	Head Loss (ft)	TSH (ft)
32000	71.299	15.16	2.249	12.911
33000	73.527	14.80	2.392	12.408
34000	75.755	14.46	2.539	11.921
35000	77.983	14.08	2.690	11.390
36000	80.211	13.68	2.846	10.834
37000	82.439	13.30	3.007	10.293
38000	84.667	12.86	3.171	9.689
39000	86.895	12.46	3.340	9.120
40000	89.123	12.00	3.514	8.486
41000	91.351	11.56	3.692	7.868
42000	93.579	11.04	3.874	7.166
43000	95.807	10.50	4.061	6.439
44000	98.036	9.94	4.252	5.688
45000	100.264	9.36	4.447	4.913
46000	102.492	8.70	4.647	4.053
47000	104.720	8.06	4.851	3.211
48000	106.948	7.40	5.060	2.340
49000	109.176	6.66	5.273	1.387
50000	111.404	5.86	5.490	0.370

Table 4. TDH, Head Loss, TSH and Discharge Relations for G508 Electric Seepage Pump -25 cfs

Flow Rate (gpm)	Flow Rate (cfs)	TDH (ft)	Head Loss (ft)	TSH (ft)
7500	16.711	13.70	1.105	12.595
8000	17.825	13.20	1.257	11.943
8500	18.939	12.50	1.419	11.081
9000	20.053	11.60	1.591	10.009
9500	21.167	10.60	1.772	8.828
10000	22.281	9.50	1.964	7.536
10500	23.395	8.26	2.165	6.095
11000	24.509	6.80	2.376	4.424
11500	25.623	5.14	2.597	2.543
12000	26.737	3.00	2.828	0.172

Table 5. Flow Rating Coefficients for the Pumps at G508

Pump Type	*No* (rpm)	Rating Coefficient	Estimate	Approximate Lower 95% Confidence Limit	Approximate Upper 95% Confidence Limit
Diesel Main Inflow Pump - 470 cfs	1640	A	478.4	474.7	482.0
		B	-9.1919	-10.6217	-7.7620
		C	1.4159	1.3491	1.4827
Electric Low Inflow Pump - 110 cfs	440	A	111.0	110.5	111.6
		B	-1.2014	-1.3618	-1.0410
		C	1.3635	1.3136	1.4135
Electric Seepage Pump - 25 cfs	880	A	26.5606	26.1583	26.963
		B	-0.186	-0.277	-0.095
		C	1.5542	1.3673	1.7412

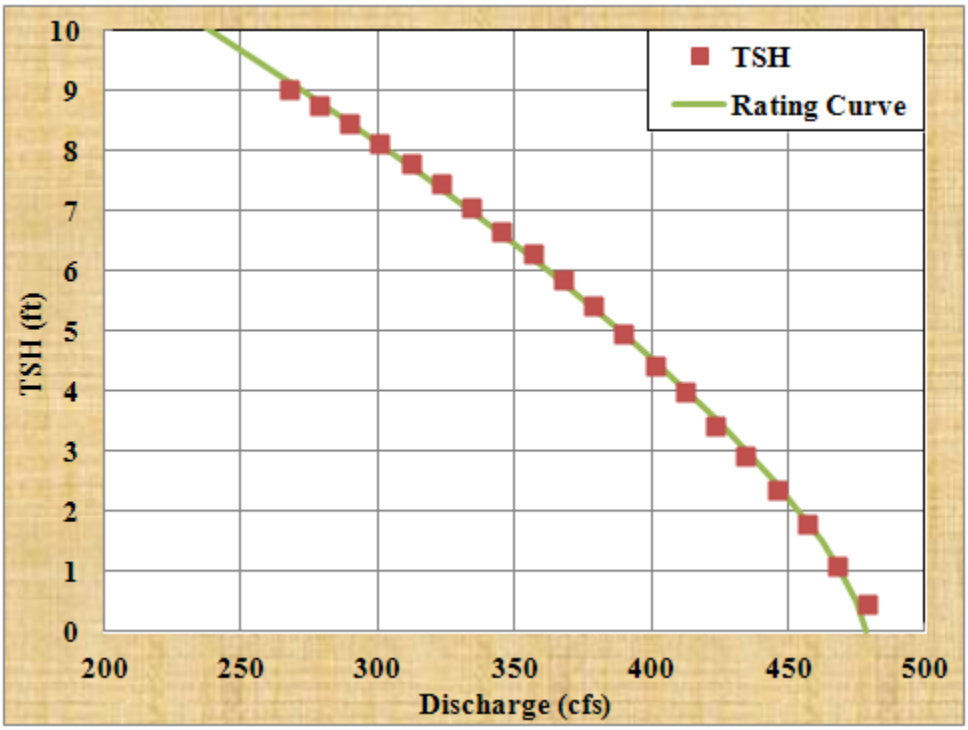

Figure 7. Flow rating curve for G508 diesel main inflow pump

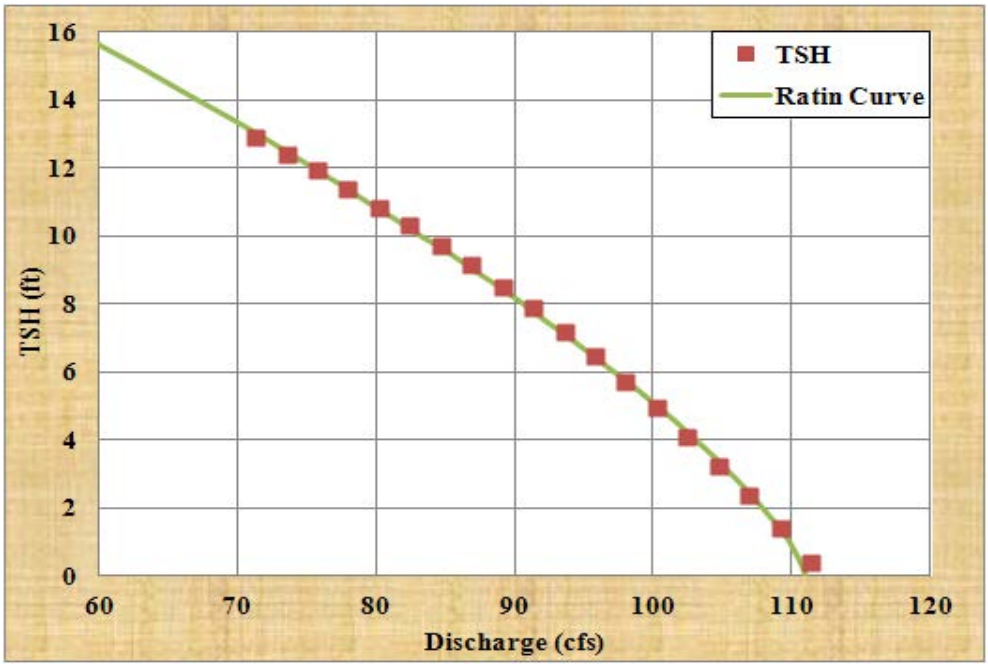

Figure 8. Flow rating curve for G508 electric low inflow pump

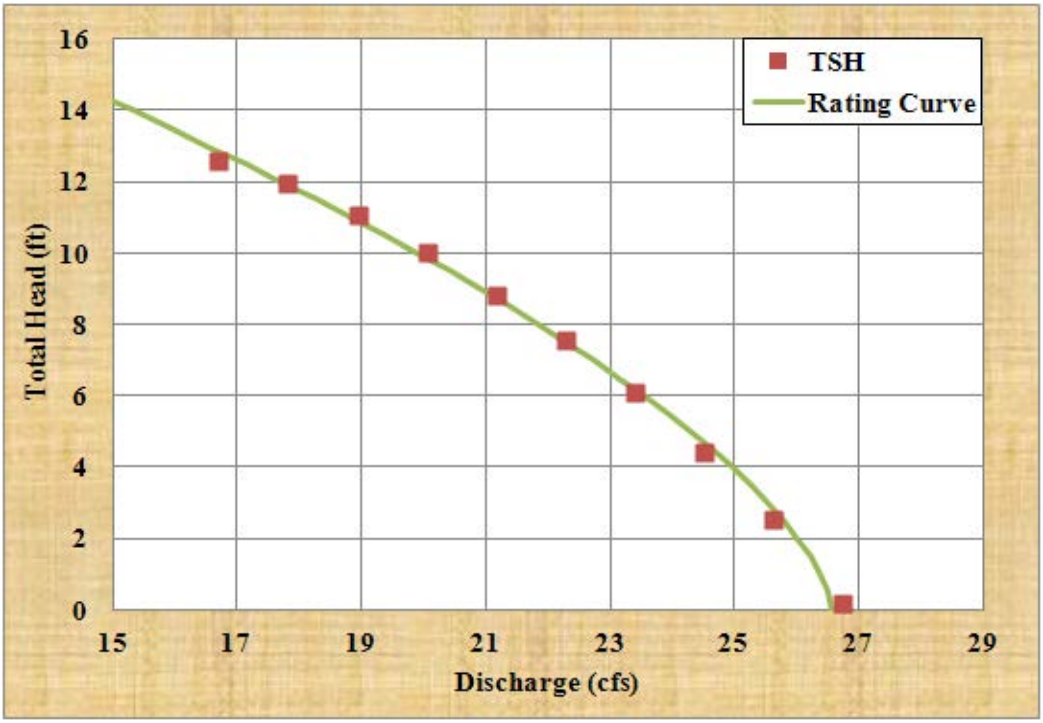

Figure 9. Flow rating curve for G508 electric seepage pump

4.0 CONCLUDING REMARKS

We conducted preliminary rating analysis for the each type of pump at Pump Station G508 based on the pump performance curve. **Table 5** presents the coefficients of the flow rating equation for Pump Station G508. The preliminary flow rating equation needs to be calibrated, and to be potentially improved based on future flow measurements after the pump stations are constructed and operated.

REFERENCES

Damisse, E. 2001. Flow rating development for G335 Pump Station in STA-2. Hydrologic Data Management Division, South Florida Water Management District, West Palm Beach, Florida.

Imru, M. and Y. Wang. 2003. Flow Rating Analysis Procedures for Pumps. Technical Publication EMA # 413, South Florida Water Management District, West Palm Beach, Florida.