B

deliver an intermediate water pressure to the District and adjacent City customers, installing rechlorination facilities at the City of Austin Martin Hill Reservoir to restore full capacity operation of City facilities, and extending a new 5500 linear foot intermediate pressure water supply main to a connection with the District. The first two alternatives were determined by the City of Austin staff to be unfeasible for a number of technical as we all as terrorist and safety related reasons. The third alternative to extend a dedicated interim pressure main was determined to be economically unfeasible by the District with an estimated cost of over $1,600,000. It is understood that this cost exceeds the District's available financial resources at this time.

A fourth apparently technically and economically feasible alternative is the design and installation of two strategically located interim variable speed booster stations inside the District. The District engineer recommends that the District Board consider employing its District Manager to construct these facilities as quickly as possible due to the apparent emergency nature of the problem. It is understood that the District currently has sufficient funds to support this alternative. The District would operate these facilities at the District's expense for a temporary period until the City of Austin can resolve its current water pressure delivery problem and restore its operations to full design capacity in this geographic area.

As it is the District's obligation to provide sufficient water capacity service to its customers, it is important that this occasional low domestic pressure problem be resolved as quickly as possible. Such response will require cooperation and support by City of Austin staff to quickly restore adequate pressure throughout the District to avoid any future health or safety concerns.

Sincerely,

David Malish, P.E.
District Engineer

cc: Sharlene Collins, Armbrust & Brown LLP
Gary Spoonts, Eco Resources Inc.

Mecfiles/malish/wordfile/namud/water pressure

MONTHLY ENGINEERING REPORT
NORTH AUSTIN MUNICIPAL UTILITY DISTRICT NO. 1

Prepared on Wednesday, September 15, 2004
For Meeting on Wednesday, September 22, 2004

By David Malish P.E., District Engineer

District Water Pressure

Following a somewhat exhaustive and time consuming alternative development and assessment for improving domestic water pressure within the District, the District Board at its August meeting selected to pursue the design and construction of two temporary internal water pressure booster systems strategically located on sites currently controlled/owned by the District. These sites include the "fire station" site on Dallas Drive and the District's lot on the northwest corner of Parmer and Tamayo. The selected lot on Dallas is currently unplatted while the lot on Parmer/Tamayo is platted. The unplatted lot will probably need to be platted but the District should seek the advice of its attorney. The cost of platting this lot through the short form process is estimated to approximate $8000.

The District engineer recently (August 21st) completed a fire flow test near the intersection of Parmer and Anderson Mill Road in support of a request from representatives of the Milwood Village development. A residual domestic water pressure of 37 psig was observed. This low pressure at this location indicated that the District, at that time, was experiencing water pressures in more critical locations of the District below the State minimum standard of 35psig. The observed water pressure measurement is perhaps the lowest pressure ever measured by the District's engineer within the District and confirms the City of Austin's intended practice to continue lowering northwest pressure zone A water pressure.

The District engineer has previously represented that this low pressure problem can most readily quickly be resolved with the installation of the two previously referenced booster stations. The District engineer recently met with Mr. Brian Gil of Hydro-Con Systems to discuss equipment availability. It was mutually agreed that the design and construction of skid mounted variable speed split case pumps would offer not only a quick response but also an economical and reliable solution within the current available financial resources of the District. Attached is a preliminary cost estimate provided by HydroCon Systems for the delivery of sled mounted systems. The estimated cost is $150,000 per each delivered to the site. Note that minimal work would be required to install the stations. To further minimize costs, these facilities can be located in open air but shielded on three sides with a decorative landscaped wall and ultimately secured with a rear and ceiling security fence. Backup generators would not be necessary for in the event of a power failure, the system will be automatically removed from service and the District will be served exclusively via City water pressure temporarily until power is restored. In addition for this event, power at both stations must be lost simultaneously. Finally, it is estimated that these systems can be designed and constructed for operations in approximately a six month period.

It is very important to note that while these systems are highly reliable and efficient; this design will not meet City of Austin criteria. The City of Austin consent to creation of the District requires that all water and wastewater utilities constructed within the District be reviewed and approved by the City implying the imposition of City criteria. This imposition will significantly increase the costs beyond the District's current financial resources, and will perhaps double the construction period while it is doubtful that reliability will be enhanced. A major concern of the City staff is that in the event the District is annexed into he corporate limits, the City would be required to operate the facilities. Alternatively, it is reasonable to expect the City of Austin to resolve the area wide geographic low water pressure problem prior to any annexation considerations. The City staff have verbally recognized that other adjacent areas wholly within the City's service area also experience low pressure water problems.

AGENDA ITEM # 13

94002.161

MEC

Murfee Engineering Company

June 10, 2005

Chris Lippe, P.E., Director
City of Austin Water and Wastewater Department
625 E. 10th Street, Suite 415
Austin, Texas 78701

Re: ***North Austin MUD No. 1***
Temporary Water Pressure Booster Station

Dear Mr. Lippe,

Enclosed for your review are construction plans for two temporary variable speed booster stations proposed for immediate installation within North Austin MUD No. 1. As you are aware, the District engineer and the City staff, in concert, conducted an exhaustive alternatives analysis to resolve the current low domestic water pressure concerns within the District. Alternatives analyzed included creating an intermediate pressure zone with the use of existing facilities and mains as well as extending new mains, and/or "freshening" the water in the Martin Hill Reservoir with rechlorination. All City of Austin alternatives identified were determined to be unfeasible.

The District currently observes domestic water pressures below the State standard of 35psi approaching near 20psi on occasion in some locations. Such low pressures constitutes a human health and safety concern and the District manager has received several complaints. Adequate pressures were once available in all of the District's subdivisions at the time of construction approval, but domestic pressures have now been lowered as a result of operational changes at Martin Hill Reservoir. It is understood that once city water demands in the geographical area of the Martin Hill Reservoir are substantially increased, full operation of the Martin Hill Reservoir will be restored and the District will again have adequate domestic pressure.

The temporary water pressure booster stations need to be installed as quickly as possible to resolve the current health and safety concerns. It is recognized that this design may not specifically meet current City standards or criteria, but it is doubtful that the City of Austin will ever operate or maintain these temporary facilities. Please note that the booster stations are located wholly within the District serving only geographical areas within the District. In addition, it is estimated that these facilities can be constructed with funds currently available which are in the range of $700,000 to $800,000 total. Any costs for such facilities in excess of this amount will require seeking additional funding sources which will result in a substantial delay.

I will appreciate an expedited review and comment on these plans. If you have any questions please call.

Sincerely,

David Malish

David Malish, P.E.
District Engineer

Mecfiles/malish/wordfile/namud/lippe-booster stations

1101 Capital of Texas Highway South • Building D, Suite 110 • Austin, Texas 78746 • 512/327-9204

MEC

Murfee Engineering Company

Sept 13, 05

David D Laughlin, P E
Texas Commission on Environmental Quality
Utility Technical Review Team
Water Supply Division MC-153
P O Box 13087
Austin, TX 78711-3087

Ron Humphrey, P.E.
City of Austin
Austin Water Utility
625 E 10th St, Suite 415
Austin, TX 78701

Re **North Austin MUD #1**
Low Domestic Water Pressure
Proposed Resolution with Installation of VFD Booster Pumps

Dear Gentleman,

After reviewing the design comments received from both the City of Austin and TCEQ, it has become apparent that there is perhaps some misunderstanding of the operational characteristics and performance of variable frequency drive (VFD) technology when used for domestic water supply purposes. Both the City of Austin and TCEQ staff have expressed or implied a concern that the imposition of this technology to solve the low domestic water pressure problem within North Austin MUD No. 1 may result in severely reduced pressure in the City of Austin's water supply mains. While no actual explanation is provided, it is suspected that the reviewers have reason to believe that the in-line pumps will attempt to withdraw or divert water for service within the District at a rate significantly exceeding the original design capacity of the water supply main thereby causing a possible collapse of the main

Any requirement for the installation of a ground storage tank with an air gap is not only technically unjustified in this case considering the employment of VFD technology, but will also eliminate this alternative from further consideration as it becomes technically, economically, and socially unfeasible. The installation of an air gap will require the installation of not only large ground storage tanks but also fire demand pumps with backup emergency power. Fire protection from the City of Austin system will no longer be available and will have to be reproduced mechanically, which is less reliable. In addition, it becomes questionable if any elevated storage is provided to the District which serves in excess of 2,500 connections and perhaps on-site elevated storage will now be required. A former plan to install an elevated storage tank was previously eliminated from consideration at the request of the City of Austin as referenced in the third amendment to the consent for creation agreement between the District and the City

The addition of ground storage tanks, fire pumps, enclosed structures with HVAC systems, back-up power facilities possibly an elevated storage tank and an on-site water quality and detention ponds will increase the cost of this alternative by several million dollars and will require the acquisition of additional adjacent properties at both sites. In addition, at this time, the installation of these facilities will be delayed a minimum of two (2) years owing to the permitting and plan approval process that will need to be re-initiated. With this increased cost and time considerations, other previously rejected alternatives should possibly be reconsidered.

The following discussion is provided to assist in more clearly understanding the use of VFD technology in an effort to support reconsideration of the required air gap and the subsequent facilities requirement consequence. It is unnecessary to address any other issues at this time as this alternative becomes unfeasible with the requirement of an air gap. Therefore, other issues will only be addressed if the requirement for the air gap is reconsidered. It should also be completely understood that the District and consultants have no intention to jeopardize in any way the integrity or operation of the City of Austin's water supply facilities

The use of VFD technology to increase domestic water pressure will not effect domestic demands or result in increased domestic flows at any time. Instantaneous flows in the City of Austin water supply mains will remain essentially unaffected with or without the installation of the proposed VFD motors/pumps. VFD water pressure boosting systems are configured and designed to maintain a set or specified discharge pressure. The actual motor/pump speed will vary directly and simultaneously with system water demand to deliver a water demand rate precisely coinciding with actual system demands. As no internal storage facilities exist within the District, the VFD facilities cannot pump or deliver flow rates in excess of system demands at any time.

It is important to note that the District currently receives water supply at four locations through water master meters as shown in Figure 1. Water supply at Amarillo is delivered from a 36" main along McNeil Drive, at Dallas Drive from a 36"/24" main along Parmer Lane, and at Tamayo Drive and Anderson Mill from the 24" main along Parmer Lane. With the installation of the proposed booster stations, water supply locations to the District will be reduced to two sites as shown in Figure 2 Note that the current water supply to the District at the intersection of McNeil Drive and Amarillo will essentially be eliminated with the installation of a check valve. To satisfy current and projected water demands within the District, water supply currently entering the District at this intersection must be redirected to one of the two entry (booster station) sites along Parmer Lane at either Dallas Drive or Tamayo Drive. In either case, additional flows, equal to that eliminated at the McNeil Drive/Amarillo intersection, will be redirected for supply through the 36"/24" transmission main in Parmer Lane.

To assess the impact of this system supply modification, water model simulations were used to determine projected domestic flows through water supply mains under existing conditions and under reconfigured and rerouted conditions. The results of the water models are provided in Table 1. As is shown, approximately 1365 gpm of domestic flow under peak hours use conditions will be diverted from the intersection at McNeil Drive and Amarillo to a point of supply to the District at the intersection of Dallas Drive and Parmer Lane. It is interesting to note that the actual flow through the 24" main along Parmer Lane from the intersection with Dallas to Tamayo is projected to actually decrease by approximately 400 gpm. The estimated effect on headloss and the subsequent reduction in pressure in the City of Austin water supply mains is summarized in Table 2. As is shown, the reduction in pressure in the 36"/24" to Dallas is negligible. Pressure in the City of Austin 24" main is also negligible.

The pumps selected for this application are designated as Flowserve 10LR-16A. The variable speed curves for this pump using a 12.75" propeller are provided in Figure 3. These pumps were selected in an effort to deliver up to collectively approximately 6600 gpm of water flow to the District at a discharge pressure of near 60 psi.

Referencing the pump performance curves, it is shown that the three pumps can each deliver approximately 3800gpm at near pump cavitation. This situation, however, will only occur if all pump controls fail during a low water pressure period with a coincidental peak demand of 11400 gpm – an unlikely if not impossible condition. At this point, cavitations will be initiated. Assuming an 11,400 gpm flow through the City of Austin's 36"/24" water supply main in Parmer Lane from McNeil Drive to Dallas Drive, a total estimated pressure drop of only 3 psi will be observed under this extreme condition. Assuming a minimum delivery pressure of 35 psi, a low pressure of 32 psi will result in the main. Little, if any, headloss will be observed in the City's water supply mains. Even under these extreme and unlikely conditions a pressure decrease to 20 psi in the City water supply mains cannot result from the installation of the proposed booster pumps. Again, it is reiterated that the imposition of variable speed technology will not increase flows but will only supply flows as dictated by demand which is independent of the proposed booster station installation.

The TCEQ staff has expressed additional concern that adequate surge protection has not been considered. Water hammer from surge results from a sudden significant decrease in pipeline velocity generally caused by rapid valve closure, a sudden loss of power at a pump station or any other situation which suddenly disrupts the velocity of the water The resulting pressure from water hammer is directly related to the water velocity at the time of disruption of flow.

As discussed previously, VFD pumps are controlled by a set discharge pressure. The speed of the pumps and consequently the resulting flow will vary precisely with system demands as dictated by routine operations. As system demand increases the motor/pump speed increases in an effort to maintain the set discharge pressure

The more recent advances in VFD technology over the last decade have allowed motor speeds to slow significantly before forced shut off. Low flows in the range of 200 to 300 gpm can be maintained by the specified pumps. With a statistical user base of approximately 2900 connections it is anticipated that the pumps will run continuously as the low flow delivered will range from 0.07 to 0.10 gpm per connection. In any event, system flows in the range of 200 to 300 gpm range will be observed at system shut off if it ever occurs.

In the event of a line break or an unusual system demand such as a major fire flow, the motor/pump speed will quickly increase in an effort to maintain the set discharge pressure of near 60 psi. The pump will deliver flows at precisely the system demand. In an effort to protect the pumps from possible cavitation, the pump controls are designed to deactivate the pumps when a discharge pressure of 53.5 psi cannot be maintained At the time of shut off, the integrated check valves will open and system demand will be provided exclusively from the City of Austin system as if the booster stations were never installed. Water hammer from surge will not occur under this situation as water pressure and flows will be released at the line break or fire hydrant at the time of pump shut off. This situation does not represent a sudden valve closure.

In the event of a sudden power outage during normal operating conditions, the pumps will also suddenly deactivate and the integrated check valve will open with water supplied directly from City of Austin system as is the current situation. As the VFD pumps will only discharge a precise flow equal to the instantaneous system demands as dictated by the current valve openings (or breaks) throughout the District, surge cannot be expected as pressure and flow will be instantaneously released through the open valves which are imposing the demand at the time of deactivation. Again, this situation does not represent sudden valve closure or disruption of velocity until all energy is released.

Based on this analysis and understanding of VFD technology, it is difficult to technically justify low suction pressure or discharge surge (water hammer) concerns with this application. It will be unfortunate to deny this technically or economically feasible alternative for resolving the on-going low pressure problem following an extensive alternative analysis if such denial is based on the misunderstanding of system operation. Again the District does not intend to jeopardize the integrity of the City of Austin's water supply facilities in any way If such concerns remain, perhaps a special condition or situation has been over-looked, please advise

I will be glad to discuss this analysis with you at your convenience, however, if the requirement for an air gap remains, this alternative becomes unfeasible and no additional response to other comments is necessary at this time. I look forward to your response.

Sincerely,

David Malish, P.E
Vice President
Murfee Engineering

Cc: Sharlene Collins – Armbrust and Brown
Gary Spoonts – Eco Resources

[Table 1]

Scenario 1:
EXISTING CONDITIONS @ 980' HGL
Steady State Analysis
Pipe Report

Label	Length (ft)	Diameter (in)	Discharge (gpm)	Velocity (ft/s)	Pressure Pipe Headloss (ft)	Headloss Gradient (ft/1000ft)	From Node	To Node	Hazen-Williams C
P-3	50.00	6	0.00	0 00	0 00	0.00	J-725	PMP-2 Tamayo	100 0
P-5	1,436.00	36	3,301 63	1.04	0.26	0.18	SR-1	J-5	100 0
P-15	205 00	12	1,364.67	3.87	1 50	7.33	J-5	J-15	100.0
P-1390	1,739.00	36	1,936.96	0.61	0.12	0.07	J-5	J-90	100.0
P-1395	294 00	24	3,271.97	2.32	0.37	1 26	SR-2	J-90	100 0
P-195	1,637.00	36	5,208.93	1.64	0.68	0.42	J-100	J-165	100.0
P-205	77.00	16	2,575.09	4 11	0.45	5 85	J-165	J-170	100.0
P-975	2,737.00	24	2,633.84	1.87	2.32	0 85	J-180	J-725	100 0
P-980	1,755.00	24	823.26	0.58	0.17	0.10	J-725	J-1145	100.0
P-1150	187.00	12	1,810.58	5.14	2 31	12 37	J-725	J-720	100.0
P-1530	1,322.00	12	823.26	2.34	3.80	2 87	J-1145	J-1080	100.0
P-220	634.00	16	2,036.09	3.25	2 40	3.79	J-170	J-185	100.0
P-8	53 00	16	0.00	0.00	0 00	0.00	J-2	J-185	100 0

Scenario 2:
PRESSURE INCREASE OF 25 PSI @ TAMAYO AND DALLAS MASTER METERS
Steady State Analysis
Pipe Report

Label	Length (ft)	Diameter (in)	Discharge (gpm)	Velocity (ft/s)	Pressure Pipe Headloss (ft)	Headloss Gradient (ft/1000ft)	From Node	To Node	Hazen-Williams C
P-3	50 00	16	2,215 79	3.54	0.22	4 43	J-725	PMP-2 Tamayo	100.0
P-5	1,436.00	36	3,301.63	1 04	0.26	0.18	SR-1	J-5	100 0
P-15	205.00	12	0.00	0.00	0.00	0.00	J-5	J-15	100.0
P-1390	1,739.00	36	2,929.31	0.92	0.25	0.14	J-5	J-90	100.0
P-1395	294.00	24	3,644 29	2 58	0.45	1.54	SR-2	J-90	100.0
P-195	1,637 00	36	6,573.60	2.07	1.05	0.64	J-100	J-165	100.0
P-205	77.00	16	4,357.82	6.95	1.19	15.50	J-165	J-170	100.0
P-975	2,737 00	24	2,215.79	1.57	1.68	0.61	J-180	J-725	100.0
P-980	1,755.00	24	-0.00	0.00	0 00	0.00	J-725	J-1145	100.0
P-1150	187.00	12	0.00	0.00	0.00	0.00	J-725	J-720	100.0
P-1530	1,322.00	12	0.00	0.00	0.00	0.00	J-1145	J-1080	100.0
P-220	634.00	16	0 00	0 00	0 00	0 00	J-170	J-185	100.0
P-8	53.00	16	3,818 82	6.09	0.64	12.14	J-2	J-185	100.0

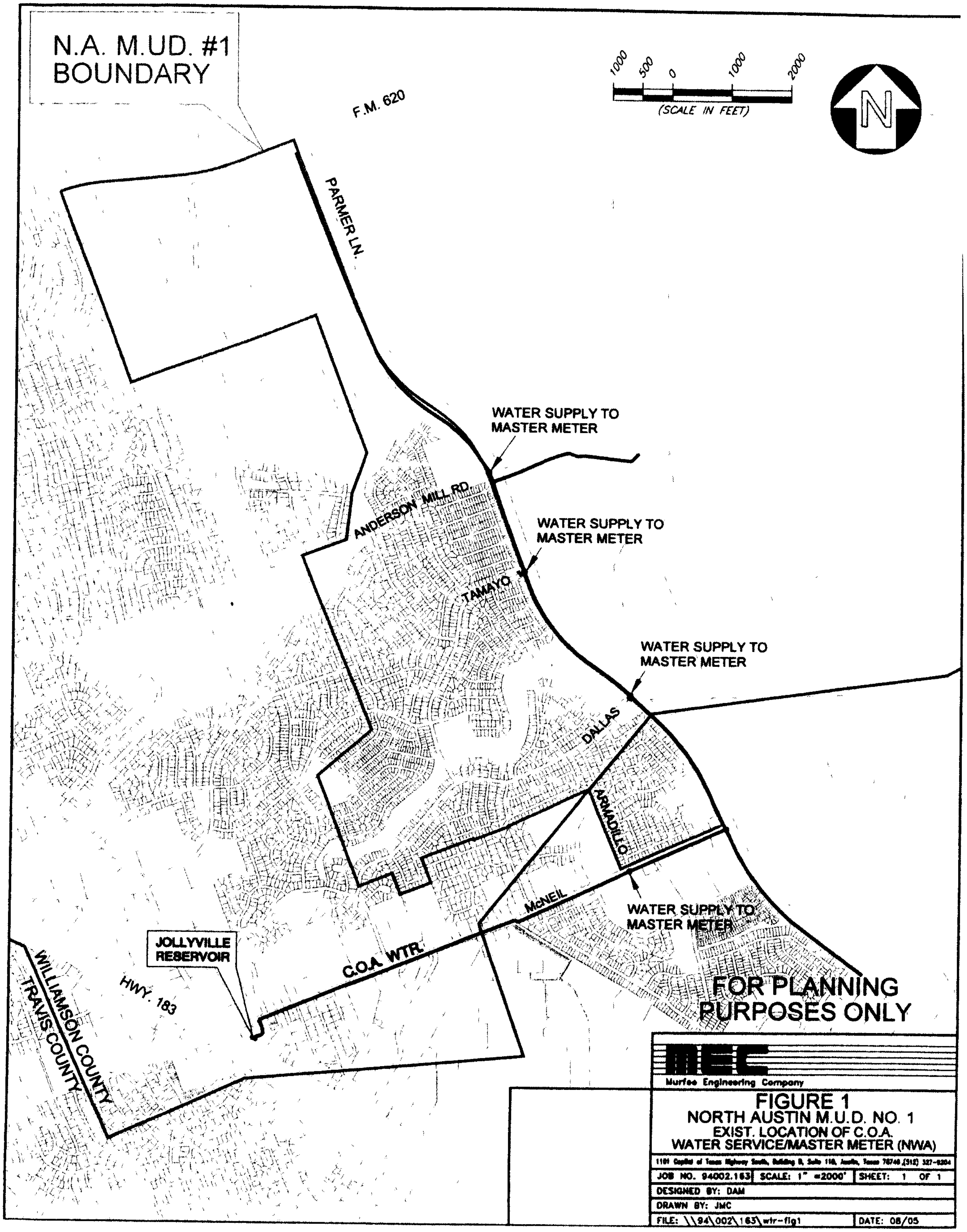
Pipe Flow Mass Balance
P-15 @ Amarillo Dr & P-195 @ Parmer Ln
Scenario 1—P-15 = 0gpm & Scenario 2—P-15 = 1,364.67gpm
Scenario 1—P-195 = 6,573.6gpm & Scenario 2—P-195=5,208.93gpm
Scenario 1—P-195 – Scenario 2—P-195 = Scenario 2—P-15 = 1,364.67gpm

\\Server\mecfiles\Baze\North Austin MUD\PumpStaModelResults\8-31-05\pipe rep.doc

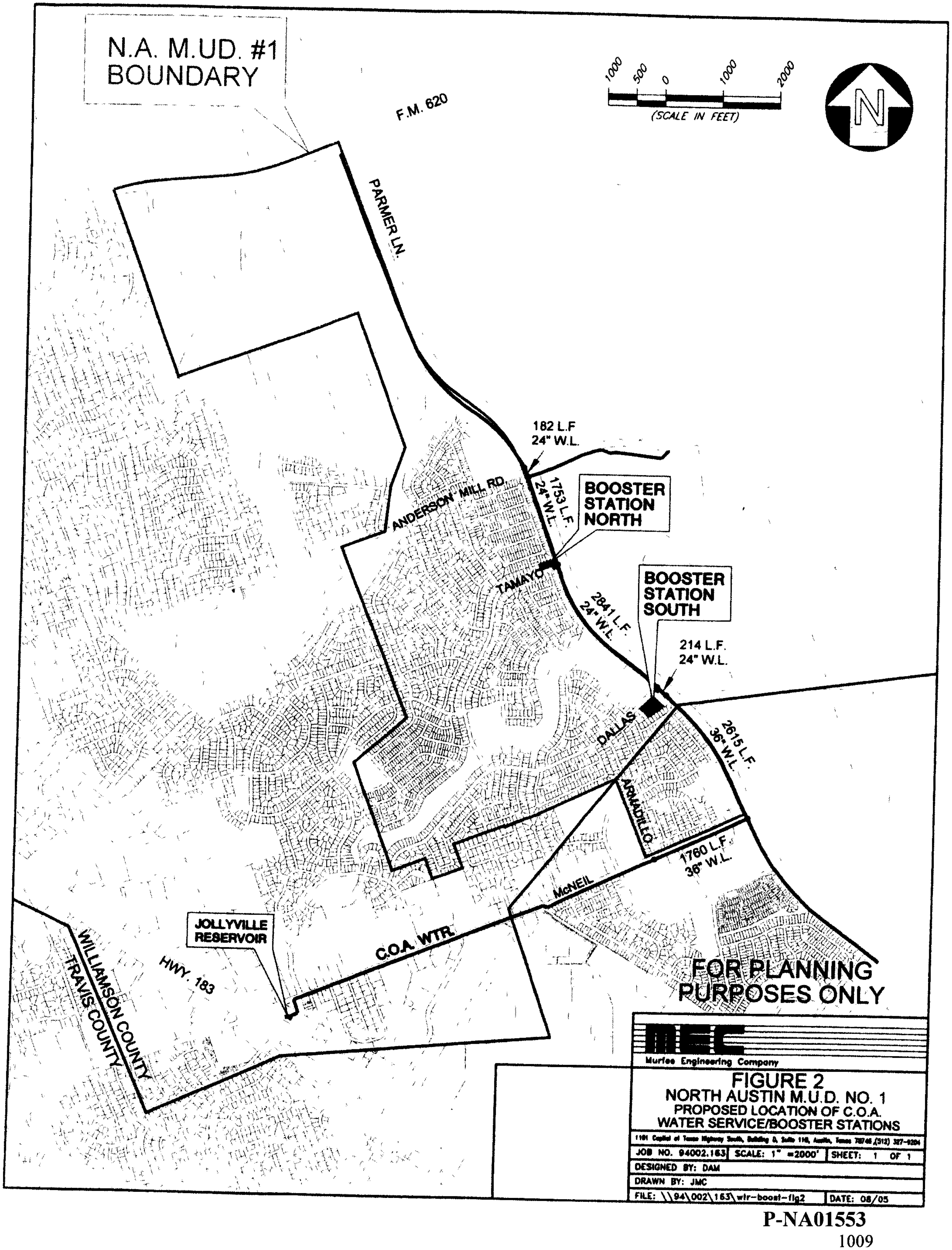
[Table 2]

An Analysis of the Effect on Suction Pressure with the Installation Of Variable Frequency Drive Booster Stations Along Palmer Lane North from McNeil Drive North Austin MUD 1

Transmission Main Analysis	Scenario	Q_{DESIGN} (gpm)	Total Friction Loss (ft)	Change in Pressure	
				ft	psi
2615 lf – 36" ø and 214 lf – 24" ø Palmer Lane Main from McNeil to Near Dallas Drive	Existing Condition	5309	1.7	-0.1	-.04
	Installed VFD Booster Station	6574	1.8		
2841 lf – 24" ø Palmer Lane Main from Dallas Drive to Tamayo	Existing Condition	2634	2.42	+0.66	+0.29
	Installed VFD Booster Station	2216	1.76		

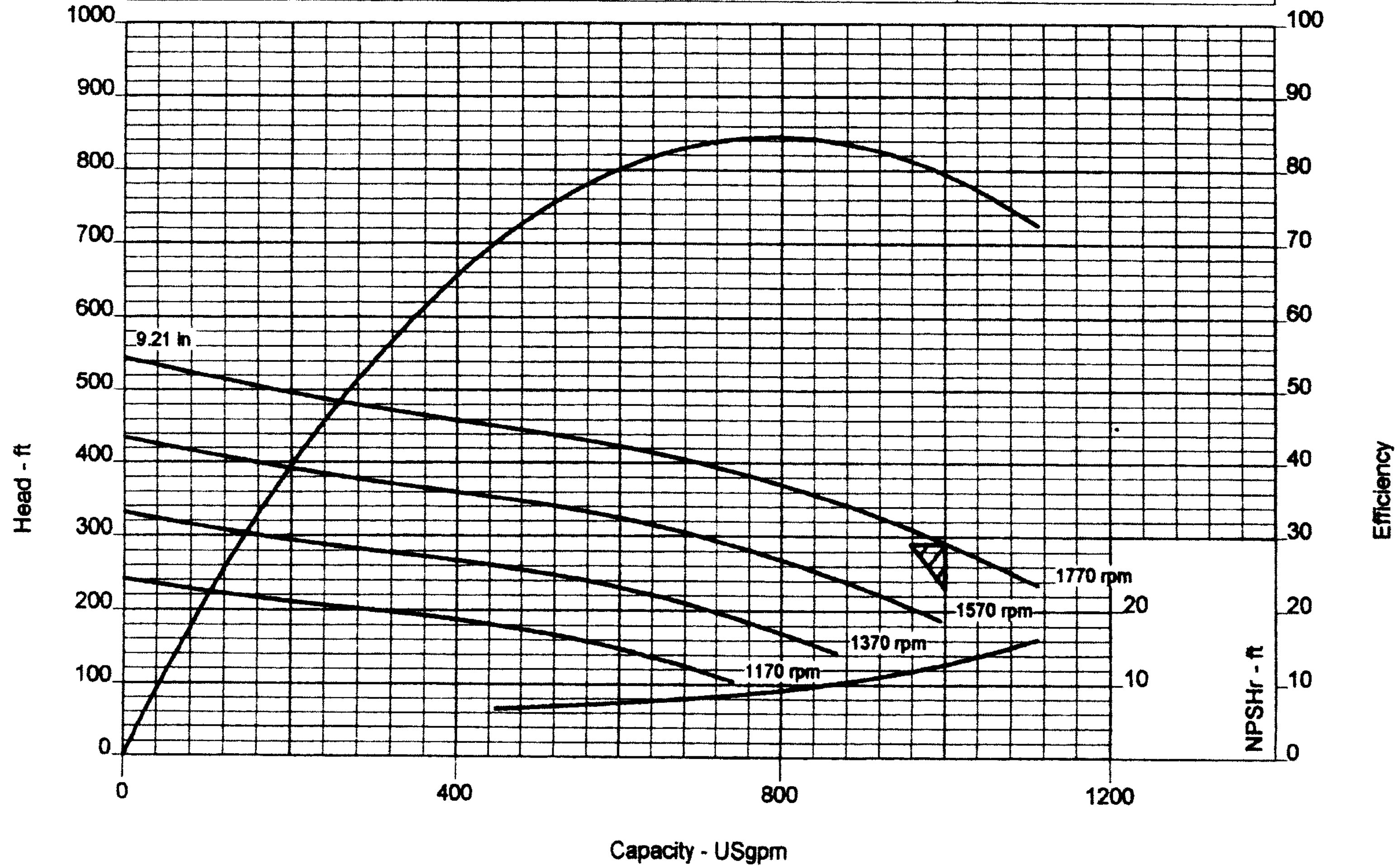


P-NA01552
1008


N.A. M.UD. #1
BOUNDARY
F.M. 620
1000 500 0 1000 2000
(SCALE IN FEET)
N
PARMER LN.
182 L.F
24" W.L.
ANDERSON MILL RD.
1753 L.F.
24" W.L.
BOOSTER
STATION
NORTH
TAMAYO
2841 L.F.
24" W.L.
BOOSTER
STATION
SOUTH
214 L.F.
24" W.L.
DALLAS
2615 L.F.
36" W.L.
ARMADILLO
1760 L.F.
36" W.L.
McNEIL
C.O.A. WTR.
JOLLYVILLE
RESERVOIR
HWY. 183
WILLIAMSON COUNTY
TRAVIS COUNTY
FOR PLANNING
PURPOSES ONLY
MEC
Murfee Engineering Company
FIGURE 2
NORTH AUSTIN M.U.D. NO. 1
PROPOSED LOCATION OF C.O.A.
WATER SERVICE/BOOSTER STATIONS
JOB NO. 94002.163
SCALE: 1" =2000'
SHEET: 1 OF 1
DESIGNED BY: DAM
DRAWN BY: JMC
FILE: \\94\002\163\wtr-boost-fig2
DATE: 08/05

P-NA01553

Pump size & type 12EML	Flowserve Pump Division		Curve number EC-2631
Capacity : 1000.0 USgpm	Specific gravity	: 1.000	Stage(s) : 6
Head : 290.0 ft	Running speed	: 1770 rpm	Date : Oct 13, 2005



MEC

Murfee Engineering Company

94002168

10/27/05

Mr. James Weddell
Texas Commission on Environmental Quality
Utility Technical Review Team
Water Supply Division MC-155
P.O. Box 13087
Austin, TX 78711-3087

RE: ***North Austin MUD No. 1 Booster Stations***

Dear Mr. Weddell,

Following our telephone conversation on October 10, 2005 with respect to the referenced project, it was my understanding that you agreed to provide a letter of clarification to the TCEQ letter of August 8, 2005. In August 2005, the North Austin MUD No. 1 district manager, Mr. Gary Spoonts and I met with you and Mr. David Laughlin, P.E. to discuss this project. Based on conversations at that meeting, Mr. Spoonts and I understood that the TCEQ would accept the installation of a low suction pressure cutoff in lieu of an air gap on the suction side of the variable speed booster station. However the TCEQ remained concerned with the potential for a pressure surge with subsequent water hammer in the absence of surge protection facilities. We were informed that the District would be required to monitor water pressure and install surge protection equipment if necessary after no more than one year of operation.

Alternatively your letter dated August 8, 2005 indicates that the acceptance of a low pressure cutoff is only temporary and an air gap with a ground storage tank would be required within one year. Such a requirement is technically and economically prohibitive for the District as a solution as was explained in my attached letter response to Mr. Laughlin, P.E. and Mr. Ron Humphrey, P.E. of the City of Austin which was sent on September 13, 2005. In addition, your should know that the City of Austin currently operates three variable speed booster stations designed and constructed without a suction air gap or discharge surge protection. Two of these stations were designed and constructed specifically at the request of the City of Austin and were approved by the TCEQ. To my knowledge no problems have been observed in their 8-10 operating history.

As the Districts customers continue to receive low domestic water pressure during frequent periods, it is requested that you issue the proposed letter of clarification as quickly as possible in an effort to allow the District to proceed with some course of action. Although the City of Austin must also approve the proposed design, the City staff cannot approve a solution unless it is also approved by the State.

If you have any questions please call. I look forward to your response.
Sincerely,

David Malish P.E.
Murfee Engineering Company

CC: Gary Spoonts – North Austin MUD No. 1
Sharlene Collins – Armbrust and Brown, LLP

1101 Capital of Texas Highway South • Building D, Suite 110 • Austin, Texas 78746 • 512/327-9204

Maintaining Water Quality in Finished Water Storage Facilities

Prepared by:
Gregory J. Kirmeyer, Lynn Kirby, and Brian M. Murphy
Economic and Engineering Services, Inc., Bellevue, WA 98009
Paul F. Noran and Katherine D. Martel
Consumers Water Company, Portland, ME 04112
Theodore W. Lund
Extech, Inc., Chester, CT 06412
Jerry L. Anderson
CH2M Hill, Dayton, OH 45402
Richard Medhurst
General Utilities Projects, Ltd., London, UK WD2 2LG

Jointly sponsored by:
AWWA Research Foundation
6666 West Quincy Avenue
Denver, CO 80235-3098

United Kingdom Water Industry Research Limited
1 Queen Anne's Gate
London SWIH 9BT

Published by the
AWWA Research Foundation and
American Water Works Association

built on the highest available ground so as to minimize the required construction cost and height requirements.

CATEGORIZATION AND DEFINITION OF WATER QUALITY PROBLEMS

There are three main categories of problems that occur in storage facilities—chemical, microbiological and physical. Many problems fit into more than one category, but will only be discussed once in the primary category. Each potential problem, associated category, possible causative factor and potential methods for improvements are listed in Table 1.3 and discussed individually in this section.

Chemical Problems

There are several problems associated with finished water storage facilities that are caused by or are the result of a chemical reaction. These include but are not limited to loss of disinfectant residual, disinfection by-product formation, development of taste and odor, increase in pH, corrosion, build-up of iron and manganese, occurrence of hydrogen sulfide, and leachate from internal coatings. The first two discussed, loss of disinfectant residual and disinfection by-product formation, are perhaps the most common chemical problems, and loss of disinfectant residual can lead to microbiological problems discussed later.

Loss of Disinfectant Residual

The loss of disinfectant residual is a chemical process resulting in the decrease of the disinfectant, generally either free chlorine or total chlorine. It is a function of time and rate of chlorine decay. The rate of decay can be affected by microbiological contamination, temperature, nitrification, exposure to ultraviolet light (sun), and amount and type of chlorine-demanding compounds present, such as organics and inorganics. Since the volume of water in a storage facility is normally large compared to the amount of exposed surface area of the container, the effect of the walls and floor on chlorine decay are normally not significant. Thus, chlorine decay in storage facilities can normally be attributed to bulk water decay rather

An AWWA Method For Maintaining Water Quality In Oversized Water Storage Tanks, An Available Alternative

Maintaining Water Quality in Finished Water Storage Facilities

Prepared by:
Gregory J. Kirmeyer, Lynn Kirby, and Brian M. Murphy
Economic and Engineering Services, Inc., Bellevue, WA 98009
Paul F. Noran and Katherine D. Martel
Consumers Water Company, Portland, ME 04112
Theodore W. Lund
Extech, Inc., Chester, CT 06412
Jerry L. Anderson
CH2M Hill, Dayton, OH 45402
Richard Medhurst
General Utilities Projects, Ltd., London, UK WD2 2LG

Jointly sponsored by:
AWWA Research Foundation
6666 West Quincy Avenue
Denver, CO 80235-3098

United Kingdom Water Industry Research Limited
1 Queen Anne's Gate
London SWIH 9BT

Published by the
AWWA Research Foundation and
American Water Works Association

P-NA01559
1015

built on the highest available ground so as to minimize the required construction cost and height requirements.

CATEGORIZATION AND DEFINITION OF WATER QUALITY PROBLEMS

There are three main categories of problems that occur in storage facilities—chemical, microbiological and physical. Many problems fit into more than one category, but will only be discussed once in the primary category. Each potential problem, associated category, possible causative factor and potential methods for improvements are listed in Table 1.3 and discussed individually in this section.

Chemical Problems

There are several problems associated with finished water storage facilities that are caused by or are the result of a chemical reaction. These include but are not limited to loss of disinfectant residual, disinfection by-product formation, development of taste and odor, increase in pH, corrosion, build-up of iron and manganese, occurrence of hydrogen sulfide, and leachate from internal coatings. The first two discussed, loss of disinfectant residual and disinfection by-product formation, are perhaps the most common chemical problems, and loss of disinfectant residual can lead to microbiological problems discussed later.

Loss of Disinfectant Residual

The loss of disinfectant residual is a chemical process resulting in the decrease of the disinfectant, generally either free chlorine or total chlorine. It is a function of time and rate of chlorine decay. The rate of decay can be affected by microbiological contamination, temperature, nitrification, exposure to ultraviolet light (sun), and amount and type of chlorine-demanding compounds present, such as organics and inorganics. Since the volume of water in a storage facility is normally large compared to the amount of exposed surface area of the container, the effect of the walls and floor on chlorine decay are normally not significant. Thus, chlorine decay in storage facilities can normally be attributed to bulk water decay rather

Table 1.3
Possible causative factors and potential methods for improvement of water quality in finished water storage facilities

Water quality problem	Category	Possible causative factors	Potential methods for improvement: Design/construction	Potential methods for improvement: Operations	Potential methods for improvement: Maintenance
Loss of Disinfectant Residual	Chemical Microbiological	Long Detention Time Depletion from Exposure to Sun/Atmosphere Entry of Chlorine Demanding Contaminants Source Water with Continued Chlorine Demand Increase in Temperature Increase in HPC Nitrification	Cover Open Reservoirs Install Baffles Install Recirculating System Relocate Inlet/Outlet Size Facility for Frequent Turnover Install Bird Wires and Fences Install Diffuser Inlet Install Mechanical Mixers Install Pumping to Increase Turnover	Increase Turnover Rate Fluctuate Water Levels More Improve Influent Water Quality Avoid Having Facilities "Ride the System" Reduce Free NH_3 Residual Provide Booster Chlorination	Clean Storage Facility Maintain Screens Increase Monitoring Inspect Coating
Increase in HPC Bacteria	Microbiological	Loss of Chlorine Residual Contaminant Entry Sediment or Biofilm	Prevent Loss of Disinfectant Residual—See Above	Prevent Loss of Disinfectant Residual—See Above Proper Training in Sample Collection	Prevent Loss of Chlorine Residual—See Above Clean Floating Cover
Coliform Bacteria Occurrence	Microbiological	Loss of Chlorine Residual Contaminant Entry Sediment or Biofilm	Prevent Loss of Disinfectant Residual—See Above	Prevent Loss of Disinfectant Residual—See Above Proper Training in Sample Collection	Prevent Loss of Chlorine Residual—See Above Clean/Repair Floating Cover
Disinfection By-Product Formation	Chemical	Long Detention Time Increase in pH Increase in Chlorine Residual Boosting Chlorine NOM Contamination or Algae Growth	Reduce Detention Time (Baffles, Recirculation, etc.) Look at Alternative Disinfectants	Control Chlorine Residual Improve Influent Water Quality Increase Turnover Rate Change Chlorine Application Point	Provide Internal Coating on Concrete Walls to Prevent pH Increase Increase Monitoring
Sediment Build-Up	Physical Chemical	Source Waters Contain Suspended Material Minimal Velocities Allow Deposition Contaminant Entry Excess Lime Sediment	Install Riser on Outlet Pipe Change Inlet/Outlet to Improve Flow Patterns	Improve Influent Water Quality Avoid Scouring	Clean More Frequently Inspect More Frequently
Development of Taste and Odor	Chemical Microbiological	Long Detention Time Growth of Algae or Other Biological Organisms Contaminant Entry Leachate from Internal Coatings Source Water with Potential for Taste and Odor	Cover Open Reservoirs Reduce Detention Time (Baffles, Recirculation, etc.)	Improve Influent Water Quality Flush Distribution System Lines Provide Booster Chlorination	Apply Coatings Properly Clean Storage Facility as Needed Increase Monitoring
Growth of Algae or Other Biological Organisms	Microbiological	Exposure to Sun Loss of Chlorine Residual Long Detention Time Sediment Biofilms	Cover Open Reservoirs Reduce Detention Time (Baffles, Recirculation, etc.) Prevent Loss of Disinfection Residual—See Above	Improve Influent Water Quality Reduce AOC or Bacterial Input Provide Booster Chlorination	Overflow Reservoir to Skim Surface Increase Monitoring
Contaminant Entry	Physical Microbiological	Uncovered Reservoirs Damaged or Missing Screens on Vents and Other Openings Cross Connection (At Drain or Overflow) Improper Design of Floating Cover Features	Cover Open Reservoirs Install Bird Wires and Fences Provide Overflow and Drain Pipes with Air Gaps Design Floating Cover Drain Systems Properly Rehab Underground Basins		Maintain Screens Lock all Hatches Maintain Pumping System on Floating Cover Drainage Inspect More Often Repair Holes in Covers
Increase in pH	Chemical	Long Detention Time in Concrete Facility	Provide Chemical Treatment	Increase Turnover Rate Fluctuate Water Levels More	Provide Internal Coating on Concrete Walls
Biodegradation of Internal Coatings	Microbiological	Loss of Chlorine Residual Allowing Biological Growth Selecting the Wrong Internal Coating	Prevent Loss of Chlorine Residual—See Above Select an NSF Approved Coating	Store a Non-corrosive water	Increase Cleaning Frequency
Biofilm Growth	Microbiological	Loss of Chlorine Residual Nutrients from Coatings Corrosion of Surface Allowing for Growth Sites Infrequent Cleaning Allowing for Growth Build-Up AOC Introduction Algae Growth Bacterial Seeding	Prevent Loss of Chlorine Residual—See Above Select an NSF Approved Coating	Prevent Loss of Chlorine Residual—See Above Provide Booster Chlorination Physical Removal	Increase Cleaning Frequency Apply Coatings Properly Improve Monitoring Inspections
Nitrification	Microbiological	Long Detention Time Increase in Temperature Loss of Chlorine Residual Excess Ammonia	Prevent Loss of Disinfection Residual—See Above	Increase Turnover Rate Remove From Service—Breakpoint Chlorinate Change Cl_2-Ammonia Ratio	
Color	Microbiological Physical	Decaying Vegetative Matter Algae Growth in Uncovered Reservoirs Sediment Scouring	Cover Open Reservoirs	Improve Influent Water Quality	Inspect and Apply Coatings Increase Cleaning Frequency
Corrosion	Chemical	Metals Uptake from Metal Surfaces Lack of or Improper Cathodic Protection	Provide Proper Corrosion Treatment	Calibrate Cathodic Protection Use Sequestering Agent	Apply Coatings Properly Install Cathodic Protection Properly
Build-Up of Iron and Manganese	Chemical	Presence in Source Water Coupled with Long Detention Time Allowing for Oxidation and Settling Improper Sequestering Agent Dose	Reduce Detention Time	Improve Influent Water Quality Reduce Detention Time Optimize Sequestering Dose	Increase Cleaning Frequency
Hydrogen Sulfide	Chemical	High Levels of H_2S in Source Water Sediment/Biofilms	Chlorinate Source Install Aeration Process Install Ventilation Systems on Storage Facilities	Provide Booster Chlorination	Monitor
Leachate from Internal Coatings	Chemical	Improper Curing/Application Selecting the Wrong Internal Coating	Select an NSF Approved Coating Apply Coatings Properly	Sample Water Before Returning to Service Ventilate Before Returning to Service (>30 days)	Avoid Coatings with VOCs and SOCs

Monitoring

Monitoring the water quality entering, exiting, and existing throughout the storage facility can be used to verify the effectiveness of the recirculation system for mixing. The monitoring locations must vary with both the horizontal and vertical planes. Frequent monitoring may be necessary immediately after start-up of the system to verify effectiveness. Once it is confirmed that the system is working correctly (diagnostic monitoring), a periodic, more limited monitoring program can be implemented (routine monitoring). Long-term monitoring may only be needed on the inlet and outlet pipes. The most appropriate parameters to be monitored are chlorine residual and temperature. If a more rigorous study is desired, then a conservative tracer such as fluoride should be considered.

Duration and Time Period

A recirculation system does not necessarily require continuous operation to achieve mixing goals. Operating the recirculation system by timer, with specified on and off periods, will likely be appropriate and would use less energy than continuous operation. Seattle Public Utilities currently operates a 32 MG reservoir's recirculation system on a 1 hour on/1 hour off cycle. A second recirculation system owned by Seattle Public Utilities on a 1 MG standpipe is set to operate only at night, when demand is low and flow rates are less than during the daytime. A monitoring program can be used to establish optimum duration and on-off cycles.

Rechlorination With Recirculation

If the recirculation system has an associated rechlorination system, operation of the recirculation system can coincide with chlorine injection. To ensure adequate mixing of the chlorine throughout the storage facility, the recirculation system may need to continue circulating water for a period of time after chlorine injection has stopped. Rechlorination is discussed in more detail in the following section.

SECONDARY DISINFECTION

Free chlorine is the most common secondary disinfectant. It can be added at the reservoir inlet, or outlet or at the recirculation system. Chlorine addition at the outlet is normally preferred over the inlet unless the residual is nearly depleted when entering the facility. Chlorine addition is sometimes followed by dechlorination to limit the chlorine taste and the formation of disinfection by-products.

Continuous Rechlorination

Proper use of a chlorine residual analyzer to control the rechlorination system is essential. The sample line supplying the water for the analyzer should be as short as possible, with a flow rate fast enough to minimize the time delay between the sample point and the analyzer. A diverter can be used to discharge to waste excess water not needed for the analyzer's operation. The analyzer should be regularly calibrated according to the manufacturer's instructions. The sample point should be located to avoid back mixing of unchlorinated with chlorinated water.

Conventional rechlorination stations, whether controlled by on-off, flow pacing, or chlorine residual pacing, may create a chlorine residual of unpredictable levels. Due to the dynamic nature of flow and chlorine demand in most water distribution systems, these methods of rechlorination can lead to periodic over- and underfeeding. Kim and Strand (1996) discuss an effective control method for rechlorination using oxidation reduction potential (ORP) measurement and control. ORP measures changes in chlorine demand and the oxidant profile in the distribution system. Chlorine feed can be modulated to maintain a specific ORP level. A redox probe measures the ORP level and reports it to a controller, which in turn modulates the chlorine feed.

Operation of the rechlorination system must also consider the impacts on additional formation of disinfection by-products. As discussed in Chapter 1, contact time, chlorine dose, and chlorine residual all impact DBP formation. Rechlorination increases the chlorine residual, thereby increasing the potential to form additional DBPs. A bench or pilot scale study can be conducted to simulate the effects of rechlorination on DBP formation and should be considered by utilities with moderate to high DBP levels and plans to install a rechlorination system.

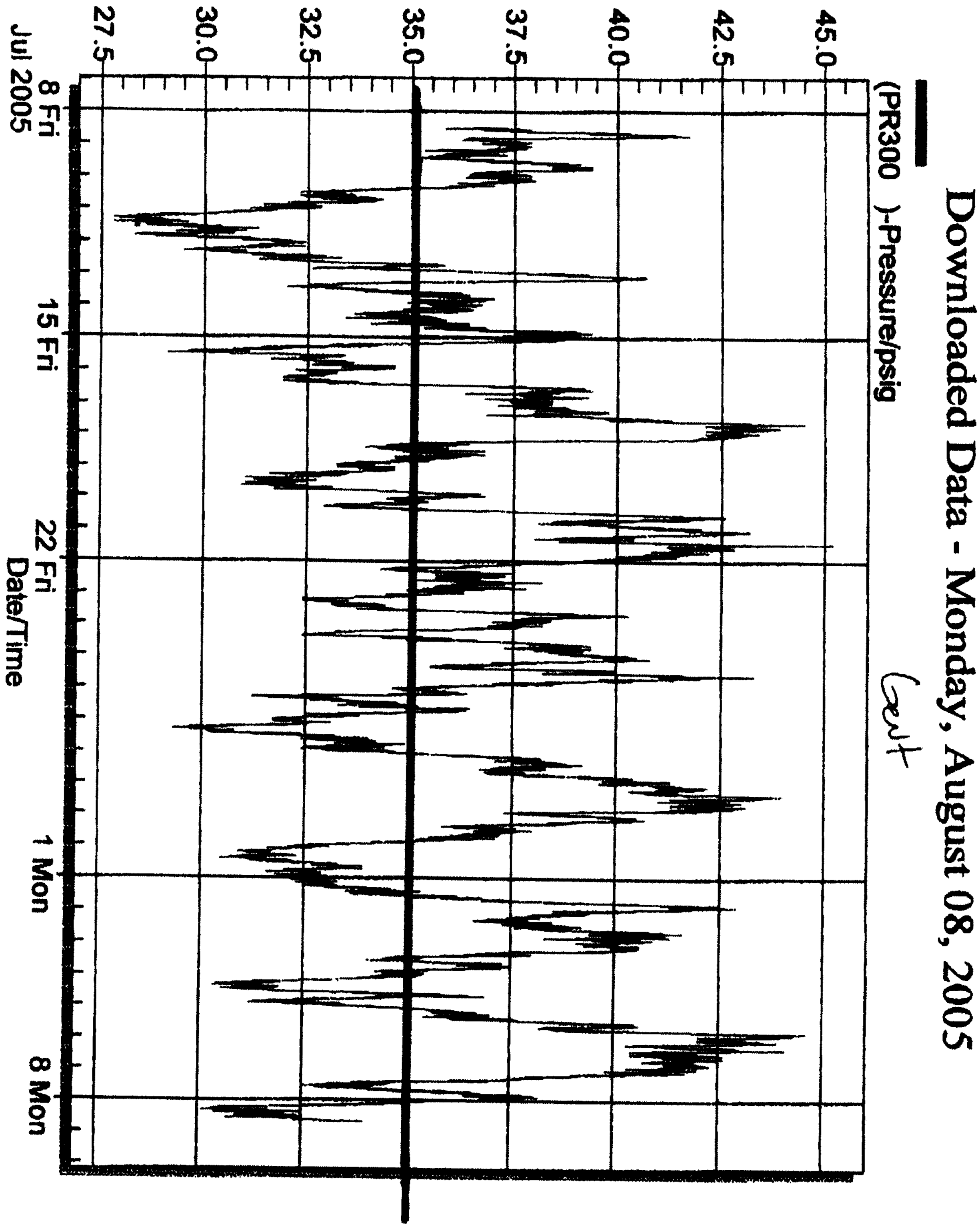
A utility practicing chloramination for disinfection must carefully evaluate and monitor any rechlorination process. The mixing of free chlorine with chloramines can result in the loss of free chlorine residual if not conducted properly. If done correctly, chloramine levels can be increased with the addition of chlorine, depending on the level of residual ammonia present. If ammonia concentrations are insufficient, ammonia addition prior to chlorine addition may be required.

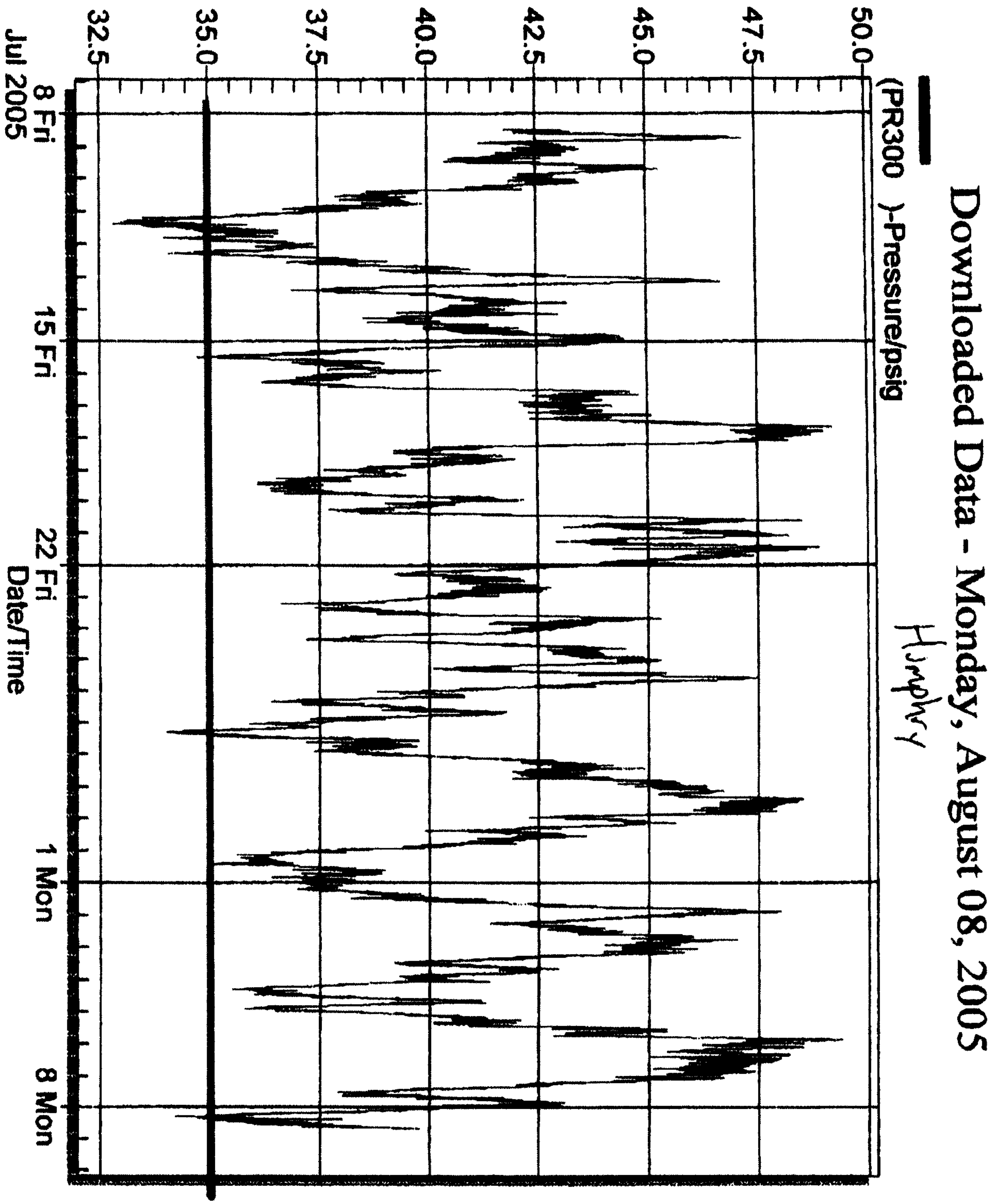
A rechlorination system requires careful operation. For an automated system, safety features are needed to limit the maximum disinfectant residual allowed. An automatic shut-off and alarm when a high residual is reached can be used to prevent exceeding the proposed maximum residual disinfectant levels (MRDLs) for chlorine or chloramines of 4.0 mg/L, the level set by the proposed D/DBP Rule.

Batch Chlorination

Batch chlorination can be used in finished water storage facilities to restore the chlorine residual, to disinfect an existing biological population, or to destroy a taste and odor condition. This can be accomplished by one of two methods: 1) injection at the inlet pipe or 2) addition into the storage facility contents through the hatches or recirculation system. The form of chlorine used can be either a portable gas chlorinator, sodium hypochlorite solution, or calcium hypochlorite in tabular or granular form. Regardless of the chemical used, safety must be a top priority in the handling and feeding of chlorine products. The first step is to evaluate the water quality in the storage facility to determine the required amount of disinfectant. Caution should be exercised in chlorinating a water which has previously been chloraminated because breakpoint issues should be evaluated.

Injection of chlorine into the inlet pipe to replenish a lost chlorine residual is difficult if no facilities such as an injection vault and on-line chlorine residual analyzer exist or if there is little mixing. At a minimum, a tap to inject the chlorine and a location where samples can be collected are needed. Mixing the chlorine in the inlet pipeline ahead of the reservoir is also important. Better mixing and control are accomplished if bends or valves exist prior to the storage facility. For a common inlet/outlet line, chlorine should be injected as the storage facility is filling, although mixing the chlorine throughout the contents may be difficult. If there are


Downloaded Data - Monday, August 08, 2005
(PR300)-Pressure/psig
Cont
45.0
42.5
40.0
37.5
35.0
32.5
30.0
27.5
8 Fri
Jul 2005
15 Fri
22 Fri
1 Mon
8 Mon
Date/Time


Downloaded Data - Monday, August 08, 2005
Humphry
(PR300)-Pressure/psig
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
8 Fri
Jul 2005
15 Fri
22 Fri
1 Mon
8 Mon
Date/Time

MEC
Murfee Engineering Company

COPY

July 19, 1999

Mr. David Laughlin P.E.
Texas Natural Resource Conservation Commission
Rate Analysis and Plan Review Team
Water Utilities Division, MC 153
P.O. Box 13087
Austin, Texas 78711-3087

RE: The Overlook at Lewis Mountain
In-Line Variable Frequency Drive Pump Station
MECI File No. 99011.10

Dear Mr. Laughlin:

Enclosed please find a copy of the engineering design report, plans, and specifications for the above-referenced project. The project is required due to the current elevation of the City of Austin 'Southwest B' pressure zone. Based on conversations with City staff, a pressure zone named 'Southwest C' is expected to serve the area at some point in the future. As such, this pump station is an interim solution for water service to this area. The project consists of a variable frequency drive pumps for domestic service and a constant speed pump for fire flow service. The proposed pressure maintenance system is sound for several reasons which will be enumerated in this letter. Water service for the proposed system is provided by the City of Austin.

We are requesting a variance from Chapter 290, 41 (d) (2) of TAC, which requires that suction for a pump station be taken directly from a storage tank. The pump station is located approximately 1,500 ft from a 2.0 MG elevated storage tank (the LaCrosse reservoir), and connected to it through a combination of 30 and 36 inch line.

It is our contention that the pump station is essentially hydraulically adjacent to the tank. At five feet per second, a standard design velocity for water lines, the 30 inch line has a capacity of 11,000 gallons per minute. The proposed pump station is going to draw, during everyday operation, no more than 200 gallons per minute from the 30 inch line, or under 2% of the total line capacity. During a fire flow situation, 1,000 gpm will be drawn, and with an allowable line velocity of 10 fps for emergency situations, this is approximately 5% of total line capacity. Based on these figures, it is apparent the proposed pump station does not significantly add to the total demand on the system.

Enclosed are the water modeling results for the Southwest 'B' system, which was designed by Murfee Engineering Company for Circle C Ranch, and serves that area and Hill Country Water Supply Corporation. These results indicate that at peak hour, pressures in the 30 inch main along FM 1826 do not drop below 35 psi, even after a 200 gpm demand is added to the line. The tank is operated by the City of Austin between 1,115 and 1,140 ft above mean sea level. The ground elevation in the area served by the 30" line ranges up to approximately 1,020 feet corresponding to a minimum static head of 41 psi.

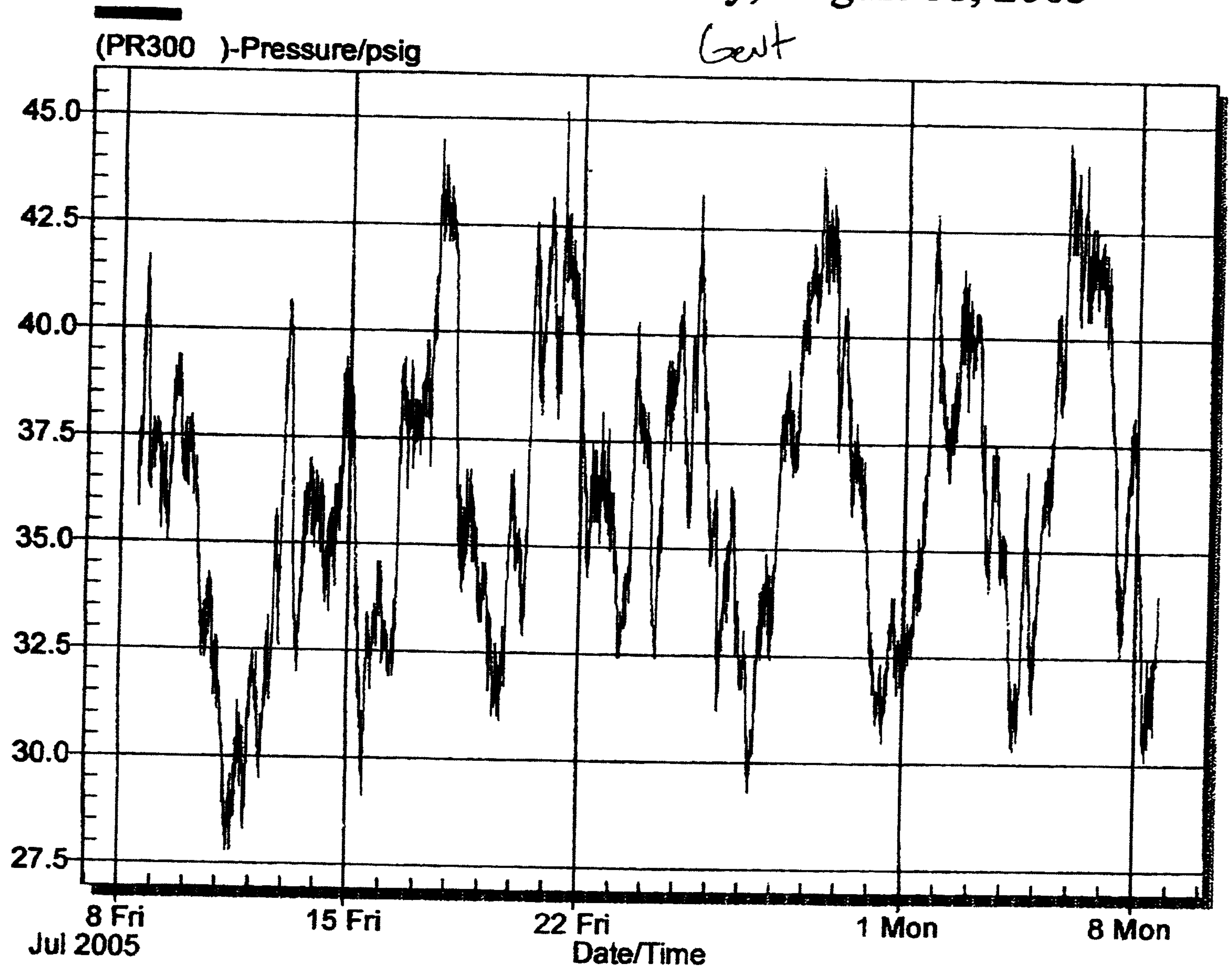
If you have any questions or need additional information please call. I look forward to your response.

Sincerely,

David Malish, P.E.

Downloaded Data - Monday, August 08, 2005

Gent



Downloaded Data - Monday, August 08, 2005

Humphry

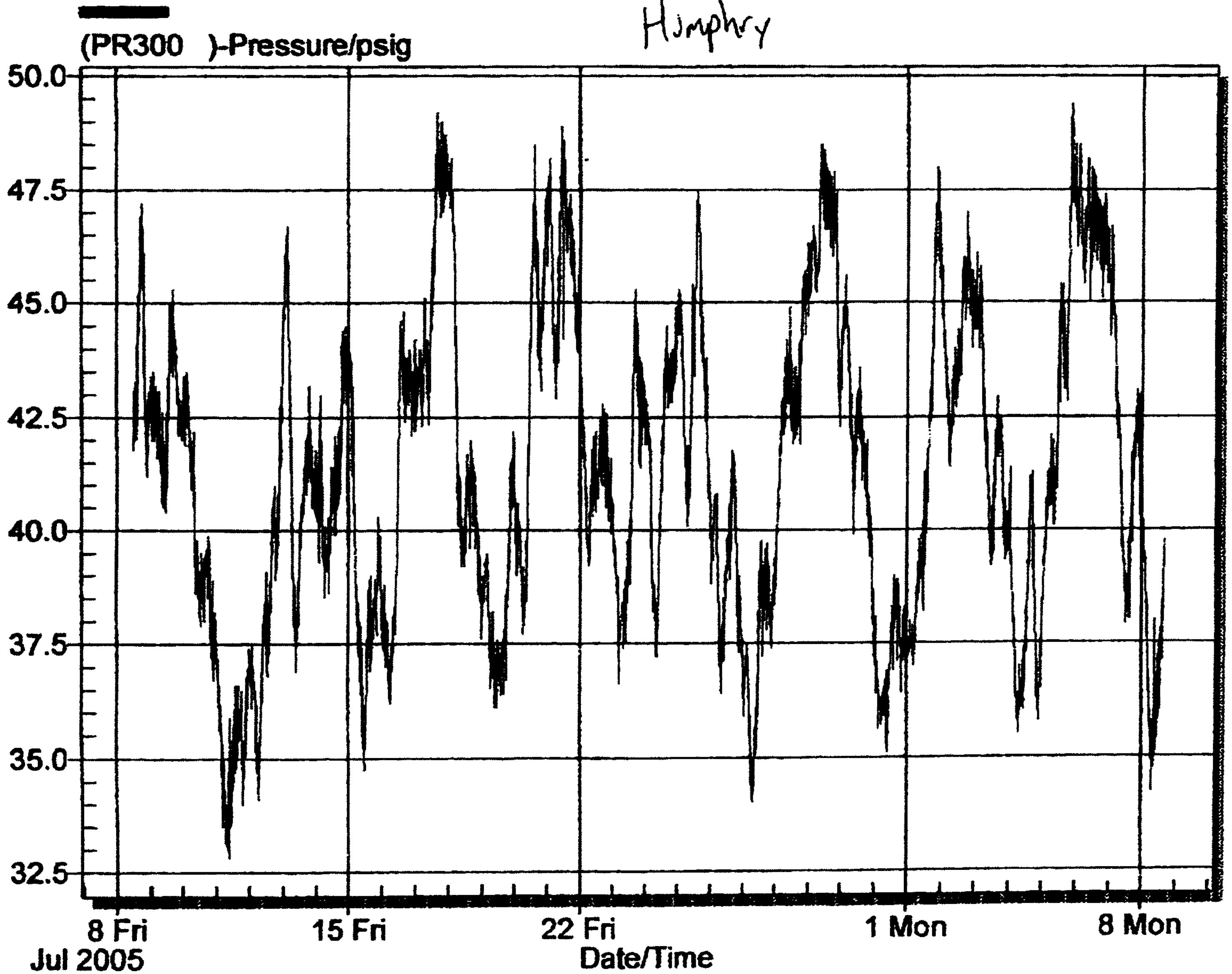


Table 1.3

Possible causative factors and potential methods for improvement of water quality in finished water storage facilities

...ve factors	Potential methods for improvement: Design/construction	Operations	Maintenance
...osphere ...inants ...ne Demand	Cover Open Reservoirs Install Baffles Install Recirculating System Relocate Inlet/Outlet Size Facility for Frequent Turnover Install Bird Wires and Fences Install Diffuser Inlet Install Mechanical Mixers Install Pumping to Increase Turnover	Increase Turnover Rate Fluctuate Water Levels More Improve Influent Water Quality Avoid Having Facilities "Ride the System" Reduce Free NH_3 Residual Provide Booster Chlorination	Clean Storage Facility Maintain Screens Increase Monitoring Inspect Coating
	Prevent Loss of Disinfectant Residual—See Above	Prevent Loss of Disinfectant Residual—See Above Proper Training in Sample Collection	Prevent Loss of Chlorine Residual—See Above Clean Floating Cover
	Prevent Loss of Disinfectant Residual—See Above	Prevent Loss of Disinfectant Residual—See Above Proper Training in Sample Collection	Prevent Loss of Chlorine Residual—See Above Clean/Repair Floating Cover
	Reduce Detention Time (Baffles, Recirculation, etc.) Look at Alternative Disinfectants	Control Chlorine Residual Improve Influent Water Quality Increase Turnover Rate Change Chlorine Application Point	Provide Internal Coating on Concrete Walls to Prevent pH Increase Increase Monitoring
...wth Material ...on	Install Riser on Outlet Pipe Change Inlet/Outlet to Improve Flow Patterns	Improve Influent Water Quality Avoid Scouring	Clean More Frequently Inspect More Frequently
...cal Organisms	Cover Open Reservoirs Reduce Detention Time (Baffles, Recirculation, etc.)	Improve Influent Water Quality Flush Distribution System Lines Provide Booster Chlorination	Apply Coatings Properly Clean Storage Facility as Needed Increase Monitoring
...aste and Odor	Cover Open Reservoirs Reduce Detention Time (Baffles, Recirculation, etc.) Prevent Loss of Disinfection Residual—See Above	Improve Influent Water Quality Reduce AOC or Bacterial Input Provide Booster Chlorination	Overflow Reservoir to Skim Surface Increase Monitoring
...Vents and Other Openings ...verflow) ...ver Features	Cover Open Reservoirs Install Bird Wires and Fences Provide Overflow and Drain Pipes with Air Gaps Design Floating Cover Drain Systems Properly Rehab Underground Basins		Maintain Screens Lock all Hatches Maintain Pumping System on Floating Cover Drainage Inspect More Often Repair Holes in Covers
...e Facility	Provide Chemical Treatment	Increase Turnover Rate Fluctuate Water Levels More	Provide Internal Coating on Concrete Walls
...ing Biological Growth ...ating	Prevent Loss of Chlorine Residual—See Above Select an NSF Approved Coating	Store a Non-corrosive water	Increase Cleaning Frequency
...for Growth Sites ...or Growth Build-Up	Prevent Loss of Chlorine Residual—See Above Select an NSF Approved Coating	Prevent Loss of Chlorine Residual—See Above Provide Booster Chlorination Physical Removal	Increase Cleaning Frequency Apply Coatings Properly Improve Monitoring Inspections
	Prevent Loss of Disinfection Residual—See Above	Increase Turnover Rate Remove From Service—Breakpoint Chlorinate Change Cl_2:Ammonia Ratio	
...servoirs	Cover Open Reservoirs	Improve Influent Water Quality	Inspect and Apply Coatings Increase Cleaning Frequency
...aces ...rotection	Provide Proper Corrosion Treatment	Calibrate Cathodic Protection Use Sequestering Agent	Apply Coatings Properly Install Cathodic Protection Properly
...led with Long Detention Time	Reduce Detention Time	Improve Influent Water Quality Reduce Detention Time	Increase Cleaning Frequency
...ettling ...ose		Optimize Sequestering Dose Provide Booster Chlorination	Monitor
...Water	Chlorinate Source Install Aeration Process Install Ventilation Systems on Storage Facilities	Sample Water Before Returning to Service ... Before Returning to Service (>30 days)	Avoid Coatings with VOCs and SOCs

Monitoring

Monitoring the water quality entering, exiting, and existing throughout the storage facility can be used to verify the effectiveness of the recirculation system for mixing. The monitoring locations must vary with both the horizontal and vertical planes. Frequent monitoring may be necessary immediately after start-up of the system to verify effectiveness. Once it is confirmed that the system is working correctly (diagnostic monitoring), a periodic, more limited monitoring program can be implemented (routine monitoring). Long-term monitoring may only be needed on the inlet and outlet pipes. The most appropriate parameters to be monitored are chlorine residual and temperature. If a more rigorous study is desired, then a conservative tracer such as fluoride should be considered.

Duration and Time Period

A recirculation system does not necessarily require continuous operation to achieve mixing goals. Operating the recirculation system by timer, with specified on and off periods, will likely be appropriate and would use less energy than continuous operation. Seattle Public Utilities currently operates a 32 MG reservoir's recirculation system on a 1 hour on/1 hour off cycle. A second recirculation system owned by Seattle Public Utilities on a 1 MG standpipe is set to operate only at night, when demand is low and flow rates are less than during the daytime. A monitoring program can be used to establish optimum duration and on-off cycles.

Rechlorination With Recirculation

If the recirculation system has an associated rechlorination system, operation of the recirculation system can coincide with chlorine injection. To ensure adequate mixing of the chlorine throughout the storage facility, the recirculation system may need to continue circulating water for a period of time after chlorine injection has stopped. Rechlorination is discussed in more detail in the following section.

SECONDARY DISINFECTION

Free chlorine is the most common secondary disinfectant. It can be added at the reservoir inlet, or outlet or at the recirculation system. Chlorine addition at the outlet is normally preferred over the inlet unless the residual is nearly depleted when entering the facility. Chlorine addition is sometimes followed by dechlorination to limit the chlorine taste and the formation of disinfection by-products.

Continuous Rechlorination

Proper use of a chlorine residual analyzer to control the rechlorination system is essential. The sample line supplying the water for the analyzer should be as short as possible, with a flow rate fast enough to minimize the time delay between the sample point and the analyzer. A diverter can be used to discharge to waste excess water not needed for the analyzer's operation. The analyzer should be regularly calibrated according to the manufacturer's instructions. The sample point should be located to avoid back mixing of unchlorinated with chlorinated water.

Conventional rechlorination stations, whether controlled by on-off, flow pacing, or chlorine residual pacing, may create a chlorine residual of unpredictable levels. Due to the dynamic nature of flow and chlorine demand in most water distribution systems, these methods of rechlorination can lead to periodic over- and underfeeding. Kim and Strand (1996) discuss an effective control method for rechlorination using oxidation reduction potential (ORP) measurement and control. ORP measures changes in chlorine demand and the oxidant profile in the distribution system. Chlorine feed can be modulated to maintain a specific ORP level. A redox probe measures the ORP level and reports it to a controller, which in turn modulates the chlorine feed.

Operation of the rechlorination system must also consider the impacts on additional formation of disinfection by-products. As discussed in Chapter 1, contact time, chlorine dose, and chlorine residual all impact DBP formation. Rechlorination increases the chlorine residual, thereby increasing the potential to form additional DBPs. A bench or pilot scale study can be conducted to simulate the effects of rechlorination on DBP formation and should be considered by utilities with moderate to high DBP levels and plans to install a rechlorination system.

A utility practicing chloramination for disinfection must carefully evaluate and monitor any rechlorination process. The mixing of free chlorine with chloramines can result in the loss of free chlorine residual if not conducted properly. If done correctly, chloramine levels can be increased with the addition of chlorine, depending on the level of residual ammonia present. If ammonia concentrations are insufficient, ammonia addition prior to chlorine addition may be required.

A rechlorination system requires careful operation. For an automated system, safety features are needed to limit the maximum disinfectant residual allowed. An automatic shut-off and alarm when a high residual is reached can be used to prevent exceeding the proposed maximum residual disinfectant levels (MRDLs) for chlorine or chloramines of 4.0 mg/L, the level set by the proposed D/DBP Rule.

Batch Chlorination

Batch chlorination can be used in finished water storage facilities to restore the chlorine residual, to disinfect an existing biological population, or to destroy a taste and odor condition. This can be accomplished by one of two methods: 1) injection at the inlet pipe or 2) addition into the storage facility contents through the hatches or recirculation system. The form of chlorine used can be either a portable gas chlorinator, sodium hypochlorite solution, or calcium hypochlorite in tabular or granular form. Regardless of the chemical used, safety must be a top priority in the handling and feeding of chlorine products. The first step is to evaluate the water quality in the storage facility to determine the required amount of disinfectant. Caution should be exercised in chlorinating a water which has previously been chloraminated because breakpoint issues should be evaluated.

Injection of chlorine into the inlet pipe to replenish a lost chlorine residual is difficult if no facilities such as an injection vault and on-line chlorine residual analyzer exist or if there is little mixing. At a minimum, a tap to inject the chlorine and a location where samples can be collected are needed. Mixing the chlorine in the inlet pipeline ahead of the reservoir is also important. Better mixing and control are accomplished if bends or valves exist prior to the storage facility. For a common inlet/outlet line, chlorine should be injected as the storage facility is filling, although mixing the chlorine throughout the contents may be difficult. If there are

North Austin MUD 94002.153
Water Division

SUBCHAPTER D: RULES AND REGULATIONS FOR PUBLIC WATER SYSTEMS §§290.38, 290.39, 290.41 - 290.47 Effective February 19, 2004

§290.38. Definitions.

The following words and terms, when used in this chapter shall have the following meanings, unless the context clearly indicates otherwise. If a word or term used in this chapter is not contained in the following list, its definition shall be as shown in Title 40 Code of Federal Regulations (CFR) §141.2. Other technical terms used shall have the meanings or definitions listed in the latest edition of *The Drinking Water Dictionary*, prepared by the American Water Works Association.

(1) **Air gap** -- The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet conveying water to a tank, fixture, receptor, sink, or other assembly and the flood level rim of the receptacle. The vertical, physical separation must be at least twice the diameter of the water supply outlet, but never less than 1.0 inch.

(2) **ANSI standards** -- The standards of the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

(3) **Approved laboratory** -- A laboratory certified and approved by the commission to analyze water samples to determine their compliance with maximum allowable constituent levels.

(4) **ASME standards** -- The standards of the American Society of Mechanical Engineers, 346 East 47th Street, New York, New York 10017.

(5) **ASTM standards** -- The standards of the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19102.

(6) **Auxiliary power** -- Either mechanical power or electric generators which can enable the system to provide water under pressure to the distribution system in the event of a local power failure. With the approval of the executive director, dual primary electric service may be considered as auxiliary power in areas which are not subject to large scale power outages due to natural disasters.

(7) **AWWA standards** -- The latest edition of the applicable standards as approved and published by the American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235.

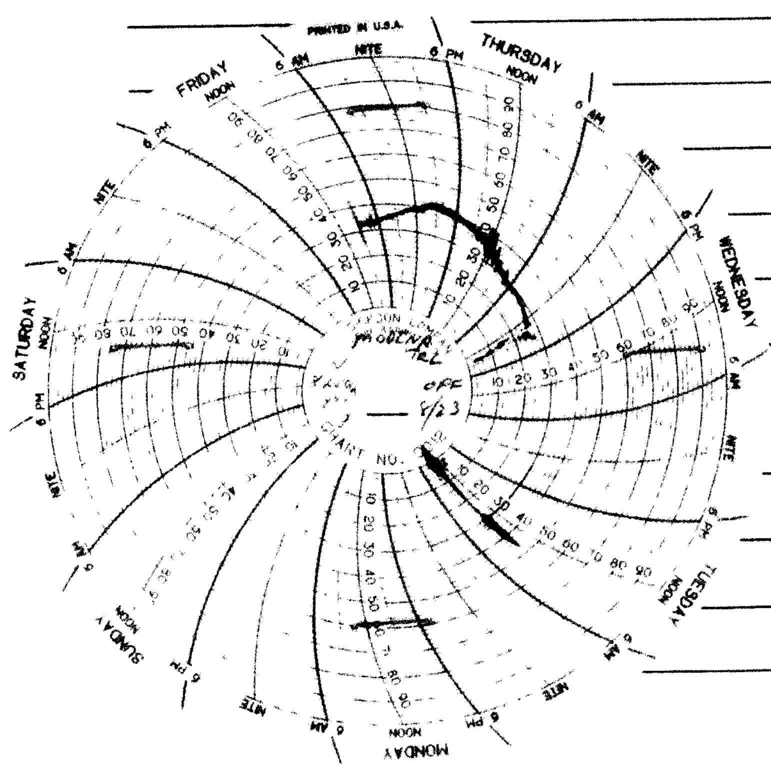
(8) **Certified laboratory** -- A laboratory certified by the commission to analyze water samples to determine their compliance with maximum allowable constituent levels.

Next page

North Austin Municipal Utility District No. 1
Water Pressure Study

12705 MODENA TRAIL - P RECORDER

Date	Hydrant Address	Time of Reading	PRESSURE RECORDER	HYDRANT Pressure
8/20/96	ACROSS STREET FROM 12711 MODENA TRL	1005	40	49
8/21		1252	30	40
8/22		1007	36	45
8/23		0856	42	45

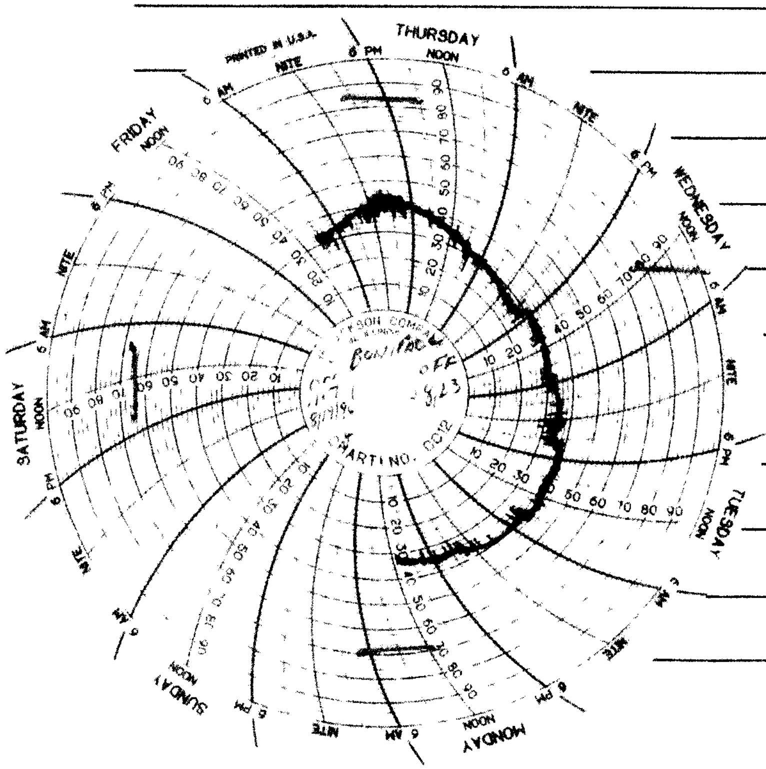


P-NA01576
1032

North Austin Municipal Utility District No. 1
Water Pressure Study

7203 BONIFACE - P. RECORDER

Date	Hydrant Address	Time of Reading	PRESSURE RECORDER	HYDRANT Pressure
8/20/96	7107 BONIFACE	0953	42	45
8/21		1245	30	39
8/22		1000	33	40
8/23		0850	36	40

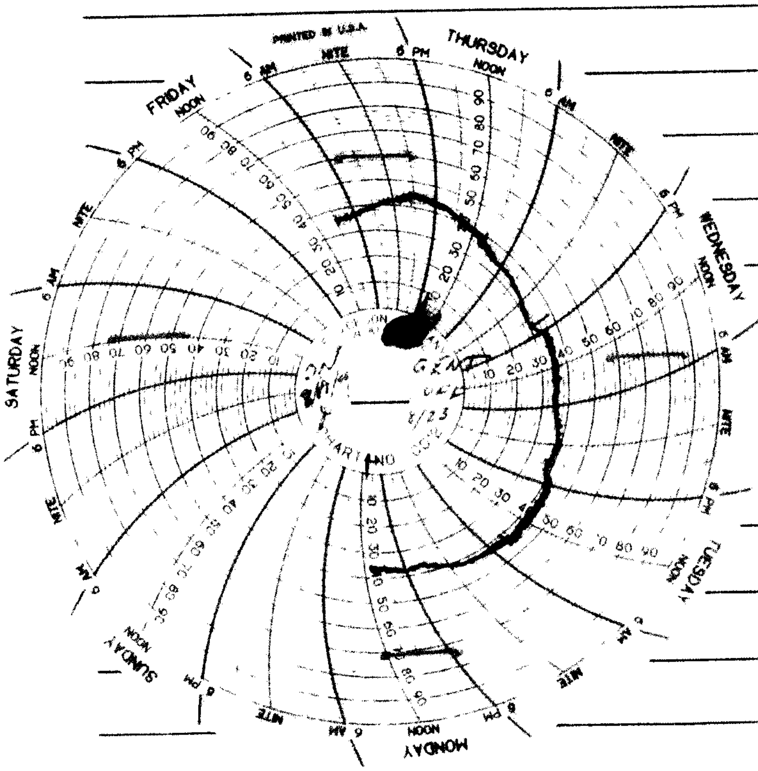


P-NA01577
1033

North Austin Municipal Utility District No. 1
Water Pressure Study

13400 GENT - P RECORDER

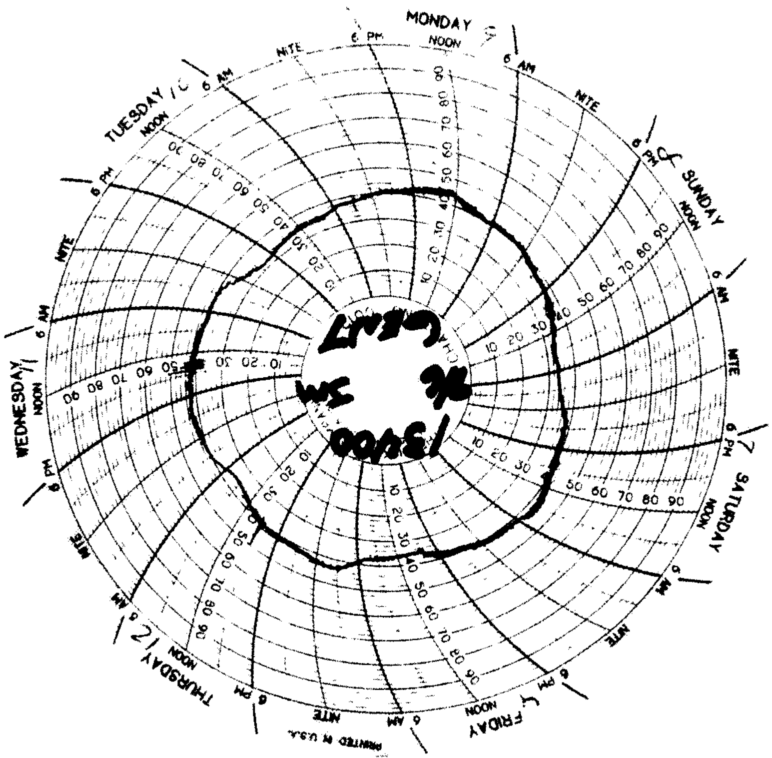
Date	Hydrant Address	Time of Reading	Pressure Recorder	Hydrant Pressure
8/20/96	13400 GENT	1016	44	50
8/21		1300	36	40
8/22		1019	38	45
8/23		0916	37	40



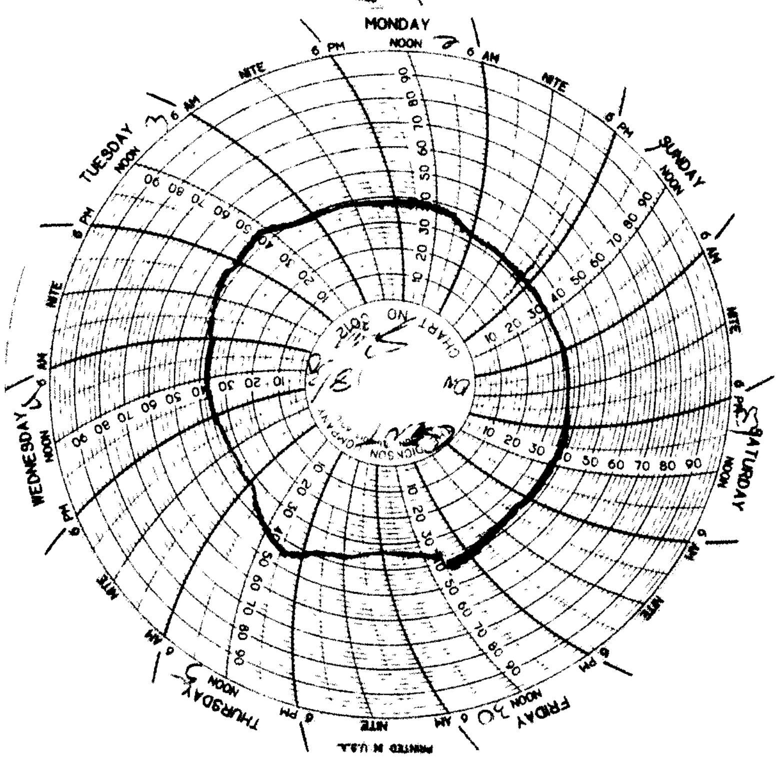
North Austin Municipal Utility District No. 1
Water Pressure Study

Date		Hydrant Address	Time of Reading	Pressure
9-1	Su.	13400 GEOT.		
9-2	M	"	HOLIDAY	
9-3	Tu	"	1000	41 PSI
9-4	W	"	1530	38 PSI
9-5	TH	"	1140	43 PSI
9-6	FRI	"	1200	38 PSI
9-7	SA	"		
9-8	Su.	"		
9-9	M	"	0920	44 PSI
9-10	Tu	"	1341	35 PSI
9-11	W	"	1500	40 PSI
9-12	Th	"	1049	39 PSI
9-13	F		1325	37 PSI
9-14	Sa.	"		
9-15	Sun	"		
9-16	Mo	"	1545	40 PSI
9-17	Tu			
9-18	W			
9-19	TH			
9-20	F			
9-21	Sa			
9-22	Su.			

COPY


MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
PRINTED IN U.S.A.

COPY

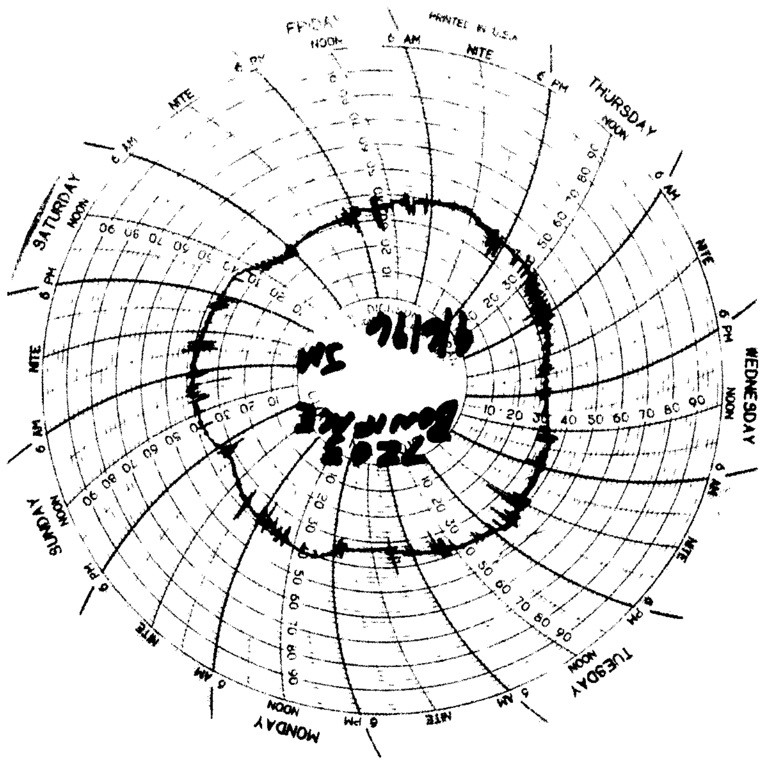

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
CHART NO
PRINTED IN U.S.A.

North Austin Municipal Utility District No. 1
Water Pressure Study

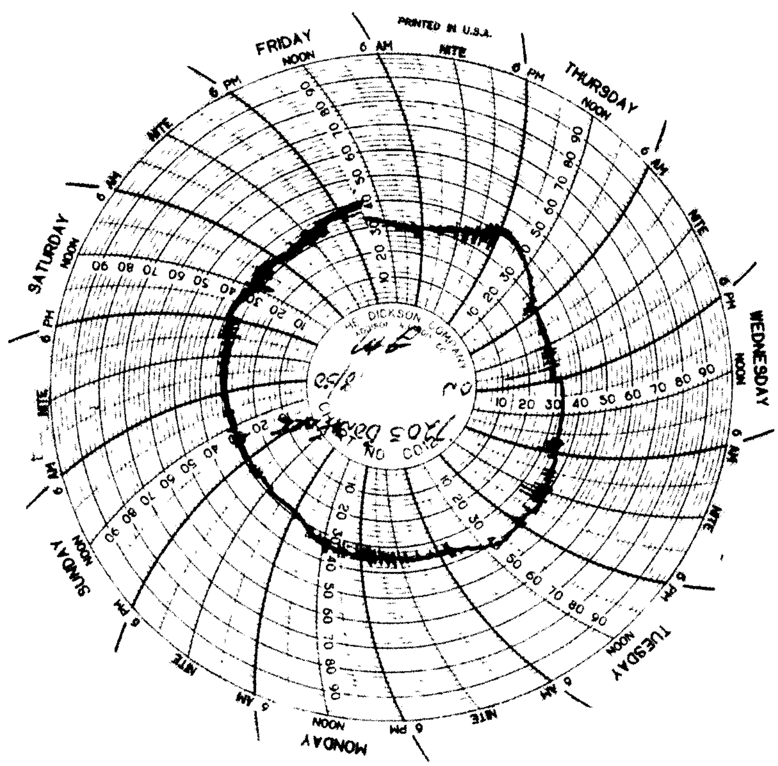
Date	1996	~~Hydrant Address~~ PSI RECORDER ADRESS	Time of Reading	Pressure
9-1	SUN	7203 BONIFACE		
9-2	MON	" HOLIDAY		
9-3	TUE	"	1030	38 lbs
9-4	W	"	1500	32 lbs
9-5	TH	"	1120	36 lbs
9-6	F	"	1145	32 lbs
9-7	SAT.	"		
9-8	SUN.	"		
9-9	M	"	0934	40 PSI
9-10	TU.	"	1149	40 PSI
9-11	W	"	1300	42 PSI
9-12	TH	"	1000	36 lbs
9-13	F	"	1215	30 lbs
9-14	SA	"		
9-15	SU	"		
9-16	M	"	1515	34 lbs
9-17	TU			
9-18	W			
9-19	TH			
9-20	F			
9-21	SA			
9-22	SUN.			

COPY

P-NA01581


FRIDAY
PRINTED IN U.S.A.
THURSDAY
WEDNESDAY
TUESDAY
MONDAY
SUNDAY
SATURDAY
7205 Boniface

COPY


FRIDAY
PRINTED IN U.S.A.
THURSDAY
WEDNESDAY
TUESDAY
MONDAY
SUNDAY
SATURDAY
THE DICKSON COMPANY
7205 Boniface

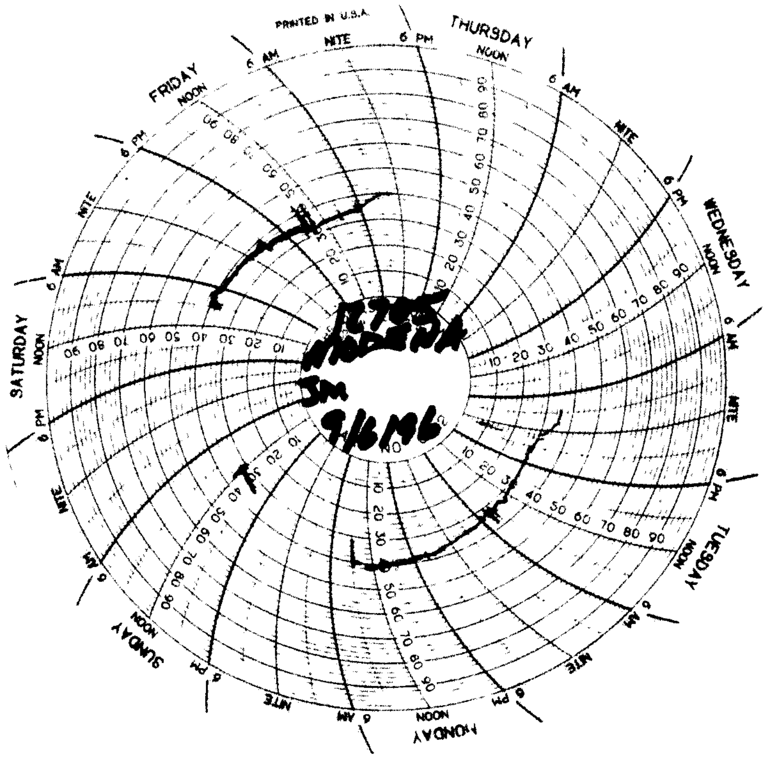
North Austin Municipal Utility District No. 1
Water Pressure Study

Date	PSI RECORDER ~~Hydrant~~ Address	Time of Reading	Pressure
9-1	12705 MODENA		
9-2	"		
9-3	"	1015	34 lbs.
9-4	"	1515	34 lbs
9-5	"	1130	40 lbs
9-6	"	1150	32 lbs
9-7	"		
9-8	"		
9-9	"	0946	38 lbs
9-10	"	1300	30 lbs
9-11	"	1230	38 lbs
9-12	"	1030	35 lbs
9-13	"	1300	34 lbs
9-14	"		
9-15	"		
9-16	"		32 lbs
9-17			
9-18			
9-19			
9-20			
9-21			
9-22			

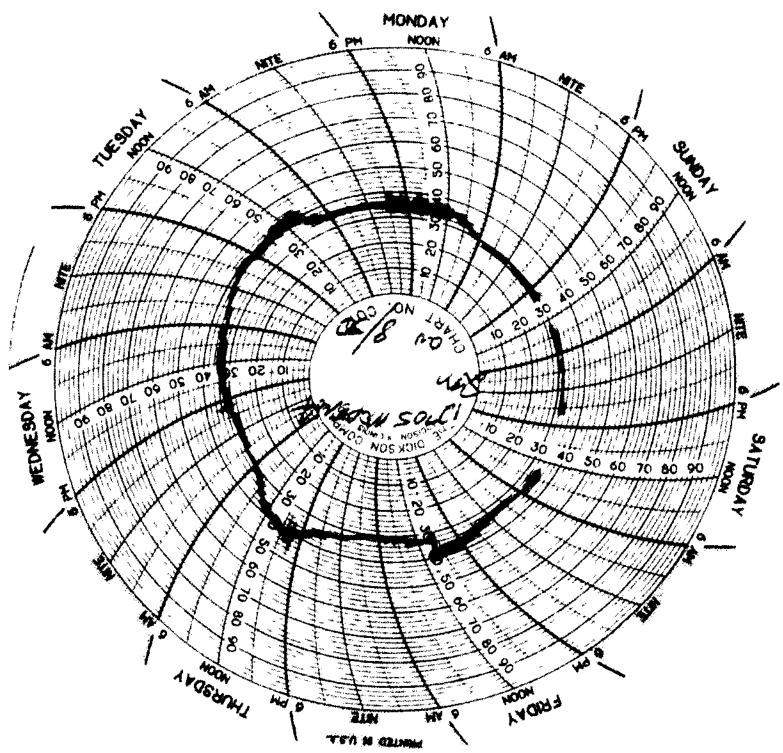
COPY

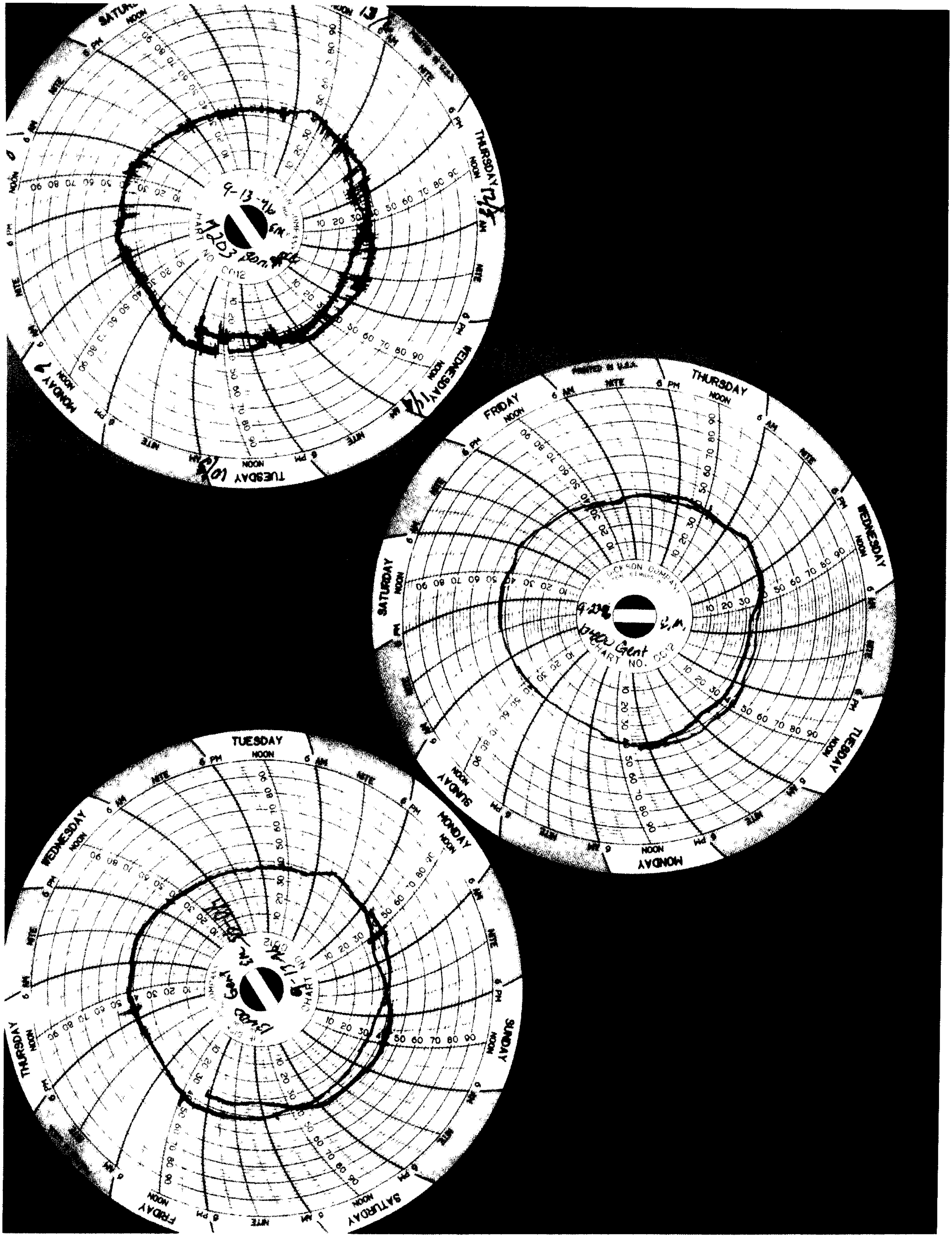
Where Are Charts for ~~9/15~~

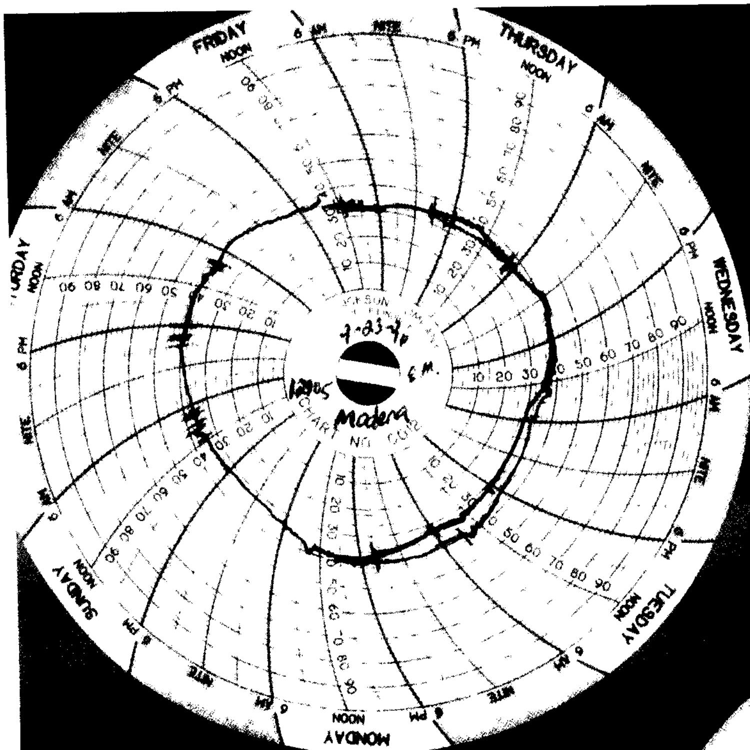
P-NA01583
1039

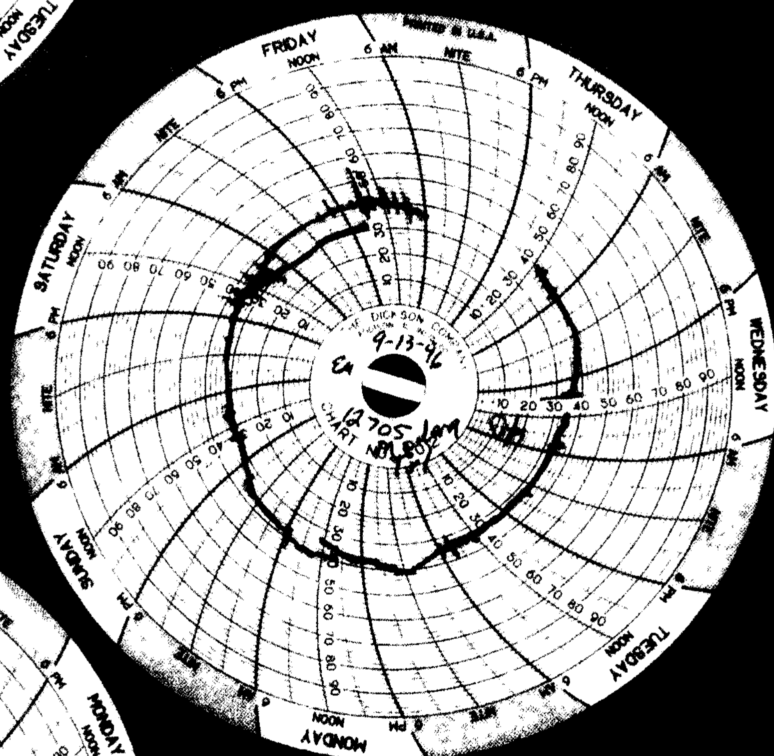

PRINTED IN U.S.A.
THURSDAY
WEDNESDAY
TUESDAY
MONDAY
SUNDAY
SATURDAY
FRIDAY

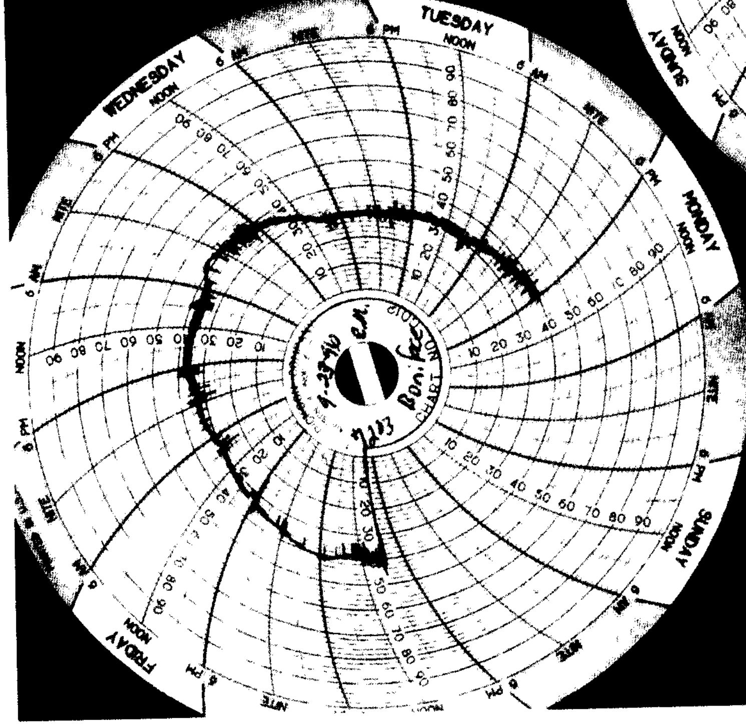
COPY


MONDAY
SUNDAY
SATURDAY
FRIDAY
THURSDAY
WEDNESDAY
TUESDAY
CHART NO.
PRINTED IN U.S.A.




FRIDAY
THURSDAY
WEDNESDAY
TUESDAY
MONDAY
SUNDAY
9-23-96
E.M.
Madera


FRIDAY
THURSDAY
WEDNESDAY
TUESDAY
MONDAY
SUNDAY
SATURDAY
PRINTED IN U.S.A.
9-13-96
EM


TUESDAY
MONDAY
SUNDAY
FRIDAY
WEDNESDAY
9-23-96
E.M.

North Austin Municipal Utility District No. 1
Water Pressure Study

Date		Hydrant Address	Time of Reading	Pressure
9-1	Su.	13400 GENT.		
9-2	M	"	HOLIDAY	
9-3	Tu	"	1000	41 PSI
9-4	W	"	1530	35 PSI
9-5	TH	"	1140	43 PSI
9-6	FRi	"	1200	38 PSI
9-7	SA	"		
9-8	Su.	"		
9-9	M	"	0920	44 PSI
9-10	Tu	"	1341	35 PSI
9-11	W	"	1500	40 PSI
9-12	Th	"	1049	39 PSI
9-13	F		1325	37 PSI
9-14	Sa.	"		
9-15	Sun	"		
9-16	Mo	"	1545	40 PSI
9-17	Tu	"	1450	39 lbs
9-18	W	"	1440	40-45 HAMMER
9-19	TH	"	1500	40 psi 40 Hyd
9-20	F	"	1446	42 HYD
9-21	Sa	"		
9-22	Su.	"		
9-23	MON	"	1531	46 HYD.
9-24	Tue	"	1500	42 psi 40 Hyd 40 F

P-NA01587
1043

North Austin Municipal Utility District No. 1
Water Pressure Study

	Date	~~Hydrant Address~~ Ps. Recorder	Time of Reading	Pressure	
wed	9-25	13400 Cant		40	HYD 44
Th	9-26			42	
F	9-27			42	Hyd 46
Sa	9-28				
Su	9-29				
M	9-30			40	

North Austin Municipal Utility District No. 1
Water Pressure Study

Date	PSI RECORDER ~~Hydrant~~ Address	Time of Reading	Pressure
9-1	12705 MODENA		
9-2	"		
9-3	"	1015	34 lbs.
9-4	"	1515	34 lbs
9-5	"	1130	40 lbs
9-6	"	1150	32 lbs
9-7	"		
9-8	"		
9-9	"	0946	38 lbs
9-10	"	1300	30 lbs
9-11	"	1230	38 lbs
9-12	"	1030	35 lbs
9-13	"	1300	34 lbs
9-14	"		
9-15	"		
9-16	"	1530	32 lbs
9-17	"	1430 ~~[illegible]~~	36 lbs.
9-18	"	1601	40 lbs HYD
9-19	"	1520	38 psi
9-20	"	1600	38 psi
9-21	"		
9-22	"		
9-23	"	1600	40 psi 40 lbs HYD
9-24	"	1530	40 psi 40 HYD

P-NA01589
1045

North Austin Municipal Utility District No. 1
Water Pressure Study

	Date	~~Hydrant Address~~ Psi Recorder	Time of Reading	Pressure	
Wed	9-25	12705 Madera		40 psi	
Th	9-26			40 Psi	
F	9-27			40 psi	Hyd 4
Sa	9-28				
Su	9-29				
M	9-30			38 psi	

North Austin Municipal Utility District No. 1
Water Pressure Study

Date 1996	~~Hydrant Address~~ PSI RECORDER ADRESS	Time of Reading	Pressure
9-1 SUN	7203 BONIFACE		
9-2 MON	" HOLIDAY		
9-3 TUE	"	1030	38 lbs
9-4 W	"	1500	32 lbs
9-5 TH	"	1120	36 lbs
9-6 F	"	1145	32 lbs
9-7 SAT.	"		
9-8 SUN.	"		
9-9 M	"	0934	40 psi
9-10 Tu.	"	1149	40 PSI
9-11 W	"	1300	42 PSI
9-12 TH	"	1000	36 lbs
9-13 F	"	1215	30 lbs
9-14 SA	"		
9-15 SU	"		
9-16 M	"	1515	34 lbs
9-17 TU	"	1450	36 lbs
9-18 W	"	1615	41 lbs
9-19 TH	"	1620	42 psi 40 lbs Hy
9-20 F	"	1615	40 psi
9-21 SA	"		
9-22 SUN	"		
9 23 MON	"	1510	36 psi HYD 40 lbs
9-24 TUE	"	1400	38 psi HD HYD

P-NA01591
1047

North Austin Municipal Utility District No. 1
Water Pressure Study

	Date	~~Hydrant Address~~ psi Recorder 7203 Boniface	Time of Reading	Pressure	
W	9-25	"		40 psi	
Th	9-26	"		38 psi	
F	9-27	"		38 psi	Hyd 4.
Sa	9-28	"			
Su	9-29	"			
M	9-30	"		40	

P-NA01592
1048