9/19/88

Elic

I enclosed the original study (March 1987) which was sent as a draft for comments; and the final (July 29, 1987) which addressed the comments.

I could not find a copy of the comments but the PWO office at Camp Lejeune can furnish one. The comments were in Ref(a) - MARCORB Camp Lejeune ltr 11000 PWO of 18 May 1987

The Fire protection for Hangar 804 is covered in par 4. of our letter 29 July-87 and Par 7F, page 4, Recommendations C & D and enclosure 16 of the original report of March 1987.

Call if you have any questions

Jerry Hammond

(804) 445 2930

A/V 565 2930

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA 23511-6287

TELEPHONE NO.
(804) 445-2930

IN REPLY REFER TO:
6280
1141JJH
29 JULY 1987

From: Commander, Atlantic Division, Naval Facilities Engineering Command
To: Commanding General, Marine Corps Base, Camp Lejeune

Subj: STUDY REPORT OF WATER SYSTEM AT MCAS NEW RIVER AND CAMP GEIGER

Ref: (a) MARCORB Camp Lejeune ltr 11000 PWO of 18 May 87
(b) ESR Study of the Water System at the MCAS New River and Camp Geiger forwarded by cover ltr of 6 Apr 87

Encl: (1) Update of ref (b) (final report)

1. ~~The following is~~ In answer to your letter, reference (a), on the Water System Study, reference (b), enclosure (1) has been updated with appropriate changes and additions from your comments. The report recommendations for the most part, can be implemented separately as needs and budget constraints direct. The study includes design hydraulic analyses for the various parts of the system which can be provided to engineers for construction plans and specifications. In the following paragraphs, we address your comments in detail.

2. Your comments 1a, 1d, 2f, and 2g about new pipes and pump house improvements are inter-related, and the new pipes and pump house are extensively discussed in our report. To provide proper operation of the system, both a new connection between the MCAS and Camp Geiger and improved pumping capacity are required. Please see paragraph 7, Schemes I and II (pages 3, 4, and 5) and Figure 1 (c, d, e, f) of our report (reference (b)) which is updated as enclosure (1). The pipes and new connection of your comments 1a and 2f are the same as our recommendation A on page 7, and which was based on our hydraulic analysis. Please see paragraphs 6, 7, 8c, figure 1, recommendations A, B, and enclosures (7a), (7b), (8), and (9). Additional study of a new connection and pumping station improvements is unnecessary.

3. Comment 1b about eliminating Camp Geiger storage reservoirs STC 500 and 509 can be accomplished by adopting Scheme II, page 4, and recommendation A of our report, enclosure (1).

Your comment, 1b, about replacing the two Camp Geiger elevated tanks, was not addressed in our study. We did not do an inspection of the tanks and your A&E inspection report should be the basis of your decision about replacement.

4. Your comments 1c and 1d about fire protection for the MOQ area and Hangar 804 area are covered in paragraph 7f on page 4, recommendations C and D and enclosure (16) of our report.

These recommendations will provide the necessary fire protection on a cost effective basis by using the existing ground level storage tank and pump station instead of a tower as shown below.

Subj: STUDY REPORT OF WATER SYSTEM AT MCAS NEW RIVER AND CAMP GEIGER

COST COMPARISON

| | ESR Recommendation | Comment Recommendation |
|---|---|---|
| Fire Protection for MOQ | | |
| 2 new 750 gpm fire pumps with controllers, etc. @ 15K | 30.0 K [1] | |
| repiping pump station | 20.0 K | |
| Fire Protection for Hangar 804 | | |
| Diesel driven 3800 gpm fire pump - 540 hp | 60.0 K [2] | 60.0 K |
| installation in AS2003 | 20.0 K | 20.0 K |
| Pipe | | |
| to Hangar, 400'-8" PVC @ 8.70 | 3.5 K [1] | 3.5 K |
| from res., 50'-12" PVC @ 17 | 1.0 K [1] | 1.0 K |
| 450' excavation @ 6/ft. | 2.7 K [1] | 2.7 K |
| Connections, fittings, etc. | 5 K | 5.0 K |
| Maintenance PV @ 10% - 20 yrs. | 3.2 K [3] | |
| Elevated Water Tank - 0.25 MG | | 310.0 K |
| Alt. valve & vault | | 20.0 K |
| | 145.4 K | 422.2 K |

NOTES:

(1) 1986 means Building Construction cost data

(2) From Aurora Pump Company

(3) Chlorination maintenance costs present value (PV)

$\frac{25000/\text{yr.} \times 1.23\% \text{ overhead}}{2080 \text{ hr/yr}} = \frac{\$15}{\text{hr.}} \times 2 \frac{\text{hrs.}}{\text{mos.}} \times 12 \frac{\text{mos.}}{\text{yr.}} \times 8.933$ (20 yrs. at 10%)= 3.2 K

(4) $\frac{6.5 \text{ lb. (65\%) HTH}}{50 \text{ mg/l} \times 10{,}000 \text{ gal.}} \times 200{,}000 \text{ gal. res.} = \frac{2.6 \text{ lb. HTH}}{1 \text{ mg/l chlorine}}$

Subj: STUDY REPORT OF WATER SYSTEM AT MCAS NEW RIVER AND CAMP GEIGER

A pipe dedicated to a new tower in the MOQ area should not be needed, but the tower would require another increase in the pumping capacity at the treatment plant. Also, a tower alone will not produce sufficient pressure for Hangar 804 fire protection sprinkler system, and a fire pump and pump house will be needed. When plans to develop the area are progressed to the point where water requirements are known, we can do another analyses for the area to determine if an elevated tank is needed and, if so, what size. The tank should be funded by the development projects. Because of the cost difference between our recommendation and the tower suggestion ($145.4K versus $422.2K), we do not think a tower is the way to go, and continue with our recommendations.

5. To preserve a chlorine residual of 2 ppm in the existing MOQ area reservoir, it should be tested once a month. When the test shows 1 ppm, add 2.6 pounds of HTH to the reservoir and operate one of the 750 gpm fire pumps of the MOQ pump house in a recirculation mode (from the tank to the pump and directly back to the tank) for 3-1/2 hours for mixing. This should restore the chlorine residual to 2 ppm (4). The existing recirculation pumps in the pumphouse are not needed, and should be removed. There should be more than sufficient room in the pump house for the new diesel fire pump for Hangar 804.

6. Regarding your comment 1e to construct a pipe loop around the airfield. Our analysis indicates that one is not needed. The cost of some 6,400 feet of 12-inch PVC with valves, hydrants and fittings is estimated at $180,000. Please notify us of any information that we are not aware of which would justify this project.

7. Regarding your comment 2a about testing hydrants and valves. Our recommendation is based upon experience with older Navy water systems, and was made as part of an overall inspection and examination program older water systems. It should be adapted or modified as needed for your system.

8. Your comment 2b was about poor leakage survey results. We agree that your experience with a leakage survey by Heath Incorporated at Courthouse Bay was a disappointment. However, some of our surveys have been beneficial, and the unaccounted for water water from Camp Geiger and the MCAS is about 30 percent of the total produced. Because leakage surveys are inexpensive, we believe that it should be tried again with another Company. Another reason for a leakage survey is that excessive leakage areas could indicate locations of pipe deterioration.

9. Your 2c "no comment" was about our recommendation for a soil resistivity/copper sulfate reference survey of the pipelines. This survey has already been performed by Menendz-Donnell & Associates, Incorporated, 11999 Katy Freeway #355, Houston, Texas 77079, Contract N62470-83-C-6148, and pertinent results are now included in enclosure (1). Please see page 6, section 8(e) of enclosure (1).

10. Your comment 1d about doing "C" factor tests on Flounder and Curtis Roads for future development. The tests were not recommended for future development, but to determine if pigging is necessary at the present time to provide fire protection in the MCAS EM Club area. Please see fire flow table for Scheme II on page 5 of enclosure (1) which indicates a residual pressure of 20 psig for a "C" factor of 90. If the "C" factor tests indicate a factor of less than 90, the lines should be pigged to increase the "C" factor for fire protection.

11. Your comment 2e is about future excavation and visual inspection of pipes for corrosion. These inspections are highly recommended for older systems. See enclosure (1), page 8e, Section 8e. At least some inspections should be done for Camp Geiger and the MCAS, at the present time, see enclosures (21a), (21b), (23a), (23b), .

12. Your comment 2f and 2g about a new pipeline and treatment plant pump house improvements are addressed in paragraph 2 of this letter.

13. Your comment 2h about maintenance and improvement of pump house 2003 is addressed in paragraphs 4 and 5 of this report. Improvements can be done by in-house design or A&E contract.

14. Your comment 2i is about altitude valve installation; installation should be done when the pumping capacity of the Water Treatment Plant is improved to provide proper tower operation.

15. Regarding comments 2j, k, l, and m about reference (b) recommendations for replacing existing pipes and valves, and cleaning lines, our recommendations for these items are to provide a systematic approach for a complete system inspection and rehabilitation. Unlike the hydraulic analysis based recommendations, they should be adopted and modified to meet your system needs and budget constraints.

16. We agree with your paragraph 3 comments about the contract and scope, and the Marine Corps should not accept liability for lighting and protecting the contractor's instruments. Regarding manpower, however, our experience indicates that arrangements should be made to have at least one PWC representative accompany the contractor. In case of a pipe rupture, he can coordinate the government's response for repairs. An alternative is to have the contractor provide for personnel and equipment to repair leaks and ruptures if they occur, but it becomes expensive to have then available all the time on a standby basis.

17. We hope we have addressed all of your comments and concerns.

18. If you have additional questions, please contact Mr. J. J. Harwood, Code 1141, LANTNAVFACENGCOM, Naval Station, Norfolk, Virginia 23511-6287, at (804) 445-2930, AUTOVON 565-2930.

J. R. BAILEY
By direction

# ENGINEERING SERVICE REQUEST
# TO STUDY THE POTABLE WATER SYSTEMS
# AT THE MCAS NEW RIVER AND
# CAMP GEIGER, CAMP LEJEUNE, NORTH CAROLINA

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MARCH 1987

ENVIRONMENTAL QUALITY BRANCH
UTILITIES, ENERGY, AND ENVIRONMENTAL DIVISION
ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA 23511-6287

Prepared by:

J. J. Harwood

J. J. HARWOOD, P.E.
Environmental Engineer

Encl (1)

LIST OF ATTACHMENTS



LIST OF ENCLOSURES

1. Introduction

The Marine Corps Base, Camp Lejeune, North Carolina, submitted an Engineering Service Request for a study of the potable water systems of the MCAS, New River and Camp Geiger. Originally, each activity had its own water supply wells, treatment, pumping and storage facilities. An emergency 8-inch line connected both systems. A new water treatment and pumping plant was built at the Air Station which now supplies water to both the Air Station and Camp Geiger via the 8-inch emergency line.

2. Because of concerns about the reliability of the system, parts of which are quite old (1940 era), equipment and operational problems, and the need for a reliable system that will support present needs and future expansion plans, a complete system study in accordance with the Navy water pipe rehabilitation guide is needed (Attachment A). The five steps of the study are:

a. Site visit to collect data and make preliminary tests.

b. Hydraulic Analysis to identify improvements that are needed assuming the existing system is in usable condition.

c. Contracted field examinations to identify parts of the system which are not in usable condition.

d. Design of system improvements from b and c.

e. Two part construction contract to install the designed improvements.

(1) To replace valves and inspect pipe

(2) Replace pipe (if needed), and construct recommended system improvements.

3. Step a - Site Visit by Mr. J. Harwood, Code 114 was in April 1986.

This report covers Steps a and b and makes recommendations and provides cost estimates and scopes of work for Steps c and d which are to be accomplished by contract. Plans and specifications for Step e will be done by Step d.

The report covers operational and hydraulic equipment problems and makes specific improvement recommendations for adequate water flow, pressure and storage for present and future, normal and fire protection needs. It also addresses problems common to aging water systems.

4. Details

Operational and hydraulic equipment problems

a. Each system, Camp Geiger and the Air Station, have two elevated water storage towers. The new Air Station treatment and pumping plant is located at the Air Station near Camp Geiger. Treated water is pumped into lines going to Camp Geiger in one direction and the Air Station in another. Apparently, there is insufficient pumping capacity to fill the Air Station and Camp Geiger tower at the same time during periods of high water usage.. The lines to the Air Station must be closed to fill the furthest Camp Geiger tower (STC 606). Water is still stored in a Camp Geiger reservoir and pumped into the system when needed to augment the Air Station pumps, and for emergencies.

b. Other reported problems were insufficient fire protection in the MOQ area; keeping the chlorine residual at the MOQ reservoir; insufficient fire protection for Hangar 840; the pumps at Camp Geiger loose their prime if the water level in the Camp Geiger ground storage reservoir gets too low; Camp Geiger elevated tower STC 1070 overflows before tower STC 606 fills unless the STC 1070 valve in the tower feed line is throttled; and much of the system is old and felt not to be reliable.

c. Recommendations to provide deluge sprinkler water supplies for Hangar 840 were also requested.

This report will provide specific recommendation that address these problems and improve the system to support present needs and future planned expansions.

5.

a. Information about population, water consumption, future plans and operation and facility problems were gathered during the site visit in April 1986. Preliminary tests to determine the condition of the pipe interiors were made and the following "C" factors were measured (enclosure (1)):

MCAS MCAVOY Road - between Campbell and Curtis; C = 119 (Good)

(This line was reported to have been previously cleaned by "pigging").

MCAS - MOQ Longstaff St; C = 111 (Good)
Camp Geiger D Street; C = 74 (Fair)

b. The results hold no surprises. The older Camp Geiger pipes are fair and the newer, probably cement lined, and cleaned pipes are in good condition.

c. A Water budget (enclosure (2)) indicates:

| | | |
|---|---|---|
| Average demand | = | 896 KGPD |
| Expected usage | = | 630 KGPD |
| Unaccounted for water | = | 266 KGPD |

$100 \times \frac{266}{890} = 30$ percent    A good part of the 30 percent is probably leakage. This would also be expected from old parts of a water system.

6. a. A skeletonized computer model of the water system was made (enclosure (3)). The two smaller pumps (enclosure (4)) at the existing MCAS and Camp Geiger pumping stations were used, enclosure (5). A 48-hour extended period simulation was made for a maximum day (2.5 x average water usage). The results are graphically presented in Figure 1a for Tower STC 606. Note how Tower STC 606 empties. This agrees with the operating experience if the Air Station is not valved off during Camp Geiger filling periods. A tower emptying is unacceptable. Notice that it empties about 0700 hours and does not recover during a maximum day of water usage.

b. A second simulation was made for the existing system using the large MCAS pumps (enclosure (4)). The results, shown in Figure 1b, also show Tower STC 606 emptying.

7. Two schemes were analyzed by computer model to resolve the hydraulic problems. Scheme I uses both MCAS and Camp Geiger pump stations and Scheme II uses only the MCAS pump station.

a. Scheme I - The computer model was improved by adding another 8-inch PVC line from the MCAS pump station to Camp Geiger, connecting at the Camp Geiger ground level reservoir, (enclosures (6a) and (7)). The flow rate to the reservoir is controlled by an orifice plate and altitude valve (enclosure (6b)). The MCAS pump station was modified as shown in enclosure (8), and three new 6x8x18A Aurora pumps with 15 1/4-inch impellers were installed at the MCAS pump station, and two at the Camp Geiger pump station, (enclosure (9)).

b. Altitude values were installed at the towers and the high water levels set at elevations of 168 feet for all the towers. The pumps were set to turn on and off at the following tower water levels:

| | Tower | HWL | LWL |
|---|---|---|---|
| MCAS Pump | STC 310 | 168 | 162 |
| Camp Geiger Pump | STC 606 | 168 | 158 |

c. The two MCAS tank low water levels (LWL) were set at 162 feet to provide adequate fire reserve stored in the tower. The LWLs were set at 158 feet on the two Camp Geiger tanks because there is not enough storage capacity in the Camp Geiger elevated tanks for normal fluctuating operating demands and fire reserve. The fire reserve for Camp Geiger will have to come from the ground storage tanks. (Please see enclosure (10)).

SHEET NO. ........ OF ........

JOB NO. ........

SUBJECT ........

BY ........ DATE ........

CHKD ........ DATE ........

FIGURE 1 - MAXIMUM DAY

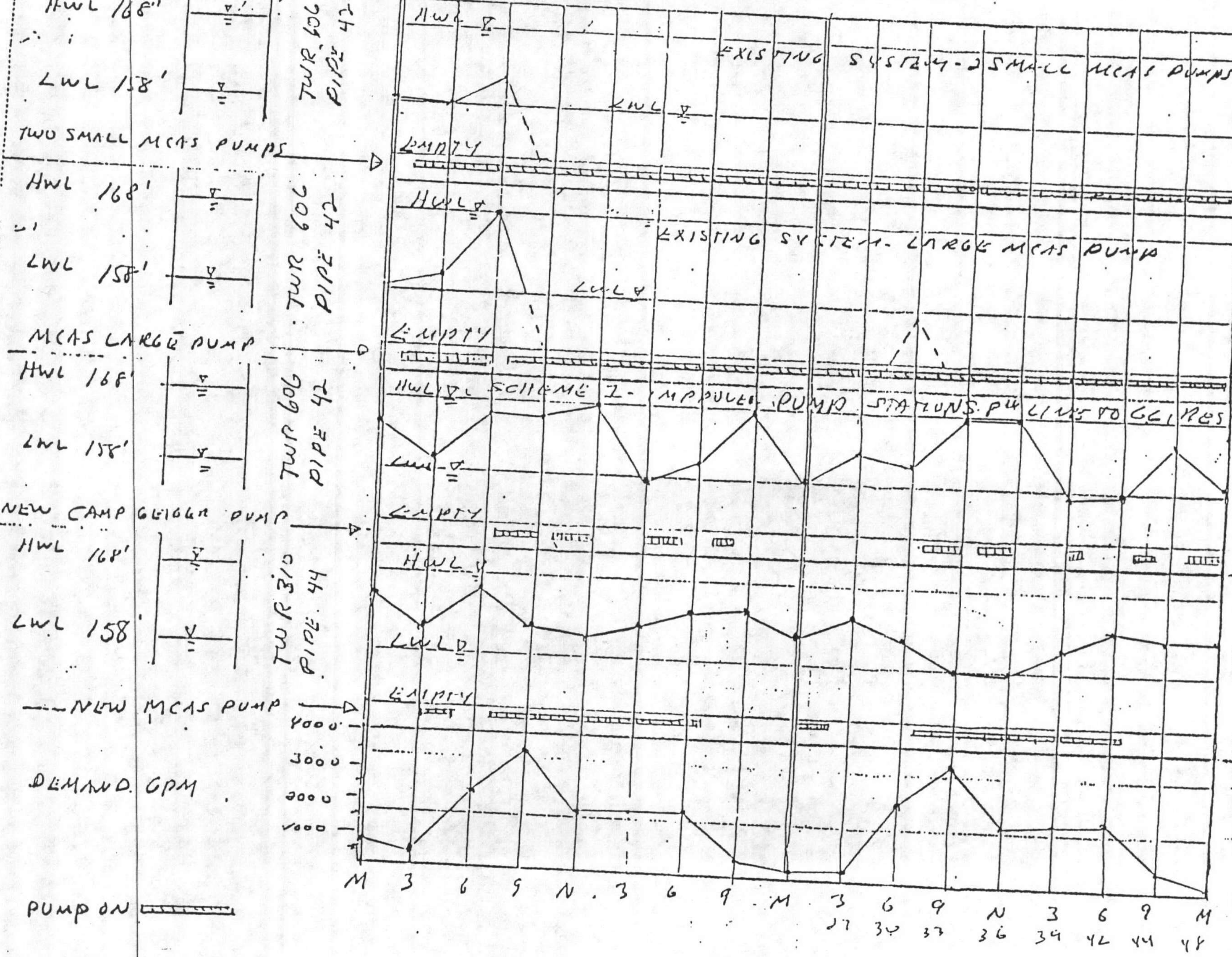


FIGURE 1

BY ........ DATE ........ SUBJECT ........ SHEET NO. ........ OF ........

CHKD. BY ........ DATE ........ JOB NO. ........

# FIG 2 - MAXIMUM DAY

SCHEME II - IMPROVED SYSTEM - 10" ... TO C? GEIBER

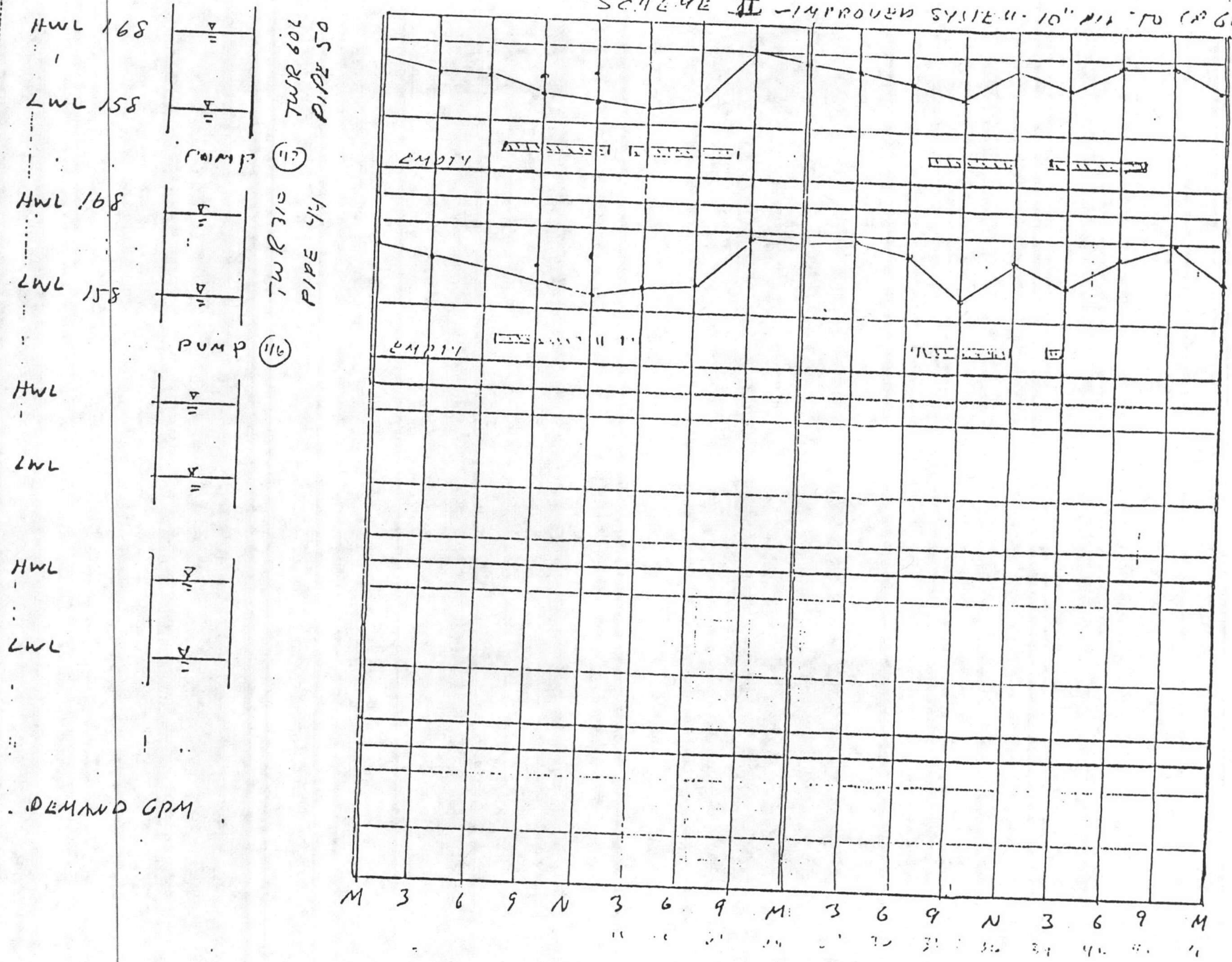


FIGURE 2

d. A 48-hour maximum day simulation was made for the improved system and the results show that the tanks do not empty (figure (1-c and d)). The MCAS pump operated for a total of 28 hours out of the 48, and the Camp Geiger pump operated 15 hours.

e. Enclosures (11a) and (11b) are excerpts from the 1983 and 1985 LANTNAVFACENGCOM fire protection surveys for the MCAS and Camp Geiger respectively. They show that fire protection capacity overall is good except for three locations at the MCAS. They are the MCQ area, Warehouse 3525 and the O'Club. The improved system model was used to simulate fire flows at those and other locations of Camp Geiger and the MCAS. The results are summarized as follows:

(FIRE FLOWS) SCHEME 1

| Location | JCT | Flow GPM | Resid PSIG | Subtract PSIG | Final PSIG | | Comments |
|---|---|---|---|---|---|---|---|
| 1. Hangar AS 4106 | 24 | 7000 | 61 | – | 61 | g.t. | 20 OK |
| 2. CG Bldg 10 | 5 | 1500 | 60 | – | 60 | g.t. | 20 OK |
| 3. CG BEQ | 1 | 1500 | 59 | – | 59 | g.t. | 20 OK |
| 4. TRL PK | 7 | 1500 | 55 | 47 | 8 | l.t. | 20 (1) |
| 5. MCAS EM Club | 33 | 1000 | 61 | 42 | 19 | a.e. | 20 (2) |
| 6. MCAS O'Club | 16 | 1000 | 49 | 24 | 25 | g.t. | 20 OK |
| 7. Cont. Fuel Tks | 24 | 3000 | 61 | 170 | -109 | l.t. | 20 (3) |
| 8. NCO Club | | 1000 | (see encl (13)) | | 40 | g.t. | 20 OK |
| 9. Officers Housing | | 1000 | (see encl (14)) | | 54 | g.t. | 20 OK |
| 10. Hangar AS 840 | | New pump REQ, see encl (16) | | | | | |
| 11. Warehouse 3525 | | New pump and RES REQ, see encl (15) | | | | | |

g.t. = greater than
l.t. = less than
a.e. = about equal

f. The NCO Club and MOQ are presently supplied fire flows and pressures from reservoir AS 2002 and pump station AS 2003. These locations were done by hand computations shown in enclosures (12), (13), and (14). The MCAS O'Club hand computations are shown in enclosure (20). Warehouse 3525 and Hangar AS 840 are remote and require flow and pressures above the capacities of present equipment. They will require separate storage tanks and booster pumps (please see enclosures (15) and (16)).

Scheme II. For this scheme, in addition to improving the MCAS pump station as shown in enclosure (8), the MCAS to Camp Geiger connection is a 10-inch PVC line from the pump station connecting Camp Geiger near Tower STC 1070 and south of Tower STC 600 instead of to Camp Geiger reservoir (enclosures (7a) and (7b)). Altitude valves were set the same as for Scheme I, and two Aurora 6x8x18a pumps were used in the MCAS pump station. Towers STC 606 and AS 301 did not empty during a 48-hour maximum day simulation (Figure 1e and 1f). The two MCAS pumps operated 17 and 13 hours respectively.

## (FIRE FLOWS) SCHEME 2

| Location | JCT | Flow GPM | Resid PSIG | Subtract PSIG | Final PSIG | Comments | |
|---|---|---|---|---|---|---|---|
| 1. Hangar AS 4106 | 24 | 7000 | 62 | - | 62 | g.t. | 20 OK |
| 2. CG Bldg 10 | 5 | 1500 | 57 | - | 57 | g.t. | 20 OK |
| 3. CG BEQ | 1 | 1500 | 46 | - | 46 | g.t. | 20 OK |
| 4. TRL PK | 7 | 1500 | 54 | 47 | 7 | l.t. | 20 (1) |
| 5. MCAS EM Club | 33 | 1000 | 62 | 42 | 20 | e.t. | 20 OK |
| 6. MCAS O'Club | 16 | 1000 | 51 | 24 | 27 | g.t. | 20 OK |
| 7. Cont. Fuel Tks | 24 | 3000 | 63 | 170 | -107 | l.t. | 20 (3) |
| 8. NCO Club | | 1000 | (see encl (16)) | | | | |
| 9. Officers Housing | | 1000 | (see encl (14)) | | | | |
| 10. Hangar AS 840 | | New pump req., see encl (16) | | | | | |
| 11. Warehouse 3525 | | New pump and res. req., see encl (15) | | | | | |

g.t. = greater than
l.t. = less than
a.e. = about equal
e.t. = equal to

### COST COMPARISON

| | Scheme I | Scheme II |
|---|---|---|
| Improve Pump Station | Same Cost | Same Cost |
| New Pump w/controllers | 5 Pumps at 30K = 150K | 3 pumps = 30K = 90K |
| New PVC Connections | 5120'-8" @ 17.25 = 87K | 3500'-10" @ 21 = 73.5K |
| Totals | 237K | 163.5K |

Scheme I is more costly but it affords extra reserve fire protection storage water.

NOTES:
(1) Additional lines will be needed at TRL park - see enclosure (17 ).
(2) 20 PSIG residual can be obtained by cleaning line - see enclosure (18).
(3) Storage tank and pump will be needed at site - see enclosure (19).

8. Conclusions

a. In addition to adding pipes, pumps, etc., to the system to provide adequate capacity and operation, the condition of the existing system must be inspected, tested and improved to provide reliable service. Appendix B is an outline of steps for contracts to efficiently inspect and test the existing system and provide repairs and designs for installing the needed additional equipment identified by the hydraulic analysis. Appendix B pages I through VII are scopes of work, cost estimates and costing information. The step sequences are based on previous examination of the system to determine what is needed for the next test or examination.

b. Initial flow tests (enclosure (1)) indicate some corrosion/scale build-up inside the pipes, but not enough to seriously affect operation. However, the 8-inch lines along Curtis and Flounder roads are suspect for low "C" factors, and should be tested. If C is less than 90, the pipe should be cleaned by pigging. The Langelier water stablization index is slightly positive, and therefore pigging is an appropriate method for cleaning and restoring "C" factors. At this point, it suggested that the Navy Rehabilitation Guide, Attachment A, be read for information about rehabilitating older systems.

c. Scheme I affords more automatic reserve water storage with Camp Geiger's reservoirs and pumps. There is, however, sufficient storage available from the MCAS treatment plant reservoirs for daily operations and fire needs. Camp Geiger's reservoir and pump station can still be retained for emergencies and used manually for its additional capacity.

d. The trailer park area use is minimal at present, and no improvements are recommended.

e. Part of the testing and inspection of the existing system is excavation of the pipes to inspect for signs of corrosion. The excavations should be done where the soil is most corrosive and the worst pipe conditions would be expected to be found. These locations are generally identified by a soil resistivity/copper sulfate (cathodic protection) survey. This survey has been performed by Menendz-Donnell and Associates, Incorporated, 11999 Katy Freeway #355, Houston, Texas 77079, Conract N62470-83-C-6148. Enclosures(21), (22) and (23) are summaries of the survey for Camp Geiger, Trailer Park and MCAS respectively. The worst locations are labeled "mildly corrossive", enclosures (21a), (22a), and (23a), and are located on maps (enclosures (21b), (22b), and (23b)). These locations were evaluated from the survey data readings by the relationship in Attachment F of the Water Pipe Rehabilitation Guide.

Recommendations for system improvements excluding the trailer park area:

1. Award a contract to:

a. Manipulate and test about 215 hydrants and hydrant valves and 560 isolation and maintenance valves 6 inches and larger (1). The test will be for condition, proper operation and valve leakage (see Attachment B, pages I to II).

b. Perform a sonic leakage survey on all the exterior station pipes. There are about 25 miles of pipe. (See Attachment B, pages I to VI for scopes and costs)

c. Excavate and inspect the pipes for external condition at locations identified as corrosive from enclosures (21), (22), and (23) (see Attachment B page VII - pipe examination for scope).

d. Perform "C" factor flow tests for pipes on Flounder and Curtis Roads by method shown in "Water Rehabilitation Guide", Attachment A.

e. Prepare plans and specifications to replace leaking or inoperative valves, hydrants, and pipes from paragraphs 1a, 1b and 1c; also prepare plans and specifications for the following list of improvements:

LIST OF IMPROVEMENTS FOR DESIGN AND CONSTRUCTION

A. Install 10-inch PVC line from MCAS treatment plant to Camp Geiger - Scheme II, see enclosures (7a and 7b).

B. Modify the MCAS pump house piping and install new pumps in MCAS and Camp Geiger pump houses as shown in enclosures (8) and (9). The pumps will be controlled by pressures at Towers STC 606 and AS 310 as shown in the enclosures and in paragraph 6b of this report.

C. Provide for an inspection of the AS 2003 pump house and make any needed repairs to place it in proper operation. The pump house has piping to recirculate water through Reservoir AS 2002. Install a chlorinator in the pump house and recirculate chlorinated water through the reservoir in order to keep the chlorine residual.

D. Design and construct a new fire pump house which will take water from Reservoir AS 2002 and service a deluge sprinkler system in Hangar AS 408, (see enclosure (16)).

E. Provide a ground level reservoir and fire pump for fire protection at Warehouse AS 3525, and the contaminated fuel tanks, enclosures (15) and (19).

F. Provide Towers STC 606 and STC 1070 with two-way altitude valves. Repair the altitude valves at Towers AS 310 and 4130 if needed. All valves should close at elevation 168 feet.

NOTES:

(1) Exclusive of trailer park, valves = about 511 plus 10 percent for counting errors = 560.

2. Purchase and stock replacement valves, pipe and pipe repair parts for those valves and pipes identified in recommendations 1a, 1b and 1e. Using plans and specifications from 1e above, award a second contract to excavate and replace the leaking valves and repair the worst pipe leaks identified in 1a and 1b. Attachment B - pages VI and VII are special specifications for valve repair work, pipe examination and unit costs. When the number of valves that need replacement is known from 1a, the unit costs of Attachment B, page VI can be used to develop a cost estimate for this second contract.

3. The excavations and pipe inspections should start at those locations where the soil is most corrosive and the pipe exteriors would be expected to be the worst. These locations will be identified by the cathodic protection survey results in 1c. The information from this survey is to be used with the result of 1a and 1b to plan the sequence of valve and pipe excavation replacements/repairs.
The pipes, especially the exteriors of the older pipes, should be examined at corrosive soil locations. Leaking valves and attached pipes at these corrosive areas should be the first to be excavated, inspected and the valves replaced. If a pipe or valve, in a corrosive location, is excavated and the exterior of the pipe is in good condition, it can be assumed that other pipes of the same age in a less corrosive location will also be in good condition.

4. Clean by "pigging" those lines found to have internal buildup from inspections of paragraph 3 and "C" factor tests of 1d.

5. Change Order the design contract 1e to provide plans and specs to replace pipes found to be deteriorated from paragraph 3.

6. Award a construction contract to replace pipes of paragraph 5 and make improvements recommended in this report and designed by paragraph 1f.

WATER PIPE REHABILITATION GUIDE

ATTACHMENTS

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A. Condensed Guide
B. Hydraulic Analysis
C. Hazen Williams "C" Factor Flow Test
D. Laboratory Analysis Form
E. Pipe Costs, Water Treatment Information, and Economic Analysis
F. Copper Sulfate Reference Electrode Measurements

INTRODUCTION

1. Rehabilitation of Navy water pipe lines is expensive and is becoming more of a problem because of the age of the systems. Many were installed in the 40's and 50's and have deteriorated to the point where they are no longer adequate to meet current or future demands, and pipe rehabilitation may be needed. The guide assists in determining where and what type of rehabilitation is appropriate. Much of the updated information for this guide was obtained from comments and publications by the Army Corps of Engineers, Waterways Experimental Station, Vicksburg, Mississippi and from numerous Navy and Municipal Water Works Departments.

2. Prior to the beginning of a pipe rehabilitation project, the scope of the rehabilitation should be developed through a study of the system needs and tests made to determine existing conditions. Typically, a complete study should include:

a. if needed, updating the system maps showing piping, sizes, elevations, hydrants, service connections, valve locations, pumps, and storage.

b. estimation of current and future water usage and fire flow rates in each section of the system.

c. hydraulic analysis to determine required pumping, storage, and pipe flow capacities (sizes and friction factors).

d. Valve and pipe flow testing to determine valve conditions and actual pipe friction flow factors.

e. leakage survey.

f. pressure and leakage testing.

g. interior and exterior corrosion inspection.

h. recommendations regarding cleaning, relining, repairs, or replacement.

3. Some of the above items may not be applicable or can be quickly assessed for a particular system or problem. The information contained in this guide should help to determine if a separate study is needed, or to select which items to include as part of the design effort. A system study can be done in-house by Public Works Engineering, by the EFD, or by a separate contract.

4. The Guide also provides information for conducting the study. Attachment A is a condensed reference guide; Attachment B contains information for conducting the hydraulic analysis; Attachment C contains three methods for performing flow tests to compute the friction flow factor and evaluate the interior condition of a pipe; Attachment D is a laboratory analysis form showing the parameters to be determined from water samples to compute the water's tendency to scale or corrode (Langelier Index), and indicate its removability (silica content); Attachment E contains water treatment information, pipe cleaning and replacement costs and an economic analysis guide. LANTNAVFACENGCOM Code 114 can provide assistance for in-house studies or for obtaining a contract. Point of contact is Mr. J. Harwood at this Command, commercial (804) 445-2930 or AUTOVON 565-2930 or FTS 955-2930.

DISCUSSION

5. The most common problems which lead to water pipe rehabilitation are:

a. insufficient pipe flow capacity (low pressures);

b. excessive pipe breaks and leaks;

c. red water problems; and

d. a combination of the above.

Where corrosive (aggressive) water exists, red water, loss of capacity, and excessive breaks are common occurrences. The rusting of the pipe interiors, which causes red water, also results in flow inhibiting tubercles and a weakening of the pipe wall. Scale forming water deposits a calcium carbonate layer on the pipe walls and protects it from rusting. However, excessive deposits will reduce the smoothness of the pipe wall and cause excessive friction resistance to flow. More importantly, deposits will reduce the internal diameter of the pipe, resulting in a greater impediment to the flow. Sometimes, both rusting and scaling exist is the same system due to a change in the chemical makeup of the water from location to location, or to a change in the water source or treatment. Rehabilitation can include restoring the flow capacity of existing pipes by cleaning (e.g., "pigging"), cleaning followed by cement-mortar lining, pipe replacement or addition.

PROCEDURE

6. Unless the system is known to be hydraulically adequate, the basis for flow capacity decisions should be the results of a hydraulic analysis to determine what sizes and what friction factors are required for the pipes to provide adequate flows (see Attachment B). These analyses can range from knowledge of adequacy or simple pipe flow calculations to full scale computer modeling. They can be performed by the activity engineering office, by LANTNAVFACENGCOM via ESR, or by an A&E contract. Comparing the required pipe sizes with the existing sizes determines the replacement decision. Except for unusual circumstances (such as large sizes or locations where replacement is very expensive), it is more economical to replace the pipe with a larger pipe or supplement it with a new parallel pipe, than to clean it and add a second pipe to provide the additional capacity.

7. Testing prior to Rehabilitation (select tests which are consistent with the existing system/problem). These tests should be done by an A&E testing contract.

a. Valve leakage and Pipe Flow Tests

Experience with Navy water systems show that many valves leak and cannot be sufficiently closed to sectionalize the systems. Often valves are frozen and cannot be operated at all. This is especially true for older or saltwater systems. Test valve conditions by manipulating them for free operation. Test valves for leakage by flowing a downstream hydrant while manipulating the valve. Leakage can be observed by a change in the hydrant flow, and heard in the valve by sonic listening devices. A small amount of leakage will not seriously affect pipe flow and pressure tests, but will determine the quantity of water needed for pressure tests. All leakage may not be detected and judgement is needed to estimate how much of the detected leakage can be tolerated. Excessively leaking valves are to be replaced. A sufficient supply of replacement valves should be stocked to prevent undue testing delays. The exterior and interior of connecting pipes are to be examined for size, type of material, corrosion, scale and cement lining while they are exposed for valve work.

Prior to selecting a water pipe for rehabilitation, the pipe is next flow tested as prescribed in Attachment C for its Hazen Williams "C" (friction factor). The results will be compared with the required "C" factors from the hydraulic analysis of paragraph (6) to decide if the present conditions are adequate, or pipe cleaning is desired. Take a sample of the water from the system where the pipe is located and field measure the temperature and pH. Have the water analyzed by a laboratory and the Langelier index computed. The lab analysis forms are shown in Attachment D. The hydrant flow tests can also be used in the field by a pipe cleaning contractor to determine if the cleaning has met specifications; by an inspector to check the results of a cleaning operation; by maintenance to determine the internal condition of a pipe; and by engineers performing a hydraulic study of the water system.

b. Pressure and Leakage Tests

Prior to rehabilitating a water pipe selected from 7a, make pressure and leakage tests according to AWWA C600-44, Section 4.1 and 4.2. Test pressures should be those determined as a result of the hydraulic analysis (including surge and factor of safety). Older valves often leak and high pressures cannot be obtained with a hand pump. A motor-driven pump may be necessary. Repair any incurred ruptures. Close service connections if the pressure tests could damage customer's plumbing. All ruptured pipes may not need replacement. The rupture and maximum pressure, prior to rupture (corrected to the elevation of the rupture point) will be the basis for deciding if the pipe is to be cleaned or replaced. If the pressure test causes a break in a pipe length (not in the joint), and the break can be attributed to a weakening of the pipe wall because of rusting, the pipe should be replaced. If the break is a result of a joint failure (not pipe strength), restoration should be considered. The rupture pressure should also be considered. If the elevation corrected pressure is substantially above the maximum pressure determined for that location from the hydraulic analysis, replacement would not be indicated based upon pressure test results alone, especially for an older pipe. In the absence of a surge or water hammer analysis, a rupture pressure one and one-half times the expected maximum should be acceptable. The decision to replace or restore the pipe should then be based upon economics. If leakage is high and water is scarce or expensive, the economic analysis should include the cost of repairing leaks identified by the leakage survey, and the cost savings associated with reduced water leakage. Bear in mind that cleaning and cement-mortar lining will reduce leaks, but cleaning alone will not.

c. Pipe Examination (Exterior)

Prior to cleaning a water pipe selected from 7b, copper sulfate potential measurements as shown in Attachment F and electrical resistivity tests as specified in U.S. Navy Corrosion Prevention and Control Manual (NAVDOCKS MO 306, Section 2) should be made for the system. Excavate the pipes where the tests indicate corrosive soils, and examine the exterior for deterioration. Rust, pits, and soft spots will be noted. Striking suspicious looking places with a hammer will often reveal soft or deteriorated pipe. Note pieces flaking off when struck. If a pipe is fairly new and is found to be badly deteriorated on the outside, replacement with an exterior protected pipe is indicated. If the pipe is old, and the exterior deterioration is minimal, it can be assumed that there are many more years of useful life remaining for the pipe, and restoration should be considered. Exterior examination of pipes should also be made during valve replacements and repairs.

d. Pipe Examination (Interior)

While the pipe is excavated for 7c, remove a section of the pipe and examine the pipe interior for lining (cement), and type of interior buildup. Examine the interior of the insitu pipe, as well as the removed spool. Determine the type of incrustation (Rust tuberculation, scale), its thickness, hardness, color, and adherance to pipe walls. Interior pipe examinations can also be made during valve repair/replacement work.

The method of cleaning pipes selected for cleaning will depend upon the type of material to be removed. If the water analysis indicates a low (less than 5 ppm) silica content and the pipe interior inspection reveals that the material inside the pipe is a soft and loosely bonded calcium scale (positive Langelier index), polly pigs can be used. If the water analysis indicates high silica content (above 5 ppm), and the corrosion or scale material is hard and/or firmly bonded to the pipe walls, then cleaning should be done by either mechanical pigs or rodding.

Unlined pipes with rust tuberculation (negative Langelier index) are to be mechanically cleaned and cement lined as specified in AWWA Standard C602-76. An alternative to cement lining (which is expensive) is cleaning followed by water treatment. The treatment is to raise the Langelier Index to a slightly positive value, followed by the addition of sodium hexametaphosphate for corrosion control. The equipment needed for treatment is listed in Attachment D.

8. Repair or rehabilitation of valves and pipes identified for work and not needed for tests should be done by a construction or maintenance repair contract. Work should be done first on those valves and pipes that are known to need work and are connected to each other. The other valves that need work should be done next. When the valves are opened or removed and the interior of the pipes connected to the valves are examined for interior conditions and identification of linings, those that show more than minimal internal corrosion during this inspection should also be considered for replacement or rehabilitation in addition to those pipes already identified during the testing contracts. This procedure may require an incremental contract or two contracts, but should result in the best water system at the lowest cost.

9. Each system decision is site specific and should be considered in light of its own test data. Under normal circumstances, it will be found that rehabilitation cost increases can be expected as follows: Lowest in cost is pigging, then cleaning and lining, and the most expensive is pipe replacement for the larger sizes. Also, replacement will be indicated in more cases for the smaller size pipes (less than 10-inch) than the larger pipes. Water treatment items to consider, cleaning/lining costs for pipes, and an economic analysis guide are listed in Attachment E.

10. Excessive breaks can be the result of pipe deterioration caused by corrosion or cavitation, excessive pressures caused by system surges, or water hammer. Surging can be seen on a pressure gage connected to the system. Corrosion can be noted by the color of water (red water) from a fire hydrant at the start of a flow test. Cavitation generally occurs at pumps, pipe diameter changes, valves, fittings, etc., and can be identified by sound. Cavitation sounds like gravel or popping at or near the fittings or pump. Water hammer can be noted by banging or thumping noises in the system, especially when a pump stops or a valve or hydrant is suddenly closed. Rust (red or black water) problems were addressed in paragraph (5). When warranted, water hammer and/or cavitation analyses should be made to determine their magnitude and suitable corrective actions. These analyses are specialized and should be performed via ESR or contract.

11. Operation Plan: Before any testing or repair work begins, a complete operation plan showing the valves and hydrants to be used and all access points for the work should be made and reviewed by all the parties involved. The plan should be submitted in advance so that an adequate supply of equipment (especially valves) can be stocked, water users can be advised of interruptions in service, and arrangements can be made for traffic, or other problems that may occur.

## CONDENSED GUIDE - ATTACHMENT A

This condensed guide is a quick reference to be used as a supplement for the "Pipe Rehabilitation Guide". The arrows indicate a probable sequence of steps, and use of condensed guide should be tailored to site specific conditions. ( ) denotes associated paragraphs in the guidance.

| I. PROBLEM | GO TO STEP |
|---|---|
| Loss of Pressure | II |
| Red Water | II |
| Excessive Breaks and/or Wear | III |
| Excessive Leakage | II or III |
| Poor Maps and/or Records | IV |

II. Determine Fire and Domestic Water and Pressure Needs (Present & Future) Go to Step V

III. Waterhammer and/or Cavitation Analysis Leakage Survey

IV. Upgrade Maps and/or Records

V. Hydraulic Analysis to Determine System Component Needs (Size & Condition)

If existing pipes are inadequately sized, replace or add pipe unless unusual circumstances exist.

VI (7c) Valves/Pipes

Field Test Valves
Leakage Survey
Soil Restivity and Copper Sulfate Reference Survey (Cathodic Protection Survey)

To determine where to excavate and inspect pipes.

Excavate and Inspect Pipes

If exterior is poor, pipe is to be replaced.

VII (7a,b) Valve and Internal Pipe Condition

"C" Factor Flow Tests,

Repair/replace valves needed for tests. Others noted for construction contract.

Low "C" factor due to corrosion is often accompanied with excessive internal pitting and weakening of pipe wall.

Pressure Tests

If pipe strength from pressure tests is inadequate, replace pipes.

Sample for Water Chemical Makeup

Take water sample for Langelier Index, Silica, and Calcium Content.

VIII. (7d) **Internal Inspection** Langelier Index, and Chemical Test Results. Inspect insitu pipe interior.

Select pipe rehalitation method from IX below.

IX. **Pipe Rehabilitation**

---

| Pipe is Cement Lined and/or Calcium Buildup (+) Langelier Index, | | Pipe is unlined, rust tuberculation, red water, (-) Langelier Index | | Special Circumstances |
|---|---|---|---|---|
| Low Silica | High Silica | Low Silica | High Silica | |
| Soft, poor pipewall bonding (Pig Lines) | Hard, firm pipewall bonding (Clean*) | Soft, poor pipewall bonding Pig & Treat** Water | Hard, firm pipewall bonding Clean* & Cement Line Pipes | -Sandblast & Expoxy Coat<br>-Insitu Plastic Lining |

*Mechanically Clean.
**Treat to positive Langelier index and add sodium hexametaphosphates.

ATTACHMENT B
HYDRAULIC ANALYSIS METHOD FOR STEP 6
OF THE WATER REHABILITATION GUIDE

While this method does not have to be rigidly followed, it is included as a guide for hydraulic analyses of water systems and should be used or adapted when appropriate for the system being studied. Computer model water and pressure demands are to be modified according to available information. For example, the future growth of a station may not be 25 percent to 50 percent as presented herein. All future planned water using projects served by the water system shall be located on a map or in a table, indicating average, daily and peak water consumptions. These values will be added to existing water demands for the appropriate computer model demands.

Hydraulic analyses should ordinarily be done by hand computations, and computers used when the system is so looped or complicated as to make hand computation tedious or impossible. Hand computations are easier to review than checking computer input/output data. Simple sketches facilitate reviewing both hand and computer computations.

Wherever possible, water distribution systems should be skeletonized and reduced by using equivalent pipes. This will decrease hand computations and model input data, reduce the opportunity for mistakes and the time needed for corrections. Skeletonizing will also make the results more conservative. Takeoff's from a computer models's main looped system can be done by hand computations. Water distribution maps showing pipe sizes, lengths, materials, junctions, junction elevations, demands and model pipe/junction identification notations are needed to understand computer data inputs and results. Pump curves should also be included, along with a sketch of the pumps and all the elevated towers, showing their elevation relationship with each other and to the common datum used for the distribution maps. Pump station and other significant minor losses should be carefully computed and included in the model data or hand computations.

# HYDRAULIC ANALYSIS

1. Determine the total metered demand for as long a period as convenient (at least one year) and compute the average, lowest and peak days.

2. Divide system into areas according to type of structures (housing, commercial, industrial, piers, storage, maintenance, training, hangars, power/steam plants, etc.).

3. Compute the expected consumption for each area in GPD.

   a. Housing/Barracks = 90 GPCD x (number of 24-hour persons) offbase residents (e.g., civilians) = 1/3 of a 24-hour resident

   b. Piers - 50 GPCD x (number of 24-hour ships personnel)

   c. Other - known water usage GPD

   d. Expected water consumption - Total of Lines (a), (b), and (c)

   e. Daily consumption per junction = Lines ((a) + (b), + (c)), divided by number of junctions in the area

   f. Total expected consumption = sum of all areas from (d) _____

   g. Unaccounted for water = total metered daily (average) - Line (f) _____

   h. Unaccounted for water/junction = Line (g)/total number of junctions _____

   i. Average Day GPM demand (Assign to <u>each junction</u>) = (Line (e) + Line (h)) divided by 1,440

   j. Maximum Day GPM (<u>each junction</u>) = (2.25 x Line (e) + Line (h)) divided by 1,440

   k. Peak Hour GPM (<u>each junction</u>) = (4 x Line (e) + Line (h)) divided by 1,440

   l. Fire flows for each area - Add the maximum fire consumption GPM at most critical appropriate junction to the Average Flow for that junction (Line (i)).

   m. Extended period simulations (EPS) - Flow variations during the day. [1]

Gallons Per Minute on Maximum Day for each junction by hour

| | | |
|---|---|---|
| Midnight - | 6 A.M.: | (0.45 [2] x Line (e) + Line (h)) divided by 1,440 |
| 6 A.M. - | 9 A.M.: | (3.60 x Line (e) + Line (h)) divided by 1,440 |
| 9 A.M. - | 11 A.M.: | (5.63 x Line (e) + Line (h)) divided by 1,440 |
| 11 A.M. - | 11 A.M.: | (2.81 x Line (e) + Line (h)) divided by 1,440 |
| 5 P.M. - | 8 P.M.: | (3.04 x Line (e) + Line (h)) divided by 1,440 |
| 8 P.M. - | Midnight: | (0.79 x Line (e) + Line (h)) divided by 1,440 |

NOTES:

(1) Hourly industrial/commercial, etc. variations may be different from housing/barracks patterns, but considering them the same does not ordinarily introduce much error. If the industrial/commercial non-housing/barracks water using facility (Line (c)) consumes a large portion (more than 25 percent) its total area consumption, it should be computed separately for growth, peaking, and hourly variations (i.e., for hourly variations, it should not be included in EPS demands as part of Lines (c) and (e), but added to the hours of the EPS according to its own past hourly usage patters).

(2) Twenty percent of maximum day for early AM hours = 0.2 x 2.25 = 0.45

4. Criteria for Analyses:

a. Maximum day and peak hour minimum system pressure greater than 35 psig

b. Pumps sized so all peaks can be met with the largest pump down (out of service).

c. Fire pump suction greater than 20 psig when taking suction from a distribution system

d. Elevated tanks should not empty during Extended Period Simulations (EPS).

e. Storage will be for at least one average day's demand or fire protection needs plus 1/2 average day's demand, whichever is greater.

f. If fire protection is provided by system water pumps, elevated tank altitude valves should close when pumps are turned on.

g. Water supply/treatment should be able to provide the maximum day's demand in one day, or the average day's demand and replenish water within 48 hours used for the greatest fire, whichever is greater.

h. Hazen Williams "C" friction factors tests will be done in accordance with Navy "Water Pipe Rehabilitation Guide" - Attachment C.

i. Fire Flow Analysis, Line (1) should meet fire protection flow/pressure requirements for sprinklered and non-sprinklered buildings in accordance with MIL-HABK-1008 30 April 1985 (MHB). Hose stream demands can be divided between the hydrants that can service the building (See MHB Section 5 and Table 5-2). Sprinkler requirements not computed directly from the sprinkler system layout can be determined by the flow computed from the density design and areas (MHB Section 6 and Table 5-1).

j. The model will be calibrated by changing "C" factors and optionally the pipe diameters, so that "C" factor field tests and model results (flow and pressure) are reasonably close. The computer calibration pressure results should be less than those found in the field tests (i.e., greater head losses).

5. Computer simulations will be run to determine how well the criteria of paragraph 4 are met. System changes in pumping, changing "C" factors to C=110 and pipe diameters to nominal diameters (to simulate pipe cleaning), and making pipe additions will be selectively made until the computer model results are adequate. The pipes that are found to need cleaning will be noted for Step 7 (testing) of the "Water Pipe Rehabilitation Guide."

(1) TEST# 1 (2) LOCATION MCAS. NEW RIVER (INDUSTR. AREA) (3) DATE 4/16/86 (4) TIME 8

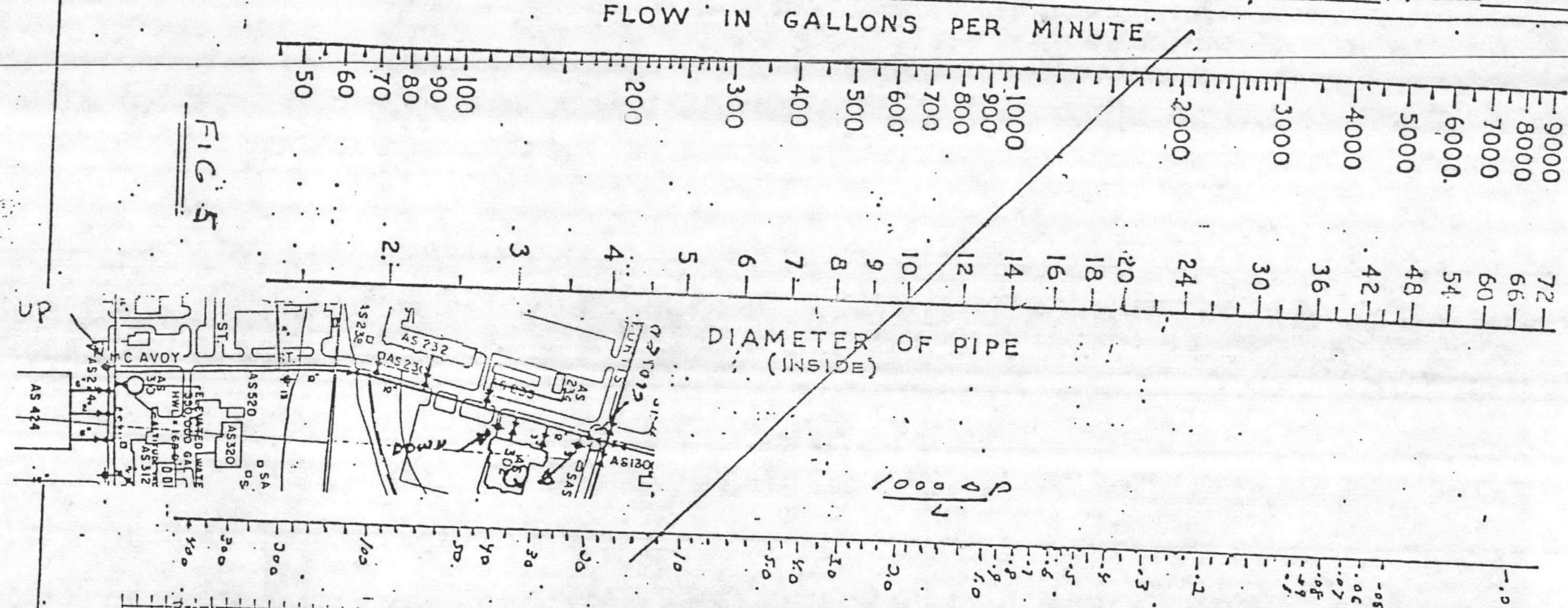
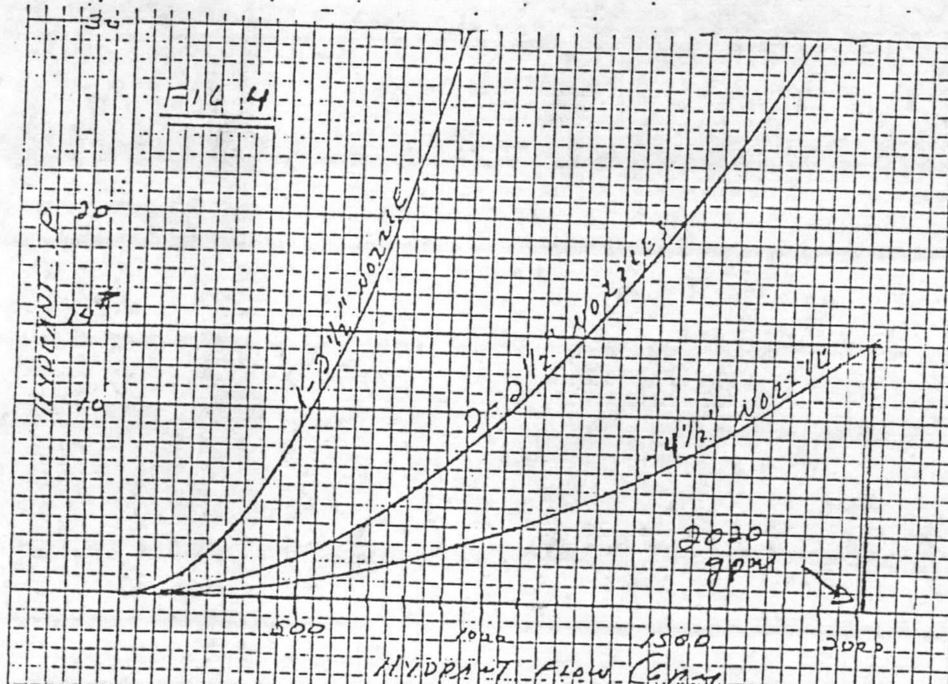



FIG 4




SKETCH

← 1300'-10" → 2020 gpm

| | UP | DN | FLOW CLOSED |
|---|---|---|---|
| (8) HIGH STAT P = | 65 | 65 | |
| (9) STAT P = | 63 | 65 | |
| (10) | 2 | 1 | |
| (11) RESID P = | 67 | 50 | 14 ← [TO FIG 4] |
| (12) | 64 | 50 | (4 1/2" NOZZLE) |
| | 50 | | |

(13) ΔP = 14#

(14) 1000 x ΔP/L = 14000/1300 = 10.8 (TO FIG 5)

(15) C = FIG 4 / FIG 5 x100 = 2020/1700 x100 = 119

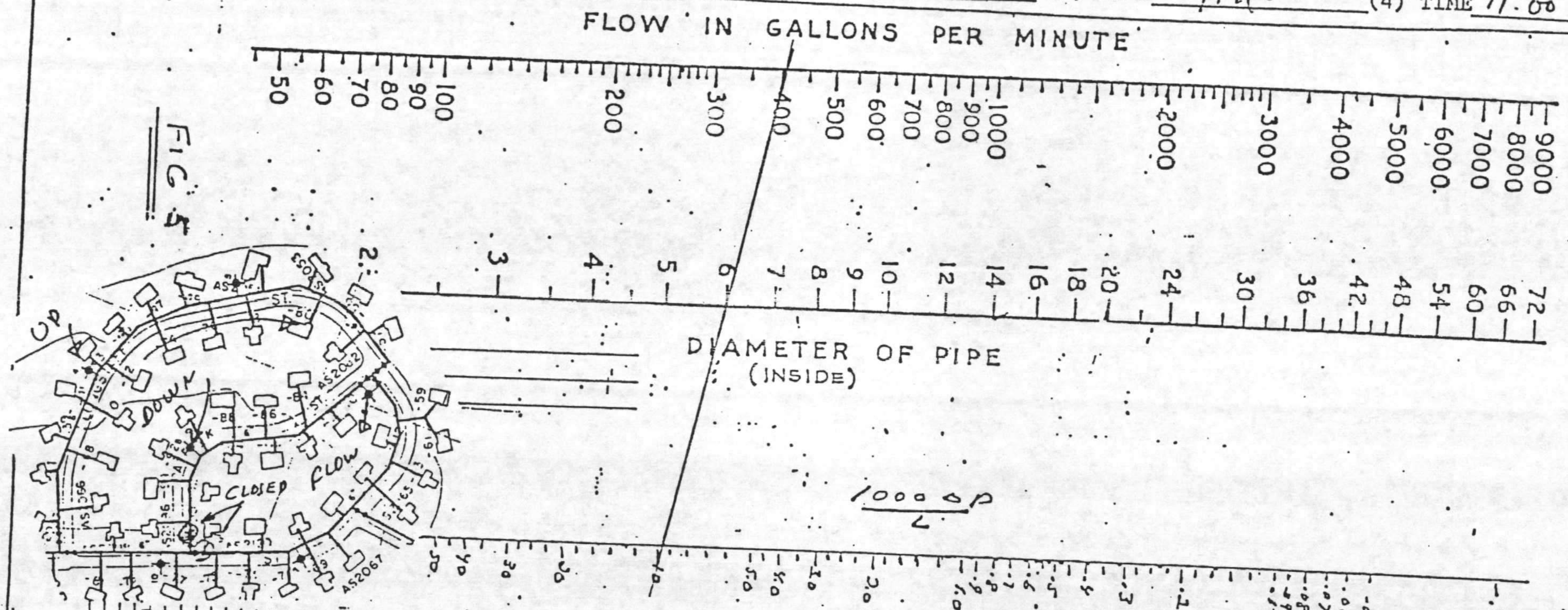
TEST BY

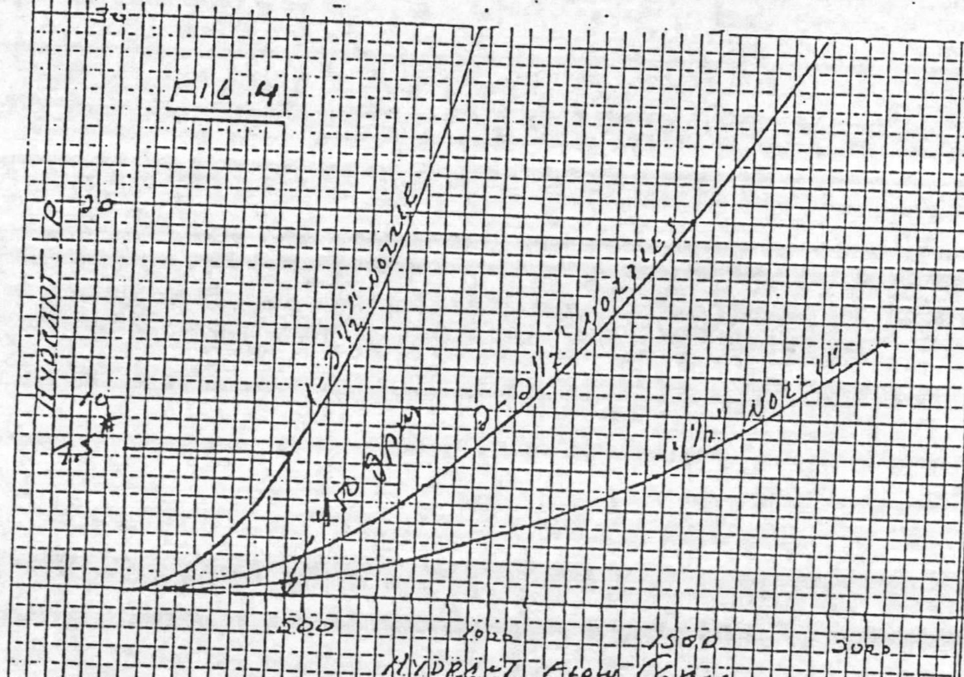
ADDRESS FIRM PHONE

ENCL (1)

ENCL (1)

(1) TEST# 2 (2) LOCATION MCAS. NEW RIVER (MOQ AREA) (3) DATE 4/17/87 (4) TIME 11:00 AM




ENCL (1)

SKETCH

924' 61
450 g.p.m.

| | UP | DN | FLOW |
|---|---|---|---|
| (8) HIGH STAT P = | 64# | 64# | |
| (9) STAT P = | 62# | 64# | 2 1/2" NOZZLE |
| (10) | 2 | — | |
| (11) RESID P = | 17 | 10 | 7.5# [TO FIG 4] |
| (12) | 19 | | |
| | 10 | | |
| (13) ΔP = | 9 | = 9.7 | |

(14) 1000 × ΔP / L = 9000 / 924 (TO FIG 5)

(15) C = FIG. 4 / FIG. 5 × 100 = 45000 / 405 = 111 (O.K.)

TEST BY

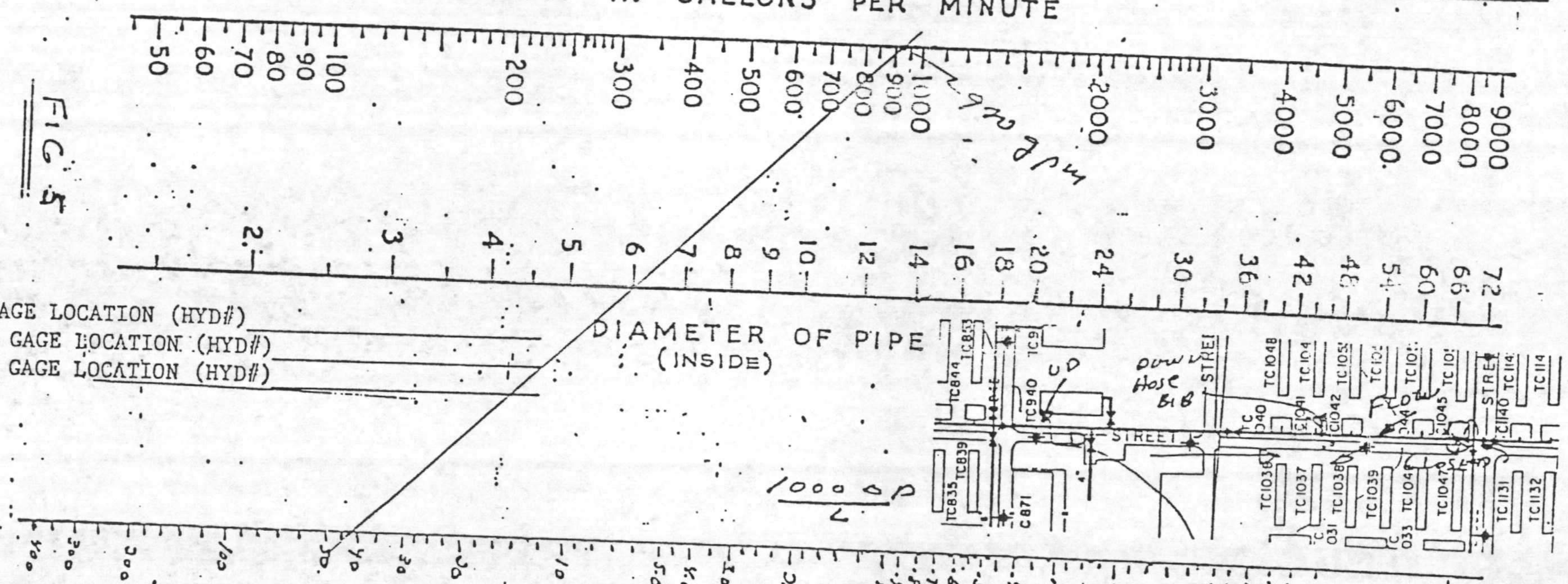
ADDRESS

FIRM

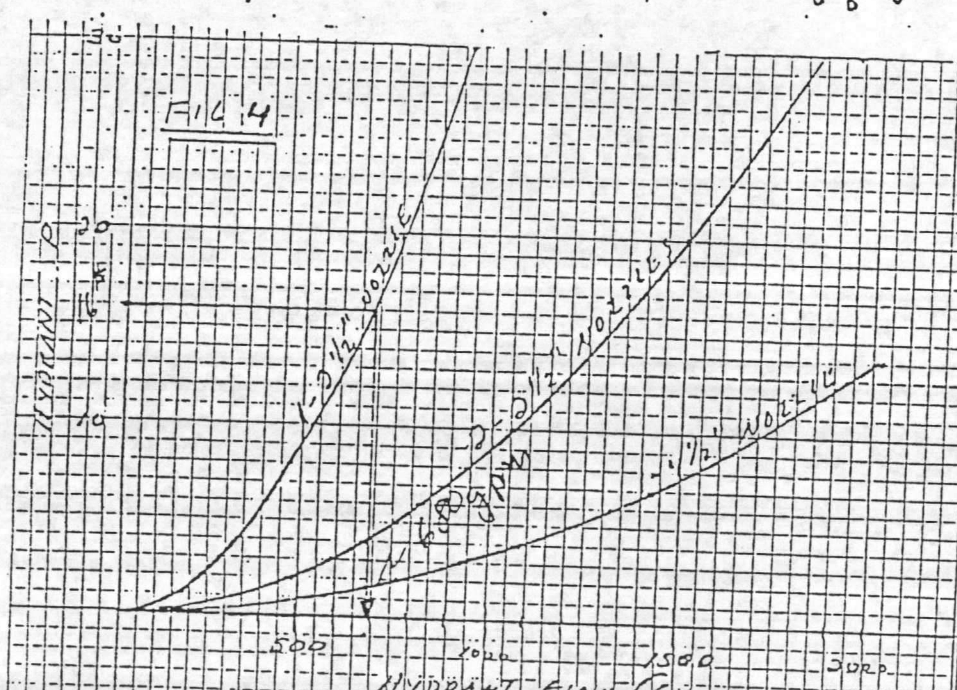
PHONE

ENCL (1)

(1) TEST# 1 (2) LOCATION CAMP GEIGER "D" STREET (3) DATE 4/17/86 (4) TIME 2:00 PM




(5) UP GAGE LOCATION (HYD#)
(6) DOWN GAGE LOCATION (HYD#)
(7) FLOW GAGE LOCATION (HYD#)




SKETCH

670' 4"
680' 4"

UP DN FLOW

(8) HIGH STAT P = 59 # 59 #
(9) STAT P = 59 57
(10) 2½" NOZZLE

(11) RESID P = 50 22 76 # [TO FIG 4]
(12) 50 / 22

(13) ΔP = 28 #
(14) 1000 x ΔP / L = 28000 / 670 = 41.8 (TO FIG 5)

(15) C = FIG 4 / FIG 5 x 100 = 68000 / 920 = 74 (FAIR)

TEST BY
ADDRESS FIRM PHONE

ENCL (1)

ENCL (1)

WATER BUDGET

AV WATER DEMAND = 896 KGPD

POPULATION - WATER USAGE DISTRIBUTION

CAMP GEIGER - 24 HR POP

PERMANENT PARTY = 2996
STUDENTS 1020
ON BASE BILLETS 2494 ] 6 JCTS

6510 x 50 GPCD = 325,500 GPD

325,500 (1440 x 6 jcts) = 37.7 gpm / JCT (1,2,3,4,5,6)

8 HR (C10) = 300/3 = 100 x 50 = 5,000 GPD

TOTAL 24 HR = 6610

EXPECTED WATER CONS @ 50 GPCD = 330,000 GPD

MCAS NEW RIVER

MOQ = 114 [illegible] UNITS x 4 PERS @ 50 = 22,800 GPD

22800 / (4 jcts x 1440) = 4 gpm / JCT (28, 29, 30, 31)

MEQ = 321 UNITS x 4 PERS @ 50 = 64,200 GPD

64,200 / (6 jcts x 1440) = 7.4 gpm / JCT (10, 11, 12, 13, 14, 15)

BEQ (4000 AREA) = 1396 x 50 = 69,800 GPD

69,800 / (3 jcts x 1440) = 16.2 gpm / JCT (25, 26, 27)

(200 AREA) = 814 PERS @ 50 = 40,700 GPD

40,700 / (1 jcts x 1440) = 28.3 gpm / JCT (17)

ENCL (2)

ENCL (2)

BEQ/BOQ (700 AREA) = 195 PERS @ 50 = 9750 gpd
9750 / (1440 x 1 jct) = 6.8 gpm (16)

SHR POP: MIL = 2800
CIV = 300
TOT = 3100 @ 50/3 = 51,670 GPD
51,670 / (1440 x 32 jcts) = 1.1 gpm / JCT

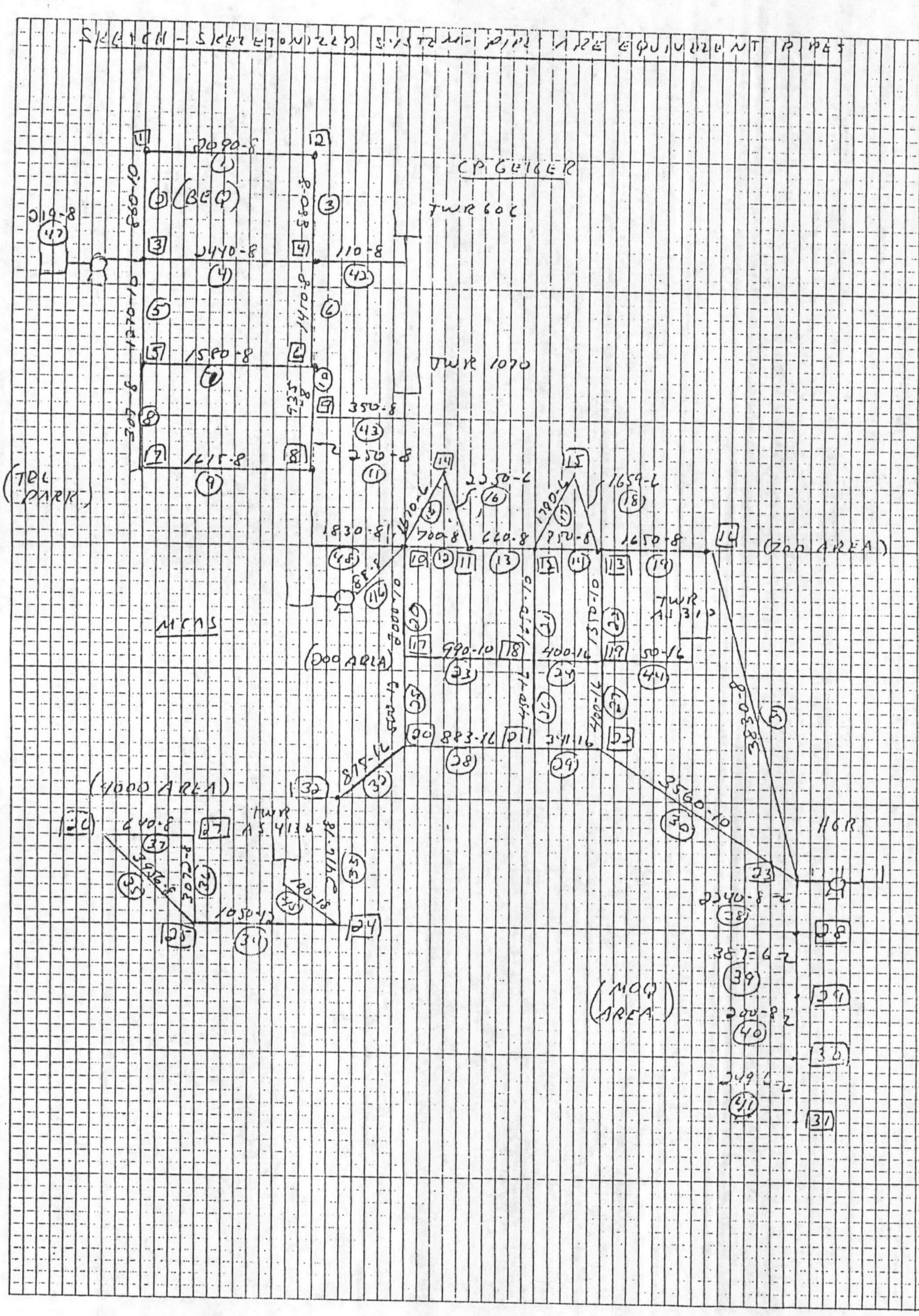
258,920 GPD - MCAS
41,080 GPD - INDUSTRIAL USE
300,000 GPD - TOTAL MCAS
330,000 " - TOTAL CP GEIGER
630,000 GPD - TOTAL EXPECTED USAGE

TOTAL AU DEMAND = 896 K GPD
EXP. CONSUMPTION = 630 K GPD
UNACCOUNTED FOR WATER = 266 K GPD / 1,440 x 32 jcts = 5.8 gpm / JCT

8 HR PERS USAGE
CP GEIGER = 5000 gpd
MCAS = 51670
56670 gpd / (1440 x 32 jcts) = 1.2 gpm / JCT
ALL JCTS = 7.0 gpm / JCT

ENCL (2)

ENCL (2)

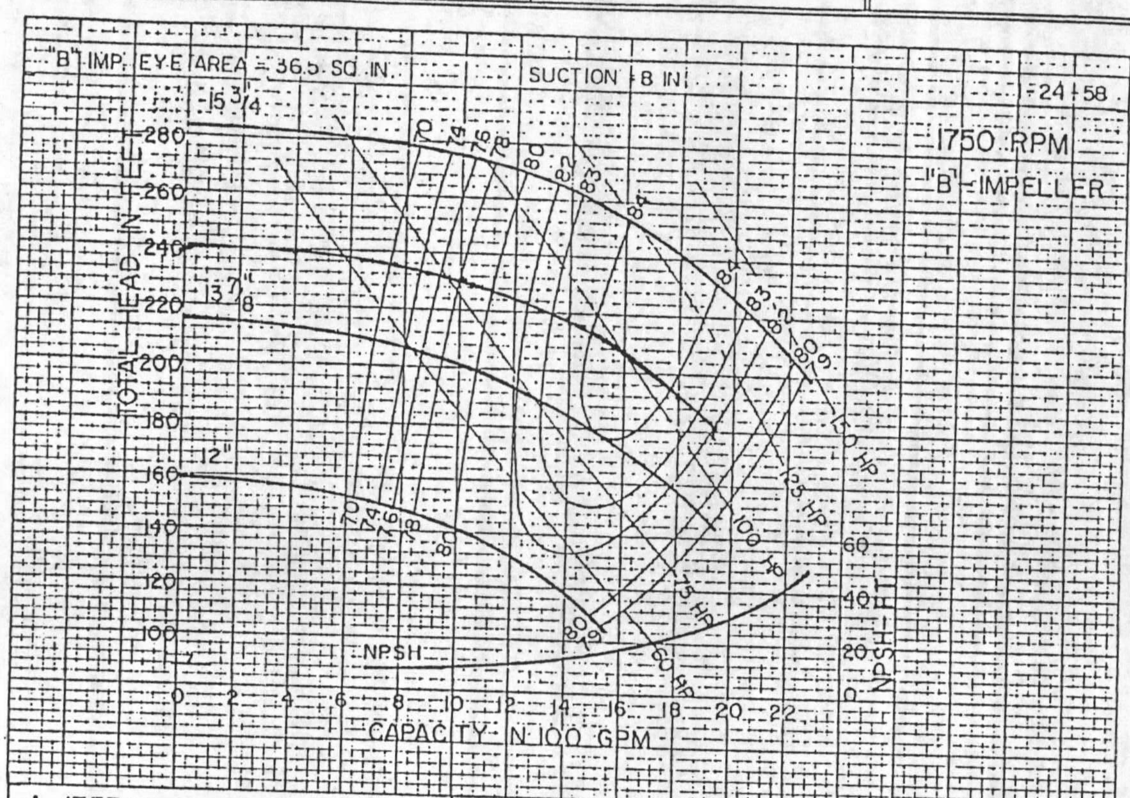

CP GEIGER
TWR 606
TWR 1070
(BEQ)
(TEL PARK)
MCAS
(200 AREA)
(1000 AREA)
(MOQ AREA)
116R

ENCL (3)

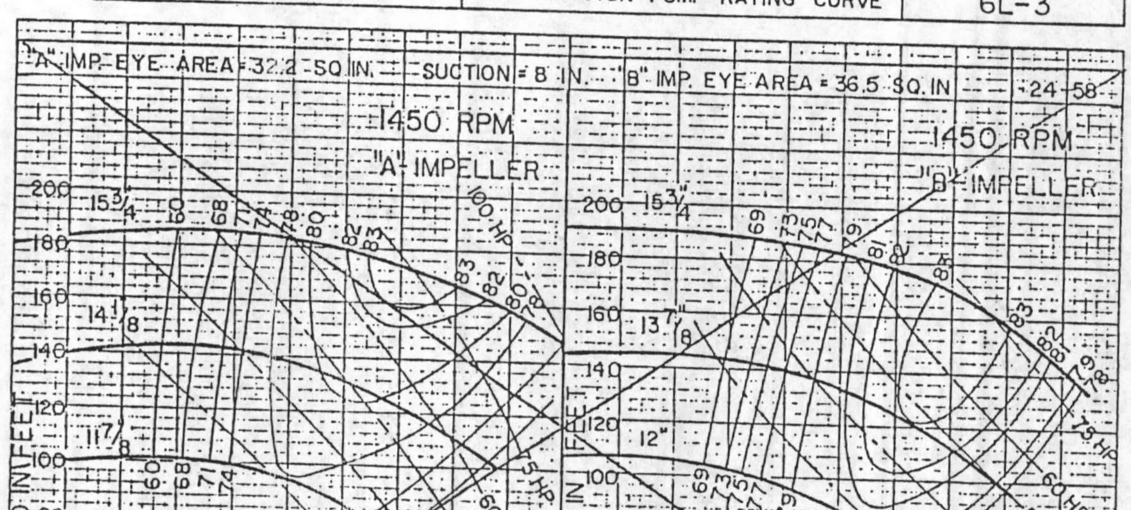
ENCL (3)

RATING CURVES

*MCAS PUMP 51A (LARGE)*




A-1353 SUPERSEDES ER-2306 | WORTHINGTON-PUMP RATING CURVE | 6L-3




A-1352 SUPERSEDES ER-2306 | WORTHINGTON-PUMP RATING CURVE | 6L-3



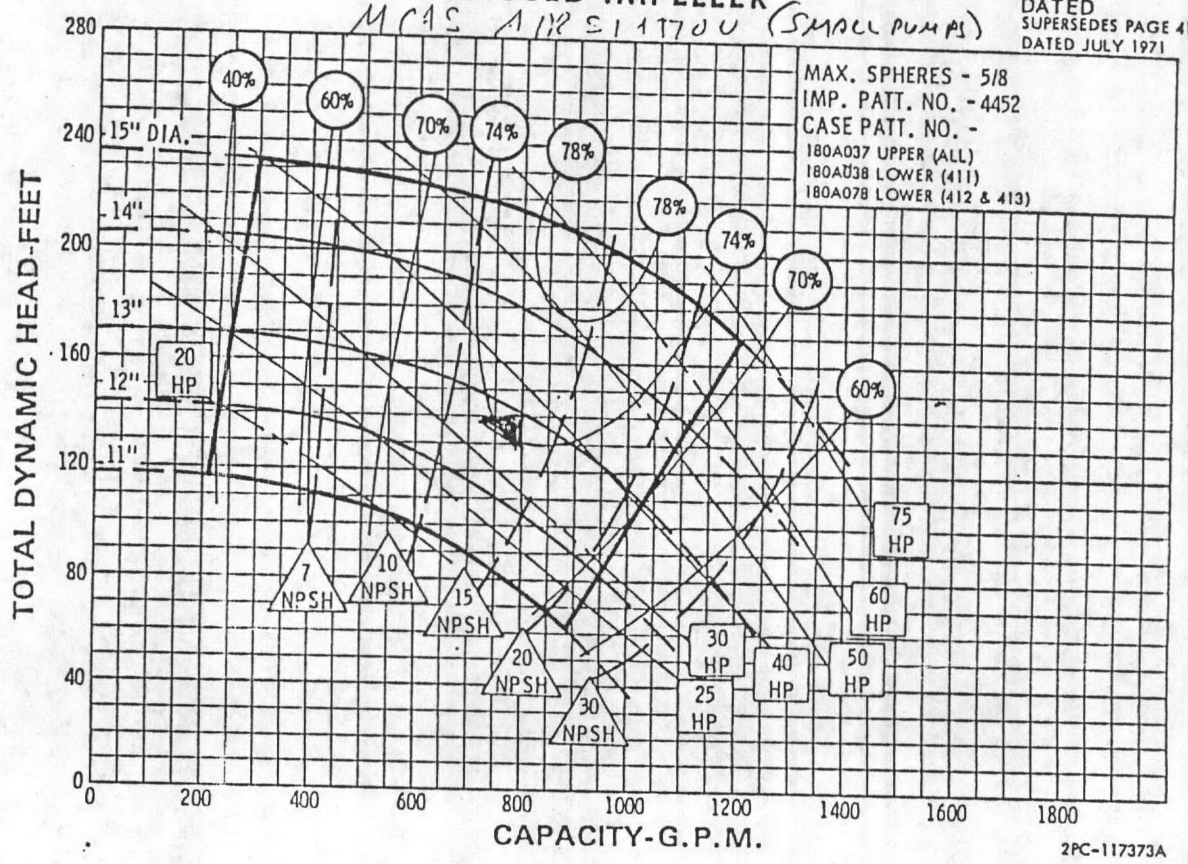
*ENCL (4)*

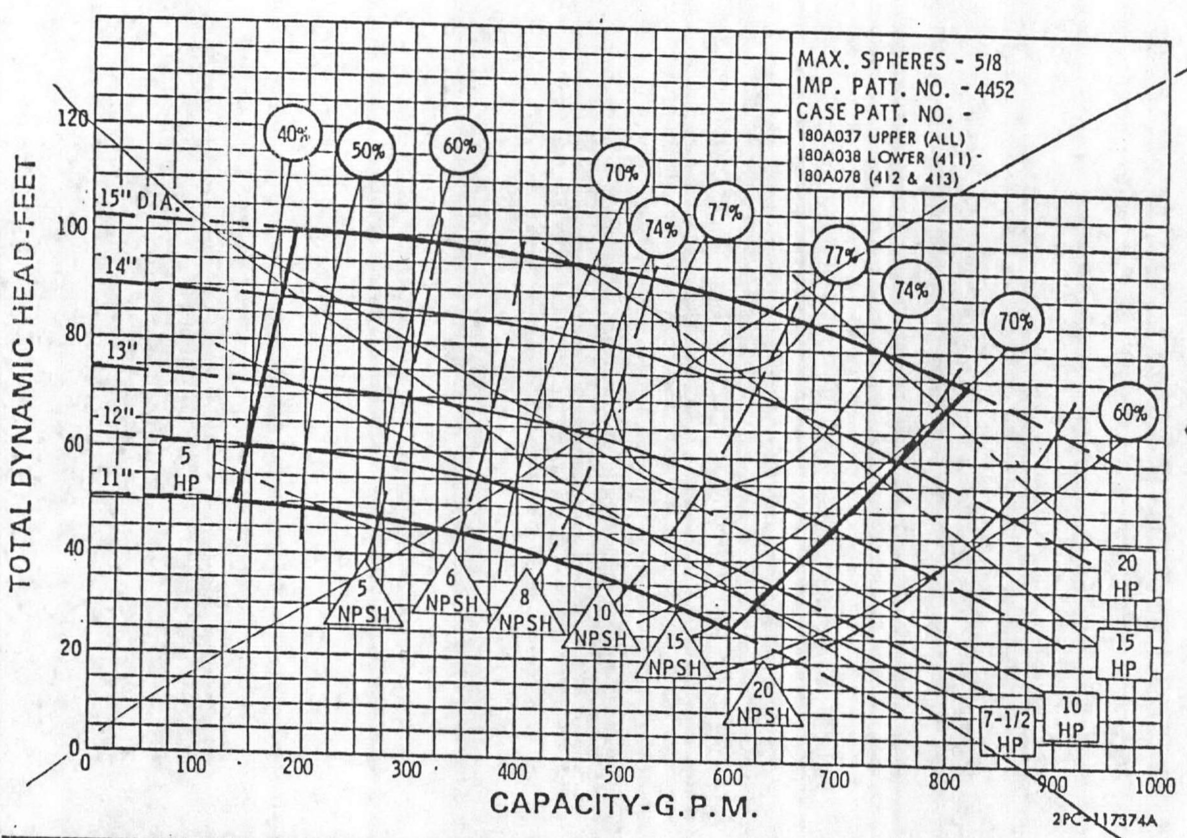
# 4 x 5 x 15 SERIES 410

SECTION 410 PAGE 411
DATED JULY 1976
SUPERSEDES PAGE 411 DATED JULY 1971

## ENCLOSED IMPELLER

(SMALL PUMPS)




AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD • NORTH AURORA, ILLINOIS • 60542

ENCL (4)

CURVES

ENCL (4)

MCAS

TO MODIFY PUMP CURVE

PUMPS 1 & 2 (AURORA PUMPS)

$$H = \frac{10.45 \times 501}{8^{4.87}} \left(\frac{Q}{100}\right)^{1.852} =$$

$$= 4.14 \times 10^{-5} Q^{1.852}$$

| Q | 0 | 800 | 1000 |
|---|---|---|---|
| H | 170 | 140 | 115 |
| ΔH | – | 10 | 15 |
| $H_{MOD}$ | 170 | 130 | 100 |

PUMP # 3 (WORTHINGTON)

$$H = \frac{10.45 \times 460.7}{8^{4.87}} \left(\frac{Q}{100}\right)^{1.852}$$

$$= 3.8 \times 10^{-5} Q^{1.852}$$

| Q | 0 | 1000 | 1900 |
|---|---|---|---|
| H | 215 | 201 | 145 |
| ΔH | – | 14 | 45 |
| $H_{MOD}$ | 215 | 187 | 100 |

ENCL (4)

ENCL (4)

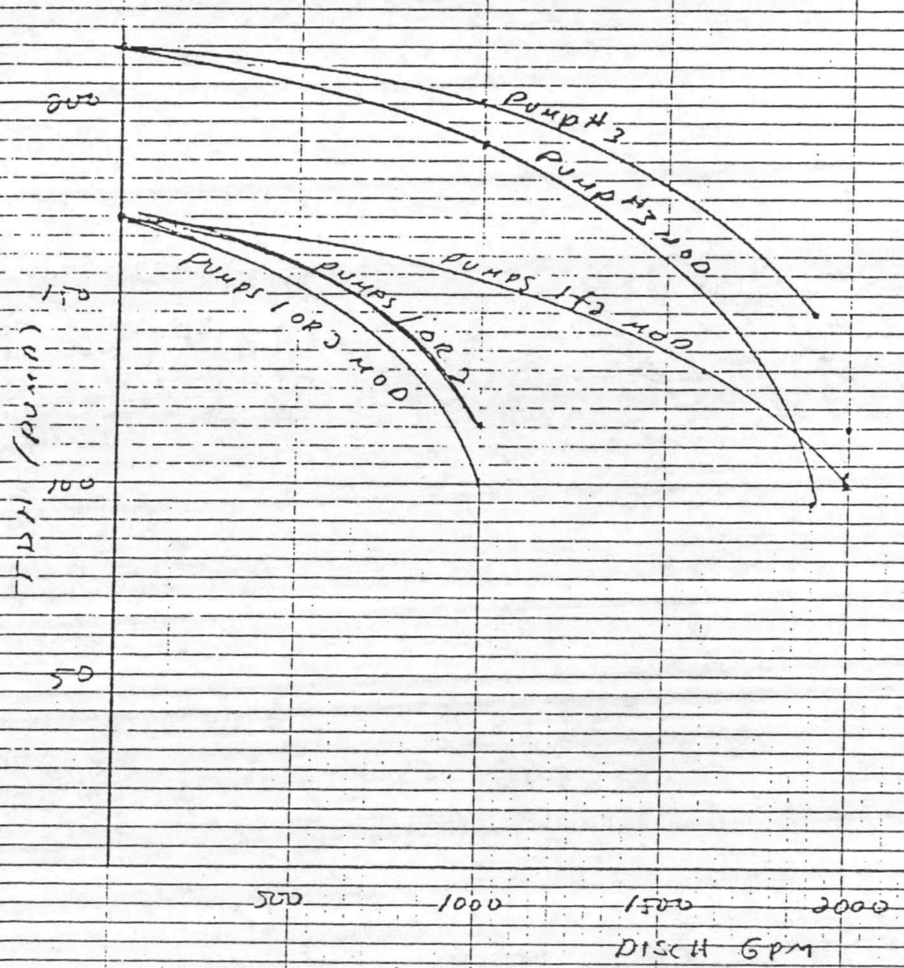
MCAS [illegible] PLANT PUMP CURVE MODIFICATIONS FOR MINOR LOSSES (EXISTING SYSTEM)

EQ 8" FITTINGS FOR PUMPS 1 & 2 CURVE MOD = 501'   $\Delta H = 10.45\,L\,(Q/100)^{1.85} / 8^{4.87}$

EQ 8" " " " 3 " " = 508'

PIPE 145 = 88' - 8" EQ

| | PUMPS # 1 & 2 (AURORA) | | | PUMP # 3 (WORTHINGTON) | | |
|---|---|---|---|---|---|---|
| Q | 0 | 500 | 1000 | 0 | 1000 | 1900 |
| H | 170 | 140 | 115 | 215 | 201 | 145 |
| ΔH | — | 10 | 15 | — | 15 | 50 |
| H MOD | 170 | 130 | 100 | 215 | 189 | 95 |




ENCL (4)

ENCL (4)

MCAS -

NPSH - PUMP #3

WATER @ 100° F = 0.9 LBS/IN² = 2.3' ATM PRESSURE = 14.7 LBS/IN² = 34'

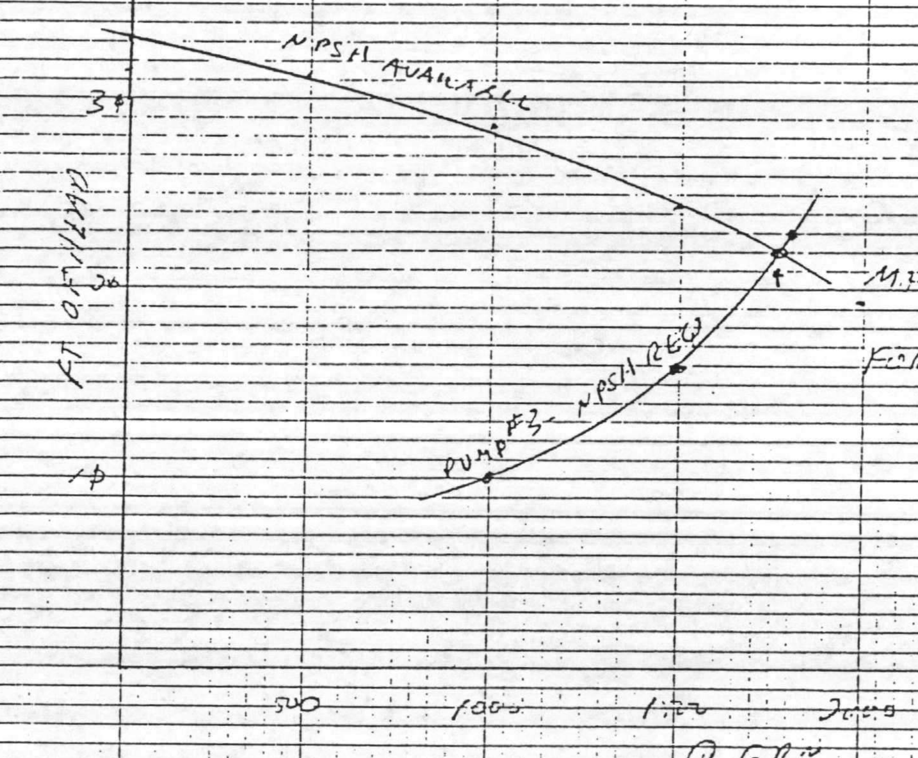
ATM HEAD AVAILABLE @ 100° F = 31.5' AO EL = 31.5

$\Delta H_f = 10.4 \times 113.5 \ (Q/100)^{1.852} / 8^{4.87} =$

| Q | 500 | 1000 | 1500 | 2000 |
| --- | --- | --- | --- | --- |
| $\Delta H_f$ | 0.9 | 3.4 | 7.2 | 12.2 |

NOTE PUMPS 1 AND 2 NOT AS CRITICAL

NPSH REQ IS LESS THAN PUMP #3



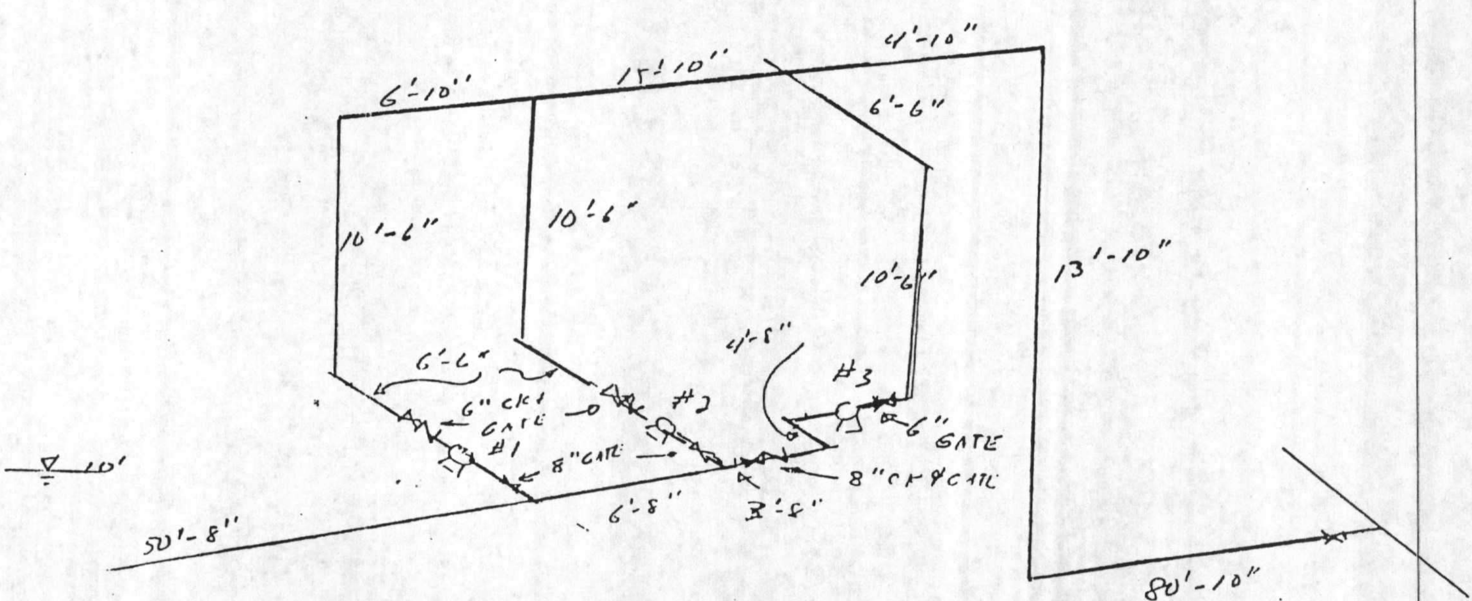

MAX Q ALLOWED - 1760 GPM @ 100° F

FOR S.F., LIMIT Q TO 1500 GPM

ENCL (4)

ENCL (4)

MCAS EXISTING SYSTEM – PIPE (4/6)




INTAKE: = 50'-8"

DISCH = $(8/10)^{4.87}(80+13+4+15)$ = 38'-8" EQ

LINE = 88'-8" EQ

PUMP MINOR LOSSES TO MOD PUMP CURVES

MINOR LOSSES

SUCTION
1-8" TR @ 45
1-8" GATE @ 4.5
48.5'

DISCH
1-6" GATE @ 3.5
1-6" CK @ 40
1-6" 90° EL @ 16
1-6" TR @ 36
6" PIPE 16
TOTAL = 111.5'

$(8/6)^{4.87} \times 111.5 + 48.5$ = 501'-8" EQ

PUMP #2

SUCTION
1-8" CK @ 52
1-8" GATE @ 4.5
2-90° EL'S @ 21 = 42
8" PIPE = 7
105.5'

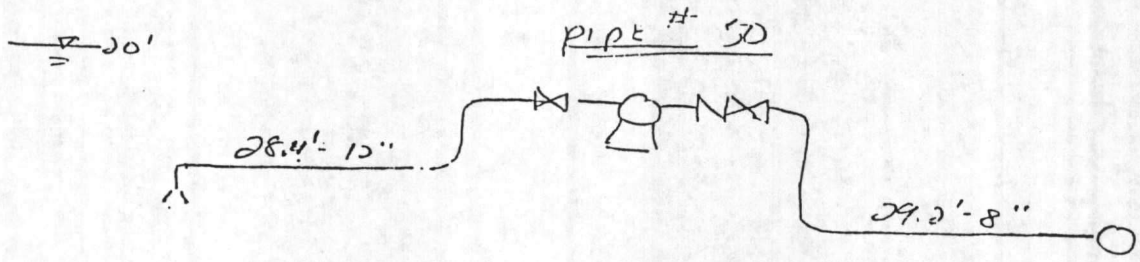
DISCH
1-6" GATE = 3.5
2-6" 90° EL @ 16 = 32
1-6" TR = 36
6" PIPE = 16
87.5'

$(8/6)^{4.87} \times 87.5 + 105.5$ = 460.7'-8" EQ

EWCL (5)

CAMP GEIGER

PIPE # 50




EQUIVALENT 8" PIPE SUCTION

| | | | |
|---|---|---|---|
| 1-12" FOOT VALVE | @ 170 | = | 170 |
| 1-12" GATE " | @ 7 | = | 7 |
| 3-12" 90° ELS | @ 32 | = | 96 |
| 28.4'- 12" PIPE | | = | 28.4 |

$(8/12)^{4.87} \times 301.4' = 42' - 8"$ EQ

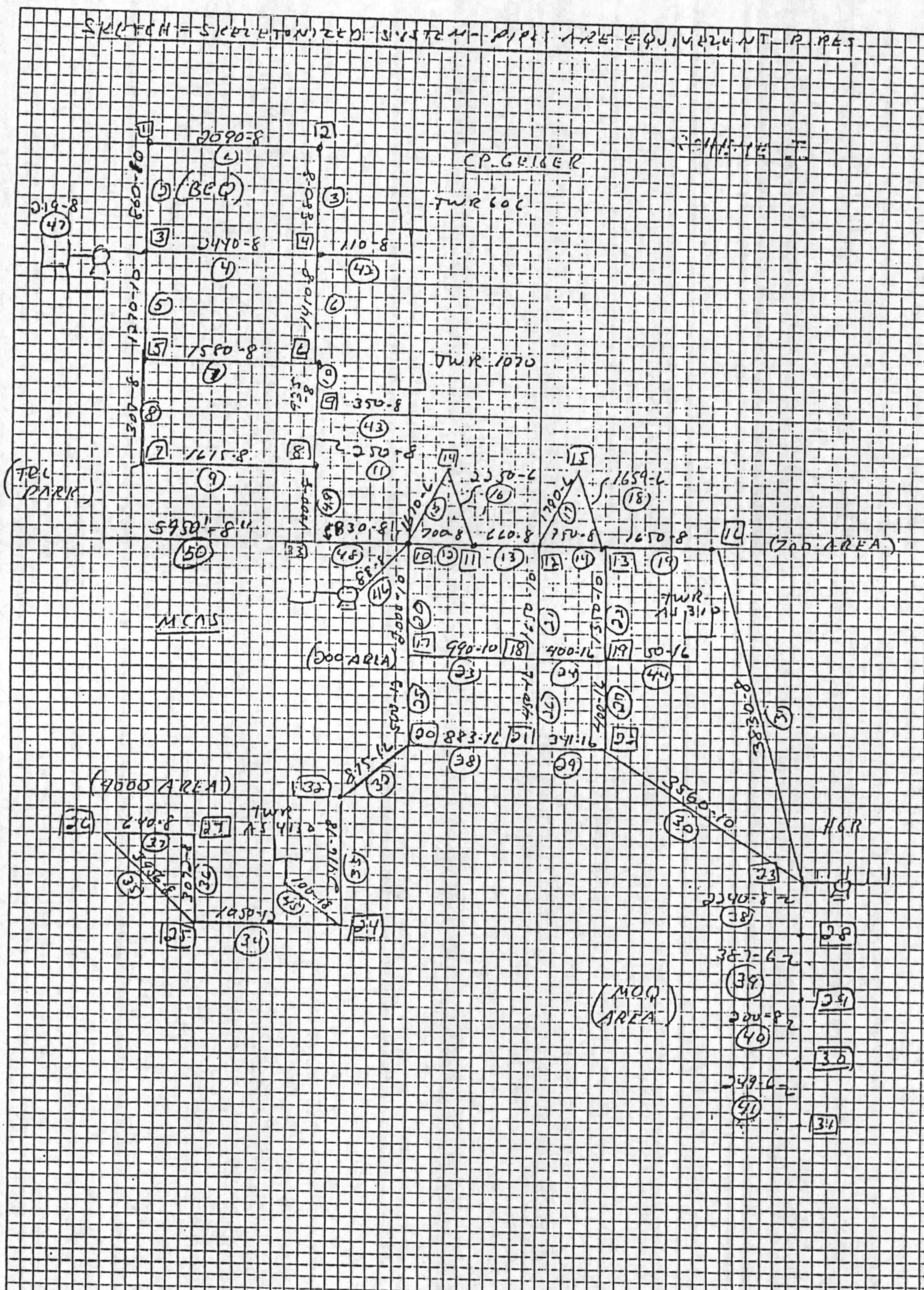
DISCH

| | |
|---|---|
| 1-8" CK @ | 54' |
| 1-8" GATE @ | 4.5 |
| 2-8" 90° ELS @ 22 | 44 |
| 1-8" TEE @ | 45 |
| 29.2'- 8" PIPE | 29.2 |
| | 219' - 8" EQUIV |

FOR 2 PUMPS TOGETHER $(2 \times 219^{-0.54})^{-1.852}$ = 60.6' - 8" EQUIV

5

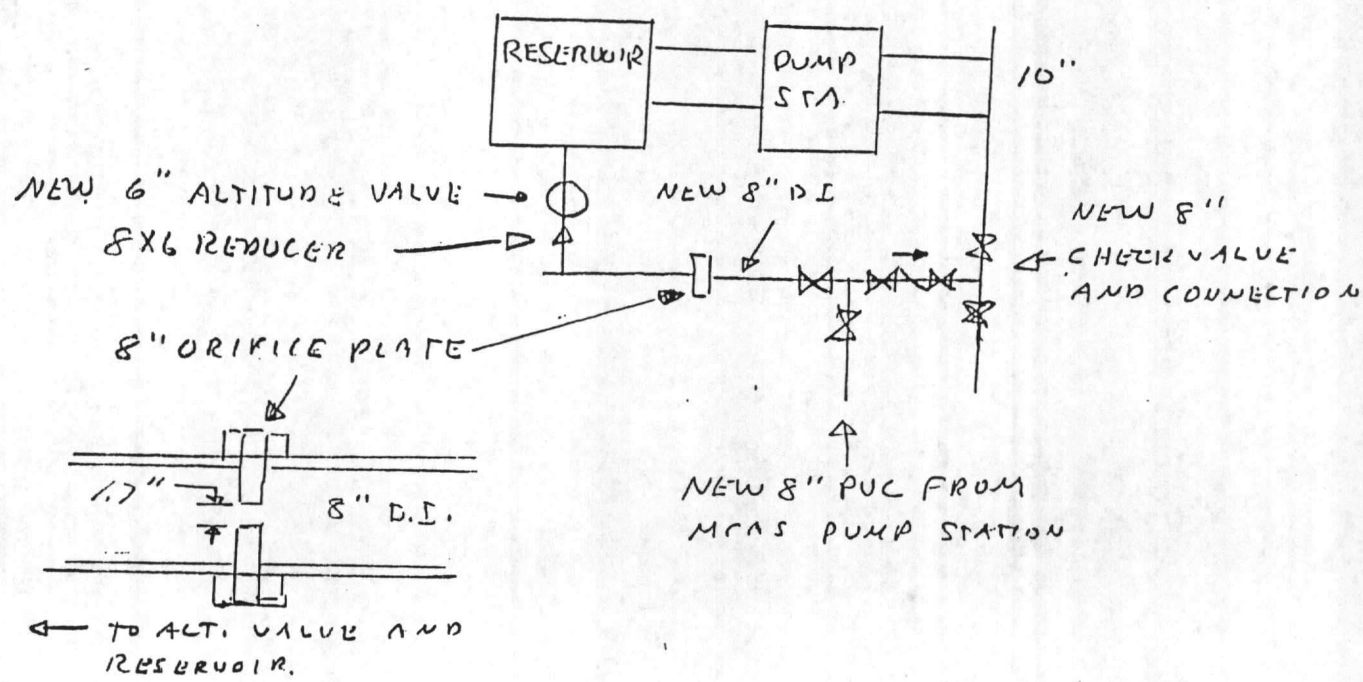
ENCL (5)




ENCL (6a)

ENCL (6a)

NEW 8" PVC CONNECTION TO CAMP GEIGER RESERVOIR

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ORIFICE PLATE FOR RESERVOIR FILLING RATE OF 450 gpm

MAX HEAD WHEN CAMP GEIGER & MCAS PUMPS ARE ON

TDH OF MCAS PUMP @ 1000 gpm (450 gpm TO RES) = 240'

$H_f$ FOR 5120'-8" PVC $= \frac{10.45 \times 5120}{8^{4.87}} \left(\frac{450}{140}\right)^{1.852} =$ 18.6'

221.4'

MCAS RES FULL = 30'
CP GEIGER RES LOW = 10'
+20' → 20.0'

241.4'

ORIFICE SIZE FOR 450 gpm @ ΔH = 241.4'

$$\left(\frac{450}{449}\right) = 0.6 \frac{\pi}{4} \left(\frac{d}{12}\right)^2 \sqrt{64.4 \times 241.4}, \quad d = 1.7"$$

ENCL (6b)

ENCL (6b)

FLOW WHEN PUMPS ARE OFF AND HEAD AT CAMP GEIGER CONNECTION IS CONTROLLED BY LOW W.L. IN TOWER:

TOWER LWL = 158'

CP GEIGER RES HIGH = 30'

128'

FOR ORIFICE = 1.7"

$$\dot{Q} = 449 \times 0.6 \times \frac{\pi}{4}\left(\frac{1.7}{12}\right)^2 \sqrt{64.4 \times 128} = 385 \text{ gpm}$$

OK

---

COMPUTER SPREAD SHEET CHECK FOR ORIFICE CAVITATION

| DEVICE | FLOW CFS | TEMP % FNHT | ID IN | SIZES DL/DS | PU PSI | PD PSI | VEL FPS |
|---|---|---|---|---|---|---|---|
| ORIFIC | 1.00 | 80.00 | 8.00 | 2.67 | 70.00 | 0.00 | 2.86 |

| PVG PSI | SIGMA SYSTEM | " | PVGO PSI | CD PSI | SIG ID ID | PUO PSI | " | PDO PSI |
|---|---|---|---|---|---|---|---|---|
| -12.50 | 0.18 | | -12.20 | 0.03 | 0.07 | 90.00 | | -5.81 |

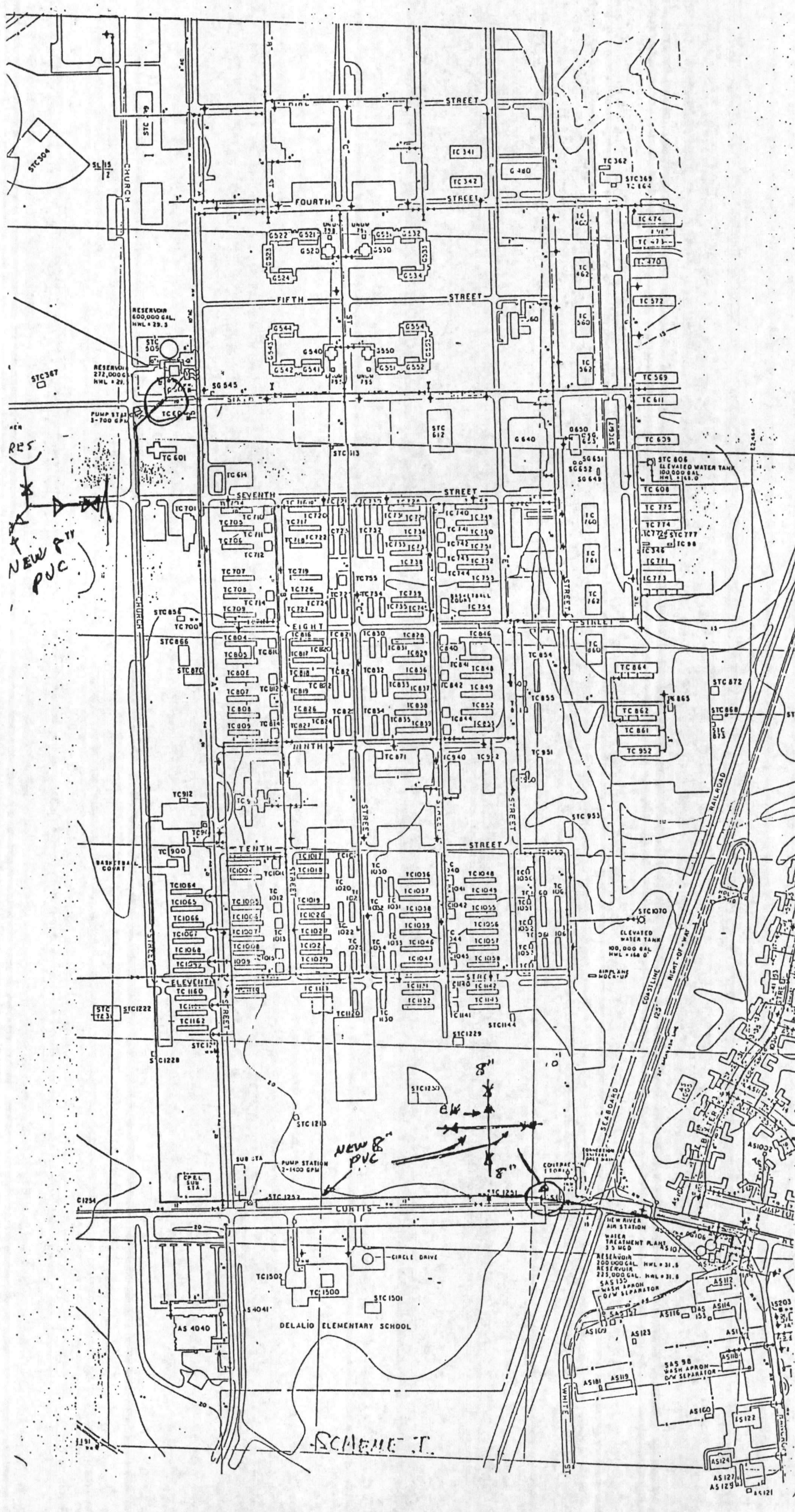
| SSE SSE | X ADJ | PSE EQN | SM-LG SIGMA | LG-SM ADJU | DO/D EQN | DO IN | AO SQ IN |
|---|---|---|---|---|---|---|---|
| 0.95 | 0.19 | 1.14 | 0.08 | 0.07 | 0.26 | 2.05 | 3.29 |

| Q | $\sigma_{SYS}$ | | $\sigma_{TEST}$ | $P_{UP}$ | $P_{DN}$ | NOTES |
|---|---|---|---|---|---|---|
| 1 CFS (449 gpm) | 0.18 | > | 0.08 | 70 psig | 0 psig | OK |

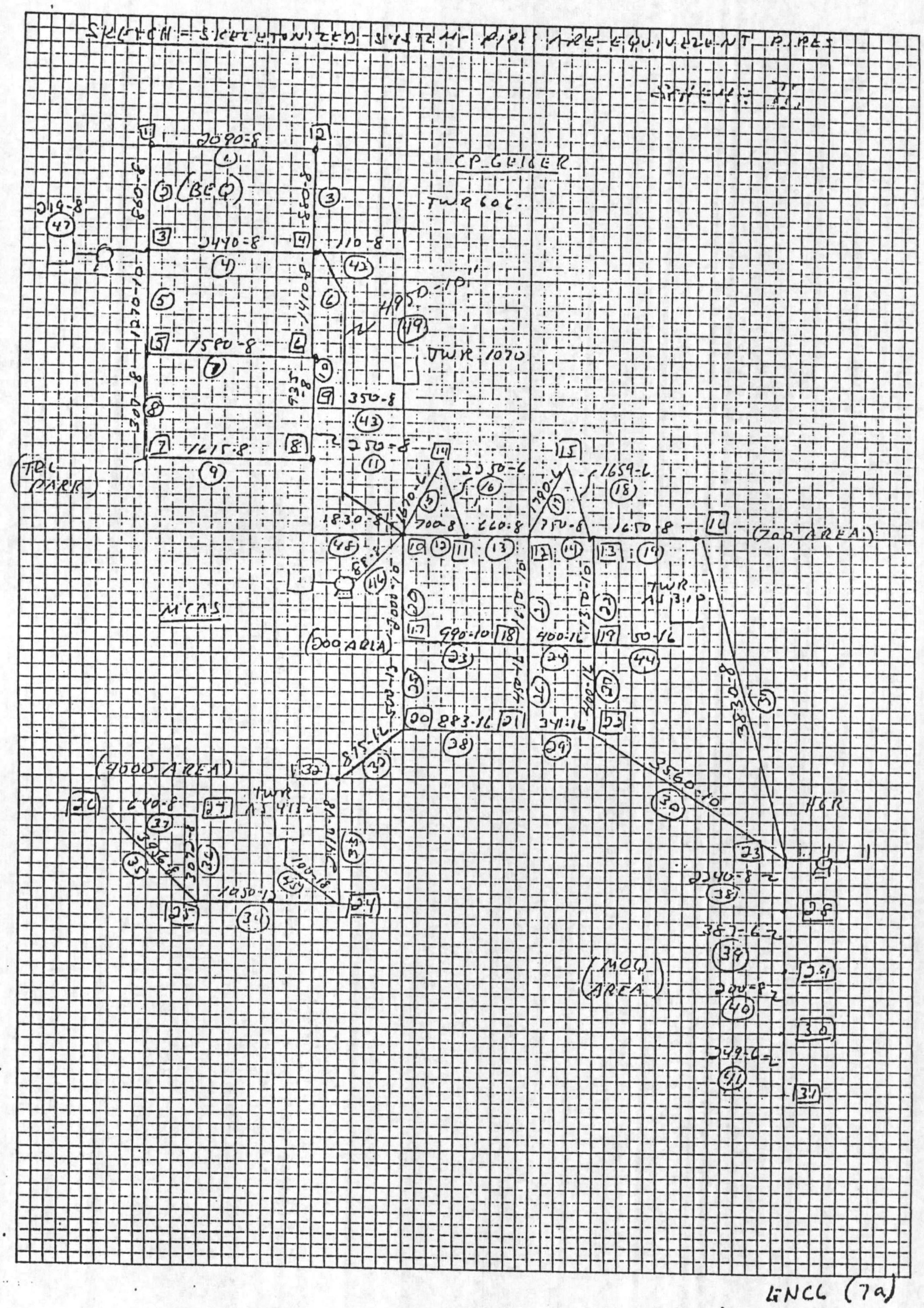
RESERVOIR FILLING TIME

$$\left(\frac{385 + 450}{2}\right) \times 1440 = 6 \text{ MG.}/\text{DAY} \quad \text{OK}$$

ENCL (6b)

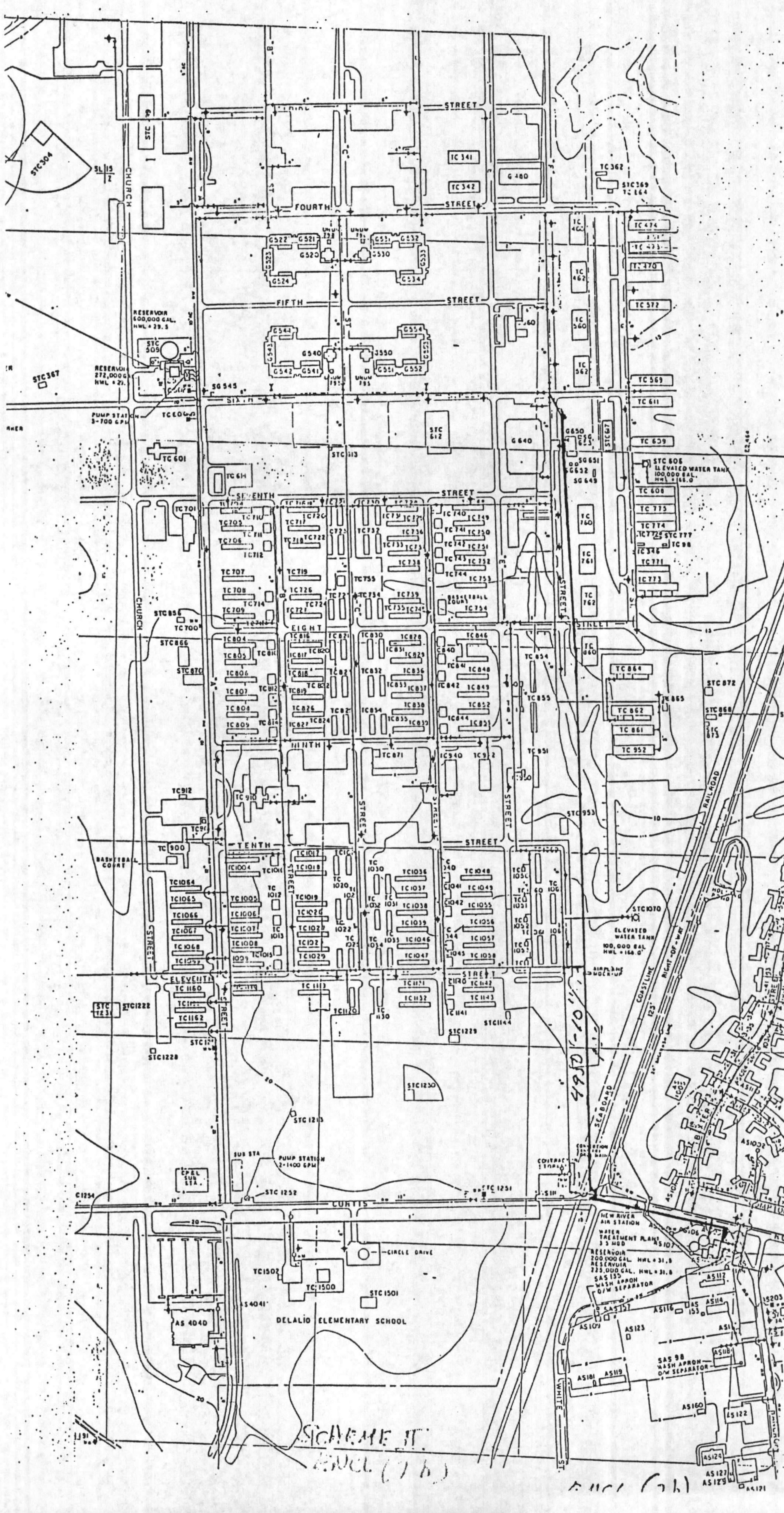

FOURTH STREET
FIFTH STREET
SEVENTH STREET
TENTH STREET
CHURCH STREET
CURTIS
RESERVOIR 600,000 GAL.
ELEVATED WATER TANK
DELALIO ELEMENTARY SCHOOL
NEW RIVER AIR STATION
CIRCLE DRIVE
RAILROAD
NEW 8" PVC
NEW 8" PVC
SCHEME I

ENCL (7)



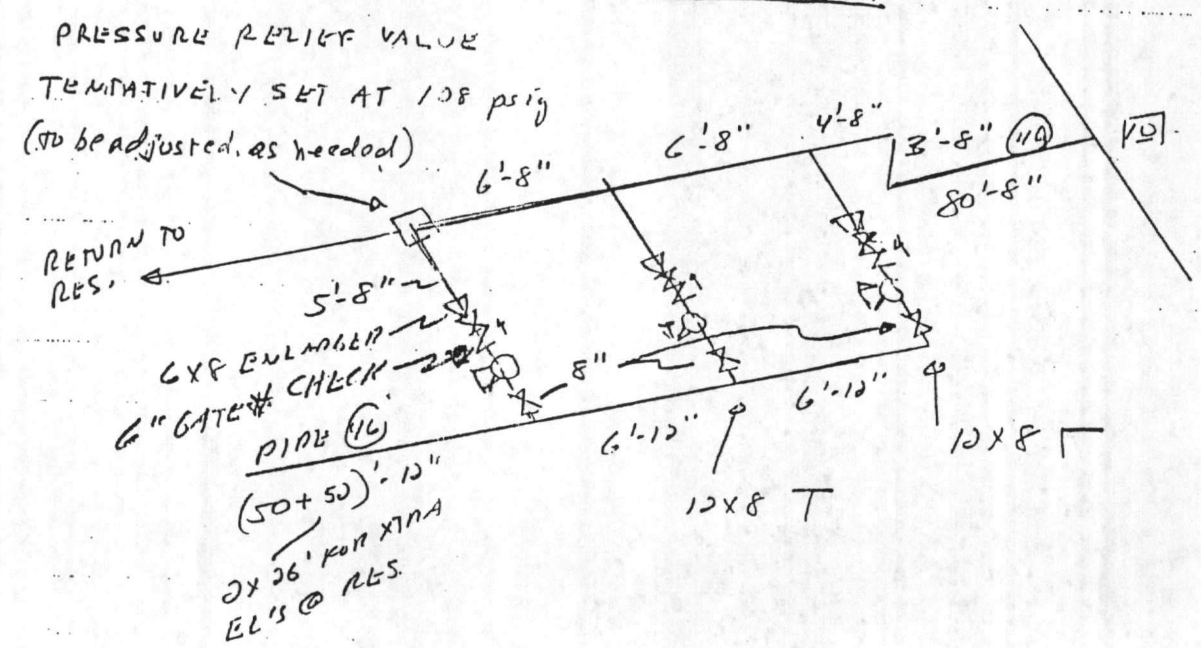

ENCL (7a)

ENCL (7a)



STREET
FOURTH
FIFTH
SIXTH
SEVENTH
EIGHT
NINTH
TENTH
ELEVENTH
CHURCH
CURTIS
RAILROAD
COASTLINE
SEABOARD
WHITE ST
CIRCLE DRIVE
DELALIO ELEMENTARY SCHOOL
RESERVOIR 600,000 GAL.
PUMP STATION
ELEVATED WATER TANK 100,000 GAL.
BASKETBALL COURT
NEW RIVER AIR STATION
WATER TREATMENT PLANT
STC 1230
STC 1252
STC 1251
TC 1500
TC 1502
STC 1501
AS 4040
TC 601
TC 611
G 640
SCHEME II
ENCL (7b)

MODIFICATION OF MCAS PUMP STA




PIPE (46) EQUIV LENGTH (8")

$$(83+3+4+6)'_{(DISCH)} + (8/12)^{4.87}(50+52+6)_{(SUCT)} = 111'-8" \text{ EQUIV}$$

PUMP CURVE MODIFICATIONS

SUCTION 8"

T 12X8 = 44
GATE = 4.5
48.5

DISCH 6"

CK 40
GATE 3.5
$43.5 \left(\frac{8}{6}\right)^{4.87} \longrightarrow = 176.6$

DISCH 8"

T = 44
PIPE = 5
= 176.6
225.6' - 8" EQ

TOTAL 8" EQ = 225.6
48.5
8" EQ 274.1

$$\Delta H = \frac{10.45 \times 274.1}{8^{4.87}} \left(\frac{Q}{120}\right)^{1.852}$$

| Q | 500 | 1000 | 1500 | 2000 | 2500 |
| --- | --- | --- | --- | --- | --- |
| H | 255 | | | | |
| ΔH | 1.6 | 5.8 | 12.3 | 21 | 32 |
| $H_F$ | 253 | 244 | 218 | 185 | 136 |

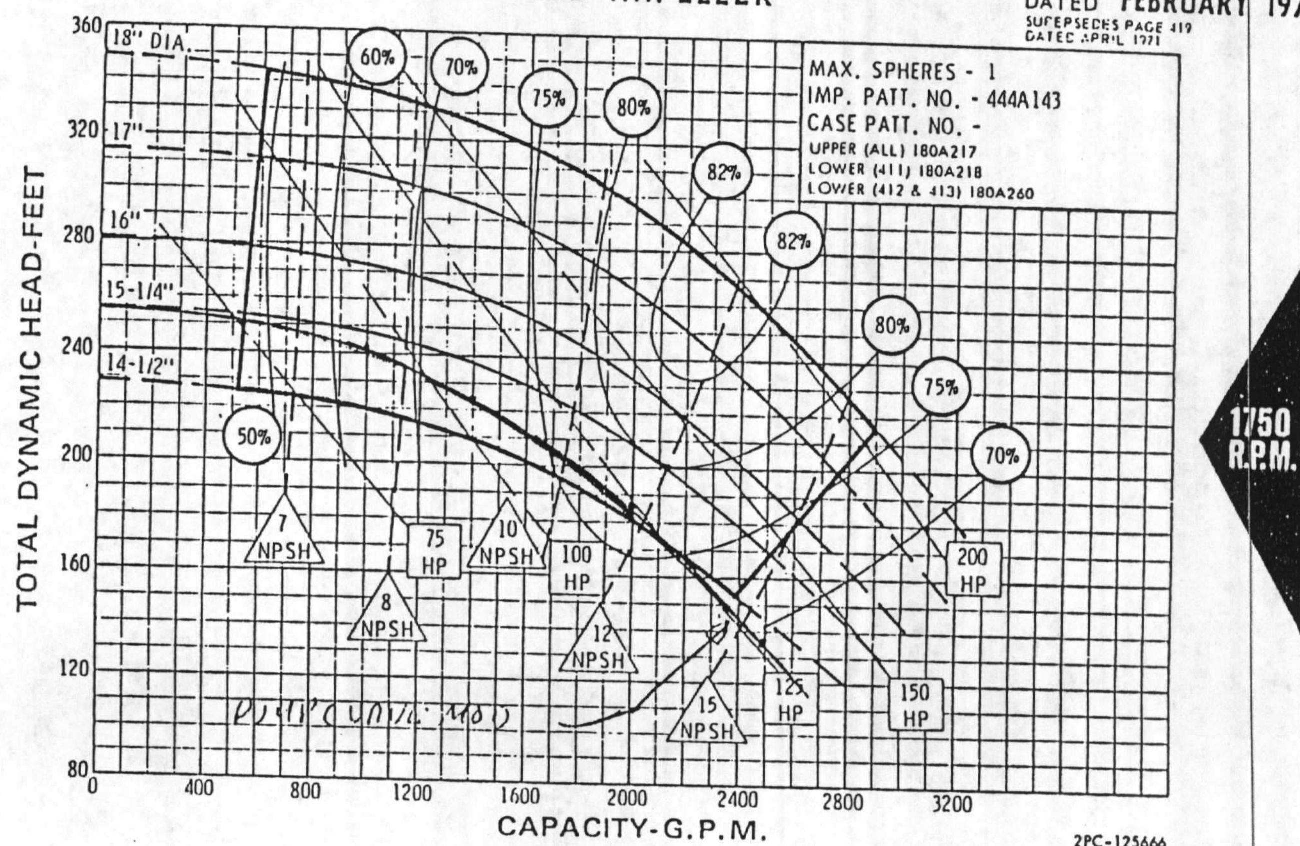
NEW MCAS PUMP

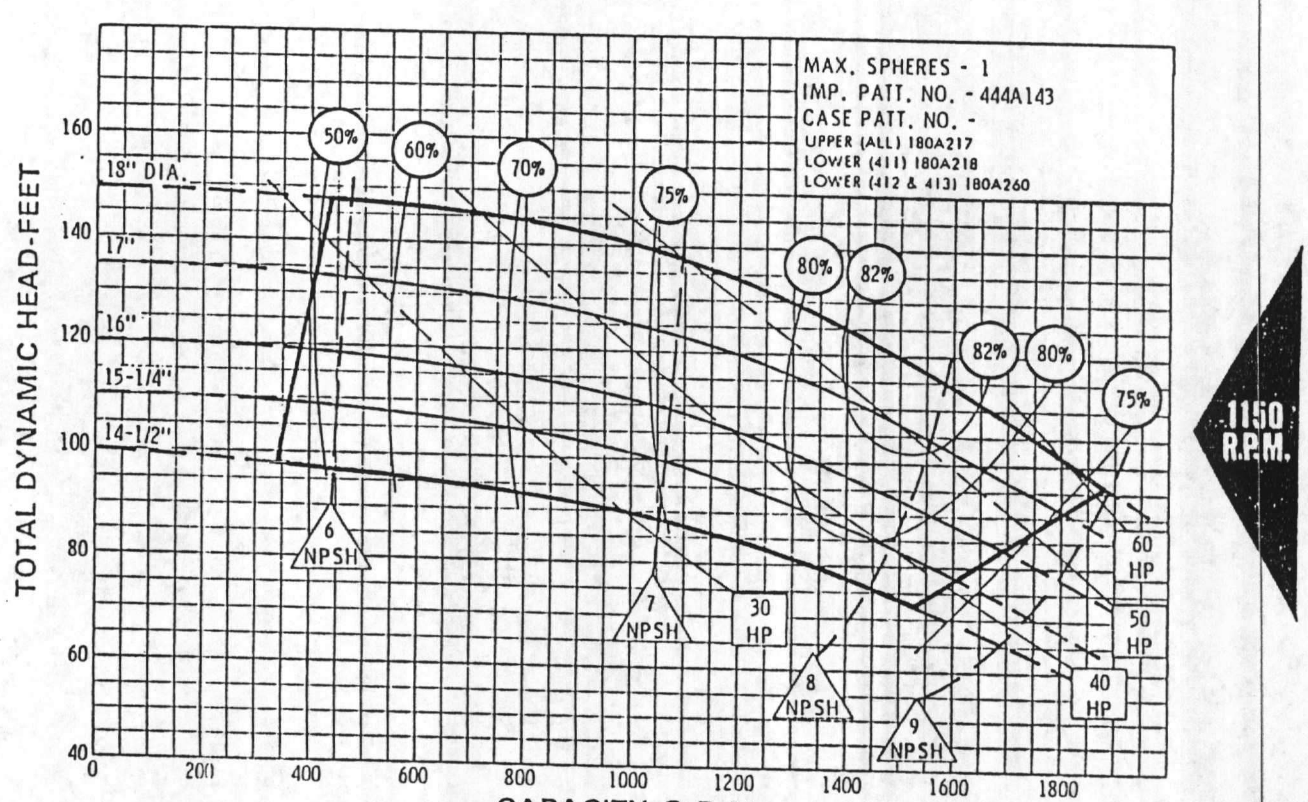
| H | 1000 | 2000 | 2300 |
| --- | --- | --- | --- |
| Q | 244 | 185 | 155 |

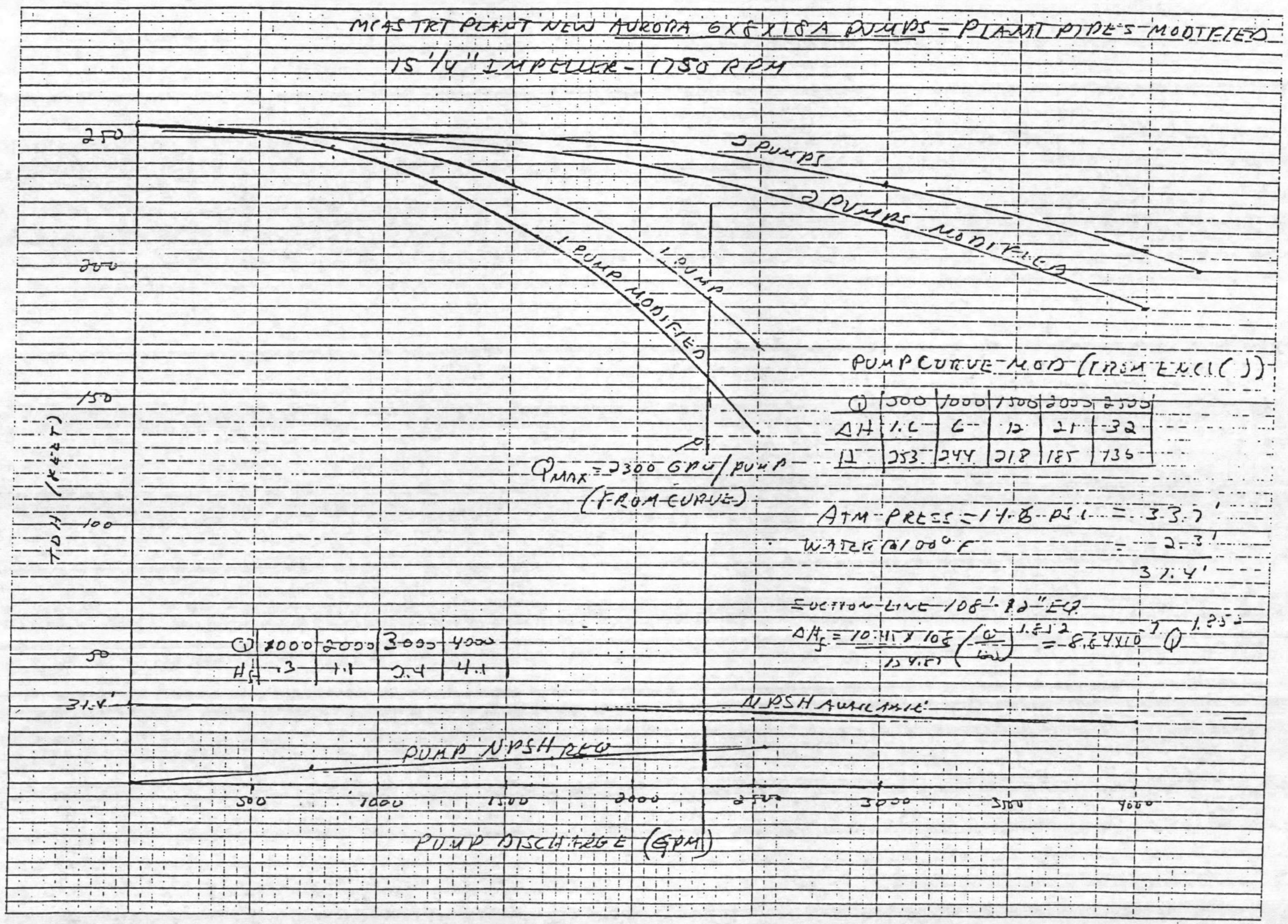
ENCL (8)

ENCL (8)

## ENCLOSED IMPELLER




MCASTRT PLANT NEW AURORA 6X8X18A PUMPS - PLANT PIPES MODIFIED
15 1/4" IMPELLER - 1750 RPM
2 PUMPS
2 PUMPS MODIFIED
1 PUMP
1 PUMP MODIFIED
250
200
150
100
50
31.4'
TDH (FEET)
QMAX = 2300 GPM/PUMP
(FROM CURVE)
PUMP CURVE MOD (FROM ENCL ( ))
Q 500 1000 1500 2000 2500
ΔH 1.6 6 12 21 32
H 253 244 218 185 135
ATM PRESS = 14.6 PSI = 33.7'
WATER @ 100° F = 2.3'
31.4'
SUCTION LINE 108' 12" EQ
ΔHf = 10.41 X 108 / 12^4.87 (Q/C)^1.852 = 8.64 X 10^-7 Q^1.852
Q 1000 2000 3000 4000
Hf .3 1.1 2.4 4.1
NPSH AVAILABLE
PUMP NPSH REQ
500
1000
1500
2000
2500
3000
3500
4000
PUMP DISCHARGE (GPM)

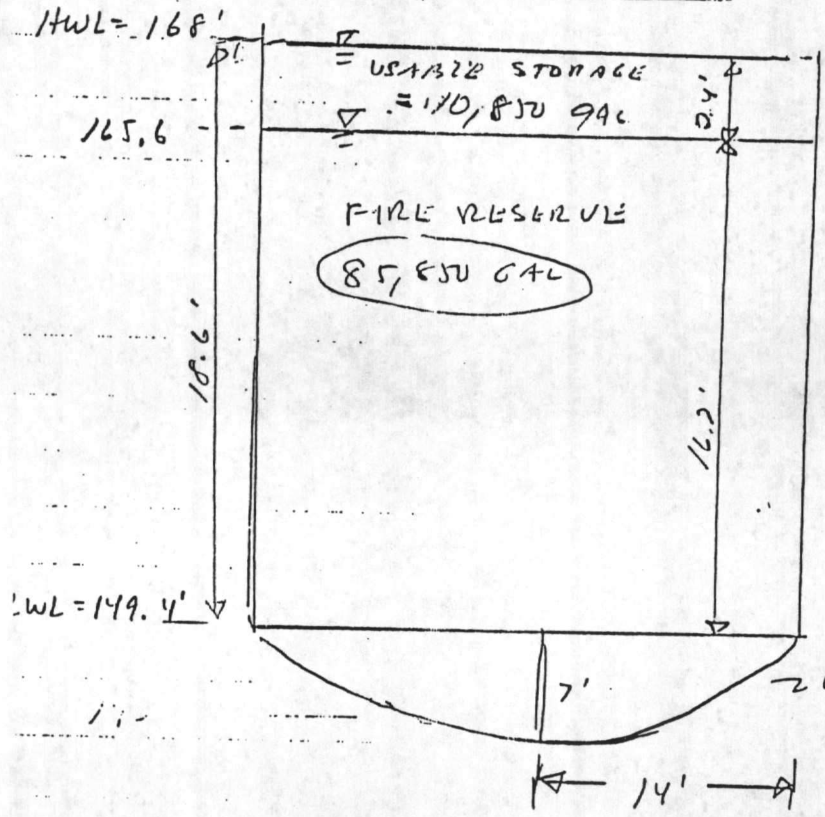
ENCL (9)

## FIRE RESERVE - CAMP GEIGER

REQ: 1500 GPM FOR 100 MIN = 150,000 GAL

FOR 2 EL TWRS = 75000 GAL / TWR

TWRS 606 + 1070




USABLE VOL = 300,000
− 14,150
85,850 GAL

$85,850 = \pi(14)^2(7.5)h$

$h = 18.6'$

LWL = 168 − 18.6 = 149.4'

FIRE RESERVE = $\frac{75000}{85850} \times 18.6 = 16.2'$

DISTRIBUTION STORAGE = 85,850 − 75000

VOL = $1.1 \times 7^2 (3 \times 14 - 7) \times 7.5 = 14,150$ GAL

USABLE STORAGE = 85850 − 75000 = 10,850 GAL

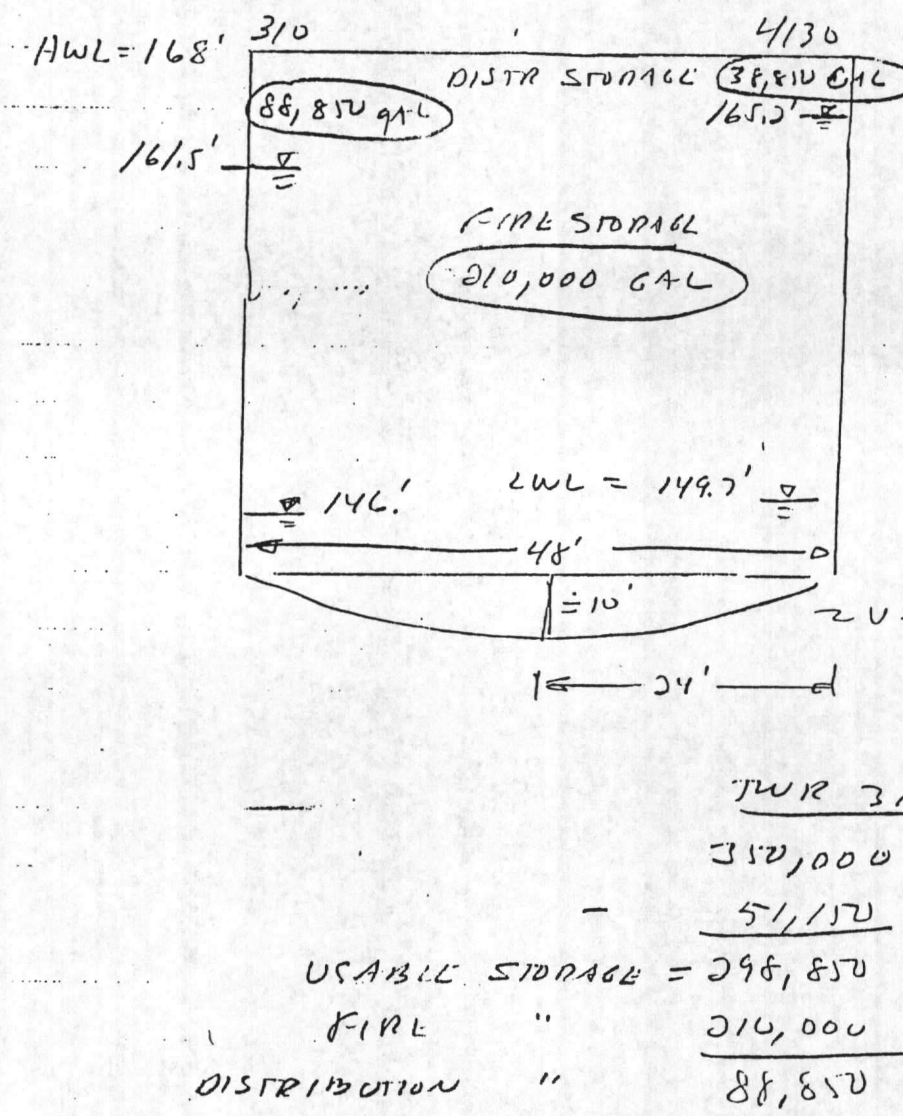
NOT ENOUGH, GND STORAGE IS STILL REQ.



ENCL (10)

MCAS –

REQ - 7000 GPM - 60 MIN = 420,000 GAL
FOR 2 EL TWRS = 210,000 GAL / TWR




FIRE STORAGE

$210000 = \pi(24)^2(h)(7.5)$

$\therefore h = 15.5'$

$\approx V \doteq 1.1 \times 10^2 (3 \times 24 - 10) \times 7.5 = 51,150$ gal

| | TWR 310 | TWR 4130 |
|---|---|---|
| | 350,000 gal | 300,000 GAL |
| – | 51,150 | – 51,150 |
| USABLE STORAGE = | 298,850 gal | 248,850 gal |
| FIRE " | 210,000 | 210,000 |
| DISTRIBUTION " | 88,850 gal | 38,850 gal |
| TOTAL " " | 127,700 ok | |

DISTRIBUTION height: $88,850 = \pi(24)^2 h(7.5)$, $h = 6.5'$
$38,810 = \pi(24)^2 h(7.5)$ $h = 2.8'$

19

ENCL (10)

EXCERPT FROM 1983 LANTDIV FIRE PROTECTION SURVEY FOR MCAS NEW RIVER

WATERFLOW TEST DATA

| LOCATION | MEASUREMENTS: STATIC PSI | RESIDUAL PSI | FLOW GPM | AVAILABLE GPM @ 20 PSI | REQUIRED GPM @ PSI |
|---|---|---|---|---|---|
| New Exchange | 70 | 50 | 965 | 1600 | 1100 @ 20 |
| Vehicle Shop 4157 | 62 | 60 | 1230 | 6000 | 1250 @ 20 |
| MOQ Area | 63 | 12 | 200 | 180 * | 500 @ 20 |
| Warehouse 3525 | 60 | 12 | 150 | 135 * | 1800 @ 40 |
| Hangar 840 | 64 | 10 | 380 | 340 | 2500 @ 20 |
| O-Club | 70 | 20 | 630 | 630 * | 1000 @ 20 |

* These areas depend upon the two 750 GPM @ 85 PSI booster pumps in Building 2003 to provide the required pressure and volume. Only one of the two pumps is operational and this pump is set on "manual" rather than automatic. Tests were conducted on the basis of "normal" conditions.

8. ENGINEERING RECOMMENDATIONS

a. Priority:

These recommendations involve major life safety hazards or conditions which could severely impact on the activity's ability to accomplish vital missions, and are those for which attention and resources should be directed.



ENCL (11a)

ENCL (11 a)

EXCERPT FROM 1985 LANTDIV FIRE PROTECTION SURVEY FOR CAMP GEIGER

7. WATER SUPPLY SYSTEM

a. Description: The water supply for fire protection and domestic use is furnished through a single 8-inch main from the adjoining Marine Corps Air Station New River Water Treatment Plant. The water is delivered under sufficient pressure to maintain 600,000-gallon and 272,000-gallon concrete reservoirs located at Camp Geiger. From these reservoirs two 700 GPM automatic electric pumps and one 900 GPM manual-start pump take suction and pump into the distribution system and two 100,000-gallon elevated tanks. The water supply and distribution system is adequate.

WATERFLOW TEST DATA

| LOCATION | MEASUREMENTS: STATIC PSI | RESIDUAL PSI | FLOW GPM | AVAILABLE GPM @ 20 PSI | REQUIRED GPM @ 20 PSI |
|---|---|---|---|---|---|
| Bldg. TC-910 "A" St. and 10th St. Hydrant #6-72-8 | 63 | 31 | 1500 | 1770 | 1500 |
| Bldg. TC-1047 11th St. Hydrant #6-78-8 | 65 | 56 | 1180 | 2745 | 1000 |

NOTE: Three main breaks occurred during the water flow test, therefore no additional tests were made during this survey. The water supply is considered adequate in all of the areas of Camp Geiger, but the condition of the mains is questionable as evidenced from this experience.



ENCL (11b)

ENCL (11b)

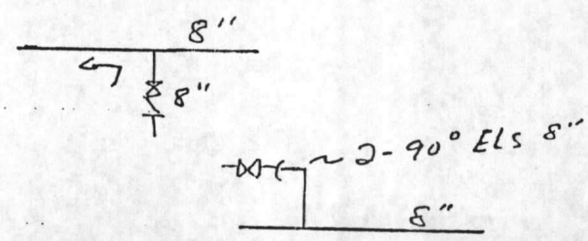
MOQ PUMP HOUSE (AS 0003.)

FOR FIRE PROTECTION

2- FAIRBANKS MORSE FIRE PUMPS :

750 gpm @ 85 psig (TDH)

PUMP STATION




| SUCTION | | DISCH | |
|---|---|---|---|
| 1-GATE | = 5 | 1-GATE | = 5 |
| 2-90° EL@ 21 | = 42 | 1-CHECK | = 52 |
| 1-TEE | = 45 | 1-TEE | = 45 |
| 8" PIPE | = 5 | 8" PIPE | = 3 |
| | 97 | | 105' |

PUMP CURVE MODIFICATIONS

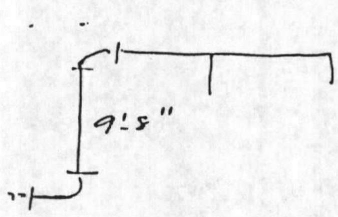
$$\Delta p = \frac{4.52 \times (97 + 105)}{8^{4.87}} \left(\frac{Q}{110}\right) = 6.05 \times 10^{-6} Q^{1.852}$$

| Q | 400 | 800 | 1200 |
|---|---|---|---|
| Δp | 0.4 | 1.4 | 3 |

PUMP STATION MINOR LOSSES

SUCTION

8" PIPE = 200'




DISCH

2- 90° L'S @ 21 = 42

8" PIPE = 20

62'

ASSUME RESERVOIR WL = 10' /2.31 = 4.3 psig

$$\Delta p = \frac{4.52 \times (200 + 62)}{8^{4.87}} \left(\frac{Q}{110}\right)^{1.852} - 4.3 = 7.8 \times 10^{-6} Q^{1.852}$$

ENCL (12a)

ENCL (12a)

MOQ PUMP HOUSE (AS2003)

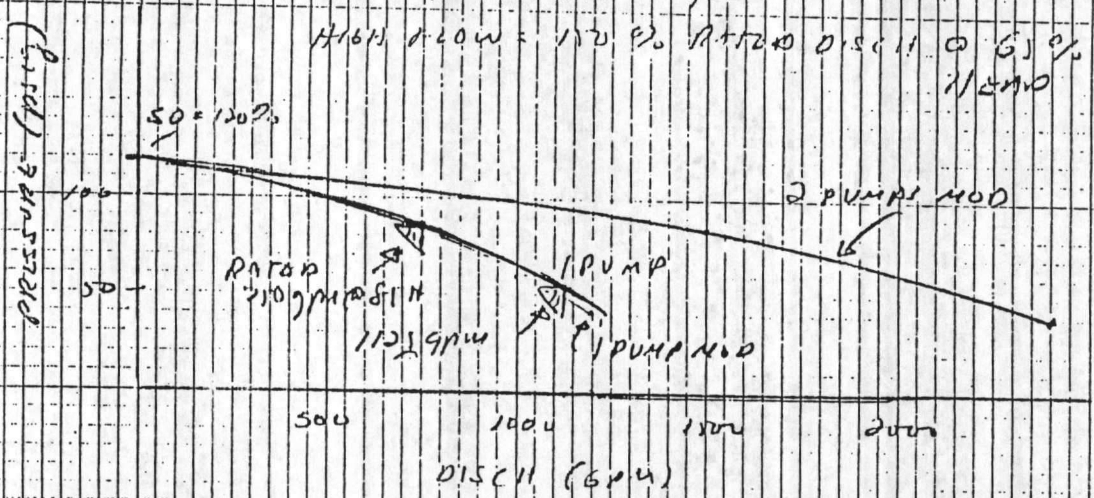
FIRE PUMPS - 2 - FAIRBANKS MORSE - 750 GPM @ 85 LBS

THE CURVES WERE NOT AVAILABLE -

TYPICAL FIRE PUMP CURVE BELOW USED

S.O = 120% RATED HEAD

HIGH FLOW = 150% RATED DISCH @ 65% RATED HEAD






ENCL (12b)

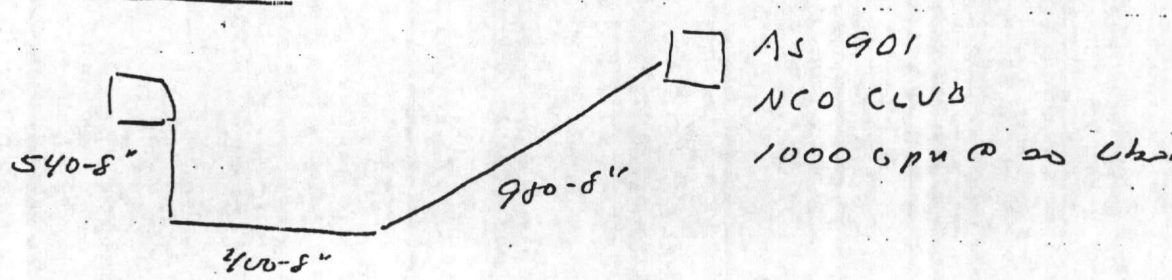
ENCL (12b)

## FIRE PROTECTION IMPROVEMENTS FOR CERTAIN AREAS

### AS 901 AREA (NCO CLUB)

REQ. 1000 GPM @ 20 PSIG

PSAS 2003




- PIPE L = 540 + 400 + 980 = 1920' - 8"

$$\Delta p = \frac{4.52 \times 1920}{84.87} \left(\frac{1000}{100}\right)^{1.852} = 24.7 \text{ Lbs}$$

RESID = 20 Lbs

1000 gpm @ 44.7 Lbs REQ.

FROM ENCL (12), 1000 GPM @ 65 Lbs AVAILABLE FROM ONE EXISTING FIRE PUMP

RESID AT NCO CLUB = 65 - 24.7 = 40.3 PSIG > 20 OK

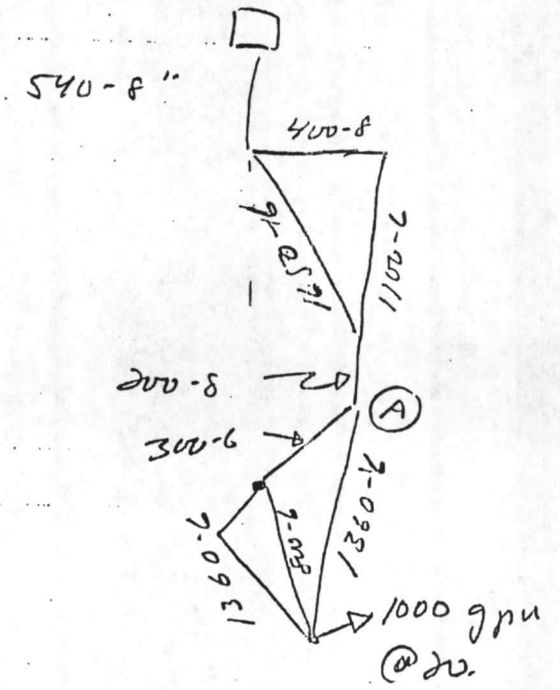
ENCL (13)

ENCL (13)

OFFICERS HOUSING (MOQ)

REQ. 1000 GPM @ 20 psig.

PS AS 2003




EQUIV 6" (PS) TO (A)

$$\left(\frac{6}{8}\right)^{4.87} \times 540 + \left\{ \left[ \left(\frac{6}{8}\right)^{4.87} \times 400 + 1100 \right]^{-.54} + \left[1650\right]^{-.54} \right\}^{-1.852} + \left(\frac{6}{8}\right)^{4.87} \times 200$$

$$= 133 + 387 + 49 = \quad 569'$$

(A) TO (DISCH)

$$\left\{ \left[ \left(800^{-.54} + 1350^{-.54}\right)^{-1.852} + 300 \right]^{-.54} + \left[1360\right]^{-.54} \right\}^{-1.852} = \quad 235'$$

804'-6" EQ

$$\Delta p = \frac{4.52 \times 804}{6^{4.87}} \left(\frac{1000}{100}\right)^{1.852} = 42 \text{ Lbs}$$

RESID = 20 Lbs

PUMP REQ = 1100 gpm @ 62 Lbs

FROM ENCL (12), 1100 GPM @ 96 Lbs IS AVAILABLE FROM 2 EXISTING FIRE PUMPS.

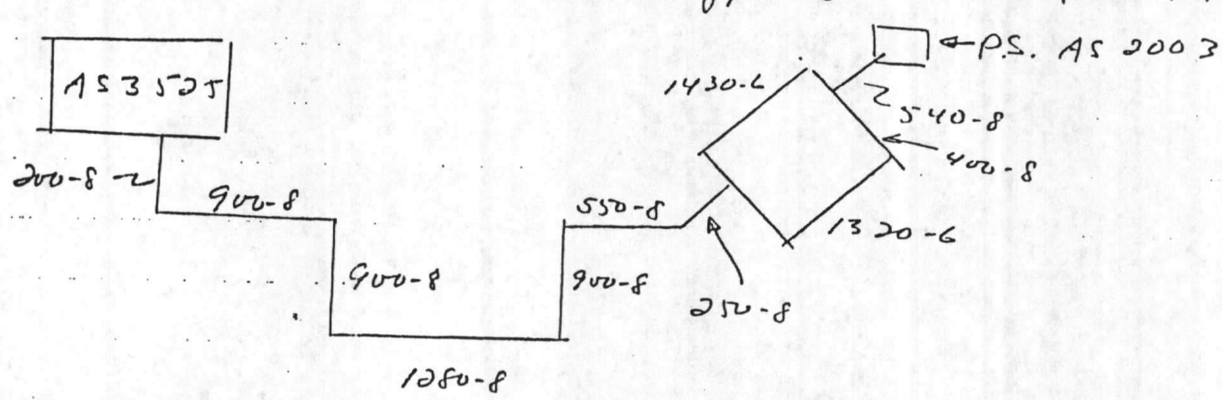
RESID AVAILABLE AT END OF HSG = 96 - 42 = 54 > 20 OK

ENCL (14)

ENCL (14)

WAREHOUSE AS 3525

SPRINKLER REQ. = 1800 gpm @ 40 Lbs (XTRA HAZARD)




EQUIVALENT 8" PS AS 2003 TO WHSE AS3525

$$\left\{\left[\left(\frac{8}{6}\right)^{4.87} \times 1430\right]^{-.54} + \left[400 + \left(\frac{8}{6}\right)^{4.87} \times 1320\right]^{-.54}\right\}^{-1.852} + 250 + 550 + 900 + 1080 + 900 + 900 + 200 + 540$$

= 7123'-8" EQUIV

$$\Delta H = \frac{10.45 \times 7123}{8^{4.87}}\left(\frac{1800}{120}\right)^{1.852} = 448'' \; (194 \text{ psig})$$

CI IRON PIPE

TOO HIGH - NEED STORAGE + PUMP STATION AT WAREHOUSE LOCATION

Q REQ FOR XTRA HAZARD = 0.3 X 3000 + 750 = 1800 GPM
FOR 105 MIN

× 105

189,000 GAL

USE 0.2 MG GND RESERVOIR

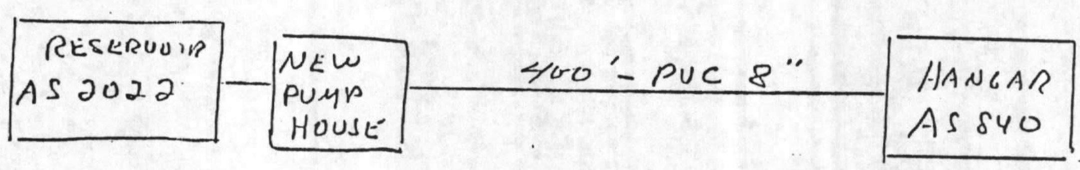
SELECT PUMP TO DELIVER AT LEAST 1800 gpm @ 40 Lbs

ENCL (15)

ENCL (15)

HANGAR AS 840

REQ - 3500 GPM @ 125 Lbs




SAY PRESSURE LOSS FROM NEW PUMP HOUSE TO HANGAR = 25 psig

$$25 = \frac{4.52 \times 400}{d^{4.87}}\left(\frac{3500}{140}\right)^{1.852}$$

$$d = \left[\frac{4.52 \times 400}{25}\left(\frac{3500}{140}\right)^{1.852}\right]^{1/4.87} = 8.2"$$

USE. 8" PIPE

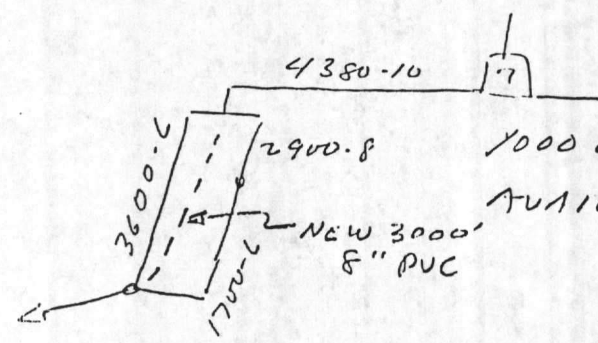
$$\Delta p = \frac{4.52 \times 400}{8^{4.87}}\left(\frac{3500}{140}\right)^{1.852} = 28 \text{ Lbs} + 125 \text{ Lbs REQ.} = 153 \text{ Lbs}$$

SELECT PUMP TO DELIVER 3500 gpm @ 153 Lbs TO THE PUMP HOUSE EXIT PIPE.

ENCL (16)

ENCL (16)

TRAILER PARK (OFF JCT 7 OF MODEL)




1000 GPM @ 54.8 Lbs AVAILABLE

EQUIV. 6" PIPE

$$\left\{\left[\left(\frac{6}{8}\right)^{4.87}\times 3000+1700\right]^{-.54}+\left[3600\right]^{-.54}\right\}^{-1.852}+\left(\frac{6}{10}\right)^{4.87}\times 4380$$

$$710' + 364 = \underline{1074'}$$

FOR 1000 GPM FIRE FLOW TO SOUTH END OF TRL PK.

$$\Delta p = \frac{4.52 \times 1074}{6^{4.87}}\left(\frac{1000}{110}\right)^{1.852} = 47 \text{ psig}$$

| | |
|---|---|
| RESIDUAL | = 20 " |
| TOTAL REQ | = 67 " |
| AVAILABLE | = 54.8. |

SYSTEM NEEDS IMPROVEMENT.

$\Delta p$ AVAILABLE = 54.8 Lbs
RESID − 20
34.8 Lbs

TOTAL EQUIV. 6" PIPE REQ = $\frac{34.8}{54.8} \times 1074 = 682'$

EQUIV 6" FOR 10" CONNECTING PIPE = 364'
EQUIV 6" TRL PARK PIPE REQ = 318'

TRY 8" PVC C=140, L=3000'

$$\left\{\left[\left(\frac{110}{130}\right)^{1.852}\times 3000\right]^{-.54}+710^{-.54}\right\}^{-1.852} = 313' < 318 \quad OK.$$

ENCL (17)

ENCL (17)

EM CLUB WITH PIPES CLEANED (C=120) (AS 4038)

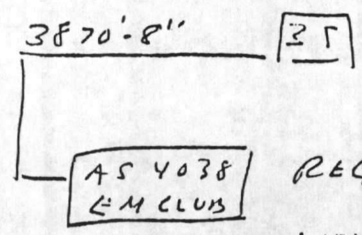
REQ = 1000 gpm @ 20 psig.

AVAILABLE OFF JCT 35 OF MODEL

@1000 gpm = 61 psi

RESID = 20 psi

AVAILABLE FOR LOSS = 41 psi




REQ = 1000 gpm @ 20 psig

$$\Delta p = \frac{4.52 \times 3870}{8^{4.87}} \left(\frac{1000}{110}\right)^{1.852} = 42 \text{ psig} \doteq 41 \text{ psig AVAILABLE}$$

OK

IF PIPE IS CLEANED TO C=120

$$42 \times \left(\frac{110}{120}\right)^{1.852} = 36 \text{ psig} < 41 \text{ psig AVAILABLE FOR LOSS}$$

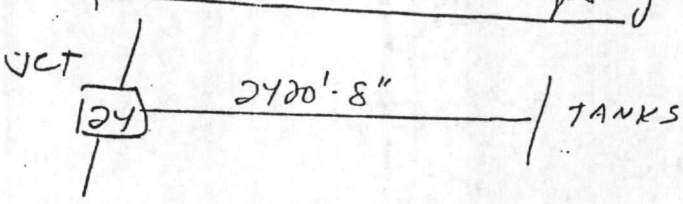
OK

ENCL (18)

ENCL (18)

CONTAMINATED FUEL TANKS OFF JCT 24 OF MODEL

REQ = 3000 GPM @ 20 psig




AVAILABLE @ JCT 24 @ 3000 gpm = 61 psig

RESIDUAL = 20 "

AVAILABLE FOR LOSS = 41 "

$\Delta p = \frac{4.52 \times 2420}{8^{4.87}} \left(\frac{3000}{120}\right)^{1.852}$ = 170 psig REQ > 41 psig AVAILABLE

NEED RESERVOIR AND PUMP HOUSE AT TANK SITE

STORAGE REQ 3000 GPM x 200 MIN = 0.6 MG.

SUPPLY PUMPS THAT WILL DELIVER 3000 GPM @ 20 psig

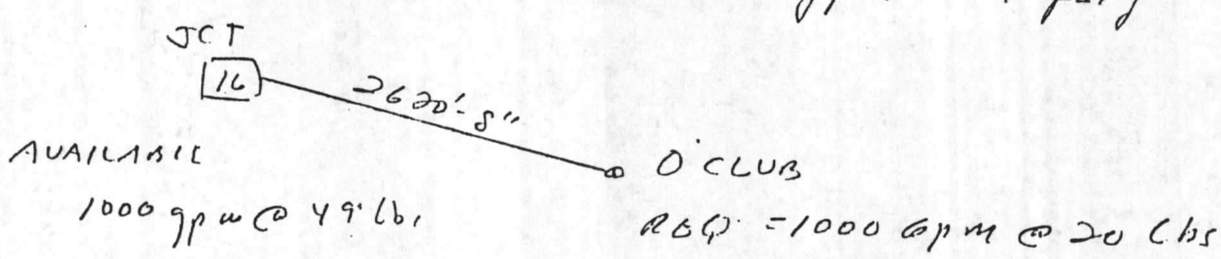
ENCL (19)

ENCL (19)

MCAS O'CLUB (AS 710) OFF JCT 16 OF MODEL

REQ = 1000 gpm @ 20 psig

AVAILABLE AT JCT 16 @ 1000 gpm = 49 psig




$\Delta p$ AVAILABLE = 49 - 20 = 29 lbs

$\Delta p$ REQ = $\frac{4.52 \times 2620}{84.87}\left(\frac{1000}{110}\right)^{1.852}$ = 24 lbs < 29 AVAILABLE

OK

ENCL (20)

ENCL (20)

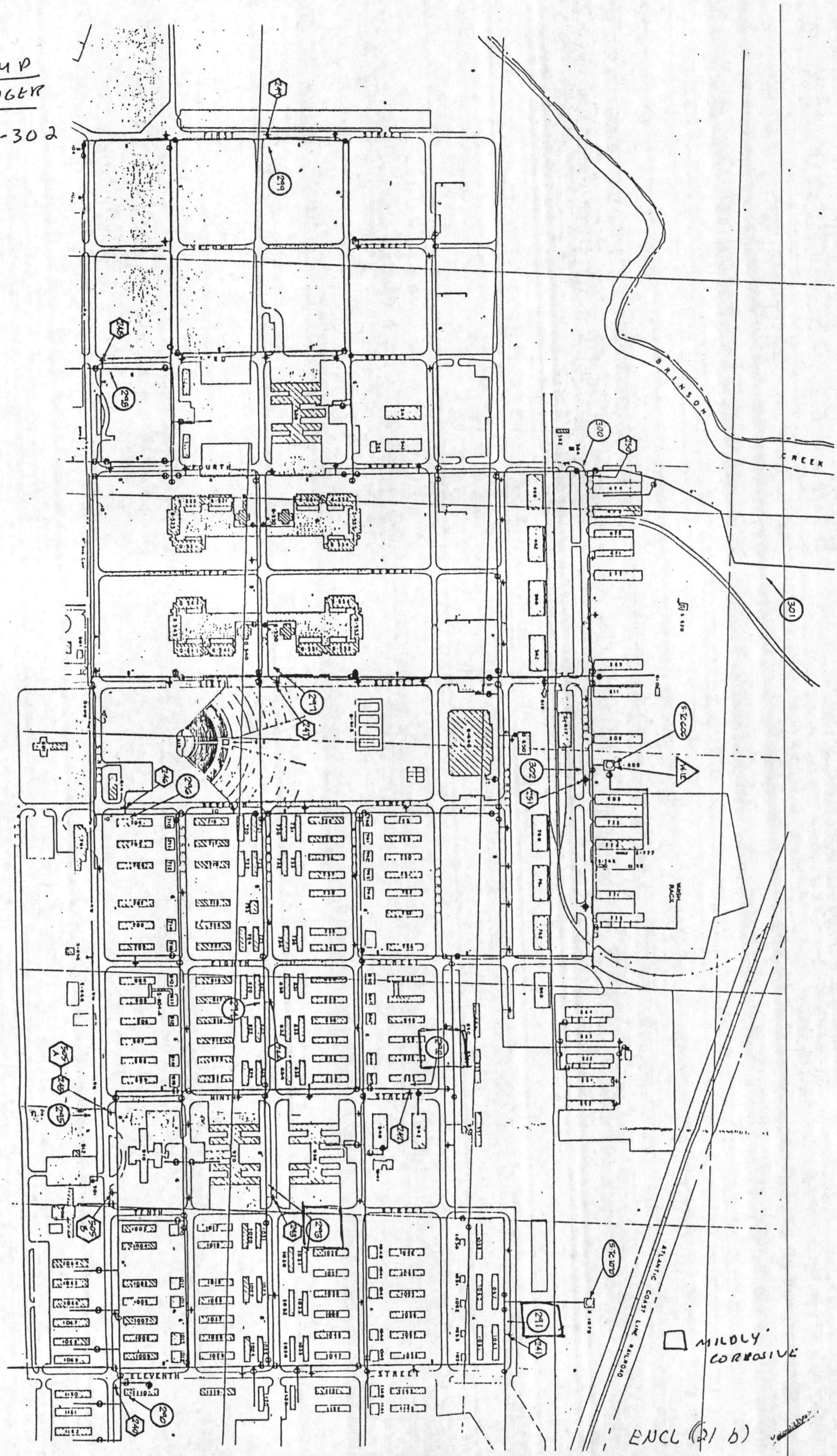
CAMP GEIGER

| Location | Potential | resistance | Comment |
|---|---|---|---|
| 290 | -.501 | 27000 | probably corrosive |
| 291 | -.535 | 8500 | mildly corrosive |
| 292 | -.529 | 9700 | mildly corrosive |
| 293 | -.537 | 7300 | mildly corrosive |
| 294 | -.492 | 5000 | probably corrosive |
| 295 | -.491 | 35000 | possibly corrosive |
| 296 | -.498 | 80000 | possibly corrosive |
| 297 | -.461 | 11000 | possibly corrosive |
| 298 | -.529 | 12000 | probably corrosive |
| 299 | -.378 | 9700 | possibly corrosive |
| 300 | -.303 | 1900 | possibly corrosive |
| 301 | -.303 | 8400 | possibly corrosive |
| 302 | -.42 | 4900 | probably corrosive |

| Location | Potential | resistance | Comment |
|---|---|---|---|
| 291 | -.535 | 8500 | mildly corrosive |
| 292 | -.529 | 9700 | mildly corrosive |
| 293 | -.537 | 7300 | mildly corrosive |
| 290 | -.501 | 27000 | probably corrosive |
| 294 | -.492 | 5000 | probably corrosive |
| 298 | -.529 | 12000 | probably corrosive |
| 302 | -.42 | 4900 | probably corrosive |
| 295 | -.491 | 35000 | possibly corrosive |
| 296 | -.498 | 80000 | possibly corrosive |
| 297 | -.461 | 11000 | possibly corrosive |
| 299 | -.378 | 9700 | possibly corrosive |
| 300 | -.303 | 1900 | possibly corrosive |
| 301 | -.303 | 8400 | possibly corrosive |

ENCL (21 a)

CAMP GEIGER
290-302




ENCL (21 b)

TRL PARK

| Location | Potential | resistance | Comment |
|---|---|---|---|
| 310 | -.555 | 4500 | mildly corrosive |
| 311 | -.534 | 25000 | probably corrosive |
| 312 | -.531 | 1200 | mildly corrosive |
| 313 | -.552 | 3800 | mildly corrosive |
| 314 | -.539 | 15000 | probably corrosive |
| 315 | -.455 | 17000 | possibly corrosive |
| 316 | -.478 | 15000 | possibly corrosive |
| 317 | -.496 | 6300 | probably corrosive |

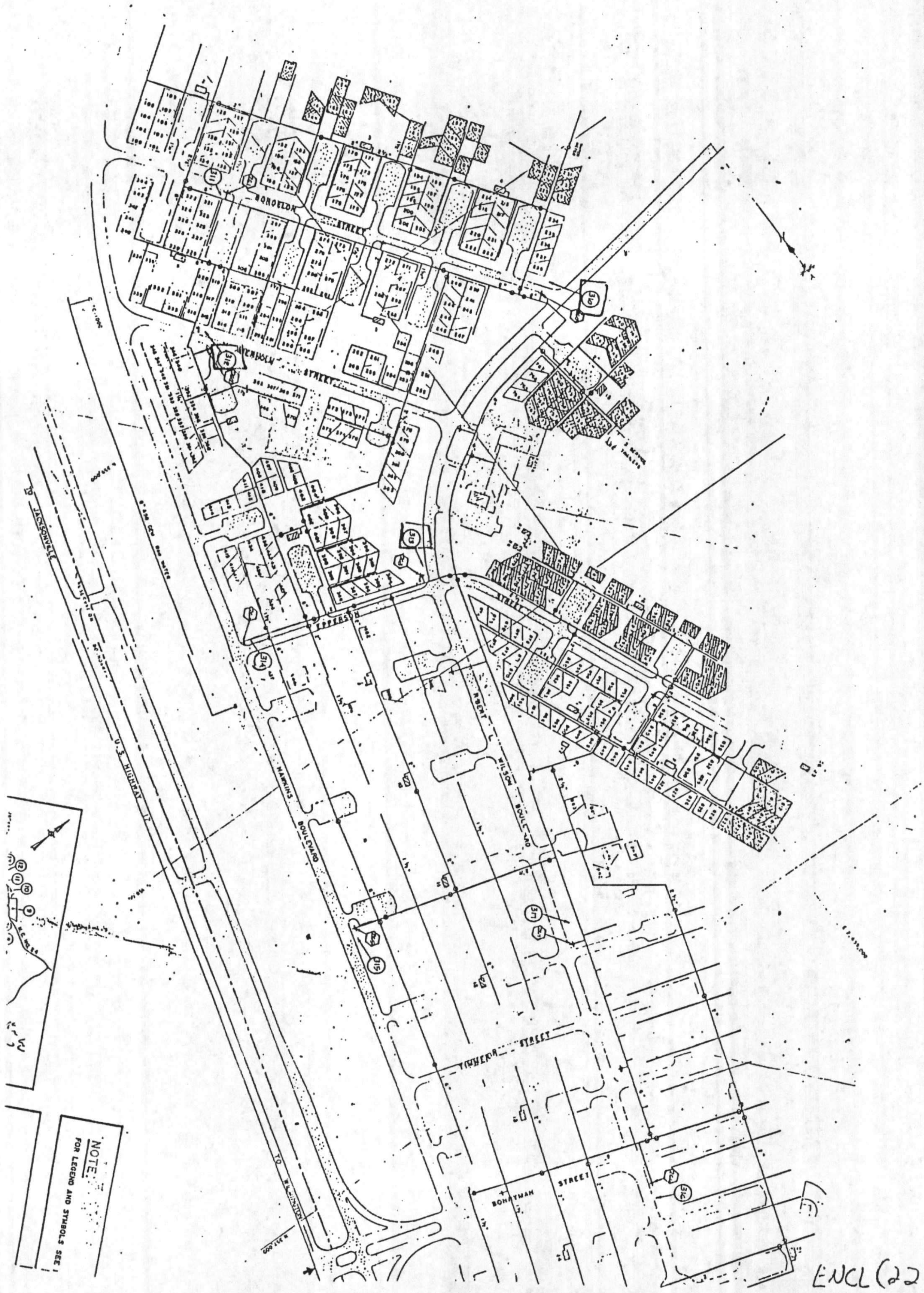
| Location | Potential | resistance | Comment |
|---|---|---|---|
| 310 | -.555 | 4500 | mildly corrosive |
| 312 | -.531 | 1200 | mildly corrosive |
| 313 | -.552 | 3800 | mildly corrosive |
| 311 | -.534 | 25000 | probably corrosive |
| 314 | -.539 | 15000 | probably corrosive |
| 317 | -.496 | 6300 | probably corrosive |
| 315 | -.455 | 17000 | possibly corrosive |
| 316 | -.478 | 15000 | possibly corrosive |

ENCL (22a)

TRL PARK

LOC 310-317

D MILDLY CORROSIVE

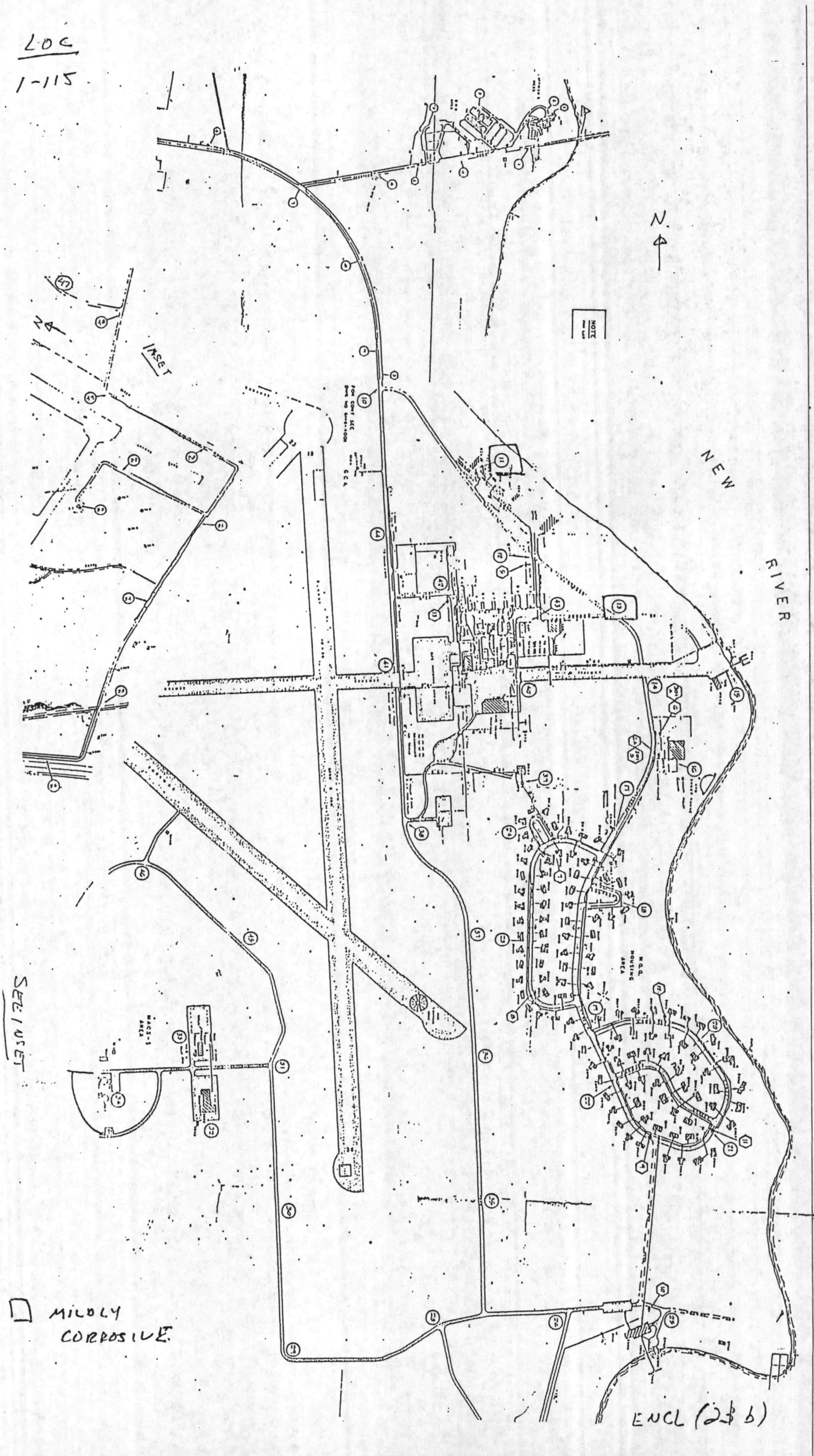



ENCL (22b)

MCAS

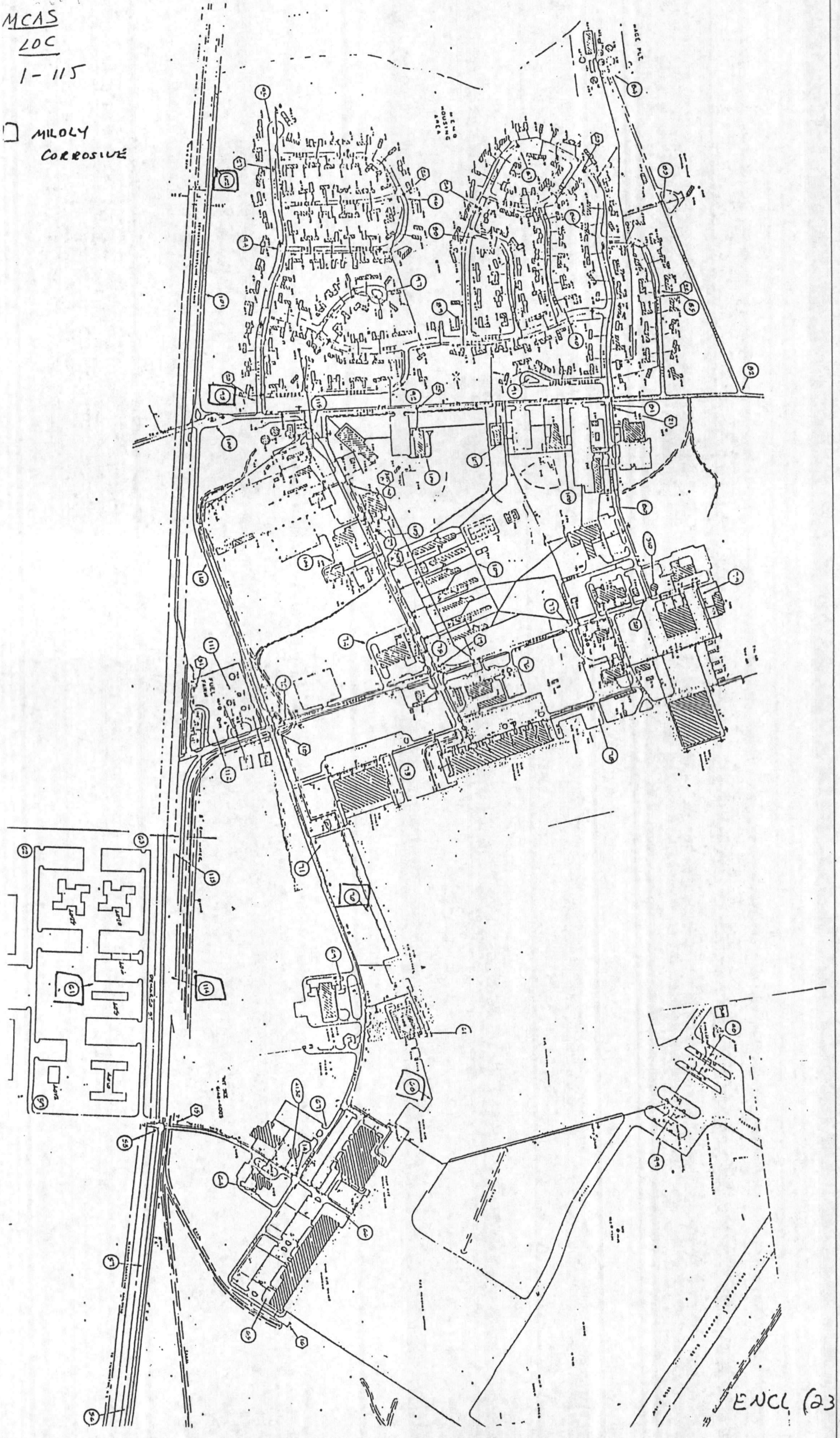
| Location | Potential | resistance | Comment |
|---|---|---|---|
| 11 | -.523 | 6600 | mildly corrosive |
| 13 | -.523 | 7000 | mildly corrosive |
| 61 | -.566 | 5700 | mildly corrosive |
| 68 | -.5030001 | 10000 | mildly corrosive |
| 70 | -.5030001 | 10000 | mildly corrosive |
| 95 | -.501 | 2700 | mildly corrosive |
| 102 | -.501 | 6100 | mildly corrosive |
| 114 | -.566 | 10000 | mildly corrosive |
| 1 | -.42 | 6000 | probably corrosive |
| 2 | -.42 | 5400 | probably corrosive |
| 3 | -.422 | 2400 | probably corrosive |
| 4 | -.422 | 6800 | probably corrosive |
| 8 | -.49 | 4300 | probably corrosive |
| 12 | -.523 | 17000 | probably corrosive |
| 14 | -.413 | 7700 | probably corrosive |
| 15 | -.413 | 2200 | probably corrosive |
| 16 | -.413 | 1100 | probably corrosive |
| 62 | -.566 | 16000 | probably corrosive |
| 63 | -.566 | 10700 | probably corrosive |
| 66 | -.406 | 1400 | probably corrosive |
| 69 | -.5030001 | 21000 | probably corrosive |
| 71 | -.451 | 5100 | probably corrosive |
| 78 | -.402 | 5600 | probably corrosive |
| 94 | -.501 | 23000 | probably corrosive |
| 96 | -.496 | 2600 | probably corrosive |
| 103 | -.501 | 17000 | probably corrosive |
| 107 | -.487 | 10000 | probably corrosive |
| 111 | -.457 | 3100 | probably corrosive |
| 112 | -.457 | 7700 | probably corrosive |
| 113 | -.457 | 3800 | probably corrosive |
| 115 | -.566 | 20000 | probably corrosive |
| 5 | -.422 | 60000 | possibly corrosive |
| 6 | -.422 | 25000 | possibly corrosive |
| 7 | -.422 | 35000 | possibly corrosive |
| 9 | -.49 | 23000 | possibly corrosive |
| 10 | -.49 | 16000 | possibly corrosive |
| 17 | -.361 | 6400 | possibly corrosive |
| 22 | -.362 | 2600 | possibly corrosive |
| 64 | -.406 | 29000 | possibly corrosive |
| 65 | -.301 | 8100 | possibly corrosive |
| 67 | -.406 | 36000 | possibly corrosive |
| 72 | -.451 | 14000 | possibly corrosive |
| 73 | -.451 | 11000 | possibly corrosive |
| 74 | -.436 | 24000 | possibly corrosive |
| 75 | -.436 | 12000 | possibly corrosive |
| 76 | -.402 | 11000 | possibly corrosive |
| 77 | -.402 | 14000 | possibly corrosive |
| 79 | -.402 | 13000 | possibly corrosive |
| 80 | -.402 | 66000 | possibly corrosive |
| 81 | -.46 | 28000 | possibly corrosive |

ENCL (23 a)


LOC
1-115
N
INSET
NEW
RIVER
SEE INSET
MILDLY
CORROSIVE
ENCL (23 b)

MCAS
LOC
1-115

☐ MILDLY CORROSIVE



ENCL (23 b)

ATTACHMENT B

WATER PIPE SYSTEM REHABILITATION
STEPS TO DETERMINE CONDITION OF EXISTING
SYSTEM AND MAKE IMPROVEMENTS

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Contracts

I. To Locate Areas for Inspection and Test:

   A. Field Test Valves and Leak Survey - Pages I, II and III for Scopes:

   B. Cost Estimate - Pages IV, V, and VI

II. To inspect and Test System:

   A. Excavate Pipes (from Cathodic Protection Survey Locations in enclosures (21), (22) and (23))
   (Inspect and Record Pipe Condition) - Page VII for Scope

   B. Do "C" factor flow tests on Curtis and Flounder Roads (Attachment A)

   C. Purchase and Install Valves (From I-A above)
   (Inspect and Record Pipe Condition) - Page VII for Scope

III. Construction Project to Improve System:

   A. Install Pipes/Pumps etc., (From recommendations - page 7 of report)

   B. Replace Pipes/Hydrants etc., (From IIA and IIC above)

   C. Clean Pipes if needed (From IIB and IIC above)

SCOPE OF WORK
PIPE AND VALVE INSPECTION
LEAKAGE DETECTION SURVEY
AND DESIGN OF VALVE REPLACEMENT WORK

General Intention. It is the intention of this contract to provide a survey of the potable water valve and distribution systems at the MCAS, New River and Camp Geiger, Camp Lejeune, North Carolina.

NOTE: The term "Engineer" shall refer to the parties associated with the recipient of this contract.

The term "Navy" shall refer to the office designated to act for the Navy.

1. General Requirements. The engineer shall furnish all labor and material necessary to perform a survey of the underground valve and distribution lines in accordance with this specification.

a. Workmanship. All work shall be accomplished as directed by and to the satisfaction of the Navy.

The Navy Public Works Department shall furnish station plans of the existing water distribution system. Also, the Navy shall be responsible to oversee the manipulation of necessary valves as required, and provide other minor assistance during the survey. Normally it is anticipated that the Contractor shall perform his work with minimum requirements from the Public Works Department.

b. Scheduling the work. Immediately after award, the Contractor shall meet with the Navy and prepare a schedule of work. The Contractor shall conduct his operation so as to cause the least possible interference with normal operation of the activity. The normal working hours are from 7:30 A.M. to 4:30 P.M., Monday through Friday.

c. Security Requirements. No employee or representative of the Contractor shall be admitted on the site unless he furnishes satisfactory proof that he is a citizen of the United States or if an alien, that his residence within the United States is legal.

1. Services. The engineer shall conduct on-site surveys of the fresh water distribution systems to determine the location of inoperative valves, leaks and other sources of water waste. There are approximately 25 miles of water lines to be surveyed and 560 valves and 215 hydrants to be tested.

2. Detail Requirements.

a. Conduct a water leakage survey of all potable water mains, laterals, feeders, hydrants and valves. Manipulate valves and hydrants to insure proper operation. Detection of the leaks can be accomplished by the use of electronic sonic devices ore other instruments or means. The use of these

ATTACHMENT B

instruments shall be by trained and qualified persons. Detecting locating, and quantifying water leaks shall be carried out from the surface. During the survey, there should normally be no need to expose the underground pipes or valve. Identify, when possible, pipe material (i.e., P.V.C., R.C., asbestos-cement or cast iron). Valve leakage can be determined by selectively flowing hydrants, manipulating valves, noting hydrant flow rates and listening to valve leakage noises with sonic electronic equipment (leak detector). Make cassette recording tapes of the valve leakage noise at various leakage rates for each valve size and type. This can be done by manipulating a valve and measuring flows from a connecting hydrant in an isolated part of the system. These tapes then can be used to facilitate subsequent valve leakage tests.

The tapes with leakage noises and associated flows will become the property of the Navy upon completion of the Contract.

3. Provide a draft written report to include a description of the systems, a description of the survey identifying and locating by sketch or table hydrant and valve numbers and each leak showing location and flow. In addition to valves located on the map, each valve will be identified by number or number scheme so that it can be cross referenced to the map. The following information shall be given for each valve:

Valve number, location, (map number, grid)
Valve size, rotation to close (right, left)
Valve opens/closes completely and freely (Y/N) describe if no
Valve leakage (much, some, little, none)

NOTES: (i.e., Buried, hard to gain access and why, etc.

Include a representative leak repair cost per type of leak, and a list locating valves and hydrants with conditions and rehabilitation recommendations. Also, provide design plans and specifications showing the locations, sizes, details of the valve replacements with cost estimates. The draft is for comments and will be followed by a final report which will also address the draft comments.

4. The Marine Corps Base, Camp Lejeune shall be furnished two copies of the draft and the original final report, plans and specifications after it has been reviewed, corrected, collated, summarized, indexed and bound. Provide one copy of the draft and final reports to each of code 405, 408, 1013G, 2011B and 114, Atlantic Division, Naval Facilities Engineering Command, Naval Station, Norfolk, Virginia 23511-6287.

5. Time for Completion. The work and a draft report shall be completed within ninety days after date of receipt of a notice of award authorizing the contractor to proceed. The Navy review time is 15 days, and the final report is required 15 days after the review.

6. The Marine Corps will:

a. Provide (1) experienced personnel to monitor valve operation, (2) appropriate lights and shelter boxes for protection of the engineer's measuring instruments.

b. Make available old and current system prints to facilitate locating "abandoned" but flowing lines.

c. Provide all necessary labor and materials to repair any leaks caused by valve manipulation or accidental breaks in accordance with a schedule to be determined by the Government.

d. Furnish to the engineer all available drawings of the water distribution and collection system that are needed for the contract.

## COST ESTIMATE FOR VALVE/PIPE INSPECTIONS

Cost estimate - inspect 560 valves (6 inches and larger) and 215 hydrants and hydrant valves. Assume average size = 8 inches (adjusted for increased difficulty closing larger sizes), - four persons testing - 16 valves/day and 25 hydrant and valves/day (1 engineer/3 technicians).

| | Man Days Project Manager | Engineer | Technician | Typist |
|---|---|---|---|---|
| 1. Review records, interview personnel, obtain info on pipe and valve cond. and age. | | 1 | | |
| 2. Plan Valve Tests | | 3 | 3 | |
| 3. Field Test Valves and Hydrants (2) | | 44 | 3 persons @ 44 days = 147 | |
| 4. Write report and cost estimate for design contract | 1 | 3 | | 4 |
| Man days | 1 | 51 | 132 | 4 |
| Day cost/persons (2) | 144 | 128 | 112 | 96 |
| Subtotals | 144 | 6528 | 14,784 | 384 |

| | |
|---|---|
| Totals | 21,840 |
| OH&P at 100 percent | 21,840 |
| Contingencies at 5 percent | 2,184 |
| Valve Inspections | 45,864 |

Expenses:

Travel - 4 persons at $304/Roundtrip = 1,216

Per Diem days: Records and Planning = 4 days

Inspect and test = 44 days

6 weekends 12

60 days x 4 @ 50 = 12,000

Car rental 1 car x 60 days @ 50/day = 3,000

Total Expenses = 16,216

Total valve inspection and test cost (45,864+16,216) = 62,080

# COST ESTIMATE FOR LEAKAGE SURVEY

| | Man Days Project Manager | Engineer | Technician | Typist |
|---|---|---|---|---|
| A&E | | | | |
| Review records/maps | | | 2p x 2 days | |
| Plan Survey | | | = 4 M.D. | |
| Report | 3 / 3 | | 4 | 4 / 4 |
| Rate | 144 | | 112 | 96 |
| | 432 | | 448 | 384 |

Total = 1264

OH and Prof @ 100% 1264

Subtotal = 2,528

Survey 25 mi x day / 1.5 miles = 17 days x $600/day = 10,200

Expenses:

Travel - 2 persons at $304/Roundtrip = $ 608
Per Diem - 17 days + 3 weekends
= 23 days for 2 persons x $50 = $ 2300
Car - 23 days at $50 = $ 1150

Total Expenses = 4,058

Total leakage survey contract = 16,786

Total Valve pipe leakage contract

| | |
|---|---|
| Valve Inspections | $62,080 |
| Pipe Leakage | $16,786 |
| | $78,866 |

SAY $80,000

NOTES:
(1) 511 valves counted on water map and estimated in pump houses + 10 percent for map and count errors = 560 valves and 215 hydrants
(2) 560 valves/16 valves/day = 35 days + 215 hydrants/25 per day = 8.6 days = Total = 44 days
(3) Man Day Costrs:

| | Project Manager | Engineer | Technician | Typist |
|---|---|---|---|---|
| Cost/hour | 18 | 16 | 14 | 12 |
| Cost/day | 144 | 128 | 112 | 96 |

## SPECIAL SPECIFICATIONS FOR VALVE REPAIR WORK

Excavate the valve and examine the exteriors of connecting pipes for corrosion and pitting. When the valve is removed examine the interior of the connecting pipes for cement lining or corrosion buildup. Determine the type of incrustation (Rust tuberculation, scale), its thickness, hardness, color, and adherance to pipe walls. Interior pipe examination should also be made during valve inspection work. If the pipe exteriors or interiors are deteriorating or have a rust buildup, record this for future pipe replacement. Replace valve with a properly operating, non-leaky valve.

## PIPE EXAMINATION (EXTERIOR)

Excavate about 7 feet of pipe where the tests shown in Corrosion Survey indicate corrosive soils, and examine the pipe exteriors for deterioration. Rust, pits, and soft spots will be noted. Striking suspicious looking places with a hammer will often reveal soft or deteroriated pipe. Note pieces flaking off when struck. If a pipe is fairly new and is found to be badly deteriorated on the outside, replacement with an exterior protected pipe is indicated. If the pipe is old, and the exterior deterioration is minimal, it can be assumed that there are many more years of useful life remaining for the pipe. Exterior examination of pipes should also be made during valve excavation and replacements.

ATTACHMENT C
HAZEN WILLIAMS "C" FACTOR
BY FLOW TEST

This flow test is to evaluate the internal condition of a pipe in regard to its resistance (friction) to water flow for a given pipe size (i.e., increased roughness or decreased diameter because of internal pipe buildup).

Energy in the form of pressure is needed to overcome the friction resistance. As the flow increases, the friction increases and there is a pressure (energy) loss to overcome the friction and maintain the flow.

This flow test measures the pressure (energy) loss between two pressure gages on a pipe line for a given hydrant flow. The flow is related to the pressure loss and the friction factor "C" by the Hazen Williams formula below.

Hazen Williams Formula: $V = 1.318\ C\ R^{0.63}\ S^{0.54}$

Where V is the water velocity in feet/second, C is the Hazen Williams factor, R is the hydraulic radius equal to one fourth of the pipe diameter in feet (D/4) for a pipe flowing full, and S is the hydraulic gradient in feet/foot.

The line is valved so that all the measured water that is discharged through the flow hydrant passes both gages (Figure 1).

The "C" values are computed on Form 1 using a modification of the Hazen Williams formula where again C is the Hazen Williams factor, $\Delta p$ is the pressure loss in (psig), d is the internal pipe diameter in inches, L is the pipe length between gages in feet, and Q is the flow hydrant discharge in gpm. The Form 1 graphs solve the equation for the flow with C=100 from $L/\Delta p$ and d values. The pipe C factor is then calculated by dividing the actual flow by the graph flow. Examples are shown following Form 1.

Modified Hazen Williams: $$C = \left[\frac{4.52 \times L}{\Delta P \times d^{4.87}}\right]^{0.54} \times Q$$

NOTES:

(1) STATIC PRESSURES (STAT) are pressures taken prior to opening a hydrant and flowing water (little or no flow of water). If the pressure gage fluctuates, it is the average of the fluctuations.
RESIDUAL PRESSURES (RESID) are pressures taken after a hydrant is opened (large flow of water is being maintained).

(2) Three calibrated (0 to 100) psig pressure gages with fittings to connect them to hydrant nozzles or hose bibs are required.

3. The test is most accurate when performed during the hours of low water use (night time). In most cases, the error caused by water usage during the day is not great. The "C" value calculated during the day can be used because water usage flow is generally much less than the fire hydrant test flow. (Exception - if a gage is mounted on a building hose bib, water usage to the building through the relatively small building connection can seriously affect the results.)

4. Pipeline length "L" can be scaled from water system maps in feet.

5. This method has been used many times and the form is easy to fill out and use in the field.

6. All inoperative and leaky valves should be replaced prior to flow testing.

7. Be sure to open all line valves and close hydrants when the tests are completed.

8. The test may be made while the line is set up for cleaning. Figure 2 is a typical "pigging" set up. If a valve (VD) is attached to the downstream end of the pipe, it can be closed between pig runs, and the upstream valve (VU) opened to pressurize the line. The test can then be made in the normal manner from a hydrant between the upstream gage mounted on the launcher, and the downstream gage near the retrieval "T".

9. The parallel pipe method of testing the internal condition of a water pipe to measure its Hazen Williams "C" factor may be used in lieu of three gages (Figure 3). It should be used for larger diameter pipes (10-inch and above). The method requires laying hose between hydrants, but is more precise and a smaller head loss can be accurately measured (see Method 2 for details). A differential pressure gage is used to measure the pressure drop. This is an advantage for larger pipes because it avoids the immense discharge of water that is required to produce the head loss needed when the three gage method is used on larger pipes.

Note:
The differential gage should be a Dwyer Model 4205B or equivalent. Cost is under $200.

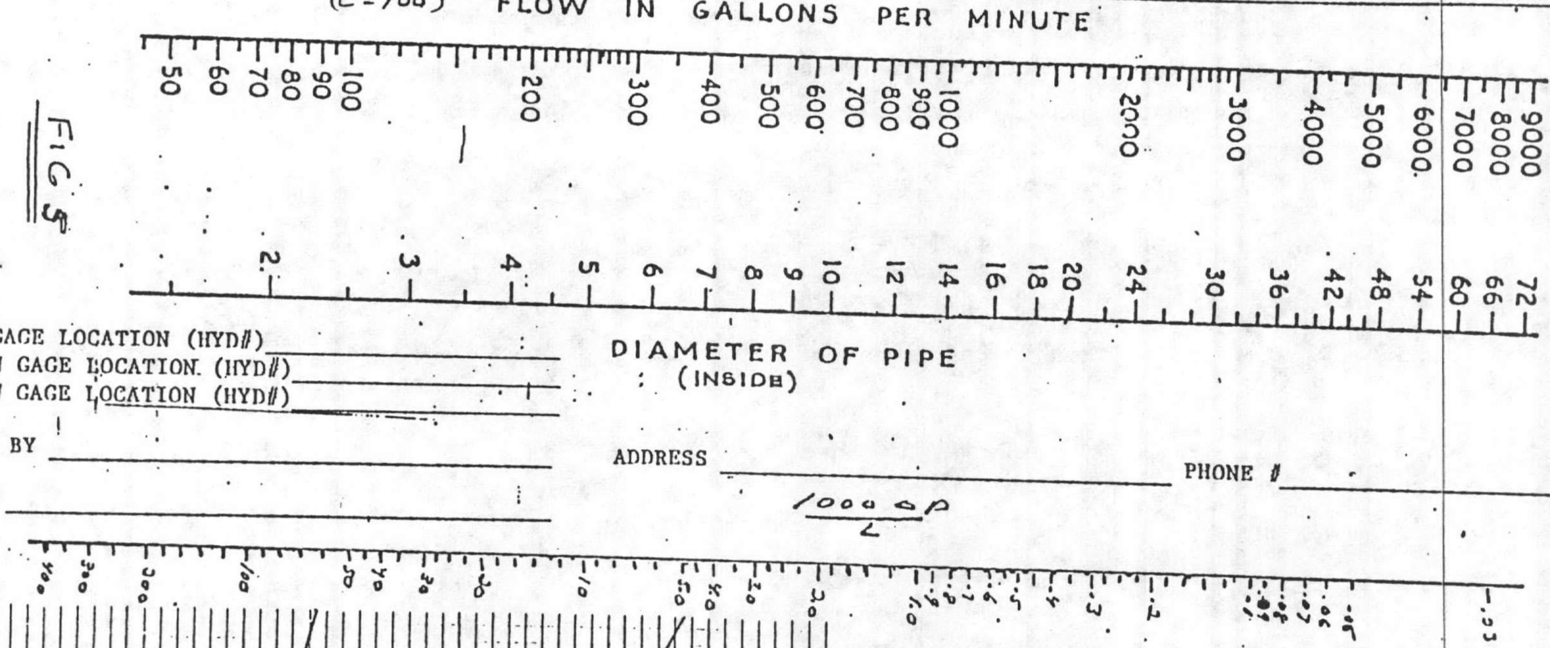
10. Figure 6 shows how a flow test can be made when the pipe cannot be isolated because of inoperative or leaking valves. The valves must be completely open. Gages 1 and 3 are mounted on hydrants connected to lines that have functioning valves that can be closed so that Gages 1 and 3 reflect the pressures at the left and right pipe junctions. A small amount of leakage through the operative valves should not significantly affect the results.

Judicious use of this method to allow testing with inoperative or leaking valves identified during the preliminary valve tests should reduce the number of valves that have to be repaired or replaced for the A/E pipe testing and inspection contract.

The equation is cumbersome to use, but it can be done with a programmable calculator. A computer program in basic is available from this office.

(1) TEST# ______ (2) LOCATION ______ (3) DATE ______ (4) TIME ______

FIG 5




(5) UP GAGE LOCATION (HYD#) ______

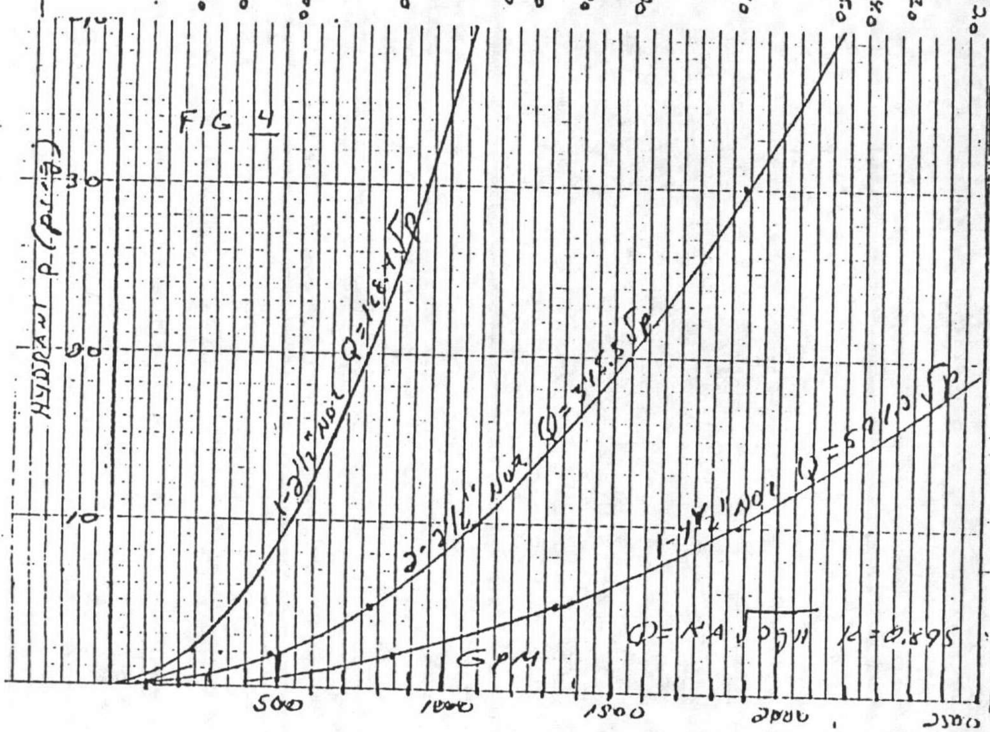
(6) DOWN GAGE LOCATION (HYD#) ______

(7) FLOW GAGE LOCATION (HYD#) ______

TEST BY ______ ADDRESS ______ PHONE # ______

FIRM ______

FIG 4




SKETCH

UP DN FLOW

(8) HIGH STAT P =

(9) STAT P =

(10)

(11) RESID P =

(12) } TO FIG 4

(13) ΔP =

(14) 1000 × ΔP / L = ______ } TO FIG 5

(15) C = FIG 4 / FIG 5 × 100 =

PHONE

FORM 1

## METHOD I - THREE GAGE

## PROCEDURE (FIGURE 1) - USE FORM 1

A. Fill in heading information (1) through (7).

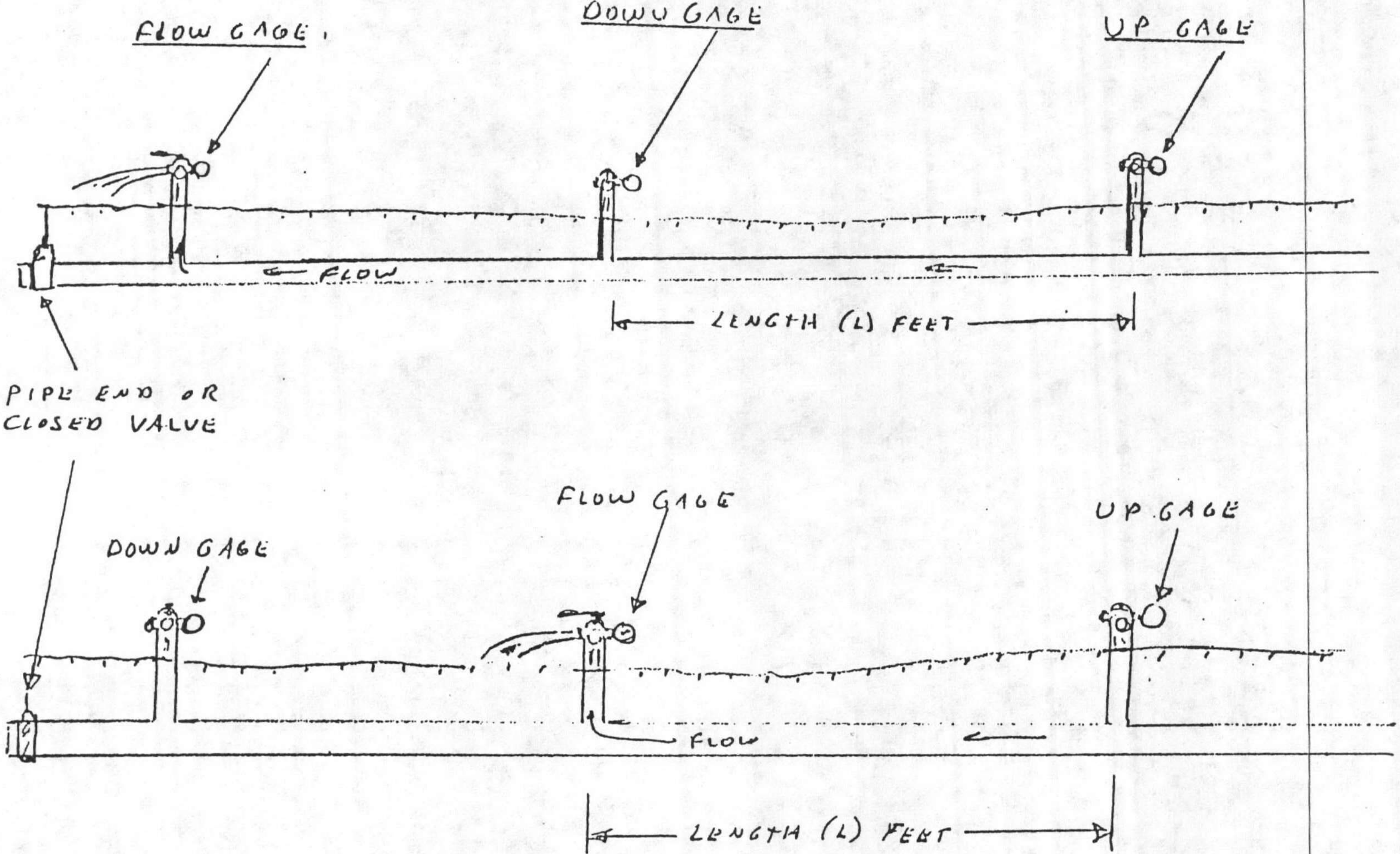
B. Complete sketch.

C. Enter the upstream (furthest from the flow hydrant) and downstream (closest to the flow hydrant) static pressures on line (9). Enter the larger of the two on line (8). Subtract lines (9) from (8) on line (10). One column should be "O", and the other column should contain a pressure difference that compensates for ground surface elevation differences between the two gages.

D. Open the flow hydrant and when the gages are steady, read all three gages. The residual pressures, are entered on line (11) with the upgage, downgage and flow hydrant pressures in their respective places. Add lines (10) and (11) for upgage and downgage totals (line 12)), then subtract the downgage total from the upgage total for $\Delta p$ Line (13). Multiply $\Delta p$ by 1,000 and divide by line length L Line (14).

E. Enter Figure 4 with flow hydrant residual pressure (line (11-flow)). Cross to appropriate hydrant nozzle curve then down to hydrant flow (GPM). Enter hydrant flow in numerator, line (15). Enter Figure 5 with 1,000 x $\Delta p/L$ from line (14). Draw straight line from 1,000 $\Delta p/L$ through pipe diameter to C=100 flow (GPM). Enter this flow in denominator of line (15). Solve line (15) for "C" factor.

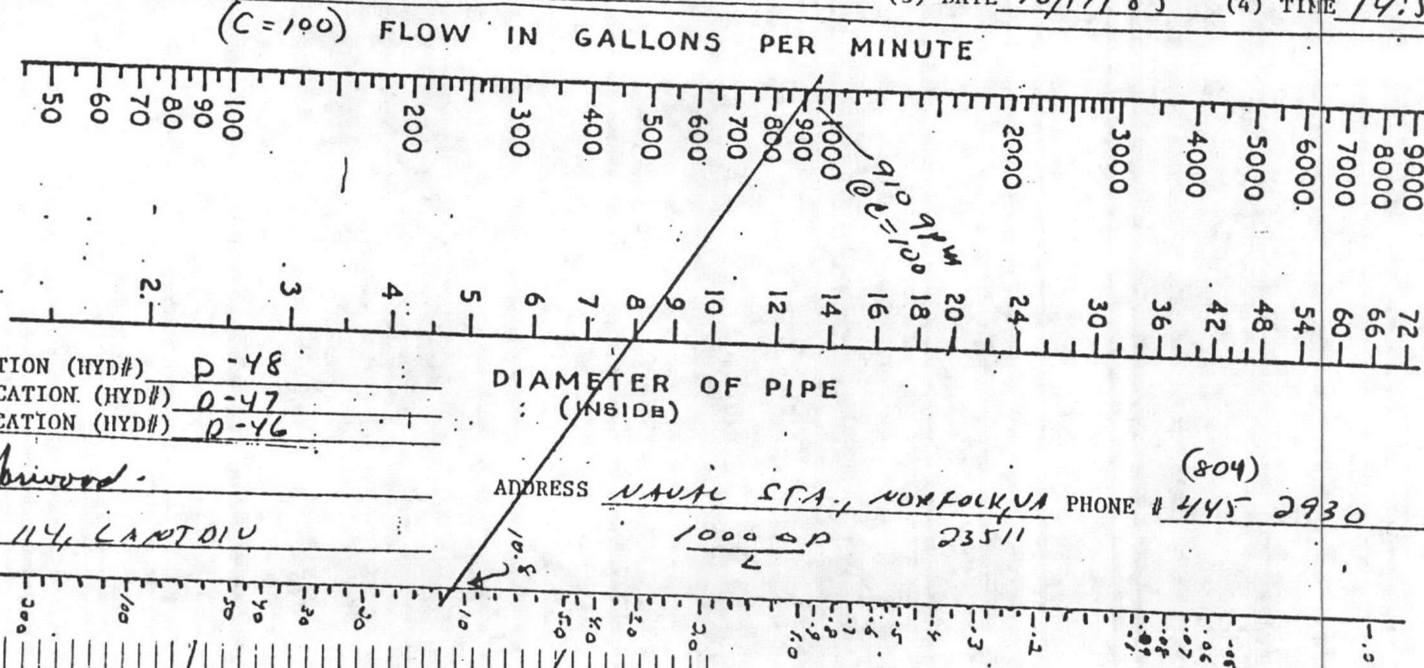
FIGURE 1 (METHOD 2)



(1) TEST# 6 (2) LOCATION NAUSTA NORVA (3) DATE 10/17/85 (4) TIME 14:50

EXAMPLE

FIG 5




(5) UP GAGE LOCATION (HYD#) D-48

(6) DOWN GAGE LOCATION (HYD#) D-47

(7) FLOW GAGE LOCATION (HYD#) D-46

TEST BY JMorwood

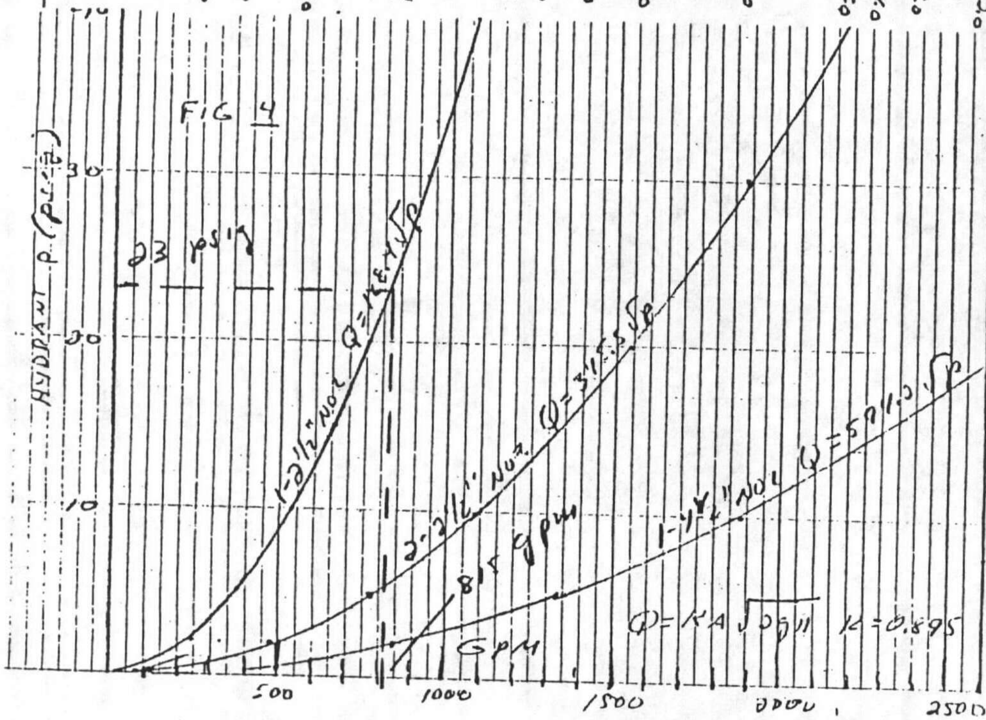
ADDRESS NAVAL STA., NORFOLK, VA 23511 PHONE # (804) 445 2930

FIRM CODE 114, LANTDIV

1000 ΔP / L

FORM 1

FIG 4




SKETCH

740'-8" UP DN FLOW 1-Nozzle VALVE #47 CLOSED

(8) HIGH STAT P = 70 | 70

(9) STAT P = 65 | 70

(10) 5

(11) RESID P = 55 | 52 (23) } TO FIG 4

(12) 60 | 52

52

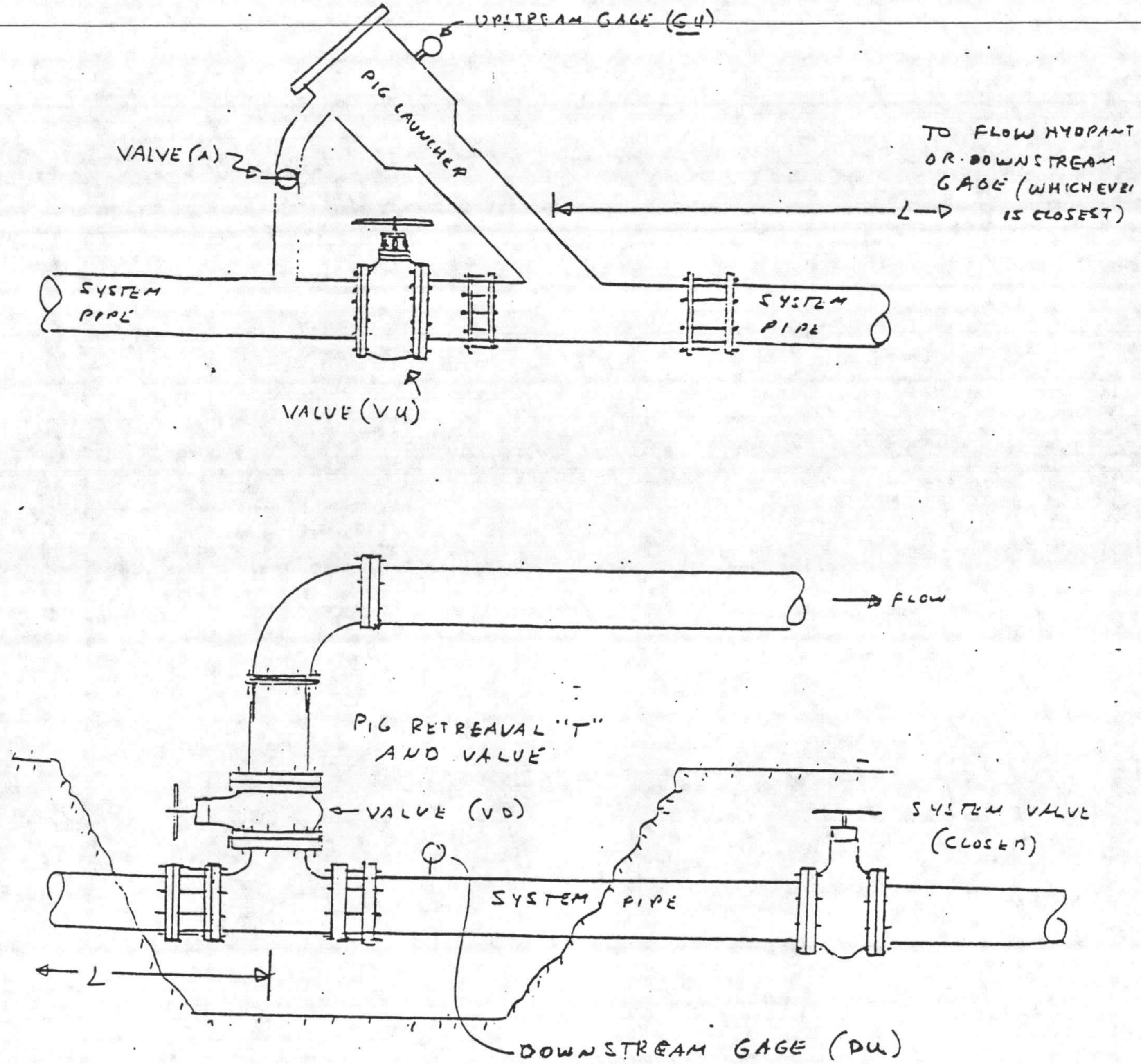
(13) ΔP = 8

(14) 1000 × ΔP/L = 8×1000/740 = 10.8 } TO FIG 5

(15) C = FIG 4 / FIG 5 × 100 = 815/910 × 100 = 90

PHONE

FIGURE 2 (METHOD 1)



METHOD 2
FORM 1
HAZEN WILLIAMS "C"
FACTOR BY HYDRANT FLOW TEST FORM
PARALLEL PIPE METHOD

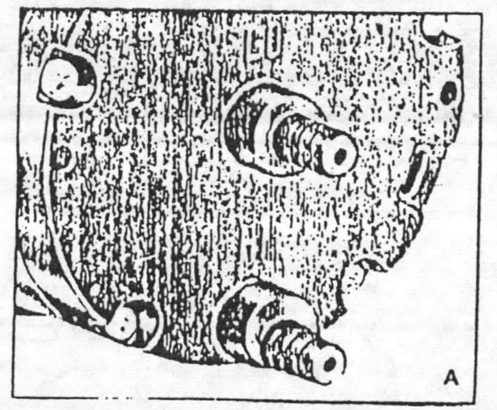
---

<u>PROCEDURE (FIGURE 3) USE FORM</u>

A. Fill in heading info (1) through (6).
B. Complete sketch.
C. Connect garden hose from hydrants to differential pressure gage (upstream hydrant to high pressure). Open upstream and downstream hydrants and bleed air from hose.
D. Note any initial pressure before flowing hydrant. Enter on line (12 DN).
E. Open the flow hydrant, read differential pressure again and enter on line (12 up). If differential pressure is greater than 5 psig, reduce flow hydrant discharge. If differential pressure is less than 0.5 psig, increase flow by using two hydrant nozzles, the 4-1/2 inch pumper connection, or flow two hydrants and use two flow hydrant gages. Correct by substracting initial pressure (12 DN) from final pressure (12 up) and enter as $\Delta p$ on line (13). Multiply $\Delta p$ by 1,000 and divide by length (L) Line (14). Continue the same as Method 1 - i.e.,look up hydrant flow on Figure 4, flow for C=100 from Figure 5, and calculate C from Line 15.

FLOWTEST - PARALLEL PIPE METHOD

PRESSURE CONNECTIONS



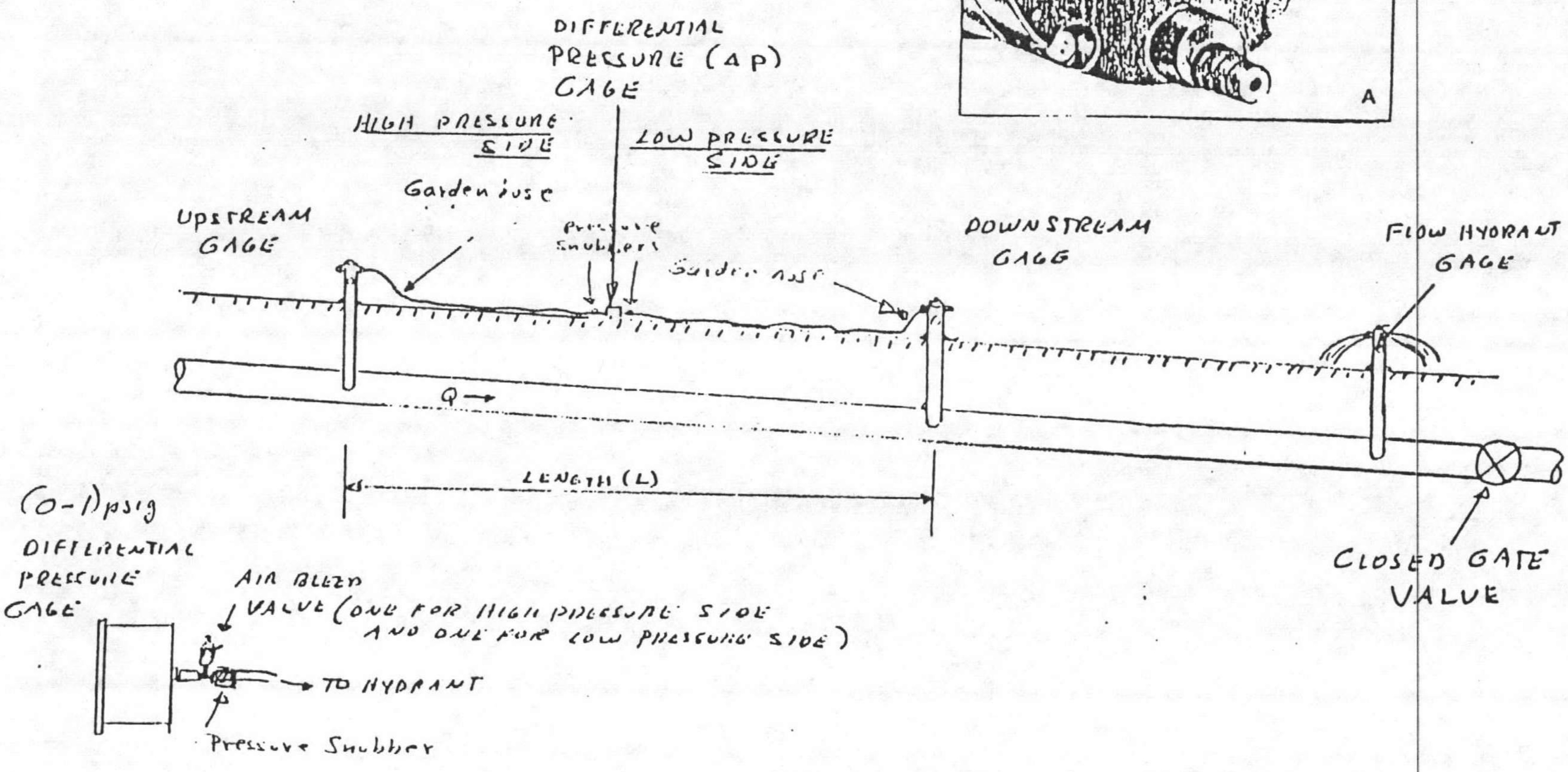



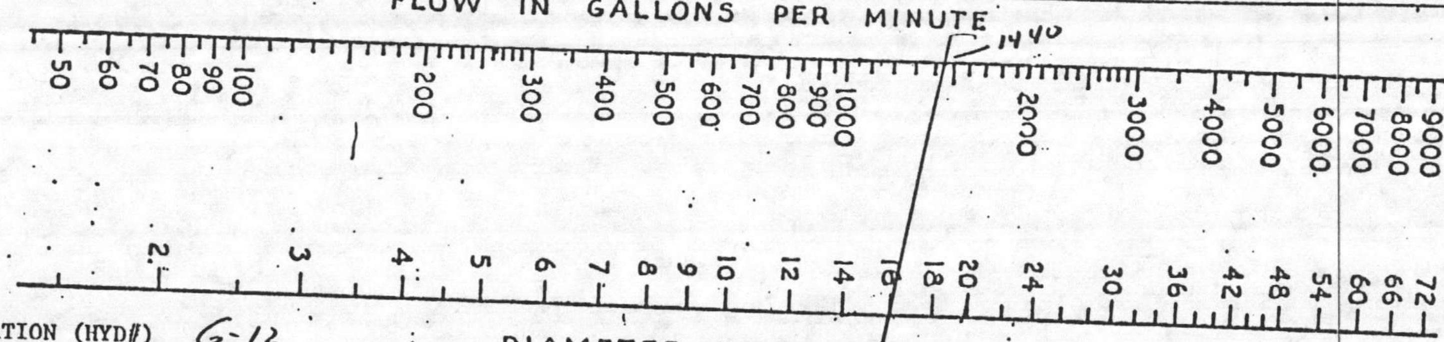

FIGURE 3
PARALLEL PIPE METHOD &

(1) TEST# 7  (2) LOCATION NAVSTA NORVA  (3) DATE 10/17/85  (4) TIME 1610

EXAMPLE

FIG 5

FLOW IN GALLONS PER MINUTE




(5) UP GAGE LOCATION (HYD#) G-12

(6) DOWN GAGE LOCATION. (HYD#) G-16

(7) FLOW GAGE LOCATION (HYD#) G-14

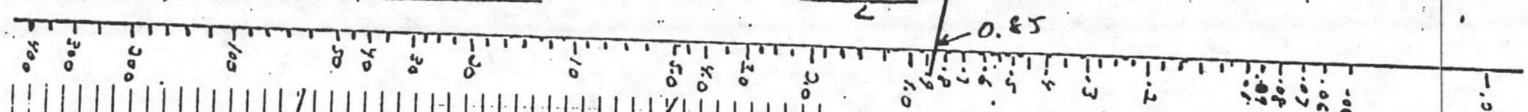
DIAMETER OF PIPE (INSIDE)

TEST BY J Harwood

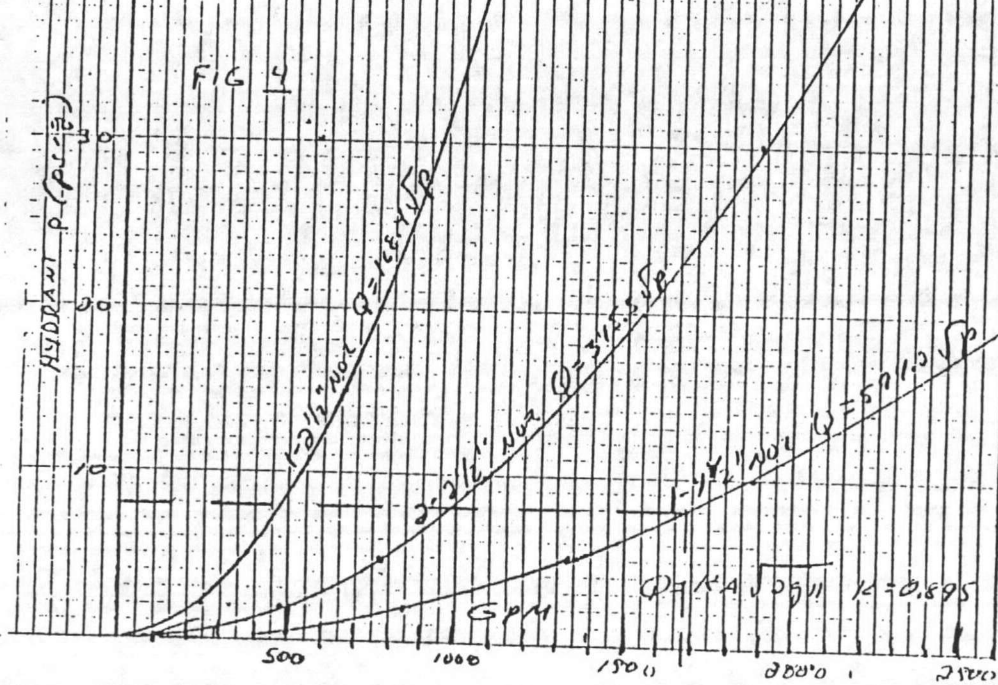
ADDRESS NAVAL STA, NORFOLK VA. 23511  PHONE # (804) 445 2930

FIRM CODE 114, LANTDIV

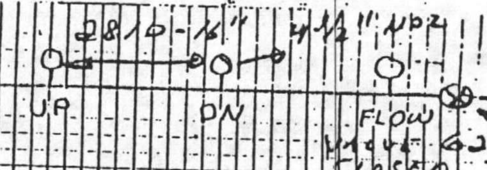
1000 ΔP / L




FORM 1




SKETCH




(8) HIGH STAT P =

(9) STAT P =

(10)

(11) RESID P = — 8 } TO FIG 4

(12) 2.6 / 0.2 ← { 0.2

(13) ΔP = 2.4

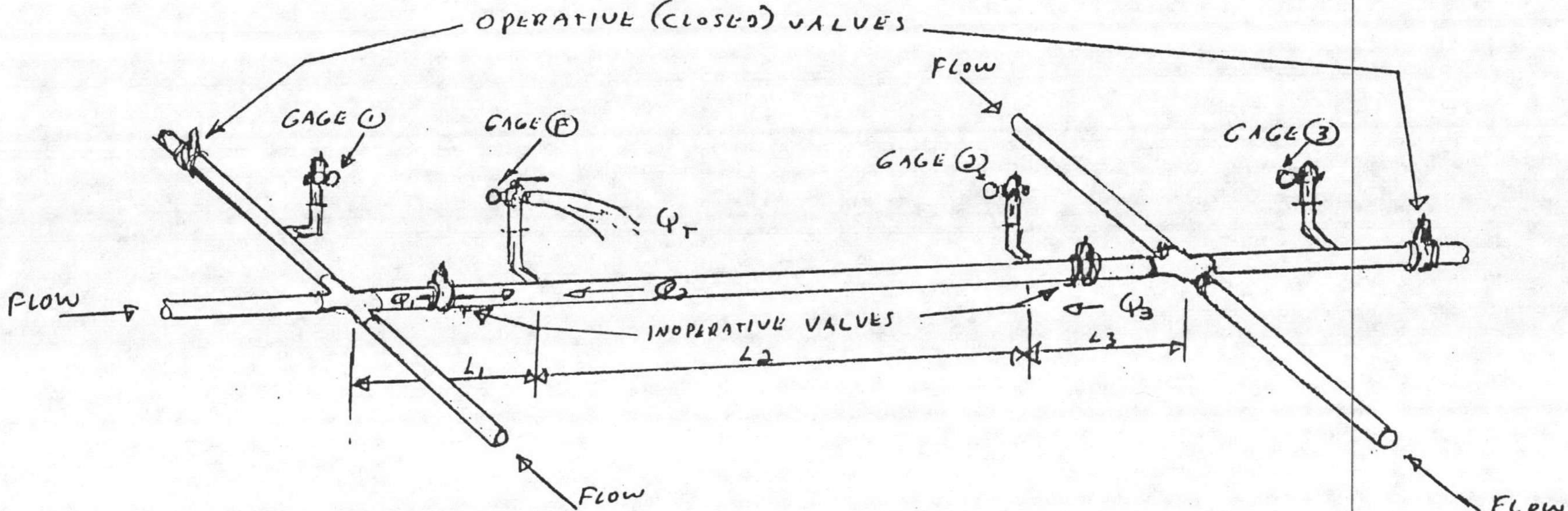
(14) 1000 × ΔP / L = 2.4 × 1000 / 2810 = 0.85 } TO FIG 5

(15) C = FIG 4 / FIG 5 × 100 = 1675 × 100 / 1440 = 116

PHONE

SHEET NO. ........ OF ........
JOB NO. ........
SUBJECT 6
BY ........ DATE ........
CHKD. BY ........ DATE ........

FIGURE 6




$$C = \frac{2.26\, Q_T}{D^{2.63}\left\{\left[\frac{(d_2-d_1)}{L_1} + \left(\frac{L_2}{L_3}\right)\frac{(d_2-d_3)}{L_1}\right]^{.54} + \left[\frac{(d_2-d_3)}{L_3}\right]^{.54}\right\}}$$

Where $C$ = HAZEN WILLIAMS "C" FACTOR
$d_1$ = STATIC ① − RESIDUAL ①
$d_2$ = " ② − " ②
$d_3$ = " ③ − " ③

$L_1, L_2, L_3$ AS SHOWN ABOVE (FEET)

$D$ = PIPE I.D. (INCHES)

$Q_T$ = HYDRANT Ⓕ FLOW (GPM) FROM RESID Ⓕ & GRAPH - FORM 1, FIG 4.

# PHYSICAL AND CHEMICAL ANALYSIS OF WATER

FROM: (Station or unit)

DATE

TO: (Name and location of laboratory)

SAMPLE FROM (Location of sampling point)

| COLLECTED BY | DATE | HOUR | SOURCE (Designate ground, surface, raw, treat |
|---|---|---|---|
| REASON FOR EXAMINATION | | EXAMINATION REQUESTED BY | |

NOTE: All results reported in parts per million unless otherwise noted except for pH, temperature, and specif. conductance. One liter of potable water is assumed to weigh one kilogram.

## I. FIELD ANALYSIS

| 1. pH | TEMPERATURE °F | TEMPERATURE °C |
|---|---|---|
| ✓ | ✓ | |

| ITEM | PPM |
|---|---|
| 2. CARBON DIOXIDE ($CO_2$) | |
| 3. DISSOLVED OXYGEN ($O_2$) | |
| 4. HYDROGEN SULFIDE ($H_2S$) | |
| 5. CHLORINE DEMAND ($Cl_2$) | |

FIELD ANALYSIS BY ✓

DATE OF ANALYSIS ✓

## II. SPECIAL LABORATORY ANALYSES

Check (X) individual items to be included in the Special Analyses. Request determination only of those substances suspected of being present in significant amounts.

| (X) | ITEM | PPM |
|---|---|---|
| | 1. As | |
| | 2. Se | |
| | 3. Pb | |
| | 4. B | |
| | 5. Cu | |
| | 6. Zn | |
| | 7. Cr (Hexavalent) | |
| | 8. PO | |
| | 9. Cd | |
| | 10. CN | |
| | 11. Phenolic Compounds (PPB) | |
| | 12. Others (Specify) | |
| | 13. | |
| | 14. | |
| | 15. | |
| | 16. | |

## III. ROUTINE LABORATORY ANALYSIS

(CHECK ONE)

| | REQUESTED | NOT REQUESTED |
|---|---|---|
| 1. COLOR | | |
| 2. TURBIDITY | | |

3. ALKALINITY ($CaCO_3$)

| P | MO |
|---|---|
| ✓ | ✓ |

4. TOTAL HARDNESS ($CaCO_3$) ✓

5. NON-CARBONATE HARDNESS ($CaCO_3$) (By Computation) ✓

6. CARBONATE HARDNESS ($CaCO_3$) (By Computation) ✓

7. TOTAL DISSOLVED SOLIDS ✓

8. SPECIFIC CONDUCTANCE (Micromhos)

| ITEM | | PPM |
|---|---|---|
| 9. CALCIUM (Ca) | ✓ | |
| 10. MAGNESIUM (Mg) | ✓ | |
| 11. SODIUM (Na) AND POTASSIUM (K) | | |
| 12. HYDROXIDE (OH)* | | |
| 13. BICARBONATE ($HCO_3$)* | ✓ | |
| 14. CARBONATE ($CO_3$)* | ✓ | |
| 15. SULFATE ($SO_4$) | ✓ | |
| 16. CHLORIDE (Cl) | | |
| 17. NITRATE ($NO_3$) | | |
| 18. IRON (Fe) TOTAL | | |
| 19. MANGANESE (Mn) | | |
| 20. SILICA ($SiO_2$) | ✓ | |
| 21. FLUORIDE (F) | | |

*State whether determined or computed from P and MO alkalin

REMARKS (Such as unusual appearance, taste, odor, etc.)

LABORATORY ANALYSIS BY

DATE OF ANALYSIS

ATTACHMENT D

ATTACHMENT E

APPROXIMATE COSTS FOR CLEANING (1983)

Cleaning Methods:

1. Polyurethane Pigs — $ 3.00 - $ 5.00 per linear ft.
2. Hydromechanical Scrapers — $ 4.00 - $ 6.00 per linear ft.

APPROXIMATE COSTS FOR RELINING (1983)

| Pipe Diameter | (1983) Cement-Mortar Lining *Relining Cost ($/LF) | (1983) *Insituform Relining Cost ($/LF) |
|---|---|---|
| 2-inch | N/A | N/A |
| 3-inch | N/A | N/A |
| 4-inch | N/A | N/A |
| 6-inch | $18.00 | $ 9.50 - $ 13.50 |
| 8-inch | $20.00 | $21.00 - $ 30.00 |
| 10-inch | $23.00 | $26.00 - $ 37.00 |
| 12-inch | $26.57 | $38.00 - $ 53.00 |
| 14-inch | $30.00 | $51.00 - $ 72.00 |
| 16-inch | $35.00 | $67.00 - $ 94.00 |
| 18-inch | $35.00 | $84.00 - $120.00 |

*Costs include cleaning with cable pulled scrapper
*Costs do not include repaving, line bypassing, or curb reconstruction

Pipe replacement costs per linear foot (1983 Means) includes material, installation, O&P. Does not include excavation, backfill, bypassing, thrust blocks, etc.

| Size | Ductile Iron Class (250) Tyron Joint | PVC Class 150 (S.D.R. - 18) |
|---|---|---|
| 4-inch | $ 9.20 | $ 5.80 |
| 6-inch | $ 10.40 | $ 7.00 |
| 8-inch | $ 15.15 | $11.05 |
| 10-inch | $ 19.25 | $13.45 |
| 12-inch | $ 24.00 | $19.80 |
| 14-inch | $ 31.00 | |
| 16-inch | $ 35.00 | |
| 18-inch | $ 44.00 | |
| 20-inch | $ 48.00 | |
| 24-inch | $ 56.00 | |

Street fire hydrant (including 6-inch gate valve, connecting pipe, thrust block), $1,800/hydrant.

GATE VALVES

| 4-inch | 6-inch | 8-inch | 10-inch | 12-inch | 14-inch | 16-inch |
|---|---|---|---|---|---|---|
| $375 | $460 | $685 | $965 | $1,175 | $2,200 | $2,975 |

NOTE:
Use above if better costs are not available.

## WATER TREATMENT INFORMATION

When the costs of replacement or cleaning and cement lining are compared with cleaning and water treatment, the following costs should be added to the latter.

1. Present value of treatment equipment (20-year life)

   a. To raise Langelier index (pH & alkalinity)

   Small Systems: (Less than 1 MGD) Soda ash feeders & solution tank.

   Large Systems: (More than 1 MGD) Lime feeders, slaking tanks, sedimentation tanks, filters, $CO_2$ addition.

   b. For corrosion control - (small & large)

   Chemical feeders - Sodium Hexametaphosphate.

2. Present Value (20 years) of annual

   a. Operation & maintenance costs,

   b. Energy costs,

   c. Chemical costs.

3. Present value (20 years) estimation of annual water cost savings in leakage reduction that would result from cement lining or pipe replacement. (Significant only if leakage is large and water is expensive).

ECONOMIC ANALYSIS

I. Cost of New Pipe ________ I

~~II. Cost of Cleaning and Cement Lining~~ ________ II

III. Cost of Pigging or Cleaning without Lining ________________

If water is aggressive (negative Langelier Index), add to III.

a. Cost of treatment equipment [1] __________________

b. Annual costs

O&M ________________

Power ________________

Chemicals ____________

Leakage [2] ________

Total ________________ X 8.933 [3] = __________

Total = __________ ________ III

Select most cost effective I, II, or III.

NOTE: Power escalation rate is ommitted above but should be considered on a case by case basis (unusually high power costs or large repair projects ( 10 MGD)).

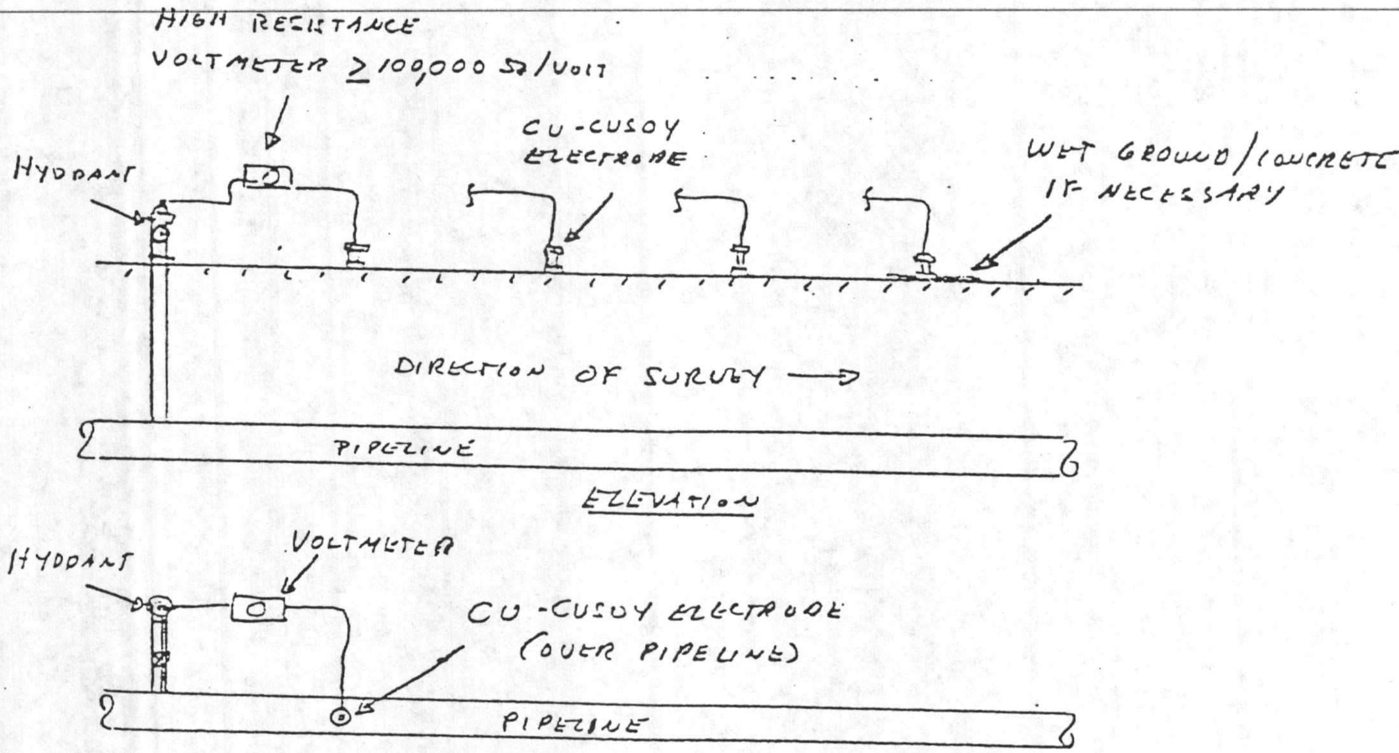
(1) From equipment venders.
(2) Cost of estimated leakage reduction expected from new pipes or cement lining. (In absence of better information, leakage can be taken as one-half of the unaccounted for water).
(3) Discount rate for 20 years at 10 percent.

BY .......... DATE .......... SUBJECT .......................................... SHEET NO. .......... OF ..........

CHKD. BY .......... DATE .......... JOB NO. ..........

COPPER SULFATE REFERENCE ELECTRODE MEASUREMENTS

ATTACHMENT E




PLAN

SOIL RESISTIVITY – COPPER SULFATE POTENTIAL RELATIONSHIPS.

| Potential of Ferrous Pipe in Volts to a Copper Sulphate Reference Electrode | Soil Resistivity Ohms per Centimeter Cube For Short (ohm-cm) | | |
|---|---|---|---|
| | Very low to low (500 to 1,000) | Medium (1,000 to 10,000) | High to Very High (10,000 to 100,000) |
| -0.4 or ~~less~~ MORE | ~~possibly~~ probably corrosive | ~~probably~~ possibly corrosive | noncorrosive |
| -0.4 to -0.5 | mildly corrosive | ~~possibly~~ probably corrosive | ~~probably~~ possibly corrosive |
| -0.5 to -0.6 | corrosive | mildly corrosive | ~~possibly~~ probably corrosive |
| -0.6 or ~~higher~~ Less | very corrosive | corrosive | mildly corrosive |

ATTACHMENT F