N00174.AR.000003
NSWC INDIAN HEAD
5090.3a

FINAL REPORT

POTABLE WATER IMPROVEMENT STUDY

Naval Ordnance Station
Indian Head, Maryland
Contract No. 62477-81-C-0170

VOLUME I: TEXT

FINAL REPORT

POTABLE WATER IMPROVEMENT STUDY

Naval Ordnance Station
Indian Head, Maryland
Contract No. 62477-81-C-0170

VOLUME I: TEXT

Prepared By

Jerry M. Shoemake, Water Conservation
Michael R. Groves, Groundwater Supply
Gregory W. Pulliam, Project Manager

AWARE, Inc.
P. O. Box 40284
Nashville, Tennessee 37204

May 1982

THE AWARE CORPORATION

AWARE

consultants in environmental management

May 27, 1982 6702

Commanding Officer
Chesapeake Division
Naval Facilities Engineering Command
Building 212, Washington Navy Yard
Washington, DC 20374

ATTN: Code 114, Mr. N. Mathur

RE: Contract N-62477-81-C-0170

Dear Sir:

This letter transmits ten copies of the Final Report of the Potable Water Improvement Study at the Naval Ordnance Station/Indian Head, Maryland, under the above referenced contract. The comments of CHESNAVFACENGCOM and other reviewers on the Draft Final Report have been incorporated, as appropriate, in this Final Report.

The Final Report is subdivided into two volumes. Volume I contains the report text, and Volume II contains the appendices. The text in Volume I is organized in three sections. Section 1 is the introduction to the overall study. Section 2 presents the water conservation aspects of the contract. Section 3 presents the groundwater supply aspects of the contract.

AWARE has appreciated this opportunity to again work with CHESDIV, and we look forward to future projects with you. If you have any questions about the Final Report, please contact me.

Sincerely,

AWARE, Inc.

Gregory W. Pulliam

Gregory W. Pulliam
Project Manager

cc: Mr. M. R. Groves
Mr. J. M. Shoemake
Dr. John H. Koon
Dr. C. E. Adams, Jr.

Enclosures: Final Report (10)

P.O. Box 40284 • Nashville, TN 37204 • Phone: (615) 794-0110

AWARE, Inc. Nashville, TN | AWARE, Inc./Southwest Houston, TX | AWARE Italy, S.p.A. Milan, Italy | AWARE Venezuela Maracay, Venezuela | AWARE Laboratories Nashville, TN

TABLE OF CONTENTS

Chapter No.	Title	Page No.
	LETTER OF TRANSMITTAL	i
	REPORT ORGANIZATION	
	Table of Contents	ii
	List of Tables	viii
	List of Figures	x
	SUMMARY AND CONCLUSIONS	xii
	Summary of Findings	xii
	Water Conservation Study	xii
	Well Water Intake, Use and Discharge	xii
	Potentially Feasible Water Conservation Alternatives	xvi
	Economic Evaluation of Water Conservation Alternatives	xvi
	Groundwater Supply Study	xxii
	Condition of Existing Well Water Supply Facilities	xxv
	Aquifer Potential	xxv
	Alternative Treatment Methods for Wells 3A and 16	xxviii
	Well Water Supply Recommendations	xxviii
	Conclusions	xxx
	FY 1982 Military Construction Project Data Form	xxxiii
1	INTRODUCTION	
Chapter 1.1	INTRODUCTION	1-1
1.1.1	Overview	1-1
1.1.2	Industry Background Information	1-2
1.1.2.1	Explosives Industry Subcategorization	1-3
1.1.3	NOS Background Information	1-4
2	WATER CONSERVATION STUDY	
Chapter 2.1	SURVEY OF WATER USES	2-1
2.1.1	Assistance Acknowledgement	2-1
2.1.2	Methodology of Well Water Use Survey	2-1
2.1.2.1	Historical Well Water Use Determination	2-2
2.1.2.2	Data Collection	2-5
2.1.2.2.1	Survey of Functional Areas	2-7
2.1.2.2.2	Well Water Volume Calculation	2-7

TABLE OF CONTENTS (Cont'd.)

Chapter No.	Title	Page No.
2.1.3	Water Balances	2-8
2.1.3.1	Line Losses	2-8
2.1.3.2	Total Well Water Seasonal Balances	2-11
2.1.3.3	Low Silica Seasonal Balances	2-13
2.1.3.4	High Silica Seasonal Balances	2-13
2.1.3.5	Diurnal Balances	2-13
2.1.3.5.1	Total Well Water Diurnal Balances	2-20
2.1.3.5.2	Low Silica Well Water Diurnal Balances	2-20
2.1.3.5.3	High Silica Well Water Diurnal Balances	2-20
2.1.4	Water Use Survey Summary and Preliminary Conservation Recommendations	2-25
2.1.4.1	Water Balances	2-25
2.1.5	Waste Discharge of Well Water	2-28
Chapter 2.2	POTENTIAL WATER CONSERVATION MEASURES	2-34
2.2.1	Introduction	2-34
2.2.2	Sidestream Softening of Boiler Blowdown	2-34
2.2.2.1	Lime Softening	2-36
2.2.2.2	Ion Exchange Softening	2-36
2.2.2.3	Applicability at NOS	2-41
2.2.3	Condensate Return	2-41
2.2.3.1	Previous Condensate Return Study	2-43
2.2.3.2	Applicability at NOS	2-44
2.2.4	Alternative Cooling Systems	2-44
2.2.4.1	Cooling Towers	2-44
2.2.4.2	River Water for Cooling	2-46
2.2.4.3	Temperature Actuated Valves	2-46
2.2.4.4	Applicability at NOS	2-46
2.2.5	Water Conservation Associated with Sanitary Fixtures	2-49
2.2.5.1	Water-Saving Toilets	2-50
2.2.5.2	Flow Restriction	2-50
2.2.5.3	Pressure Reducing Valves	2-51
2.2.5.4	Applicability at NOS	2-51
2.2.6	Conservation in Photographic Processing	2-51
2.2.6.1	Applicability of NOS	2-52
Chapter 2.3	APPLICABLE WELL WATER CONSERVATION MEASURES AND ECONOMIC EVALUATIONS	2-53
2.3.1	Projected Well Water Use Through the Year 1990 for the NOS, Indian Head	3-53
2.3.2	NOS Employee Water Conservation Awareness	2-54

TABLE OF CONTENTS (Cont'd.)

Chapter No.	Title	Page No.
2.3.3	Conversion of Low Silica Well Water Use Areas to High Silica Well Water	2-59
2.3.4	Sanitary Water Savings	2-63
2.3.4.1	Water-Saving Sanitary Fixtures	2-64
2.3.4.2	Pressure Reducing Valves	2-67
2.3.5	Reduction of Well Water for Once-Through Cooling Water Use	2-67
2.3.5.1	Manual Controls	2-71
2.3.5.2	Existing Equipment Modifications	2-71
2.3.5.2.1	Solenoid Valve Installation	2-71
2.3.5.2.2	Utilization of Potomac River Water for Equipment Cooling	2-74
2.3.6	Conversion of Washdown Water from Well Water to River Water	2-81
2.3.7	Installation of Cooling Towers to Reduce Once-Through Cooling Water	2-89
2.3.7.1	Environmental Test Area Regional Cooling Tower	2-90
2.3.7.2	Pilot Processes Area Regional Cooling Tower	2-90
2.3.7.3	Multi Base Area Regional Cooling Tower	2-94
2.3.7.4	Goddard Power Plant Cooling Tower	2-94
2.3.7.5	Cooling Tower Summary	2-96
2.3.8	Economic Evaluation	2-99
2.3.8.1	Economic Evaluations of the Various Alternatives	2-99
2.3.8.2	Intermediate Well Water Conservation Measures	2-99
2.3.8.3	Sanitary Water Use Reduction	2-103
2.3.8.4	Reduction of Once-Through Well Water for Equipment Cooling and Area Washdown	2-103
2.3.8.4.1	Conversion of Low Silica Use Areas to High Silica Supply	2-103
2.3.8.4.2	Solenoid Valve Installation	2-104
2.3.8.4.3	Conversion to Potomac River Water for Once-Through Cooling	2-104
2.3.8.4.4	Conversion of Washdown Water to Potomac River Water	2-105
2.3.8.4.5	Regional Cooling Towers	2-105
Chapter 2.4	RECOMMENDED WELL WATER CONSERVATION MEASURES	2-107
2.4.1	Selection of Recommended Measures	2-107
2.4.2	Cost Estimates of Recommended Water Conservation Measures	2-109

TABLE OF CONTENTS (Cont'd.)

Chapter No.	Title	Page No.
2.4.3	Savings/Investment Ratios of Recommended Measures	2-111
2.4.4	Projected Well Water Use Reduction	2-114
	REFERENCES	
3	WELL SURVEY AND HYDROGEOLOGICAL STUDY	
Chapter 3.1	SURVEY OF EXISTING WELLS, PUMPS, AND STORAGE TANKS	3-1
3.1.1	Survey of Wells and Pumps	3-1
3.1.1.1	Well 2 (New), Also Known as Well 2A	3-6
3.1.1.2	Well 6	3-7
3.1.1.3	Well 7	3-7
3.1.1.4	Well 15	3-8
3.1.1.5	Well 17	3-8
3.1.1.6	WEll 18	3-9
3.1.1.7	Well A (No. 24)	3-9
3.1.1.8	Well B (No. 23)	3-10
3.1.1.9	Well 3A	3-11
3.1.1.10	Well 5	3-12
3.1.1.11	Well 9	3-13
3.1.1.12	Well 12	3-14
3.1.1.13	Well 14	3-15
3.1.1.14	Well 16	3-15
3.1.1.15	Other Wells	3-15
3.1.2	Survey of Storage Tanks	3-17
3.1.2.1	Tank 1 (Building 867)	3-18
3.1.2.2	Tank 2 (Building 784)	3-19
3.1.2.3	Tank 3 (Building 896)	3-19
3.1.2.4	Tank 4 (Building 1533)	3-19
3.1.2.5	Ground Storage Tank (Building 898)	3-19
Chapter 3.2	HYDROGEOLOGY	3-20
3.2.1	General Aquifer Description	3-20
3.2.2	Patuxent and Arundel Clay Formations	3-24
3.2.3	Patapsco and Raritan Formations	3-28
Chapter 3.3	WATER TREATMENT FOR IRON REMOVAL EVALUATION	3-32
3.3.1	Evaluation of Groundwater Quality, Wells 3A and 16	3-33
3.3.2	Present Water Treatment	3-35

TABLE OF CONTENTS (Cont'd.)

Chapter No.	Title	Page No.
3.3.3	Water Treatment Methods for Iron Removal	3-35
3.3.4	Alternative Evaluation	3-36
3.3.4.1	Aeration/Sedimentation/Filtration (Alternative 1)	3-36
3.3.4.2	Aeration/Chemical Oxidation/Sedimentation/Filtration (Alternative 2)	3-37
3.3.4.3	Coagulation/Sedimentation/Filtration (Alternative 3)	3-37
3.3.4.4	Manganese Zeolite Process (Alternative 4)	3-37
3.3.5	Recommended Alternative	3-38
Chapter 3.4	WATER USE AND WELL CAPACITIES	3-41
3.4.1	Current and Historical Water Use and Well Yields	3-41
3.4.2	Recommended Monitoring Program	3-44
3.4.3	Decreased Yields from Wells 2 (New) and B	3-47
3.4.4	Low Silica Supply Contingency Evaluation	3-48
3.4.5	High Silica Supply Contingency Evaluation	3-51
Chapter 3.5	USABLE LIFE OF EXISTING WELLS	3-55
3.5.1	Anticipated Corrosion Problems at NOS	3-55
3.5.1.1	Remedial Actions Related to Corrosion	3-58
3.5.2	Anticipated Incrustation Problems at NOS	3-59
3.5.2.1	Remedial Actions Related to Incrustation	3-59
Chapter 3.6	AQUIFER DEVELOPMENT POTENTIALS	3-61
3.6.1	Estimated Aquifer Yields	3-61
3.6.1.1	Estimated Yield from the Lower Sand	3-62
3.6.1.2	Estimated Yield from the Patuxent Formation	3-64
3.6.2	Differentiated Water Quality Areas	3-64
3.6.3	Potential Well Locations	3-66
3.6.3.1	Potential High Silica Well Installations at NOS	3-67
3.6.3.2	Potential Low Silica Well Installations at NOS	3-69
3.6.3.3	Potential High Silica Well Installation along the White Plains Railroad	3-70
Chapter 3.7	RECOMMENDED WELL WATER SUPPLY IMPROVEMENTS	3-72
3.7.1	Summary	3-72
3.7.1.1	Condition of Existing Wells, Pumps, and Storage Tanks	3-72
3.7.1.2	Water Treatment for Iron Removal, Wells 3A and 16	3-72

TABLE OF CONTENTS (Cont'd.)

Chapter No.	Title	Page No.
3.7.1.3	Hydrogeological Evaluation	3-73
3.7.2	Alternatives for Increasing Well Water Supply	3-74
3.7.3	Well Water Supply Recommendations	3-76
3.7.4	Recommended Improvements to the Well, Pump and Storage System	3-78
3.7.5	Cost Estimate of Recommended Well Water System Actions	3-78
	REFERENCES	3-80
APPENDICES	VOLUME II	
2-A	Historical Well Pumping Records Working Data Sheets	
2-B	Completed Water Use Survey Working Data Forms	
2-C	Evaporative Losses Calculation	
2-D	Cost Estimate Development	
2-E	Recommended Potable Water Conservation Cost Estimates	
3-A	Well Inventory Records	
3-B	Storage Tanks Inspection Report	
3-C	Monthly Pumping Tables	
3-D	MCA Test Well Records	
3-E	Cost Estimates	

LIST OF TABLES

Table No.	Title	Page No.
1	Summary of Seasonal Well Water Consumption	xv
2	Summary of Water Conservation Alternatives and Uniform Annual Costs	xviii
3	Summary of Well Water Use After Implementation of Recommended Water Conservation Measures	xxi
4	Savings/Investment Ratios of Applicable Water Water Conservation Alternatives[a]	xxiii
5	Well Water Supply System Recommendations And Cost Estimates	xxxi
2.1-1	Seasonal Low Silica Water Pumping Summary	2-3
2.1-2	Seasonal High Silica Water Pumping Summary	2-4
2.1-3	Maximum Quantity of Water Through Pipe	2-9
2.1-4	Combined Low Silica and High Silica Weekly Average Seasonal Balances	2-12
2.1-5	Low Silica Seasonal Balances	2-14
2.1-6	Area Low Silica Seasonal Balances	2-15
2.1-7	High Silica Seasonal Balances	2-17
2.1-8	Area High Silica Seasonal Balances	2-18
2.1-9	Estimated Seasonal Well Water Discharges	2-30
2.2-1	Descriptors Used in Computer Literature Search	2-35
2.2-2	Lime Softening Advantages and Disadvantages	2-40
2.2-3	Ion Exchange Softening Advantages and Disadvantages	2-42
2.2-4	Comparative Summary, Dry Versus Wet Cooling	2-45
2.3-1	Intermediate Water Conservation Measures and Estimated Savings	2-57
2.3-2	Example of NOS Employee Education Material	2-58
2.3-3	Conversion of Low Silica Well Water Use for NOS Air-Assisted Toilet Cost Estimate	2-60
2.3-4	Manpower Projection and Sanitary Water Use for NOS	2-65
2.3-5	Air-Assisted Toilet Cost Estimate	2-66
2.3-6	Seasonal Once-Through Cooling Water Summary	2-69
2.3-7	Measures Considered for Reducing Once-Through Cooling Water	2-72

LIST OF TABLES (Cont'd.)

Table No.	Title	Page No.
2.3-8	Solenoid Installation to Reduce Once-Through Cooling Water	2-75
2.3-9	Potomac River Water Quality at Buoy 54 Off Indian Head	2-79
2.3-10	Well Water Volume Reduction by Conversion to River Water for Cooling	2-83
2.3-11	Summary of Well Water Used for Area Washdown	2-86
2.3-12	Regional Cooling Tower #1 Equipment List	2-92
2.3-13	Regional Cooling Tower #2 Equipment List	2-93
2.3-24	Regional Cooling Tower #3 Equipment List	2-95
2.3-15	Regional Cooling Tower #4 Equipment List	2-97
2.3-16	Summary Comparison of Cooling Tower Installation	2-98
2.3-17	Summary of Water Conservation Alternatives and Uniform Annual Costs	2-100
2.4-1	Summary of Well Water Conserved by Recommended Conservation Alternatives	2-108
2.4-2	Capital Costs of Recommended Water Conservation Measures	2-110
2.4-3	Savings/Investment Ratio of Applicable Water Conservation Alternatives	2-112
2.4-4	Summary of Well Water Use After Implementation of Recommended Water Conservation Measures	2-115
3.1-1	NOS Wells and Present Status	3-2
3.3-1	Results of Chemical Analyses of Groundwater From Wells 3A and 16	3-34
3.4-1	Estimated Maximum Well Water Supply at NOS	3-45
3.7-1	Well Water Supply System Recommendations and Cost Estimates	3-79

LIST OF FIGURES

Figure No.	Title	Page No.
1	Historical Annual Well Water Pumping	xiv
2.1-1	Schematic of NOS, Indian Head, Maryland	2-6
2.1-2	Schematic of the Well Water Distribution Network	2-10
2.1-3	Winter Total Well Water Diurnal Balance	2-21
2.1-4	Summer Total Well Water Diurnal Balance	2-22
2.1-5	Winter Low Silica Diurnal Balance	2-23
2.1-6	Summer Low Silica Diurnal Balance	2-24
2.1-7	Winter High Silica Diurnal Balance	2-26
2.1-8	Summer High Silica Diurnal Balance	2-27
2.2-1	Sidestream Softening of Boiler Blowdown	2-37
2.2-2	Lime Softening Reactions	2-38
2.2-3	Process Flow Schematic for Lime Softening	2-39
2.2-4	Simplified Schematics of Combination Dry-Wet Cooling Towers	2-47
2.2-5	Schematic Representation of Three Parallel Air Flow Configurations of Combination Dry-Wet Cooling Systems	2-48
2.3-1	Typical Pressure Reducing Station	2-68
2.3-2	Typical Solenoid Valve Installation	2-73
2.3-3	Typical River Water Connection to Process Building	2-82
2.3-4	Regional Cooling and Associated Equipment	2-91
3.1-1	Well Location Map	3-3
3.1-2	Group 1 Wells	3-4
3.2-1	Generalized Lithologic Column for the Indian Head Area	3-21
3.2-2	Generalized Cross-Section Showing Stratigraphy of Indian Head Area	3-23
3.2-3	Cross-Section at NOS Using Lithologic Logs of Wells	3-26
3.2-4	Cross-Section at NOS Using Lithologic Logs of Wells	3-27
3.2-5	Estimated Potentiometric Surface Map for the LowerSand of the Patapsco and Raritan Formations	3-30
3.4-1	Monthly Pumpage Rates for Wells Producing High Silica Water	3-42
3.4-2	Monthly Pumpage Rates for the Wells Producing Low Silica Water	3-43

LIST OF FIGURES (Cont'd.)

Figure No.	Title	Page No.
3.4-3	Total Monthly Pumpage Compared to Measured Monthly Water Level in Well 19	3-46
3.4-4	Critical Time During Winter Water Use	3-49
3.4-5	Critical Time During Summer Water Use	3-50
3.4-6	Estimated Critical Times During Winter Water Use (High Silica)	3-53
3.4-7	Estimated Critical Times During Summer Water Use (High Silica)	3-54
3.5-1	Length of Well Use at NOS	3-57
3.6-1	Area Extent of Groundwater Quality Types	3-65
3.6-2	Potential High Silica Well Location at Site of MCA 1 Test Well	3-68

SUMMARY AND CONCLUSIONS

This report presents the findings of Water Conservation and Groundwater Supply studies at the Naval Ordnance Station (NOS) in Indian Head, Maryland. The primary goals of the studies were to determine present and future potable water use, recommend potable water conservation measures, and to investigate new sources of potable water at NOS.

SUMMARY OF FINDINGS

Water Conservation Study

The Water Conservation Study consisted of three broad tasks. First, the existing and projected 10-yr well water intake, use and discharge patterns at NOS were defined. Secondly, potentially feasible alternatives of reducing well water consumption were identified and then screened for applicabilty at NOS. Finally, the potentially applicable alternatives were economically evaluated to select the most cost-effective means of reducing NOS well water consumption.

Well Water Intake, Use and Discharge. The NOS well water distribution system is subdivided into high silica and low silica water supplies. The low silica supply is important in providing boiler make-up water to the Goddard Power Plant. A summary of the average seasonal well water intake, based on historical NOS pumping records, is the following:

High Silica System

Summer	3,639,000 gal/wk
Winter	3,049,000 gal/wk

Low Silica System

Summer	3,986,000 gal/wk
Winter	4,253,000 gal/wk

NOS Total

Summer	7,625,000 gal/wk
Winter	7,302,000 gal/wk

Figure 1 indicates that there was a slight upward trend in total well water pumping between 1976 and 1981. This upward trend appears to be related primarily to increases in high silica pumping.

The survey of well water uses determined that the Goddard Power Plant (GPP) consumes the most well water at NOS, and the majority of this use is low silica water. Well water for sanitary uses by station residents and employees accounts for the next largest well water consumption, which is entirely high silica water. A summary of the seasonal average consumption of high silica and low silica well water is presented in Table 1.

Well water pumped to NOS facilities is discharged in the following ways: to the Potomac River and Mattawoman Creek, to the various sanitary treatment facilities, to the ground, and to the atmosphere. Water from other sources is also discharged in these same ways. These other sources of water include inflow/infiltration of stormwater and groundwater into the wastewater collection system, river water discharges from cooling and washdown in some production areas, and river water discharges from the

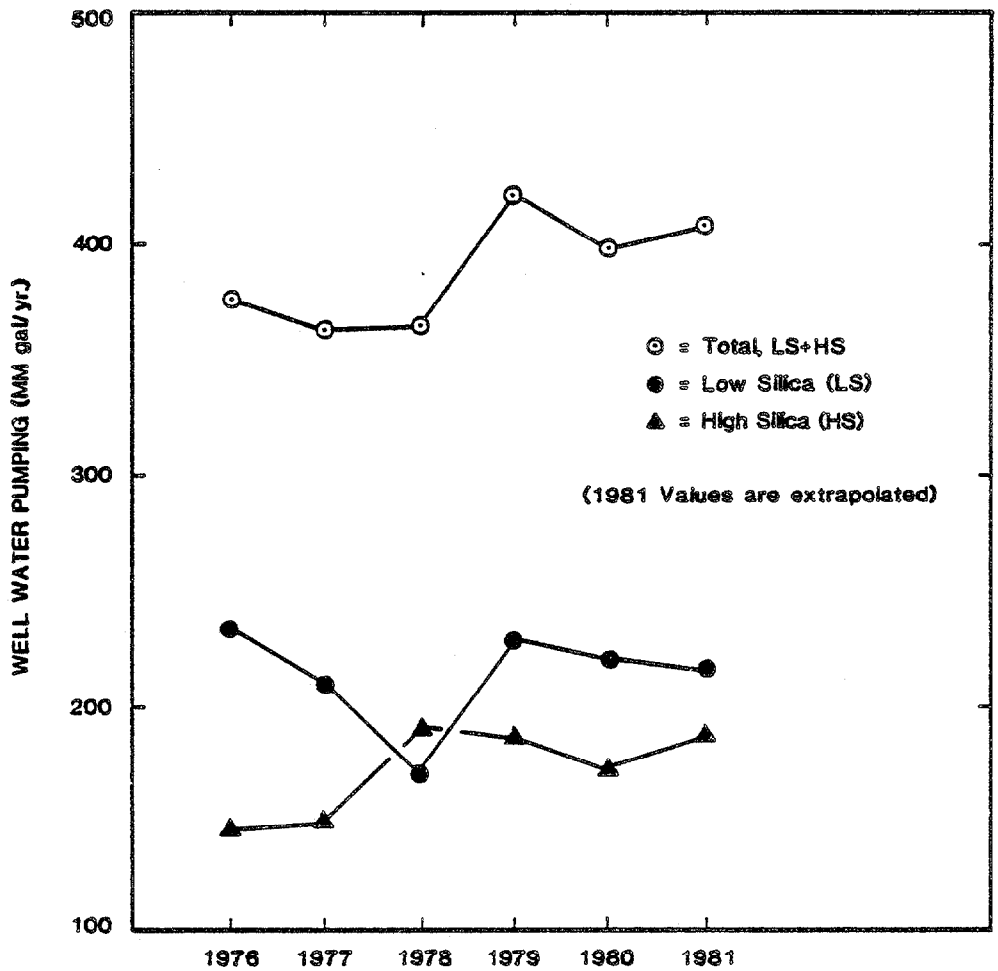


FIGURE 1 HISTORICAL ANNUAL WELL WATER PUMPING

SUMMARY AND CONCLUSIONS

TABLE 1

SUMMARY OF SEASONAL WELL WATER CONSUMPTION

Well Water Source	Summer (gal/wk)	Winter (gal/wk)
High Silica		
GPP	1,290,500	78,800
Sanitary Uses	1,134,300	1,134,300
Other Uses	1,292,200	1,229,400
Total	3,717,000	2,442,500
Low Silica		
GPP	2,678,400	3,623,700
Sanitary Uses	0	0
Other Uses	918,600	918,600
Total	3,597,000	4,542,300
NOS Total		
GPP	3,968,900	3,702,500
Sanitary Uses	1,134,300	1,134,300
Other Uses	2,210,800	2,148,000
Total	7,314,000	6,984,800

routine testing of the fire protection sprinkler system. A summary of the average seasonal water discharges is the following:

Summer

Potomac River and Mattawoman Creek	5,898,200 gal/wk
Sanitary Treatment Facilities	478,900 gal/wk
Ground	2,028,000 gal/wk
Atmosphere	223,000 gal/wk
Total	8,628,100 gal/wk

Winter

Potomac River and Mattawoman Creek	4,767,500 gal/wk
Sanitary Treatment Facilities	478,200 gal/wk
Ground	2,693,100 gal/wk
Atmosphere	355,800 gal/wk
Total	8,295,300 gal/wk

Potentially Feasible Water Conservation Alternatives. A literature survey identified a large number of water conservation methods for both sanitary and industrial applications. Many of the sanitary water conservation methods were not applicable to NOS. The major areas, where water conservation methods could potentially be technically and economically implemented, included the following:

1. Reduction of once-through cooling water use by various means.
2. Return of steam condensate.
3. Water-saving sanitary fixtures.
4. Increased employee water conservation awareness.
5. Water reuse at wastewater treatment plants.

Economic Evaluation of Water Conservation Alternatives. Cost estimates were prepared for each technically feasible water conservation

alternative. To provide a common unit of comparison for all alternatives, the cost estimates were divided by the projected water savings to determine the uniform annual cost per unit water savings for each alternative. This information is presented in Table 2.

Well water conservation recommendations were made on the basis of the economic evaluation data in Table 2. The recommended water conservation measures are the following:

1. Various low-cost, readily-implemented intermediate measures, which would conserve an annual average of 763,800 gal/wk at an average uniform annual cost per unit water savings of $0.05/1,000 gal.
2. Installation of system-wide pressure reducing valves on the water mains to the base housing and office areas. This measure is estimated to conserve 417,400 gal/wk at a uniform annual cost per unit water savings of $1.93/1,000 gal.
3. Conversion to Potomac River water for equipment cooling in 36 buildings, which is estimated to conserve an annual average of 1,780,000 gal/wk at a uniform annual cost per unit water savings of $0.45/1,000 gal.

Implementation of the recommended water conservation measures would conserve estimated annual averages of 871,000 gal/wk low silica water and 2,090,000 gal/wk high silica water. NOS would realize reductions of approximately 20 percent in the current low silica water use and 60 percent in the current high silica water use. This information is summarized in Table 3.

TABLE 2

SUMMARY OF WATER CONSERVATION ALTERNATIVES AND UNIFORM ANNUAL COSTS

Area/Building	Water Conservation Alternative(s)	Current Water Use (gal/wk)	Projected Water Use (gal/wk)	Uniform Annual Cost of Installation ($)	Uniform Annual Cost per Unit Water Savings ($/1,000 gal)
INTERMEDIATE WELL WATER CONSERVATION MEASURES					
Multi Base Building 704	Supply cooling water only to equipment in operation.	22,000	0	0	0.00
Pumphouse No. 1 Building 128	Eliminate the overflow from the grit chamber through operation/pumping capacity.	290,000	0	886	0.06
Spray Cooling Pond Building 137	Install a float make-up control to eliminate overflow of make-up cooling water.	79,000	0	406	0.10
Package Waste Treatment Plant Building 1563	Repair valve on water tap.	30,000	0	50[a]	0.03
Waste Treatment Plants Buildings 511C and 1470	Convert to use of treated effluent for injection of chlorine.	342,800	0	585	0.03
SANITARY WATER USE REDUCTION					
Housing and Offices	Installation of system-wide pressure reducing values.	1,391,300[d]	973,900[d]	41,940	1.93
CONVERSION OF LOW SILICA WELL WATER SUPPLY TO HIGH SILICA WELL WATER SUPPLY					
Multi Base Area		208,450[b]	208,450[b]	2,607[c]	
Pilot Processes Area		90,150[b]	90,150[b]	1,986[c]	
Cast Products Area		51,400[b]	51,400[b]	2,265[c]	
		350,000	350,000	6,858	

THE RUARE CORPORATION

TABLE 2 (Cont'd)

SUMMARY OF WATER CONSERVATION ALTERNATIVES AND UNIFORM ANNUAL COSTS

Building	Water Conservation Alternative(s)	Current Water Use (gal/wk)	Projected Water Use (gal/wk)	Uniform Annual Cost of Installation ($)	Uniform Annual Cost per Unit Water Savings ($/1,000 gal)
REDUCTION OF ONCE-THROUGH COOLING WATER					
Multi Base Cast Products CAD Environmental Testing Pilot Processes Nitration Base Dispensary Power Plant Photo Processing	Solenoid valves[e]	1,811,750[f]	1,268,200[f]	69,250	2.45
LOW SILICA WELL WATER CONVERSION TO POTOMAC RIVER FOR ONCE-THROUGH COOLING					
Multi Base Cast Products CAD Environmental Testing Pilot Processes Nitration Base Dispensary Power Plant	Conversion to Potomac River water for once-through equipment cooling water.[g]	1,779,950[h]	0	41,405	0.45
CONVERSION OF WASHDOWN WATER FROM WELL WATER TO RIVER WATER					
Power Plant Multi Base Cast Products	Conversion to Potomac River water for area washdown water.[i]	27,050	0	43,900[j]	31.21[j]
Extruded Materials Enviornmental Testing Organic Chemicals Nitration Waste Treatment		27,050	0	31,450[k]	22.36[k]

THE AWARE CORPORATION

TABLE 2 (Cont'd)

SUMMARY OF WATER CONSERVATION ALTERNATIVES AND UNIFORM ANNUAL COSTS

Building	Water Conservation Alternative(s)	Current Water Use (gal/wk)	Projected Water Use (gal/wk)	Uniform Annual Cost of Installation ($)	Uniform Annual Cost per Unit Water Savings ($/1,000 gal)
INSTALLATION OF COOLING TOWERS TO REDUCE ONCE-THROUGH COOLING WATER					
Environmental Testing	Regional cooling tower installations.	390,150	8,085	15,100	0.76
Pilot Processes		138,800	3,035	17,791	2.52
Multi Base		167,500	4,045	18,882	2.22
Goddard Power Plant		1,290,000	20,215	12,285	0.19
		1,986,450	35,380	64,058	0.63

[a]Cost is estimated for 1 year payment. No capital costs are anticipated for future operation other than operation or maintenance which should be negligible.

[b]Low silica well water supply converted to high silica well water supply.

[c]Well water is not conserved by this alternative. Low silica well water use is converted to high silica well water use.

[d]Value based on 1984 peak estimated sanitary demand.

[e]A listing of the buildings designated for installation of solenoid values is contained in Table 3.4-3.

[f]Average value for summer and winter operating conditions.

[g]A listing of the buildings to be converted to Potomac River water for once-through cooling are found in Table 3.4-5.

[h]Average value for summer and winter operating conditions.

[i]A listing of the buildings considered in this alternative are found in Table 3.5-1.

[j]This value considers having to tap the river water distribution system approximately 100 ft from the building.

[k]This value is based on connection to the river water distribution system, used as once-through equipment cooling water, inside the building and only requiring inside pipe runs.

THE AUBRE CORPORATION

TABLE 3

SUMMARY OF WELL WATER USE AFTER IMPLEMENTATION
OF RECOMMENDED WATER CONSERVATION MEASURES

	Low Silca	High Silica	Total
Current pumping, 1,000-gal/wk	4,120[a]	3,344[b]	7,464
Estimated savings from recommended measures, 1,000-gal/wk	871[c]	2,090[c]	2,961
Projected pumping after implementation of conservation measures, 1,000-gal/wk	3,249	1,254	4,503
Percent reduction in use	21%	62%	40%

[a]Value determined by averaging the summer and winter weekly pumping values in Table 2.1-5.

[b]Value determined by averaging the summer and winter weekly pumping values in Table 2.1-7.

[c]Values obtained from Table 2.4-1.

THE AQUARE CORPORATION

The most significant well water use reduction would be achieved by converting to water from the Potomac River for once-through cooling water applications. Implementation of this measure is contingent on a hydraulic network analysis to confirm that all parts of the existing river water distribution system have adequate hydraulic capacity to meet both the cooling water requirements and the fire protection requirements of NAVFAC DM-8. If the hydraulic network analysis determines that river water use for cooling cannot be achieved, then AWARE recommends the cooling tower water conservation alternative be implemented in its place.

In addition to achieving the water conservation goals of NOS, the recommended well water conservation measures also have favorable Savings/Investment Ratios (SIR). The overall SIR of the recommended measures is 2.2, which is determined by comparing the total present value costs of the measures to the present value of the well water cost savings. The well water cost savings are based on the current $0.71/1,000-gal NOS cost for well water. The SIR of the recommended measures, and other measures considered, are presented in Table 4.

Groundwater Supply Study

The Groundwater Supply Study consisted of three broad tasks, also. First, the condition of existing wells, pumps, and storage tanks at NOS were determined, so recommendations for any needed repairs or improvements could be made. Secondly, the aquifer potential was defined, including estimating the usable life of the existing wells and recommending potential new well locations. Finally, alternative treatment methods to improve the water quality of Wells 3A and 16 were investigated.

TABLE 4

SAVINGS/INVESTMENT RATIOS OF APPLICABLE WATER CONSERVATION ALTERNATIVES[a]

Water Conservation Alternative	Projected Water Savings[b] (gal/wk)	Investment: Capital Cost[c] ($'s)	Investment: Annual O & M Cost[d] ($/yr)	Investment: Discounted O & M Cost[d] ($'s)	Investment: Total Present Value Cost ($'s)	Savings: Annual Savings[e] ($/yr)	Savings: Discounted (Present Value) Savings[f] ($'s)	SIR
INTERMEDIATE MEASURES								
Supply cooling water only to operating equipment (Bldg. 704)	22,000	0	0	0	0	810	5,220	--[g]
Eliminate overflow from grit chamber (Bldg. 128)	290,000	3,900	300	1,810	5,710	10,710	69,050	12.1
Install float controller on spray cooling pond (Bldg. 137)	79,000[h]	380	350	2,240	2,620	1,515[h]	9,770	3.7
Repair valve at package WTP (Bldg. 1563)	30,000	<50[i]	0	0	50	1,110	7,160	143.2
Convert to effluent for chlorination at WTP's (Bldgs 511C & 1470)	342,800	1,960	300	1,810	3,770	12,660	81,620	21.6
Subtotal	763,800	6,290	950	5,860	12,150	26,805	172,820	14.2
SANITARY WATER USE REDUCTION	417,400	36,800[j]	300	1,810	38,610	15,410	99,350	2.6
CONVERSION TO RIVER WATER FOR COOLING	1,779,950	260,900[j,k]	1,000	6,040	266,940	65,715	423,660	1.6
SUBTOTAL, RECOMMENDED MEASURES	2,961,150	303,990	2,250	13,710	317,700	107,930	695,830	2.2
OTHER MEASURES CONSIDERED								
Solenoid valves for cooling water control	543,550	134,900[j]	1,600	9,700	144,600	20,070	129,370	0.9
River water conversion for washdown								
with new taps to main	27,050	275,300[j]	1,250	7,550	282,850	1,000	6,450	<0.1
using cooling water taps	27,050	195,110[j]	1,250	7,550	202,660	1,000	6,450	<0.1

THE BLUARE CORPORATION

TABLE 4 (Cont'd.)

SAVINGS/INVESTMENT RATIOS OF APPLICABLE WATER CONSERVATION ALTERNATIVES[a]

Water Conservation Alternative	Projected Water Savings[b] (gal/wk)	Investment: Capital Cost[c] ($'s)	Investment: Annual O & M Cost[d] ($/yr)	Investment: Discounted O & M Cost[d] ($'s)	Investment: Total Present Value Cost ($'s)	Savings: Annual Savings[e] ($/yr)	Savings: Discounted (Present Value) Savings[f] ($'s)	SIR
Cooling Towers								
Environmental Testing	382,050[j]	76,450	3,250	20,730	97,180	14,100	90,900	0.9
Pilot Processes	135,800[j]	99,770	2,350	15,150	114,920	5,010	32,300	0.3
Multi Base	163,450[j]	106,370	2,420	15,600	121,970	6,030	38,900	0.3
Goddard Power Plant	1,269,800[j]	49,500	4,650	29,980	79,480	46,880	302,200	3.8
Subtotal, Cooling Towers	1,951,100[j]	332,090	12,670	81,460	413,550	72,020	464,300	1.1

[a]All costs and savings are presented in 1982 dollars.

[b]Refer to Table 2.3-17.

[c]Refer to Appendix 2-D.

[d]Operations costs calculated for years 0 to 10 with a discount factor of 6.447. Maintenance costs calculated for years 1-10 with a discount factor of 6.042.

[e]Based on current NOS-calculated well water cost of $0.71/1,000-gal.

[f]Discount factor of 6.447 for 10 years.

[g]SIR cannot be calculated, since no costs are incurred for this water savings.

[h]Spray pond overflow can occur approximately 27 wk/yr.

[i]Maintenance item.

[j]Contingency at 10 percent included in these major capital cost items.

[k]Includes hydraulic network analysis at $50,000.

THE DUPRE CORPORATION

Condition of Existing Well Water Supply Facilities. A total of 28 wells and several test holes have been drilled and completed at NOS between 1898 and the present. Eight wells are currently in use, and another six wells are thought to be usable by NOS personnel. The other wells include those that have been used and abandoned in the past, those with low yields, and several test wells. The wells, pumps, and associated piping of the wells currently in use were found to be well-maintained and in satisfactory operating condition. Corrosion of well screens and casings appears to be a cause of decreased yields at many of the NOS wells, as evidenced by "sanding-up." Incrustation also appears to be a cause of decreased yields at several NOS wells, including Wells 2(New) and B(23). General maintenance recommendations include rehabilitate the existing air line assemblies so semi-annual pumping water levels can be recorded and cap all abandoned wells, e.g., Wells 5 and 10.

The existing elevated storage tanks and ground storage tank were found to be in generally good condition. Exterior painting and replacement of the safety rail are recommended for Tank 2 (Building 784). Maintenance-related recommendations include spot-painting of the other three elevated storage tanks; repair of the Tank 2 and Tank 4 (Building 1533) altitude valves; and cleaning and painting of the valves and piping in the valve pit of Tank 3 (Building 896).

Aquifer Potential. The aquifers for the area were identified as the Lower Sand of the Patapsco and Raritan Formation and the Patuxent Formation. These aquifers are present at NOS and extend past the White Plains area. Hydrogeologic evaluations indicate that the theoretical yield of

the aquifers should be 2.28 mgd for the NOS area, but evaluation of the pumping water level trends and the area of influence around NOS indicate the yield may not be that great. The current groundwater withdrawal at NOS from the Lower Sand unit may be the maximum available without further greatly lowering the water levels. The Patuxent aquifer could be further developed; however, it contains many lateral discontinuities and has not been found under the entire NOS area.

Low silica water is obtained from a limited zone in the Lower Sand unit, and no further increase in yield is expected. The wells supplying high silica potable water are meeting the current demand, although the total yield from the wells has decreased. The decrease in yield from the older wells is probably caused by lowered water levels and compounded by partial filling of the wells with sand.

The aquifer and well capacity evaluations identified several ways to increase the high silica water supply for NOS. No areas for installation of new low silica water wells were found; however, construction of a new well in the low silica area would provide a standby or intermittent supplemental low silica water supply. The alternatives identified for increasing the available water supply include the following:

1. Install a pump in Well 14 and begin to use the well, which would have an expected yield of 100 gpm. Use of Well 14 would eliminate the need to drill replacement wells in the Group 2 area.
2. Rehabilitate the existing iron removal system for Well 3A, and install a 1,250 gal tank before the greensand filter to increase the retention time. The use of Well 16 is not recommended, because it would decrease the yield of Well 3A.

3. Construct a standby well for the low silica system. A test well should be drilled in the Olson Road area. If a sufficient supply of low silica water is found, a production well should be constructed. The well cannot be used for continuous pumping, because it would adversely affect the yields from Wells 15 and 17. The standby well should be maintained for critical use periods or should be used alternately with Well 15.
4. Construct a high silica production well at the indicated location on Caffee Road. The use of this well in the high silica system requires conversion of the potable water supply in the Pilot Process area from low silica to high silica use.
5. Acid treat Well B to increase low silica yield.
6. Acid treat Well 2 to increase high silica yield, before drilling test wells at the recommended potential well locations. (Item 8, below).
7. Construct two replacement high silica wells in the Group 1 area. These two wells could increase the yield from the area by replacing Wells 6, 7, and 9 that have declining yields and are pumping sand.
8. Drill test wells at several potential high silica well locations. Install production wells at those locations, if test results indicate usable quantities of water are available. These sites include the area along Bronson Road and the areas along the railroad right-of-way from the NOS boundary to White Plains.

Alternative Treatment Methods for Wells 3A and 16. The water quality for Wells 3A and 16 was reviewed for water treatment alternatives. The recommended iron and manganese removal system is the manganese greensand process, similar to that already installed at Well 3A. Use of Well 3A will require rehabilitation of the presently installed system and addition of a storage tank to increase the retention time before treatment through the greensand unit. Well 16 is now capped. It is recommended that Well 16 not be used, because its proximity to Well 3A would reduce the yield from 3A.

Well Water Supply Recommendations. The water conservation recommendations in Chapter 2.4 of this report would enable reductions in water use of approximately 20 percent for low silica water and approximately 60 percent for high silica water. Water use reductions of these magnitudes would eliminate the immediate need to increase water supply. The recommended water conservation measures to reduce the use of high silica water eliminate the need to develop new sources of high silica water at this time.

The current high silica well system should adequately supply the predicted demand after implementation of the recommended water conservation measures. It is recommended, however, that the greensand iron removal system at Well 3A be rehabilitated to provide additional high silica water supply reserve capacity. The only potential problem associated with the rest of the high silica system is the sand problem occuring in the older wells, but the remaining life of these wells cannot be predicted with any certainty. Future improvements will be needed in the high silica system to replace wells that fill with sand and cannot be repaired due to age. Wells 6, 7, and 9 in Group 1 will need to be replaced when they begin

pumping excessive sand, because their age makes repairing well casings and screens unfeasible. It is recommended that when the wells in Group 1 are replaced, they be replaced by only two new production wells.

The reduction in low silica water use by the recommended water conservation measures is significant; however, in the event of pumping equipment failure, critical shortages could occur. No additional aquifers producing low silica water were identified in this study; it is doubtful that other low silica aquifers exist in the Indian Head region. Recommendations are directed toward improving the existing wells and providing for standby capacity.

It is recommended that Well B (23) be acid treated to increase its yield. The acid treatment must be accompanied by agitation with high pressure horizontal jets or swabbing the inside of the screens with wire brushes. The use of high pressure jetting or wire brushes will more effectively clean incrustation from the well screen. Improvement in the Well B yield will add to the available low silica supply.

[redacted] It is recommended that a test well be drilled along Olson Road to identify available water producing sand zones and to determine the quality of the groundwater at the site. If usable amounts of low silica water are present, it is recommended that a standby production well be completed at the location. Continuous pumping of the standby well would reduce the current yield from Wells 15 and 17. The standby well could either be pumped alternately with Well 15 or be maintained as a standby or supplemental well for short term use.

Cost estimates for the recommended actions for the well water supply system are summarized in Table 5.

CONCLUSIONS

Implementation of the recommended well water conservation measures should enable NOS to obtain its potable water requirements for the next ten years. New production wells for high silica water and acid treatment of existing high silica wells, e.g., Well 2, will not be required unless some of the existing wells fill with sand. No new sources of low silica groundwater in the NOS area were identified in this study. The low silica well water capacity should be reinforced by acid treating Well B(23) and by installing a standby low silica well, if a test well site with adequate yield can be located.

Recommended water conservation actions include the following:

1. Implement the intermediate measures.
2. Install system-wide pressure reducing valves on the water mains to the station's housing and office areas.
3. Convert to Potomac River water for equipment cooling at 36 buildings.
4. Implement an employee water conservation awareness program.

The most significant well water use reduction would be achieved by converting to water from the Potomac River for once-through cooling water applications. Implementation of this measure is contingent on a hydraulic network analysis to confirm that all parts of the existing river water distribution system have adequate hydraulic capacity to meet both the cooling water requirements and the fire protection requirements of NAVFAC

TABLE 5

WELL WATER SUPPLY SYSTEM RECOMMENDATIONS AND COST ESTIMATES

Recommendation	Estimated Cost[a]
Paint and repair elevated storage tank #2	$ 15,000
Acid treat low silica Well B (23)	$ 20,000
Drill test well at potential low silica site on Olson Road	$ 19,600
Complete production well at site on Olson Road, if test well is successful	$137,200
Rehabilitate the iron removal system at Well 3A	$ 28,100

[a]1982 dollars. Detailed cost estimates are included in Appendix 3-E.

DM-8. If the hydraulic network analysis determines that river water use for cooling cannot be achieved, then AWARE recommends the cooling tower water conservation alternative be implemented in its place.

Recommended well water supply and distribution actions, besides normal maintenance items, include the following:

1. Paint and repair elevated storage Tank 2 (Building 784).
2. Acid treat low silica Well B(23).
3. Drill a test well at the potential low silica water site on Olson Road.
4. Install a standby low silica production well at the site on Olson Road, if the test well is successful.
5. Rehabilitate the iron-removal system at Well 3A.

Items that should be achieved during the course of the station's normal maintenance are rehabilitation of the existing air line assemblies on pumps; spot painting and minor mechanical repairs at Tanks 1, 3, and 4; and installation of caps or covers on Wells 5 and 10.

A completed DD Form 1391 for the recommended well water conservation and well water supply and distribution actions is presented in the following pages.

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
NAVY		28 MAY 1982

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
NAVAL ORDNANCE STATION INDIAN HEAD, MD	POTABLE WATER IMPROVEMENT

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST (SCCO)
			650

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST (SCCO)
WATER CONSERVATION ALTERATIONS				231
INTERMEDIATE MEASURES	LS			(6)
PRESSURE REDUCING VALVES	LS			(33)
RIVER WATER FOR COOLING	LS			(192)
WELL WATER SUPPLY AND DISTRIBUTION				220
PAINT AND REPAIR STORAGE TANK	LS			(15)
ACID TREAT WELL B	LS			(20)
TEST WELL	LS			(20)
STANDBY LOW SILICA WELL	LS			(137)
REHABILITATE GREENSAND SYSTEM, WELL 3A	LS			(28)
SUBTOTAL				451
CONTINGENCY (10%)				45
ENGINEERING ESTIMATE (FY 82)				496
ENGINEERING DESIGN (15%)				74
FIELD ENGINEERING INSPECTION (6%)				30
HYDRAULIC NETWORK ANALYSIS	LS			50
FY 82 BUDGET ESTIMATE				650

10. DESCRIPTION OF PROPOSED CONSTRUCTION

Provide water conservation alterations to the potable water system where technically and economically feasible. Paint and repair an elevated water storage tank. Increase the yield of well water and provide standby capacity for the stations power plant.

11.

PROJECT: Reduce volume of well water consumption. Improve the well water supply and distribution system.

REQUIREMENT: Project required to assure adequate potable water supply for manufacturing requirements and for steam power production.

CURRENT SITUATION: The Naval Ordnance Station Indian Head uses well water for its many sanitary and production requirements where a lesser quality water supply is adequate or where a more conservative approach to use of well water is technically and economically feasible. Many of the wells at Naval Ordnance Station are no longer pumping at full capacity.

IMPACT IF NOT PROVIDED: Continued use at present conditions could result in a shortage of well water. This would disrupt the present Naval Ordnance Station activities. Future activities would require re-evaluation.

1. COMPONENT NAVY	FY 19 82 MILITARY CONSTRUCTION PROJECT DATA	2. DATE

3. INSTALLATION AND LOCATION
NAVAL ORDNANCE STATION
INDIAN HEAD, MARYLAND

4. PROJECT TITLE	5. PROJECT NUMBER
POTABLE WATER IMPROVEMENT	

MANDATORY STATEMENTS:

A. Pollution prevention, abatement and control:

The volume of sanitary waste to be treated would be decreased. No significant reduction in equipment cooling water would be accomplished through conversion to river water as the cooling medium.

B. Flood hazard evaluation:

Requirements of Executive Order No. 11296 (Flood Hazards) are not applicable.

C. Environmental impact:

D. Facility construction in the NATO area:

Not applicable.

E. Planning in the national capitol region:

Not applicable.

F. Fallout shelter construction:

Not applicable.

G. International balance of payments procedures:

Not applicable.

H. Preservation of historical sites and structures:

The project facilities do not directly or indirectly affect a district, site, building, structure, object, or setting which is listed in the National Register or otherwise possesses a significant quality of American History.

I. Design for accessibility of physically handicapped personnel:

Provisions for physically handicapped personnel are not required in this facility.

1. COMPONENT	FY 1982 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
NAVY		

3. INSTALLATION AND LOCATION
NAVAL ORDNANCE STATION
INDIAN HEAD, MARYLAND

4. PROJECT TITLE	5. PROJECT NUMBER
POTABLE WATER IMPROVEMENT	

J. "New Start" criteria for commercial or industrial activities program:

The requirements of Office of Management and Budget Circular A-76 are not applicable.

SECTION 1

INTRODUCTION

CHAPTER 1.1

INTRODUCTION

1.1.1 OVERVIEW

The Chesapeake Division, Naval Facilities Engineering Command (CHESNAVFACENGCOM) retained The AWARE Corporation (AWARE, Inc.) to perform water conservation and groundwater supply studies at the Naval Ordnance Station (NOS), Indian Head, Maryland. This draft final report presents the findings and recommendations from the studies.

NOS obtains groundwater from wells on the base. This water is used for all potable and production requirements at the facility. Two types of well water, high silica or low silica, are accessible to the NOS. Water for fire protection is obtained from the Potomac River.

The scope of work of the water conservation study is as follows:

1. Identify all well water uses at NOS.
2. Correlate well water uses with the well water pumping records.
3. Identify potential water conservation measures which may be implemented to reduce well water consumption, based on specific circumstances at NOS.
4. Identify final disposition of waste well water discharges.
5. Estimate the ten-year future groundwater needs of the station.

The scope of work for the groundwater study at the station includes:

1. Survey the condition of existing wells, pumping equipment, storage tanks and related equipment.

2. Evaluate alternative methods of water treatment for Wells 3A and 16.
3. Estimate the usable life of existing wells.
4. Evaluate aquifer potential and recommend potential well locations.

Based on the results of the water conservation and groundwater supply studies, the scope of work includes the following summary tasks:

1. Prepare cost estimates of all recommended actions.
2. Prepare an economic analysis of all recommended alternatives.
3. Complete DD Form 1391 and facility study forms for the recommended actions.

1.1.2 INDUSTRY BACKGROUND INFORMATION

Two major sectors of explosives manufacturing are the military and the commercial sectors. Military plants are involved in bulk manufacturing of explosives and propellants. Military plants performing munitions loading are classified as load, assemble, and pack plants (LAP). Common military explosives are nitroguanidine, trinitrotoluene (TNT), RDX, and Composition B. These are less sensitive explosives and are manufactured in bulk. In addition, the military manufactures sensitive explosives commonly called initiating compounds. Examples of such initiating compounds are mercury fulminate, tetryl, and lead styphnate (lead trinitroresorcinate).

The commercial sector of explosives manufacturing can also be divided into plants manufacturing bulk explosives, propellants and initiating compounds. Others are designated load, assemble, and pack plants. Examples

of explosives manufactured commercially are nitroglycerin (NG), dynamites, and gelatin dynamites. Load, assemble and pack plants typically buy the raw materials and blend explosives on-site in a recipe operation.

The industry is characterized by two major "activities":

1. Manufacture - This involves production of an explosive or propellant or intermediate product from raw materials. Examples of manufacturing include TNT, nitrocellulose, nitroglycerin, nitric acid, sulphuric acid, etc.
2. Load, Assemble, and Pack (LAP) - This involves the loading of an explosive or propellant product into a munition. It also usually involves "blending" of various ingredients in the loading process.

The industry produces three major categories of products: acids, explosives, and propellants. The explosives and propellants are final products, whereas the acids are intermediate products used in the manufacture of such products as TNT and nitrocellulose (NC).

1.1.2.1 Explosives Industry Subcategorization

The classification of the NOS at Indian Head can be established through utilization of the Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Explosives Manufacturing Industry. Initially the industry was divided

into three subcategories. Later, the first subcategory was further subdivided into two more subcategories. The four designated subcategories are as follows:

1. Subcategory A - Manufacture of explosives
2. Subcategory B - Manufacture of propellants
3. Subcategory C - Load, assemble and pack plants
4. Subcategory D - Manufacture of initiating compounds.

1.1.3 NOS BACKGROUND INFORMATION

The Navy operates six ordnance installations, two of which are engaged in the manufacture of explosives (nitroglycerin only) and propellants. These two facilities also engage in load, assemble, and pack (LAP) activities. The NOS at Indian Head, Maryland is one of these. Activities at the NOS include manufacture, testing, and research and development of gun and rocket propellants. Explosives industry Subcategories A, B, and C are descriptive of the NOS at Indian Head. The other four Navy installations are involved only in LAP activities. The Navy manufactures propellants for its own use as well as use by the U.S. Air Force and is a major contractor to the U.S. Air Force for loading of explosives into bombs.

The NOS at Indian Head encompasses about 2,072 acres which is mostly woods, open fields, and gently rolling terrain. It is bordered on two sides by the Potomac River and the Mattawoman Creek, and by the City of Indian Head on the other two sides.

SECTION 2

WATER CONSERVATION STUDY

CHAPTER 2.1

SURVEY OF WATER USES

2.1.1 ASSISTANCE ACKNOWLEDGEMENT

AWARE personnel conducted two on-site surveys of well water uses at NOS. During these on-site survey periods, October 26 through 30 and November 2 through 6, the well water uses investigation was performed. NOS personnel provided the following assistance in the surveys:

1. Copies of the station map for the entire facility and utility maps for each area were provided by the NOS Public Works Department.
2. NOS personnel responsible for maintenance of the well water pumping and storage supplied pumping records for the wells.
3. NOS personnel responsible for the piping network maintenance assisted AWARE personnel in identifying the two well water distribution systems.
4. NOS personnel interviewed concerning well water use were interested and cooperative in responding to questions.
5. CHESDIV personnel supplied AWARE with information concerning the standard value for volume of water to be utilized in developing the sanitary water use.

2.1.2 METHODOLOGY OF WELL WATER USE SURVEY

The methodology used in this study involved the collection (identification of use, frequency, volume of flow quantification, well source),

collation, analysis, and evaluation of data. The data are comprised of values supplied by the CHESNAVFACENGCOM, NOS Public Works personnel, NOS well water pumping and piping maintenance personnel, NOS production personnel, and from observations and measurements made through on-site plant visits.

2.1.2.1 Historical Well Water Use Determination

The NOS Indian Head pumping records for the period January 1976 through June 1981 were used to determine historical water use. This evaluation focused on the wells supplying the NOS at Indian Head. Well water supplied to the Stump Neck area was not considered.

Two types of well water (low silica and high silica) are supplied to the NOS. Low silica water contains approximately 15 mg/l silica, and high silica water contains approximately 30 mg/l silica. The wells supplying low silica water are as follows: B, 15, 17, and 18. Presented in Table 2.1-1 are average seasonal summaries of low silica water pumping. High silica wells used in developing the water balances are as follows: 2, 2A, 3A, 6, 7, 9, 10, 12, 14 and A. Wells 6, 7, and 9 flows are combined at the #1 Pumphouse, and Wells 12 and 14 flows are combined at the #2 Pumphouse. Presented in Table 2.1-2 are average seasonal summaries of high silica water pumping. Low silica water is used primarily to supply the power plant for steam and resin column backwash and rinse. However, the production areas also have access to this supply. High silica water is also available to the production areas. The major use of the high silica water is for sanitary purposes.

The total seasonal weekly average values, found in Tables 2.1-1 and 2.1-2 do not appreciably vary. The low silica weekly average flows during

TABLE 2.1-1

SEASONAL LOW SILICA WATER PUMPING SUMMARY[a]

Season	Month[b]	Well Identification B (gal x 10^3/ month)	15 (gal x 10^3/ month)	17 (gal x 10^3/ month)	18 (gal x 10^3/ month)	Total Average (gal x 10^3 month)
Winter	January	1,248	9,399	5,291	4,284	20,222
	February	1,291	8,726	4,674	4,051	18,742
	March	1,190	8,363	4,904	4,308	18,765
	April	707	8,151	4,286	3,597	16,741
	November	616	9,086	5,534	3,995	19,231
	December	1,151	9,394	6,198	4,383	21,126
	Total Low Silica Weekly Average = 4,253,000 gal/wk[c]					
Summer	May	531	8,467	3,770	2,990	15,758
	June	328	8,313	4,137	2,571	15,349
	July	484	8,689	5,621	2,256	17,050
	August	771	8,037	5,665	2,424	16,897
	September	592	8,494	5,409	2,221	16,716
	October	656	8,786	5,668	2,762	17,872
	Total Low Silica Weekly Average = 3,986,000 gal/wk[c]					

[a]Seasonal division was established from operational mode of the steam generating facilities. The auxillary steam supply is required during the months designated winter.

[b]The averaging period was from January 1976 through June 1981.

[c]Working data sheets for historical well pumping records are presented in Appendix 2-A.

TABLE 2.1-2

SEASONAL HIGH SILICA WATER PUMPING SUMMARY[a]

Season	Month[b]	Well Identification											
		#1[c] Pumphouse (galx10^3/ month)	#2[d] Pumphouse (galx10^3/ month)	2 (galx10^3/ month)	2A (galx10^3)/ month)	3A (galx10^3/ month)	6[e] (galx10^3/ month)	7[e] (galx10^3/ month)	9[e] (galx10^3/ month)	12[e] (galx10^3/ month)	14[e] (galx10^3/ month)	A (galx10^3/ month)	Total Average (galx10^3 month)
Winter	January	2,147	1,106	3,505	826	573	0	991	496	612	0	4,949	15,205
	February	2,241	923	2,637	676	649	0	878	385	555	0	4,237	13,181
	March	2,341	646	2,830	692	345	32	972	38	657	0	4,651	13,198
	April	2,293	795	2,848	809	69	400	915	112	598	0	4,265	13,104
	November	3,222	1,329	3,185	1,206	299	0	0	0	0	0	4,196	13,437
	December	3,215	1,665	3,094	983	514	0	0	0	0	0	4,728	14,199
Total High Silica Weekly Average = 3,049,000 gal/wk[f]													
Summer	May	1,286	957	4,005	1,438	0	470	935	49	597	0	4,574	14,311
	June	2,500	1,153	4,300	1,477	0	355	902	112	224	0	4,473	15,496
	July	3,193	1,930	4,325	1,868	0	0	0	0	0	0	4,521	15,837
	August	3,131	1,897	4,557	1,967	0	0	0	0	0	0	4,408	15,960
	September	2,781	1,419	3,912	1,902	0	0	0	0	0	0	4,414	14,428
	October	3,709	1,485	3,351	1,853	112	0	0	0	0	0	4,441	14,951
Total High Silica Weekly Average = 3,639,000 gal/wk[f]													

[a]Seasonal division was established from operational mode of the steam generating facilities. The auxillary steam supply is required during the months designated as winter.

[b]The averaging period was from January 1976 through June 1981.

[c]Wells 6, 7, 9 are combined to form the flow from Pumphouse #1.

[d]Wells 12 and 14 are combined to form the flow from Pumphouse #2.

[e]The recorded monthly flow was reported for Wells 6, 7, 9 (Pumphouse #1) and Wells 12 and 14 (Pumphouse #2) as individual well flows and as combined well flows. Where no flow is reported for these individual wells it was combined and reported as flow from a pumphouse.

[f]Working data sheets for historical well pumping records are presented in Appendix 2-A.

THE DUPRE CORPORATION

the winter and summer months were determined to be 4,253,000 gal/wk and 3,986,000 gal/wk, respectively. High silica average weekly seasonal flows were 3,049,000 gal/wk and 3,639,000 gal/wk, respectively, for winter and summer periods. The low silica percentage of pumping for total water use of 7,302,000 gal/wk (low silica and high silica) during the winter months was calculated to be 58 percent. Thus, high silica percentage of pumping for total water use was 42 percent. A historical presentation of the well pumping records is found in Section 3, Chapter 3.4 of this report.

2.1.2.2 Data Collection

The facility was divided into several major functional areas as presented in Figure 2.1-1; other lesser use sources were categorized as miscellaneous. The major functional area divisions are as follows:

1. Environmental Testing
2. Cast Products
3. Pilot Processes
4. Nitration
5. Multi-Base
6. Extruded Products and Chemical Processes
7. Power Plant
8. Cartridge Actuated Devices
9. Personnel Housing

Other water uses areas categorized as miscellaneous are:

1. Food preparation facilities
2. Facility laboratories

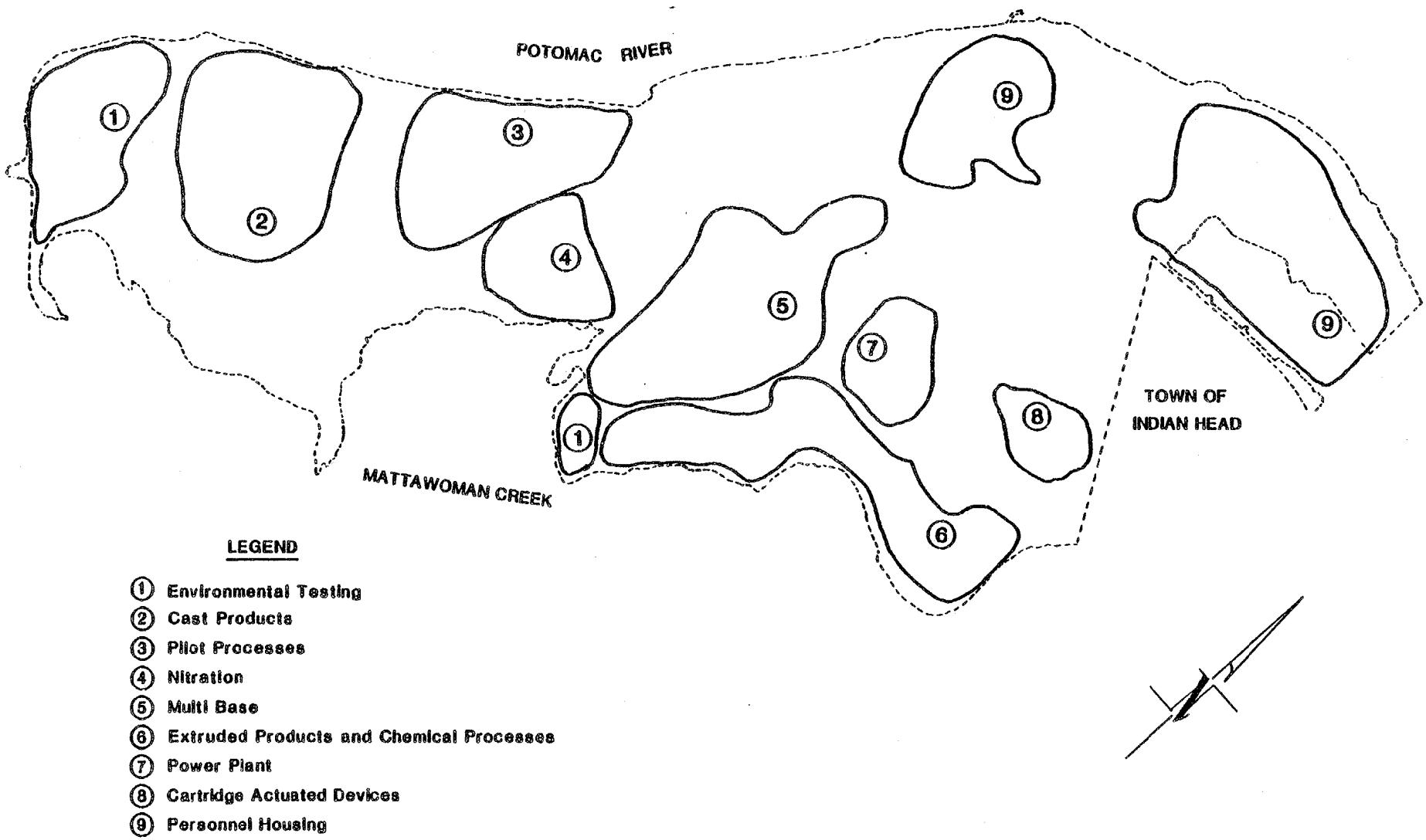


FIGURE 2. 1-1 SCHEMATIC OF NOS, INDIAN HEAD, MARYLAND

3. Waste treatment facilities
4. Well water pump house
5. NOS recreation facilities
6. NOS medical facilities
7. Fire protection
8. Laundry
9. Naval Explosive Ordnance Disposal Technology Center

2.1.2.2.1 Survey of Functional Areas. With the assistance of the NOS personnel, AWARE personnel visited the production areas and other areas designated as miscellaneous users. AWARE personnel visited each production/process area with an individual(s) from that area knowledgeable in the production processes and equipment. Due to the size of the facility and great number of buildings at the NOS this was required to ensure a cognizant and thorough survey. While in the areas AWARE personnel would note the volume of well water used, the discharge line size, well water use, the number and type of equipment supplied well water, frequency of equipment use, seasonal variations of equipment use, and general activity within the building. An insignificant volume of well water is consumed by the product, therefore, no investigation into actual product mix was performed. Found in Appendix 2-B are completed working data forms used in the on-site well water use surveys.

2.1.2.2.2 Well Water Volume Calculation. Where possible the flow of well water was measured or determined from NOS records. In many instances the discharge end of the well water was not accessible to actual "hands-on" measurement. Thus, the volume of well water supplied to the equipment had to be derived indirectly from line sizes and system pressure. Presented in

Table 2.1-3 are maximum quantities of water through pipe at various pipe size and system pressure. The system pressure at the NOS was determined to be approximately 75 psi. This value was observed at locations throughout the NOS facility and from information supplied by NOS personnel. Assumptions were made as to the percentage of flow loss due to scaling and friction. The loss associated with these through engineering judgment was 25 percent. Thus, a factor of 0.75 was applied to the values in Table 2.1-3 to calculate the adjusted flows.

2.1.3 WATER BALANCES

The various water balances in this section were developed to present the water use as average weekly flows. Summaries of seasonal and diurnal balances for the two types of well water are also discussed. Estimated well water use for production and sanitary purposes and calculated volumes of loss due to line losses were incorporated in the uses part of the balances. Historical well water pumping records were used in the supply volume.

2.1.3.1 Line Losses

Through discussion with NOS personnel knowledgeable in the water main and piping network, the low silica and high silica piping network was established. Depicted by Figure 2.1-2 is the NOS freshwater piping network. AWARE personnel made take-off measurements for lineal feet of pipe in each distribution system from the NOS area utility maps. Approximately 260,000 ft (50 miles) of pipe with diameters less than or equal to 14 in. are laid in the freshwater distribution system. Water loss values were estimated from specifications of the American Water Works Association

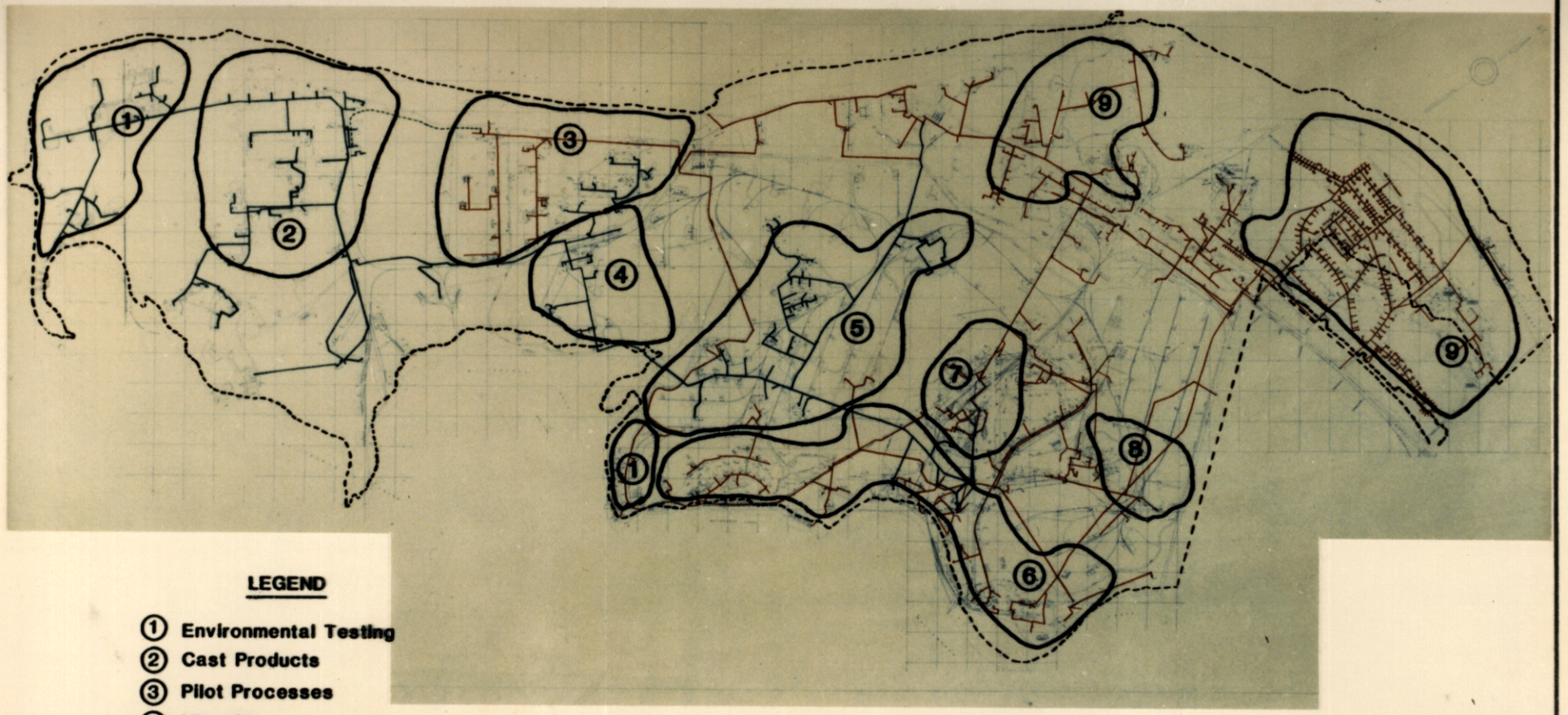
TABLE 2.1-3

MAXIMUM QUANTITY OF WATER THROUGH PIPE[a]

(Source: Well Water Technology[1])

Pressure	Size Pipe, inch(es)								
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
17 lbs	3.2	9.1	18.7	33.5	51.5	106	200	290	589
30 lbs	5	14	28	52	78	160	308	436	885
40 lbs	6	16	33	60	90	184	350	504	1,023
50 lbs	6.5	17.5	37	70	101	206	390	564	1,143
60 lbs	7	19.5	40	76	110	226	430	617	1,252
75 lbs	7.5	22	45	85	123	253	480	690	1,400
100 lbs	9	25	52	99	142	292	558	797	1,607

[a]Maximum quantities of water (gal/min) which may be pumped through 100 ft of wrought iron pipe.



LEGEND

1. Environmental Testing
2. Cast Products
3. Pilot Processes
4. Nitration
5. Multi Base
6. Extruded Products and Chemical Processes
7. Power Plant
8. Cartridge Actuated Devices
9. Personnel Housing

— High Silica Water
— Low Silica Water

FIGURE 2. 1-2 SCHEMATIC OF THE WELL WATER DISTRIBUTION NETWORK

(AWWA)[2] and the relationship that line losses are directly proportional to the square root of the main pressure[3]. At a main pressure of approximately 75 psi, which is similar to the NOS Indian Head facility, and a pipe diameter of 14 in., the AWWA specification value corresponds to 1,535 gpd of line losses per mile of pipe. The AWWA specifications would have accepted approximately 168,200 gal/wk leakage from this network at 75 psi when the mains were laid.

2.1.3.2 Total Well Water Seasonal Balances

To determine the overall completeness and accuracy of the water use survey a balance was performed incorporating low silica and high silica water pumping records and flow estimates and measurements throughout the various areas. The five-year average pumping records were used to establish the intake volume of water. The total seasonal average intake volumes during winter and summer were calculated to be 7,302,000 gal/wk and 7,625,000 gal/wk, respectively. Total low silica and high silica waters use were determined to be 6,985,000 gal/wk and 7,314,000 gal/wk, respectively, for winter and summer. The combined volume of low silica well water and high silica well water was within 1 percent of the historical pumping records for the winter and summer balances. An evaluation of the seasonal weekly average water demands for low silica and high silica water is presented in Table 2.1-4. In both cases the balance was rounded to the nearest percent. This evaluation indicates close agreement between the water survey results and the historical pumping data.

TABLE 2.1-4

COMBINED LOW SILICA AND HIGH SILICA WEEKLY AVERAGE SEASONAL BALANCES

Area	Winter		Summer	
	Pumping Average Weekly, gal/wk	Water Survey Results, gal/wk	Pumping Average Weekly, gal/wk	Water Survey Results, gal/wk
Power Plant[a,b,c,d]		3,702,500		3,968,900
Housing & Personnel[e,f]		1,134,300		1,134,300
Multibase		157,700		157,700
Casting		52,900		52,900
Transportation		5,800		5,800
Extruded Chemicals		2,700		2,700
CAD		3,100		3,100
Environmental Testing		690,600		690,600
Organic Chemicals		8,600		8,600
Pilot Processes		115,500		115,500
Nitration		81,200		81,200
Miscellaneous Uses[g]		861,700		924,700
Line Losses[h]		168,200		168,200
	7,302,000	6,985,000	7,625,000	7,314,000
	Percent Agreement = 96 percent Water Use Survey Underage = 317,000 gal/wk		Percent Agreement = 96 percent Water Use Survey Underage = 311,000 gal/wk	

[a]Power Plant water use was derived through proportional steam production as reported by NOS steam production records.

[b]The resin bed regeneration and rinsing was calculated by proportional steam production. The water use survey reflects 2 resin bed regenerations and rinses per day during the winter period and 1 resin bed regeneration and rinse per day during the summer period. However, the steam generation records do not reflect a 2:1 winter-to-summer ratio as the resin bed regeneration and rinse survey would indicate.

[c]The spray cooling basin water is used during the winter period to cool the electrical power generating turbines and other equipment. Spray aeration basin water use during the winter is from evaporative losses. Presented in Appendix 2-C is the equation and explanative material for evaporative loss calculation. Low silica water is used for make-up water. Summer turbine cooling is not accomplished by the spray cooling basin. High silica water is used as once-through cooling water. It then flows to the spray cooling pond and is allowed to overflow as surface drainage into the Mattawoman Creek.

[d]Climatological data was obtained from the meteorological data for Baltimore, Maryland, as supplied by the National Oceanic and Atmospheric Administration Environmental Data Service.

[e]Housing and Personnel will be defined further in the low silica water balances and high silica water balances.

[f]Water use by military personnel stationed and living at NOS and their dependents was estimated to be 100 gpcd. Military personnel stationed at NOS and living off base and civilian NOS personnel were considered to consume 15-20 gpcd.

[g]Miscellaneous Uses will be defined further in the low silica water balances and high silica water balances.

[h]Line Losses will be defined further in the low silica water balances and high silica water balances.

2.1.3.3 Low Silica Seasonal Balances

Low silica water is supplied by wells designated as B, 15, 17, and 18. Historical pumping records indicate approximately 4,253,000 gal/wk has been supplied for the winter periods, and approximately 3,986,000 gal/wk for the summer period. The water use survey seasonal averages were 4,542,300 gal/wk during winter and 3,597,000 gal/wk during summer. A summary of the low silica water seasonal balance is presented in Table 2.1-5. Further definition of seasonal low silica water use is presented in Table 2.1-6.

2.1.3.4 High Silica Seasonal Balances

High silica water is supplied by wells designated as #1 Pumphouse, #2 Pumphouse, 2, 2A, 3A, 6, 7, 9, 12, 14, and A. Historical pumping records indicate approximately 3,049,000 gal/wk has been supplied for the winter period, and approximately 4,253,000 gal/wk for the summer period. The water use survey seasonal averages were 2,442,500 gal/wk during the winter period and 3,717,000 gal/wk during the summer period. A summary of the seasonal high silica water balance is presented in Table 2.1-7. Further definition of seasonal high silica water use is presented in Table 2.1-8.

2.1.3.5 Diurnal Balances

A balance to estimate well water usage for day (0500-1700 hr) and night (1700-0500 hr) was developed from data obtained during the water use survey area investigations. Information concerning equipment frequency and hours for use was collected specifically for this balance. Volumes of

TABLE 2.1-5

LOW SILICA SEASONAL BALANCES

Area	Winter		Summer	
	Pumping Average[a] Weekly, gal/wk	Water Survey Results, gal/wk	Pumping Average[a] Weekly, gal/wk	Water Survey Results, gal/wk
Power Plant		3,623,700		2,678,400
Housing & Personnel		0		0
Multibase		157,500		157,500
Casting		52,900		52,900
Transportation		0		0
Extruded Chemicals		0		0
CAD		2,700		2,700
Environmental Testing		446,600		446,600
Organic Chemicals		7,600		7,600
Pilot Processes		98,500		98,500
Nitration		66,900		66,900
Line Losses		54,000		54,000
Miscellaneous Uses				
Waste Treatment (Building 1563)		30,100		30,100
Officers' Club (Building 324)		1,800		1,800
	4,253,000	4,542,300	3,986,000	3,597,000
	Percent Agreement = 107 percent Water Use Survey Overage = 289,300 gal/wk		Percent Agreement = 90 percent Water Use Survey Underage = 389,000 gal/wk	

[a]Wells B, 15, 17, and 18 supply the low silica demand.

TABLE 2.1-6

AREA LOW SILICA SEASONAL BALANCES

Area	Identification/ Building Number	Activity/Equipment	Winter Volume, gal/wk	Summer Volume, gal/wk
Power Plant	873	Resin bed regeneration and rinse, chemical make-up, steam generation (Goddard and Steam B), boiler blow down	3,623,700	2,678,400
Housing & Personnel	Military Civilian	Housing and dependents sanitary use 24 hr/day Day shift sanitary use	0 0	0 0
Multibase	707, 706, 705 704, 471, 858	Hydraulic presses, blockers, cutters, reblockers of propellant, washdown, catch medium dust collection, mix propellant compounds, cooling and heating water	157,500	157,500
Casting	730, 731, 1136, 1042, 725, 724 722, 723, 1018, 720	Cooling and heating water, catch medium paint spray, washdown, grain-saw cooling, cooling medium oil for vacuum pumps	52,900	52,900
Transportation		NOS vehicle maintenance and repair	0	0
Extruded Chemicals		Pressing and cutting of propellants, cooling, washdown, propellant moistening for storage prior to disposal.	0	0
CAD	329	Induction soldering	2,700	2,700
Environmental Testing	754, 759, 1140, 1605, 731, 798 753, 890, 1523, 1526	Heat exchange equipment, film cleaning and washing, washdown	446,600	446,600
Organic Chemicals	497, 498	Dilution medium for recrystallization of HBNQ, washdown	7,600	7,600
Pilot Processes	854, 856, 905, 1182, 1047, 1046, 849	Hydraulic mixers and pumps, heat exchange, extrusion press heater, blocking, hydraulic press cooling, jacket, grain-saw cooling	98,500	98,500
Station Laboratories	101, 102 502, 600	Laboratory services	0	0

TABLE 2.1-6 (Cont'd.)

AREA LOW SILICA SEASONAL BALANCES

Area	Identification/ Building Number	Activity/Equipment	Winter Volume, gal/wk	Summer Volume, gal/wk
Nitration	781, 775, 786 787, 790, 1464 1465, 1463, 1461 1462, 1006, 801	Soda water make-up, water cooling jacket for refrigeration equipment, wash of nitroglycerin, water flush of acid spills, washdown	66,900	66,900
Wastewater Treatment	1563	Chlorine injection	30,100	30,100
Pumphouse Wells	128	Grit chamber overflow	0	0
Swimming Pool		Recreation - evaporative and spillage make-up, initial fill	0	0
Base Dispensary	1600	Compressor cooling pneumatic system	0	0
Food Preparation	D324	Food preparation, clean-up of cooking utensils and serving pieces	1,800	1,800
Fire Station	878	Equipment maintenance, personnel vehicle maintenance, filling tanks on trucks	0	0
EODS	901	Fill diving tanks, personnel showers, equipment wash	0	0
Photography Laboratories	1601	Print and film developing wash and rinse baths, temperature sensitive developing baths	0	0
Laundry	152	Anti-static coverall cleaning	0	0
Line Losses		Water Distribution system	54,000	54,000
TOTAL WATER USE FACILITY SURVEY RESULTS			4,542,300	3,597,000

THE PUARE CORPORATION

TABLE 2.1-7

HIGH SILICA SEASONAL BALANCES

Area	Winter		Summer	
	Pumping Average[a] Weekly, gal/wk	Water Survey Results, gal/wk	Pumping Average[a] Weekly, gal/wk	Water Survey Results, gal/wk
Power Plant		78,800		1,290,500
Housing & Personnel		1,134,300		1,134,300
Multibase		200		200
Casting		0		0
Transportation		5,800		5,800
Extruded Chemicals		2,700		2,700
CAD		400		400
Environmental Testing		244,000		244,000
Organic Chemicals		1,000		1,000
Pilot Processes		17,000		17,000
Nitration		14,300		14,300
Line Losses		114,200		114,200
Miscellaneous Uses				
Station Laboratories (Building 101, 102, 502, 600)		57,500		110,300
Wastewater Treatment Plants (Building 511C, 1470, 1563)		344,700		344,700
Pumphouse Wells (Building 128)		290,300		290,300
Swimming Pool		0		10,000
Base Dispensary (Building 1600)		6,200		6,200
Food Preparation (Building 503, 620)		3,000		3,000
Fire Station (Building 878)		11,200		11,200
EODS (Building 901)		38,200		38,200
Photography Laboratories (Building 1601)		71,900		71,900
Laundry (Building 152)		6,800		6,800
	3,049,000	2,442,500	3,639,000	3,717,000
	Percent Agreement = 80 percent Water Use Survey Underage = 606,000 gal/wk		Percent Agreement = 102 percent Water Use Survey Overage = 78,000 gal/wk	

[a]Wells Pumphouse No. 1, Pumphouse No. 2, 2, 2A, 3A, 6, 7, 9, 12 and A supply the high silica demand.

THE RUARE CORPORATION

TABLE 2.1-8

AREA HIGH SILICA SEASONAL BALANCES

Area	Identification/ Building Number	Activity/Equipment	Winter Volume, gal/wk	Summer Volume, gal/wk
Power Plant	873	Turbine cooling and area washdown	78,800	1,290,500
Housing & Personnel	Military Civilian	Housing and dependents sanitary use 24 hr/day Day shift sanitary use	907,200 227,100	907,200 227,100
Multibase	218, 219, 326, 327, 328	Washdown of power dry houses	200	200
Casting		Cooling and heating water, catch medium paint spray, washdown, grain-saw cooling, cooling medium oil for vacuum pumps	0	0
Transportation	290, 695	NOS vehicle maintenance and repair	5,800	5,800
Extruded Chemicals and Products		Pressing and cutting of propellants, cooling, washdown propellant moistening for storage prior to disposal	2,700	2,700
CAD	160, 286, 329	Parts wash and catch medium spray paint booth	400	400
Environmental Testing	558	Heat exchange equipment, cooling	244,000	244,000
Organic Chemicals	859	PNC manufacture and washdown	1,000	1,000
Pilot Processes	678, 682, 680, 685	Hydraulic mixers and pumps, dilution medium, rolling mill, and grain-saw cooling	17,000	17,000
Station Laboratories	101, 102, 502, 600	Laboratory services	57,500	110,300
Nitration	1543, 676, 672 671, 670, 674 690	Washing process, dissolving of metreol, compressor cooling, dilution of spent acid prior to neutralization	14,300	14,300
Wastewater Treatment	511C, 1470	Chlorine injection	344,700	344,700

THE AUARE CORPORATION

TABLE 2.1-8 (Cont'd.)

AREA HIGH SILICA SEASONAL BALANCES

Area	Identification/ Building Number	Activity/Equipment	Winter Volume, gal/wk	Summer Volume, gal/wk
Pumphouse Wells	128	Grit chamber overflow	290,300	290,300
Swimming Pool		Recreation - evaporative spillage make-up, initial fill	0	10,000
Base Dispensary	1600	Compressor cooling pneumatic system	6,200	6,200
Food Preparation	503, 620	Food preparation, clean-up of cooking utensils and serving pieces	3,000	3,000
Fire Station	878	Equipment maintenance, personnel vehicle maintenance, filling tanks on trucks	11,200	11,200
EODS	901	Fill diving tanks, personnel showers, equipment wash	38,200	38,200
Photography Laboratories	1601	Print and film developing - wash and rinse baths, temperature sensitive developing baths	71,900	71,900
Laundry	152	Anti-static coverall cleaning	6,800	6,800
Line Losses		Water distribution system	114,200	114,200
TOTAL WATER USE FACILITY SURVEY RESULTS			2,442,500	3,717,000

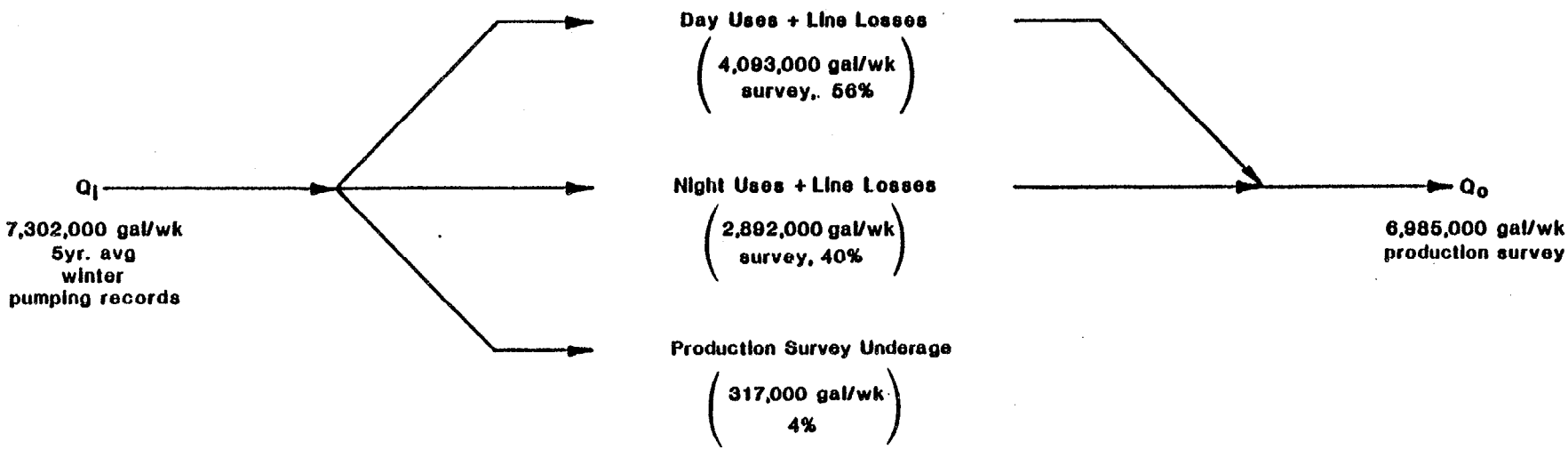
THE AUARE CORPORATION

flows presented are directly taken from the area investigations or proportionally calculated from the hours of equipment operation.

2.1.3.5.1 Total Well Water Diurnal Balances. Low silica and high silica well water flows were combined to estimate the day and night use. The total intake volume pumped was calculated to be 7,302,000 gal/wk during the winter months and 7,625,000 gal/wk during the summer months. The winter water use survey total was determined to be 6,985,000 gal/wk of which 4,093,000 gal/wk was consumed during day operation and 2,892,000 gal/wk for night operation. Depicted in Figure 2.1-3 is a line diagram balance of the winter diurnal well water use. The summer water use survey total was determined to be 7,314,000 gal/wk of which 4,289,000 gal/wk was consumed during day operation and 3,025,000 gal/wk for night operation. Presented in Figure 2.1-4 is a line diagram balance of the summer diurnal well water use.

2.1.3.5.2 Low Silica Well Water Diurnal Balances. The low silica historical, winter pumping records indicate 4,253,000 gal/wk were supplied to the NOS. Day uses were estimated to be 2,470,000 gal/wk, and night uses were estimated to be 2,072,000 gal/wk. A line diagram balance for winter low silica diurnal use is presented in Figure 2.1-5. Historical summer low silica pumping records show 3,986,000 gal/wk were supplied to the NOS. Day uses were estimated to be 1,997,000 gal/wk and night uses were estimated to be 1,600,000 gal/wk. A line diagram balance for summer low silica diurnal use is presented in Figure 2.1-6.

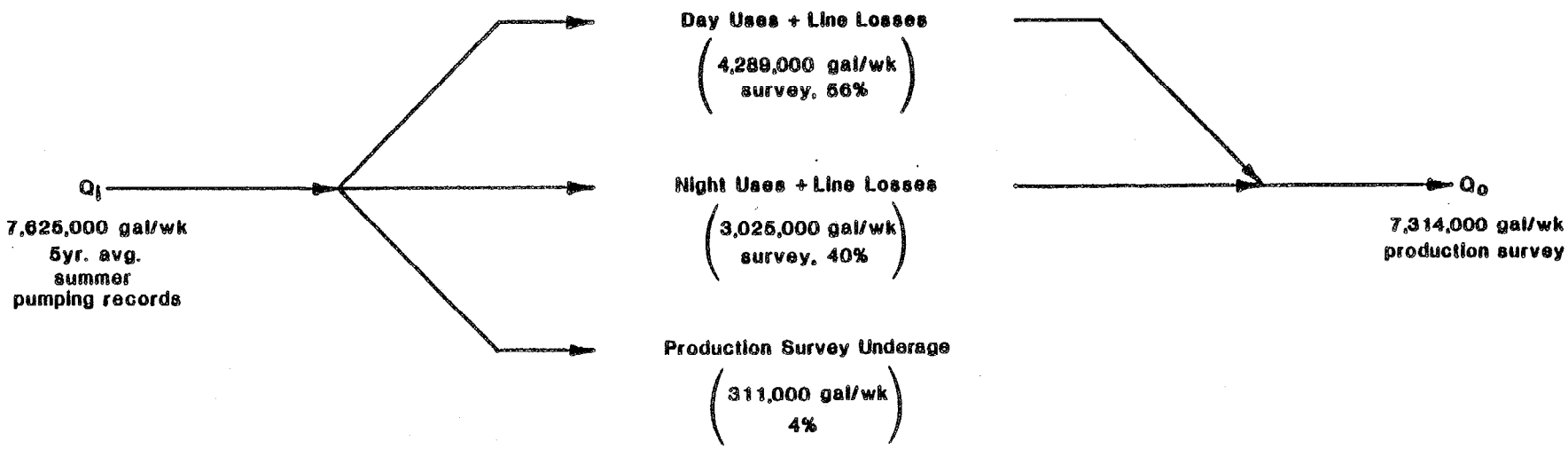
2.1.3.5.3 High Silica Well Water Diurnal Balances. Historical NOS winter high silica well water pumping records indicate 3,049,000 gal/wk



7,302,000 gal/wk Q_I
− 6,985,000 gal/wk production uses
317,000 gal/wk pumping excess

FIGURE 2.1-3 WINTER TOTAL WELL WATER DIURNAL BALANCE [a]

[a] Day hours were considered as 0500–1700. Night hours were considered as 1700–0500.



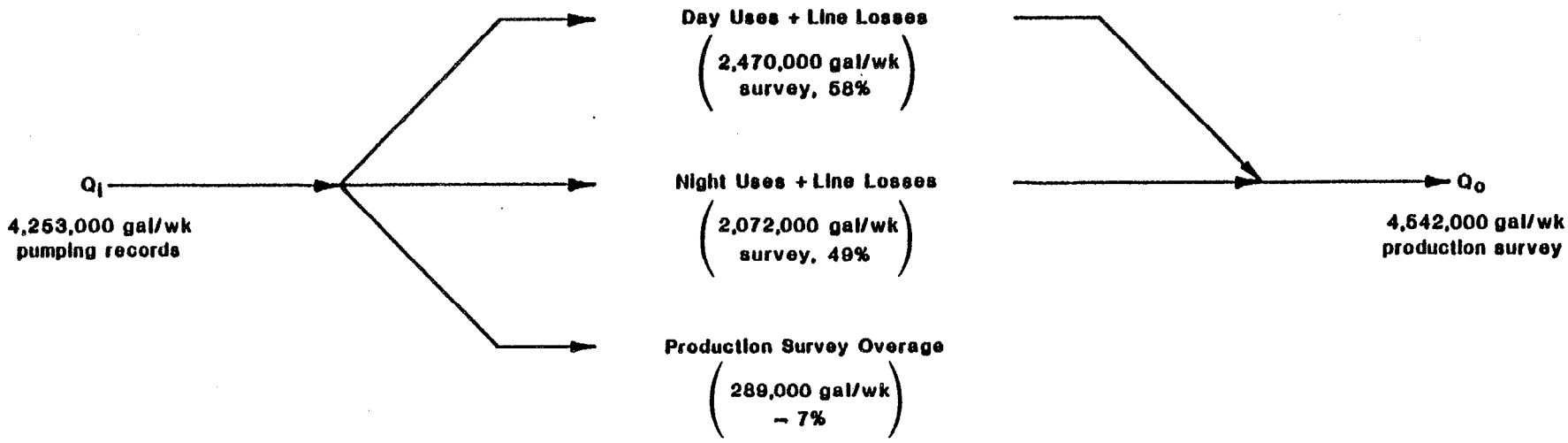
7,625,000 gal/wk Q_i

−7,314,000 gal/wk production uses

311,000 gal/wk pumping excess

FIGURE 2.1-4 SUMMER TOTAL WELL WATER DIURNAL BALANCE [a]

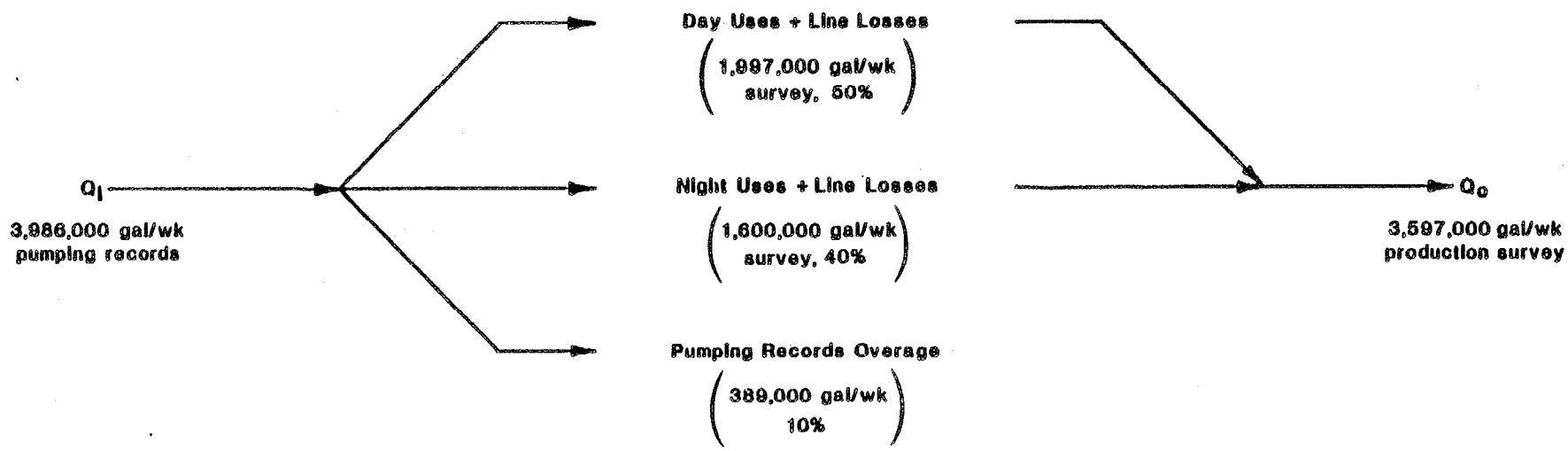
[a] Day hours were considered as 0500–1700. Night hours were considered as 1700–0500.



4,253,000 gal/wk Q_i
−4,631,000 gal/wk production uses
−378,000 gal/wk survey excess

FIGURE 2.1-5 WINTER LOW SILICA DIURNAL BALANCE [a]

[a] Day hours were considered as 0500–1700. Night hours were considered as 1700–0500.



3,986,000 gal/wk Q_I

−3,597,000 gal/wk production uses

389,000 gal/wk pumping excess

FIGURE 2.1-6 SUMMER LOW SILICA DIURNAL BALANCE[a]

[a] Day hours were considered as 0500–1700. Night hours were considered as 1700–0500.

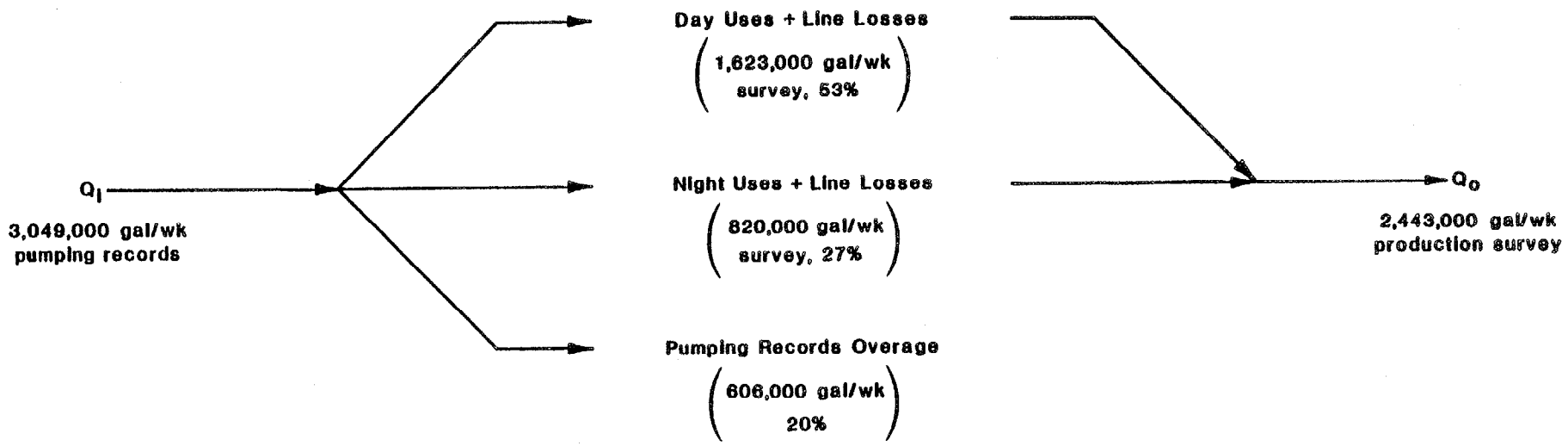
were supplied for use. Estimated volumes for day and night were calculated from the water use survey. The corresponding volumes were 1,623,250 gal/wk and 820,000 gal/wk, respectively. These total 2,442,500 gal/wk. A line diagram balance is presented in Figure 2.1-7. The historical summer high silica intake volume was calculated to be 3,639,000 gal/wk. Day and night high silica water uses were 2,292,000 gal/wk and 1,425,000 gal/wk, respectively. The day and night volumes sum is 3,717,000 gal/wk. Presented in Figure 2.1-8 is a line diagram balance.

2.1.4 WATER USE SURVEY SUMMARY

Various water balances accounting for low silica and high silica well water uses, seasonal well water uses, and diurnal well water uses, were performed at the NOS facility. The total well water (low silica and high silica) seasonal uses balances were in close agreement with historical well water pumping records. The other balances performed did not exhibit the same level of agreement with historical well water pumping records. However, these balances were within 10 percent of the historical well water pumping records.

The differences in the various balances can be accounted for in the following manner:

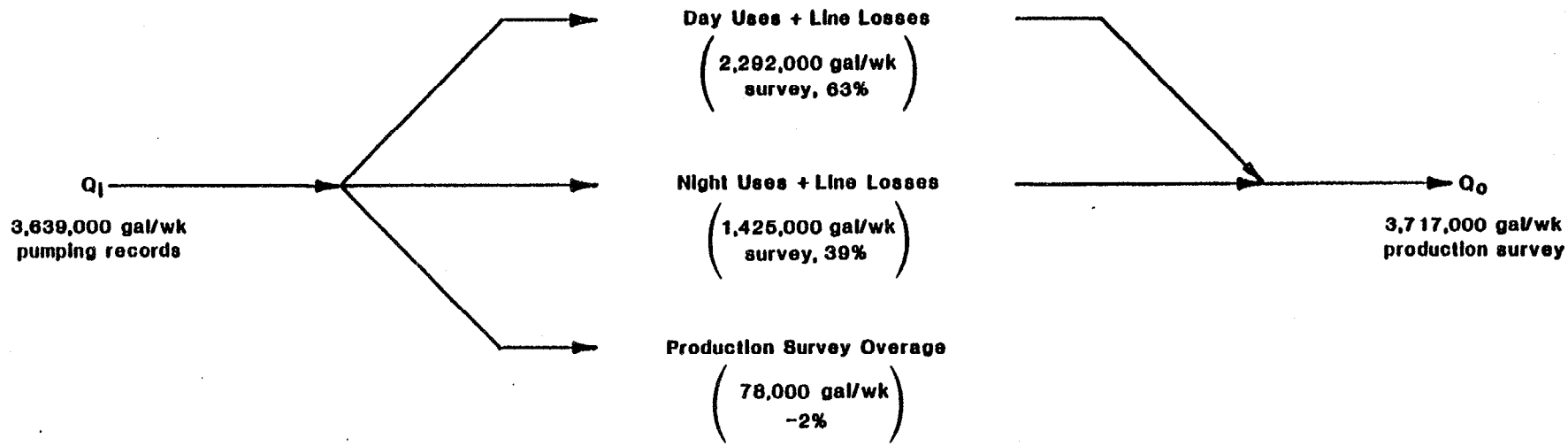
1. The well water distribution system has inherent flexibility to change the type (low silica or high silica) or combine the two types of well waters to maintain system pressure. Several valves exist in the piping network that through manipulation allow the NOS personnel to control the type of water supplied to



3,049,000 gal/wk Q_I
−2,443,000 gal/wk production uses
606,000 gal/wk unaccounted

FIGURE 2.1-7 WINTER HIGH SILICA DIURNAL BALANCE[a]

[a] Day hours were considered as 0500–1700. Night hours were considered as 1700–0500.



3,639,000 gal/wk Q_I
- 3,717,000 gal/wk production uses
-78,000 survey excess

FIGURE 2.1-8 SUMMER HIGH SILICA DIURNAL BALANCE[a]

[a] Day hours were considered as 0500–1700. Night hours were considered as 1700–0500.

the various production areas at NOS. Thus, by altering the volume of flow of one type water, the accountability of the water use balances for both waters would have been affected.

2. Some degree of error in water uses estimation was unavoidably included, but overall the volumes determined were within an acceptable range.
3. Treatment of the data in reduction and correlation may have biased the balances.
4. Line losses were computed for new pipe. Most of the well water distribution network was installed over 20 yr ago, thus, more leakage may be present than accounted for in the balances.

2.1.5 WASTE DISCHARGES OF WELL WATER

Estimates of waste discharges of well water were developed from utility drawings provided by NOS Public Works personnel, on-site AWARE personnel observations, discussions with NOS personnel, recent reports on wastewater sources prepared for NOS, and engineering judgments. The final wastewater discharge points were determined to be the Potomac River and Mattawoman Creek, the various sanitary treatment facilities, the ground, and the atmosphere. Four categories were established in reference to the final discharge points. A tabular summary of well water uses, discharge points, and discharge volumes, including seasonal variations, is presented in Table 2.1-9.

The sum of the waste discharges of water in Table 2.1-9 is greater than the sum of well water intake in Tables 2.1-1 and 2.1-2. This difference is attributable to inflow/infiltration of stormwater/groundwater

into the wastewater collection network. Other factors contributing to this difference include the contribution of river water used for cooling and washdown in some production areas, and river water from the routine testing of the fire protection sprinkler system.

TABLE 2.1-9

ESTIMATED SEASONAL WATER DISCHARGES

Building(s)	Use	Water Discharged to[a]				
		Ground (gal/wk)	Waste[b] Treatment (gal/wk)	Atmosphere (gal/wk)	IW Outfall Volume (gal/wk)	IW Outfall IW Number
62, 253	Sanitary		1,500			
101	Equipment temperature control				30,600	06
102	Glassware washing, cooling water stills				15,450	06
128	Well water grit chamber overflow				190,300	40
137	Turbine cooling			78,550[c]/19,650[c]	0[d]/1,270,350[e]	
152	NOS base laundry				6,750	06
160	Particulate catch paint spray booth				350	06
194, 194A	Sanitary		11,000			
274	Sanitary		12,500			
286	Parts washing				50	06
290	Equipment wash				5,100	48
313	Sanitary		2,500			
315	Sanitary		1,000			
D324	Food preparation				1,800	48
329	Overflow propellant chip basin				2,750	30
336	Washdown				350	30
471	Water spray dust collection, washdown				3,700	30
497	Process water				7,500	05
498	Washdown				150	42
501	Sanitary		1,500			
502	Equipment cleaning, cooling water				3,850	06
503	Food preparation				1,250	06
511C	Chlorination				171,400	48
526, 544, 559, 587, 588, 595, 601, 611, 1479, 1480	Sanitary		125,000			
530	Cooling water propellant mixing vessel and extrusion presses				50	17
558	Temperature control (non-contact cooling water) for the conditioning chambers				244,050	54, 57
560, 561, 562, 563, 564, 565, 566	Equipment cooling, washdown				500	18
600	Cooling water still, glassware wash, air conditioning				7,700/60,500	06
620	Food preparation				1,750	48
670	Compressor cooling water				4,950	10
671	Medium for dissolving metreol				50	10

THE AUARE CORPORATION

TABLE 2.1-9 (Cont'd)

ESTIMATED SEASONAL WATER DISCHARGES

Building(s)	Use	Water Discharged to[a]				
		Ground (gal/wk)	Waste[b] Treatment (gal/wk)	Atmosphere (gal/wk)	IW Outfall Volume (gal/wk)	IW Number
672	Washdown				200	10
674	Spent acid dilution and neutralization				250	02
676	Washdown				550	03
678	Hydraulic fluid cooling pumps and mixers				9,900	10
680	Gear box cooling				3,450	10
682	Hydraulic fluid cooling product mix				100	10
685	Cooling water grain-saw				3,650	10
690	Washdown				200	10
695	Sanitary		5,000			
702, 703, 1136,	Sanitary		25,250			
704	Non-contact cooling				109,050	30
	Sanitary		3,000			
705	Equipment temperature control, washdown				9,450	30
706	Non-contact cooling, washdown				17,550	30
707	Non-contact cooling, washdown				17,850	30
712	Sanitary		600			
713, 714, 813, 1610	Sanitary		75,000			
720	Cooling water grain-saw				500	21
722, 723	Washdown				200	21
724	Washdown mold evacuation and casting				29,000	21
725	Washdown casting solvent evacuation				7,200	21
730	Catch medium paint spray booth				400	21
731	Washdown, vacuum pump cooling, film developing				9,400	21
743	Washdown, vacuum pump cooling				2,000	21
748, 749, 759, 763	Sanitary		9,000			
753	Heat exchanger				17,000	25
754	Conditioning chamber temperature control				219,800	25
759	Distillation cooling				100	62
765, 766	Sanitary		35,000			
775	Cooling water, washdown				18,250	31
781	Washdown				300	31

PUDRE CORPORATION

TABLE 2.1-9 (Cont'd)

ESTIMATED SEASONAL WATER DISCHARGES

Building(s)	Use	Water Discharged to[a]				
		Ground (gal/wk)	Waste[b] Treatment (gal/wk)	Atmosphere (gal/wk)	IW Outfall Volume (gal/wk)	IW Outfall IW Number
786	Soda water washer cooling jacket, washdown, wash of nitroglycerin or propylenic glycol dinitrate, dilution of waste acid				30,700	10
787	Washdown				1,000	10
790	Dilution of waste acid				600	31
798	Equipment cooling				153,350	25
801	Washdown				200	35
822	Sanitary		6,000			
823	Sanitary		6,000			
829	Sanitary		6,000			
845	Sanitary		15,000			
849	Cooling water				7,100	10
855	Cooling water for compressor and vacuum pump, temperature control reactor				14,400	01
855, 863, 864	Sanitary		22,500			
856	Process water, cooling water, washdown				2,700	01
859	Washdown				950	06
869	Sanitary		3,000			
873	Boiler blowdown and water used in backwashing exchange columns for boiler feed water				838,200[f]/645,750[f]	06
878	Fire station				11,250	30
	Sanitary		5,000			
888, 889, 890, 1576, 1523, 1526	Sanitary		91,000			
890	Compressor cooling, washdown				5,200	37
901	Diving tank make-up water, equipment wash, backwash during tank filter				38,200	48
905	Temperature control product cooling hydraulic pump and extrusion press				7,050	10
1006	Washdown				200	35
1018	Washdown				200	30
1042	Cooling water				2,250	10
1046	Hydraulic blocking press				20,400	10
1047	Hydraulic pumps and presses				36,000	10
1104	Sanitary		7,500			
1182	Mix of product, cooling water vacuum pump				10,800	10

THE AUARE CORPORATION

TABLE 2.1-9 (Cont'd)

ESTIMATED SEASONAL WATER DISCHARGES

Building(s)	Use	Water Discharged to[a]				
		Ground (gal/wk)	Waste[b] Treatment (gal/wk)	Atmosphere (gal/wk)	IW Outfall Volume (gal/wk)	IW Number
1424	Sanitary		4,000			
1444	Sanitary		2,000			
1457	Sanitary		1,500			
1461, 1462	Washdown				400	31
1463	Equipment and floor washdown				7,200	31
1464	Washdown				1,000	10
1465	Product compound solution				250	10
1470	Chlorination				171,400	06
1540	Sanitary		3,000			
1543	Product rinse				8,050	17
1563	Leaking water tap	30,100				
1600	Equipment Cooling				6,150	48
1601	Film rinse developing process, solution base				71,900	48
1605	Film developing rinse				7,350	37
Burning Point	Water from scrap propellants transportation containers				1,300	51
Power Plant	Steam production	2,387,700/1,829,700		265,300[g]/203,300[g]		
712	Auxiliary steam generation	107,100/0		11,900/0		
WWTP No. 1	Sanitary				1,610,000	40
WWTP No. 2	Sanitary				525,000	48
Line Losses	Sanitary & Process Related	168,200				
NOS TOTAL BY DISCHARGE CATEGORY		2,693,100/2,028,000	480,350	355,750/222,950	4,767,500/5,898,200	
NOS TOTAL DISCHARGE		8,296,700/8,629,500				
NOS TOTAL WELL WATER INTAKE		7,302,000/7,625,000[h]				
NOS DISCHARGE OVERAGE		994,700/1,004,500[i]				

[a]Where two values are listed indication is for winter/summer.

[b]The sanitary wastewater is locally treated by septic tanks, Imhoff tanks, or septic/sand filters.

[c]Evaporation from the spray cool pond was calculated to be 78,500/19,650 gal/wk. Presented in Appendix 2-C is an example calculation.

[d]No overflow should be experienced during winter operation. The only water loss should be to evaporation. Reference footnote c.

[e]Overflow is experienced as well water is used as once-through cooling water for the turbines during summer operation. Reference footnote c for evaporation losses.

[f]The volume of discharge was calculated proportionally for steam supplied winter/summer.

[g]Evaporation losses were assumed to be 10 percent of the steam supplied to the NOS facility.

[h]Values are the sum of the historical seasonal averages of low silica and high silica water pumping from Tables 2.4-1 and 2.1-2.

[i]The overage is attributable to inflow/infiltration of stormwater/groundwater into the wastewater collection network, river water used for cooling and washdown in some production areas, and river water from the routine testing of the fire protection sprinkler system.

THE BUARE CORPORATION

CHAPTER 2.2

POTENTIAL WATER CONSERVATION MEASURES

2.2.1 INTRODUCTION

Potential measures for conserving water at the Naval Ordnance Station in Indian Head, Maryland were investigated by a literature survey of water conservation alternatives for the military explosives and propellants industry and for the sanitary and power generation water uses at the Indian Head facility. Since power generation and sanitary water uses comprise a major portion of the station water demand, investigative efforts were primarily focused on conservation measures in these areas.

A computer search of the Selected Water Resources Abstracts was performed by the Southern Water Resources Scientific Information Center, using the descriptors listed in Table 2.2-1. The search resulted in many citations, including articles on industrial cooling water and processes, water reuse in communities and industrial settings, and EPA documents of water conservation conference proceedings and explosives manufacturing.

2.2.2 SIDESTREAM SOFTENING OF BOILER BLOWDOWN

Boiler water must be of sufficient quality to prevent the deposition of dissolved calcium and magnesium salts, also known as hardness, on interior boiler surfaces and transfer piping systems. As water departs the boiler in the form of steam, hardness of the remaining boiler water is increased through a distilling effect. This hardness must be removed by boiler blowdown. The blowdown water may be softened by one of several

TABLE 2.2-1

DESCRIPTORS USED IN COMPUTER LITERATURE SEARCH

Explosives
Munitions
Water Conservation
Water Management
Industrial Water Management
Water Reuse
Water Recycling
Cooling Water Recycle
Red Water
Boiler Feed Water
Cooling Towers
Cooling Water

procedures and then returned to the boiler, thereby reducing the amount of makeup water required.

A sidestream softening system is depicted schematically in Figure 2.2-1. The mass balance and steady-state equations are also presented in the figure. Two methods for sidestream softening are with lime and with zeolites, as discussed below.

2.2.2.1 Lime Softening

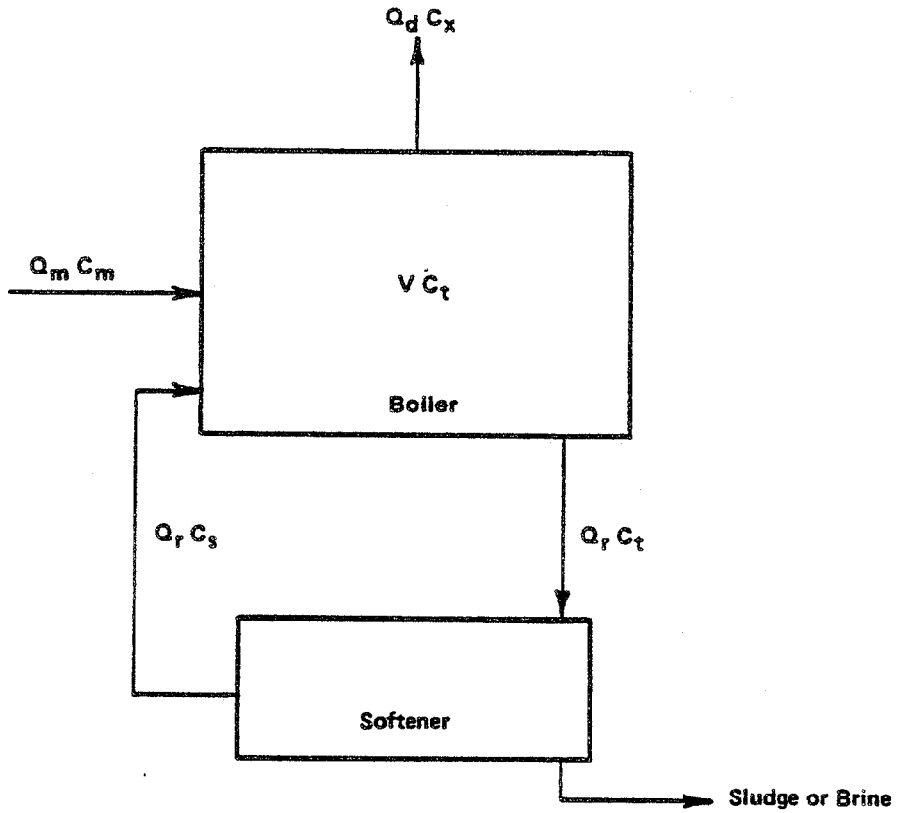
Softening with lime involves precipitation of calcium as calcium carbonate and of magnesium as magnesium hydroxide. The process relies upon the relative insolubilities of calcium carbonate and magnesium hydroxide at approximately pH 11, to remove those hardness causing salts from solution. The reactions for lime softening are presented in Figure 2.2-2 and a process schematic is shown in Figure 2.2-3. The advantages and disadvantages which are claimed for lime softening are presented in Table 2.2-2.

2.2.2.2 Ion Exchange Softening

An alternative to lime softening is ion exchange softening. Ion exchange resins used for softening have a preference for multivalent cations.[4] As a result, they tend to give up monovalent cations, such as sodium, and take on divalent cations, such as calcium and magnesium. The reaction for ion exchange water softening is:

$$M^{++} + Na_2R \rightleftarrows MR + 2Na^+$$

The reaction is reversible but strongly favors the reaction proceeding to the right. Regeneration is accomplished by increasing the concentration of monovalent cations to the point where the reverse reaction is favored. The reactions involved for removal of calcium and magnesium hardness are essentially the same and can be described as:



Where: V = Volume of boiler
C_t = Parameter concentration in boiler (and hence in recirculating boiler water.)
Q_m = Make - up water flow rate
C_m = Parameter concentration in make-up water
Q_d = Rate of water loss due to steam generation
C_x = Parameter concentration in effluent steam
Q_r = Flow rate to sidestream softener
C_s = Parameter concentration in softener effluent

Mass Balance : $$V \frac{d C_t}{dt} = Q_m C_m + Q_r C_s - Q_d C - Q_r C$$

Steady State ($\frac{dC_t}{dt} = 0$) : $$C_t = \frac{Q_m C_m + Q_r C_s - Q_d C_x}{Q_r}$$

FIGURE 2.2-1 SIDESTREAM SOFTENING OF BOILER BLOWDOWN

Calcium Removal

$$Ca\ (HCO_3)_2 + Ca\ (OH)_2 \rightarrow 2\ CaCO_3 \downarrow + 2H_2O$$

$$Ca\ (OH)_2 + CO_2 \rightarrow CaCO_3 \downarrow + H_2O$$

$$Ca\ (OH)_2 + 2CO_2 \rightarrow Ca\ (HCO_3)_2$$

Magnesium Removal

$$Mg\ (HCO_3)_2 + Ca(OH)_2 \rightarrow MgCO_3 + CaCO_3 \downarrow + 2H_2O$$

$$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$$

FIGURE 2.2-2 LIME SOFTENING REACTIONS

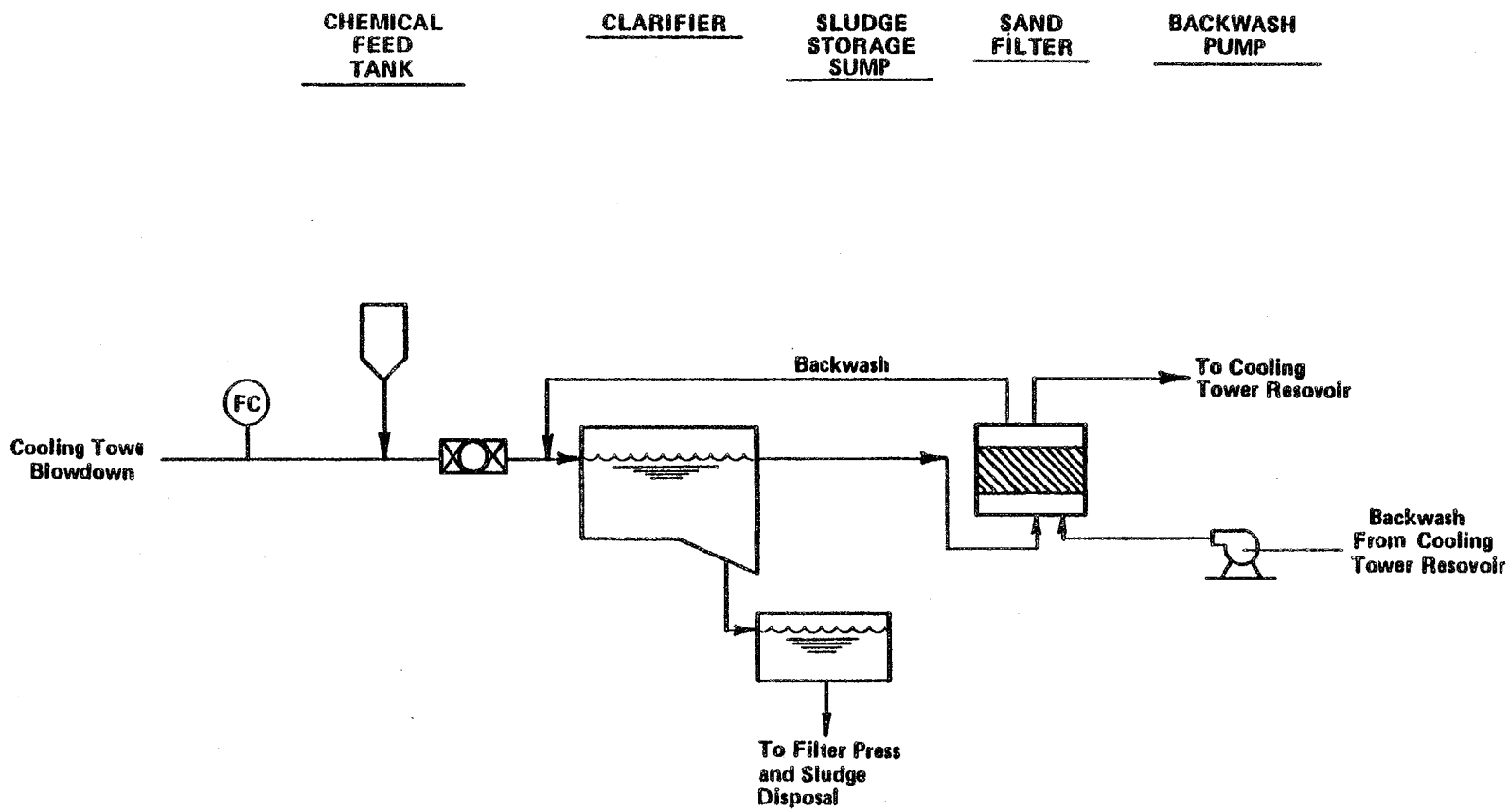


FIGURE 2.2-3 PROCESS FLOW SCHEMATIC FOR LIME SOFTENING

TABLE 2.2-2

LIME SOFTENING ADVANTAGES AND DISADVANTAGES

Advantages	Disadvantages
1. Effective and proven removals of cations responsible for hardness.	1. The system is labor intensive, even with automation.
2. Chemical costs for the system are low.	2. Capital costs for small systems are high.
3. The system amy be automated.	3. The resultant lime sludge requires disposal.
	4. The sytem, when applied to sidestream softening, does not remove monovalent cations, which require periodic blowdown.

$$Ca(HCO_3)_2 + Na_2R \rightarrow CaR + 2Na^+ + 2HCO_3^-$$

$$Mg(HCO_3)_2 + Na_2R \rightarrow MgR + 2Na^+ + 2HCO_3^-$$

The advantages and disadvantages, which are claimed for ion exchange softening, are presented in Table 2.2-3.

2.2.2.3 Applicability at NOS

The NOS currently generates approximately 12,600 gal of boiler blowdown water per week. If softened and recycled, this water would partially offset the high water demand of the powerhouse through use as a cooling water or as additional makeup for the boiler feed. Generation and disposal of lime sludge must be considered when viewing lime softening as an alternative measure for water reuse. With the use of an ion exchange system, fuel savings may be experienced by returning the softened high temperature blowdown water for reuse in steam generation. Blowdown returned from a lime softening process, however, would re-enter the boiler at a temperature lower than from the ion exchange system.

2.2.3 CONDENSATE RETURN

The NOS requires approximately 2,033,000 gal/wk of water, as steam, for power generation during summer months. This accounts for 51 percent of the total low silica well water used on station. During winter months, steam requirements rise to 2,653,000 gal/wk or 62 percent of the low silica well water used. As this steam passes through transmission pipe lines across the station, it condenses and is collected in traps. When a sufficient volume of condensate has collected in the traps the evacuation mechanism is actuated and the condensate is discharged to the storm sewers.

TABLE 2.2-3

ION EXCHANGE SOFTENING ADVANTAGES AND DISADVANTAGES

Advantages	Disadvantages
1. A high quality water is generated.	1. The regenerant brine requires disposal (approximately 60 gal/backwash for an 8-gpm unit).
2. The system may be automated.	2. Monovalent ions are concentrated in the system and require periodic blowdown.
3. The capital and operating costs for small applications are relatively low.	

If this condensate could be efficiently collected and recycled back to the Goddard Power Plant, it could effectively cut the amount of fresh makeup water. In addition, the fuel required to reheat the condensate in the boiler could be reduced since it would enter the boiler at a significantly higher temperature than would fresh makeup water. Because the collected condensate water quality would be similar to that of distilled water, the frequency and/or volume of boiler blowdown could be reduced as a result of a slower rate of calcium and magnesium accumulation in the boiler water.

2.2.3.1 Previous Condensate Return Study

In 1980, the Navy conducted a study to determine the feasibility for the construction and operation of a steam condensate return system in the area of the Goddard Power Plant. The study was conducted under the Energy Conservation Investment Program. Its purpose was to provide for the installation of a condensate return system to collect the high temperature steam condensate yielded from approximately 40 buildings in the neighborhood of the Goddard Power Plant. It was estimated 90 percent of the well water used to generate the steam supplied to the 40 buildings would be returned.[5]

The study estimated that a condensate return system could be provided by installing 9,000 linear ft of line varying in diameter from 3/4 in. to 6 in. The condensate lines could be placed alongside the existing steam distribution lines and would be outfitted with fiberglass insulation and aluminum jackets. Other required equipment would include condensate pumps with associated fittings and electrical controls.

2.2.3.2 Applicability at NOS

Return of steam condensate to the Goddard Power Plant as an alternative for conservation of low silica well water was removed from consideration. Based on the review of information presented in the Energy Conservation Investment Program (ECIP), Project P-023, approximately 1,890 lb/hr of water (5,425 gal/day) would be returned. The total annual volume of low silica water saved would be 1,980,000 gal which is about three days of low silica well water demand. At an estimated total cost of $831,600, this alternative is not economically feasible for the conservation of this volume.

2.2.4 ALTERNATIVE COOLING SYSTEMS

Water for cooling equipment and reaction processes comprises a large portion of water use at the NOS. The following sections briefly discuss various alternatives for the reduction of fresh water as a coolant.

2.2.4.1 Cooling Towers

Once-through cooling water for equipment cooling may be eliminated by recirculating the water through either wet or dry coolers, or a combined wet-dry system. Wet coolers are feasible for low flows and are marketed for residential air conditioning units in the two- to four-ton range. Dry coolers are effective at elevated temperatures and require generally higher flows to prevent freezing in colder climates. A comparative summary of dry versus wet cooling is presented in Table 2.2-4.

A wet-dry cooling system combines the characteristics of each of the component systems. Basically all combinations can be classified as either

TABLE 2.2-4

COMPARATIVE SUMMARY, DRY VERSUS WET COOLING

Advantages	Disadvantages
1. Dry coolers are effective at elevated temperatures (600-700°F).	1. Temperature reduction is not as great as with wet coolers.
2. Dry coolers can handle fluids which do not lend themselves to wet coolers.	2. Capital costs of dry coolers are approximately ten times those for wet coolers.
3. Dry coolers allow nearly total recycle of water.	3. At low flows, dry coolers may have problems with freezing in colder climates.

parallel path towers or series path towers according to their design air flow, as illustrated in Figure 2.2-4[6]. Figure 2.2-5a, b, and c shows three configurations of wet-dry cooling systems which allow use of the wet or dry systems individually or in combination. The various operational modes are achieved by shutting off the fans in either the wet or dry sections, or by rerouting water flows. This combined system would provide a greater flexibility than either of the component systems.

2.2.4.2 River Water for Cooling

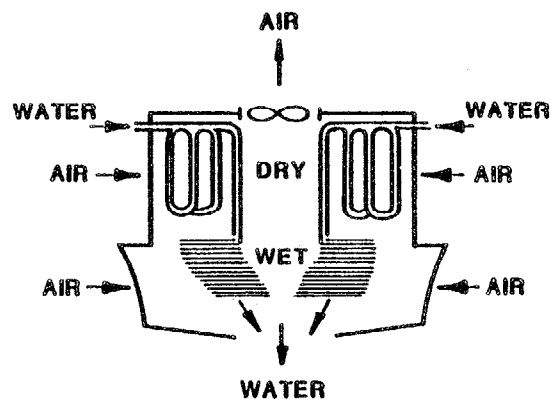
River water is currently used in some cooling applications at NOS. Some cooling systems cannot use river water at present, however, because of scouring or scaling (silt accumulation) that might be experienced with the use of this water. Screening would remove coarse material, while sand bed filtration would eliminate any remaining suspended particles.

2.2.4.3 Temperature Actuated Valves

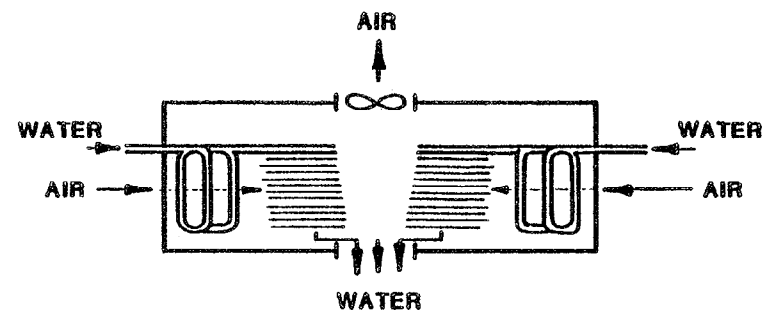
Temperature actuated valves on process cooling systems would provide fresh water savings by a demand type of cooling water flow. Cooling water in this arrangement would remain stationary within a cooling jacket until it reached a preset temperature. At this time, the temperature valve would actuate and allow new cooling water to flow into the jacket. After a period of time, the valve would close and a new heating and flush cycle would begin.

2.2.4.4 Applicability at NOS

The use of recirculated cooling is currently practiced in some areas of the NOS. Those areas not using recirculated cooling do use once-through



PARALLEL PATH DRY-WET
COMBINATION COOLING TOWER



SERIES PATH DRY-WET
COMBINATION COOLING TOWER

FIGURE 2.2-4 SIMPLIFIED SCHEMATICS OF COMBINATION DRY-WET COOLING TOWERS

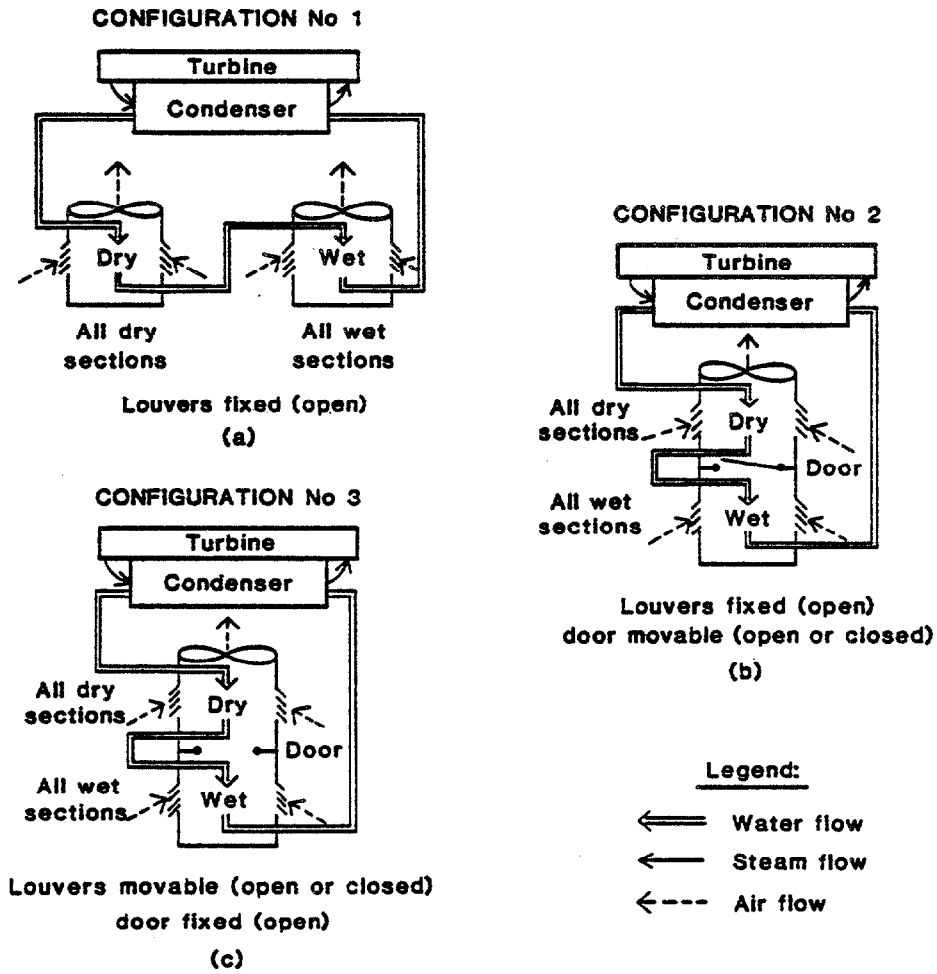


FIGURE 2.2-5 SCHEMATIC REPRESENTATION OF THREE PARALLEL AIR FLOW CONFIGURATIONS OF COMBINATION DRY-WET COOLING SYSTEMS

cooling in many cases. This is due to the small size of the equipment involved. A number of large cooling towers on the other hand, if centrally located in areas now using once-through cooling, might feasibly treat and recycle waters now being discharged. These large central cooling towers might utilize a dry cooling or wet-dry combination cooling approach to achieve efficient temperature adjustment while reducing the total volume of water required. Some factors to be considered in such a project would include:

1. High initial investment of dry cooling units.
2. Locating a centralized site for the unit(s) which will be near all sources of water to be serviced in a particular area.
3. Construction and maintenance of collection and distribution lines with associated pumps and fittings.

A dry or wet-dry cooling system might also be feasible for power house turbine cooling since the turbines require a substantial volume for cooling water.

Screened and filtered river water would reduce the need for a fresh water recirculated cooling arrangement since the Potomac River is a plentiful and renewable resource. This could be accomplished through use of screens and sand filters.

Another means of conserving well water would be the use of temperature activated valves.

2.2.5 WATER CONSERVATION ASSOCIATED WITH SANITARY FIXTURES

Sanitary demands comprise approximately 10 percent of freshwater use at NOS. The following section illustrates methodology available to con-

serve water in homes and offices for activities using fresh water for sanitary purposes.

2.2.5.1 Water-Saving Toilets

Smaller tanks and tank inserts have been devised to decrease toilet flush volumes to 3.5 gal, from 4 to 6 gal/flush for conventional toilets. Air-assisted toilets are also available that consume approximately 0.5 gal of water/flush.[7,8] This accounts for up to 88 percent reduction in water use for toilet flushing. The air-assisted toilet requires approximately 60 psi air pressure and may be operated on a house compressed air system.

Standard automatic flush valves dispense 4 1/2-4 3/4 gal/flush. Water saving flush valves and retrofit kits for standard flush valves are available which reduce water use by 1 gal/flush.[9] Some toilets will not operate at less than the standard volume during flushing so required flush volume should be checked before installing a water saving valve.

2.2.5.2 Flow Restriction

Reportedly, the second largest use of water in the home is for bathing and showering, at approximately 30 percent of household use. The American National Standards Institute maximum shower flow rate standard is 2.75 $\pm$ 0.25 gpm. This standard flow rate may be obtained through the use of flow restricting shower heads. However, maximum water savings cannot be achieved at this rate, and significant savings are not realized until flow rates approach 2.0 gpm. Devices are available which limit shower flows to 2.0 gpm but some of these produce aesthetically unacceptable results.[10] Therefore, it is necessary to determine the acceptability of such a device before mass installation.

Most codes stipulate a maximum flow rate in faucets, other than tub fillers, at 2.5 gpm, but again flows should be limited to 1.0 gpm for satisfactory flow reductions.[10] If shutoff valves are provided at the fixture, they may be partially shut to allow a maximum flow of 0.5 gpm for the individual hot and cold water lines if a single center faucet is used. If separate hot and cold faucets are used, flow should be adjusted to provide 1.0 gpm from each faucet.

2.2.5.3 Pressure Reducing Valves

For sanitary water uses, 50 psi water pressure is adequate.[7,8] Therefore, in buildings requiring water for sanitary use only, line pressure entering the building should be limited to a range of 50 to 60 psi through use of a pressure-reducing valve. The WSSC Cabin John Project resulted in residential water reductions of 30 to 35 percent through use of pressure-reducing valves to cut 70 to 120 psi line pressure to 50 psi entering houses.[11]

2.2.5.4 Applicability at NOS

There is currently no station policy, or records, for the installation of water saving devices on sanitary fixtures of the NOS. It appears, therefore, that significant conservation of fresh water might be achieved through application of the devices described in Sections 2.2.5.1, 2.2.5.2, and 2.2.5.3.

2.2.6 CONSERVATION IN PHOTOGRAPHIC PROCESSING

Water conservation features have been incorporated by many manufacturers of photographic film and print processors into the design of

modern processing machines. These features include rinse water control devices and automatic rinse water shut-offs, when film or prints are not being processed. Eastman Kodak markets an electrically controlled valve apparatus that conserves water by reducing flow to the rinse tank when the unit is on standby.

Ion exchange resin columns are available for reuse of rinse water from hypo-fix and bleach-fix processes. One vendor claims that use of the ion exchange system reduces total water use by 65 percent, reduces energy requirements for temperature control by 42 percent, and enables recovery of 90 percent of the silver in process rinse waters.[12]

2.2.6.1 Applicability of NOS

The NOS photo lab presently operates a black and white (Versamat) film processer and a color film processer. These devices require water for film rinse in the process steps and to maintain a critical operating temperature within the units. While the color processer is equipped with a standby mode water cutoff valve, the black-and-white-Versamat processer flows constantly at a full rate. A standby cutoff valve would, therefore, be applicable to the Versamat unit to conserve rinse water.

No hypo-fix or bleach-fix operations are employed in the photo-lab, and silver recovery from rinse waters is currently practiced. Therefore, the use of ion exchange columns appears impractical.

CHAPTER 2.3

APPLICABLE WELL WATER CONSERVATION MEASURES AND ECONOMIC EVALUATIONS

The primary goal of the water conservation investigation at NOS is to develop a plan to effectively reduce the volume of well water consumed. The applicable well water conservation alternatives from Chapter 2.2 are discussed in this chapter. Reported flows incorporate the annual well water use projections supplied by NOS personnel. Economic evaluations of each applicable alternative are also discussed.

2.3.1 PROJECTED WELL WATER USE THROUGH THE YEAR 1990 FOR THE NOS, INDIAN HEAD

Two major projects are to be initiated at NOS by the year 1990. The first to come on-line will be the LOVA project. The estimated increase in well water consumption for LOVA will be 69,300 gal/wk for once-through cooling water and washdown water. The LOVA project is located in an area that is currently supplied with low silica water. The other project is the Warhead Demilitarization Facility 1419. This process will initially require 26,000 gal of low silica well water, and then 2,000 gal/yr to replenish the working volume to 26,000 gal. NOS personnel report that equipment cooling will be accomplished with river water.

The seasonal low silica well water use would accordingly increase to 4,322,600 gal/wk during winter operation and 4,055,550 gal/wk during summer operation for the first year with both projects operating simultaneously. After the initial start-up of the Warhead Demilitarization Facility the water demand would decrease slightly by approximately

24,000 gal/yr (450 gal/wk) to 4,322,100 gal/wk during winter operation, and 4,055,050 gal/wk during summer operation. High silica well water uses associated with increases in personnel to staff the LOVA and Warhead Demilitarization Facility projects are incorporated in the sanitary water use projections.

2.3.2 NOS EMPLOYEE WATER CONSERVATION AWARENESS

A potentially feasible means of reducing water consumption at NOS is a program to increase employee awareness of water wastage. The water savings realized from such a program are not quantifiable.

A key factor in the success of any NOS activity is the support of the production area, shop and laboratory supervisors. The need for water conservation at the facility should be clearly presented to the supervisors. Supervisors should be encouraged to perform water audits in their areas of responsibilities. Wherever feasible, actual measurements of water flows should be made. One of the findings of the AWARE investigations was that supervisory personnel were not aware of unnecessary continuous water flows. Five well water conservations which could have been suggested by NOS personnel and which would not require large capital expenditures are:

1. Eliminate unnecessary water flows by NOS personnel awareness and action. The recognition of unnecessary well water flow and resultant shut down of these flows by NOS personnel requires no investment, operation, or maintenance costs. The estimated cost savings of the unnecessary 22,000 gal/wk low silica flow found in the Multi Base area is $810/yr.

2. Eliminate overflow from the spray cooling pond by installing a float valve a uniform annual cost of $406. The total present value cost is estimated to be $2,616. Installation of the float valve would eliminate the need to manually control the level of the spray cooling pond. Approximately 79,000 gal/wk of high silica well water could be saved which translates to $56.09/wk or $1,515/yr. The realized savings is $1,108.

3. A water tap at one of the package wastewater treatment plants (Building 1563) is leaking. Replacement of a valve would save an estimated 30,000 gal/wk of low silica well water. This translates to a monetary savings of $21.30/wk or $1,060/yr.

4. Chlorination of effluent from the main wastewater treatment facilities (Buildings 511-C and 1470) is presently accomplished using high silica well water as the stream into which chlorine is injected. This stream could be converted to treated wastewater effluent. The estimated well water savings of 342,800 gal/wk translates to $243.39/wk or $12,660/yr. The estimated uniform annual cost to make the conversion to treated wastewater effluent is $585. The realized savings would be $12,075/yr. The total present value cost is estimated to be $3,773.

5. A level control and sending unit installed at Pumphouse No. 1 would eliminate the grit chamber overflow through cutting the Well 12 pump on/off per demand. It is estimated 290,000 gal/wk of high silica well water is lost due to overflow from Building 128. This calculates to 1,160,000 gal/month. The reported historical average pumping rate of Well 12 is 1,274,000 gal/month. The estimated uniform annual cost of the

level control and sending unit is $886. The total present value cost is estimated to be $5,713. Well water savings of 290,000 gal/wk translates to $205.90/wk, or a $10,710 annual cost reduction in pumping. The realized savings would be $9,824/yr.

Conservation measures for each example are presented in Table 2.3-1. A total of 52,000 gal/wk low silica well water and 711,800 gal/wk of high silica well water could be saved. This translates to an annual savings of $24,877.

The NOS employee publications, area planning meetings, and bulletin boards could be used to encourage water use awareness by all employees. Information could be provided for the following topics:

1. The need for water conservation.
2. Recommended ways of reducing water usage.
3. Reporting of all water leaks to maintenance.
4. Regular updates of facility water use and wastewater discharge.
5. Recognize water conservation accomplishments by employees or areas.

Table 2.3-2 is an example of information which could be presented to NOS employees. It is based in part on an item in the Washington Suburban Sanitary Commission (WSSC) public service publication, "A Customer Handbook on Water-Saving and Wastewater Reduction."

Signs could be conspicuously posted in all restrooms to request that anyone noticing malfunctioning flush valves or leaking faucets notify maintenance personnel immediately. Janitorial personnel should also be requested to notify maintenance of any such problems that they observe.

TABLE 2.3-1

INTERMEDIATE WATER CONSERVATION MEASURES AND ESTIMATED SAVINGS

Area	Conservation Measure	Type Water Low Silica, L High Silica, H	Estimated Water Savings (gal/wk)	Conversion Measure Cost[a] ($/yr)	Cost of Water Saved[b] ($/yr)	Realized Savings[c] ($/yr)
Multi Base (Building 704)	Supply cooling water only to equipment in operation.	L	22,000	0	810	810
Pumphouse No. 1 (Building 128)	Eliminated the overflow from the grit chamber through operation/pumping capacity.	H	290,000	886	10,710	9,824
Spray Cooling Pond (Building 137)	Install a float make-up control to eliminate overflow to make-up cooling water.	H	79,000	406	1,515	1,108
Package Waste Treatment Plant (Building 1563)	Repair valve on water tap.	L	30,000	< 50[d]	1,110	1,060
Waste Treatment Plants (Buildings 511C and 1470)	Convert to use of treated effluent for injection of chlorine.	H	342,800	585	12,660	12,075
TOTAL			763,800	1,927	26,805	24,877

[a]Uniform annual cost estimate development is presented in Appendix 2-D.

[b]NOS cost for 1,000 gal of well water is $0.71, supplied by the NOS Public Engineering Department, February, 1982.

[c]These savings are based on February, 1982 cost of water.

[d]This is a one-time cost.

RUBAT CORPORATION

TABLE 2.3-2

EXAMPLE OF NOS EMPLOYEE EDUCATION MATERIAL[a]

Water Leaks Are Money Leaks

Size Leak (in.)	Description	Wasted Water (gpd)	Wasted Water (gal/yr)	Cost[b] ($/day)	Cost[b] ($/yr)
1/32	Pinhole Leak	170	62,050	$ 0.12	$ 43.80
1/16	Fast Drip	600	219,000	$ 0.43	$156.95
1/8	Small Steady Stream	2,500	912,500	$ 1.78	$649.70

[a]This table was based in part on information presented in "A Customer Handbook on Water-Saving and Wastewater Reduction", a public service publication of the WSSC, May 1976.

[b]Cost is based on the current well water supply of $0.71/1,000 gal.

The government employee's Beneficial Suggestion program could provide financial incentives to employees to determine ways of reducing water use of wastewater discharges. NOS employees should be made aware that the Beneficial Suggestions program applies to water conservation and that water conservation does pay.

It is recommended these actions be taken. An overall volume quantification for the entire NOS facility is not possible, however, the cost to implement this conservation measure should be offset by the savings in power costs to pump the unnecessary well water.

2.3.3 CONVERSION OF LOW SILICA WELL WATER USE AREAS TO HIGH SILICA WELL WATER

Three areas exist at the NOS facility in which low silica well water is used as once-through cooling water and for washdown of production and storage areas. These areas are: Multi Base, Pilot Processes, and Cast Products. To conserve this low silica water a convenient alternate source is required. This alternate source is high silica well water. The seasonal total well water balances demand would not decrease as a result of this alternative. Increased high silica water demand is estimated at 350,600 gal/wk. A list of buildings is presented in Table 2.3-3 for which the conversion to a high silica source of well water can be accomplished. The development of the cost estimate for each connection to the high silica distribution system is found in Appendix 2-D.

Five high silica well water distribution system connections are required. Three connections are proposed to serve the Multi-Base area. Connection No. 1 would require a tap into the high silica piping network

TABLE 2.3-3

CONVERSION OF LOW SILICA WELL WATER USE TO HIGH SILICA WELL WATER

Location	Activity	Volume (gal/wk) Summer	Volume (gal/wk) Winter
Multi Base			
Connection No. 1			
1183, 1186	Washdown	200	200
1018	Washdown	400[a]	400[a]
1026	Washdown	3,000	3,000
1024	Washdown	3,000	3,000
1032	Cooling Water	14,400	14,400
1034	Cooling Water	14,400	14,400
1036	Cooling Water	28,800	28,800
1190	Washdown	400	400
		64,600	64,600
Connection No. 2			
707	Cooling Water	16,800	16,800
	Washdown	750	750
706	Cooling Water	16,800	16,800
	Washdown	1,050	1,050
		35,400	35,400
Connection No. 3			
704	Cooling Water	108,000	108,000
	Washdown	1,050	1,050
		109,050	109,050

TABLE 2.3-3 (Cont'd.)

CONVERSION OF LOW SILICA WELL WATER USE TO HIGH SILICA WELL WATER

Location	Activity	Volume (gal/wk) Summer	Winter
Pilot Processes			
854	Cooling Water	14,400	14,400
1047	Cooling Water	36,000	36,000
849	Cooling Water	7,050	7,050
1046	Cooling Water	20,400	20,400
1182	Cooling Water	10,800	10,800
905	Cooling Water	1,500	1,500
		90,150	90,150
Cast Products			
722,723	Washdown	200	200
724	Cooling Water	28,800	28,800
	Washdown	200	200
725	Cooling Water	7,200	7,200
731	Cooling Water	10,800	10,800
	Washdown	200	200
1136	Cooling Water	4,000	4,000
		51,400	51,400
	TOTAL	350,600	350,600

[a]Multi-Base and Cast Products maintain separate areas in Building 1018. The water is used for washdown purposes. It is estimated 200 gal/wk is the volume consumed.

near Building 469. The diameter of the high silica pipe at this point is 4 in. A reduction in diameter to 3 in. is necessary to connect to the low silica piping network near Building 1307. Approximately 500 ft of 3-in. pipe is needed. Valving exists to isolate Connection No. 1 from the 8-in. low silica water line presently supplying the area. An estimated 64,600 gal/wk of low silica water could be conserved by this action.

Connection No. 2 would require a tap into the high silica piping network near Building 702, and a tap into the low silica piping network near Building 703. The pipe diameter for both connections is 3 in. Approximately 300 ft of 3-in. pipe is needed. Valving exists to isolate Connection No. 2 from the 6-in. low silica line presently supplying water. An estimate of low silica well water savings of Connection No. 2 is 35,400 gal/wk.

Connection No. 3 would supply Building 704. Approximately 100 ft of 4-in. diameter is required to tap the high silica well water system near Building 1163. Approximatley 109,050 gal/wk of low silica well water savings could be realized by this action.

The estimated total present value is $16,810 for the conversion in the Multi Base area. The uniform annual cost is calculated to be $2,607.

Approximately 90,150 gal/wk of low silica well water could be conserved through conversion to high silica water in the Pilot Proccess area. An estimated 700 ft of 4-in. diameter pipe is required to connect to the high silica well water system near the intersection of Caffee Road and Strauss Avenue. The estimated total present value of materials and labor is $12,804. The uniform annual cost is calculated to be $1,986. A valve near Building 765 is available to isolate the buildings in this area.

Low silica water could be reduced by 51,400 gal/wk with a connection to the high silica distribution network near Building 1532. Approximately 800 ft of 4-in. diameter pipe is needed to connect the low silica distribution in the Cast Products area. The estimated total present value of the connection near Building 725 is $14,604. The uniform annual cost is calculated to be $2,265. Valving exists to isolate this area from the 10-in. low silica well water supply line presently serving the area.

The estimated low silica well water savings by converting to high silica well water for once-through cooling is 350,600 gal/wk. The total present value cost of the conversion to high silica well water is estimated to be $44,218. The uniform annual cost of this alternative is $6,858. The development of the cost estimates for the conversion from low silica well water to high silica well water for use as once-through equipment cooling water is presented in Appendix 2-D.

2.3.4 SANITARY WATER SAVINGS

The estimated sanitary water use at NOS is 15-20 gpcd for civilian employees and offbase-housed military personnel. A median value of 17.5 gpcd was selected. The projected maximum number of civilian employees and offbase-housed military personnel is 3,458. Well water use by this segment of the total base population is estimated to be 334,250 gal/wk. Approximately, 1,510 people will reside at the NOS. Water consumption was estimated at 100 gpcd. Well water use by this segment of the total base population is estimated to be 1,057,000 gal/wk. The NOS total well water use for sanitary purposes is estimated to be 1,391,250 gal/wk. This translates to a cost of $975/wk or $50,650/yr. The

projection of the civilian and military base population through 1990 is presented in Table 2.3-4.

2.3.4.1 Water-Saving Sanitary Fixtures

Plumbing fixtures manufacturers produce various devices designed for water conservation. These devices reduce the flow or volume per flush. Approximately 7 gal of water is used per flush by a toilet without water-saving devices. NOS has already installed water saving devices in the form of volume displacement equipment. It is reported by NOS Public Works personnel that the volume displacement equipment was not accepted by the NOS residents and was removed from the toilets. Water-saving showerheads were also installed. These were not accepted by NOS residents either. It was reported a comfortable warm water temperature could not be maintained throughout the fall of the shower spray.

Water use reduction of up to 88 percent has been projected by replacing conventional toilets with air-assisted toilets. [6,7] Air-assisted toilets rely on compressed air to assist the transport of waste products. These toilets consume approximately 0.5 gal of water per flush. Air-assisted toilets require 60 psi air pressure and may be operated on a centralized compressed air system. A cost estimate for an air-assisted toilet is presented in Table 2.3-5. This is not considered to be a practical well water conservation method for the following reasons:

- The toilet facilities are not centrally located.
- Installation would encompass individual residences and multi-unit residences.
- Extensive piping networks would be required to supply the air pressure to each residence.

TABLE 2.3-4

MANPOWER PROJECTION AND SANITARY WATER USE FOR NOS

Year	NOS Civilian Employees			Other Civilians			NOS Military & Dependents			Total
	Number	Usage (gpcd)	Volume (gal/wk)	Number	Usage (gpcd)	Volume (gal/wk)	Number	Usage (gpcd)	Volume (gal/wk)	Volume (gal/wk)
1982	2,011	17.5	175,950	1,017	17.5	120,650	1,510	100	1,057,000	1,353,600
1983	2,187	17.5	191,350	1,017	17.5	120,650	1,510	100	1,057,000	1,369,000
1984	2,441	17.5	213,600	1,017	17.5	120,650	1,510	100	1,057,000	1,391,300
1985	2,410	17.5	210,900	1,017	17.5	120,650	1,510	100	1,057,000	1,388,600
1986	2,410	17.5	210,900	1,017	17.5	120,650	1,510	100	1,057,000	1,388,600
1987	2,410	17.5	210,900	1,017	17.5	120,650	1,510	100	1,057,000	1,388,200
1988	2,029	17.5	177,550	1,017	17.5	120,650	1,510	100	1,057,000	1,355,200
1989	2,029	17.5	177,550	1,017	17.5	120,650	1,510	100	1,057,000	1,355,200
1990	2,029	17.5	177,550	1,017	17.5	120,650	1,510	100	1,057,000	1,355,200

THE RUARE CORPORATION

TABLE 2.3-5

AIR-ASSISTED TOILET COST ESTIMATE[8]

Equipment	Cost
Toilet Fixture	$301
Installation Kit (compressor, regulator)	$ 72
Drip Blades	$ 24
Air Filter	$ 66
	$463[a]

[a]Based on a four toilet installation.

2.3.4.2 Pressure Reducing Valves

A residential study by the WSSC demonstrated water savings of 30 to 50 percent by the installation of pressure reducing valves to reduce the 70 to 120 psi main service pressure to 50 psi.[9] Three points exist in the sanitary well water distribution system where system-wide pressure reducing valves could be incorporated. Installation of the reducing valves would affect the main office buildings and basic housing units. This alternative would require installation of reducing values in a 4-in. supply main near Building 901; a 6-in. supply main near Building 1534; and a 10-in. supply main near Building 868. The estimated costs include the pressure reducing valves, coupling flanges, materials of construction for the valve box, and labor. An illustration of a typical pressure reducing station is found in Figure 2.3-1. The uniform annual cost is $41,940, which includes capital investment plus contingency at 10 percent, cost of water, and maintenance costs. The estimated sanitary water use savings for 30 percent reduction is 417,400 gal/wk of high silica well water. This translates to 21,704,800 gal saved annually and a monetary savings of $15,410. The annual cost of well water for sanitary use without installation of the pressure reduction valves is $51,410. The cost estimate development for the two alternatives is presented in Appendix 2-D.

2.3.5 REDUCTION OF WELL WATER FOR ONCE-THROUGH COOLING WATER USE

Significant amounts of once-through cooling water are used at the NOS. A summary of well water used for once-through cooling is presented in Table 2.3-6. Annual high silica well water and low silica well water costs

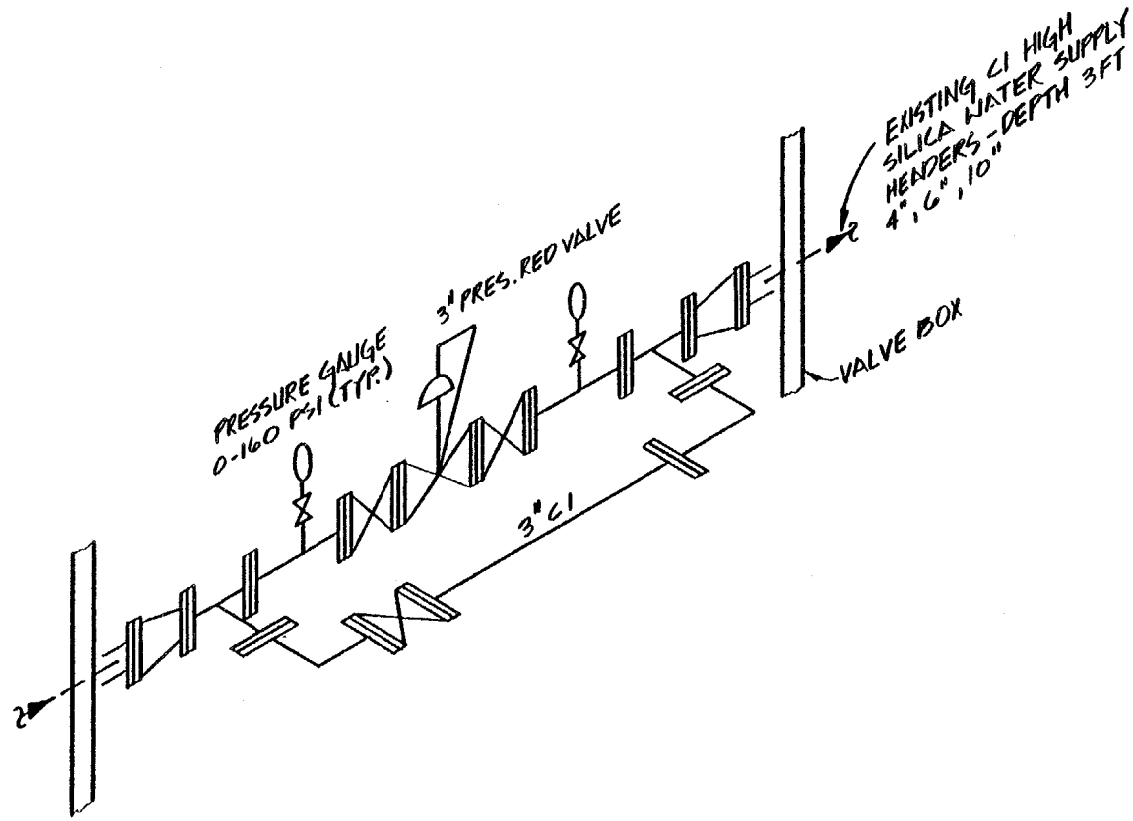


FIGURE 2.3-1 TYPICAL PRESSURE REDUCING STATION

TABLE 2.3-6

SEASONAL ONCE-THROUGH COOLING WATER SUMMARY

Location	Activity/ Equipment	Volume, gal/wk High Silica Summer	High Silica Winter	Low Silica Summer	Low Silica Winter
Power Plant					
873	turbine	1,290,500	78,800		
		1,290,500	78,800	0	0
Multi Base					
707	hydraulic press			8,400	8,400
	hydraulic cutter			8,400	8,400
706	hydraulic press			8,400	8,400
	hydraulic cutter			8,400	8,400
705	hydraulic pieblock press			4,200	4,200
	hydraulic strain & reblock press			4,200	4,200
704	propellant mix water jackets			108,000	108,000
1032	vertical hydraulic press			14,400	14,400
1034	vertical hydraulic press			14,400	14,400
1036	hydraulic press			28,800	28,800
		0	0	207,600	207,600
Casting					
731	vacuum pump oil cooling			10,800	10,800
1042	vacuum pump			2,250	2,250
725	vacuum pump			7,200	7,200
724	vacuum pump			28,800	28,800
743	vacuum pump			2,000	2,000
1136	jacket			4,000	4,000
		0	0	55,050	55,050
CAD					
329	induction soldering			2,750	2,750
		0	0	2,750	2,750
Environmental Testing					
890	cooling jacket pump compressor			4,950	4,950
1523	cooling jacket cookoff oven			3,950	3,950
1526	propellant conditioning unit			28,900	28,900
558	propellant conditioning chambers	95,050	95,050		
754	propellant conditioning chamber			95,050	95,050
759	still			100	100
798	compressor			97,900	97,900
	water pump			55,450	55,450
754	compressor			124,750	124,750
753	environmental conditioning			17,000	17,000
558	Oven No. 4	39,600	39,600		
	Oven No. 11	81,600	81,600		
	compressor	27,700	27,700		
		243,950	243,950	428,050	428,050

TABLE 2.3-6 (Cont'd.)

SEASONAL ONCE-THROUGH COOLING WATER SUMMARY

Location	Activity/ Equipment	Volume, gal/wk High Silica Summer	High Silica Winter	Low Silica Summer	Low Silica Winter
Pilot Processes					
854	150 gal mixer			14,400	14,400
856	pump			2,700	2,700
905	pump			1,500	1,500
1182	one gal mixer			900	900
	vacuum pump			9,900	9,900
678	vacuum pump	9,900	9,900		
1047	pumps & presses			36,000	36,000
1046	blocking press			20,400	20,400
849	press cooling jacket			7,050	7,050
680	rolling mill	3,450	3,450		
		13,350	13,350	92,850	92,850
Nitration					
775	refrigeration cooling jacket			12,000	12,000
786	soda water washer cooling jacket			15,600	15,600
670	compressor	5,000	5,000		
		5,000	5,000	27,600	27,600
Base Dispensary					
1600	compressor	6,150	6,150		
		6,150	6,150	0	0
Photo Processing					
1601	Versamat	21,600	21,600		
		21,600	21,600		
	Seasonal Once-Through Cooling Water Volume	1,580,550	368,550	813,900	813,900

are calculated to be $85,800, and $41,600, respectively, for once-through cooling water. Various alternatives for reduction of each significant once-through cooling water use at NOS were identified and evaluated. The alternatives which were considered are listed in Table 2.3-7.

2.3.5.1 Manual Controls

The use of manual controls to reduce cooling water usage would be the least costly alternative, where current cooling water use is greater than the equipment requirements. However, manual control is highly operator-dependent, and any initial water savings realized could subsequently be lost.

2.3.5.2 Existing Equipment Modifications

This alternative concerns alterations to existing cooling equipment through the installation of temperature sensitive flow control equipment or by switching from well water as the cooling medium to appropriately treated river water as the cooling medium.

2.3.5.2.1 Solenoid Valve Installation. The most practical device to regulate flow in relation to temperature is a solenoid valve. The solenoid valve operates only when the piece of equipment to which it is attached is in operation. Working conditions at the NOS make explosion-proof solenoid valves necessary. A typical solenoid valve installation is shown in Figure 2.3-2.

Approximately 30 percent of the well water used for equipment cooling could be saved with installation of the solenoid valves. From the summary of seasonal flows in Table 2.3-6, a total of 2,394,450 gal/wk is used for

TABLE 2.3-7

MEASURES CONSIDERED FOR REDUCING ONCE-THROUGH WELL WATER COOLING WATER

1. Manual control of cooling water flows based on the specific requirement of equipment.

   a. Adjust water valves so only as much cooling water flows as is required for the desired operating temperature of the equipment.

   b. Turn cooling water valves off, when the equipment is not in use.

2. Installation of solenoid valves in cooling water lines to be controlled by a temperature sensing element.

3. Utilize Potomac River water as the cooling medium replacing the well water.

4. Installation of cooling towers to replace once-through cooling water.

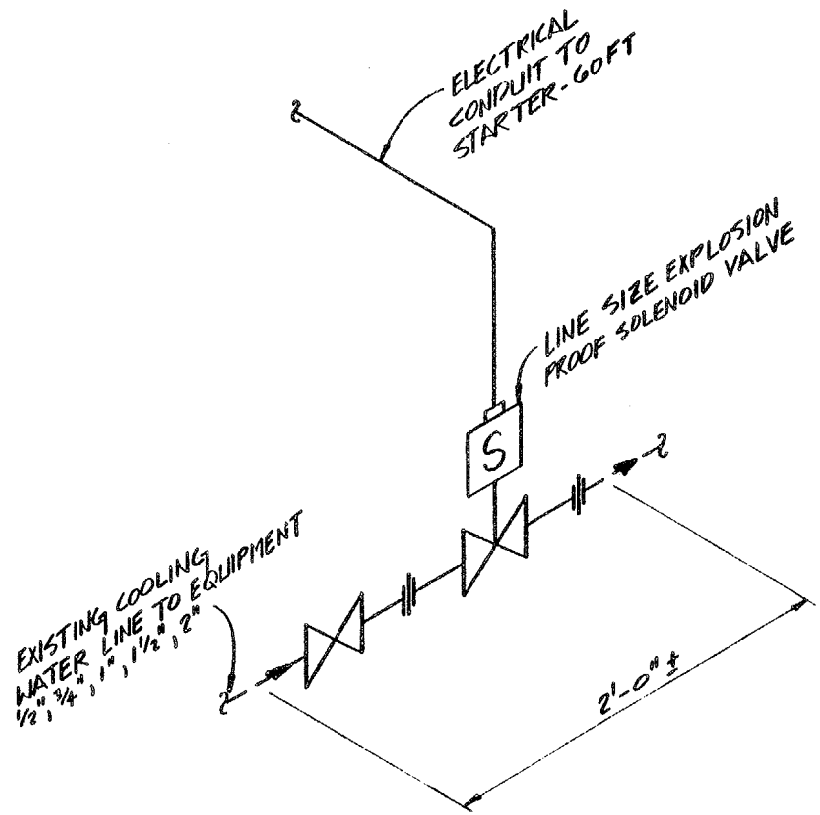


FIGURE 2.3-2 TYPICAL SOLENOID VALVE INSTALLATION

equipment cooling during the summer months, and 1,182,450 gal/wk during the winter months. A reduction in cooling water volume of 30 percent translates to a well water volume savings of 718,350 gal/wk during summer operation, and 354,750 gal/wk during winter operation. The annual well water volume savings is estimated to be 28,259,400 gal. This volume saved translates to $20,065 annually.

Cooling water lines for the equipment serviced would range from lines having a diameter of 2 in. to lines with a 3/4 in. diameter. Listed in Table 2.3-8 are the NOS areas where well water is used as once-through cooling water and the equipment served. The estimated total capital cost of the solenoid valves is $134,900. The uniform annual cost is $69,250, which includes capital investment plus contingency at 10 percent, cost of water, and maintenance costs. The annual cost of well water used for cooling without installation of the solenoid valves is $66,890. The development of cost estimates are presented in Appendix 2-D.

2.3.5.2.2 Utilization of Potomac River Water for Equipment Cooling. This alternative considers use of the Potomac River as a source of cooling water. At present the NOS utilizes a river water distribution network mainly for supplying water for washdown and to supply the fire protection sprinkler system. The minimum water pressure maintained in the river water piping network is approximately 180 psi. Screened river water is pumped into the distribution network until 210 psi is achieved. The pumps do not shut down when 210 psi is achieved; rather, a 6-in. side stream of river water is created. Once the pressure in the river water piping network drops to 180 psi, the pumps again charge the system to 210 psi. The

TABLE 2.3-8

SOLENOID INSTALLATION TO REDUCE ONCE-THROUGH COOLING WATER

Location	Activity/ Equipment
Multi Base	
707	hydraulic press
	hydraulic cutter
706	hydraulic press
	hydraulic cutter
705	hydraulic preblock press
	hydraulic strain & reblock press
704	propellant mix water jackets
1036	hydraulic press
1032	vertical hydraulic press
1034	vertical hydraulic press
Cast Products	
731	vacuum pump
1042	vacuum pump
725	vacuum pump
724	vacuum pump
743	vacuum pump
1136	jacket
CAD	
329	induction solderer

TABLE 2.3-8 (Cont'd.)

SOLENOID INSTALLATION TO REDUCE ONCE-THROUGH COOLING WATER

Location	Activity/ Equipment
Environmental Testing	
890	cooling jacket pump compressor
1523	cook-off oven
1526	propellant conditioning unit
558	propellant conditioning chambers
754	propellant conditioning chambers
798	compressor
	water pump
754	compressor
753	environmental conditioning
558	oven no. 4
	oven no. 11
	compressor
Pilot Processes	
854	hydraulic pump
856	hydraulic pump
905	hydraulic pump
1182	one gal mixer
678	vacuum pump
1047	hydraulic pump
1046	blocking press
849	press cooling jacket
Nitration	
775	refrigeration cooling jacket
786	soda water washer cooling jacket
670	compressor cooling

TABLE 2.3-8 (Cont'd.)

SOLENOID INSTALLATION TO REDUCE ONCE-THROUGH COOLING WATER

Location	Activity/ Equipment
Base Dispensary	
1600	compressor
Power Plant	
873	turbines
Photo Processing	
1601	Versamat

estimated side stream flow is 2,700 gpm at 180 psi, or 3,888,000 gpd. This estimation is based on the Colebrook-White equation for discharge volume from a pipe. Engineering judgment was incorporated in assuming a coefficient of friction of 0.025 for the pipe. The length of pipe intake and discharge (100 ft) and the pressure differential across the pump (416 ft) were determined from the actual field conditions.

Approximately 2,394,450 gal/wk is required for equipment cooling at the NOS for summer operation and 1,182,450 gal/wk for winter operation. These volumes are combined high silica and low silica well water. The estimated available river water side stream flow of 3,888,000 gpd by one pump is greater than the total volume required for summer or winter equipment cooling demands. If the average summer cooling water requirement of 2,394,450 is assumed to occur during a 5-day working week and an 8-hr working day, the peak cooling water flow would be approximately 1,000 gpm. The calculated river water supply is 2,700 gpm.

Water quality of the Potomac River at Indian Head is summarized in Table 2.3-9. The data are for the period June 1980 through June 1981 and were collected at Buoy 54 off Indian Head. This water quality is acceptable for use as a non-contact cooling medium. Copper tubing is adversely affected at a high pH and stainless steel is adversely affected at a low pH. The pH is reported to range from 7.3 to 7.8 standard units.

The solids in the river water could cause deposition problems if the flow in the heat exchangers were less than 1 gpm; however, no cooling flows less than 1 gpm were observed at NOS. Additionally, at least one site at NOS is already using river water for cooling. Some particulate matter is beneficial. As the water circulates in the cooling tubes the particles

TABLE 2.3-9

POTOMAC RIVER WATER QUALITY AT BUOY 54 OFF INDIAN HEAD[a]

Date	Water Temperature °C	pH Standard Units	Solids mg/l
80/06/09	23.3	7.3	124
80/07/14	27.2	7.3	125
80/08/25	26.3	7.6	136
80/10/20	17.1	7.6	252
80/12/01	6.6	7.8	447
81/03/02	7.5	7.6	128
81/04/08	13.7	7.6	193
81/05/04	16.5	7.5	140
81/06/01	21.8	7.3	140

[a]Data furnished by the Interstate Commission on the Potomac River Basin.

strike the inner surface of the tubes creating an abrasive cleaning effect. This striking action of the particles helps to deter build-up of scale in the exchange tubes. Scale restricts the flow of cooling water and also retards the desired exchange of heat from the equipment to the circulated cooling medium.

The normal operating temperature of the oil for the various pieces of equipment, as reported by NOS personnel, ranges between 90 to 100°F (32.2-37.8^{o}C), and should never exceed 120°F (48.9^{o}C). The maximum reported river water temperature for the data period was in the month of July, 1980 at 27.2^{o}C (81°F) which is 10.6^{o}C (39°F) cooler than the upper normal operating temperature range and 5°C (14°F) than the lower normal operating temperature. Reported influent and effluent cooling water did not exhibit marked temperature increases across the equipment. A temperature increase of 25°F was reported for the cooling of turbines located at the power plant. Influent cooling water temperature was reported as 100°F (37.8^{o}C), and effluent cooling water temperature was reported as 125°F (51.7^{o}C). At the maximum summer river water temperature of 27.2^{o}C (81°F), which is less than the temperature of the cooling water supplied at 37.8^{o}C (100°F) during winter operation, the river water is considered an acceptable source of cooling medium.

To estimate the cost to tap the river water distribution system mains as a supply for cooling water the following assumptions were made:

1. Approximately 100 ft of 2-in. pipe would be laid from the river water main to each affected building with pressure reduction to 75-80 psi.

2. Approximately 100 ft of 1/2-3/4 in. diameter pipe would be required to service the various pieces of equipment in each affected building.

3. In some instances it may be necessary to lay multiple 2-in. pipe connections to adequately supply a building with cooling water.

A schematic of a typical river water connection to a process building is presented in Figure 2.3-3.

Implementation of this alternative would eliminate the majority of use of low silica and high silica well water as a cooling medium source. An estimated 2,385,700 gal/wk of the total of 2,394,450 gal/wk well water used for summer operation equipment cooling should be saved, as would an estimated 1,174,200 gal/wk of the total 1,182,450 gal/wk well water used for winter operation equipment cooling. A summary of the well water replaced by river water for once-through cooling is found in Table 2.3-10.

The estimated total cost for implementing this alternative is $260,900 of which $210,900 is initial capital investment, including contingency at 10 percent, for equipment and $50,000 is for a hydraulic network analysis. No operating costs are incurred. River water presently being wasted as a 6-in. side-stream would be utilized as the cooling medium. The estimated uniform annual cost of this alternative is $41,405; whereas, the annual cost of continuing to use well water for equipment cooling is $65,700. Development of the cost estimate is found in Appendix 2-D.

2.3.6 CONVERSION OF WASHDOWN WATER FROM WELL WATER TO RIVER WATER

The nature of the various intermediate products and final products at the NOS requires washdown of process and storage areas. In most production

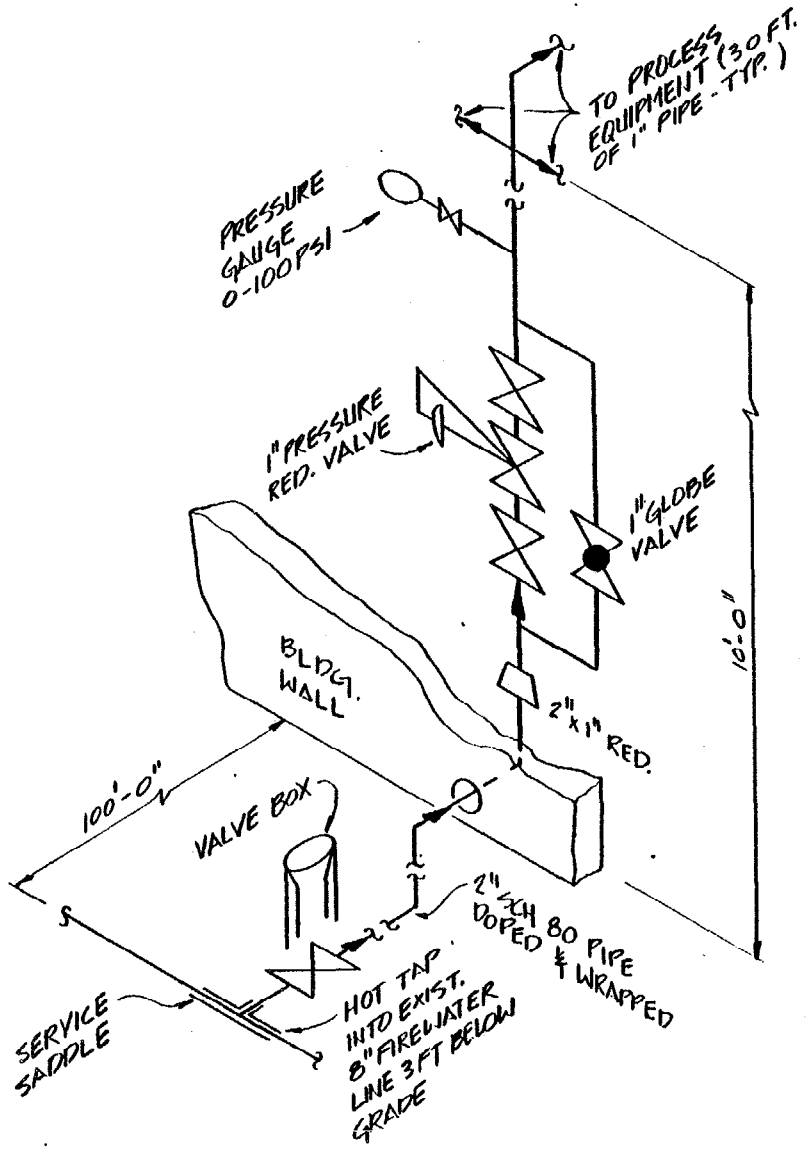


FIGURE 2.3-3 TYPICAL RIVER WATER CONNECTION TO PROCESS BUILDING

TABLE 2.3-10

WELL WATER VOLUME REDUCTION
BY CONVERSION TO RIVER WATER
FOR COOLING

Location	Volume, gal/wk			
	High Silica		Low Silica	
	Summer	Winter	Summer	Winter
Multi Base				
707			16,800	16,800
706			16,800	16,800
705			8,400	8,400
704			108,000	108,000
1036			14,400	14,400
1032			14,400	14,400
1034			28,800	28,800
	0	0	207,600	207,600
Cast Products				
731			10,800	10,800
1042			2,250	2,250
725			7,200	7,200
724			28,800	28,800
743			2,000	2,000
1136			4,000	4,000
	0	0	55,050	55,050
CAD				
329			2,750	2,750
	0	0	2,750	2,750
Environmental Testing				
890			4,950	4,950
1523			3,950	3,950
1526			28,900	28,900
558	243,950	243,950		
754			219,800	219,800
753			17,000	17,000
759			100	100
798			153,350	153,350
	243,950	243,950	428,050	428,050

TABLE 2.3-10 (Cont'd)

WELL WATER VOLUME REDUCTION
BY CONVERSION TO RIVER WATER
FOR COOLING

Location	Volume, gal/wk			
	High Silica		Low Silica	
	Summer	Winter	Summer	Winter
Pilot Processes				
854			14,400	14,400
856			2,700	2,700
905			1,500	1,500
1182			10,800	10,800
678	9,900	9,900		
1047			36,000	36,000
1046			20,400	20,400
849			7,050	7,050
680	3,450	3,450		
	13,350	13,350	92,850	92,850
Nitration				
775			12,000	12,000
786			15,600	15,600
670	5,000	5,000		
	5,000	5,000	27,600	27,600
Base Dispensary				
1600	6,150	6,150		
	6,150	6,150	0	0
Power Plant				
873	1,290,000	78,500		
	1,290,000	78,500	0	0
Seasonal Once-Through Cooling Water Volume Eliminated	1,558,450	346,950	813,900	813,900

process areas, washdown frequency is daily. However, washdown may occur more frequently depending on the product. Spills also occur that require washdown or dilution prior to action to neutralize the spilled material.

In most cases the water supplied for washdown is well water; however, river water is used in some areas of the NOS for washdown, but infrequently. A summary of the areas that use well water for washdown and the estimated volume is presented in Table 2.3.-11. An estimated 27,050 gal/wk of well water is used for washdown during summer and winter operation. This volume is based on results of the water use survey reported in Chapter 2.1.3 of this report. Approximately 85 percent (22,000 gal/wk) of the well water used in washdown is low silica supplied. The remaining 15 percent (5,000 gal/wk) is from high silica supply. The cost of the well water for washdown is $19.21/wk or $998.92/yr.

The cost to convert to river water for the purpose of washdown may be calculated for two modes. The first mode is to make a connection to the river water distribution system as a feeder to the building and then make two runs of distribution pipe inside the building to supply washdown water. The second mode is to connect the two inside distribution pipe runs to the feeder line supplying the equipment cooling water.

To accomplish the first alternative of conversion to river water as washdown supply, the following were assumed:

1. Approximately 100 ft of 2-in. pipe would be laid from the river water main to the building with pressure reduction to 75-80 psi.
2. Approximately 100 ft of 1/2- to 3/4-in. diameter pipe would be required to service areas within the building.

TABLE 2.3-11

SUMMARY OF WELL WATER USED FOR AREA WASHDOWN

Location	Volume, gal/wk			
	High Silica		Low Silica	
	Summer	Winter	Summer	Winter
Power Plant				
873	300	300		
	300	300		
Multi Base				
707			750	750
706			1,050	1,050
705			1,050	1,050
704			1,050	1,050
471	840	840	840	840
1024			3,000	3,000
1026			3,000	3,000
1190			400	400
1018			200	200
1183, 1186			200	200
313			200	200
1007			200	200
1009			200	200
218, 219 326, 327 328	50	50		
	890	890	11,300	11,300
Cast Products				
730			200	200
731			200	200
724			200	200
722, 723			200	200
1018			200	200
720			200	200
	0	0	1,200	1,200

TABLE 2.3-11 (Cont'd.)

SUMMARY OF WELL WATER USED FOR AREA WASHDOWN

Location	Volume, gal/wk			
	High Silica		Low Silica	
	Summer	Winter	Summer	Winter
Extruded Materials				
336	300	300		
530	100	100		
	400	400	0	0
Environmental Testing				
1140			1,850	1,850
731			1,850	1,850
	0	0	3,700	3,700
Organic Chemicals				
497			150	150
859	200	200		
	200	200	150	150
Nitration				
775			1,000	1,000
786			2,000	2,000
787			1,000	1,000
1464			1,000	1,000
1461, 1462			400	400
1006			100	100
801			200	200
1543	200	200		
676	200	200		
672	200	200		
674	250	250		
690	250	250		
	1,100	1,100	5,700	5,700

TABLE 2.3-11 (Cont'd.)

SUMMARY OF WELL WATER USED FOR AREA WASHDOWN

Location	Volume, gal/wk			
	High Silica		Low Silica	
	Summer	Winter	Summer	Winter
Waste Treatment				
1470	2,100	2,100	———	———
	2,100	2,100	0	0
Total	5,000	5,000	22,050	22,050

A total of 47 buildings use well water for washdown. The resulting estimated investment cost is $275,300, including contingency at 10 percent, to make the conversion to river water. The uniform annual cost is estimated to be $43,900. The present cost of well water for washdown is estimated to be $1,000/yr.

The second alternative utilizes what would be existing feeder lines for the river water equipment cooling system discussed in the preceding section. The two 1/2- to 3/4-in. pipe runs inside the building would be connected to this feeder line. The estimated equipment investment cost is $195,110, including contingency at 10 percent, for river water washdown connections. The estimated uniform annual cost is $31,450. The present cost of well water for washdown is estimated to be $1,000/yr. Development of the cost estimates is presented in Appendix 2-D.

2.3.7 INSTALLATION OF COOLING TOWERS TO REDUCE ONCE-THROUGH COOLING WATER

To conserve well water, cooling towers are considered an alternative method. Wet cooling towers were chosen, rather than either dry or wet/dry coolers, for the following reasons:

1. Wet coolers are feasible for low flows.
2. Elevated temperatures (600-700°F) are not present in the equipment to be serviced.
3. The capital cost of a dry cooler is approximately 10 times those of wet coolers.

The combination of equipment cooling water flows is required for consideration of cooling towers as a viable alternative to conserving well water presently being used as once-through cooling water. Regional cooling of water for equipment temperature control could be accomplished by

cooling towers serving NOS Buildings 753, 754, and 798 in the Environmental Test area; NOS Buildings 849, 854, 905, 1046, 1047, and 1182 in the Pilot Processes area; NOS Buildings 704, 705, 706, and 707 in the Multi Base area; and NOS Building 873 which is the Goddard Power Plant. A schematic of a regional cooling tower and associated equipment is presented in Figure 2.3-4.

2.3.7.1 Environmental Test Area Regional Cooling Tower

Approximately 390,150 gal/wk (54 gpm) of low silica well water is used as once- through cooling water. The regional cooling tower would supply equipment cooling water in Buildings 753, 754, and 798. The necessary cooling equipment and costs are found in Table 2.3-12.

An estimated 420,500 gal/yr well water would be consumed for continuous operation of the cooling tower. The estimated annual well water use for the present method of using well water for once-through cooling is 20,287,800 gal. The annual cost for this volume of well water is $14,400. The capital investment cost for the cooling tower is $76,450, including contingency at 10 percent. The uniform annual cost for the cooling tower is estimated to be $15,100. Development of the cost estimates is found in Appendix 2-D.

2.3.7.2 Pilot Processes Area Regional Cooling Tower

Low silica well water is used for once-through cooling in the Pilot Processes area in Buildings 849, 854, 905, 1046, 1047, and 1182. Approximately 138,800 gal/wk (19 gpm) is consumed. The necessary cooling equipment and its cost is found in Table 2.3-13.

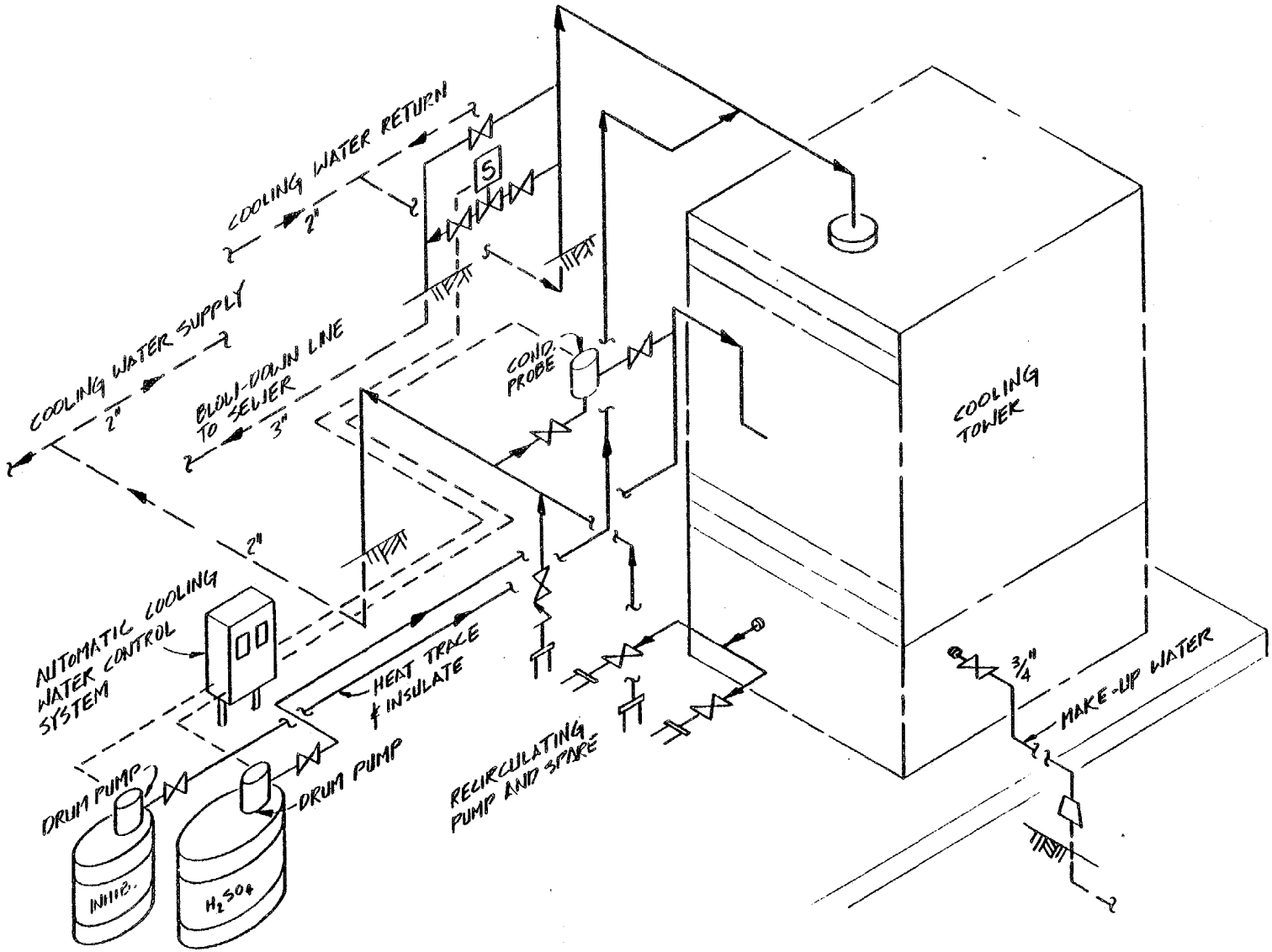


FIGURE 2.3-4 REGIONAL COOLING AND ASSOCIATED EQUIPMENT

TABLE 2.3-12

REGIONAL COOLING TOWER #1 EQUIPMENT LIST

Item	Number of Items	Type	Cost ($)
Recirculating Pumps	2	Goulds Model 3196 ST 1 x 1½ x 8 AA with 3 HP TEFC Motor	2,400
Nalco Power Pack	1	VII	1,650
Acid Drum Pump	1		275
Inhibitor Drum Pump	1		275
Solenoid Valve	1	3/4 inch	86
Cooling Tower	1	Marley Model 4720	2,640

TABLE 2.3-13

REGIONAL COOLING TOWER #2 EQUIPMENT LIST

Item	Number of Items	Type	Cost ($)
Recirculating Pumps	2	Goulds Model 3196 ST 1 x 1½ x 8 AA with 1 HP TEFC Motor	2,300
Nalco Power Pack	1	VII	1,650
Acid Drum Pump	1		275
Inhibitor Drum Pump	1		275
Solenoid Valve	1	3/4 inch	86
Cooling Tower	1	Marley Model 4707	2,140

An estimated 157,700 gal/yr well water would be consumed for continuous operation of the cooling tower. The estimated annual well water use for the present method of using well water for once-through cooling is 7,217,600 gal. The annual cost for this volume of well water is $5,125. The capital investment cost for the cooling tower is $99,770, including contingency at 10 percent. The uniform annual cost for the cooling tower is estimated to be $17,791. Development of the cost estimates is found in Appendix 2-D.

2.3.7.3 Multi Base Area Regional Cooling Tower

Low silica well water is used for equipment cooling in Buildings 704, 705, 706, and 707. Cooling equipment and associated costs are found in Table 2.3-14. Approximately 167,500 gal/wk (23 gpm) is presently consumed by using low silica well water for once-through cooling.

An estimated 210,240 gal/yr well water would be consumed for continuous operation of the cooling tower. The estimated consumption of well water for the present practice of once-through cooling is 8,710,000 gal/yr. The annual cost of this volume of well water is $6,185. The capital investment cost for the cooling tower is $106,370, including contingency at 10 percent. The uniform annual cost for the cooling tower is estimated to be $18,882. Development of the cost estimates is found in Appendix 2-D.

2.3.7.4 Goddard Power Plant Cooling Tower

An estimated 1,290,000 gal/wk (128 gpm) of high silica well water is used to cool the steam turbines at the Goddard Power Plant, which is

TABLE 2.3-14

REGIONAL COOLING TOWER #3 EQUIPMENT LIST

Item	Number of Items	Type	Cost ($)
Recirculating Pumps	2	Goulds Model 3196 ST 1 x 1½ x 8 AA with 1 HP Motor	2,300
Nalco Power Pack	1	VII	1,650
Acid Drum Pump	1		275
Inhibitor Drum Pump	1		275
Solenoid Valve	1	3/4 inch	86
Cooling Tower	1	Marley Model 4710	2,240

designated as Building 873. The cooling equipment and its cost is presented in Table 2.3-15.

Continuous operation of the cooling tower would consume an estimated 1,051,200 gal/yr. The estimated annual consumption for the present practice of using well water for once-through cooling is 67,080,000 gal. The annual cost of this volume of well water is $47,630. The capital investment cost for the cooling tower is $49,500, including contingency at 10 percent. The uniform annual cost for the cooling tower is estimated to be $12,285. Development of the cost estimates is presented in Appendix 2-D.

2.3.7.5 Cooling Tower Summary

An estimated total volume of 1,986,450 gal/wk of well water is presently consumed as once-through cooling water in the Environmental Test Area, Pilot Processes Area, Multi Base Area, and by the Goddard Power Plant. The estimated volume of water which would be consumed by the cooling towers is 1,839,650 gal/yr, which is approximately two percent of the current well water usage for cooling purposes.

The uniform annual cost of operating the cooling towers is projected to be $64,058. The annual cost of the present operation of well water as once-through cooling water is $73,340. The total uniform annual cost for installation of all four cooling towers is less than the present mode of operation. However, only the Goddard Power Plant is economically feasible by itself. The other three areas (Environmental Test, Pilot Processes, Multi Base) are not economically attractive. A summary of the gallons of well water required and saved and annual operating costs is found in Table 2.3-16.

TABLE 2.3-15

REGIONAL COOLING TOWER #4 EQUIPMENT LIST

Item	Number of Items	Type	Cost ($)
Recirculating Pumps	2	Goulds Model 3196 MT 3 x 2 x 8 A60 with 3 HP Motor	3,000
Nalco Power Pack	1	VII	1,650
Acid Drum Pump	1		275
Inhibitor Drum Pump	1		275
Solenoid Valve	1	3/4 inch	86
Cooling Tower	1	Marley Model 4745	3,140

THE RUPARE CORPORATION

TABLE 2.3-16

SUMMARY COMPARISON OF COOLING TOWER INSTALLATION

Area	Well Water Use, gal/yr		Operation Cost, $		Cost Savings	
	Present Practice	Installation of Cooling Tower	Present Practice	Cooling Towers	Yes	No
Environmental Test	20,287,800	420,500	14,400	15,100		X
Pilot Processes	7,217,600	157,700	5,125	17,791		X
Multi Base	8,710,000	210,240	6,185	18,882		X
Goddard Power Plant	67,080,000	1,051,200	47,630	12,285	X	
Total	103,295,400	1,839,640	73,340	64,058	X	

2.3.8 ECONOMIC EVALUATION

Preliminary cost estimates for the potential technically and economically feasible water conservation alternatives have been discussed in the previous sections. The cost estimating work sheets for development of the preliminary cost estimates are contained in Appendix 2-D. Included in the cost estimate are allowances for indirect charges on labor and materials and subcontracting. The cost estimates do not reflect engineering design costs nor field engineering inspection fees. These are factored into the estimate found in Form DD 1391, which is presented in the Summary and Conclusions section of this report.

2.3.8.1 Economic Evaluations of the Various Alternatives

A summary of the projected water savings and cost estimates for each potentially feasible water conservation alternative is presented in Table 2.3-17. The uniform annual capital cost per unit water savings is also listed in Table 2.3-17, so there is a common unit of comparison for all alternatives.

2.3.8.2 Intermediate Well Water Conservation Measures

All of the intermediate well water conservation measures, as presented in Section 2.3.2, are economically attractive. These measures could be implemented until a more encompassing well water conservation plan is established. Approximately 711,800 gal/wk of high silica well water and 52,000 gal/wk of low silica well water could be saved. The uniform annual cost of these measures is estimated to be $1,927. The uniform annual cost per unit water savings is less than $0.10/1,000-gal for all measures.

TABLE 2.3-17

SUMMARY OF WATER CONSERVATION ALTERNATIVES AND UNIFORM ANNUAL COSTS

Area/Building	Water Conservation Alternative(s)	Current Water Use (gal/wk)	Projected Water Use (gal/wk)	Uniform Annual Cost of Installation ($)	Uniform Annual Cost per Unit Water Savings ($/1,000 gal)
INTERMEDIATE WELL WATER CONSERVATION MEASURES					
Multi Base Building 704	Supply cooling water only to equipment in operation.	22,000	0	0	0.00
Pumphouse No. 1 Building 128	Eliminate the overflow from the grit chamber through operation/pumping capacity.	290,000	0	886	0.06
Spray Cooling Pond Building 137	Install a float make-up control to eliminate overflow of make-up cooling water.	79,000	0	406	0.10
Package Waste Treatment Plant Building 1563	Repair valve on water tap.	30,000	0	50[a]	0.03
Waste Treatment Plants Buildings 511C and 1470	Convert to use of treated effluent for injection of chlorine.	342,800	0	585	0.03
SANITARY WATER USE REDUCTION					
Housing and Offices	Installation of system-wide pressure reducing values.	1,391,300[d]	973,900[d]	41,940	1.93
CONVERSION OF LOW SILICA WELL WATER SUPPLY TO HIGH SILICA WELL WATER SUPPLY					
Multi Base Area		208,450[b]	208,450[b]	2,607[c]	
Pilot Processes Area		90,150[b]	90,150[b]	1,986[c]	
Cast Products Area		51,400[b]	51,400[b]	2,265[c]	
		350,000	350,000	6,858	

TABLE 2.3-17 (Cont'd)

SUMMARY OF WATER CONSERVATION ALTERNATIVES AND UNIFORM ANNUAL COSTS

Building	Water Conservation Alternative(s)	Current Water Use (gal/wk)	Projected Water Use (gal/wk)	Uniform Annual Cost of Installation ($)	Uniform Annual Cost per Unit Water Savings ($/1,000 gal)
REDUCTION OF ONCE-THROUGH COOLING WATER					
Multi Base Cast Products CAD Environmental Testing Pilot Processes Nitration Base Dispensary Power Plant Photo Processing	Solenoid valves[e]	1,811,750[f]	1,268,200[f]	69,250	2.45
LOW SILICA WELL WATER CONVERSION TO POTOMAC RIVER FOR ONCE-THROUGH COOLING					
Multi Base Cast Products CAD Environmental Testing Pilot Processes Nitration Base Dispensary Power Plant	Conversion to Potomac River water for once-through equipment cooling water.[g]	1,779,950[h]	0	41,450	0.45
CONVERSION OF WASHDOWN WATER FROM WELL WATER TO RIVER WATER					
Power Plant Multi Base Cast Products	Conversion to Potomac River water for area washdown water.[i]	27,050	0	43,900[j]	31.21[j]
Extruded Materials Enviornmental Testing Organic Chemicals Nitration Waste Treatment		27,050	0	31,450[k]	22.36[k]

AUARE CORPORATION

TABLE 2.3-17 (Cont'd)

SUMMARY OF WATER CONSERVATION ALTERNATIVES AND UNIFORM ANNUAL COSTS

Building	Water Conservation Alternative(s)	Current Water Use (gal/wk)	Projected Water Use (gal/wk)	Uniform Annual Cost of Installation ($)	Uniform Annual Cost per Unit Water Savings ($/1,000 gal)
INSTALLATION OF COOLING TOWERS TO REDUCE ONCE-THROUGH COOLING WATER					
Environmental Testing	Regional cooling tower installations.	390,150	8,085	15,100	0.76
Pilot Processes		138,800	3,035	17,791	2.52
Multi Base		167,500	4,045	18,882	2.22
Goddard Power Plant		1,290,000	20,215	12,285	0.19
		1,986,450	35,380	64,058	0.63

[a]Cost is estimated for 1 year payment. No capital costs are anticipated for future operation other than operation or maintenance which should be negligible.

[b]Low silica well water supply converted to high silica well water supply.

[c]Well water is not conserved by this alternative. Low silica well water use is converted to high silica well water use.

[d]Value based on 1984 peak estimated sanitary demand.

[e]A listing of the buildings designated for installation of solenoid values is contained in Table 3.4-3.

[f]Average value for summer and winter operating conditions.

[g]A listing of the buildings to be converted to Potomac River water for once-through cooling are found in Table 3.4-5.

[h]Average value for summer and winter operating conditions.

[i]A listing of the buildings considered in this alternative are found in Table 3.5-1.

[j]This value considers having to tap the river water distribution system approximately 100 ft from the building.

[k]This value is based on connection to the river water distribution system, used as once-through equipment cooling water, inside the building and only requiring inside pipe runs.

THE RUARE CORPORATION

2.3.8.3 Sanitary Water Use Reduction

Reduction of the volume of well water used for sanitary purposes could be accomplished through the installation of system-wide pressure reducing valves. Approximately 417,400 gal/wk of high silica well water (30 percent) could be saved. The uniform annual cost for this measure is estimated to be $41,940. The uniform annual cost per unit water savings is $1.93/1,000-gal.

2.3.8.4 Reduction of Once-Through Well Water Used for Equipment Cooling and Area Washdown

The alternatives considered include conversion of low silica use areas to high silica supply; installation of on/off-controlled solenoid valves; conversion to Potomac River water for once-through cooling; conversion to Potomac River water for area washdown; and regional cooling towers. The conversion of low silica use areas to high silica water does not result in an overall well water use reduction. It does, however, conserve low silica water which is important for the Goddard Power Plant operation.

2.3.8.4.1 Conversion of Low Silica Use Areas to High Silica Supply. This alternative considers converting areas presently utilizing low silica well water for once-through equipment cooling and area washdown to high silica supply. Implementation of this alternative would conserve approximately 350,000 gal/wk of low silica well water; however, 350,000 gal/wk of high silica well water would be required. The uniform annual cost of this alternative is estimated to be $6,858. There is no cost per unit of water saved with this alternative, since low silica water use is only replaced by high silica water use.

2.3.8.4.2 Solenoid Valve Installation. Approximately 30 percent of the present volume of well water used for once-through equipment cooling could be conserved by installation of on/off-controlled solenoid valves. The total summer cooling water flow is estimated to be 2,394,450 gal/wk and the winter cooling water flow is estimated to be 1,182,450 gal/wk. The summer high silica well water volume is 1,580,550 gal/wk and the low silica well water volume is 813,900 gal/wk, of which 474,150 gal/wk and 244,200 gal/wk could be conserved for high silica and low silica well water, respectively. The total volume of well water conserved during summer operation would be 718,350 gal/wk. The winter high silica well water volume is 368,550 gal/wk and the low silica well water volume is 813,900 gal/wk, of which 110,550 gal/wk and 244,200 gal/wk could be conserved for high silica and low silica well water, respectively. The total volume of well water conserved during winter operation would be 354,750 gal/wk. The overall weekly average volume of well water saved is 543,550 gal. The uniform annual cost of this alternative is estimated to be $69,250. The uniform annual cost per unit water savings is $2.45/1,000-gal.

2.3.8.4.3 Conversion to Potomac River Water for Once-Through Cooling. This alternative considers use of the Potomac River as a source of cooling water. Approximately 2,394,450 gal/wk is required for equipment cooling for summer operation and 1,182,450 gal/wk for winter operation. Summer operation cooling water volumes for high silica and low silica are 1,580,550 gal/wk and 813,900 gal/wk, respectively. Winter operation cooling water volumes for high silica and low silica are

368,550 gal/wk and 813,900 gal/wk, respectively. The total volume of well water for summer and winter operation would be saved. The uniform annual cost for alternative is estimated to be $41,405. The uniform annual cost per unit water savings is $0.45/1,000-gal.

2.3.8.4.4 Conversion of Washdown Water to Potomac River Water. This alternative has two possible modes of implementation to conserve an estimated 27,050 gal/wk of well water. The low silica well water volume is 5,000 gal/wk. The balance of 22,050 gal/wk is high silica well water. The first mode is based on the assumption that all 47 buildings utilizing washdown would require connection to the river water distribution system approximately 100 ft from the building. The uniform annual cost for this alternative is $43,900. The uniform annual cost per unit water savings is $31.21/1,000-gal.

The second mode is based on the assumption that 36 of the 47 buildings have been connected to the river water distribution system for once-through equipment cooling. This would require 11 more connections to the river water distribution system and 47 inside pipe runs. The uniform annual cost of the conversion is estimated to be $31,450. The uniform annual cost per unit water savings is $22.36/1,000-gal.

2.3.8.4.5 Regional Cooling Towers. Regional cooling towers would conserve low silica and high silica well water by reducing once-through cooling water requirements. Approximately 681,285 gal/wk low silica well water and 1,269,785 gal/wk high silica well water could be saved. The areas which would be served by the regional towers are Environmental Testing, Pilot Processes, Multi Base, and the Goddard Power Plant. The uniform

annual cost of the regional towers is estimated to be $64,058. The uniform annual cost per unit water savings is $0.63/1,000-gal.

CHAPTER 2.4

RECOMMENDED WELL WATER CONSERVATION MEASURES

Four of the well water conservation alternatives described in Chapter 2.3 are recommended for implementation at NOS. The recommended alternatives are the following:

1. Implementation of an employee awareness program.
2. Implementation of inexpensive intermediate conservation measures.
3. Installation of pressure reducing valves on the water supply mains to the station's office and housing areas.
4. Conversion to river water for selected once-through cooling water applications.

2.4.1 SELECTION OF RECOMMENDED MEASURES

A summary of the estimated well water to be conserved by each of the recommended measures is found in Table 2.4-1. A complete estimate of water conserved by implementation of an employee awareness program is not included in Table 2.4-1, since water conservation from this measure cannot be well-defined. The recommended measures have the lowest uniform annual cost per unit water savings, as presented in Table 2.3-17. Installation of cooling towers to reduce once-through cooling water flows has a lower

TABLE 2.4-1

SUMMARY OF WELL WATER CONSERVED BY RECOMMENDED CONSERVATION ALTERNATIVES

Conservation Measure	Well Water			
	Current Use, gal/wk		Conserved, gal/wk	
	High Silica	Low Silica	High Silica	Low Silica
Intermediate				
Level Control Installed at Grit Chamber (Building 128)	290,000	0	290,000	0
Employee Awareness (Building 704)	0	22,000	0	22,000
Install Float Valve at Spray Cooling Pond (Building 137)	79,000	0	79,000	0
Repair Water Tap (Building 1563)	0	30,000	0	30,000
Convert to Treated Effluent for Chlorine Injection (Buildings 511C & 1470)	342,800	0	342,800	0
Sanitary Conservation by Installation of Pressure Reducing Valves	1,134,300	0	417,400	0
Conversion to River Water Supply for Once-Through Equipment Cooling Water	961,170	818,780	961,170	818,780
TOTALS	2,807,270	870,780	2,090,370	870,780

THE PUPRE CORPORATION

uniform annual cost per unit water savings than the recommended alternative for sanitary water use reduction. However, the cooling tower alternative is supplanted by the recommended alternative for conversion to river water for cooling, which applies to many of the same cooling water uses as the cooling towers. Most of the low silica water, which would be conserved by converting selected low silica water use areas to high silica water use, is also conserved by the recommended alternative of using river water for cooling.

2.4.2 COST ESTIMATES OF RECOMMENDED WATER CONSERVATION MEASURES

Detailed cost estimates for the recommended measures, with the exception of the employee awareness program, are presented on NAVFAC 11013/7 (1-78) forms in Appendix 2-E. The cost estimates in Appendix 2-E were prepared from the cost estimates used for the economic evaluations, which are contained in Appendix 2-D. A summary of the capital costs of the measures is presented in Table 2.4-2. The total capital cost for the recommended measures is approximately $281,500. The capital costs include indirect factors of 90 percent of labor costs for contractor's profit and indirect field costs, 20 percent of material costs for purchasing and administration and 10 percent of subcontract costs for coordination and administration by the contractor. The capital costs in Table 2.4-2 do not include allowances for contingencies (normally 10 percent of the direct plus indirect costs), engineering design (estimated to be 15 percent of the direct plus indirect costs plus contingency for construction at an existing site), nor field engineering inspection services (estimated to be 6 percent of the direct plus indirect costs plus contingency.)

TABLE 2.4-2

CAPITAL COSTS OF RECOMMENDED
WATER CONSERVATION MEASURES

Water Conservation Measure	Capital Costs[a]
Intermediate Measures	
Supply cooling water only to operating equipment (Building 704)	$ 0
Eliminate overflow from grit chamber (Building 128)	3,900
Install float controller on spray cooling pond (Building 137)	380
Repair valve at package WTP (Building 1563)	50[b]
Convert to effluent for chlorination at WTP's (Buildings 511C and 1470)	1,960
Subtotal	$ 6,290
Sanitary Water Use Reduction	33,500
Conversion to River Water for Cooling	241,700[c]
TOTAL	$281,490

[a]1982 dollars, exclusive of allowance for contingencies.

[b]Normally a maintenance item.

[c]Includes $50,000 for a hydraulic network analysis.

2.4.3 SAVINGS/INVESTMENT RATIOS OF RECOMMENDED MEASURES

In addition to achieving the water conservation goals of NOS, the recommended well water conservation measures also have favorable Savings/Investment Ratios (SIR). The overall SIR of the recommended measures is 2.2, which is determined by comparing the total present value costs of the measures to the present value of the well water cost savings. The well water cost savings are based on the current $0.71/1,000-gal NOS cost for well water. The SIR of the recommended measures, and other measures considered, are presented in Table 2.4-3.

It is notable in Table 2.4-3 that the SIR of 3.8 for a cooling tower installation at the Goddard Power Plant (GPP) is more favorable than the overall 1.6 SIR for conversion to river water for cooling. The river water alternative was selected for GPP because the use of river water for cooling completely eliminates 20,000 gal/wk of well water that would be consumed in the cooling tower for drift, evaporation, and flowdown.

During the detailed design of the water conservation measures, it is recommended that the cost of converting to river water for cooling be evaluated building-by-building. The costs developed in this study for the river water conversion were based on average conditions for the selected buildings. The installation of on/off-controlled solenoid valves may be determined to be more cost-effective for some of these buildings during the detailed design. This is especially applicable where high silica water is used for cooling, since the high silica supply is not as critical as the low silica supply.

TABLE 2.4-3

SAVINGS/INVESTMENT RATIOS OF APPLICABLE WATER CONSERVATION ALTERNATIVES[a]

Water Conservation Alternative	Projected Water Savings[b] (gal/wk)	Investment: Capital Cost[c] ($'s)	Investment: Annual O & M Cost[d] ($/yr)	Investment: Discounted O & M Cost[d] ($'s)	Investment: Total Present Value Cost ($'s)	Savings: Annual Savings[e] ($/yr)	Savings: Discounted (Present Value) Savings[f] ($'s)	SIR
INTERMEDIATE MEASURES								
Supply cooling water only to operating equipment (Bldg. 704)	22,000	0	0	0	0	810	5,220	-- [g]
Eliminate overflow from grit chamber (Bldg. 128)	290,000	3,900	300	1,810	5,710	10,710	69,050	12.1
Install float controller on spray cooling pond (Bldg. 137)	79,000[h]	380	350	2,240	2,620	1,515[h]	9,770	3.7
Repair valve at package WTP (Bldg. 1563)	30,000	<50[i]	0	0	50	1,110	7,160	143.2
Convert to effluent for chlorination at WTP's (Bldgs 511C & 1470)	342,800	1,960	300	1,810	3,770	12,660	81,620	21.6
Subtotal	763,800	6,290	950	5,860	12,150	26,805	172,820	14.2
SANITARY WATER USE REDUCTION	417,400	36,800[j]	300	1,810	38,610	15,410	99,350	2.6
CONVERSION TO RIVER WATER FOR COOLING	1,779,950	260,900[j,k]	1,000	6,040	266,940	65,715	423,660	1.6
SUBTOTAL, RECOMMENDED MEASURES	2,961,150	303,990	2,250	13,710	317,700	107,930	695,830	2.2
OTHER MEASURES CONSIDERED								
Solenoid valves for cooling water control	543,550	134,900[j]	1,600	9,700	144,600	20,070	129,370	0.9
River water conversion for washdown with new taps to main	27,050	275,300[j]	1,250	7,550	282,850	1,000	6,450	<0.1
using cooling water taps	27,050	195,110[j]	1,250	7,550	202,660	1,000	6,450	<0.1

THE AUBREY CORPORATION

TABLE 2.4-3 (Cont'd.)

SAVINGS/INVESTMENT RATIOS OF APPLICABLE WATER CONSERVATION ALTERNATIVES[a]

Water Conservation Alternative	Projected Water Savings[b] (gal/wk)	Investment: Capital Cost[c] ($'s)	Investment: Annual O & M Cost[d] ($/yr)	Investment: Discounted O & M Cost[d] ($'s)	Investment: Total Present Value Cost ($'s)	Savings: Annual Savings[e] ($/yr)	Savings: Discounted (Present Value) Savings[f] ($'s)	SIR
Cooling Towers								
Environmental Testing	382,050[j]	76,450	3,250	20,730	97,180	14,100	90,900	0.9
Pilot Processes	135,800[j]	99,770	2,350	15,150	114,920	5,010	32,300	0.3
Multi Base	163,450[j]	106,370	2,420	15,600	121,970	6,030	38,900	0.3
Goddard Power Plant	1,269,800[j]	49,500	4,650	29,980	79,480	46,880	302,200	3.8
Subtotal, Cooling Towers	1,951,100[j]	332,090	12,670	81,460	413,550	72,020	464,300	1.1

[a]All costs and savings are presented in 1982 dollars.

[b]Refer to Table 2.3-17.

[c]Refer to Appendix 2-D.

[d]Operations costs calculated for years 0 to 10 with a discount factor of 6.447. Maintenance costs calculated for years 1-10 with a discount factor of 6.042.

[e]Based on current NOS-calculated well water cost of $0.71/1,000-gal.

[f]Discount factor of 6.447 for 10 years.

[g]SIR cannot be calculated, since no costs are incurred for this water savings.

[h]Spray pond overflow can occur approximately 27 wk/yr.

[i]Maintenance item.

[j]Contingency at 10 percent included in these major capital cost items.

[k]Includes hydraulic network analysis at $50,000.

THE RUARE CORPORATION

2.4.4 PROJECTED WELL WATER USE REDUCTION

Implementation of the recommended water conservation measures would conserve estimated annual averages of 871,000 gal/wk low silica water and 2,090,000 gal/wk high silica water. NOS would realize reductions of approximately 20 percent in the current low silica water use and 60 percent in the current high silica water use. This information is summarized in Table 2.4-4.

The most significant well water use reduction would be achieved by converting to water from the Potomac River for once-through cooling water applications. Implementation of this measure is contingent on a hydraulic network analysis to confirm that all parts of the existing river water distribution system have adequate hydraulic capacity to meet both the cooling water requirements and the fire protection requirements of NAVFAC DM-8. AWARE's preliminary evaluation has determined that adequate capacity is available with the existing river water pumps, which recirculate approximately 3.89 mgd directly to the Potomac River. Another positive indication is that river water is currently being used and is planned for use at several NOS locations for once-through cooling and/or area washdown. If the hydraulic network analysis determines that river water use for cooling cannot be achieved, then AWARE recommends the cooling tower water conservation alternative be implemented in its place.

TABLE 2.4-4

SUMMARY OF WELL WATER USE AFTER IMPLEMENTATION OF RECOMMENDED WATER CONSERVATION MEASURES

	Low Silca	High Silica	Total
Current pumping, 1,000-gal/wk	4,120[a]	3,344[b]	7,464
Estimated savings from recommended measures, 1,000-gal/wk	871[c]	2,090[c]	2,961
Projected pumping after implementation of conservation measures, 1,000-gal/wk	3,249	1,254	4,503
Percent reduction in use	21%	62%	40%

[a]Value determined by averaging the summer and winter weekly pumping values in Table 2.1-5.

[b]Value determined by averaging the summer and winter weekly pumping values in Table 2.1-7.

[c]Values obtained from Table 2.4-1.

REFERENCES

1. Campbell and Lehr, Water Well Technology, McGraw-Hill Book Company, 1973.

2. AWWA Specifications C600-497, JAWWA, December, 1949, p. 1079.

3. Babbitt, Doland, Cleasby, Water Supply Engineering, Sixth Edition, McGraw-Hill Book Company, 1967.

4. Sawyer, C.N. and McCarty, P.L., Chemistry for Sanitary Engineers, New York, 1967.

5. U.S. Navy, Energy Conservation Investment Program, Project P-023, "Condensate Return System, Goddard Power Plant," Naval Ordnance Station, Indian Head, Maryland, May 22, 1980.

6. Croley, T.E., Patel, V.C. and Cheng, M.S., "The Water and Total Optimizations of Wet and Dry-Wet Cooling Towers for Electric Power Plants," National Technical Information Service Document PB-252856, January, 1975.

7. Fletcher, P.W. and Sharp, W.E., "Water Conservation Methods to Meet Pennsylvania's Water Needs," Journal American Water Works Association, 200, April, 1978.

8. Stove, B.G., "Suppression of Water Use by Physical Methods," Journal American Water Works Association, 483, September, 1978.

9. Conversations with Sloan Valve Co. and Crane Valve Co., November 30, 1979.

10. Proceedings of the National Conference on Water Conservation and Municipal Wastewater Flow Reduction, Chicago, Illinois, November 28 and 29, 1978.

11. Washington Suburban Sanitary Commission, "Final and Comprehensive Report Cabin John Drainage Basin Water Saving Customer Education and Appliance Test Program," February 14, 1975.

12. Letter from Pace International Corportion, July 7, 1980.

SECTION 3

WELL SURVEY AND HYDROGEOLOGICAL STUDY

CHAPTER 3.1

SURVEY OF EXISTING WELLS, PUMPS, AND STORAGE TANKS

The survey included a site visit to all existing wells at the NOS, a visual inspection of all pumping equipment and accessories, and a review of the available files for information on well and pump conditions. The NOS wells had been inventoried prior to 1965 by the USGS, and the data were published in "Water Resources Basic Data Report No. 2" by the Maryland Geological Survey in 1966. Photographs were made during the survey to document the well head and pump installation conditions. The four elevated storage tanks and the ground level storage tank were also visually inspected for general conditions.

3.1.1 SURVEY OF WELLS AND PUMPS

A total of 28 wells and several test holes have been drilled and completed at NOS from 1898 to the present (Table 3.1-1 and Figure 3.1-1). Fourteen wells are currently being used or are thought to be useable by NOS. The oldest wells at the station were all drilled in the vicinity of Buildings 899 and 143. These wells have been labeled as the Group 1 wells (Figure 3.1-2) and include Wells 1, 1A (old), 2 (old), 3, 4, 5, 6, 7, 8, 9, and 15A. With the exception of Well 1A, which was drilled to replace Well 1, these wells were constructed from 1898 to 1918. The next series of wells was drilled in the 1930's along Benson Road and Mattawoman Creek. These have been classified as the Group 2 wells and are located on Figure 3.1-1. This group includes Wells 10, 11, 12, 13 and 14. The wells

TABLE 3.1-1

NOS WELLS AND PRESENT STATUS

Well[a]	Status
1 (Group 1)	Sanded Up, Pump Removed
1A (Group 1)	Abandoned, Pump Remains
2 (Old) (Group 1)	Abandoned, Pump Remains
2 (New) (2A)	In Use
3 (Group 1)	Abandoned & Cemented, Not Located
3A	High Iron, Considered for Use
4 (Group 1)	Abandoned, Pump Remains
5 (Group 1)	Sanded Up, Pump Removed, Considered for Future Use
6 (Group 1)	In Use
7 (Group 1)	In Use
8 (Group 1)	Sanded Up, Pump Removed
9 (Group 1)	Pump Replaced, In Use[b]
10 (Group 2)	Sanded Up, Pump Removed
11 (Group 2)	Abandoned & Cemented
12 (Group 2)	Pump Replaced, In Use[b]
13 (Group 2)	Abandoned and Filled
14 (Group 2)	Considered for Use
15*	In Use
15A (Group 1)	Abandoned & Cemented, Not Located
16	High Iron, Considered for Use
17*	In Use
18*	In Use
19	Test Well, Insufficient Yield
20	Test Well, Insufficient Yield
21	Test Well, Insufficient Yield
22	Test Well, Insufficient Yield
23(B)*	In Use
24(A)	In Use

[a]Low silica wells indicated by *.

[b]NOS purchased replacement pumps and plans to use wells.

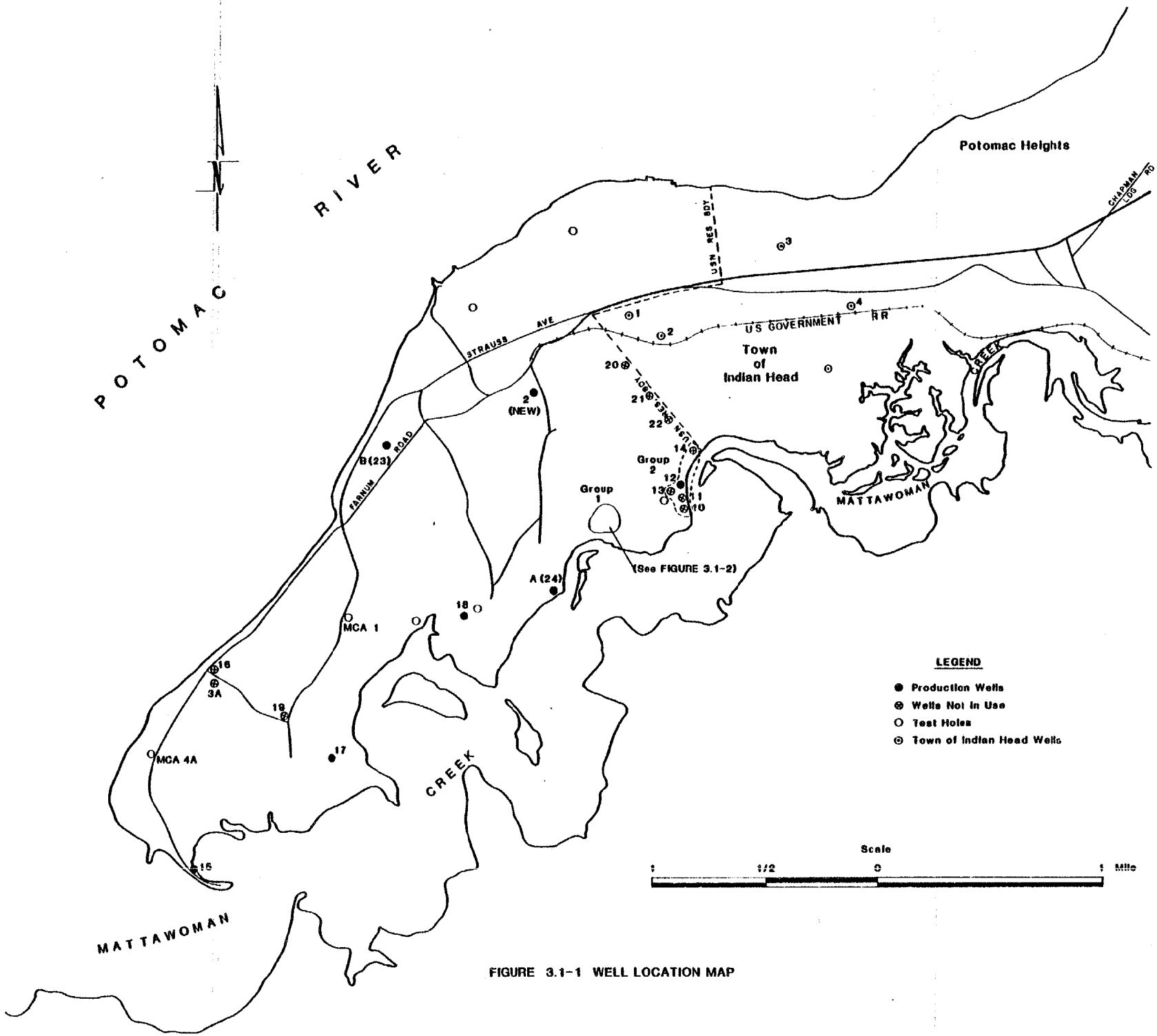


FIGURE 3.1-1 WELL LOCATION MAP

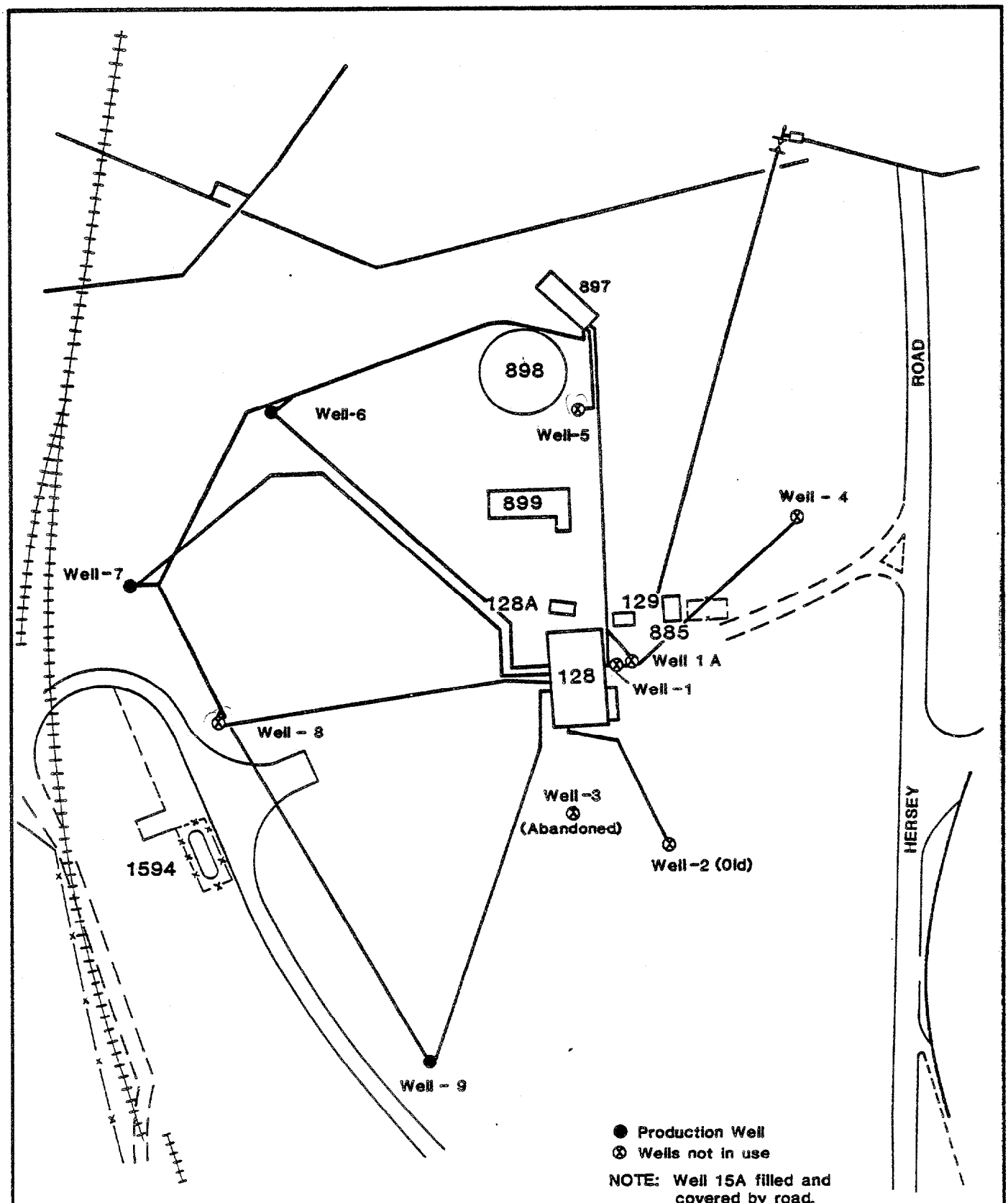


FIGURE 3.1-2 GROUP 1 WELLS

drilled since the Group 2 period are generally numbered sequentially beginning with Well 15, with the exception of Wells 2 and 3A which were drilled as part of the groundwater study conducted in 1970 to 1971. Of the wells in Groups 1 and 2, Wells 3, 11, 13, and 15A have been filled with concrete and abandoned. Wells 1, 5, 8, and 10 filled with sand and are currently capped with metal plates or are standing open. Wells 1A, 2 (old) and 4 were abandoned with pumps still in them. Wells 6 and 7 are currently in use. NOS has purchased replacement pumps for Wells 9 and 12 and plans to return them to use. Well 14 is being considered for use by NOS. Of those remaining, Wells 15 through 24, plus Wells 2 (New) and 3A, are being used or considered for use, except Wells 19, 20, 21, and 22 which were test wells that did not produce a sufficient yield.

A subcontract was issued as part of this study to have the pumps and associated equipment in Wells 9 and 12 removed. They were inspected to determine the condition of the internal parts and to determine necessary repairs or replacements in the pump assembly to return the two wells to production.

The current well system includes Wells 2, 6, 7, 15, 17, 18, A (No. 24) and B (No. 23). Wells considered available for future use are 3A, 5, 9, 12, 14, and 16. These fourteen wells were surveyed for the present condition of the wells and pumping equipment, present well yields, and the potential for future use.

Generally, the pumps and related equipment of all wells currently in use were found to be well-maintained and in satisfactory operating condition. The file data were incomplete for most of the wells. The available

well construction and pumping equipment information for each well is contained in the Well Inventory Records in Appendix 3-A. Photographs showing the pump head assembly and the discharge piping and valves for the wells are also contained in Appendix 3-A. The following sections contain a synopsis of the well construction data and pumping equipment inspections for the fourteen wells considered usable. The first eight wells discussed are the current production wells and then the wells thought to be usable are listed. Other wells not considered usable are discussed in Section 3.1.1.15.

3.1.1.1 Well 2 (New), Also Known as Well 2A

Well 2 is one of the newer high silica wells at the facility. Reported well yields were 500 gpm during a 24-hr well test at the time the well was installed, 245 gpm in 1973 and only 88 gpm in June, 1981.

The well head is located inside Building 1534 off Hanlon Road. The pump motor, pump discharge head, and discharge piping appeared to be in well-maintained, satisfactory operating condition. The pumping water level could not be measured because the air line fittings at the well head were badly corroded and the air line pressure gauge was inoperable and disconnected.

Well 2A is a duplicate designation for Well 2. The test well at this site was drilled in 1971 as part of a previous groundwater supply study and was designated as 2A at that time. The current well number is 2 but some duplication still exists in the NOS records.

3.1.1.2 Well 6

Well 6, located near Building 899, is one of the original wells drilled at the Station. It yields high silica water. The well was drilled in 1915 to a depth of 398 ft and reportedly screened from 252 to 259 ft, 301 to 311 ft, and 377 to 397 ft. The depth of the well was measured as 348 ft 10 in. in 1955, indicating the well had partially filled with sand.

Well 6 is currently in use and is pumping about 50 gpm. No information was found about the well yield in 1916, but reportedly the well was producing 125 gpm in 1956. It is not known whether the present yield is reduced because of lowered water levels, sand in the well or use of a smaller capacity pump.

The pumping equipment presently in the well is reportedly composed of salvaged equipment from several used pump columns. The pump was operating satisfactorily at the time of the survey; however, sand is being pumped with the water and the pump life will be shortened.

The pump installation was not equipped with an air line tube for measuring the pumping water level.

3.1.1.3 Well 7

Well 7 was drilled in 1915 and is another of the original wells located near Building 899. It yields high silica water. The reported well depth when constructed was 419 ft, and the screened intervals were 255 to 265 ft, 305 to 314 ft, and 375 to 396 ft. The well yield was reportedly 145 gpm in 1956 and the well is currently being pumped at a rate of 130 gpm.

The pump head and piping are an older installation, but appear to be operating satisfactorily. The well is also pumping sand which will shorten the pump life. The well was not equipped with an air line for measuring water levels.

3.1.1.4 Well 15

Well 15 is the major well in the low silica water system. The well is adjacent to Building 726 on Strauss Avenue. The file data indicate the well was drilled in 1953, cased to a depth of 280 ft, with screened intervals from 191 to 206 ft, 230 to 234 ft, 240.5 to 244.5 ft, and 268 to 280 ft. The well was constructed as a gravel packed well. The reported well yields were 310 gpm in 1953, 206 gpm in 1960, 185 gpm in 1978, 206 gpm in 1980, and 150 gpm in June, 1981. It is not known what has caused the decline in well yield. A possible factor is lowered water levels, but the well was not equipped with an air line for measuring water levels.

The pump motor, discharge head, and piping were in well-maintained, satisfactory operating condition at the time of the survey.

3.1.1.5 Well 17

Well 17 produces low silica water and is adjacent to Building 788 off Hussey Road. The well was constructed in 1954 and cased to a depth of 295 ft. The screened interval is reported to be 259 to 295 ft. The well was constructed as a gravel packed well.

The present pump was installed in 1977. The file data indicate the pump is a Bryan Jackson, 11-stage turbine set at 258 ft. The well had a yield of 160 gpm at a pumping water level of 218 ft in 1977. The present well yield is approximately 125 gpm.

The pump motor, discharge head, and piping appeared to be in well-maintained, satisfactory operating condition at the time of the survey. The concrete pump mounting pad is spalling and should be repaired. The well is not equipped with an air line, and the pumping water level could not be measured.

3.1.1.6 Well 18

Well 18 yields low silica water and is adjacent to Building 789 off Bronson Road. The well was constructed in 1954 to a total depth of 302 ft. The well is screened from 208 to 220 ft and from 274 to 302 ft. The well was constructed as a gravel packed well. The historical well yields are reported to be 363 gpm in 1954, 170 gpm in 1970 and 115 gpm in 1980. The current yield is approximately 80 gpm.

The well is equipped with an 11-stage Bryan Jackson pump installed in 1970. The intake depth is reported as being 203.25 ft. The reported air line depth is 193 ft, but the air line was not equipped with a pressure gauge.

The pump motor, discharge head, and piping all appear to be in well-maintained, satisfactory operating condition.

3.1.1.7 Well A (No. 24)

Well A or No. 24 produces high silica water and is located adjacent to Building 782 off Farnum Road. This well was drilled in 1957 by Sydnor Hydrodynamics of Richmond, Virginia. The well is a 10-in. diameter well cased to 289.7 ft, and the screened intervals are 228 to 239 ft and 269 to 286 ft. The well was gravel packed from the bottom of the casing to land

surface. The well had a tested yield of 350 gpm for 24 hr in 1957. Recently reported yields were 160 gpm in 1979, 108 gpm in 1980, and approximately 100 gpm in 1981.

The well is presently equipped with a Layne pump and a Holloshaft motor that appeared to be operating satisfactorily at the time of inspection. No information was available about the number of pump stages, but the intake depth is reported to be 215 ft. The well was not equipped with an air line assembly.

3.1.1.8 Well B (No. 23)

Well B or No. 23 yields low silica water and is adjacent to Building 782 off Farnum Road. This well was also drilled in 1957 by Sydnor Hydrodynamics of Richmond, Virginia. The well is a 10-in. diameter well cased to 294 ft. The well is screened from 240 to 294 ft. The well was gravel packed from 294 ft to land surface. The well had a reported yield of [redacted] which had declined to [redacted]. The well was acid treated in 1977 in an attempt to restore the yield. The acid treatment was ineffective in restoring the well yield, and the current yield is reported to be [redacted] This well was equipped with the only functional air line assembly. The pumping water level at the time of the survey was measured as 176 ft below land surface.

The pump motor, discharge head, and piping appeared to be in well-maintained, satisfactory operating condition. The well head is equipped with extra piping that was probably installed at the time of the acid treatment. The pipe and valve arrangement is such that water containing the acid could be pumped from the well and recirculated back into the well at the top of the well casing.

3.1.1.9 Well 3A

Well 3A was constructed after a test well was drilled at the site in 1970 as part of a previous groundwater study at NOS. The well head is located in Building 1531 on Greenslade Road. The production well was constructed as an underreamed, gravel-packed well and was screened from 217 to 232 ft. Well 3A is screened in one of the same water-bearing sand zones as Well 16, which is located just across Greenslade Road. The quality of water produced from both wells is poor due to excessive amounts of iron and manganese. A water sample was collected from Well 3A and analyzed during the survey. The results of the analysis are discussed in Chapter 3.3.

The well head and pumping equipment are located inside Building 1531, and an iron removal system is installed on the discharge line from the well. The system consists of chemical oxidation, ion exchange, and filtration. Potassium permanganate is used as the oxidizing agent, and an activated carbon/manganese greensand bed is the ion exchange and filtration medium. The pumping equipment, iron removal units, and piping appeared to be in satisfactory operating condition, but the well was not being utilized during the time of the survey. The well was equipped with an air line assembly but the pressure gauge was inoperable.

A Johnston pump driven by a 50-hp motor is installed in the well. The intake level is 260 ft, and the pump capacity is 250 gpm. Well 3A had a tested yield of 250 gpm for 18 hr at the time of construction. The present yield is less than that amount, because pump cavitation occurs at full pump capacity. The discharge rate for the short period of time when the water sample was collected was approximately 170 gpm, which was obtained by throttling the discharge valve until no air was pumped with the water. The

current yield of Well 3A is estimated to be between 170 and 200 gpm. A more accurate yield could be obtained by pumping the well for several hours and adjusting the discharge valve to assure no air is pumped.

3.1.1.10 Well 5

Well 5 is one of the original wells drilled at the NOS. The well yields high silica water and is adjacent to the ground level water storage tank (Building 898) near Building 899, off Bailey Road. The well was drilled in 1910 to a reported depth of 395 ft. The screened intervals were reported to be 271 to 281 ft, 320 to 322 ft, and 381 to 391 ft. The yield was reported to be 127 gpm in 1954 and 85 gpm in 1961.

The well was used until 1979 when it began pumping considerable amounts of sand. Measured well depths were 367 ft in 1965 and 335 ft in 1981, indicating the well had filled with sand. The well was inspected in 1979 by a well contractor, and the recommendation at that time was to abandon the well. The opinion of the well contractor was that the amount of sand being pumped indicated a hole in the well casing or well screen and that the age of the well made any type of repair unreasonable. The pump was removed during the 1979 inspection. The suction screen from the bottom of the pump bowls was missing and had probably fallen to the bottom of the well.

At the time of the AWARE survey, there was no pump installed in Well 5. The well head and uppermost section of the well casing were in poor condition. There was evidence that broken pieces of wood and other objects may have fallen down the well. The well was inspected by the AWARE hydrogeologist and the drilling subcontractor. It is recommended that Well 5 be abandoned and capped.

3.1.1.11 Well 9

Well 9 was drilled in 1918 and is one of the original wells at the facility. The well produces high silica water and is located near Building 1472 off Hersey Road. The well is 8-in. diameter and was reportedly drilled to 390 ft. Recent measurements indicate the well has now filled with sand to about 305 ft. The screened intervals are reported to be 185 to 195 ft, 235 to 245 ft, 284 to 294 ft, and 355 to 376 ft. The reported well yield was 90 gpm in 1956.

The pump installed in Well 9 was removed during the survey and inspected by the AWARE subcontractor. The subcontractor inspected each section of the pump column as it was removed from the well and identified the useable and unuseable sections for NOS personnel present during the procedure. The subcontractor report indicated the pump was an 8-in. Cast Iron Fairbanks Morse, with a 12-stage bowl assembly and 250 ft of pump column. The inspection of the parts as they were removed determined that the following parts are useable:

1. 15 spiders, if rubber bushings are replaced
2. 19 sections of column pipe
3. Discharge elbow
4. Stuffing box if rebushed
5. Motor if leads rewired
6. Bowls could be reused for light pumping conditions

NOS had ordered a replacement pump prior to the survey and plans were initiated to install the pump immediately after removing the old pump. The well should be in operation at the present time.

3.1.1.12 Well 12

Well 12 is a high silica well, located near Building 143 off Benson Road. The well is 8-in. diameter and was drilled in 1938 by Sydnor Pump and Well Company, Richmond, Virginia. The total depth when drilled was reported to be 390 ft, but current measurement of the depth shows it to be about 300 ft. The screened intervals in this well are unknown. The reported well yields were 115 gpm in 1960 and 87 gpm in 1980.

The well was equipped with a pump that reportedly had a broken shaft. The pump was removed by the AWARE subcontractor and the parts inspected. The inspection showed that five column shafts were broken and five spiders were broken. All the remaining spiders, sections of pump column, and sections of column shaft were too worn to be reused. The completely worn condition of the pump column parts was attributed to not having the water lubrication line for the spider bushings connected. The pump bowls were very rusty, and one bowlcase had a hole in it. The complete bowl assembly was judged not useable. The suction screen from the bottom of the bowl assembly was missing and presumed to have fallen to the bottom of the well.

The well was in good condition at the time of the survey but the present yield was not known. The well could be utilized by installing a complete new pump assembly. NOS had reportedly already ordered a complete new pump assembly, which should have been installed within one month of the survey.

3.1.1.13 Well 14

Well 14 was drilled in 1938 at the same time as Well 12. It is a high silica well. The well is 10-in. diameter and reportedly 480 ft deep when drilled. A depth measurement during the survey showed the total depth to be about 480 ft. The screened intervals are unknown, as no construction information was available in the files. The reported well yield was 130 gpm with a pumping water level at 234 ft in 1960, but no more recent information was found.

The well was not equipped with a pump at the time of the survey. The well head was inspected, and the well appeared to be useable. No pumping equipment that had previously been removed was available for inspection. A complete new pumping assembly will be necessary to put the well in production. The new pump should have a capacity of about 100 gpm and be installed with the intake near 300 ft.

3.1.1.14 Well 16

Well 16 yields high silica water and is adjacent to Building 741 off Greenslade Road. The well was drilled in 1952 and cased to a depth of 242 ft. The well casing is reported to be 12-in. diameter to 152.5 ft, and 10-in. diameter from 152.5 ft to 242 ft. The screened intervals are reported to be 85 to 93 ft, 123.5 to 133 ft, 144.5 to 152.5 ft, 221 to 229 ft, and 234 to 242 ft. The reported well yield was 470 gpm in 1953, and was tested at 326 gpm in 1971.

The reported water quality was poor with a measured iron content from 2.1 ppm to 18.8 ppm. Well 16 is located directly across the road from

Well 3A which has similar water quality. It was originally proposed by AWARE to collect a sample from Well 16, but the condition of the pump made collection of a sample impossible.

The well was equipped with a pump column and discharge head but no pump motor. The pump column has been sitting idle in the well for possibly ten years and would be impossible to use. The only possible way to collect a water sample would be to remove the existing pump and install another pump.

3.1.1.15 Other Wells

There have been many wells and test holes drilled at the NOS. At present, 14 wells are considered by NOS to be usable or suitable for future use. The remaining wells include wells that have been used and abandoned in the past, wells with low yields, and several test wells.

Of the remaining wells, 11 were found and inspected during the survey. None were found that are considered usable. Well inventory records for the other wells found during the survey are included in Appendix 3-A. These 11 wells include Wells 1, 1A, 2 (old), 4, 8, 10, 11, 19, 20, 21, and 22. The use of Wells 1, 1A, 2 (old), 4, 8, and 10 was discontinued, because the wells partially filled with sand, making further use impossible. Well 19 was a test well, screened in only one zone, and had a reported poor water quality. Well 19 has been used by the USGS as a water level observation well from 1952 to the present. Well 11 partially filled with sand and was filled with cement. Wells 20, 21, and 22 are test wells drilled along Benson Road, and all had reported low yields. Wells 3, 13, and 15A were not located during the survey, and file data indicate the wells were abandoned and filled.

The wells that have been abandoned but not filled with concrete should be filled or securely capped to prevent potential contamination of the aquifer by inadvertent use of the well for waste disposal. If the potential for aquifer contamination is found to be significant at NOS, all the abandoned wells should be filled.

Several map references found during the file search indicate that several test holes were drilled within the NOS boundaries, but no production wells were constructed at the sites. It is assumed that these test wells did not locate water-bearing sand zones. The approximate locations of these test holes are shown on Figure 3.1-1.

A previous well survey was conducted at NOS in 1970-71 by Matz, Childs and Associates. As part of that study, six test wells were drilled. Four locations were recommended for well construction, and Wells 2 (new) and 3A were drilled at two of the sites in 1972. The two other recommended well sites are shown on Figure 3.1-1 as MCA 1 and MCA 4A. Records for the six test wells are included in Appendix 3-D.

3.1.2 SURVEY OF STORAGE TANKS

The NOS water supply systems include four elevated storage tanks and one ground level storage tank. Elevated tanks 1 and 3 are on the high silica water system. Elevated tanks 2 and 4 and the ground storage tank are part of the low silica water system. An exterior visual inspection was completed for each tank to determine the general condition of the tank and associated accessories. Where accessible, a visual inspection of the interior of the tank from the access hatch was made. The inspection checklist and brief letter report for the inspections is included in Appendix 3-B.

Tank 1 has been equipped with a cathodic protection system since 1961 or 1962. Annual maintenance inspections of the cathode system have been made by Electro-Rust Proofing Corporation since that time. The appearance of Tank 1 was good for its age, which is possibly attributable to the cathodic protection. The other three steel elevated storage tanks did not appear to have significant rusting or corrosion problems at the time of the inspection. The limited visual inspection did not find any major interior rusting problems. The visual inspection performed as part of this project was not designed to determine the need for cathodic protection. A decision to install cathodic protection on the remaining tanks should be based on a detailed inspection for that purpose.

The inspection revealed some problems that will require some painting and a minimal amount of repair to correct. Completion of the painting and repairs should put the tanks in excellent condition for several more years. The locations of areas on the individual tanks that need spot painting are detailed in the tank inspection reports in Appendix 3-B. The structural condition of the tanks and supports was not inspected in detail, however, no signs of any structural defects were noted. The recommended maintenance and/or repair items for each tank are discussed below.

3.1.2.1 Tank 1 (Building 867)

The exterior paint of Tank 1 is in fair to good condition with some spots missing paint or chalky. Some spot painting has been completed, but there is need for additional spot painting. The interior is in good condition, although it is rusty.

3.1.2.2 Tank 2 (Building 784)

The exterior paint of Tank 2 has deteriorated, and some rust and bare metal is showing through. It is recommended that Tank 2 be painted on the exterior. The safety rail on the revolving ladder on the tank top has come loose from its fittings and needs to be repaired. The altitude valve is not functional and needs to be repaired. The safety rail on the ladder is bolted too closely to the ladder to be useful and needs to be replaced.

3.1.2.3 Tank 3 (Building 896)

The exterior paint of Tank 3 is in good condition with only very minor spot painting necessary. The valves and piping in the valve pit are very heavily rusted and should be cleaned and painted.

3.1.2.4 Tank 4 (Building 1533)

The exterior paint of Tank 4 is in generally good condition; however, minor spot painting is needed. The altitude valve is reported to not be working properly and should be repaired.

3.1.2.5 Ground Storage Tank (Building 898)

Visual inspection of the exterior of the Ground Storage Tank, and the portion of the interior that could be viewed, revealed no flaws. The tank is of concrete construction and appears to be in excellent condition.

CHAPTER 3.2

HYDROGEOLOGY

3.2.1 GENERAL AQUIFER DESCRIPTION

The Indian Head area is located in the Atlantic Coastal Plain Geologic Province. The sedimentary deposits of the Coastal Plain outcrop to the west of Indian Head in Virginia and dip and thicken to the southeast. The sediments overlay crystalline metamorphic and igneous bedrock. The sediments consist of sand, gravel, silt and clay beds that are generally intermixed and both horizontally and vertically gradational.

The recharge area for the several defined units extends from southwest of Indian Head in a broad arc to the northeast through the Washington, D. C. area to Baltimore.

The general lithologic column found at Indian Head consists of Cambrian and Precambrian bedrock, which are overlain by sedimentary deposits of Cretaceous age and capped by surfical sediments of Recent age. The lithology is illustrated in Figure 3.2-1. The sedimentary deposits identified at Indian Head are the Patuxent and Arundel Clay Formations (undifferentiated) of Lower Cretaceous age, the Raritan and Patapsco Formations of Upper Cretaceous age, and the surficial Columbia Formation of Quaternary or Recent age. The water-bearing sand aquifers developed at Indian Head are found in the lower section of the Patapsco and Raritan Formation and the upper section of the Patuxent Formation.

The sedimentary formations at Indian Head strike to the northeast and dip toward the southeast. The total thickness of the sediments in the

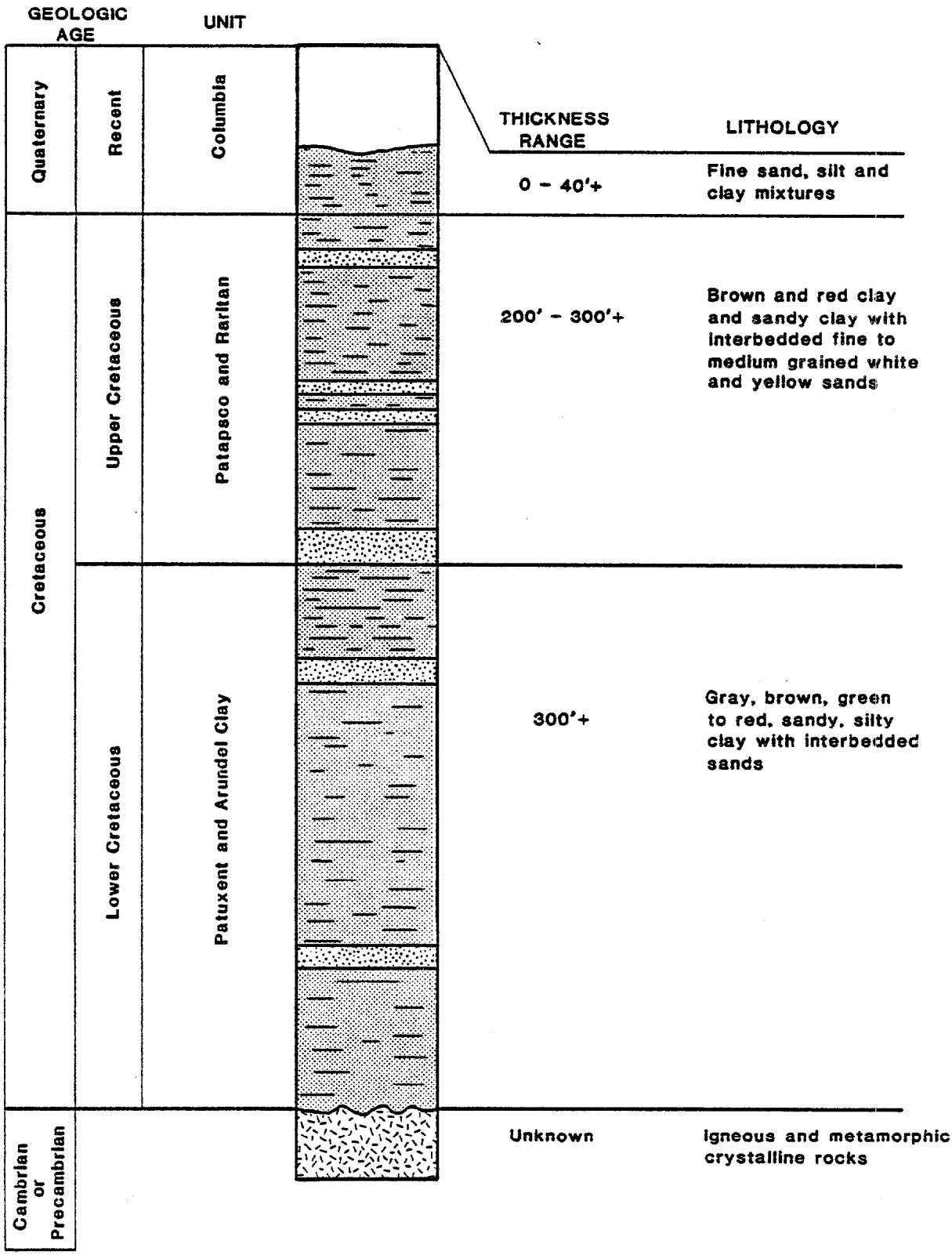


FIGURE 3.2-1 GENERALIZED LITHOLOGIC COLUMN FOR THE INDIAN HEAD AREA

Indian Head area is approximately 600 ft. The outcrop area in Virginia is the recharge area for the formations. Precipitation falling on the exposed sections of the units infiltrates into the formation and provides the groundwater pumped from the aquifers at down dip locations, including NOS. The southeast dip of the formations causes them to pass under the Potomac River. There is no evidence of major recharge to the aquifers from the Potomac River; however, some recharge may occur from tributaries to the Potomac in Virginia. The bottom sediments of the Potomac River possibly restrict infiltration of the sometimes saline water in the main river channel.

The outcrop and recharge area of the Patuxent extends from Virginia northeast to the Baltimore area and encompasses an area of about 75 sq mi across the Potomac River from Indian Head. The recharge area for the Patapsco and Raritan also extends from Virginia northeast toward Baltimore, but about 40 percent of the outcrop area lies under the Potomac River where recharge is limited by the river bottom sediments. Figure 3.2-2 shows a general cross-section of the formations from the Virginia outcrop area through the Indian Head area.

The crystalline bedrock and the alluvial surficial sediments are not viable aquifers in the Indian Head area. The bedrock is composed of dense igneous and metamorphic rocks such as granites, gneisses and schists. Only a few wells have been drilled into the crystalline bedrock in the area. These wells have only penetrated a few tens of feet into the formation, and very little is known about it. Generally however, crystalline bedrock is not considered a useful aquifer.

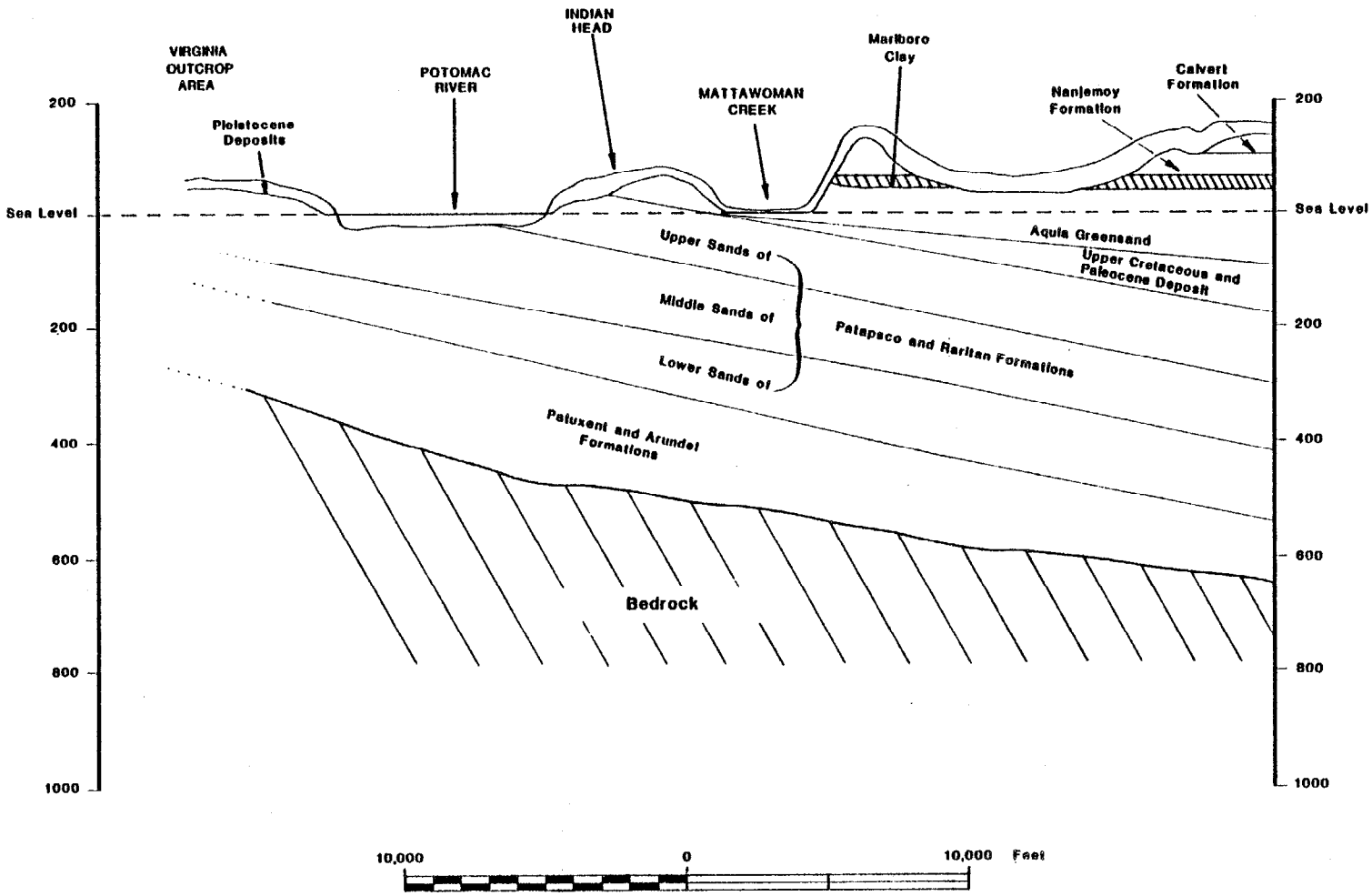


FIGURE 3.2-2 GENERALIZED CROSS - SECTION SHOWING STRATIGRAPHY OF INDIAN HEAD AREA

The surfical sediments are thin in the Indian Head area, ranging from 0 to 40 ft in thickness. A survey consisting of test borings for the entire Indian Head peninsula was made by the Raney Collector Well Company many years ago to determine the feasibility of using the surficial deposits for water supply production. The survey located a few thin lenses of water producing gravel in the surfical deposits; however, most of the units found were of mixed lithology. The water available was estimated to be muddy and would potentially contain iron. Therefore, the surficial zone is not considered a useful aquifer in the Indian Head area.

The hydrogeology of the Patuxent and Arundel Clay Formations and the Patapsco and Raritan Formation is discussed in the following sections.

3.2.2 PATUXENT AND ARUNDEL CLAY FORMATIONS

The Patuxent and Arundel Clay Formations are differentiated to the north of Indian Head, in the Washington, D.C. and Baltimore areas. No differentiation has been made in the Indian Head area, and the entire sequence is considered the Patuxent Formation. The Patuxent overlies the Cambrian bedrock on an irregular erosional surface. The top of the Patuxent is not exactly known but has been arbitrarily designated as the bottom surface of the lowermost sand in the Patapsco and Raritan Formation. In the Indian Head area, the Patuxent has an average thickness of 300 ft, with the elevation of the top of the unit approximately 250 to 300 ft below mean sea level. The surface of the unit dips to the southeast at approximately 30 to 50 ft/mile.

The unit consists of clays, sandy clays and silty clays with interbedded water-bearing sand zones. The water-bearing sand zones are

laterally discontinuous, and most are only one or two miles in length. Formation logs of wells drilled in the area show the lateral discontinuity, as well as, vertical changes in lithology. Figures 3.2-3 and 3.2-4 show cross-sections for the NOS area using lithologic logs from wells drilled at NOS. The Figure 3.2-3 cross-section shows sand beds present in Well 3A that may grade to the sandy clay zones in Well 19 and disappear entirely in Well 17. This illustrates the lateral gradation of the sand units over short distances. The available formation logs describe the Patuxent as gray to green or red clays and sandy clays. The logs indicate clays are predominant at the top of the unit and sandy clays near the bottom. The Arundel Clay overlies the Patuxent in the areas where the formations are differentiated and would explain the predominance of clays at the top of the unit in the Indian Head area.

The USGS has made aquifer tests on wells screened in the Patuxent formation in the Indian Head area. These tests have shown the transmissivity (the capacity of the sand zones to transmit water through a unit thickness under a unit head) of the sands in the Patuxent to be moderately low, in the range from 535 sq ft/day to 800 sq ft/day. (In older terminology, this is equivalent to transmissibility from 4,000 gpd/ft to 6,000 gpd/ft). The aquifer storage coefficient, which is a dimensionless factor describing the amount of water the aquifer will release from storage per unit surface area per unit change in head, was measured in the range from 0.0002 to 0.0004. The storage coefficient is within the expected range for an aquifer under artesian conditions as is found at NOS. Static water levels and pumping water levels in the Patuxent formation at NOS

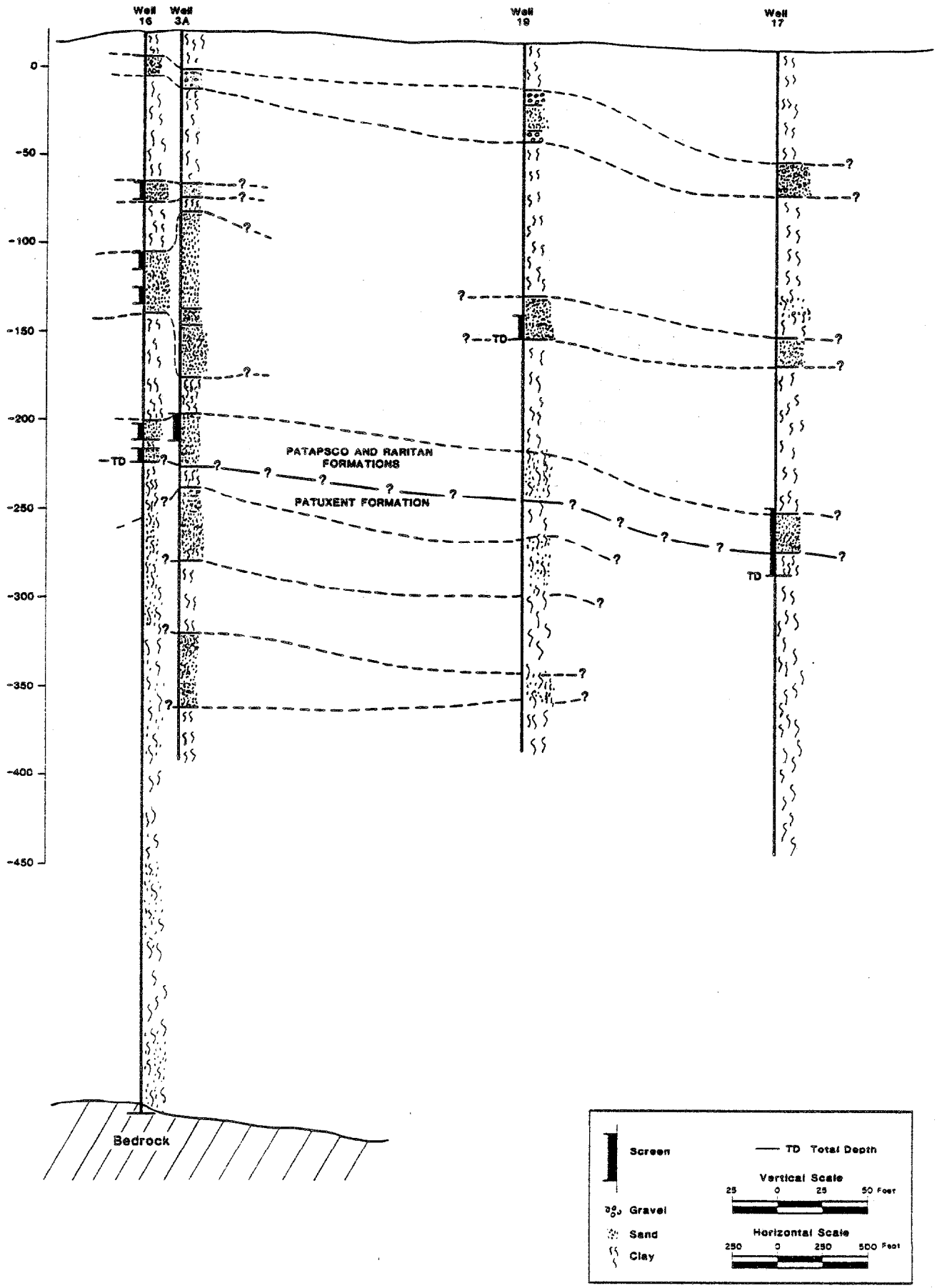


FIGURE 3.2-3 CROSS - SECTION AT NOS USING LITHOLOGIC LOGS OF WELLS

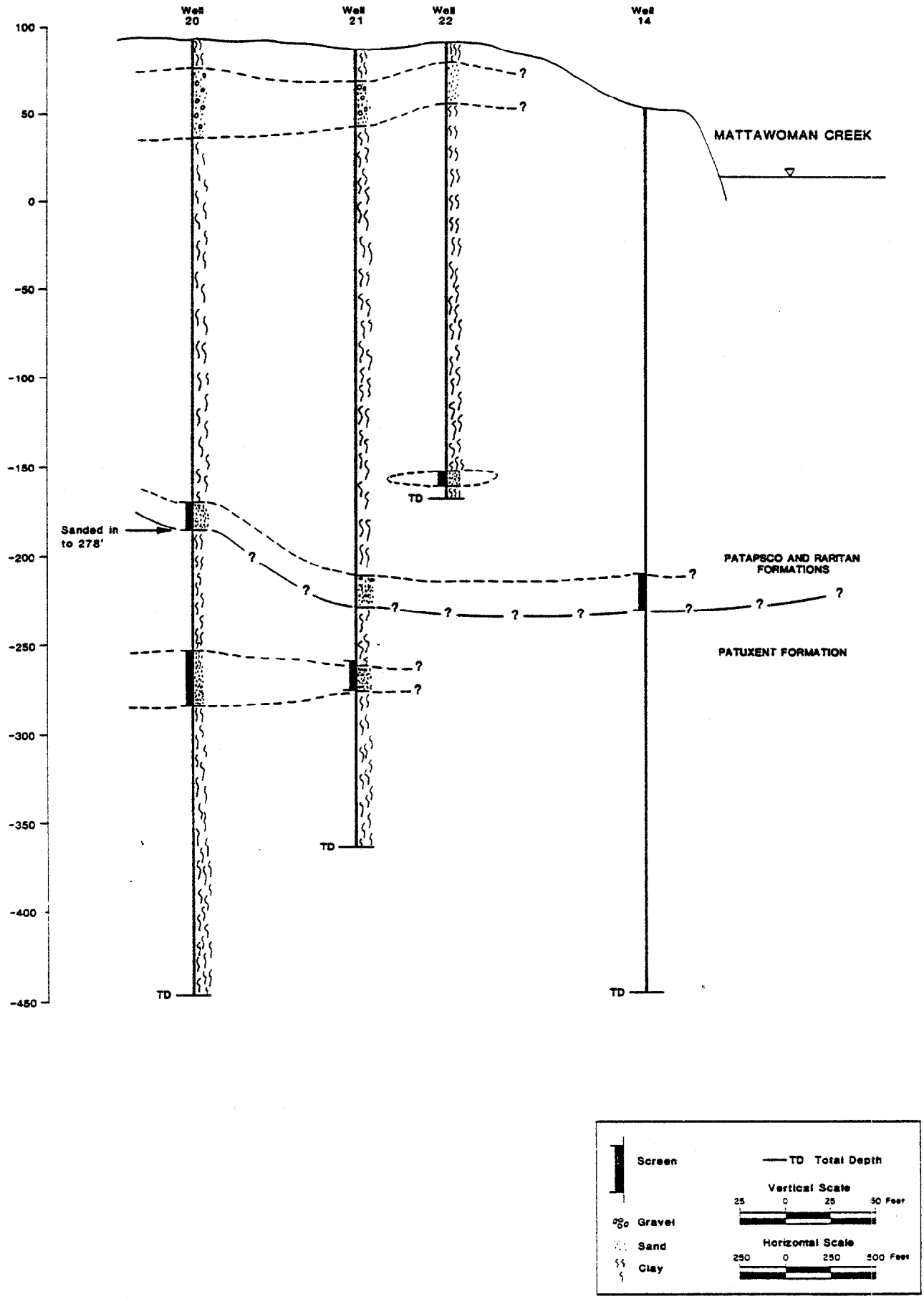


FIGURE 3.2-4 CROSS - SECTION AT NOS USING LITHOLOGIC LOGS OF WELLS

cannot be measured, because no wells are available screened only in the Patuxent. The NOS wells screened in the Patuxent are also screened in the overlying Patapsco and Raritan Formations, and measured water levels would not be representative of the Patuxent aquifer.

Well yields, as inventoried and reported by the USGS, range from 100 to 385 gpm (gallons per minute) for the Patuxent formation. Specific capacity is the amount of water produced by a well per foot of pumping water level drawdown and is used as a measure of the productivity of a well. Specific capacities for the Patuxent range from 1.0 to 6.0 gpm/ft of drawdown and are in the moderately low range.

3.2.3 PATAPSCO AND RARITAN FORMATIONS

The Patapsco and Raritan Formations consist of 200 to 300 ft of intermixed fine sands, silts, and clays. The water-bearing zones are generally tan or gray, fine- to medium-grained sands. The formations are laterally and vertically discontinuous, but a general lithologic sequence is identifiable throughout the unit. Three zones have been identified in the general sequence of the formation that generally contain water-bearing sands. The Upper Sand is absent or found near land surface in the Indian Head area. The Middle Sand occurs at elevations between 50 ft and 200 ft below sea level and is generally not considered an aquifer to be developed in the area. The Lower Sand is found at elevations from 200 to 300 ft below sea level and is the major aquifer used in the Indian Head area.

The Upper Sand, formed at or near land surface has limited ground-water storage and limited recharge area. The unit is not feasible for development at NOS.

The Middle Sand also has a limited groundwater storage and recharge area. Some wells in the Indian Head area have been screened in the Middle Sand. Reported information from these wells is that the groundwater contains excessive amounts of iron and has a marshy or swampy odor. Well construction data available for Well 16 shows a screen interval at a depth of 85 to 93 ft below land surface. This screen is possibly in the Middle Sand and may explain the poor water quality in that well.

The Lower Sand is the major aquifer developed in the Indian Head area and at NOS. Available well formation logs at the station indicate that Wells 2 (New), 3A, 15, 17, 18, A(24), and B(23) are screened only in the Lower Sand unit. Wells 6, 7, 8, and 9 are screened in the Lower Sand, as well as, the underlying Patuxent.

The USGS has conducted aquifer tests on the Lower Sand in the Indian Head area. The transmissivity of the individual water-bearing sand zones ranges from 270 sq ft/day to 535 sq ft/day (transmissibility from 2,000 gpd/ft to 4,000 gpd/ft). The transmissivity of the entire Patapsco and Raritan Formations was estimated by the USGS to be 1,070 sq ft/day (transmissibility of 8,000 gpd/ft). Well yields reported by the USGS range from 200 gpm to 560 gpm in the Indian Head area. The specific capacities ranged from 2.2 to 7.1 gpm/ft of drawdown.

Water levels have been measured in several wells screened only in the Lower Sand unit. The potentiometric surface map for the Lower Sand is shown in Figure 3.2-5. The potentiometric contours show an area of lowered water levels forming a cone of depression, or area of influence, at NOS. The area of influence is estimated to extend for six miles in a NE-SW direction and for three miles in a NW-SE direction.

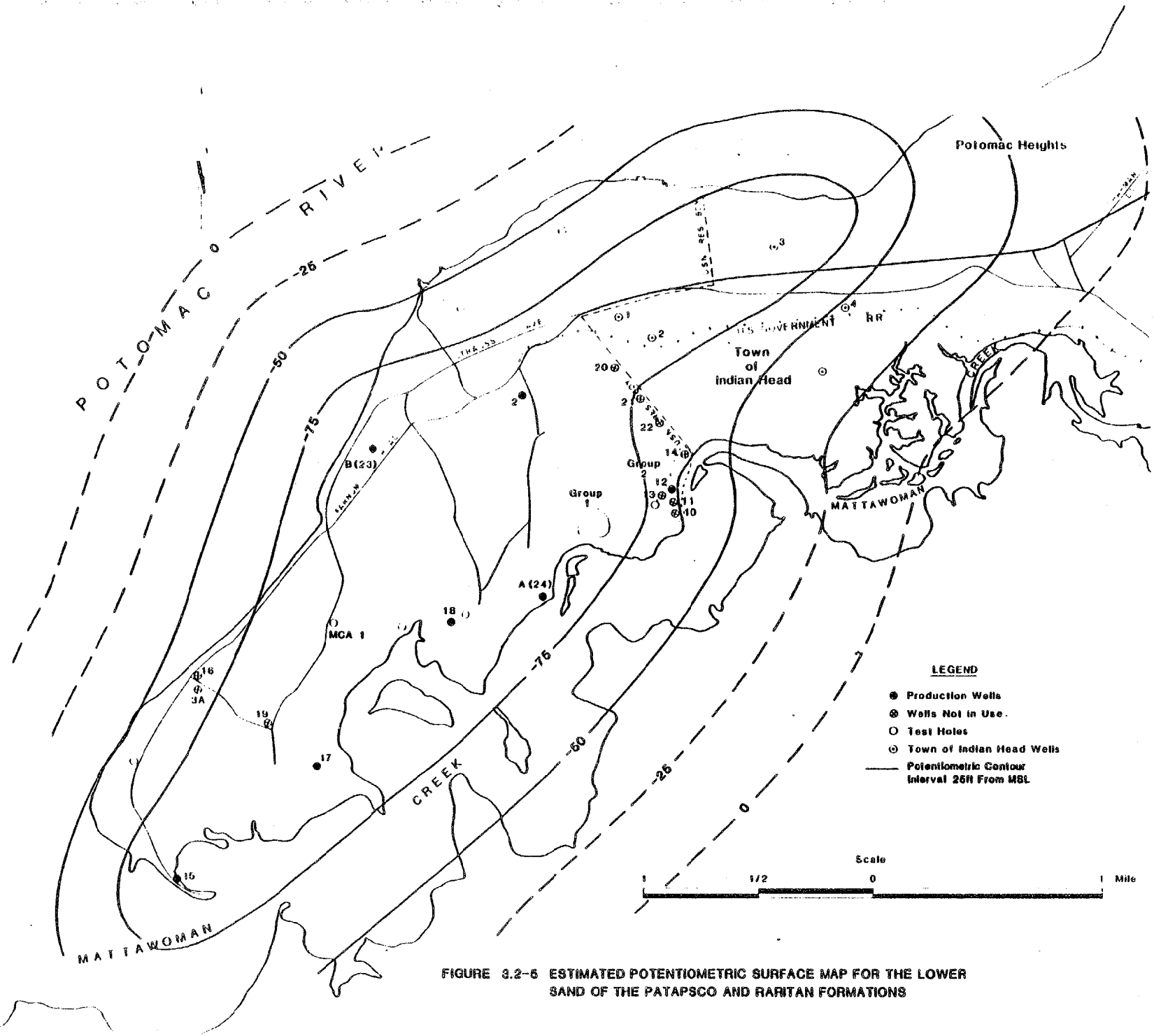


FIGURE 3.2-5 ESTIMATED POTENTIOMETRIC SURFACE MAP FOR THE LOWER SAND OF THE PATAPSCO AND RARITAN FORMATIONS

The potentiometric water level for the Patapsco and Raritan formation is estimated to have been at 10 ft above mean low tide level in the late 1800's. The present potentiometric surface map shows the 0-ft contour extending under the Potomac River channel. The pumpage at Indian Head since 1900 has lowered the potentiometric water levels and created an area where recharge of poor quality river water into the aquifer is possible. The available water quality records (USGS, 1979) contain data for specific conductance in the Potomac River. The maximum conductance for the period of record is 3,490 micromhos/cm and the minimum is 118 micromhos/cm. This wide range indicates that the salt content of the river does vary considerably.

All pumping wells at NOS along the Potomac River side of the station have the potential to be affected by recharge of poor quality river water into the aquifer. The analytical results for the samples collected from Wells 3A and 16 indicate that some intrusion of salty river water into the aquifer may be occurring. The chloride content of the water from the two wells ranges from 20 to 161 mg/l for the several samples analyzed. The water quality data available for the remainder of the wells indicate the normal chloride concentration ranges from 1 to 10 mg/l.

The occurrence of elevated chloride concentrations is not a problem at NOS at the present time. The recommended drinking water standard for chloride is 250 mg/l, and no well water is near that concentration. The periodic water samples collected from the wells should be evaluated for continued increases in chloride content that might indicate intrusion of Potomac River water into the aquifer.

CHAPTER 3.3

WATER TREATMENT FOR IRON REMOVAL EVALUATION

The scope of study included sampling the water from Wells 3A and 16, and evaluating the water treatment alternatives available to correct or remove problems to make the water quality comply with applicable drinking water standards. A sample was collected from Well 3A; however, it was impossible to collect a water sample from Well 16 due to inoperable pumping equipment. The file search located several past analyses of the water from both Wells 3A and 16, as well as, past recommendations for water treatment methods. Natural groundwater quality will remain generally the same over a period of years. By comparing the analytical results of the current water sample with the past quality found in Well 3A, the present quality of the water from Well 16 can be estimated. Review of the historical analyses shows that Wells 3A and 16 produce groundwater with similar characteristics. Therefore, the current quality should be similar. Additionally, the fact that the wells are adjacent and producing water from the same zones also indicates the quality should be similar.

Discussions with NOS personnel and file material indicated the chief problem with the water quality was excessive concentrations of iron and manganese and a disagreeable odor. Station personnel also indicated the water from Well 3A contained excessive amounts of hardness.

3.3.1 EVALUATION OF GROUNDWATER QUALITY, WELLS 3A AND 16

The groundwater sample collected from Well 3A was analyzed by the AWARE Laboratory for 12 selected parameters. The results of this analysis and the analytical results for past chemical analyses for Wells 3A and 16 are shown in Table 3.3-1. The past data include analyses made for Well 16 by the U.S. Geological Survey in 1953, and analyses made on Wells 3A and 16 during an engineering study contracted by NOS in 1970.

The present water quality for Well 3A can be described as high in iron and manganese content and high in total dissolved solids (TDS). The TDS may be caused by the chloride concentration or by total hardness. The water from Well 3A also contains 33 mg/l silica, which is comparable to the wells in the high silica water system.

The analytical results for the sample collected in 1971 indicate the water quality parameters of concern were iron and manganese. The analyses show the water contained low hardness (17.0 mg/l as $CaCO_3$) and 39.9 mg/l silica. The chloride concentration of 95 mg/l was higher than that for most other wells at NOS, but it was not above the recommended limit of 250 mg/l. The iron removal unit at Well 3A was recommended and installed on the basis of the 1971 analytical results, which showed iron and manganese as the only constituents requiring treatment.

The three analyses in Table 3.3-1 for Well 16 show that the water quality is similar to that found in Well 3A. The results indicate that the iron concentration in Well 16 is higher than that in Well 3A, and the water in Well 16 contains more hardness. The silica concentrations ranged from 32 to 35 mg/l, which are within the range of other high silica wells at

TABLE 3.3-1

RESULTS OF CHEMICAL ANALYSES OF GROUNDWATER FROM WELLS 3A AND 16

Parameter	Well Number and Sample Date						U.S. EPA Drinking Water Standards
	3A 11/81	3A 1973	3A 1/71	16 5/71	16 1971	16 8/53	
	(Results in mg/l, unless otherwise indicated)						
Fe	4.7	12.9	2.0	23.0	16.0	2.1	0.3
Mn	0.57	-	0.11	0.46	0.36	0.54	0.05
Mg	12	44	8	56	7.8	19	d
Ca	5.8	16	-	62	30	23	d
Na	53	-	-	-	29	47	d
SiO_2	33	30.4	39.9	35	34	32	d
SO_4	10	-	0.5	-	1.8	0.8	250
Bicarbonates	110	-	-	-	-	137	d
Cl	20	146	95	137	61.0	101	250
TDS	430	-	399	410	244	339	500
TSS	3.4	-	18	-	-	-	d
pH[a]	6.7	7.1	7.3	6.9	6.9	6.9	-
Specific Conductance[b]	-	950	-	-	385	536	d
Total Hardness (as $CaCO_3$)	-	60	17	118	120	114	d
Alkalinity	-	218	5	93	200	-	d
Al	-	-	-	-	1.0	0.3	d
K	-	-	-	-	2.4	2.7	d
NO_3	-	-	0.5	-	1.1	0.8	10
PO_4	-	-	-	-	0	0.2	d
F	-	-	0.00	-	0	-	1.4-2.4
Source of Analyses	AWARE	MCA[c]	MCA	MCA	MCA	USGS	

[a]Standard pH units

[b]Micromhos/cm at 25°C

[c]Matz, Childs and Associates

[d]No Standard

THE AWARE CORPORATION

NOS. The comparable water quality in Wells 3A and 16 means that the same alternative treatment methods apply to both wells.

3.3.2 PRESENT WATER TREATMENT

Well 3A is presently equipped with a water treatment system designed for iron removal only. The unit is a chemical oxidation, filtration, and ion exchange system, which uses potassium permangante as the oxidizing agent and for regeneration of the ion exchange column. Operation of the system requires continuous injection of the potassium permanganate solution and periodic backwashing of the filter and ion exchange column to remove precipitated iron and manganese. Information gathered during the initial stages of the project indicated that the system had not provided satisfactory results and had never been operated continuously for an extended period of time. Complaints heard about the treated water included objectionable odors and "green slime" coating several filter units. The comment was also received that the water was too hard, but the system was not designed for removal of hardness.

3.3.3 WATER TREATMENT METHODS FOR IRON REMOVAL

A literature review provided the following processes or combination of processes as applicable treatment methods for iron removal:

1. Oxidation/Filtration
2. Reverse Osmosis
3. Electrodialysis
4. Ion Exchange
5. Diatomite Filtration

6. Stabilization

7. Coagulation/Sedimentation/Filtration

The above processes were reviewed for efficiency of operation and applicability at NOS. Reverse osmosis, electrodialysis, diatomite filtration, and stabilization were judged not acceptable methods due to high installation and operating costs. The generally accepted methods of iron removal are oxidation/filtration, ion exchange, and coagulation/sedimentation/filtration.

Iron and manganese are found in groundwater in the dissolved or soluble form. Removal can be accomplished by oxidation to the insoluble form, and filtration of the precipitate. Oxidation is generally accomplished by aeration or chemical oxidation. Filtration to remove the precipitate is by gravity or pressure sand filter units. The chemistry of manganese is similar to iron, and the same oxidation/filtration treatment methods are effective for manganese removal; however, the rate of reaction of manganese is much slower than iron and longer contact time is necessary in the treatment process.

3.3.4 ALTERNATIVES EVALUATION

The alternative methods for iron and manganese removal at NOS are discussed below.

3.3.4.1 Aeration/Sedimentation/Filtration (Alternative 1)

Oxidation of the iron and manganese is achieved by mechancial aeration of the water. A sedimentation basin or chamber is required to provide retention time for the oxidation process to become complete. Sufficient

oxidation of manganese usually requires adjustment to pH 8.5 or greater and passage through a coke bed. The oxidized and precipitated iron and manganese are removed by a sand filter unit. Iron concentrations greater than several ppm can plug the filter unit and cause short filter runs.

3.3.4.2 Aeration/Chemical Oxidation/Sedimentation/Filtration (Alternative 2)

This is the most common method utilized to remove iron and manganese from large volume surface water supplies. Mechanical aeration is used to initiate the oxidation reaction and chemical oxidants such as chlorine or potassium permanganate ($KMnO_4$) are added to complete the oxidation process. A sedimentation basin is used to provide the necessary retention time for the oxidation reaction to become complete and to provide some precipitate removal. Filtration by a sand filter is used as the final step to remove the iron and manganese precipitate.

3.3.4.3 Coagulation/Sedimentation/Filtration (Alternative 3)

Water softening by lime-soda addition and coagulation will remove small amounts of precipitated iron and manganese. This process includes aeration, coagulation, lime treatment, sedimentation and filtration. The process is generally used to treat large surface water supplies containing color, turbidity and organically-bound iron and manganese.

3.3.4.4 [redacted] (Alternative 4)

The manganese zeolite process is the generally recommended method of iron and manganese removal for groundwater systems. T[redacted]

zeolite with oxides. Soluble iron (Fe) and manganese (Mn) are oxidized and removed from the water passing through the zeolite. This process generally includes [redacted] followed by passing the water through an anthracite/manganese greensand dual media unit. The anthracite top layer filters the oxidized Fe and Mn precipitate. The greensand provides oxidation and ion exchange removal of any non-oxidized Fe and Mn. The greensand can be periodically batch-regenerated with $KMnO_4$ solution or continuously regenerated by addition of excess $KMnO_4$ in the oxidation step. The anthracite portion of the system requires periodic backwashing to remove the collected precipitates.

3.3.5 RECOMMENDED ALTERNATIVE

The manganese zeolite process (Alternative 4) is the recommended iron removal method for Wells 3A and 16 for the following reasons:

1. The aeration/sedimentation/filtration process (Alternative 1) would require construction of a mechancial aeration tower, a sedimentation holding basin, and a sand filter system. It would also require pumping into the distribution system after treatment.
2. The aeration/chemical oxidation/sedimentation/filtration process (Alternative 2) is best suited to treatment of larger volumes of water than that from Wells 3A and 16. The costs for such a system are unjustified at NOS.
3. The coagulation/sedimentation/filtration procedure for water softening (Alternative 3) is primarily implemented for hardness

removal and achieves iron removal incidentally. It generates large quantities of sludge which would be costly to dispose.

4. The existing greensand unit at Well 3A is appropriate technology for the volume of water. With minor modifications and proper operation, it should consistently and cost-effectively achieve the desired water quality.

The existing Well 3A greensand unit includes injection of potassium permanganate ($KMnO_4$) into the discharge line from the well pump. The water is then piped to the dual media filter unit which contains a layer of anthracite and a greensand layer. The greensand is continuously regenerated by the excess $KMnO_4$ coming into the unit. The filtration unit requires periodic backwashing to remove the precipitated iron and manganese. The backwash wastewater is discharged to a small lagoon near the building.

Potential problems which can cause inefficient iron and manganese removal, taste and odor complaints or color complaints, include the following:

1. Insufficient potassium permanganate addition or too short retention time before the water reaches the filter unit, can cause incomplete iron and manganese removal.
2. Running the filter too long before backwashing can cause buildup of mudballs in the filter material and/or breakthrough of suspended solids.
3. Excessive addition of potassium permanganate can cause the effluent to have a noticeable purple color.

4. Taste and odor in the treated water can be caused by anaerobic bacterial buildup in the filter unit or by taste and odor constituents in the water that are not amenable to treatment by the manganese zeolite unit.

The major problem with the presently installed unit appears to be insufficient retention time between the potassium permanganate injection point and the dual media filter unit. Approximately five minutes contact time is required for completion of the potassium permanganate oxidation reaction. To obtain the suggested retention time, a 1,250-gal tank should be added in-line between the potassium permanganate injection point and the filter units. The recommended tank (Appendix 3-E) has a 6-ft diameter and a 6-ft depth. Mixing would be accomplished by a stainless steel baffle in the tank.

Visual inspection of the existing iron removal system for Well 3A indicated the system could be rehabilitated and returned to use by adding the in-line retention tank and replacing the greensand. The cost estimate for this rehabilitation is $30,900 and is presented in Appendix 3-E. If the existing system is inoperable due to equipment problems that were not evident in the visual inspection, the cost of a new skid-mounted greensand unit would be $89,200 (Appendix 3-E).

The ultimate need for treating the water from Well 3A for iron removal will be based on the projected NOS water supply requirements in conjunction with water conservation measures. This determination is discussed elsewhere in this report. If an iron removal system is restored at Well 3A (or added to Well 16), it is strongly recommended that the NOS personnel responsible for the system operation be adequately trained according to the manufacturer's operating specifications and procedures.

CHAPTER 3.4

WATER USE AND WELL CAPACITIES

3.4.1 CURRENT AND HISTORICAL WATER USE AND WELL YIELDS

The current groundwater use at the Naval Ordnance Station is estimated to be 1.1 mgd. Historical records estimated the water use at 0.25 mgd in 1898, 1.6 mgd in 1963, and 2.1 mgd in 1970. The water use represented by the 1970 figure reflects increased activity at NOS during the period of military conflict. The present water use is considered to be the requirement during normal peace time conditions. The 2.1 mgd in 1970 was supplied by basically the same well system that is currently operating at NOS.

The monthly pumpage data for the wells in use is available from 1976 to June 1981 (Appendix 3-C), but the pumping time by each well to produce the pumped amount is unknown. Assuming continuous pumping for most months, the data can be plotted for the period of record to illustrate any changes in monthly yields. Gradual decreases in yield over the period of record can be assumed to be caused by decreases in pump efficiency, well efficiency or aquifer yield.

Graphical plots of monthly pumpage are shown in Figures 3.4-1 and 3.4-2. The general trend of the monthly well yields has been a slight decline during the period from 1976 to 1981. The decline may have been caused by water conservation practices instituted at NOS causing a small decrease in use. The decline could also be due to gradual lowering of the potentiometric surface, which would increase the effective head on the pump and thereby reduce the amount of water pumped.

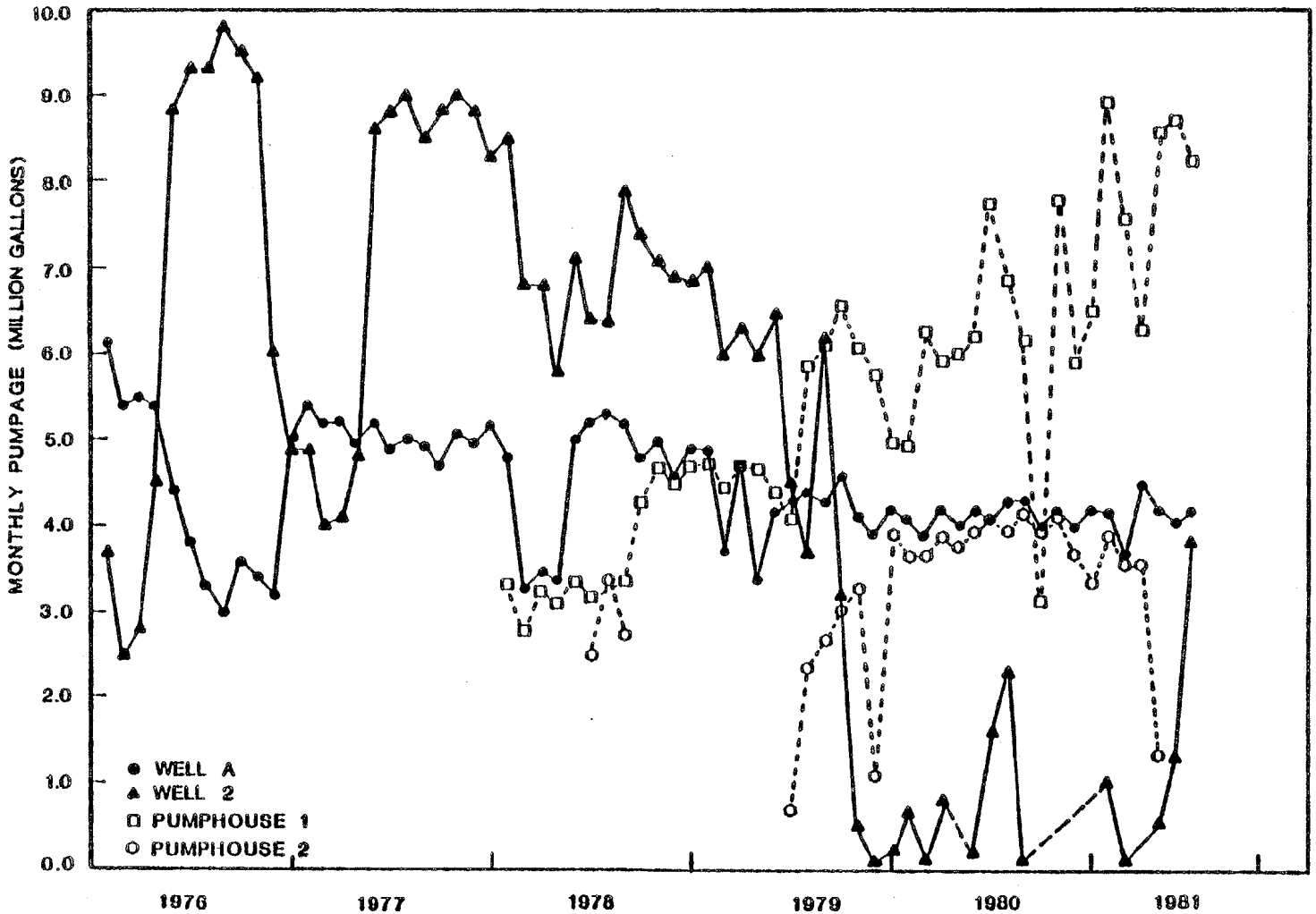


FIGURE 3.4-1 MONTHLY PUMPAGE RATES FOR WELLS PRODUCING HIGH SILICA WATER

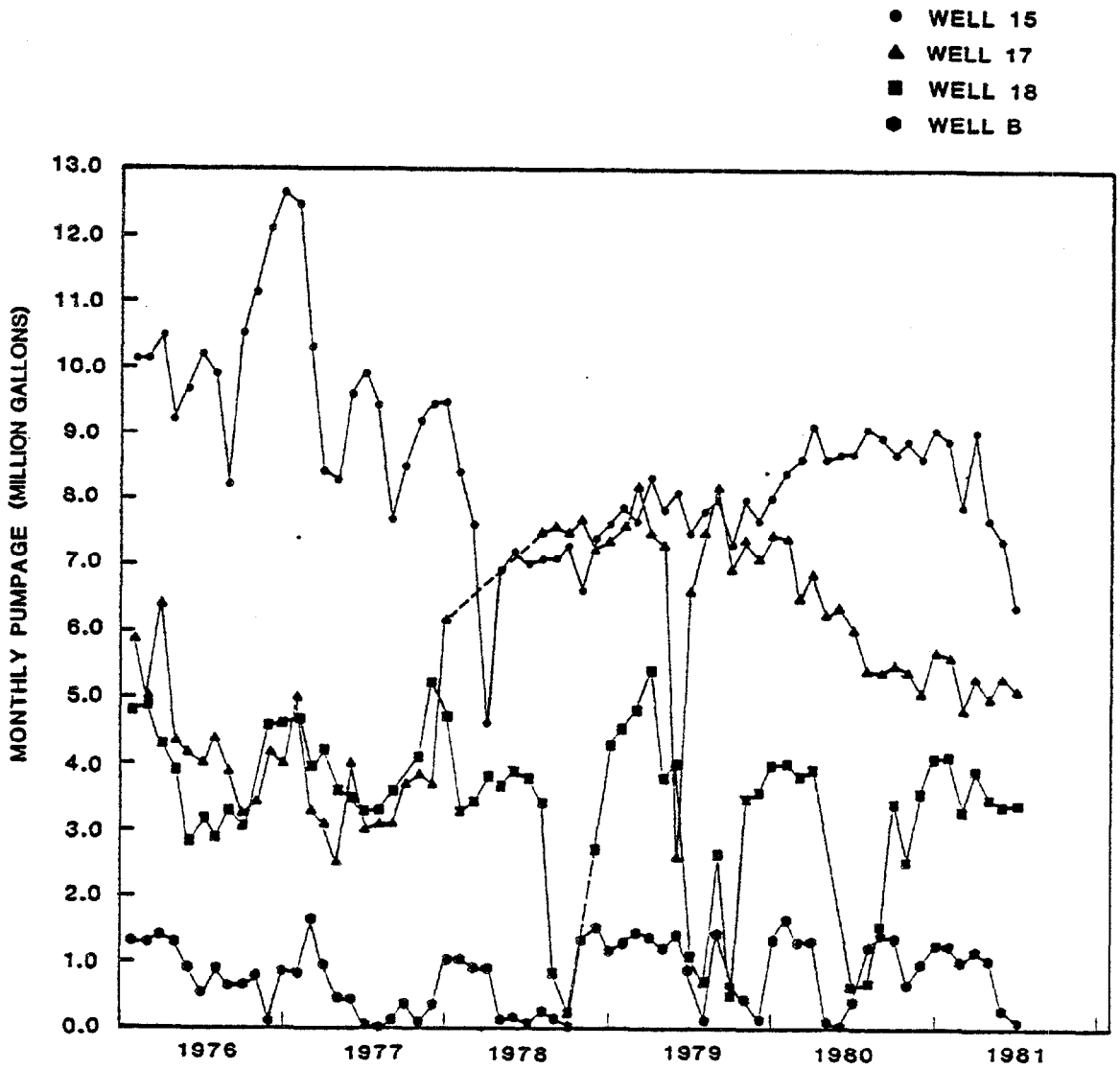


FIGURE 3.4-2 MONTHLY PUMPAGE RATES FOR THE WELLS PRODUCING LOW SILICA WATER

The maximum monthly pumpage rates recorded for each well between January and June 1981 were used to estimate the maximum amount of well water that can be pumped with the existing NOS facilities during one month. The maximum pumpage rates per well are listed in Table 3.4-1. The estimated maximum low silica supply capacity from the table is 647,000 gpd. The maximum high silica supply capacity at the time of the well survey was 557,000 gpd. When Wells 9 and 12 are restored to service, the high silica capacity should increase to approximately 779,000 gpd.

The water levels in an aquifer will decline until a steady-state condition is reached. At steady-state, the water being removed is balanced by an increase in recharge to the aquifer and an increased velocity of water toward the well. Under these conditions, the water levels will remain stable. The static water level has been measured in Well 19 by the U.S.G.S. since 1952. The water level trend showed a decline during the first several years of measurement and then a period of essentially steady-state. The measured water level has shown a slight increase from 1977 through 1981 (Figure 3.4-3). Well 19 is screened in only one water-bearing sand zone and the water level characteristics are not representative of the conditions expected in the deeper water-bearing sand units supplying water to the production wells. The expansion of the cone of depression is shown in Figure 3.2-5 and represents the expected conditions in the Lower Sand unit.

3.4.2 RECOMMENDED MONITORING PROGRAM

A program of routine pumping water level measurements would show the rate of head decline in the aquifers and could be used to estimate the

TABLE 3.4-1

ESTIMATED MAXIMUM WELL WATER SUPPLY AT NOS
(With Existing Facilities, Spring 1982)

	Well No.	Supply Rate 1,000 gal per month	1,000 gal per day	gpm	Month of Record (1981)
LOW SILICA SYSTEM					
	15	9,007	291	202	March
	17	5,653	182	127	January
	18	4,148	134	93	January
	B(23)	1,245	40	28	January
	Subtotal	20,053	647	450	
HIGH SILICA SYSTEM	2	3,820	127	88	June
	6	2,819	91	63	May
	7	5,944	192	133	January
	A(24)	4,560	147	102	March
	Subtotal	17,143	557	386	
	9	2,974	96	67	January
	12	3,903	126	87	March
	Total	24,020	779	540	

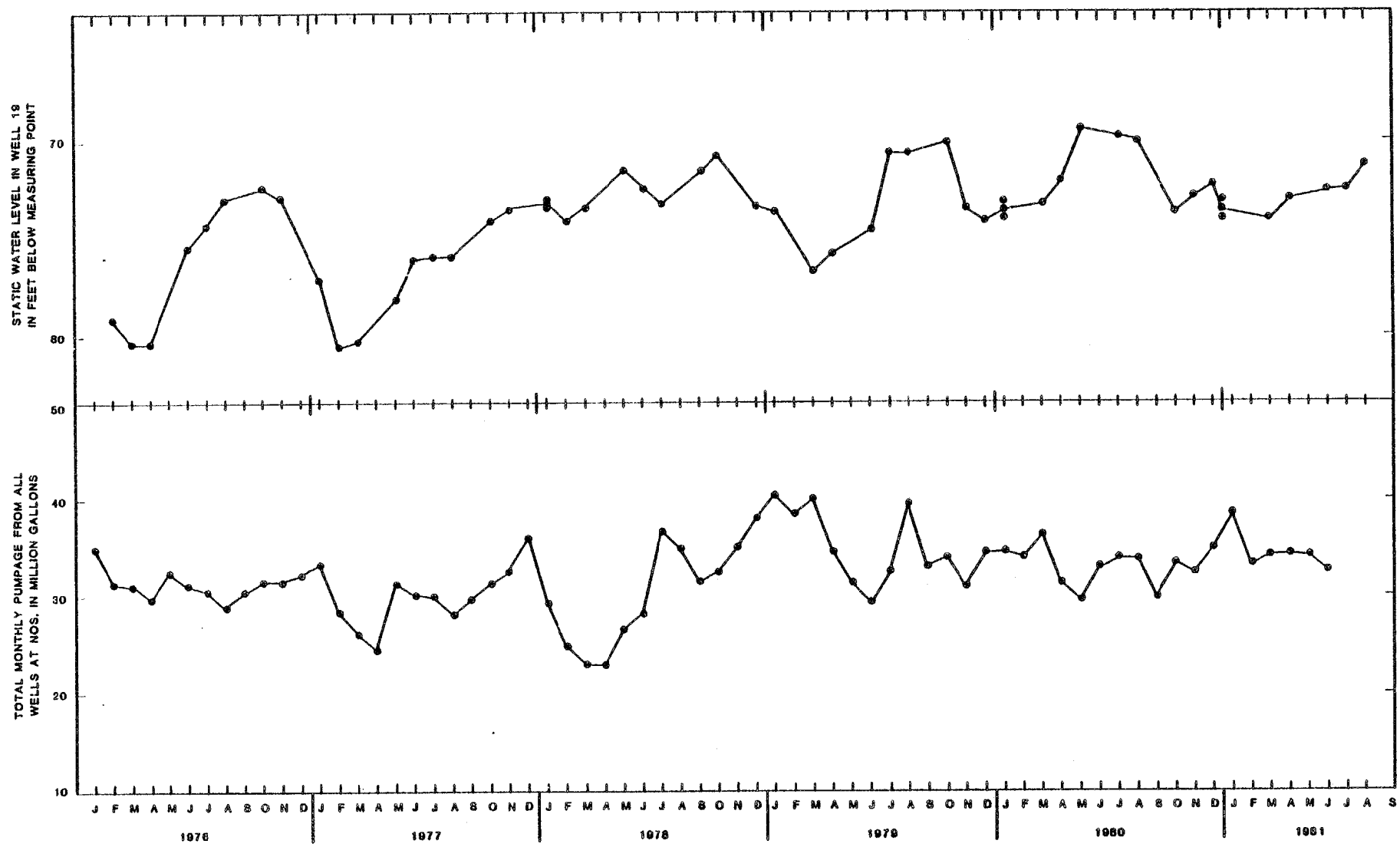


FIGURE 3.4-3 TOTAL MONTHLY PUMPAGE COMPARED TO MEASURED MONTHLY WATER LEVEL IN WELL 19

expected life of the wells. A time-drawdown graph could be plotted, and the drawdown extended to the depth of the uppermost screened interval in each well. The time to reach that point will estimate the life of the aquifer for water supply at the current usage.

All pump installations within the last thirty years at NOS included airline assemblies for measuring water levels. A number of the airlines have been removed as pumps were changed. The few assemblies still installed in wells are generally in poor mechanical condition. At the present time, only Well B(23) has an operable airline. The measured pumping water level in Well B was 176 ft below land surface. It is recommended that all pumping wells be equipped with airlines and that water level measurments be made on a regular basis. The measurements should be made at least semi-annually and included on the semi-annual pumpage reports for each well. A graphical record of the pumping water levels should be maintained for each well to aid in evaluating the well and aquifer life.

3.4.3 DECREASED YIELDS FROM WELLS 2 (NEW) AND B

The pumping records shown in Figures 3.4-1 and 3.4-2 reflect the low yield currently being obtained from Well B and an extreme reduction in the yield of Well 2 (New) during the summer of 1979. The reduction in yield from Well B is thought to be caused by plugging of the well screen. The reduction in yield from Well 2 could be caused by plugging of the well screen or by a mechanical malfunction within the pump caused by excessive wear or breakage. No data were found to indicate which of the potential problems caused the Well 2 reduction; however, plugging of the well screen is the most probable. The pump is relatively new and the well has not been

pumping sand. Therefore, it is unlikely the pump has broken or been excessively worn by sand. Discussion of remedial measures to restore the yield at these two wells is contained in Chapter 3.5.

3.4.4 LOW SILICA SUPPLY CONTINGENCY EVALUATION

The pumpage records of the low silica wells for the period January to June 1981 were analyzed to estimate the maximum monthly yield for each well. The maximum total low silica yield available from Wells B, 15, 17, and 18 is estimated to be 647,000 gpd. The total low silica demand from historical pumping records is estimated to be 634,000 gpd in winter and 542,000 gpd in summer. The low silica demand, as determined by the water use survey (Chapter 2.1), is estimated to be 649,000 gpd in winter and 514,000 gpd in summer. With all wells pumping at the reported maximum yields for the selected 6-month period of record, the low silica water requirements are marginally met.

If a low silica well pump should malfunction during a period of high demand, a water shortage could develop. In estimating the critical time period until such a low silica water shortage could develop, it was assumed that, prior to the malfunction, all wells would be pumped at the estimated maximum yields and all storage tanks would be full. The calculations were also based on the assumption that only one well would be inoperable at a time. Graphical presentations of the estimated low silica critical time analyses are contained in Figures 3.4-4 and 3.4-5 for winter and summer water demand conditions.

The critical time would be 1.5 to 2 days in winter if Well 15 (the major low silica water source) were inoperable. The critical time during

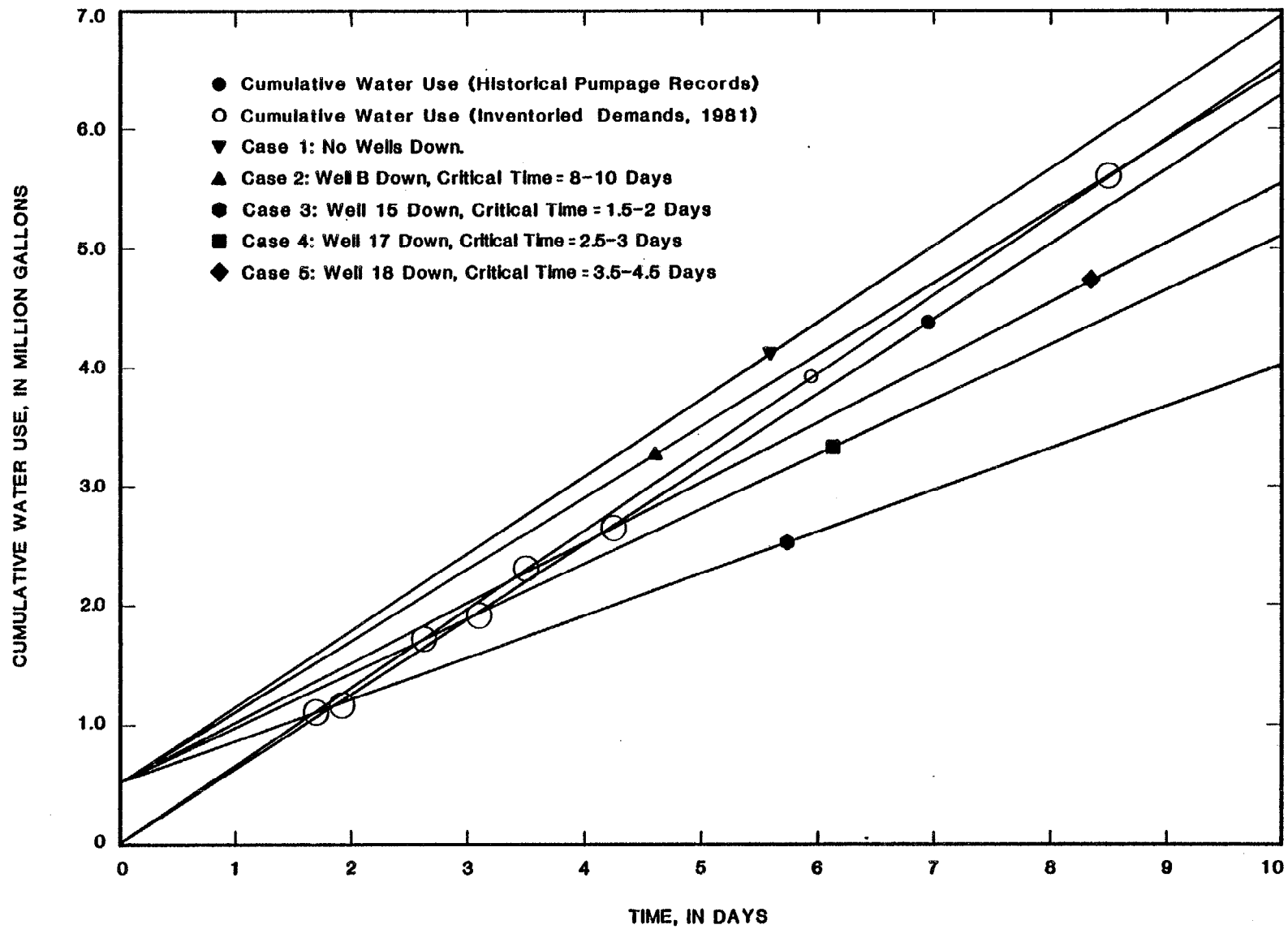


FIGURE 3.4-4 ESTIMATED CRITICAL TIMES DURING WINTER WATER USE (Low Silica)

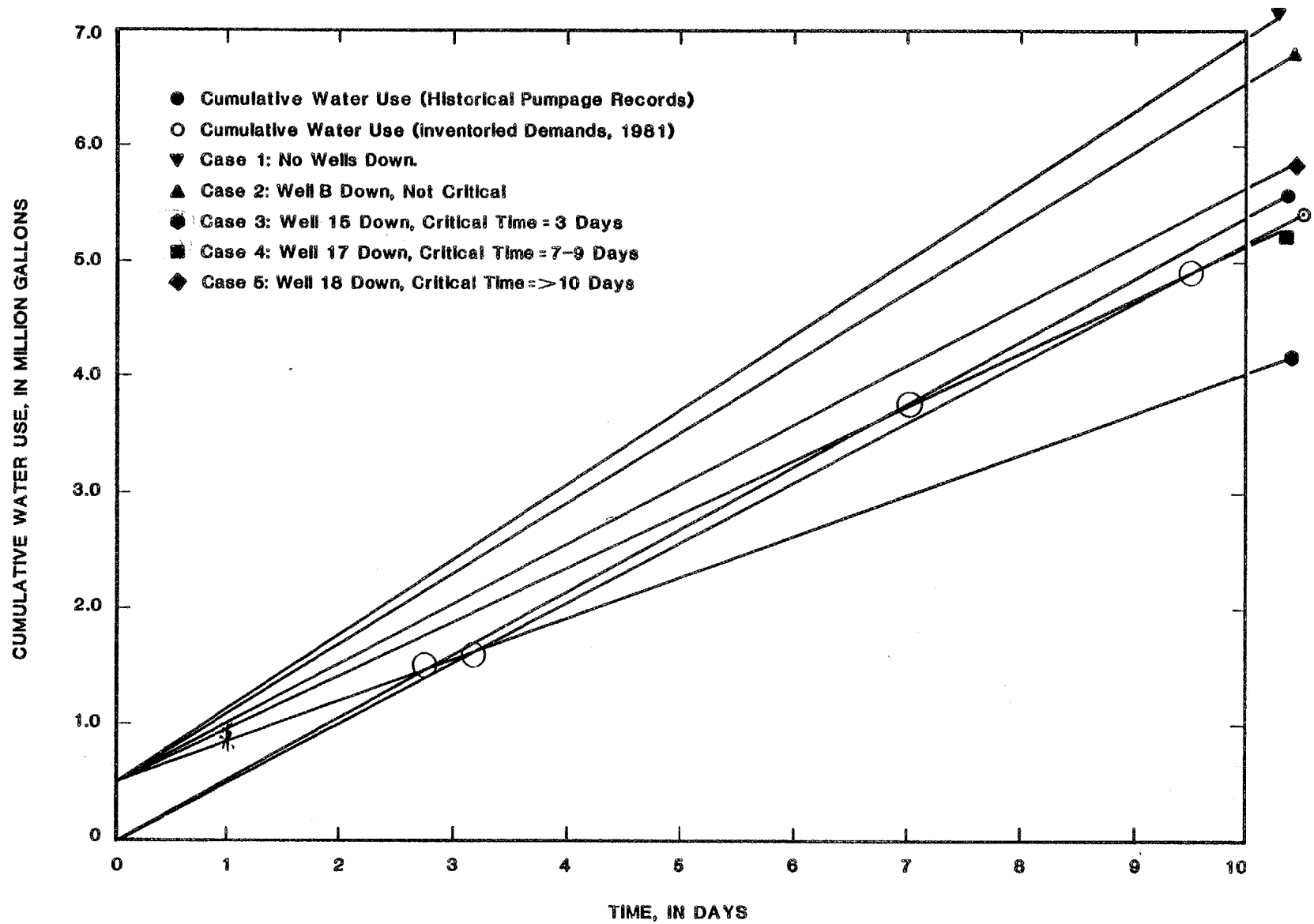


FIGURE 3.4-5 ESTIMATED CRITICAL TIMES DURING SUMMER WATER USE (Low Silica)

summer demand periods is estimated to be approximately 3 days if Well 15 were inoperable. If Well 17 were inoperable, the critical times would be 2.5 to 3 days in winter and 7 to 9 days in summer. If Well 18 were down, the critical times would be 3.5 to 4.5 days in winter and greater than 10 days in summer. If Well B were inoperable, the critical time would be 8 to 10 days in winter and none in summer.

There are periods when Tank 2 is empty and when the ground storage tank is drawn-down, which would reduce the critical time periods. To assure standby low silica water supply, it is recommended that a new low silica well be installed. A test well should be drilled in the Olson Road area. If a sufficient supply of low silica water is found, a production well should be constructed. The well cannot be used for continuous pumping because it would adversely affect the yields from Wells 15 and 17. The standby well should be maintained for critical use periods or used alternately with Well 15. [redacted]

3.4.5 HIGH SILICA SUPPLY CONTINGENCY EVALUATION

The pumpage records for the high silica wells for the period January to June 1981 were also evaluated to estimate the maximum monthly yields for each well. The high silica wells are estimated to produce a total maximum yield of 779,000 gpd, which includes Wells 2, 6, 7, 9, 12, and A(24). The historical average high silica water pumpage rates, as determined from six years of records (1976 to 1981), are 435,000 gpd in winter and 519,000 gpd in summer. The high silica water demand, as determined by the water use survey (Section 2.1), is estimated to be 349,000 gpd in winter and 531,000 gpd in summer.

The potential for a high silica water shortage to occur if a single well were out of service was evaluated similarly to the low silica well analysis. The results of this evaluation are depicted graphically in Figures 3.4-6 and 3.4-7 for winter and summer demand conditions. A high silica water shortage should not occur if any one of the high silica wells is out of service.

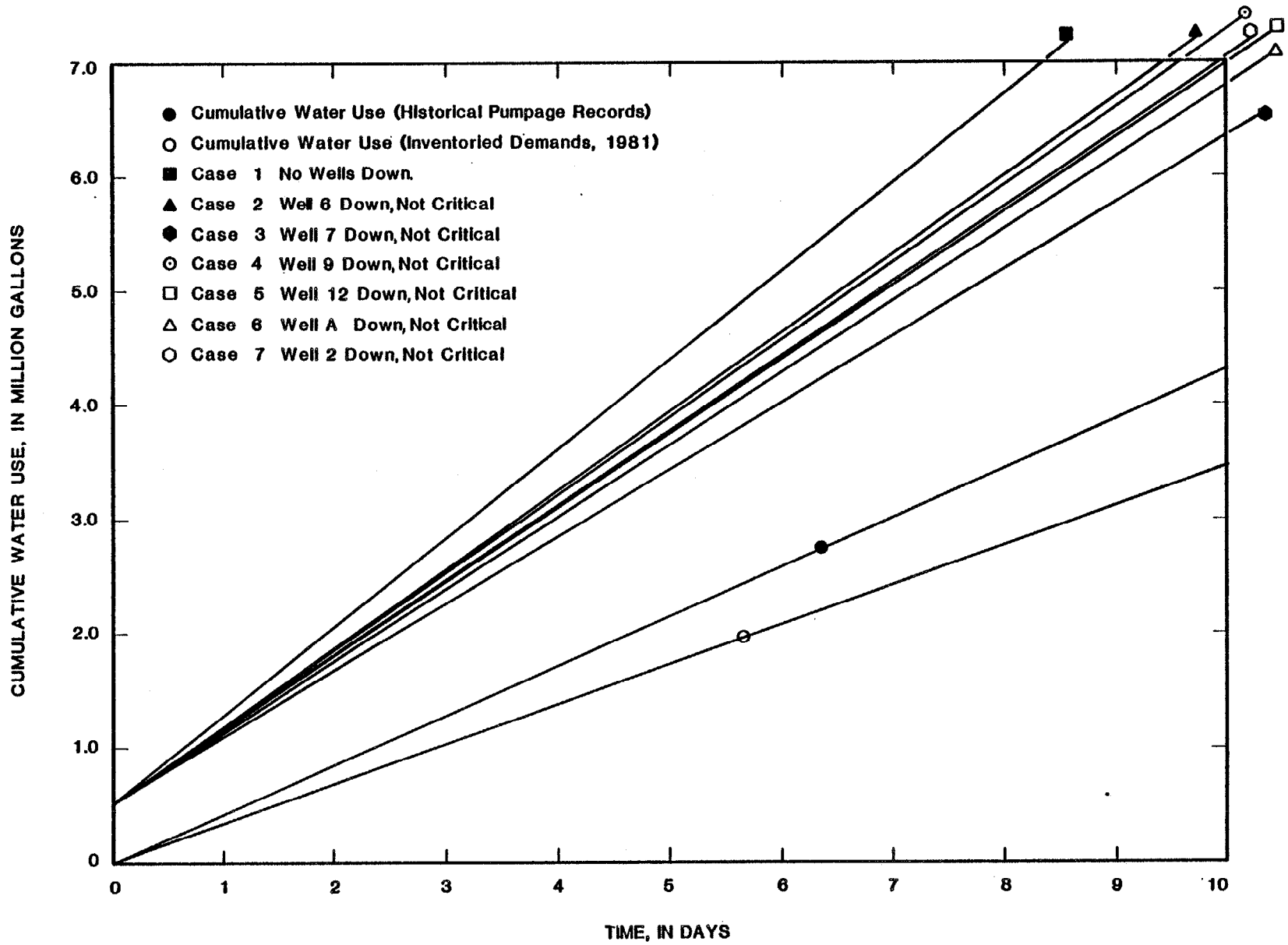


FIGURE 3.4-6 ESTIMATED CRITICAL TIMES DURING WINTER WATER USE (High Silica)

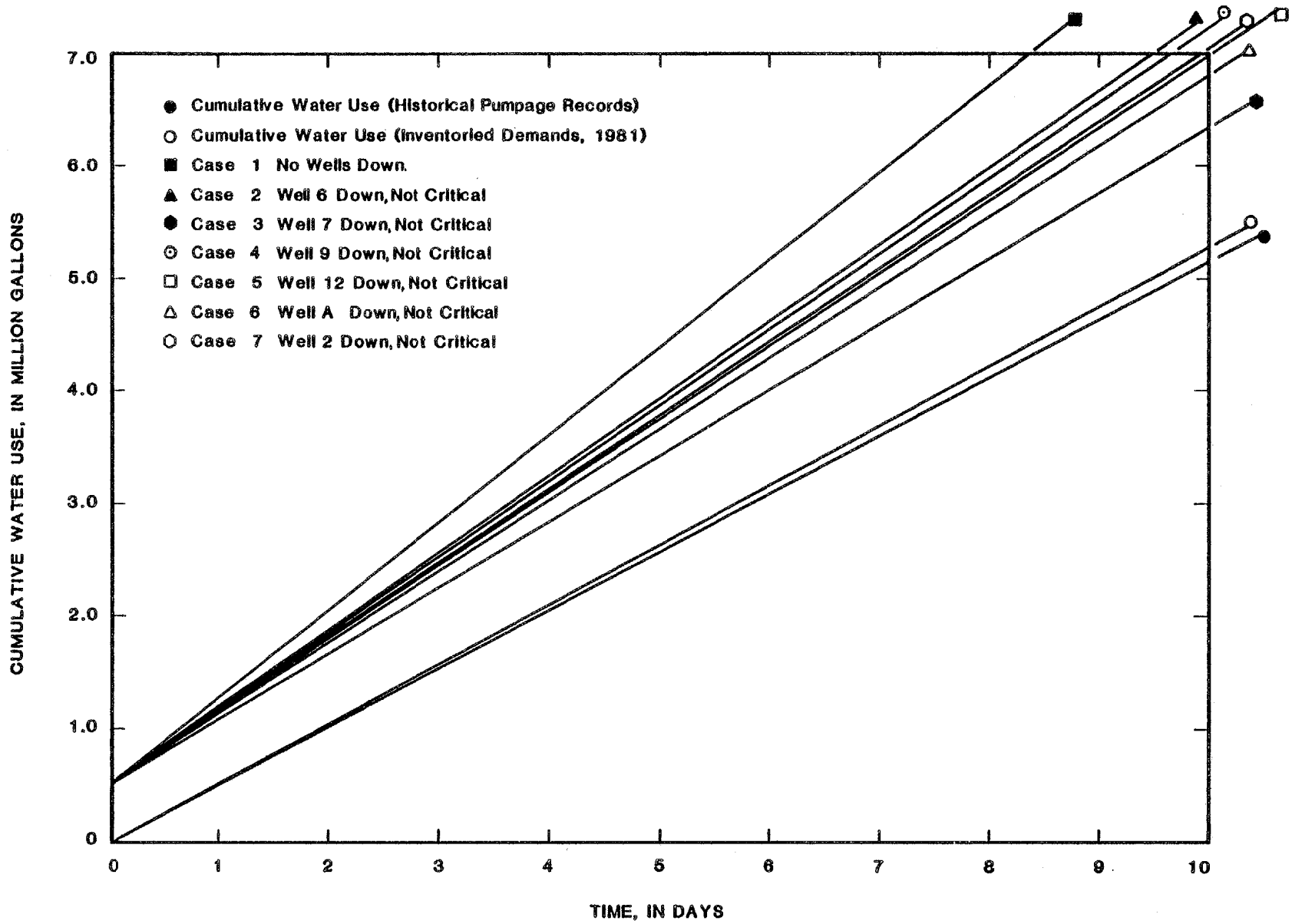


FIGURE 3.4-7 ESTIMATED CRITICAL TIMES DURING SUMMER WATER USE (High Silica)

CHAPTER 3.5

USABLE LIFE OF EXISTING WELLS

The usable life of the NOS wells is dependent on the length of time the well casings and screens maintain their physical integrity. Two mechanical problems that could limit the well life are incrustation and corrosion. Incrustation is the accumulation of scale or slime deposits on well screens or in the surrounding formation, which eventually plug the openings and restrict the flow of water into the well. Corrosion occurs when large holes in the casing or screen are created by the chemical action of the groundwater on the metal well screen or casing.

3.5.1 ANTICIPATED CORROSION PROBLEMS AT NOS

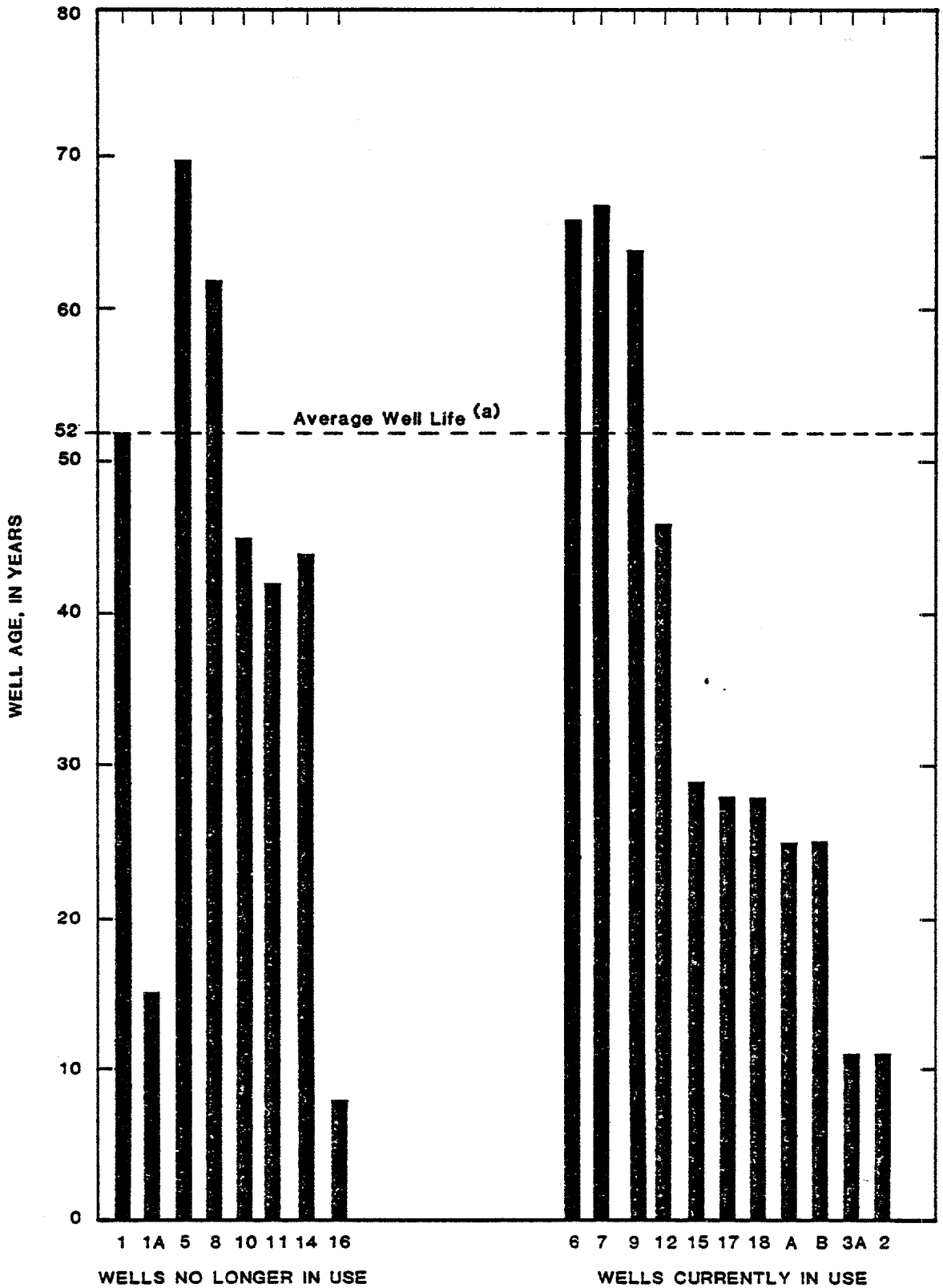
The predominance of NOS wells that have "sanding" problems indicates that corrosion is the most common occurrence. Holes in casings or well screens caused by corrosion allow sand to enter the well and be pumped with the groundwater. Eventually, the well bore will fill with sand. The rate at which corrosive action occurs is dependent on factors such as the acidity of the groundwater, the presence or absence of oxidizing agents, movement of solutions over areas being corroded, electrolytic effects, the formation or non-formation of scale, the temperature of the groundwater, and the age of the well.

The deterioration of well casings and screens by corrosion can only be corrected by replacement of the affected parts. If the age of the well is great, then correction may require construction of an entirely new well to

replace the damaged well. The chemical factors of corrosion are generally present in the groundwater of the Indian Head area, but corrosion is not a quickly occurring problem. The age of the NOS wells is probably the major contributing factor to corrosion and failure of well screens and casings and the resultant sand problems. Several wells currently in use at NOS were constructed in 1915, and several others in 1938. These wells are currently producing sand, and the water is being routed through the grit chamber located in Building 128. The wells in Group 1 were all drilled prior to 1918 and have been affected by the development of sand. Of the eleven wells in the group, six have already been abandoned because of sand problems, and three (Wells 6, 7, and 9) are currently in use but pumping sand. The Group 2 wells have also experienced sand problems, and the only one currently in use (Well 12) is pumping sand.

Figure 3.5-1 shows the historical production life of all water supply wells at NOS. The figure includes the life span for wells already abandoned, as well as, the period of use to-date for the wells currently in use. The average life for those wells already abandoned because of sand problems has been 52 yr. The graph illustrates that Wells 6, 7 and 9 have exceeded the 52-yr life expectancy. They are now pumping sand and are potentially prone to complete filling with sand at any time.

The materials used for the Group 1 and Group 2 wells were probably steel pipe and screen that may or may not have been galvanized. The top several feet of well casing in Wells 5, 8, 10 and 14 were inspected, and all were found to be heavily rusted with deep pits in the metal. The materials presently used in well construction are generally of better



(a) Average well life calculated using period prior to abandonment of wells 1, 5, 8, 11, 10, 14

FIGURE 3.5-1 LENGTH OF WELL USE AT NOS

quality. Several different alloys such as Everdur, red brass and stainless steel now used for well screens have been developed for many applications and many different types of groundwater. The well construction records for most of the newer wells at NOS indicate that alloy metal materials, such as red brass or Everdur, were used for the well screens. Therefore, resistance to corrosion will be greater, and average well life should be longer.

3.5.1.1 Remedial Actions Related to Corrosion

Water levels were measured in Wells 5, 8, 12, and 14 in the Group 1 and Group 2 areas. These measured water levels indicated that the water-bearing zones in these areas are not being excessively pumped and that adequate groundwater is available in these areas. However, many of the existing wells have "sanded-up" due to corrosion, and the available groundwater in those areas cannot be fully utilized. If additional high silica water supply is needed at NOS after implementation of, or in lieu of, water conservation measures, two replacement wells should be installed in the Group 1 area. If sand is found to be a problem in Well 14, two replacement wells are also recommended for the Group 2 area.

New wells could be developed in the Group 1 area with yields from 150 to 200 gpm, and yields of 100 to 150 gpm would be expected in the Group 2 area. Drilling and use of these replacement wells would require discontinuing the use of the existing wells in the area. Properly constructed and developed wells would increase the high silica water supply and would provide sand free water that would not have to be pumped through the grit chamber. The installed cost per well is estimated to be $137,200 (Appendix 3-E).

3.5.2 ANTICIPATED INCRUSTATION PROBLEMS AT NOS

Incrustation can occur when precipitates from the groundwater deposit on the well casing, screen, and gravel pack surrounding the well. Precipitates are usually carbonates but may be other substances, such as aluminum silicates and iron compounds.

Well B and Well 2 (New) at NOS have experienced extreme decreases in yield. Well B was tested at 469 gpm in 1957, but the yield has decreased to about 36 gpm at the present time. Well 2 was tested at 245 gpm in 1973 and currently has a yield of approximately 39 gpm. These decreases in yield are possibly caused by incrustation on the well screens.

3.5.2.1 Remedial Actions Related to Incrustation

Incrustation can be removed in most cases by proper chemical treatment of the well. Several different solutions are commercially available for use in treating wells. The most common type of treatment for carbonate and iron incrustation removal is with muriatic acid. The chemical treatment should be accompanied by agitation of the solution in the well bore, by swabbing with a wire brush, or by use of high-pressure horizontal jets. These measures force the solution through the well screen into the surrounding gravel pack.

Well B was acid treated in 1977 in an effort to improve the yield. The treatment consisted of charging the well with muriatic acid and then recirculated pumping of the solution out of and into the well. The treatment was largely ineffective, possibly because of inadequate agitation of the acid solution. In order to increase the reserve capacity of low silica

water supply, it is recommended that Well B be acid treated again. The acid treatment should be accompanied by the concurrent use of high-pressure horizontal jets or swabbing with a wire brush to more effectively clean the screens and gravel pack. The cost of this treatment for Well B is estimated to be $20,000. The magnitude of increased well yield from this procedure cannot be estimated with confidence.

If additional high silica water supply is needed at NOS after implementation of, or in lieu of, water conservation measures, Well 2 could be acid treated in an attempt to improve the yield. The treatment cost for Well 2 would also be approximately $20,000. The magnitude of increased well yield from this procedure also cannot be estimated with confidence. If the acid treatment increases the Well 2 yield to 150 to 200 gpm, the replacement of one of the Group 1 or Group 2 wells, as discussed in Section 3.5.1.1, may be unneeded.

CHAPTER 3.6

AQUIFER DEVELOPMENT POTENTIALS

3.6.1 ESTIMATED AQUIFER YIELDS

The potential yield of the aquifers underlying NOS is dependent on the estimated yield for the area and the current and projected pumpage. The USGS has estimated the potential yield in the Indian Head area to be 1.5 mgd for the Lower Sand of the Patapsco and Raritan and 2.8 mgd for the Patuxent. The current pumping rate for the Indian Head area is estimated to be 1.33 mgd, which includes primarily NOS and the Town of Indian Head. The total yield of 4.3 mgd estimated by the USGS was for the entire Indian Head area surveyed. NOS encompasses approximately one-half of the USGS study area, so the sustained yield available to NOS would be estimated at 0.75 mgd for the Lower Sand and 1.4 mgd for the Patuxent. The variability and lenticity of the water-bearing sands will tend to reduce this sustained yield estimate.

The historical water levels measured in several wells, and the current water level measurements, show that the potentiometric water surface for the aquifer system has declined in the past 20 years. The cone of depression, or radius of influence, has expanded outward from the NOS location. The pumping centers have shifted from the Group 1 area and now include the low silica well area and the Town of Indian Head.

3.6.1.1 Estimated Yield from the Lower Sand

The theoretical yield of the Lower Sand aquifer can be estimated by evaluating the groundwater flow across two closed contours around a pumping center. Assuming the aquifer is in steady-state conditions and interpolating the extensions of the -25 and -50 ft contours, the quantity of groundwater can be estimated using the following equation:

$$Q = -T\left(\frac{L_1 + L_2}{2}\right) \quad \left(\frac{\Delta h}{\Delta r}\right)$$

where:

Q	=	Quantity of groundwater available (cu ft/day)
T	=	Transmissivity of unit (sq ft/day)
L_1, L_2	=	Length of adjacent contour lines (ft)
Δh	=	Potentiometric head difference between the contour lines (ft)
Δr	=	Average distance between the two contour lines (ft)

The transmissivity (T) of the sand units in the Patapsco and Raritan Formation has been estimated to be 270 sq ft/day by the USGS. The lengths of the -25 ft (L_1) and -50 ft (L_2) contours were determined to be 72,550 ft and 61,015 ft, respectively, from a map similar to Figure 3.2-5. The potentiometric head difference (Δh) between the -25 ft and the -50 ft contour lines is -25 ft. The average distance between the two contour lines (Δr) was determined to be 1,480 ft from a map similar to Figure 3.2-5. Substituting these values into the above equation and converting to mgd:

$$Q = \frac{-270 \text{ sq ft}}{\text{day}} \times \frac{72{,}550 \text{ ft} + 61{,}015 \text{ ft}}{2} \times \frac{-25 \text{ ft}}{1{,}480 \text{ ft}} \times \frac{7.48 \text{ mil gal}}{10^6 \text{ cu ft}}$$

$$Q = 2.28 \text{ mgd}$$

This theoretical analysis uses interpolated actual conditions and indicates an aquifer yield of 2.28 mgd, which is 50 percent greater than the USGS-estimated amount of 1.5 mgd for the Lower Sand. Several assumptions in the analysis affect the accuracy of the calculation. The aquifer was assumed to be homogeneous and in a steady-state condition, both of which are not the case. Additionally, the irregularity of the contour lines and the density and accuracy of the distance measurements between the lines affect the calculation. The transmissivity value of 270 sq ft/day is also an estimated value.

The above analysis indicates that a yield of 2.28 mgd should be expected for the entire Indian Head area including the Town of Indian Head. The area occupied by NOS is approximately three-fourths of the analysis area; therefore, the expected yield at NOS is 2.08 mgd. The declining yields, the apparent decrease in water levels, and the resultant expansion of the area influence indicate that the aquifer is not in steady-state conditions. The above analysis is only valid for steady-state conditions. The discrepancies between the calculated yield and the actually observed and reported yield indicate the need for periodic measurements of pumping water levels to define the actual conditions in the aquifer.

Another major source of discrepancy in the calculation is the assumption of homogeniety in the aquifer. Test well drilling has shown the aquifer to be highly non-homogeneous; therefore, the area encompassed by the calculation was too large and the resultant estimated yield too high.

The estimated yield of the Lower Sand aquifer is more than the current pumping rate. The discrepancies between the theoretical calculation and the actual conditions reported make it impossible to estimate the maximum yield to be expected from the aquifer. It should also be noted that the estimated yield does not differentiate between high silica and low silica water. It is possible that the low silica area is currently being over-pumped, while the high silica area is not being pumped to capacity.

3.6.1.2 Estimated Yield from the Patuxent Formation

The potential yield of the Patuxent Formation cannot be further evaluated at this time, because sufficient data are not available. The extrapolated USGS-estimate of 1.4 mgd available in the NOS area is the only estimate available. Drilling records indicate the Patuxent Formation is more lenticular and spotty than the Patapsco and Raritan, which makes locating water-bearing sands more difficult. Development of additional wells in the Patuxent will require test well exploration.

3.6.2 DIFFERENTIATED WATER QUALITY AREAS

The differences in water quality from the wells at NOS are also an indication of lenticity in the water-bearing zones. The areas producing the different qualities of water are indicated on the NOS area map in Figure 3.6-1. This map may be used as an indicator of anticipated water quality in the development of any future wells.

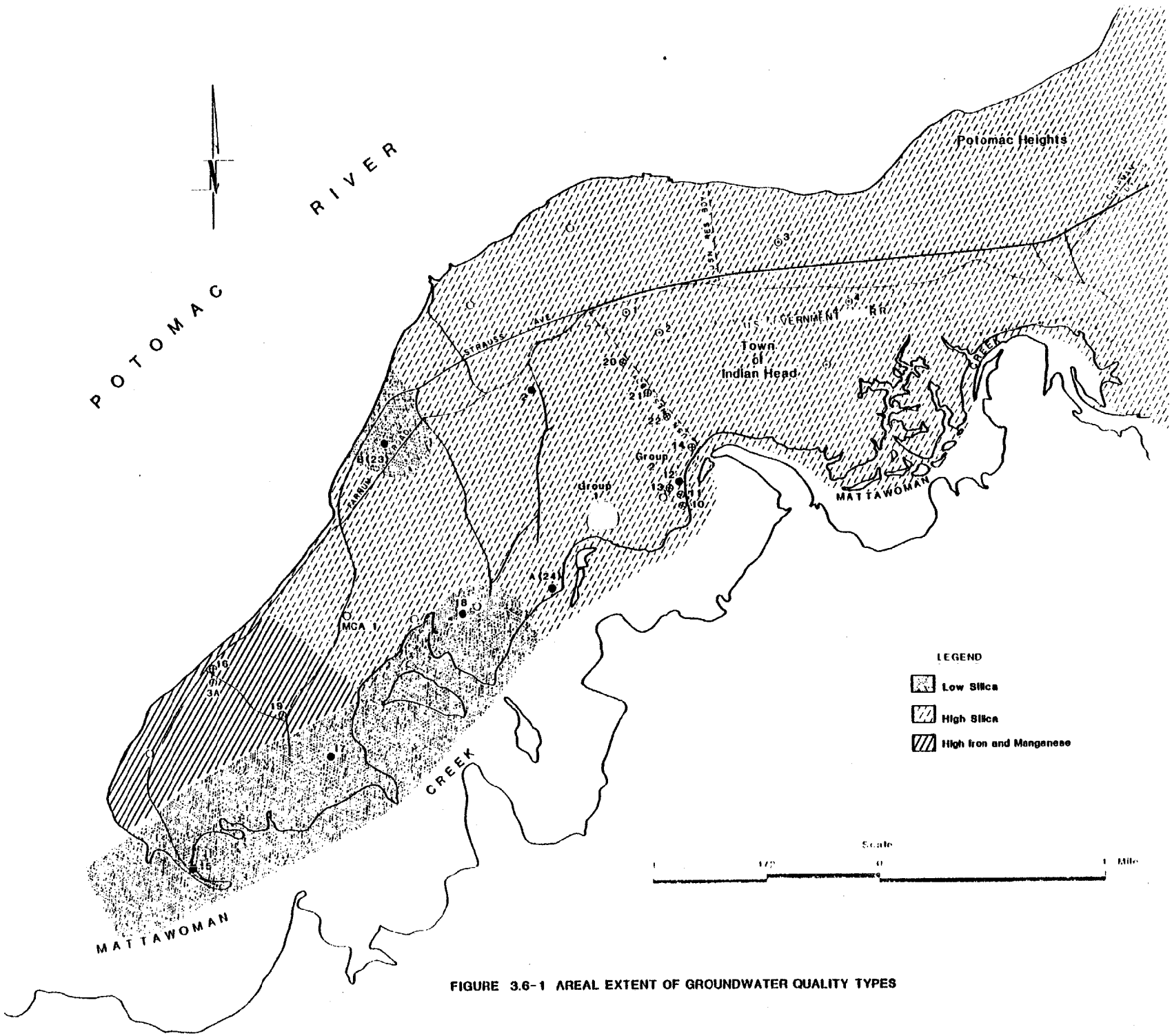


FIGURE 3.6-1 AREAL EXTENT OF GROUNDWATER QUALITY TYPES

The low silica area is represented by a thin zone located along the lower one half of the NOS along Mattawoman Creek. The well spacing in this area is currently at minimal distances, and there are no areas available for expansion. A second small area of low silica water is found at Well B. The area containing Wells 3A, 16 and 19 is known to be an area of excessive iron content and should not be used for future well expansion. The remainder of the NOS area, and extending to the northeast past the Town of Indian Head, is an area of high silica water. Any future wells drilled in this area would be expected to have silica concentrations ranging from 30 to 40 ppm.

3.6.3 POTENTIAL WELL LOCATIONS

Future well construction in the Indian Head area is dependent on the proximity to other wells, including those of the Town of Indian Head, and test drilling to locate water-bearing sands. The NOS property has been extensively explored by past drilling. The hydrogeologic information obtained from these explorations can be used to suggest potential sites for new well construction. The Indian Head area is described by local well contractors as being "spotty". Therefore, drilling in predicted areas will not assure finding a useable water supply. The discontinuities in the formations cause sand zones to disappear or change characteristics over short horizontal distances. Test wells will be necessary at sites suggested for potential new well construction to locate water-bearing zones and to define the expected aquifer yield at the location.

Future aquifer development is also dependent on other groundwater use in the area. The largest user of groundwater in the area is NOS. Other

groundwater users include the Town of Indian Head, the Potomac Heights area, and several small public water supplies to the northeast of NOS. The upgradient areas of the aquifers in Virginia have a potential for development; however, at this time, no major groundwater supplies are developed in that region. The small public water supplies that do exist in the upgradient Virginia region will have no effect on aquifer yield or potential for development at NOS. The locations of the wells used by the Town of Indian Head and the several smaller public water supplies will affect any potential well locations along the railroad right-of-way for several miles from the NOS property boundary.

3.6.3.1 Potential High Silica Well Installations at NOS

During the test well drilling program conducted in 1970, a test well (designated MCA 1) indicated the site located on Caffee Road was suitable for construction of a production well; however, no production well was constructed. The records of the test well show that 210 gpm was obtained with screens located from 192 to 212 ft and 220 to 240 ft. The enginering study at that time recommended construction of a production well at the site, with screened intervals from 190 to 210 ft and 220 to 245 ft, and estimated the expected yield to be from 250 to 300 gpm. If additional high silica water supply is needed at NOS after implementation of, or in lieu of, water conservation measures, AWARE recommends that a production well with the above specifications be drilled at the Caffee Road site, as shown in Figure 3.6-2. However, the Pilot Plant area will have to be converted to high silica water use to provide the necessary piping system to connect the well to the high silica water system.

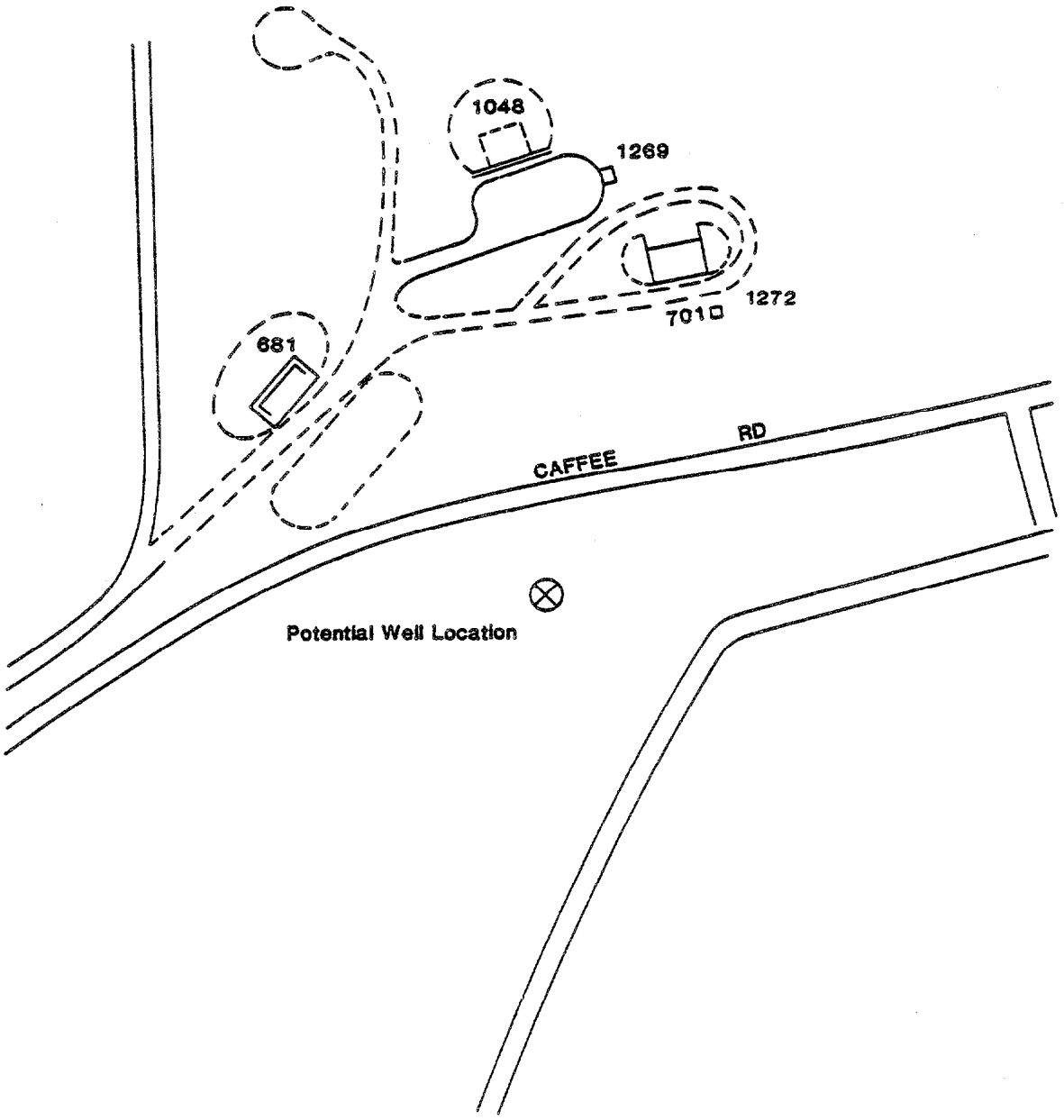


FIGURE 3.6-2 POTENTIAL HIGH SILICA WELL LOCATION AT SITE OF MCA 1 TEST WELL

The area along Bronson Road from Farnum Road to the upper extent of the Multi-Base area is recommended for future test well drilling. No aquifer information has been collected for this central area of NOS, and the potential for developing a high silica well with sufficient yield is considered good. The static water levels in this area, as previously measured in Well 2 (New), have been lowered by pumping. With the decrease in yields from Wells 2 and B(23), and with the non-use of several wells in Groups 1 and 2, the water level influence may have decreased. Acid treatment of Wells 2 and B(23) should be attempted to alleviate anticipated incrustation of these wells, before new wells are installed in this area. Successful acid treatment could increase the yield of these wells sufficiently that new well development in the area would not be needed.

As discussed in Chapter 3.5, the pumpage of high silica water could be increased from the Group 1 and Group 2 areas by replacing the old wells that are pumping and filling with sand. No test well drilling would be necessary in this area, if the replacement wells are drilled within several tens of feet of existing wells for which a formation log is available.

3.6.3.2 Potential Low Silica Well Installations at NOS

The area of NOS where the low silica wells are located is a desirable area for new well development. The low silica wells are located on a NE-SW trending line along the Mattawoman Creek side of the Indian Head peninsula. The well spacing ranges from 2,300 to 4,600 ft along this line. The installation and continuous use of any additional wells along this line would potentially reduce the yield of the existing wells by lowering the water levels. However, installation of such a well as a standby would

decrease the critical problem if one of the existing low silica wells should experience pump failure. AWARE recommends that a test well be drilled along the low silica line in the area between Wells 15 and 17, to determine the potential for installing a production well in that area. This well should be located off Caffee Road in the area along Olson Road. The cost of a production well, including one test well, is estimated to be $156,800 (Appendix 3-E).

3.6.3.3 Potential High Silica Well Installations along the White Plains Railroad

The aquifers at Indian Head are the same aquifers present from Indian Head along the railroad right-of-way to White Plains. The same lithologic characteristics exist for the Patuxent Formation and the Patapsco and Raritan Formation. The direction from Indian Head to White Plains is down dip for the units, which are approximately 300 ft deeper in the White Plains area. In the White Plains area, the upper and middle sands of the Patapsco and Raritan formation are at a sufficient depth to allow a well to be developed with a useable pumping head.

Controlling factors for using the railroad right-of-way up to Maryland Highway 225 are the locations of the Town of Indian Head wells. The Town of Indian Head is currently using four wells, three of which are located near or adjacent to the right-of-way. The Town's Well 1 is located approximately 700 ft northeast of the point where the right-of-way leaves the NOS boundary. The Town's Well 2 is located 200 ft north of a point on the right-of-way 1,500 ft from the NOS property boundary. The third Town well adjacent to the right-of-way is Well 4, which is within 50 ft of the right-of-way about 0.9 miles from the NOS property boundary.

Potential NOS well sites along the right-of-way are, therefore, restricted to areas far enough away from the Town wells to minimize the extent of influence on the pumping water levels and yields. The minimum distance required is estimated to be 0.5 miles. Potential NOS well locations are recommended to be at least 1.5 miles from the property boundary. The right-of-way at this distance is on the edge of the low flood plain of Mattawoman Creek, and a well location would have to be selected at one of the higher elevation sites with limited potential for flooding. Three such areas have been tentatively identified along the right-of-way from the 1.5 mile distance outward to Maryland Highway 225. These areas are located on the north side of the right-of-way, at locations where sloping land extends to Mattawoman Creek and areas of slightly higher elevations are available in the right-of-way. One of these areas would be suitable for a future well location, but drilling is not recommended at this time.

The area in the railroad right-of-way from Maryland Highway 225 to White Plains has the same potential for development as NOS and the area along the right-of-way from the NOS boundary to Highway 225. Test wells can be drilled at accessible locations along the right-of-way. The controlling factor for well construction, after test wells have located water-bearing sands, will be the costs associated with supplying power at the well head and constructing the necessary pipeline to connect the well with the existing 12-in. ceramic line, which is reported to extend up the right-of-way at least to Highway 225. This portion of the right-of-way has the potential for adequately-yielding wells. This area should be explored only if water conservation and well rehabilitation and development at NOS are inadequate to meet the future high silica water demands.

CHAPTER 3.7

RECOMMENDED WELL WATER SUPPLY IMPROVEMENTS

3.7.1 SUMMARY

The current potable water supply at NOS is being supplied by 11 wells of varying age. The older wells in use are experiencing problems with sand, and several other wells have already been removed from service. The yields of all wells in the system have been slowly declining over the past 20 years. The current total pumpage at NOS is only slightly greater than the current water demand. An additional problem at NOS is the high demand for low silica water in conjunction with the decreasing yield of the low silica wells.

3.7.1.1 Condition of Existing Wells, Pumps, and Storage Tanks

The existing wells, pumps, piping and storage tanks were inspected for current operating condition. The wells pumps and associated piping were generally found to be in satisfactory operating condition. The inspection of the storage tanks indicated that several minor mechanical repairs are needed, Tank 2 requires exterior painting, and spot painting is required for Tanks 1, 3, and 4. Wells 5 and 14 were inspected for future use. Well 14 could be used, but Well 5 is experiencing sand problems and should not be used.

3.7.1.2 Water Treatment for Iron Removal, Wells 3A and 16

The water quality for Wells 3A and 16 was reviewed for water treatment alternatives. The recommended iron and manganese removal system is the manganese greensand process, similar to that already installed at Well 3A.

Use of Well 3A will require rehabilitation of the presently installed system and addition of a storage tank to increase the retention time before treatment through the greensand unit. It is recommended that Well 16 not be used at this time, because its proximity to Well 3A will reduce the yield from 3A.

3.7.1.3 Hydrogeological Evaluation

The aquifers for the area were identified as the Lower Sand of the Patapsco and Raritan Formation and the Patuxent Formation. These aquifers are present at NOS and extend past the White Plains area. Hydrogeologic evaluations indicate that the theoretical yield of the aquifers should be 2.28 mgd for the NOS area, but evaluation of the pumping water level trends and the area of influence around NOS indicate the yield may not be that great. The current groundwater withdrawal at NOS from the Lower Sand unit may be the maximum available without further greatly lowering the water levels. The Patuxent aquifer could be further developed; however, it contains many lateral discontinuities and has not been found under the entire NOS area.

Low silica water is obtained from a limited zone in the Lower Sand unit, and no further increase in yield is expected. An additional well should be constructed in the low silica area as a reserve supply if a problem is experienced in one of the existing wells. Construction of this well would not significantly increase the total low silica yield. Any increase in yield from continuous use of the reserve well would likely be offset by a decrease in yield from the existing wells.

The wells supplying high silica potable water are meeting the current demand, although the total yield from the wells has decreased. The decrease in yield from the older wells is probably caused by lowered water levels and compounded by partial filling of the wells with sand. The yield from wells in the areas designated Group 1 and Group 2 may be increased by replacing the old wells currently in use.

The recommendations developed from the well and aquifer study emphasize maintaining current well yields. The study indicates that no major source of low silica water is available and that the water levels in the Lower Sand are declining. The potential to develop major new supplies of groundwater are limited at NOS. The water conservation study under this contract has developed recommendations for significant well water consumption savings. The water conservation measures should be implemented to limit any increased need for groundwater pumping.

3.7.2 ALTERNATIVES FOR INCREASING WELL WATER SUPPLY

The aquifer and well capacity evaluations identified several ways to increase the high silica water supply for NOS. No areas for installation of new low silica water wells were found; however, construction of a new well in the low silica area would provide a standby or intermittent supplemental low silica water supply. The alternatives identified for increasing the available water supply include the following:

1. Install a pump in Well 14 and begin to use the well, which would have an expected yield of 100 gpm. Use of Well 14 would eliminate the need to drill replacement wells in the Group 2 area.

2. Rehabilitate the existing iron removal system for Well 3A, and install a 1,250 gal tank before the greensand filter to increase the retention time. The use of Well 16 is not recommended, because it would decrease the yield of Well 3A.
3. Construct a standby well for the low silica system. A test well should be drilled in the Olson Road area. If a sufficient supply of low silica water is found, a production well should be constructed. The well cannot be used for continuous pumping, because it would adversely affect the yields from Wells 15 and 17. The standby well should be maintained for critical use periods or should be used alternately with Well 15.
4. Construct a high silica production well at the indicated location on Caffee Road. The use of this well in the high silica system requires conversion of the potable water supply in the Pilot Process area from low silica to high silica use.
5. Acid treat Well B to increase low silica yield.
6. Acid treat Well 2 to increase high silica yield, before drilling test wells at the recommended potential well locations. (Item 8, below).
7. Construct two replacement high silica wells in the Group 1 area. These two wells could increase the yield from the area by replacing Wells 6, 7, and 9 that have declining yields and are pumping sand.
8. Drill test wells at several potential high silica well locations. Install production wells at those locations, if test

results indicate usable quantities of water are available. These sites include the area along Bronson Road and the areas along the railroad right-of-way from the NOS boundary to White Plains.

3.7.3 WELL WATER SUPPLY RECOMMENDATIONS

The water conservation recommendations in Chapter 2.4 of this report would enable reductions in water use of approximately 20 percent for low silica water and approximately 60 percent for high silica water. Water use reductions of these magnitudes would eliminate the immediate need to increase water supply. The recommended water conservation measures eliminate the need to develop new sources of high silica water at this time.

The current high silica well system should adequately supply the predicted demand after implementation of the recommended water conservation measures. It is recommended, however, that the greensand iron-removal system at Well 3A be rehabilitated to provide additional high silica water supply reserve capacity. The only potential problem associated with the rest of the high silica system is the sand problem occurring in the older wells, but the remaining life of these wells cannot be predicted with any certainty. A well may sand-up from one week to the next with no advance signs of the impending condition. It would be reasonable to expect at least one well to sand-up at NOS within the next five years. Future improvements will be needed in the high silica system to replace wells that fill with sand and cannot be repaired due to age. Wells 6, 7, and 9 in Group 1 will need to be replaced when they begin pumping excessive

sand, because their age makes repairing well casings and screens unfeasible. It is recommended that when the wells in Group 1 are replaced, they be replaced by only two new production wells.

The reduction in low silica water use by the recommended water conservation measures is significant; however, in the event of pumping equipment failure, critical shortages could occur. No additional aquifers producing low silica water were identified in this study; it is doubtful that other low silica aquifers exist in the Indian Head region. Recommendations are directed toward improving the existing wells and providing for standby capacity.

It is recommended that Well B (23) be acid treated to increase its yield. The acid treatment must be accompanied by agitation with high pressure horizontal jets or swabbing the inside of the screens with wire brushes. The use of high pressure jetting or wire brushes will more effectively clean incrustation from the well screen. Improvement in the Well B yield will add to the available low silica supply.

[redacted] Continuous pumping of the standby well would reduce the current yield from Wells 15 and 17. [redacted]

3.7.4 RECOMMENDED IMPROVEMENTS TO THE WELL, PUMP AND STORAGE SYSTEM

The recommendations developed from the well and distribution system inspections can be categorized as general maintenance activities by NOS personnel and major activities. No major problems needing repair were identified during the inspection of the wells and pumps. Recommendations that can be accomplished as part of general maintenance activities at NOS include the following:

1. Rehabilitate the existing air line assemblies, and measure pumping water levels at least semi-annually. The water level measurements can be recorded on the existing semi-annual pumpage reports.
2. Spot paint and repair minor mechanical problems found on Tanks 1, 3, and 4.
3. Install covers or caps on Wells 5 and 10.

The only major repair item is painting the exterior and replacing the safety ladder of Tank 2. The inspection showed the exterior paint to be in poor condition. The safety rail on the ladder is bolted too closely to the ladder for use and needs to be replaced.

3.7.5 COST ESTIMATE OF RECOMMENDED WELL WATER SYSTEM ACTIONS

Cost estimates for the recommended actions for the well water supply system are summarized in Table 3.7-1. Completed NAVFAC 11013/7 (1-78) forms for the actions are contained in Appendix 3-E.

TABLE 3.7-1

WELL WATER SUPPLY SYSTEM RECOMMENDATIONS AND COST ESTIMATES

Recommendation	Estimated Cost[a]
Paint and repair elevated storage tank #2	$ 15,000[b]
Acid treat low silica Well B (23)	$ 20,000[b]
Drill test well at potential low silica site on Olson Road	$ 19,600[b]
Complete production well at site on Olson Road, if test well is successful	$137,200[b]
Rehabilitate the iron removal system at Well 3A	$ 28,100[b]
General maintenance items	$ 4,500[c]

[a]1982 dollars.

[b]Detailed cost estimates are included in Appendix 3-E.

[c]Order of magnitude estimate for rehabilitating existing air line assemblies; minor spot painting and mechanical repairs to Tanks 1, 3, and 4; and capping Wells 5 and 10.

REFERENCES

REFERENCES

1. American Society of Civil Engineers, American Water Works Association and Conference of Sanitary Engineers, 1969, Water Treatment Plant Design, AWWA, New York, NY.

2. Clark, J.W., Viessman, W., Jr., and Hammer, M.J., 1977, Water Supply and Pollution Control, Third Edition, Harper and Row, New York, NY.

3. Dryden, A.L., Jr., 1939, Map of Charles County showing the geological formation; scale 1:62500, Maryland Geological Survey.

4. Fair, G.M., Geyer, J.C., and Okun, D.A., 1968, Water Purification and Wastewater Treatment and Disposal, Volume 2, Wiley and Sons, Inc., New York, NY.

5. Johnston, P.M., 1964, Geology and Ground-Water Resources at Washington D.C., and Vicinity, U.S. Geological Survey Water Supply Paper 1776, Washington, D.C.

6. Slaughter, T.H. and Laughlin, C.P., 1966, Records of Wells and Springs, Chemical Analyses, and Selected Well Logs in Charles County, Maryland: Maryland Geological Survey Water Resources Basic Data Report No. 2.

7. Slaughter, T.H. and Otton, E.G., 1968, Availability of Ground Water in Charles County, Maryland: Maryland Geological Survey, Bulletin 30.

8. U.S. Environmental Protection Agency, August, 1977, State of the Art of Small Water Treatment Systems, Office of Water Supply, and U.S. EPA, Washington, D.C.