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Preliminary Study of Planned Replacement of Plant and Facility Equipment at the NBS Gaithersburg Site

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PRELIMINARY STUDY OF PLANNED REPLACEMENT OF PLANT AND FACILITY EQUIPMENT AT THE NBS GAITHERSBURG SITE

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PREFACE

This study was conducted by the Applied Economics Program of the Building Economics and Regulatory Division for the Plant Division to demonstrate how economic analysis and cost engineering can be applied to the planned replacement of the aging and obsolete plant and facility equipment at the National Bureau of Standards. Drs. Harold E. Marshall, David A. Didion, James E. Hill and Stephen F. Weber, Mr. Robert E. Chapman and Miss Iris M. Lloyd, provided general reviews of this paper. Mr. A. A. White furnished maintenance engineering data and leadership. Messrs. T. B. McKneely, D. Z. Rathbone, L. E. Wachter, K. L. Lowe, B. Wigglesworth, P. F. Schutz, J. P. Manning, and D. C. Sullivan provided engineering and maintenance data. Mr. T. Gary and Mms. T. DeGrange and J. Beck provided information on the budgeting process. The author wishes to express his appreciation to the above persons without whose help this study could not have been completed.

LIST OF TABLES

1. INTRODUCTION

The current maintenance of the physical plant at the NBS is not aimed at the replacement of major plant and facility equipment or system components, but focused on the repair of such systems to the greatest extent practicable. As the physical plant ages, the useful life[1] of these systems is approached and failure requiring replacement or extensive repair, rather than normal repair, can therefore be anticipated.

The replacement of obsolete equipment represents a unique opportunity since Executive Order 12003, dated July 20, 1977, states that by 1985 all existing Federally-owned buildings shall reduce the average annual energy use per gross square foot of floor area by 20 percent compared to the energy consumption in 1975. Energy conservation should thus play a major role in the selection of replacement equipment at the NBS.

The NBS is widely recognized as a leader in the development and application of techniques for cost-effective decisions regarding energy conservation in buildings. Among these techniques are life-cycle costing, computer simulation, and building economics. Using these techniques as firm technical underpinnings, it will be possible to develop a planned budgeting strategy for the replacement of aging and obsolete plant and facility equipment.

On September 5, 1978, the Plant Division of the Center for Facility Management (CFM) sent an Interdivision Work Order (IWO-351-5028) to the Applied Economics Program of the Building Economics and Regulatory Technology Division, Center for Building Technology (CBT) for conducting this preliminary study.

1.1 OBJECTIVE

The goal of this study is to develop a preliminary plan for scheduling and financing the replacement of obsolete plant and facility equipment

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[1] According to the General Services Administration, the useful life of building equipment and components for Federal buildings is between 10 and 20 years. Most of the NBS plant and facility at Gaithersburg has been in operation for thirteen years. The physical plant at the Boulder site is much older. Generally, the useful life of pieces of plant equipment is affected by these factors: (1) the generally accepted life-span published by the manufacturer or trade association; (2) the effect of particular design arrangement of the total system have on the life-span of an individual piece of equipment and (3) the effect of operation and maintenance procedure has on the equipment life-span. Therefore the historic engineering performance of the existing facilities is vital to the evaluation of equipment life-spans.

at the National Bureau of Standards, Gaithersburg site. The study will describe task requirements, time schedule and estimated funding levels to complete the future determination of appropriate means to finance the equipment costs in each year for a number of years at the National Bureau of Standards, Gaithersburg site.

1.2 APPROACH

The findings of this preliminary study rely on three basic sources of information:

1. Interviews with the Chiefs of Maintenance Engineering and Design Engineering Offices, and the Acting General Foreman and Shop Foremen.

2. Inspection of physical plant and representative equipment and facility.

3. Data from the NBS budgetary process for facility maintenance, modifications, and improvements.

The analysis of the information gathered from these sources was conducted in three stages:

1. Preliminary engineering analysis to determine which plant and facility equipment items are good candidates for replacement due to obsolescence[1].

2. Identification of potential studies required for an effective building maintenance program in operating the NBS plant.

3. Estimation of the time and funding level required to conduct the final study.

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[1] In general, plant and facility obsolenscence can be grouped into two types: physical obsolescence and technical obsolescence. Physical obsolescence deals with a piece of equipment attaining its natural life-span or useful life and is therfore replaced. Technical obsolescence is caused by the occasion that an identical or simular piece of equipment installed many years ago is no longer available in the market place at the present and hence a new design of this piece of equipment will have to be selected for the replacement. Technical obsolescence can also be caused by the availability of a much more efficient piece of equipment. The replacement of an existing piece of equipment would thus result in increased life-cycle benefit.

2. FINDINGS, STUDY PLAN AND RECOMMENDATIONS

At the conclusion of the personal interviews and site visits, a preliminary engineering analysis was made. The conclusions of engineering analysis on the representative plant and facility replacement needs and the companion special studies required for the selection of these replacements are presented here. A study plan is also made to show the task requirements, time scheduling and estimated funding levels for the completion of this study. Finally, recommendations for implementing the final study are made.

2.1 FINDINGS

The findings for this study are divided into two groups: replacement survey and special studies.

2.1.1 Replacement Survey

Of the approximately 90 groups of equipment in the NBS, only 22 groups are identified in this survey are the preliminary replacement needs. The preliminary replacement needs of obsolete plant and facility equipment are in Table 2.1:

Table 2.1. Preliminary Replacement Survey

Total Quantity	Plant Shop No.	Symbol and Name		Problem Identification[1]
11	01	AC	Air Compressor	Replacement of cast iron water jackets and rings for the two in Bldg 302 are needed.
12	08	ACC	Air Conditioning Console	Three have been replaced to date.
236	08	ACU	Air Conditioning Unit	Some replacement of steam coils, cooling coil supports, and floor channels are expected in the near future.
4	03	AS	Air Separator Tank	Corrosion is apparent; may require replacement.

[1] In many cases of the problem identification, it is noted that the Maintenance Engineering Office and various shops have taken actions to either maintain or replace the components as noted.

Total Quantity	Plant Shop No.	Symbol and Name	Problem Identification
2	08	AW Air Washer	The one in Bldg 301 may need replacement.
1000	02	BA Batteries (Acid)	Life expectancy is 10 years.
9	01	CNP Control Panel	A computerized control may be required for the boilers.
40	03	CP Condensate Pumps	Four were replaced after eleven years.
1	01	CT Cooling Tower	Wood fills and wood deck have to be replaced periodically.
4	01	CTF Cooling Tower Fan	Fan stacks have to be replaced soon because of apparent corrosion.
1110	08	E-EH Fan	Elephant trunk exhausts have to be improved because of insufficient exhaust capacity.
577	02	EI Emergency Illumination	Provide transfer switch to possibly save money.
28	03	ET Expansion Tank	Five have been replaced because of corrosion.
1 Lot	09	GL Grading and Landscaping	Some excavation and grading are required for outside grounds. Replacement of dead plants is also required.
18	03	HE Heat Exchanger	Corrosion of outside shell occurred for two heat exchangers.
225	03	P Pump	Twenty four pumps have been replaced so far.
1 Lot	07	RR Roof Repair	Some roofs are dead flat; some roof drains are higher than the roof.

4	01	RV	Refrigeration Unit	One gear box failed after twelve years. An efficiency study for minimum capacity is recommended.
1 Lot	--	RW	Road and Walk	Some roads, curbs and walks have to be repaired or replaced.
4	01	SG	Steam Generator	Relining is expected in fifteen years. An efficiency study for minimum capacity is recommended.
234	02	SL	Street Light	Replacement with more efficient lighting may be advisable.
20	03	VP	Vacuum Pump	Three vacuum pumps have been replaced in 8 or 9 years of use.

2.1.2 Special Studies

Special studies suitable for supporting the engineering evaluation of the plant and facility replacement needs are recommended as follows:

(a) Investigate and recommend energy and cost savings as determined by a computer simulation for the site distribution systems.

(b) Investigate and recommend energy and cost savings as determined by a computer simulation for the central chillers.[1]

(c) Investigate and recommend energy and cost savings as determined by a computer simulation for the central boilers.[2]

(d) Evaluate the existing Computerized Monitoring and Control System (CMCS) in Bldg. 223 and recommend how this CMCS can be extended to serve the whole NBS site including the impact of the CMCS on facility maintenance. Special attention is called to the possible need of computerized control for the boilers in Building 301 and for the fresh air in-take control of all buildings for conserving energy.

(e) Investigate and recommend how the few cases of defective roof can be effectively corrected.

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[1] The general model of the computer simulation has been developed by CBT for (b).

[2] The general model of the computer simulation has been developed by CBT for (c).

(f) Investigate and recommend whether solar energy[1] can be technically and economically added for supplemental heat. One possible use of solar energy is to provide for the reheat of HVAC during the summer.

(g) Investigate and recommend whether additional insulation should be provided for the building envelopes.

(h) Investigate and recommend the possible use of the wasted heat discharged through the boiler stacks in Building 302.

An example of the need for the above special studies is that, based on past engineering performance data, the capacity of the existing central compressor and central boiler may be too large for cost-effective operation. Special Sutdies (a), (b) and (c) are proposed to determine whether to replace the pieces of equipment with the same capacity or with a smaller capacity. The Plant Division and CBT have collected sufficient engineering data to evaluate the cost-effectiveness of the CMCS in Building 223 as described in Special Study (d).

2.2 STUDY PLAN

The study plan described the tasks required for the planned replacement of aging and obsolete plant and facility equipment at the NBS Gaithersburg site. Through the use of economic analysis, cost engineering, computer simulation, maintenance and design engineering, and the NBS budgeting process, this study plan can be effectively carried out. Technical personnel from the CBT, CFM, Budget Office, and outside consultants can be employed to complete this study. The detailed tasks, time scheduling, and estimated funding levels are listed in Table 2.2. Because special studies may result in recommending additional opportunities for the efficient selections of plant equipment replacement, two funding levels is given.

The following steps[2] are incorporated in the tasks listed in Table 2.2

(a) Identification of the portions of the physical plant that have a finite useful life and assigning a life expectancy based on usual engineering practices.

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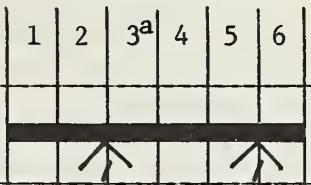
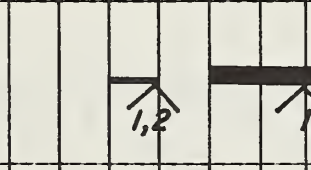
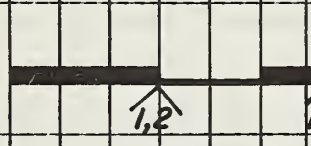
[1] Coordination is required between this proposed project and the Federal Solar Buildings Program run by the Department of Energy, DoE. This program is established for Federal agencies to request up to 100 million dollar in the deminstration of solar energy use in existing federal buildings.

[2] The steps, (a) through (g) are extracted from the recommendation made in budget review of the Site Maintenance Program, Code 83100.

Table 2.2 Study Plan[1]

Tasks	Schedule in Month	Estimated Funding Levels in Thousand Dollars
1. Conduct Special Studies		40 to 80
2. Identify replacements		10 to 15
3. Select alternative replacements and list for each the engineering performance and cost		40 to 50
4. Perform economic analysis for replacement alternatives		10 to 20
5. Conduct budget planning at several levels		10 to 20
6. Write report		10 to 15
	Total estimated funding levels	120 to 200[b]

Symbols:

Major involvement

Preliminary or continuing involvement

1, 2 Review by CFM, 1, and by the Budget Office, 2. The outputs can be considered milestones for this specific task.

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[a] Preliminary results are scheduled to be available for the budgetary process after 3 months.

[b] It is noted that the one-time-only funding levels ranging from $120K to $200K represent from 10 percent to 16 percent of the proposed Plant Division projects for FY 79 estimated to be $1190K as listed in Appendix A.6. It is reasonable to assume that the results of this proposed final study will be useful for budgetary planning for at least five years and perhaps as long as twenty years.

[1] A different format to describe the manpower requirement and milestones will be prepared for a NBS Automatic Project Report Worksheet, NBS-228W.

(b) Separation of the equipment and systems components into meaningful groups or subsystems with assigment of life expectancy to the subgroup. Separate plans should be developed for Boulder and Gaithersburg.
(c) Establishing the timeframe for the failure of these facilities and sytems which includes a predictive range on either side of the usual engineering life expectancy.
(d) Making a first cut at estimating the replacement cost of the items and establishing the likely funds needed in a given year to replace the items likely to fail.
(e) Matching the replacement cost to the potential year of failure and determining the likely cost per year of all failures in that year.
(f) Framing a replacement cost plan for each year involved and determining the period the plan should be in effect.
(g) Determining the appropriate means to finance the costs in each year and seeking the resources.

2.3 RECOMMENDATIONS

a. It is recommended that the Applied Economics Program of the Building Economics and Regulatory Technology Division, CBT, NEL, be funded at $120K to conduct this study and that $80K be reserved for supplemental funding subject to the concurrence of the CFM.

b. It is recommended that this study be started in October, 1978 so that the preliminary results of this study can be included in the budgeting process for FY 1981.

c. It is recommended that this study approach be applied to the Boulder Laboratories because the physical plant and facility there are older than the Gaithersburg site and because much of the study methods applied here can also be transferred to the Boulder site.

APPENDIX A

PLANNING INFORMATION

The following lists of information were used for the planning of this study.

A.1 Programs and Tasks of Plant Division, CFM.

A.2 List of Instructions for Preventive Maintenance Program at the NBS.

A.3 List of Items Not on Regular Preventive Maintenance Program.

A.4 List of Excavation, Grading and Seeding in 1978.

A.5 List of Planting Material Replacement in 1978.

A.6 List of Proposed Physical Plant Projects in Plant Division for FY 1979.

PROGRAMS[1] AND TASKS OF PLANT DIVISION, CFM

83000	Subactivity:	Facilities Management
83100	Program:	Site Maintenance
83101	Task:	Prventive Maintenance
83102	Task:	Other Maintenance and Repair
83103	Task:	Grounds Maintenance
83104	Task:	Maintenance Engineering
83105	Task:	Apprentice Training
83106	Task:	Janitorial Services
83107	Task:	Boulder Laboratory Building Maintenance
83108	Task:	Boulder Laboratory Grounds Maintenance
83200	Program:	Site Utilities
83201	Task:	Central Steam and Chilled Water Generation
83202	Task:	Purchased Utilities
83203	Task:	Service Contracts
83204	Task:	Apprentice Training
83300	Program:	Facilities Construction and Modification
83301	Task:	Plant and Facilities Projects
83302	Task:	Minor Modification Projects
83303	Task:	Reimbursable Fixed Price Projects
83304	Task:	Design Engineering
83305	Task:	Apprentice Training
83306	Task:	Delta 2000 Monitor

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[1] It is noted that although the budget request deals only with the Site Maintenance Program 83100, the impact of the Facilities Construction and Modification Program, 83300 and the Site Utilities Program 83200 on the Site Maintenance Program cannot be excluded.

LIST OF INSTRUCTIONS FOR PREVENTIVE MAINTENANCE PROGRAM[1] AT NBS

PM Instruction No.	Description	Plant Division Shop
1	Cooling Tower (CT)	01
2	Pumps (P) Verti-Line Booster	02
3	Air Compressor (AC), General Plant	01
4	Fans (E) (EH)	08
5	Air Conditioning Unit (ACU)	08
6	Filters (F) Remote	08
7	Refrigeration Unit (RU) Turbocompressor	01
8	Steam Generator (SG)	01
9	Sprinkler System (SP) (Inactive)	03
10	Electric Water Coolers (EWC)	08
11	Motorized Values (MV) (No instructions)	03
12	Gas Boilers (GB)	01
13	Unit Heater (UN)	03
14	Strainers (STR) (Inactive)	03
15	Concentrator (CO)	08
16	Control Panels (CNP), Central Plant (No instructions)	01
17	Water Softener (WS)	01
18	Pressure Reducing Valve (PRV) (No instructions)	03
19	Cathodic Protection System (CPS)	02
21	Deaerators (DE)	01
22	Non-fired Pressure Vessels (Inactive)	03

[1] This study may result in recommending changes in the preventive maintenance program.

PM Instruction No.	Description	Plant Division Shop
23	Elevators (ELH) Hydraulic	02
24	Elevators (EL) Electric	02
25	Fan-Coil Units (FCU)	08
26	Aftercooler (AFC),	01
28	Sanitary Sewer Meter (SSM)	03
29	Network Proctor (NP)	02
30	Network Transformer (NT)	02
31	Switchboards (SB) 15 KV	02
32	Switchboards (SB) Heavy Duty	02
33	Panel Boards (PA-PB) (Inactive)	02
34	Transfer Switches (TS)	02
35	Motor Starters (SM)	02
36	Motor Control Centers (MCC)	02
37	Louvres(L) (No instructions)	08
38	Ventilation Units (VU)	08
39	Pumps (P) Centrifugal	03
40	Pumps (CP) Condensate and (P) Sump	03
41	Pumps (P) Chemical Feed	01
42	Pumps (P) Horizontal Circulator	03
43	Pumps (FOP) Fuel Oil	01
44	Fans (CTF) Cooling Tower	01
46	Outside Service - Steam (ST)	01
47	Plugboards (PPB)	02
48	Air Conditioning Consoles (ACC)	08

PM Instruction No.	Description	Plant Division Shop
49	Purification Loop (PL)	03
50	4000 Volt Motor Starter (SMRU)	02
51	Carbon Dioxide System (CDS) (Inactive)	03
52	Bridge Cranes (C) & Monorails (M) (Elect. Only)	02
53	Street Lighting (SL)	02
54	Refrigeration Units (RU) Reciprocating	08
55	Roll-Up Doors (RDE) Electric	02
56	Packaged Chillers (PKC) (No Instructions)	08
57	Air Compressors (AC) Centrifugal	08
58	Heating - Ventilating Units (HV)	08
59	Batteries (BC) Cadmium & (BA) Acid	02
60	Air Compressors (AC)	08
61	Induction Relays (RY)	02
62	Dumbwaiters (DW)	02
63	Radiation Shielding Doors (RDS)	04
64	Dry Transformers (DT)	02
65	Roll-up Doors (RD) Manual	04
66	Outside Service - (EM) (SM) (TM) (PM)	02
68	Supervisory Panels (F), (S), (M)	02
69	Supervisory Consoles (SC)	02
70	Vacuum Pumps (VP) (No. instructions)	03
71	Diesel Generator (DG) Electric	02
72	Diesel Generator (DG) Mechanical	01
73	Obstruction Lighting (OL)	02

PM Instruction No.	Description	Plant Division Shop
74	Folding Doors (FDE) Electric	02
75	Rectifiers (RE)	02
76	Emergency Illumination (EL)	02
77	Dock Leveler (DL)	02
78	Folding Doors (FDM) Manual	04
79	Dock Leveler (DLE) Electric	02
80	Dust Collectors (DC)	08
81	Steam Humidifiers (SH) (Remote)	08
82	Auto-Matic Door Operators (ADO)	02
83	Gas Generators (GG)	02
84	Voltage Regulators (VR)	02
85	Motor Generators (MG)	02
86	Electric Heaters (EH) (Inactive)	02
87	Air Washers (AW)	08
88	Dimmers (D)	02
89	Distillation Apparatus (DA)	03
90	Roof Repairs (R)	07
91	Oil Separators (OS)	03

List of Items Not on Regular Preventive Maintenance Program[1]

Roads and walks

Trees and shrubs, grass mowing

Piping (within building)

Piping (under ground)

Fence painting

Sidewalks - concrete

Walkways - stone

Stone paved areas (101 courtyard, main entrance, library north side)

Duct lining (kitchens and certain fire research areas)

Thermographic testing of electrical gear in substation and elsewhere

Testing for air leaks of compressed air valves

Sealing of air-conditioning unit (ACU) fan bases in attics to prevent water leaking drain

Cooling coil (ACU) support replacement and other plenum repairs

Painting building (238) interior and exterior

Termite inspection

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[1] Some of the items listed here may be good candidates for the Preventive Maintenance Program. The items listed have not been grouped according to its functions.

List of Excavation, Grading and Seeding in 1978[1]

Location	Description
Near Bldg 220	Regraded to eliminate water leak
Near Bldg 245	Regraded to eliminate water leak
Near Bldg 101	Regraded to eliminate water leak
Near Bldg 245	Excavated and backfilled for repairing water line
Near Bldg 308	Changed contour
Near Bldg 302	Excavated and backfilled for installing electrical service
Near Bldg 304	Excavated and backfilled for repairing gas leak
Near Bldg 101	Installed drain on the terrace

[1] This list was not included in the 1978 budget.

List of Planting Material Replacement in 1978[1]

No. and Kind of Plant	Location
2 Linden	Main row - North Drive
2 Hemlock	Bldg. 101 - Courtyard
50 Azalea	Various locations
100 Annuals	Bldg 101 - Gate
100 Bulbs	Bldg 101 - Gate
4 Red Maple	Various locations
40 Holly	Bldg 235
2 State Trees	State Tree Grove
2 Darlington Oak	Various locations

[1] This list was not included in the 1978 budget

List of Proposed Physical Plant Work in Plant Division for FY 1979[1]

Division	Bldg	Description	Estimated Subtotal Cost
331	101	Domestic Water Booster Pump	
	101	Lights Lecture Rooms A and B	
	101	Handicapped Access	
	231	B Wing Steps	
	235	P/S CW Loop	
	245	Relocate Switchgear	
	301	Relocate Sheet Metal Shop	
	301	Dock Leveler	
	302	Refrig Wing Doors	
	302	Addition	
	GPL	Bearings Modification	
	GPL	Temporary Electrical Power	
	GPL	Partitions	
	Site	Hand Rails	
	Site	Fence	
	Site	Water Connection	
	Site	Water Loop	
	Site	Steam Loop	
	GPL	55° F Cooling Water Heater	
		Estimated Subtotal Cost	$950K

[1] Some of the items listed here have not been approved for maintenance or modification for FY 79. However, this list is quite comprehensive for the Plant Division Work.

Division	Bldg	Description	Estimated Subtotal Cost
352	304	Screen Loading Dock	
	304	Optic Shop	
	304	Acid Drain	
		Estimated Subtotal Cost	$50K
353	101	Accoustical Treatment of Switch Board Room	
	301	A/C Warehouse	
	301	Steam to Door Heater	
	301	Emerg Door Rm B194	
	303	Lunch Room	
		Estimated Subtotal Cost	$100K
533	245	A/C Rm F101*	
535	245	Storage Bldg	
562	231	Relocate FTM*	
564	231	A/C B Wing West	
566	235	Counting Rooms	
	235	Gate Lock	
		Estimated Total Cost	$1,190K

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* Technical research project related.

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This preliminary study identifies twenty-two building systems and components as likely candidates for the replacement of the aging and obsolete plant and facility equipment at the National Bureau of Standards, Gaithersburg Site. The study, conducted by the Applied Economics Program, also shows a research plan for future engineering and economic evaluations involving the replacement of plant and facility equipment.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Budgeting process; building design; building maintenance; economic analysis; energy conservation; life-cycle costing; rehabilitation cost.

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