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WATER USAGE PROFILE -- FORT CARSON, CO.(U)
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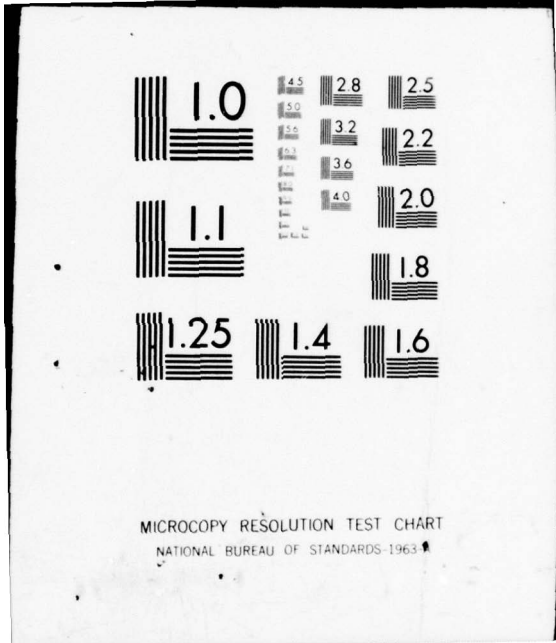
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INTERIM REPORT N-34
March 1978

Water Conservation Techniques in Military Construction

WATER USAGE PROFILE—FORT CARSON, CO

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by
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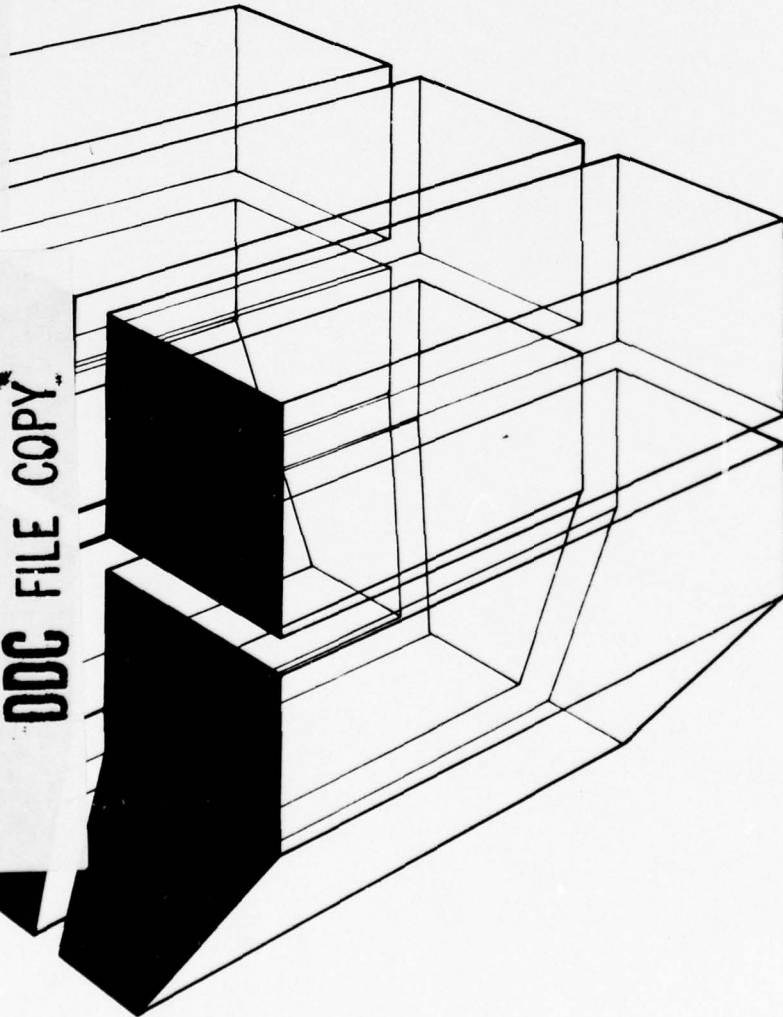
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report presents preliminary data from an investigation of water usage at Fort Carson, CO. Water meters were installed on supply lines to various facility types, and data were accumulated for a 3-month period. This investigation is continuing, and similar studies will be performed at other U.S. Army installations. Preliminary data reported herein will help formulate the basis for selecting water conservation devices to be installed at Fort Carson. Water metering after water conservation devices have been installed will provide data		

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for assessing the impact of such devices on total water usage.

Results of the water metering effort at Fort Carson, CO, have revealed unusually high consumption of water in family housing areas, presumably for irrigation. The study has indicated that civilian water demands must be compared with those of Fort Carson in order to ascertain why per capita water usage at the installation is so high. ←

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FOREWORD

This investigation was performed for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities," Task Area 02, "Pollution Abatement Systems," and Work Unit Number 001, "Water Conservation Techniques in Military Construction." The applicable QCR is 1.03.006(2). The OCE Technical Monitor is Don Knudsen, DAEN-MCE-U.

The investigation was performed by the Environmental Division (EN) of the U. S. Army Construction Engineering Research Laboratory (CERL).

Dr. R. K. Jain is Chief of EN, COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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WATER USAGE PROFILE--FORT
CARSON, CO

1 INTRODUCTION

Background

Current construction practices at military installations do not incorporate water conservation technology. This has amplified the impact of water shortages caused by recent extended periods of below normal precipitation and has put the burden of increasing water demands on already diminished water supplies. Thus, many installations are now expressing a need for potable water and better wastewater treatment to meet these increasing water demands. Design of water distribution systems and wastewater collection systems continue to be based on obsolete per capita water consumption and wastewater production data. This need for new design criteria, as well as the need to alleviate water shortages as economically as possible, has made it necessary to improve the efficiency of U. S. Army water usage.

Overall Research Objective

The overall objective of this project is to provide the U. S. Army with information which will increase the efficiency of water usage at military installations. Improved efficiency of water usage will decrease the costs associated with water supply and wastewater treatment. Less obvious benefits will be (1) conservation of energy through reduced pumping and water heating requirements, and (2) improved design parameters for water distribution and wastewater collection systems.

Objective of This Study

The objectives of this study are to provide current water usage data from Fort Carson, to evaluate the gathered data, and to appraise the monitoring techniques used in the data acquisition.

Approach of This Study

Fort Carson, CO, was selected as the first location for installing water meters at typical military installation facilities. Barracks, family housing units, commercial, industrial, and recreational facilities were equipped with water meters, and data were collected on current water usage practices.

Future Work

Phased installation of water conservation devices will be conducted in the facilities for which water usage data have been obtained. The impact of a particular device or procedure on water usage will be measured and evaluated in terms of cost versus benefit. The resulting data will be the basis for recommending devices and procedures for increasing water usage efficiency both for new construction and remodeling older facilities. Initial experience and data from Fort Carson will be the basis for similar water usage studies at other U. S. Army installations. Energy requirements associated with hot water service to housing, commercial, and industrial facilities will be assessed through further meter installations at Fort Carson.

Mode of Technology Transfer

It is anticipated that this study will result in several draft Engineer Technical Letters and Technical Notes related to water conservation at military installations. The technology transfer will be accomplished through field demonstrations, training courses, and technical reports. Study results may impact Technical Manuals in the 5-814 series.

2 PROCEDURE

Water Usage Data

The City of Colorado Springs, CO, supplies potable water to Fort Carson. Because of the quantity purchased, the cost to Fort Carson is substantially below the cost that other purchasers pay. In 1976, the overall cost of water to Fort Carson was approximately \$0.50/1000 gal (\$0.13/m³). However, the cost of potable water supplied to Fort Carson is expected to increase by 2.5 percent in the immediate future. The average cost of water supplied by the Department of Public Utilities, Colorado Springs, to all users was \$0.69/1000 gal (\$0.18/m³). This average cost to all users encompasses a rate structure which ranges from \$2.11 to \$0.72/1000 gal (\$0.55 to \$0.19/m³).

Water usage at Fort Carson has increased during the past several years:

<u>Year</u>	<u>Water Used (mgd)</u>
1970	2.71
1971	2.54
1972	3.02
1973	2.80
1974	2.99
1975	3.50
1976	3.68

Much of the 36 percent increase in water usage since 1970 is the result of added water services; for example, several family housing units were constructed between 1971 and 1974.

Site Selection and Meter Installation

Fort Carson, CO was selected for initial water metering for several reasons. It is located in an area which has experienced frequent water shortages. Installation personnel are aware of the need for water conservation. Fort Carson was experiencing what was believed to be excessive water usage on a per capita basis, but was unable to explain the apparently high water demands. The installation has a broad range of water-using facility types for which water usage data were believed to be necessary for the overall study. It was also

anticipated that Fort Carson could use the data produced by the study as they were obtained for ongoing water conservation efforts.

A survey revealed that there were very few water metering devices at Fort Carson. Tentative sites for additional meter installations were selected from available water distribution system maps. CERL personnel then selected 37 sites where meters could be installed at reasonable cost while achieving minimum data requirements. The meters were procured and installed under the direct supervision of Fort Carson personnel. Table 1 describes the locations of water meters at Fort Carson. (CERL did not consider readings from many of the existing meters because they were inaccessible or because their data were already recorded elsewhere.)

The Fort Carson Directorate of Facilities Engineering hired a temporary employee to read meters on a schedule fixed by the installation and CERL. Automated data collection procedures were considered to be too expensive for this project; however, since more continuous water usage data will be required, it is anticipated that automated and continuous water usage data collection devices will be procured as soon as resources become available. These devices will allow collection of data pertaining to peak water demand rates; the times of occurrence, duration, and frequency of water demand; and parameters for designing new water supply systems.

Metered Facilities

After numerous delays in meter procurement and installation, readings began in March 1977. Meter locations and installation sites were photographed and documented. CERL personnel interviewed occupants of the metered facilities and obtained information about water usage fixtures (make, model, location) occupants, and the facilities' operational schedules. The number of interviews was rather extensive, since meters were installed not only in single-family housing units, but also on water lines supplying large segments of family housing units. It is anticipated that meters on water lines supplying large segments of family housing will provide reliable average per capita and family housing unit water usage data, and that those on individual units will provide valid ranges for per capita and family water usage parameters.

Other metered installation facilities were barracks, commercial establishments, vehicle maintenance and other industrial operation centers, and recreational facilities. Information about water usage operations was obtained at each metered facility as a basis for evaluating the water usage data obtained during the study.

Table 1

Water Meters--Fort Carson, CO
(Metric Conversion Factor: 1 in. = 25.4 mm)

Building No.	Existing or CERL-Installed	Size and Type of Meter	Service Notations
P-3	E	5/8 in. American	Brig. Gen. quarters
P-4 through P-25	C.I.	6 in. Badger turbo in man- hole (M.H.) (not remote yet)	Senior officer housing 24 units
T-303	E	1-1/4 in. x 1 in. out Badger	Sandwich shop
P-318	C.I.	1 in. Badger	Central supply
T-403	E	5/8 in. on boiler feed	Laundry
T-403	E	4 in. Trident (softener)	Laundry
T-403	E	4 in. Trident (softener)	Laundry
P-600	E	2 in. Badger	Grade school
P-981	E	1 in. Badger in M. H.	Gas station with car wash
P-1008	E	2 in. Badger	Branch PX
P-1044	C.I.	3 in. Badger compound	Enlisted men's barracks
P-1161	E	2 in. Badger	Branch PX

Table 1 (Cont'd)

Building No.	Existing or CERL-Installed	Size and Type of Meter	Service Notations
P-1217	C.I.	3 in. Badger compound	Enlisted men's barracks
P-1230	C.I.	2 in. Badger compound	Enlisted men's club
P-1361	C.I.	3 in. Badger	Enlisted men's mess
P-1382	C.I.	2 in. Badger	Motor pool
P-1386	C.I.	6 in. Badger turbo in M.H.	Washrack
P-1392	C.I.	2 in. Badger	Motor pool
P-1396	C.I.	6 in. Badger turbo in M.H.	Washrack
P-1466	C.I.	4 in. Badger turbo in M.H.	Indoor swimming pool
P-1510	C.I.	3 in. Badger compound	PX commissary--main
P-1512	E	1 in.	Bank
P-1513	E	1-1/2 in. Badger	Credit union
P-1525	E	1 in. Badger	PX commissary--branch
P-1686	C.I.	6 in. Badger turbo in M.H.	Washrack
P-1696	C.I.	6 in. Badger turbo in M.H.	Washrack
P-1860	E	1 in. Neptune	Boiler make-up

Table 1 (Cont'd)

Building No.	Existing or CERL-Installed	Size and Type of Meter	Service Notations
P-1860	E	1 in. Neptune	Boiler make-up
P-2061	C.I.	3 in. Badger	Enlisted men's mess
P-2150	C.I.	3 in. Badger	Enlisted men's barracks
P-2161	C.I.	3 in. Badger	Enlisted men's mess
T-2302	E	5/8 in. Badger	General's quarters
T-2302	E	5/8 in. Badger	General's quarters
P-2992	C.I.	2 in. Badger	Motor pool
P-3092	C.I.	2 in. Badger	Motor pool
P-4404A	C.I.	5/8 in. Badger	NCO family housing
P-4400	E	2 in. Badger in M.H.	NCO family housing (services 16 units)
P-4406A	C.I.	5/8 in. Badger	NCO family housing
P-4616	E	4 in. Badger turbine in M.H.	NCO family housing (services 148 units)
P-4616A	C.I.	3/4 in. Badger	NCO family housing
P-4616B	C.I.	3/4 in. Badger	NCO family housing
P-4669	E	4 in. Badger turbine in M.H.	NCO family housing (services 92 units)
P-4669C	C.I.	3/4 in. Badger	NCO family housing

Table 1 (Cont'd)

Building No.	Existing or CERL-Installed	Size and Type of Meter	Service Notations
P-4669D	C.I.	3/4 in. Badger	NCO family housing
P-4801	C.I.	4 in. Badger turbo in M.H.	NCO family housing (services 44 units w/4909)
P-4909	C.I.	4 in. Badger turbo in M.H.	NCO family housing (services 44 units w/4801)
P-4909A	C.I.	3/4 in. Badger	NCO family housing
P-4909B	C.I.	3/4 in. Badger	NCO family housing
P-5621	C.I.	4 in. Badger turbo in M.H.	NCO family housing (services 132 units w/5655)
P-5621A	C.I.	3/4 in. Badger	NCO family housing
P-5621B	C.I.	3/4 in. Badger	NCO family housing
P-5655	C.I.	4 in. Badger turbo in M.H.	NCO family housing (services 132 units w/5621)
P-5551A	E	2 in. American	NCO family housing
P-5544C	E	2 in. American	NCO family housing
P-5727	E	3/4 in. American (unable to install remote)	NCO family housing
P-5723	E	3/4 in. American (unable to install remote)	NCO family housing

Table 1 (Cont'd)

Building No.	Existing or CERL-Installed	Size and Type of Meter	Service Notations
P-5814F	E	5/8 in. Badger	NCO family housing
P-5932A	E	5/8 in. Badger	NCO family housing
P-6276	E	1 in. Trident	Boiler plant, hospital area, make-up
P-7003	E	2 in. American	Officer family housing
P-7200	C.I.	4 in. Badger turbo in M.H.	Officer family housing (services 93 units w/7276)
P-7269A	E	5/8 in. Badger	Officer family housing
P-7274A	E	3/4 in. American	Officer family housing
P-7274B	E	3/4 in. American	Officer family housing
P-7276	C.I.	4 in. Badger turbo in M.H.	Officer family housing (services 93 units w/7200)
P-7300	E	2 in. Trident	Officers' club
P-7304	C.I.	3 in. Badger	Bachelor Officer's Quarters
P-8000	C.I.	6 in. Badger turbo in M.H.	Field maintenance facility
P-9609	E	3/4 in. Neptune	Butts airfield boiler
P-9609	E	1 in. Niagara	Butts airfield boiler
P-9609	E	1 in. Niagara	Butts airfield boiler

3 RESULTS AND DISCUSSION

Appendix A provides water usage data obtained from water meters installed at Fort Carson. The reader is cautioned that the plots for several individual meters are not continuous. Water usage at numerous family housing units greatly exceeded the amount anticipated by investigators, which was based on "normal" civilian family housing water usage of 50 to 100 gal (198.5 to 597.0 ℓ) per capita per day.¹ Fort Carson family housing units have exceeded 600 gallons per capita per day.

Tables 2 through 6 summarize water usage data obtained during 4 months of metering. The tables report the information in conventional terms of volume per "commonly used denominator" per unit time. Data for family housing units are reported in terms of water usage volume per capita or per housing unit per day. For consolidated mess facilities, the data are given in terms of volume of water per meal served per month. Table 5 data do not relate directly to water usage activities or to personnel, since appropriate denominators have not yet been determined, and because there is insufficient information about what activities take place within the metered facilities.

The family housing unit data in Tables 2 and 4 exhibit a broad range of values. Based on limited on-site observations, it is suspected that the unexpectedly high average daily water usages for some units reflect extensive irrigation of lawns and gardens. If this is correct, irrigation practices and equipment would be a prime area for reducing Fort Carson's demand for water. When the necessity for irrigation has been examined, it is likely that improvements in irrigation policies, practices, and equipment will substantially reduce water demand. Normal domestic water use ranges between 45 and 75 gal (178.7 to 297.8 ℓ) per capita per day. This range of values is somewhat substantiated for Fort Carson by data in Table 3. Water usage on a per capita per day basis ranges between 29 and 77 gal (111.9 to 305.7 ℓ) in troop housing. If the difference between a normally expected value of approximately 75 gal (297.8 ℓ) and the 670 gal (2660.0 ℓ) per capita per day (gpcd) reported for Building 4406A during May 1977 (Table 2) is due solely to irrigation, tremendous volumes of water are being used to maintain lawns. In May 1977, Building 4406A could have used an average of 1784 gal per day (2009 - [3 x 75 gpcd]) for irrigation; this amount is equivalent to a 1-in. (2.54-cm) rain on a 10,000 sq ft lot every 3.5 days. Further clarification of the extent to which irrigation is impacting total water usage at Fort Carson will be achieved as more data are obtained and investigated. Additional information on water usage in civilian communities near Fort Carson, such as

¹ "Household Water Characterization," *Journal of the Environmental Engineering Division*, Vol 100, No. EE1 (American Society of Civil Engineers, 1974); *Wastewater Engineering* (McGraw-Hill, 1972).

Table 2

Average Water Usage--Family Housing
 (Gallons per capita per day [Metric Conversion Factor: 1 gal = 3.785 l])

Building No.	No. Occupants	March 77	April 77	May 77	June 77
4909A	3	89	194	203*	116**
4909B	6	158	171	304	238
5621A	4	101	106	104	108
5621B	5	48	52	53	60
5814F	4	--	213	199	149
5932A	3	--	97	193	203
4404A	4	85	281	265	210
4406A	3	248	430	670	673
4616A	5	133	241	360	308
4616B	4	132	146	345	343
4669C	7	54	56	79	58
4669D	5	86	95	202	93
7269A	-	--	--	--	--
3	4	--	--	163	334

Table 2 (Cont'd)

Building No.	No. Occupants	March 77	April 77	May 77	June 77
2302	9	42	66	76	46
5551A	5	--	68	82	54
5544C	7	--	81	83	77

*Unit 4909A vacant May 77; lawn irrigation observed periodically. Water usage figure is shown in gallons per day.

**Unit 4909A reoccupied by family of four in June 1977.

Table 3

Average Water Usage--Troop Housing
 (Gallons per occupant per day [Metric Conversion Factor: 1 gal = 3.785 l])

Building No.	No. Occupants	March 77	April 77	May 77	June 77
1217	174	57	47	41	46
1044	148	29	--	29	31
2150	118	67	49	49	51
7304	78	69	77	65	68

Table 4

Average Water Usage--Family Housing
(Gallons per family housing unit per day [Metric Conversion Factor: 1 gal = 3.785 L])

Building No.	No. Occupants	No. Units Monitored	March 77	April 77	May 77	June 77
4909A	3	Single unit	268	583	203*	463**
4909B	6	Single unit	945	1027	1822	1430
4909, 4801	--	44 units	265	397	751	815
5621A	4	Single unit	403	423	416	433
5621B	5	Single unit	242	260	266	300
5621, 5655	--	132 units	---	454	639 ⁺	--- ⁺⁺
5814F	4	Single unit	---	850	794	597
5932A	3	Single unit	---	290	578	610
5551A	5	Single unit	---	339	408	269
5544C	7	Single unit	---	569	578	541
4404A	4	Single unit	339	1124	1059	840
4406A	3	Single unit	745	1290	2009	2020
4400	--	16 units	---	307	1072	1027
4616A	5	Single unit	665	1207	1800	1540

Table 4 (Cont'd)

Building No.	No. Occupants	No. Units Monitored	March 77	April 77	May 77	June 77
4616B	4	Single unit	529	583	1378	1373
4616	--	148 units	265	523	752	769
4669C	7	Single unit	374	390	553	407
4669D	5	Single unit	429	476	1009	465
4669	--	92 units	294	649	826	818
7200, 7276	--	93 units	318	512	1050	--- ⁺⁺
7269A	--	Single unit	---	---	916	800
3	4	Single unit	---	1640	653	1337
5	--	24 units	348	---	1978	2636
2302	9	Single unit	374	596	685	418

*Unit 4909A vacant during May 77; lawn irrigation observed periodically. Water usage figure shown in gallons per day.

**Unit 4909A reoccupied by a family of four, June 1977.

+Meters inoperable after 13 May; figure shown is a 14-day average.

++Meter(s) inoperable.

Table 5

Average Water Usage--Industrial/Commercial/Recreational
 (Gallons per day [Metric Conversion Factor: 1 gal - 3.785 l])

Building No.	Type Facility	March 77	April 77	May 77	June 77
1382	Motor pool	1407	1966	2031	1533
1392	Motor pool	1207	2172	1781	1367
2292	Motor pool	1724	3654	1353	1332
3092	Motor pool	---	3400	3313	2933
1386	Washrack	5800	5828	7412	6567
1396	Washrack	5643	11,448	6844	9500
1686	Washrack	7069	16,379	5844	9333
1696	Washrack	8379	17,448	11,250	17,833
8000	Consolidated maintenance	14,000	14,286	9688	14,667
318	Central supply	263	242	248	107
1510	Main PX	8214	8803	9505	11,600
1008	Branch PX	---	706	765	720
1161	Branch PX	2303	1946	2756	2859
1525	PX commissary--branch	3983	5087	3951	4409

Table 5 (Cont'd)

Building No.	Type Facility	March 77	April 77	May 77	June 77
1512	Bank	337	335	348	257
1513	Credit union	264	354	672	848
1446	Indoor swimming pool	4933	8655	28,531	19,533
600	Grade school	4090	3751	3151	1289
1230	EMC	600	621	625	567
7300	OC	4223	7534	4641	4713
303	Sandwich shop	1679	1113	1228	949
981	Gas station and car wash	1798	2163	1287	1179
2302	Boiler	79	71	67	67

Table 6

Average Water Usage--Consolidated Mess Facilities
(Gallons per meal served)

Building No.	March 77		April 77		May 77		June 77	
	Vol Used	Meals Served	Vol Used	Meals Served	Vol Used	Meals Served	Vol Used	Meals Served
1361	--	--	17	22,000	17	26,285	22	17,963
2061	--	--	10	52,854	9	59,668	12	40,841
2161	--	--	6	70,129	6	64,046	6	46,512

Colorado Springs, will determine whether Fort Carson family housing policies, locale, or other causes are contributing to the apparently high per capita water usage.

Current planning calls for water conservation devices to be installed starting in September 1977. At that time, additional "background" water usage data will have been obtained--data which will form the baseline for predicting and assessing the impact of water conservation devices on water usage at an Army installation. As originally planned, initial efforts at water conservation device evaluation will be in the area of domestic water usage because of its applicability to all U.S. Army installations. It is anticipated that effort will be expended for developing more efficient methods of irrigation as this study progresses.

4 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

From the data now available, it is concluded that:

1. Fort Carson, CO, is probably unique in terms of water usage practices in family housing areas because of the large amounts of water that appear to be used for irrigation.
2. At Fort Carson, water usage on a per capita basis in family housing areas greatly exceeds the amount expected on the basis of normal civilian water demand.
3. Information on civilian water demands within the City of Colorado Springs must be compared with water demands at Fort Carson.
4. Current manual methods of data collection are satisfactory for initial data requirements; however, automated methods will be required to obtain the more continuous data necessary for measuring peak water demand rates, their times of occurrence, duration, and frequency, and other parameters necessary for efficient design of water supply systems.

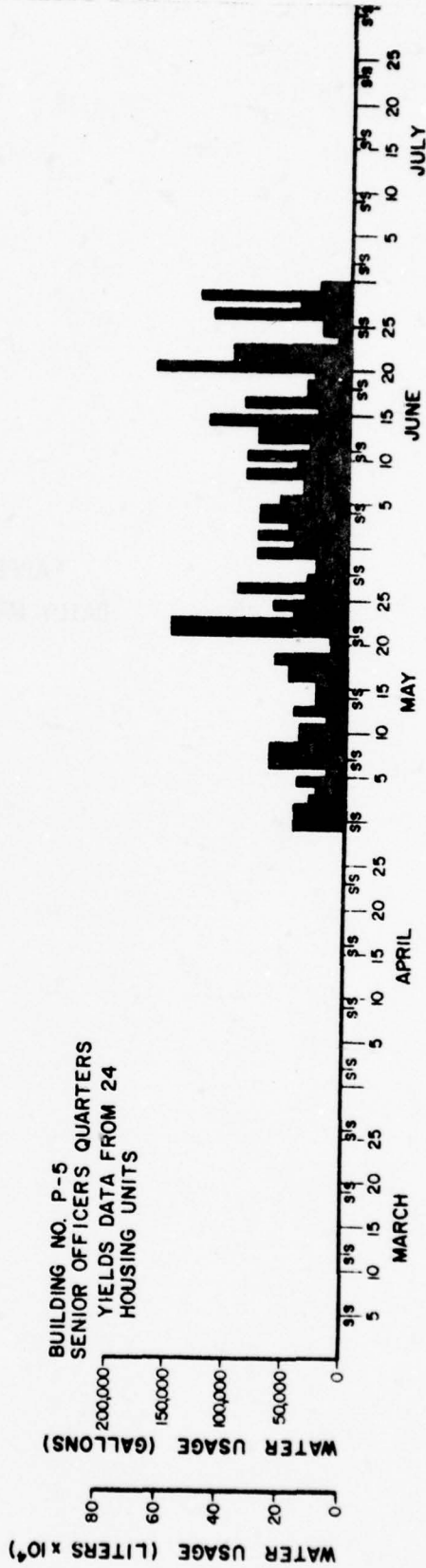
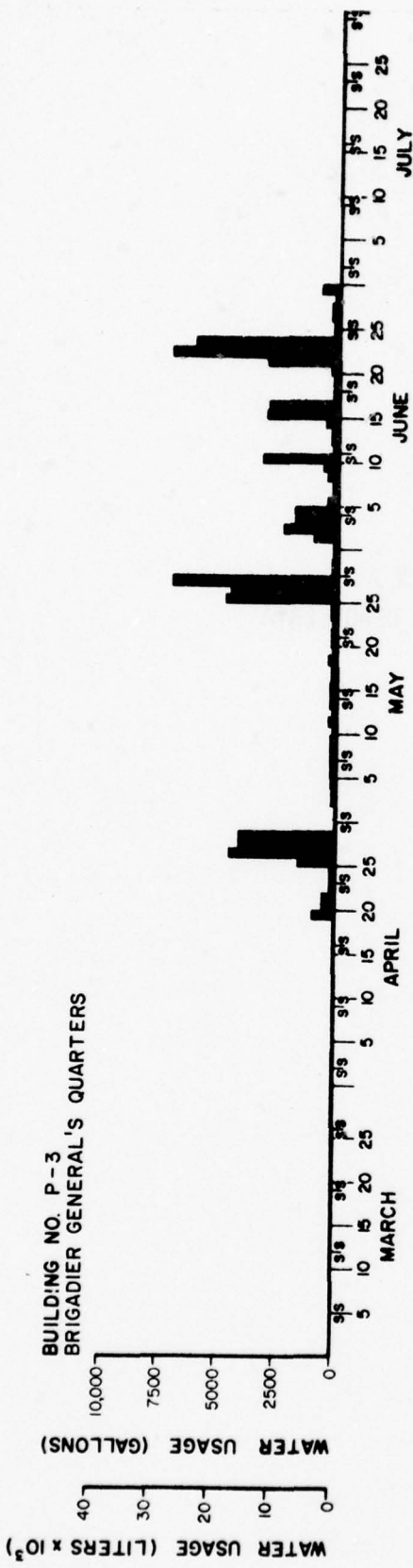
Recommendations

It is recommended that:

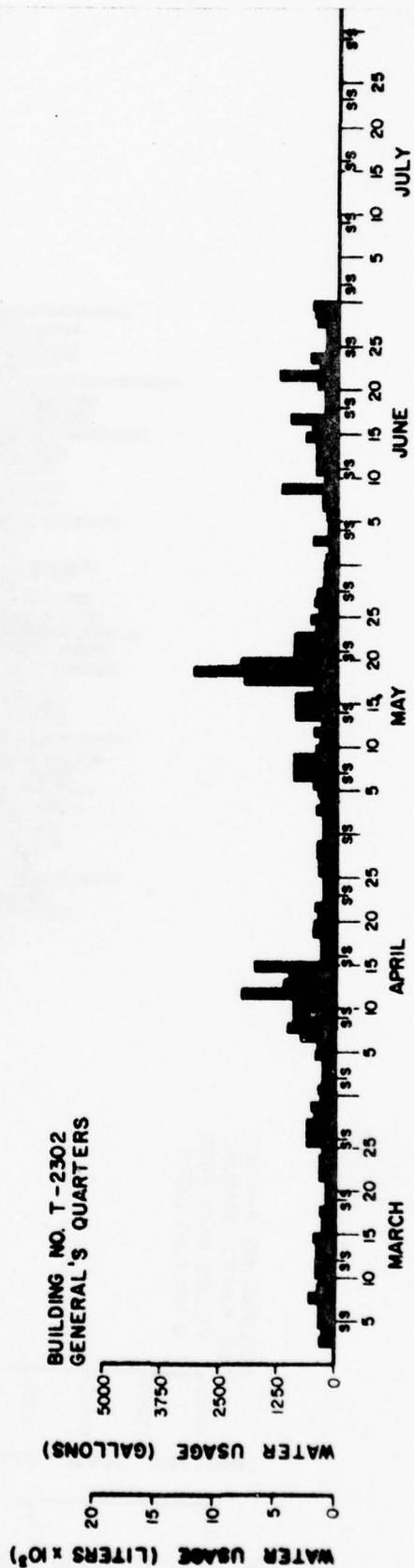
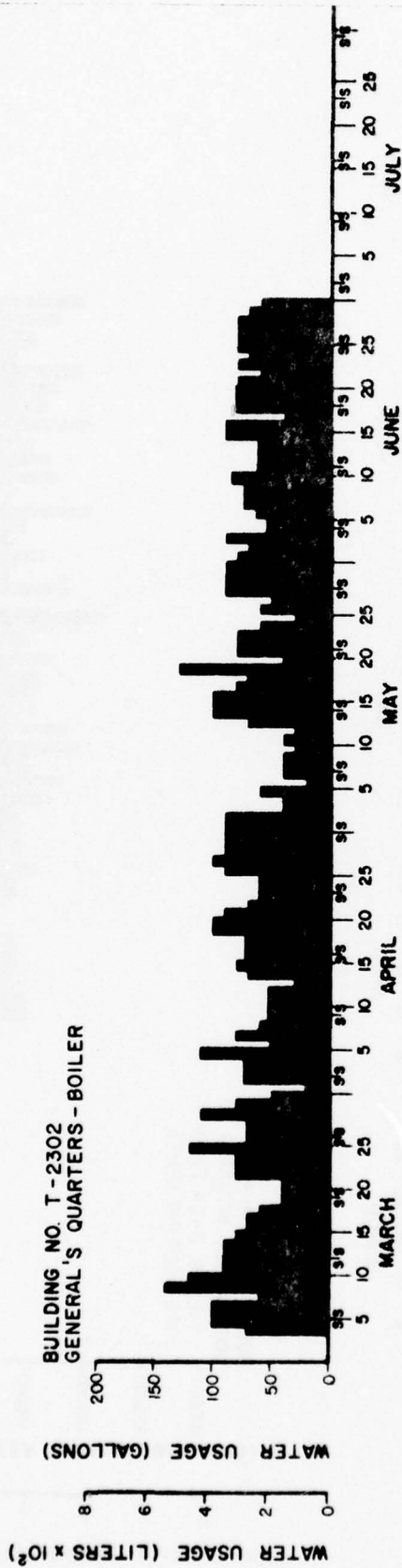
1. Water metering similar to that being performed at Fort Carson be performed at other Army installations having different missions and climate conditions.
2. Improved methods of irrigation should be sought for family housing areas at Fort Carson.

APPENDIX A:
DAILY WATER USAGE DATA

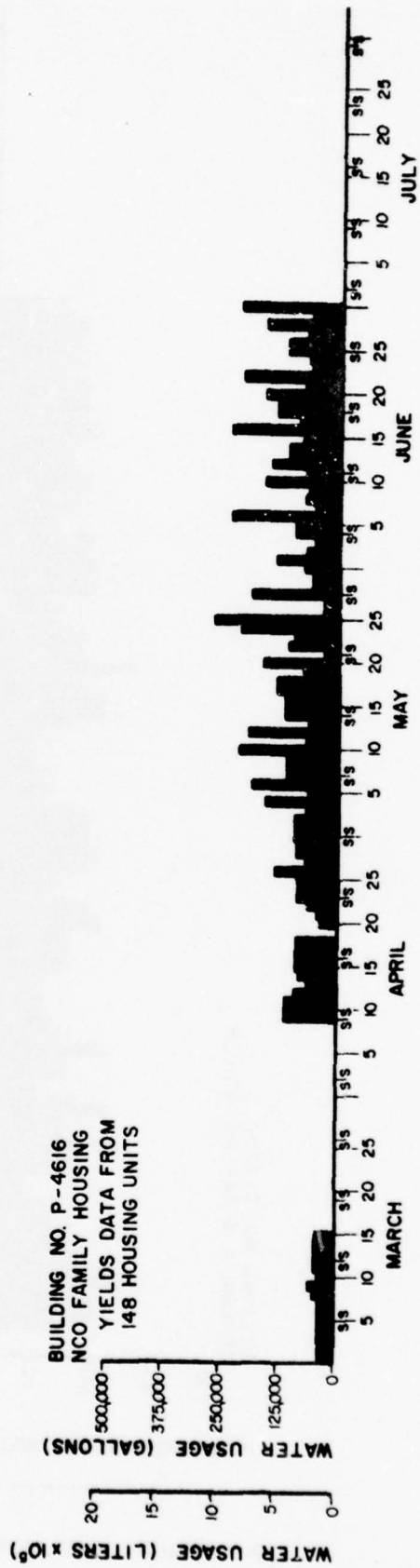
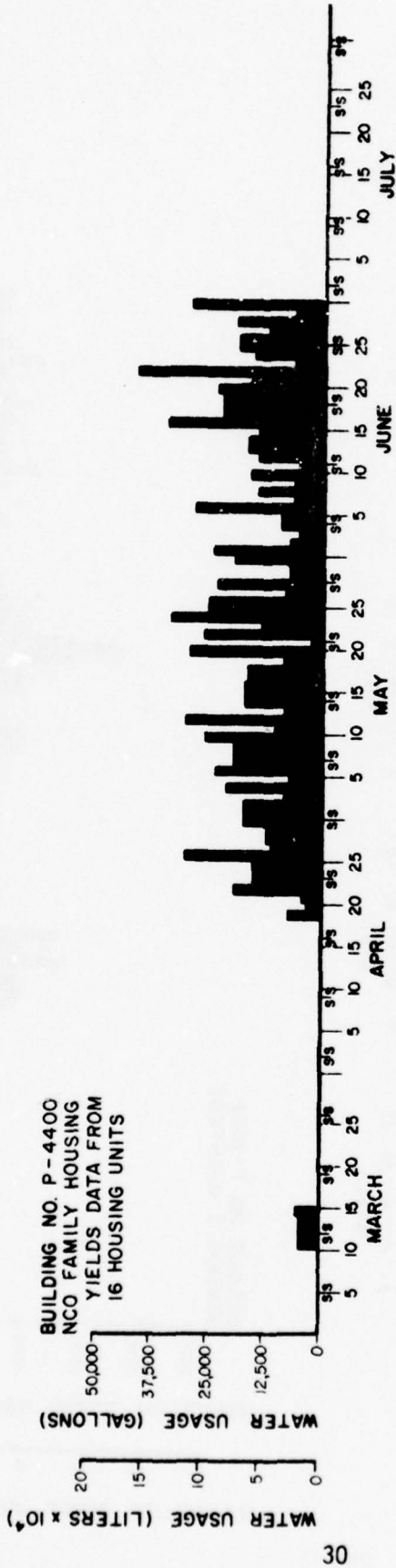
WATER USAGE DATA, FORT CARSON, COLORADO



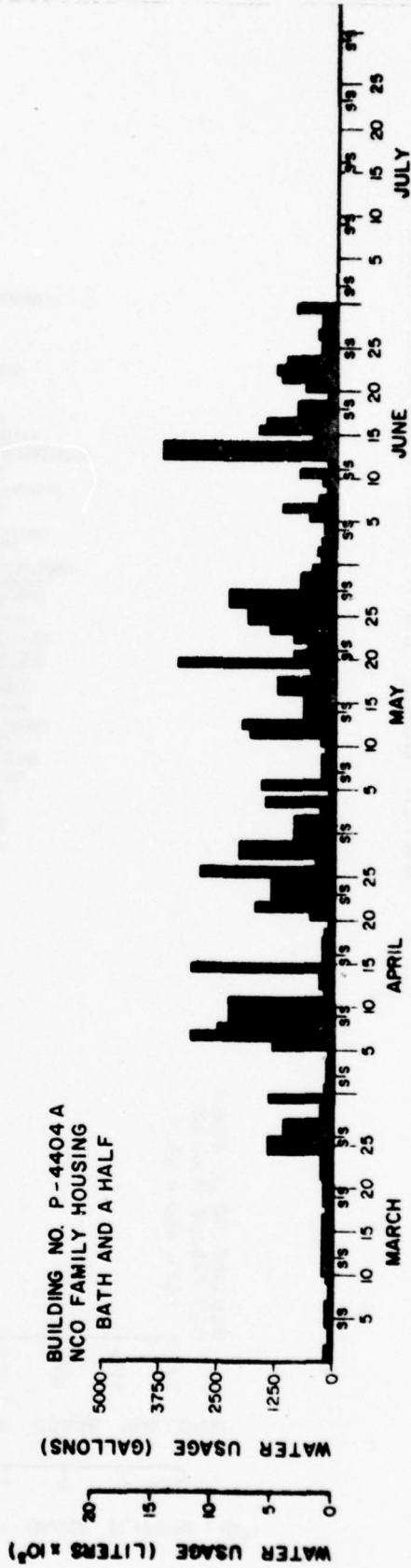
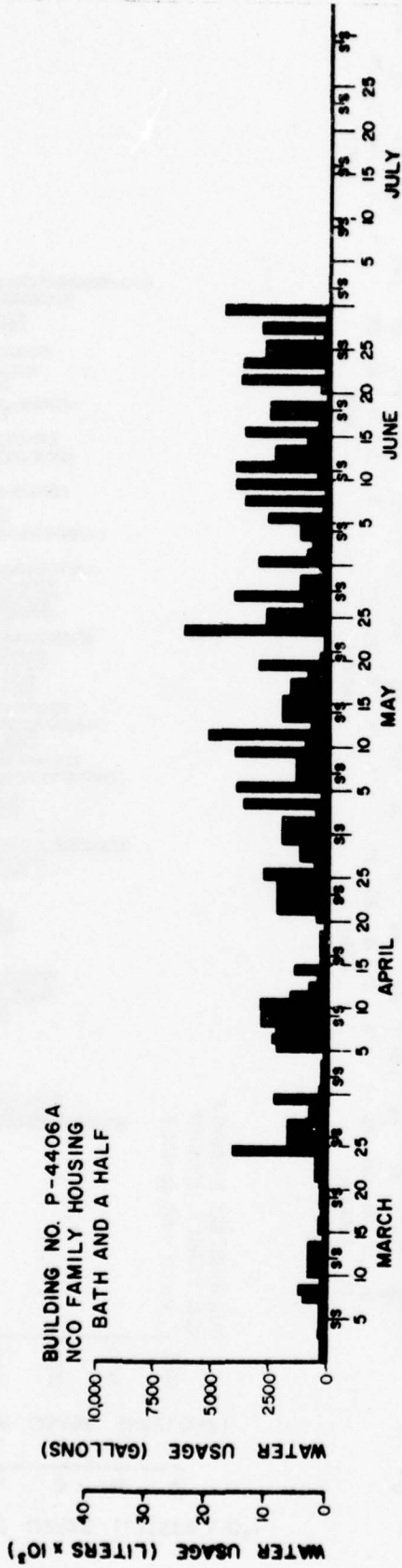
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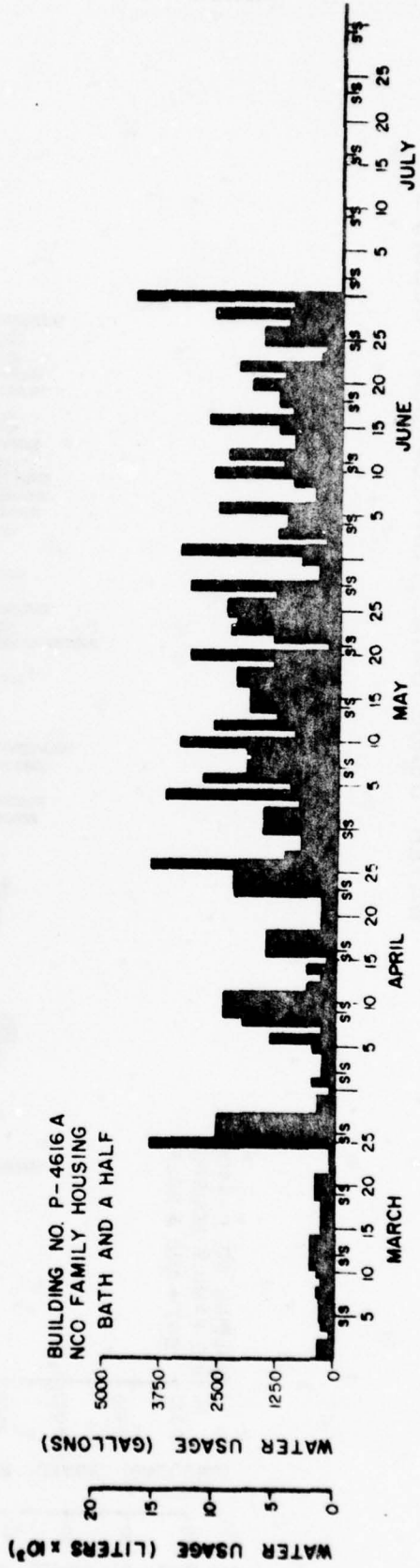
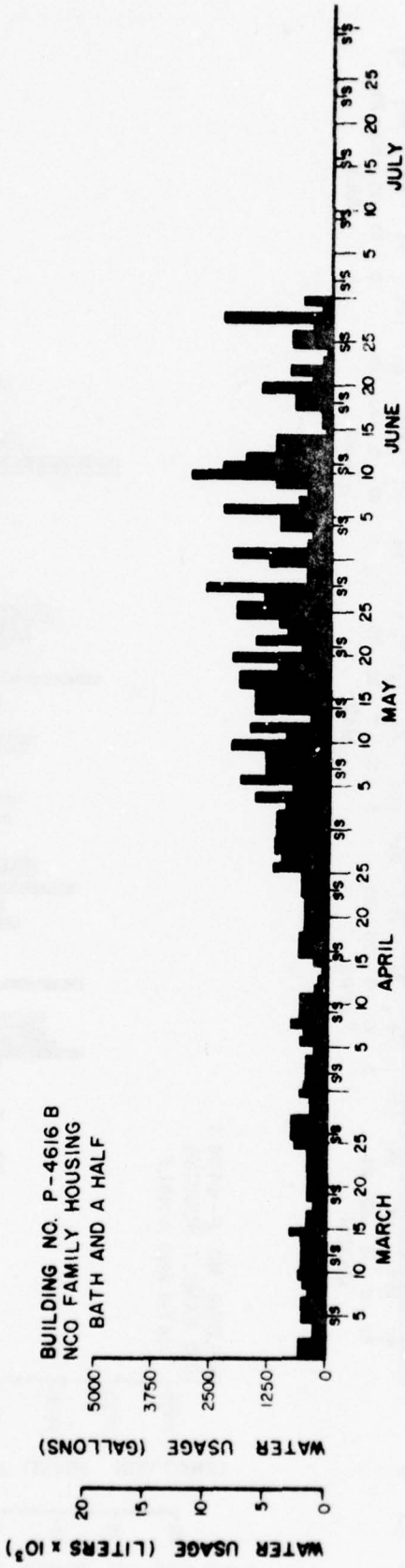
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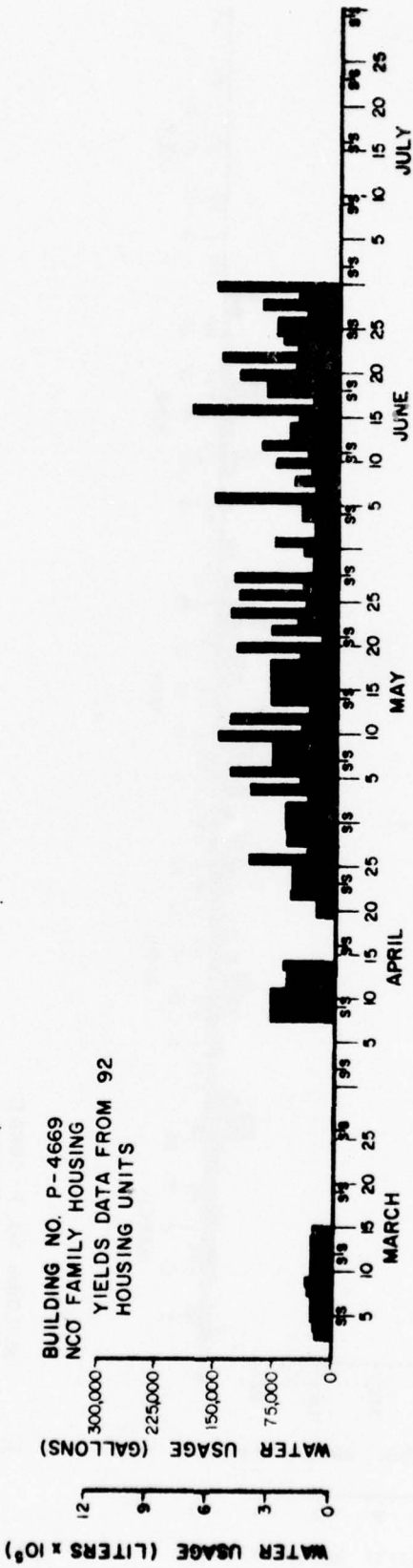
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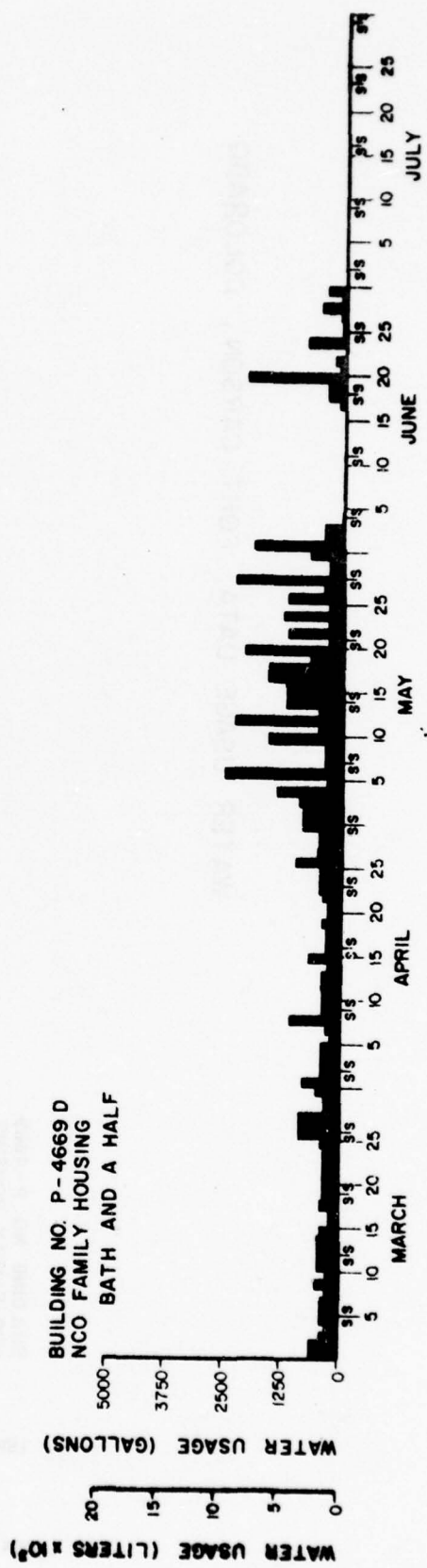
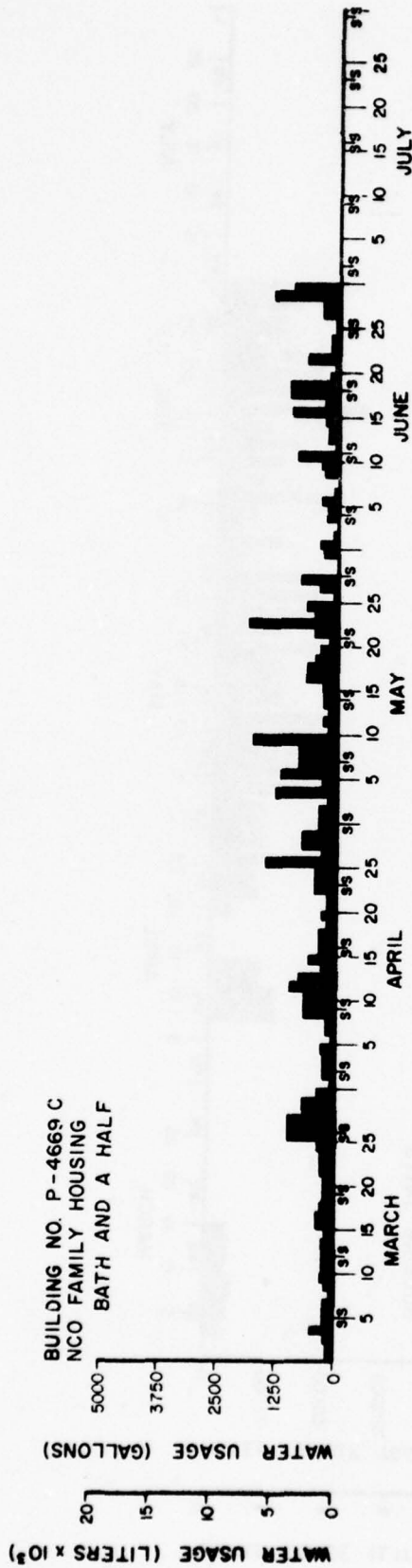
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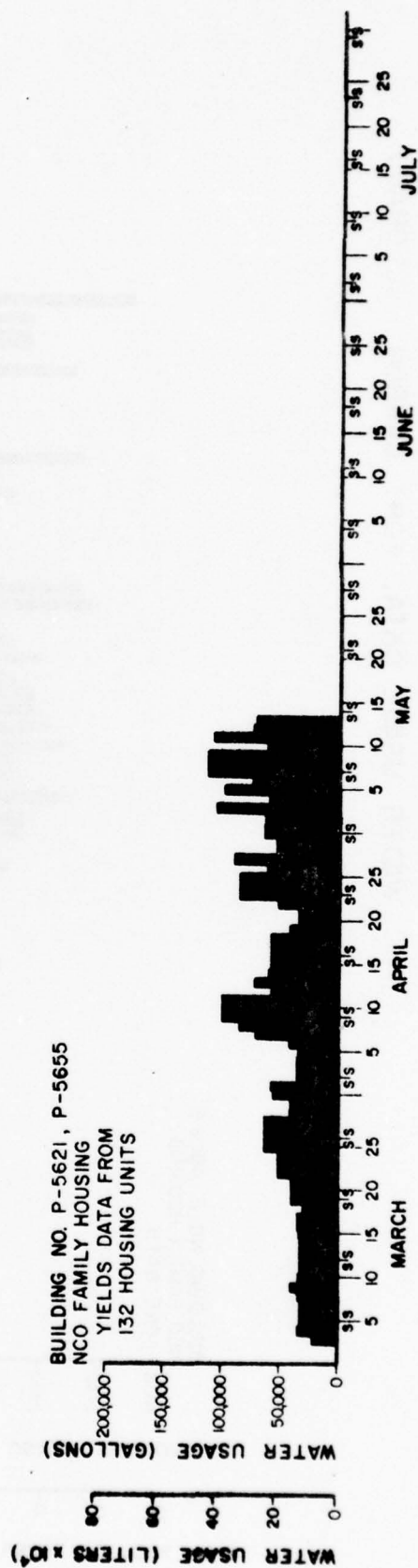
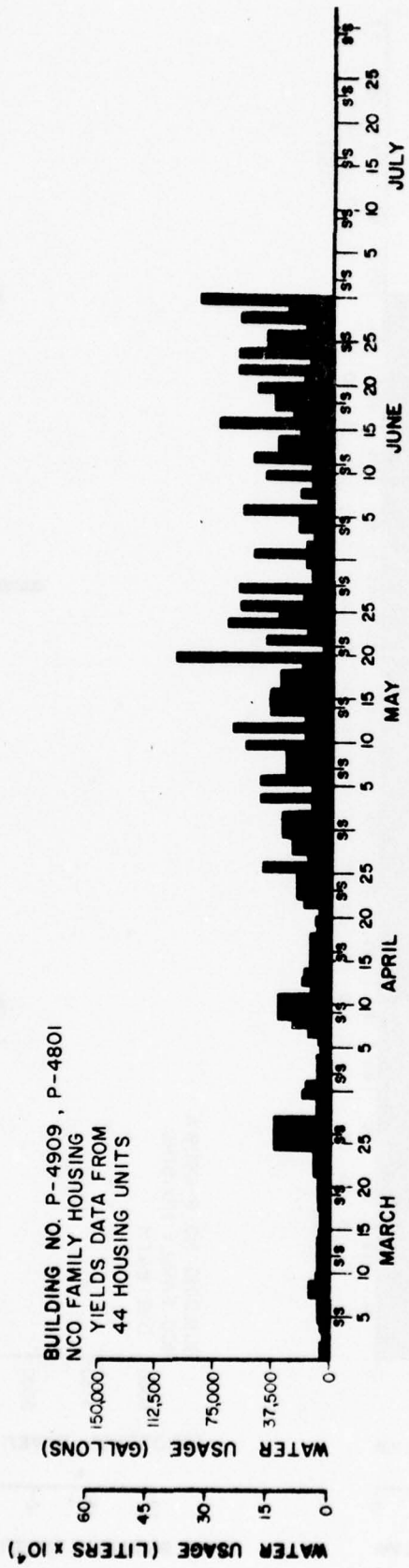
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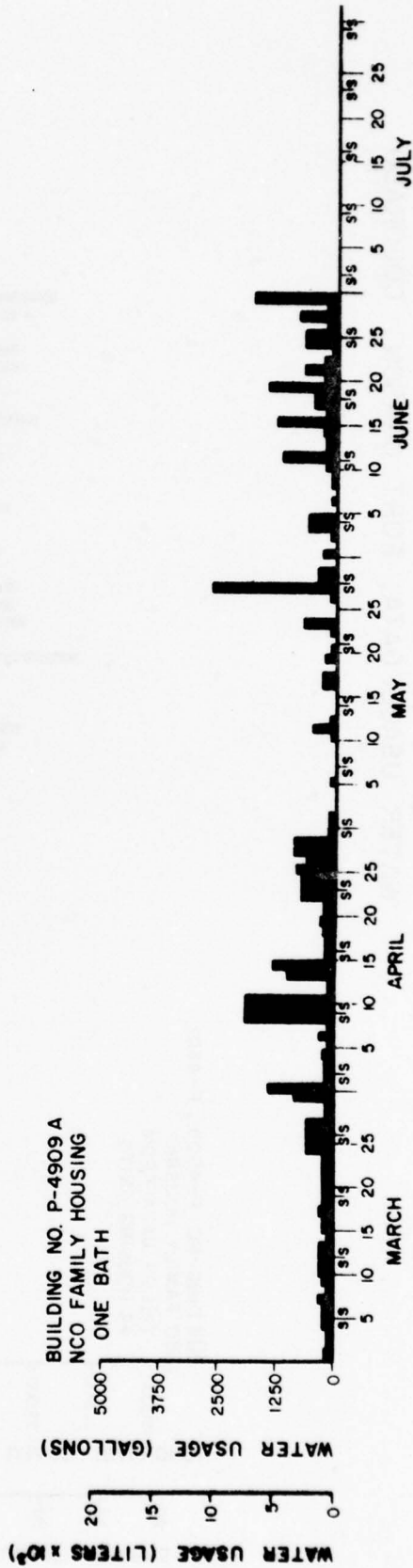
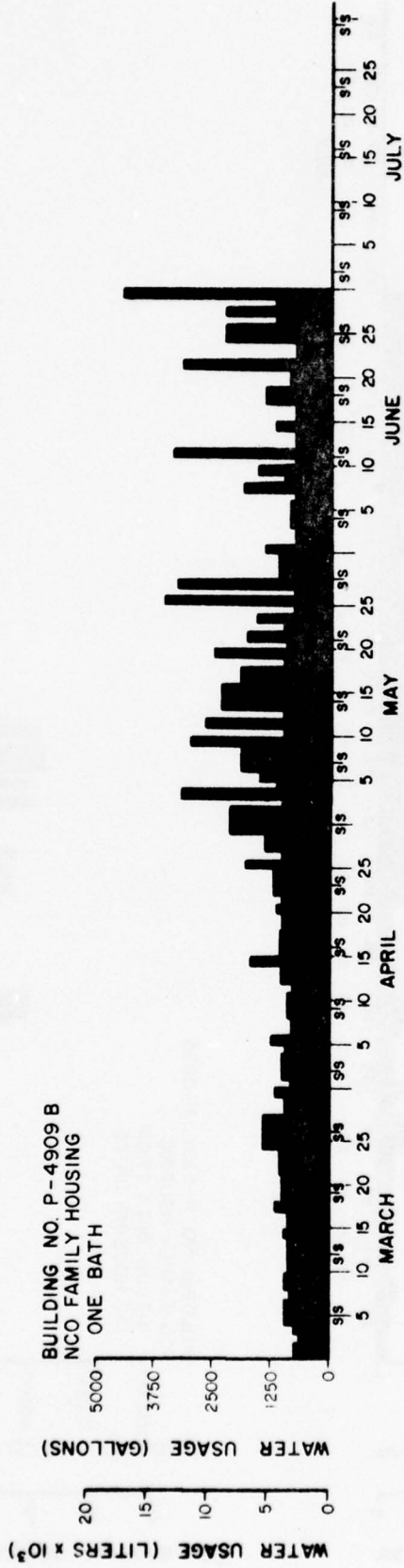
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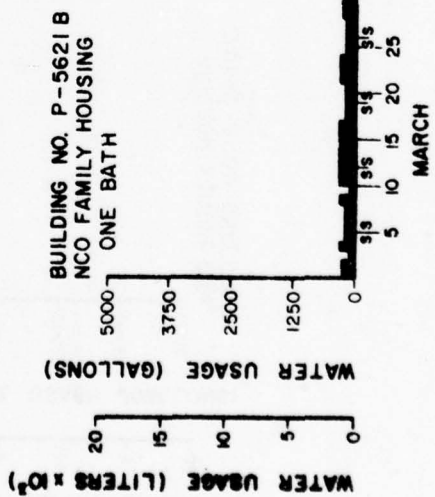
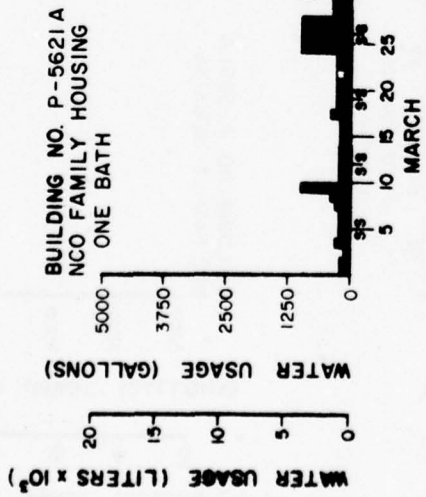
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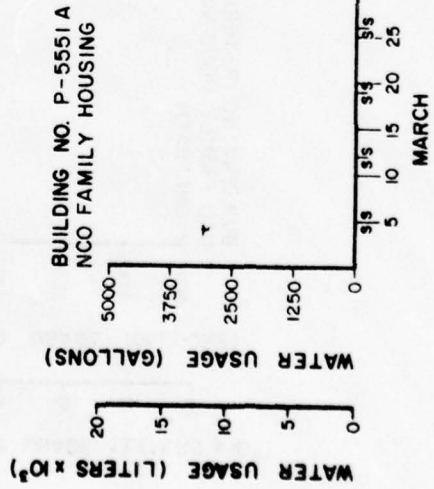
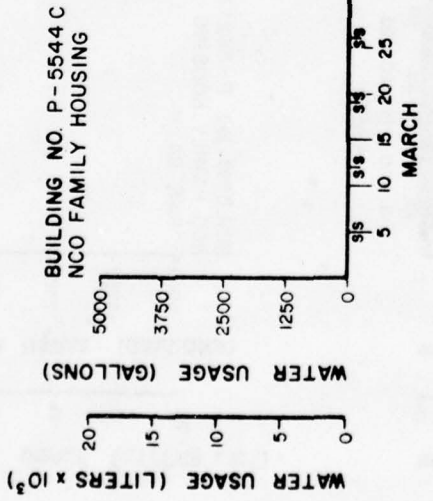
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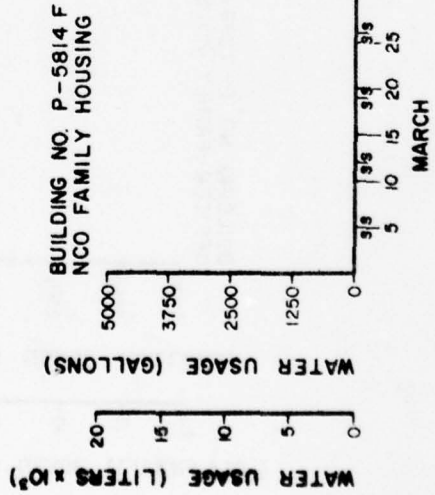
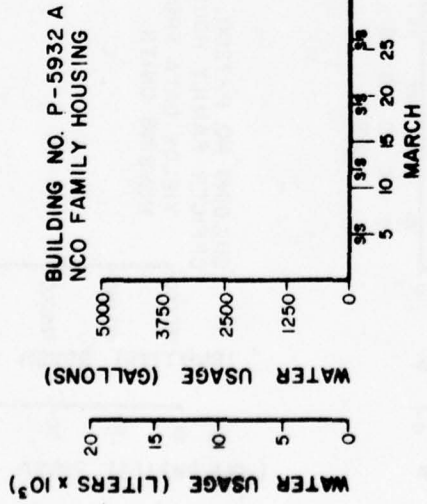
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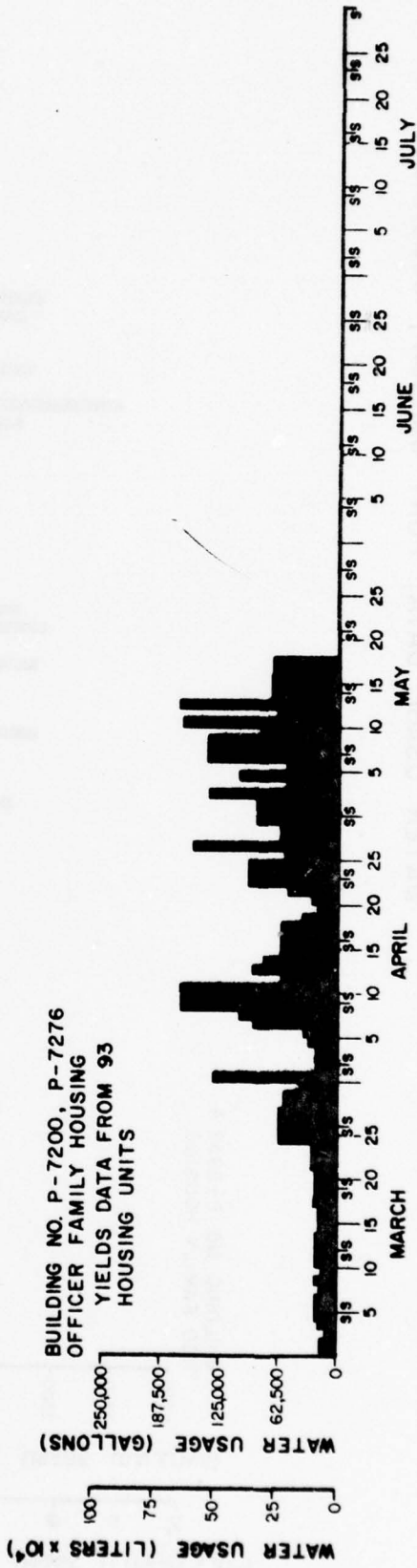
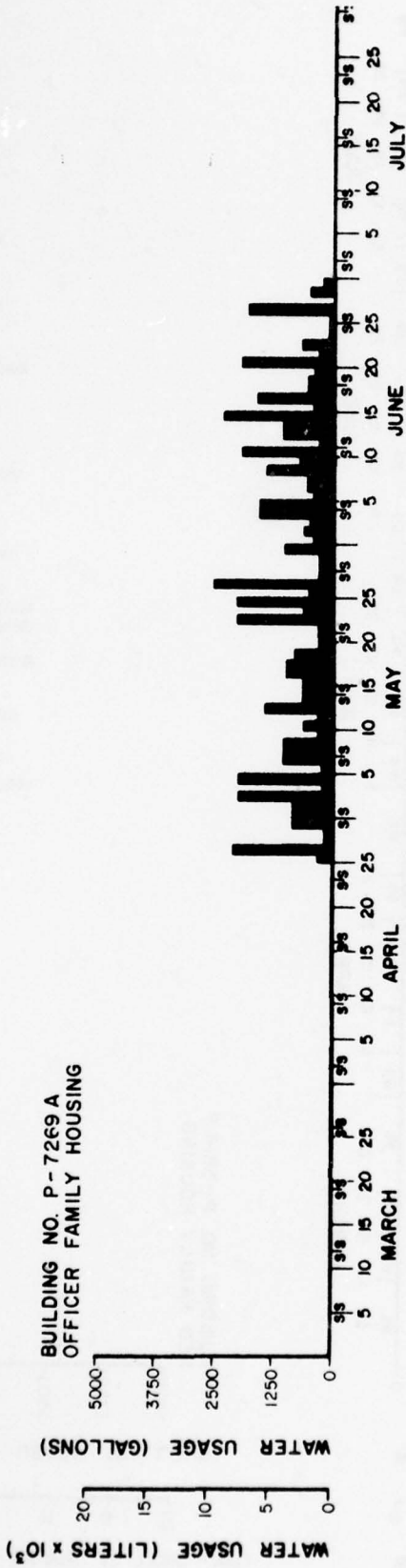
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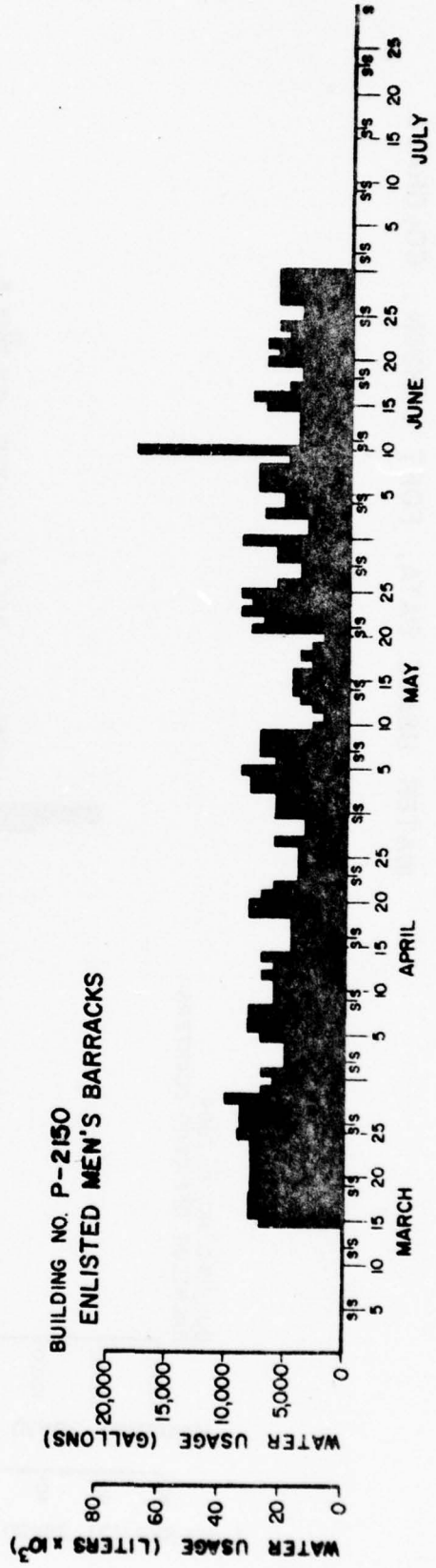
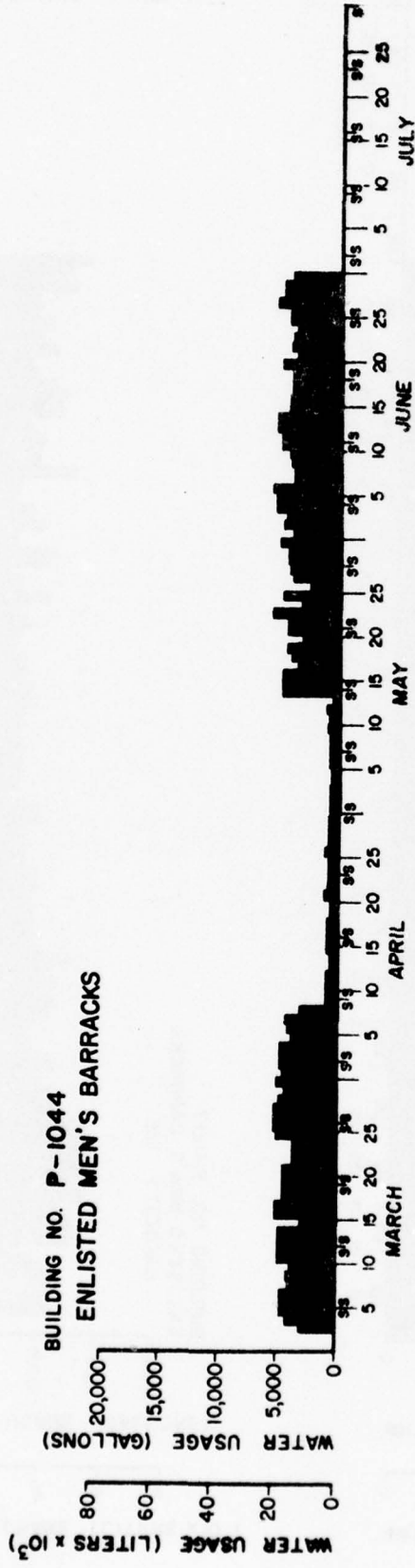
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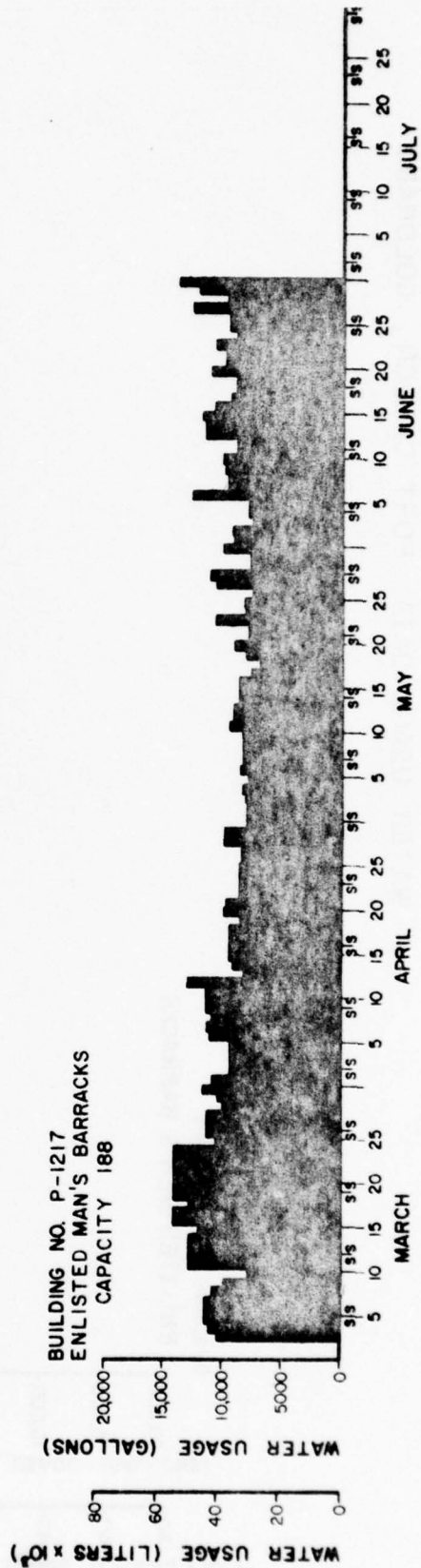
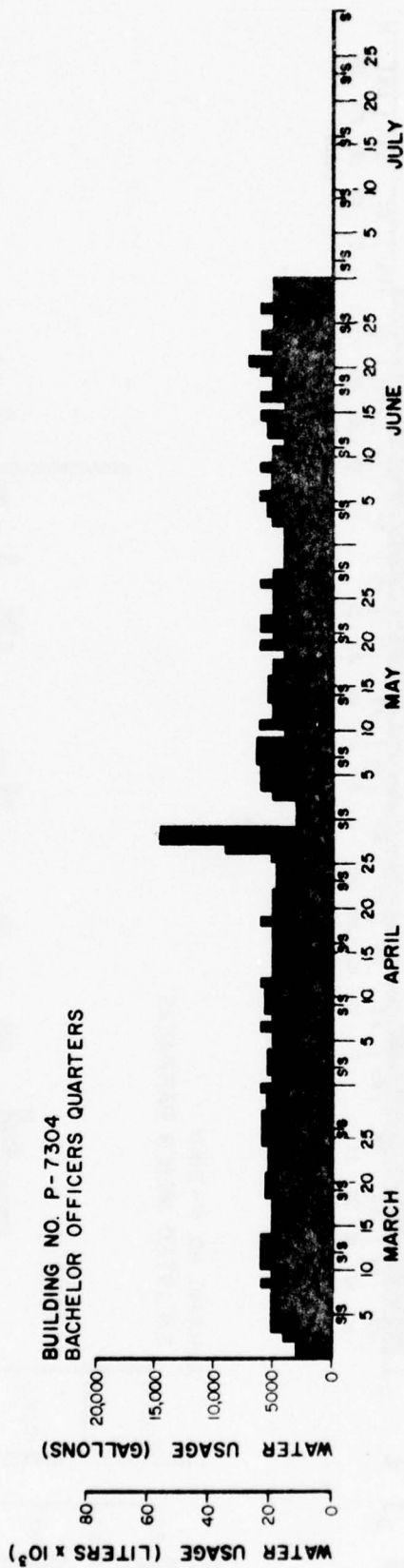
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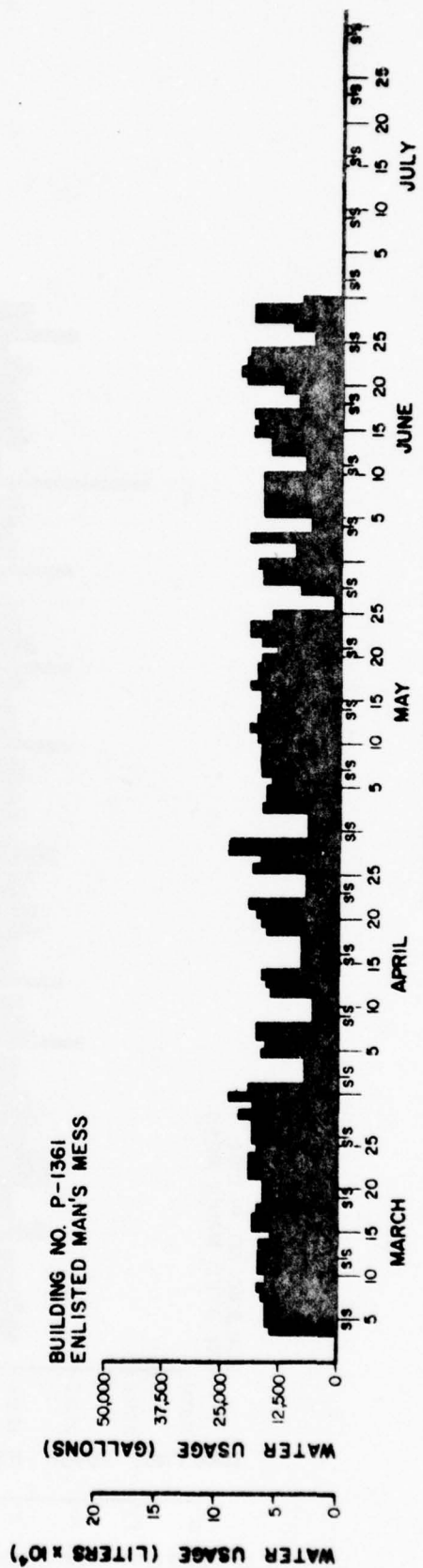
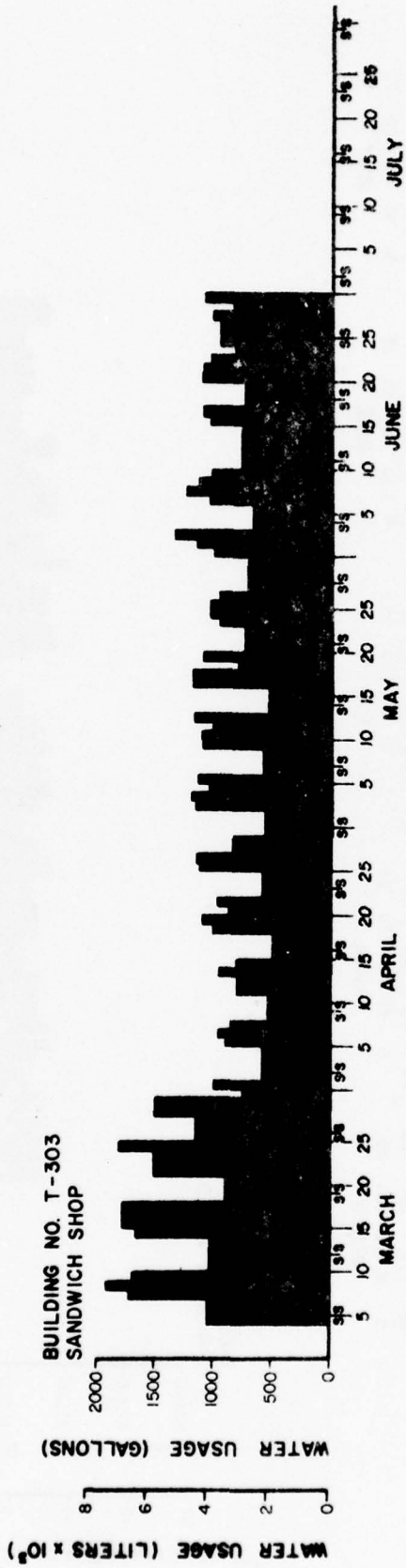
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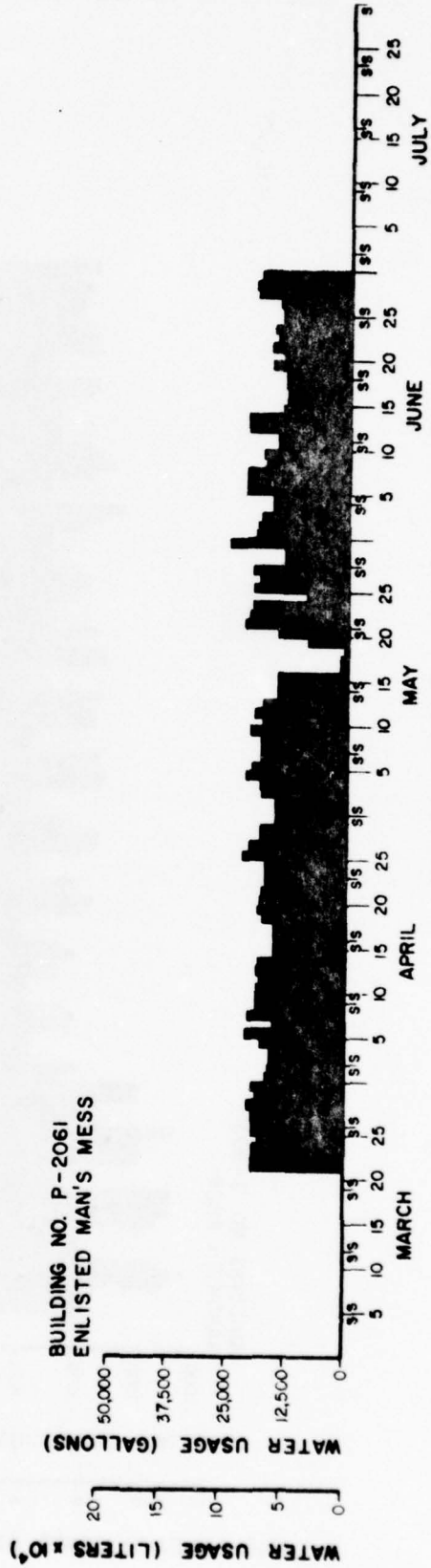
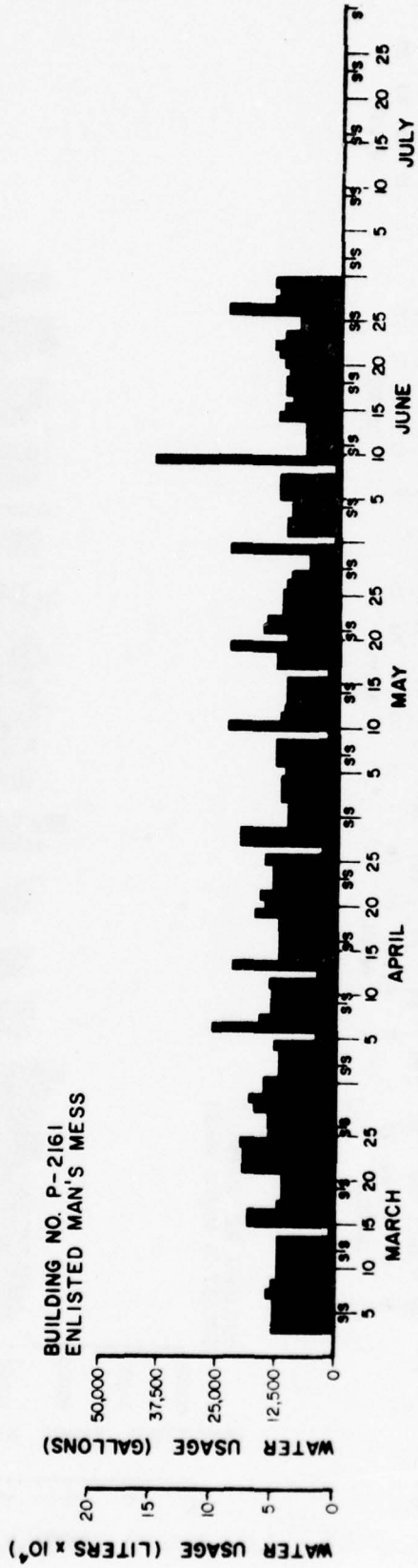
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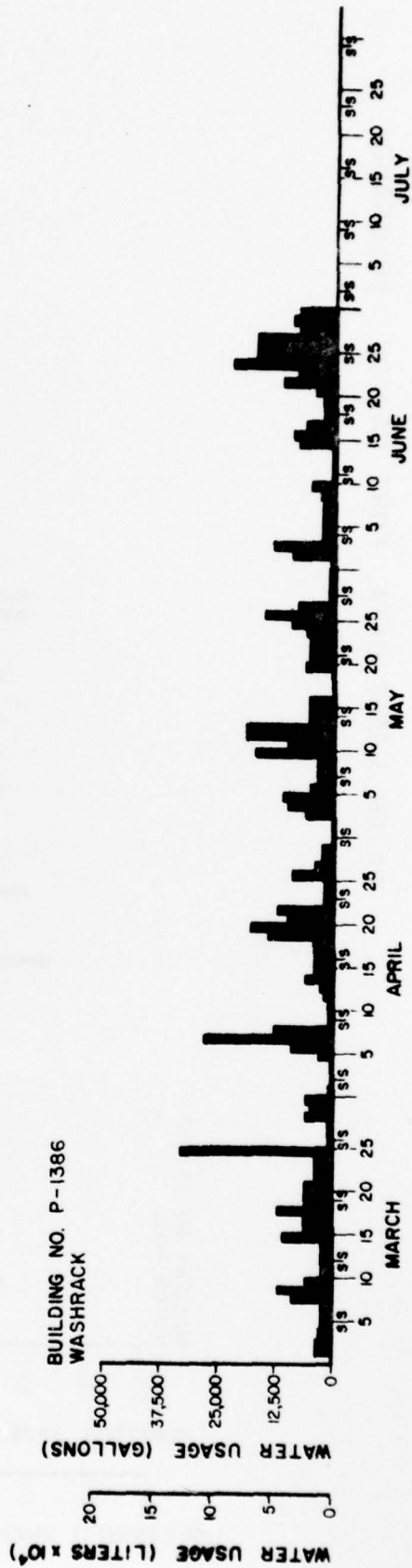
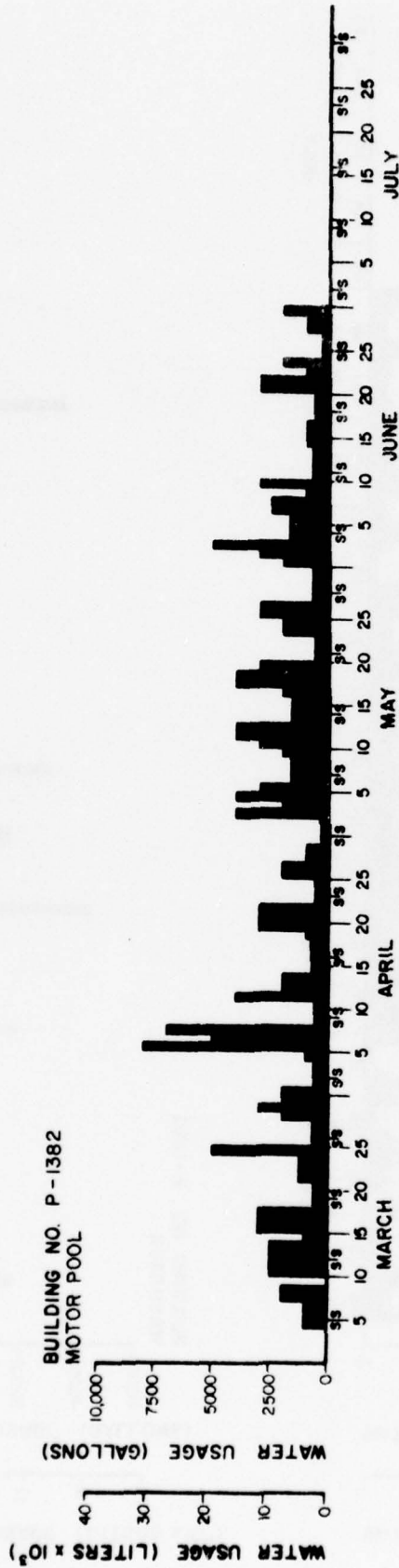
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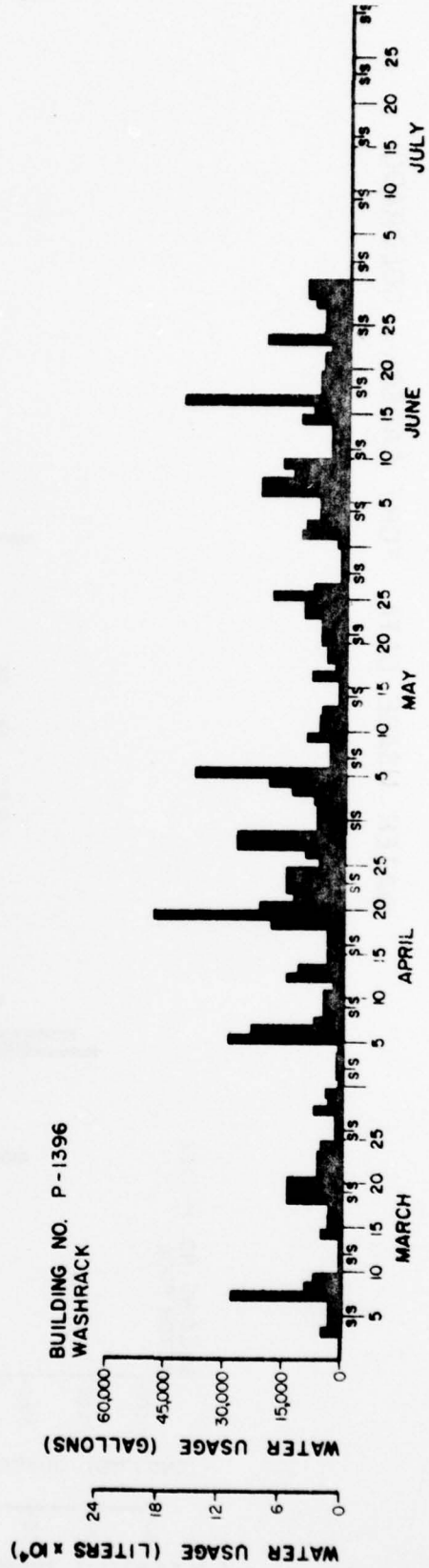
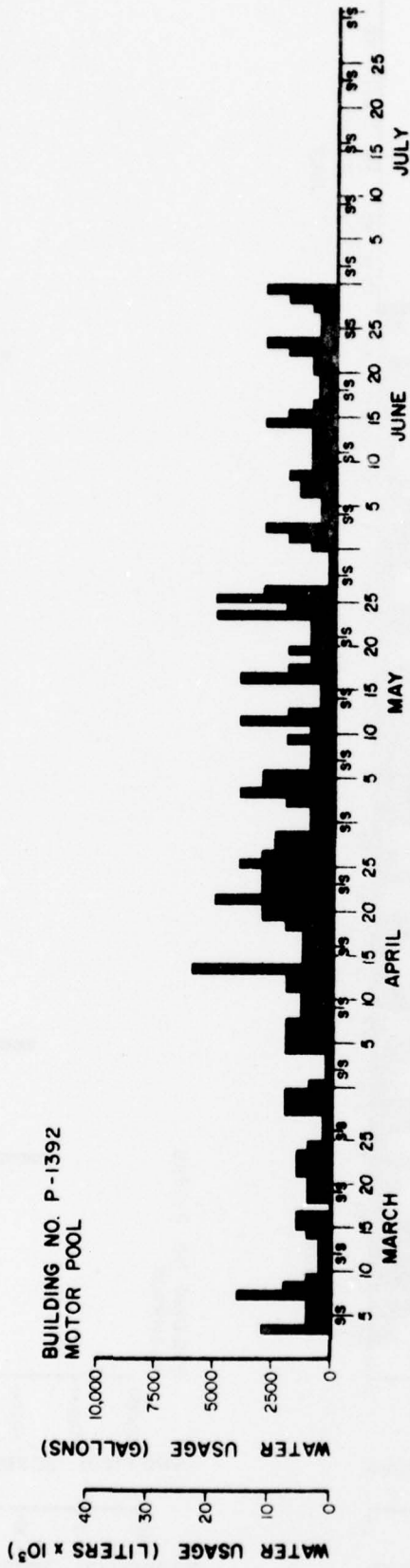
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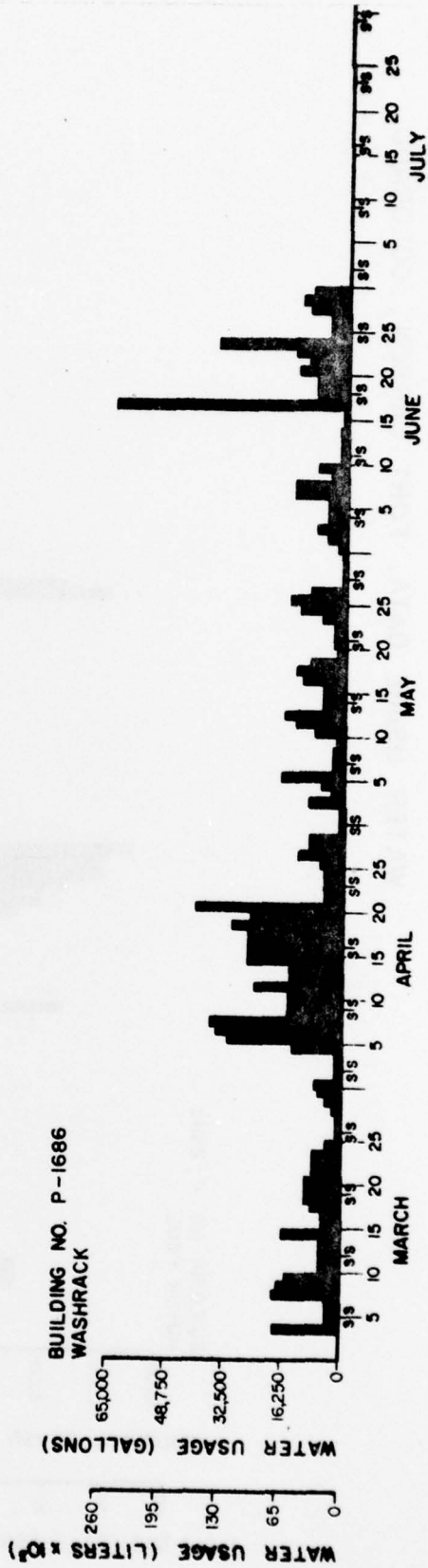
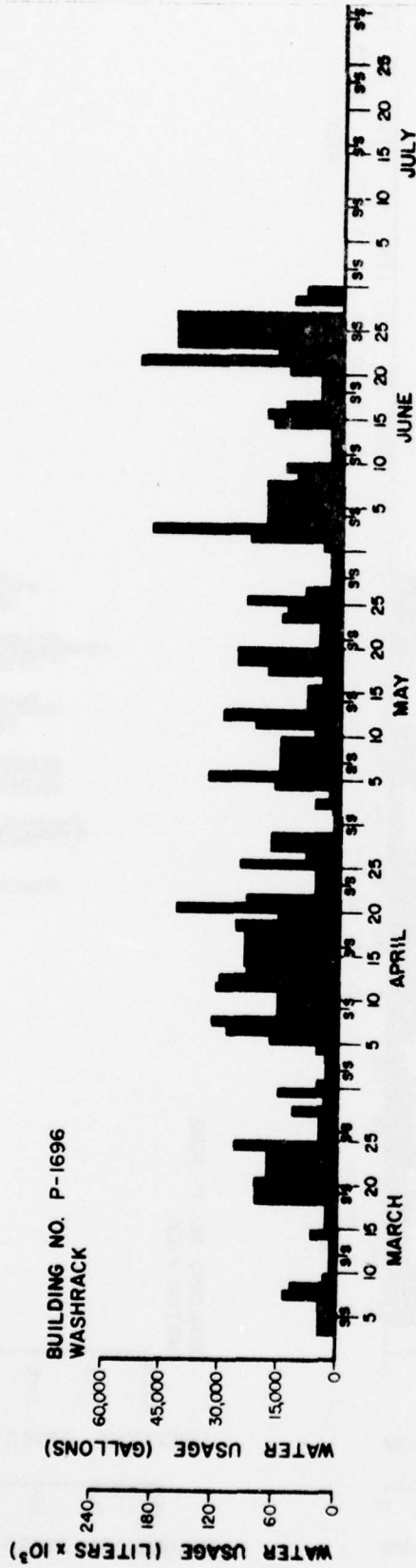
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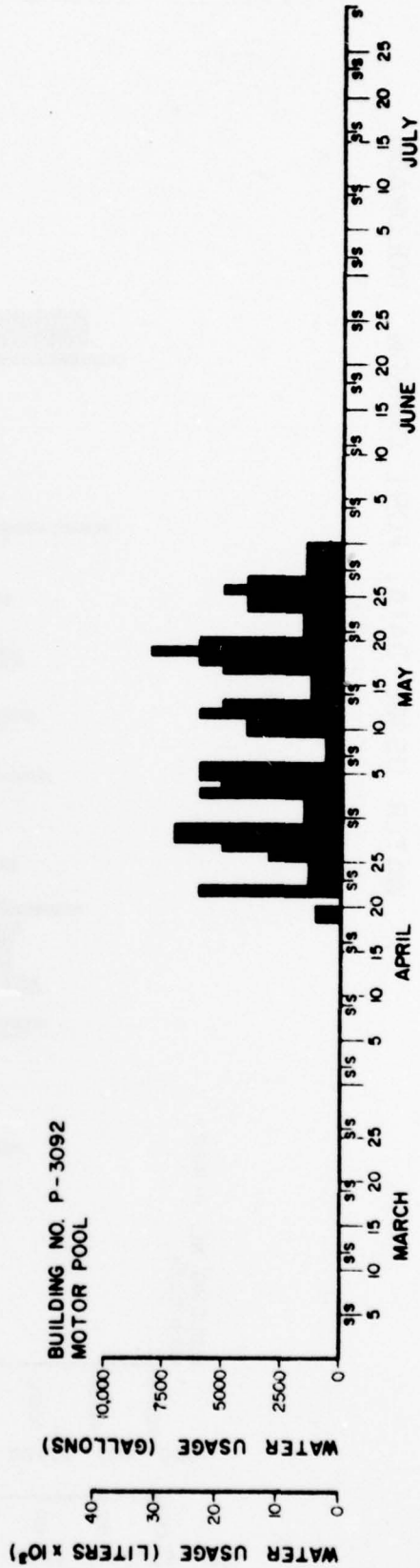
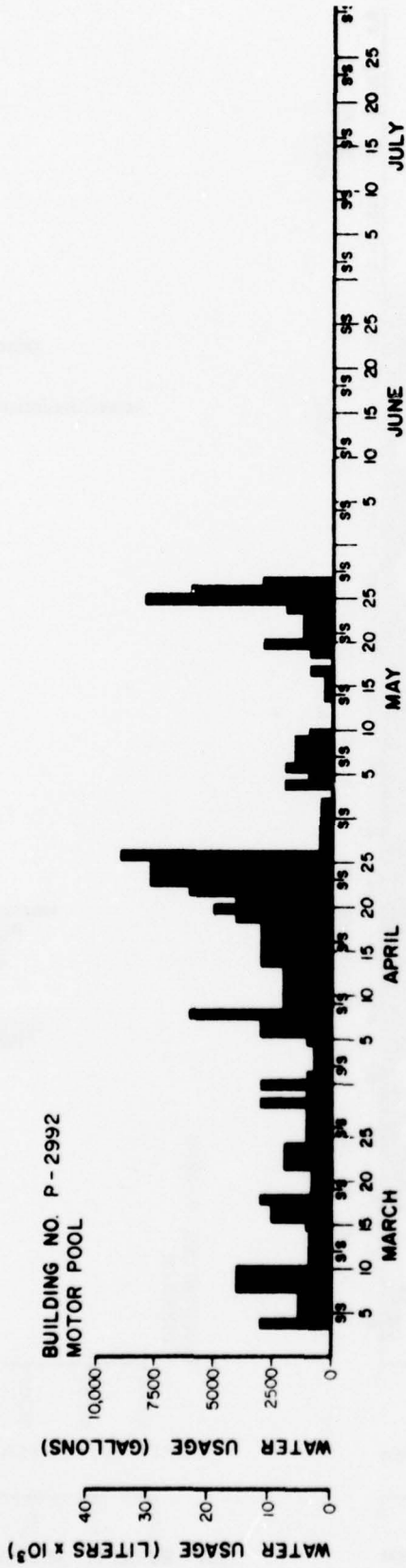
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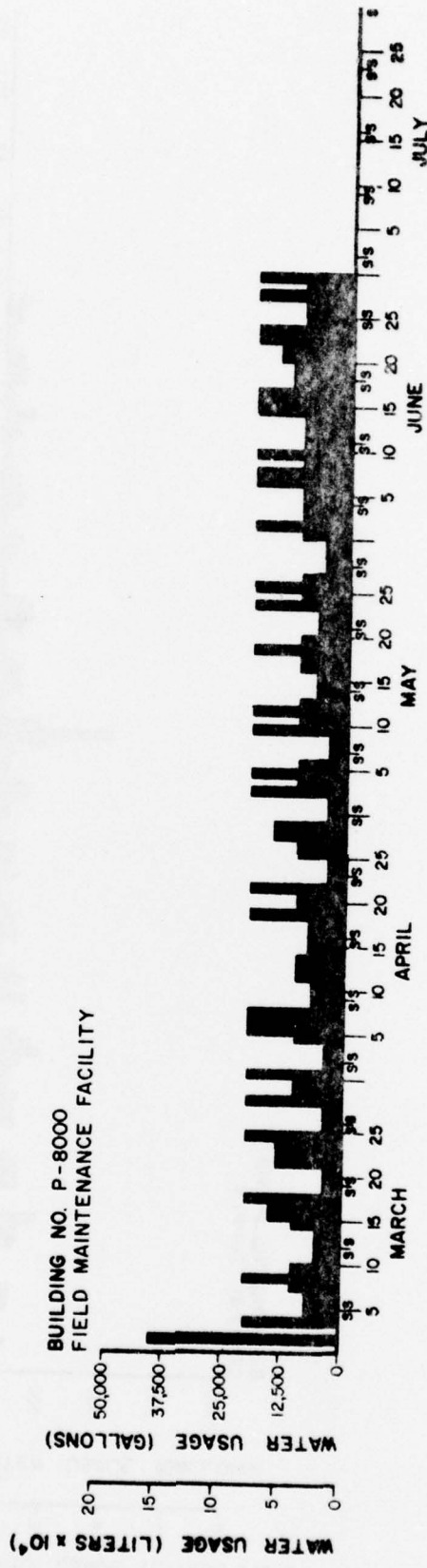
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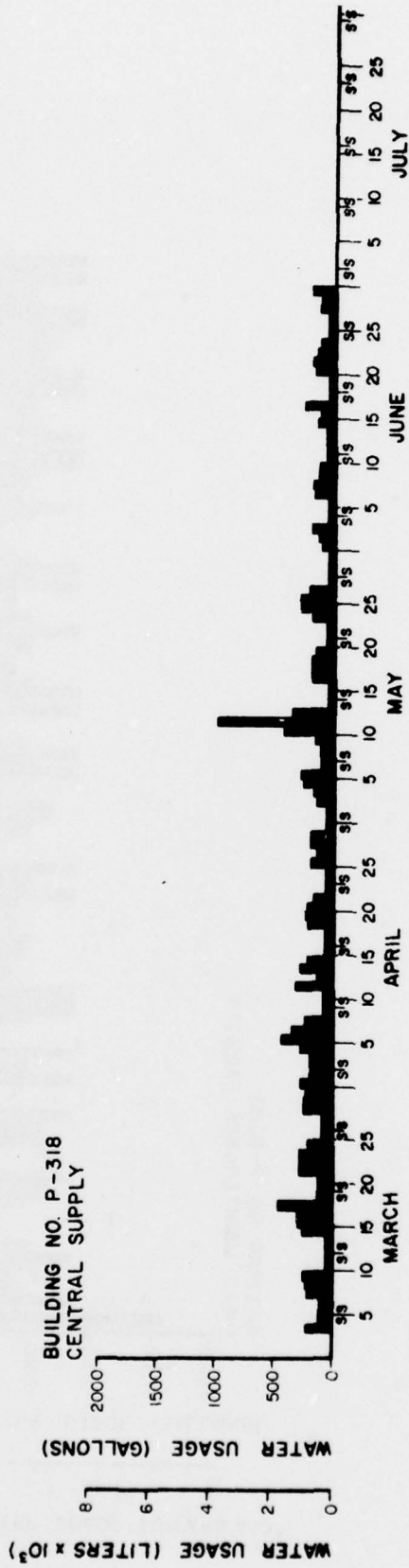
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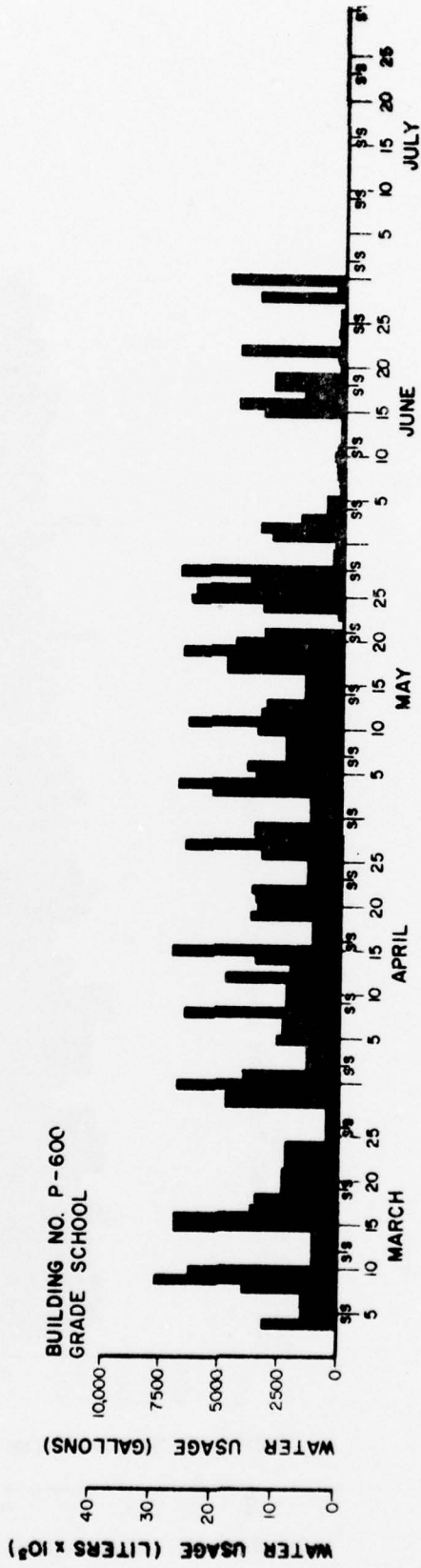
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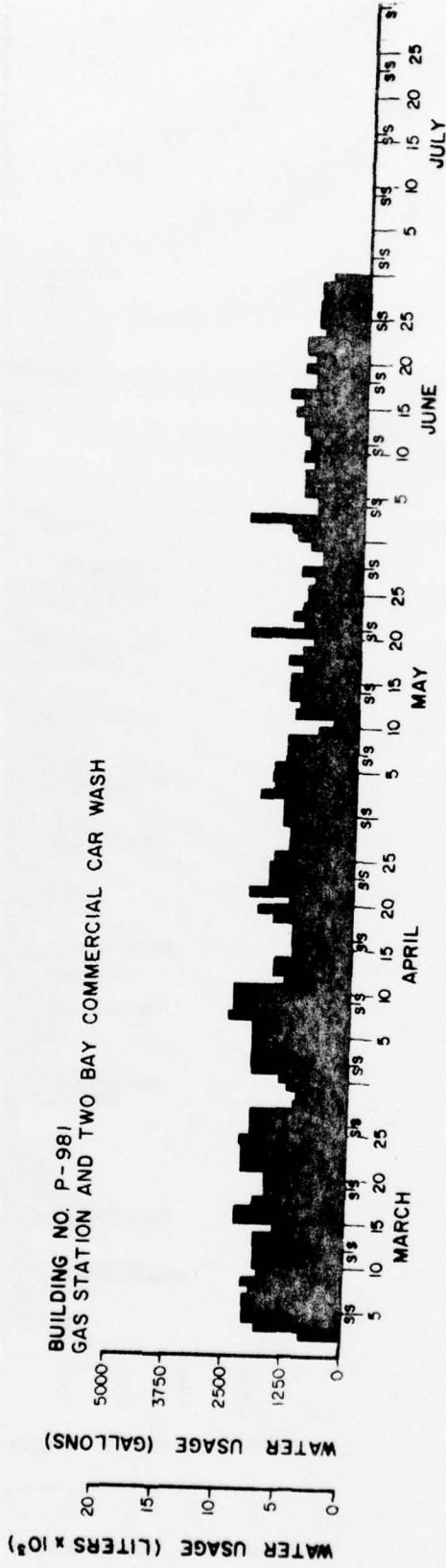
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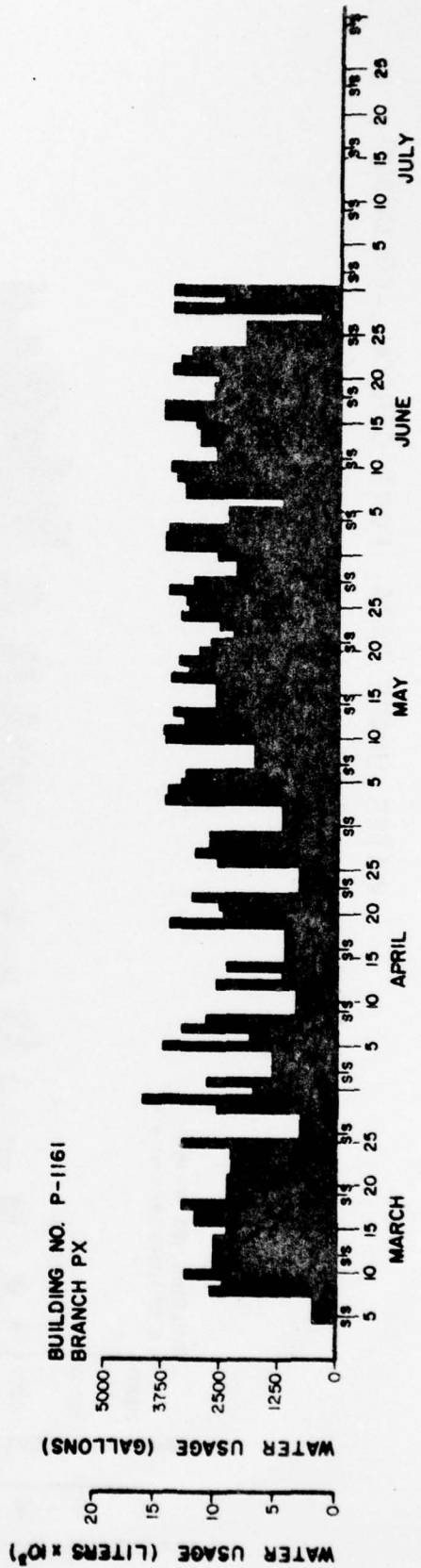
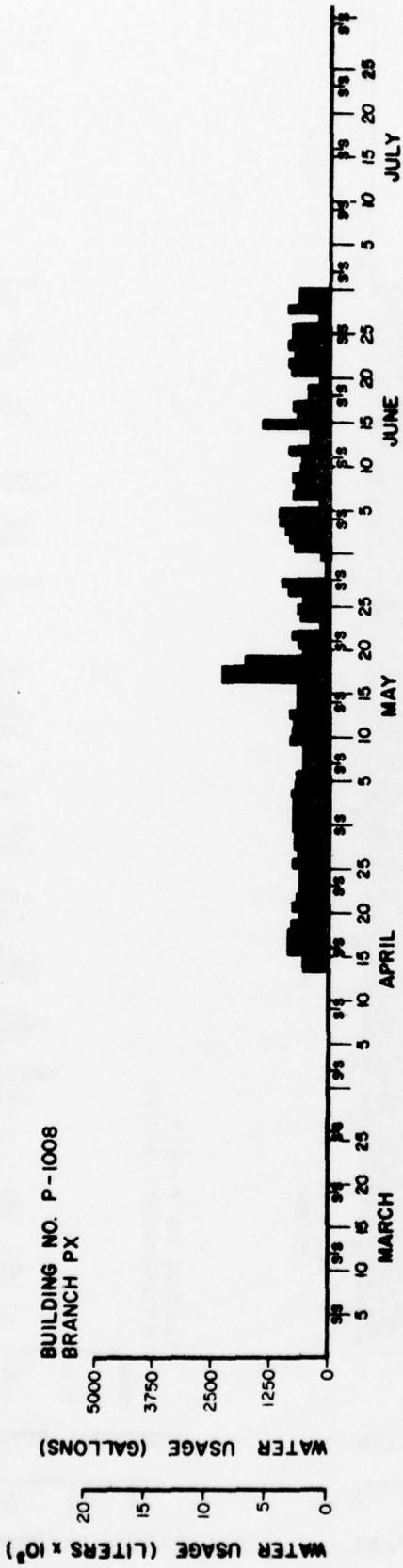
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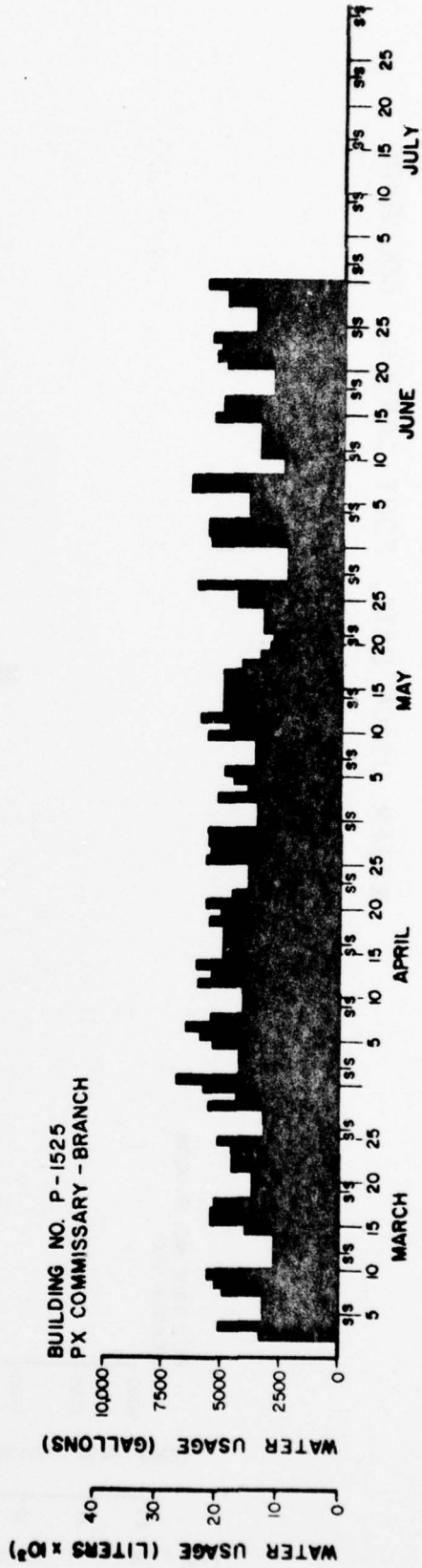
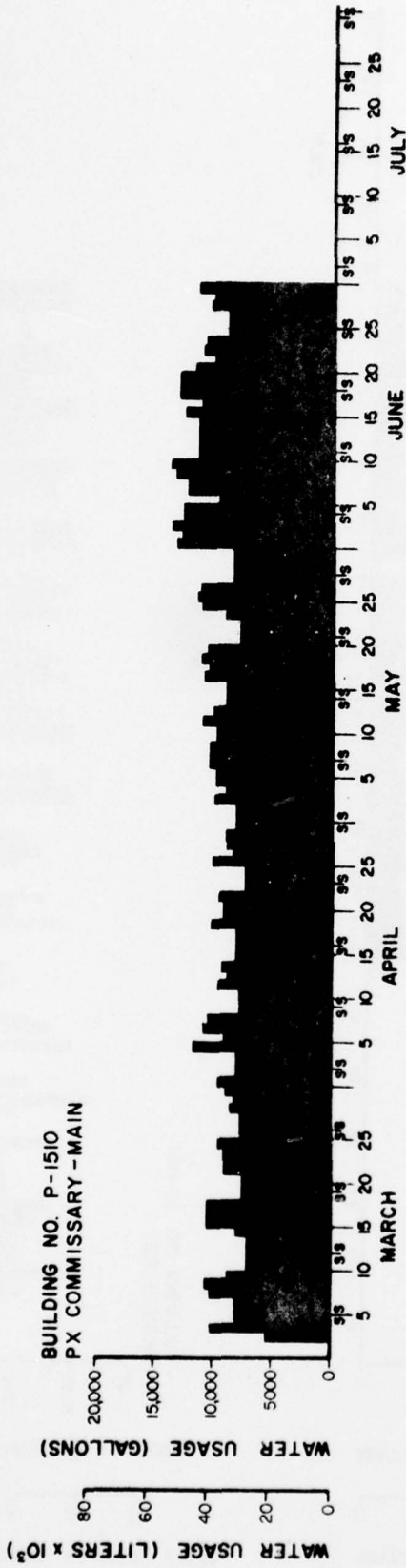
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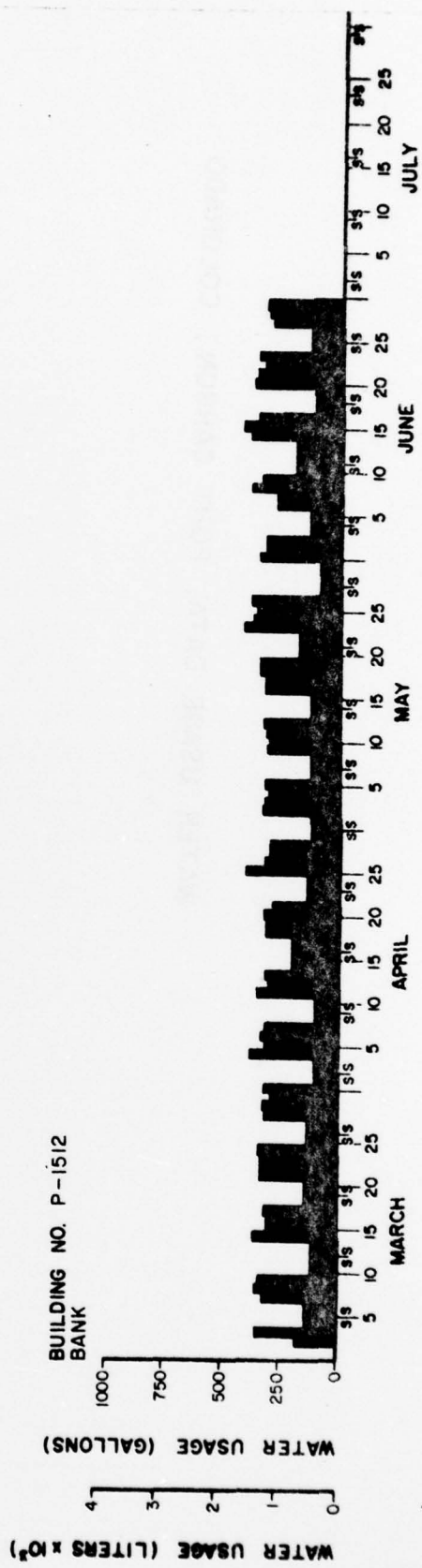
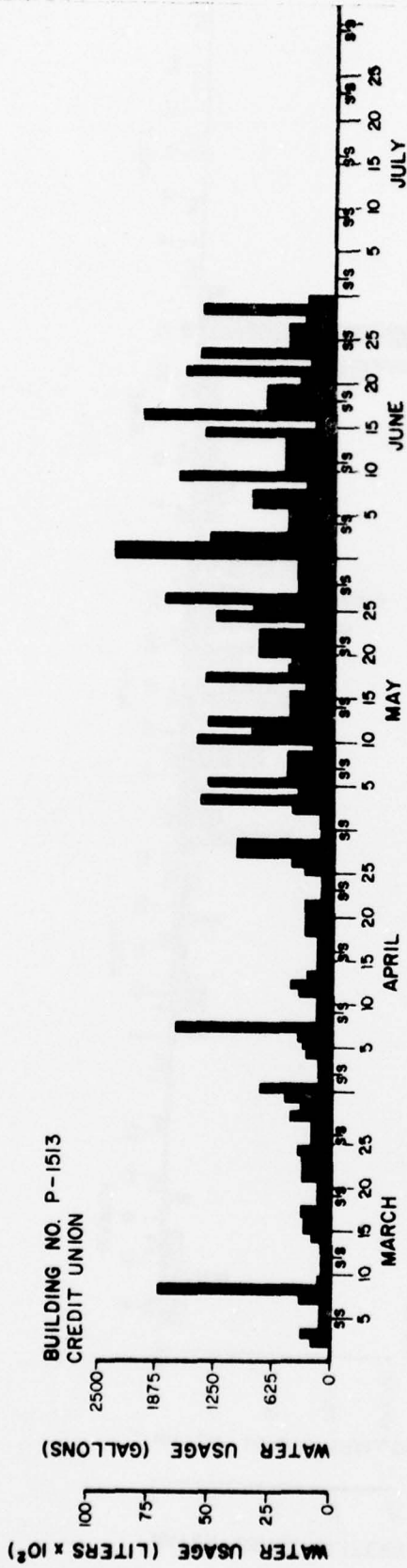
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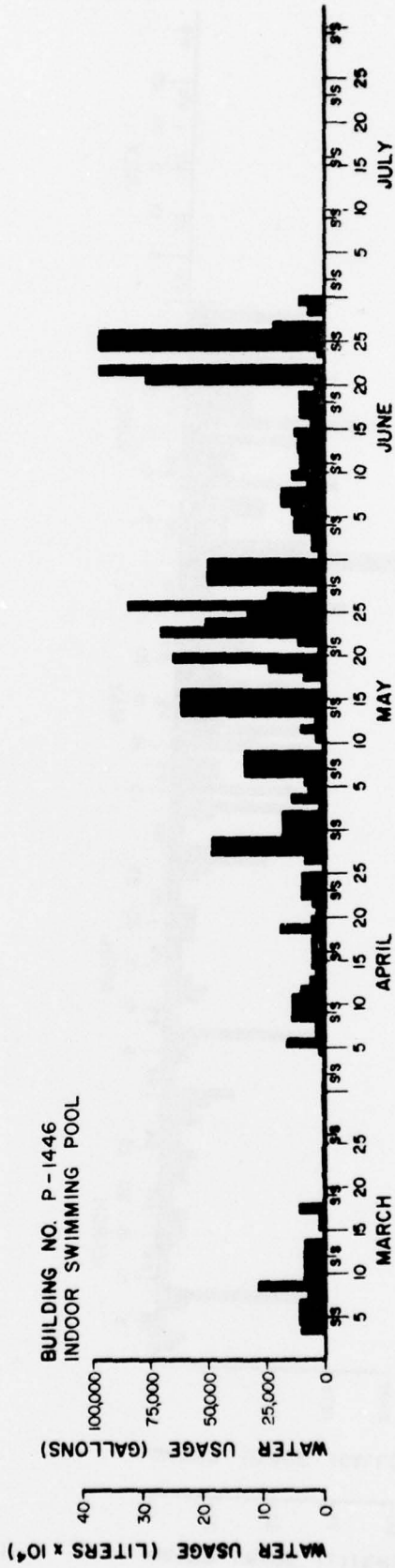
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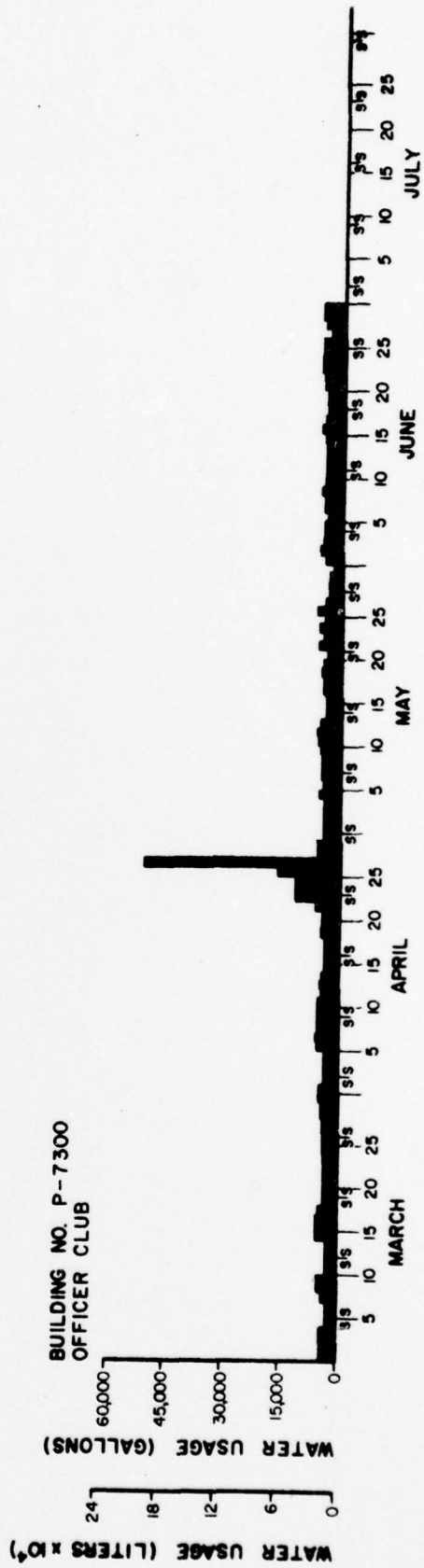
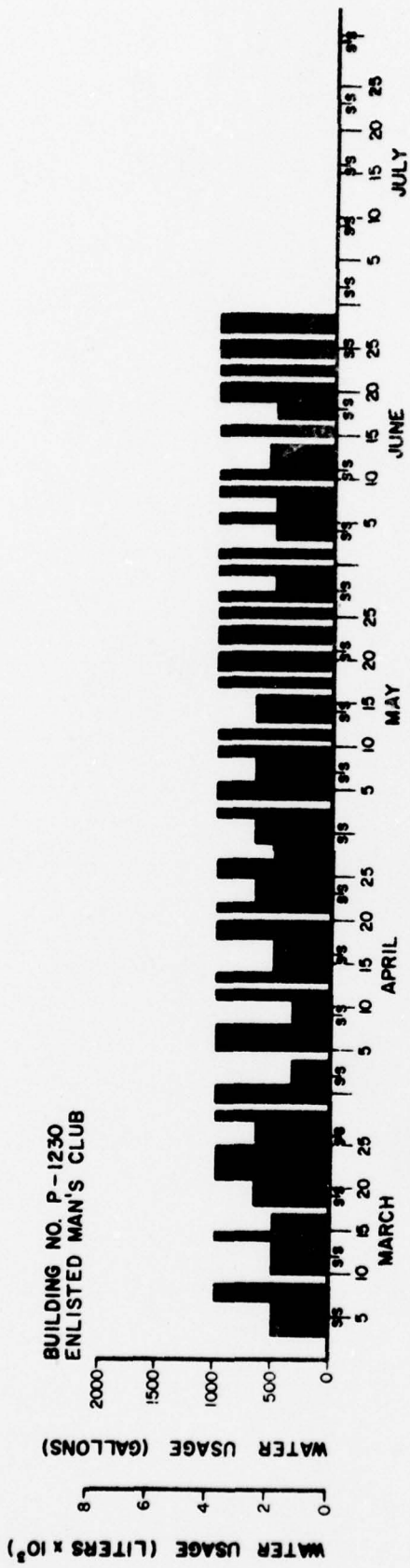
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57 p. ; 27 cm. (Interim report - Construction Engineering Research Laboratory ; N-34)

1. Fort Carson, CO. 2. Water consumption. I. Staub, Mary J. II. Benson, Leslie J. III. Fileccia, Robert J. IV. Title. V. Series : U.S. Construction Engineering Research Laboratory. Interim report ; N-34.