DEVELOPMENT of TASK STATEMENTS and STANDARDS for WATER and WASTEWATER TREATMENT PLANT MAINTENANCE
The Pennsylvania State University
The Graduate School

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Development of Task Statements and Standards
for
Water and Wastewater Treatment Plant Maintenance

A Report in
Environmental Engineering
By
Roland S. MOREAU

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Requirements for the Degree of
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Roland S. Moreau
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Date of Signature:

8/14/85

David A. Long
Professor of Civil Engineering
Report Advisor

8/16/85

Robert M. Barnoff
Professor and Head, Department of Civil Engineering
TABLE OF CONTENTS

I. Introduction 1
II. Literature Review 4
III. Study Procedure 9
IV. Discussion 19
V. Conclusions 22
VI. Author’s Observations 24
VII. References 25
VIII. Appendices 27
INTRODUCTION

The supply of safe potable water and the proper treatment and disposal of the resultant sewage are services that impact everyone. Consequently, costs for construction, operation, and maintenance of the necessary treatment facilities are borne by all who receive service, either directly or indirectly. Construction costs usually are funded through government grants and bonding. Competitive bidding and agency overviews tend to keep those costs under control without limiting them unduly. However, costs of operations and maintenance usually are the responsibility of the local owner (ie. authority, municipality, etc.) and normally are funded through service charges assessed to the consumers. Without a rigid system in place to dictate operations and maintenance levels, the only forces acting on the owners generally are those of the consumers, ie. a desire for the lowest possible rate.

Webster states that maintenance is the upkeep of property and equipment in a state of efficiency. Looked at in another way, maintenance is the act of keeping property and equipment in the same condition it was yesterday. That
definition is the crux of the problem, as there is little evidence that the work that has been accomplished justified the expenditures made. The rate of deterioration is often times slow enough that deferral of maintenance can be an accepted course of action for many years. The incidence of breakdowns and process interruptions gradually increases to the point that major overhaul or replacement is necessary. The irony of the situation is that the manager of the facility during the period of deferred maintenance is very highly thought of because of his success in keeping current operating costs down. Higher level management does not realize that, in actuality, he is consuming their capital investment by deferring maintenance expenditures.

The function of management is to obtain the most return for the least investment. Normally, the only costs included in the equation are those that are experienced during the fiscal calendar. Deferred maintenance is not included unless there has been a conscious effort to quantify its value. However, the oil filter advertisement that said "you can pay me now or pay me later" is very true. The deferred maintenance costs will be paid eventually, and probably at a very high rate.

The purpose of this paper is to develop a series of labor hour standards
that can be applied to maintenance and repair actions on water and wastewater treatment plant equipment. Through application of the appropriate standards, a manager will be able to estimate the yearly cost of maintenance (both preventative and corrective) for his facilities. The system developed as part of this project will provide documentation that can be used to justify budget requests, staffing, and quantify the impact that deferred maintenance will have in future budgets. The standards also can be used to evaluate employee efficiency and identify deficiencies in supervision and training that otherwise would go unrecognized.
LITERATURE REVIEW

A review of the literature has revealed no published standards for the maintenance and repair tasks that are developed later in this paper. There is substantial evidence in the literature to indicate that maintenance and repair has not been sufficient to maintain plants in many cases. The national desire to have clean rivers, lakes, and streams has resulted in massive programs to build treatment plants that are designed to remove contaminants from waste streams prior to discharge into a receiving body of water. The Government Accounting Office has reported that, as of December 1979, almost 18,000 plants, representing a federal government investment of 25 billion dollars and several billion dollars more from State and local governments, were in operation or under construction. This huge investment in capital by Federal and State governments in furtherance of National policy has been turned over to local municipalities and sewer authorities to maintain and operate. By the late 1970's, it was becoming obvious that an increasing number of treatment plants were failing to perform as expected. In a white paper on operation and maintenance of water pollution control facilities, the Water Pollution Control Federation (WPCF) found that emphasis in this area had
been greatly overlooked in the haste to get waste treatment systems in place and on-line. They recommended that owners should require a realistic updated cost of operations and maintenance from the design consultant both at the time 50 percent of the construction is completed and prior to the last budget cycle before the system is ready for operation.

In a comprehensive study by EPA of 103 facilities, a total of 70 potential problem areas (10 of which were maintenance) were weighed and ranked for severity of impact on performance. While a maintenance factor was the leading cause of poor performance in only one plant, it was a contributing factor noted in at least twenty percent of the plants studied. One of the recommendations made as a result of the study was that budgeting for operation and maintenance of wastewater treatment facilities must become organized and a higher priority in municipal budgets.

The AWWA Committee on Job Measurement Standards reported on the methods and benefits of applying standards to water utilities operations in 1979. They gave no actual standards to use, but described methods to be used for development of standards. The report did indicate that the benefits to be gained by using standards included increased productivity, better collection of cost data, and discovery of new work methods. Productivity
was improved because management was able to effect better coordination, maintain continuous operations and obtain better utilization of the available manpower. Better collection of cost data and discovery of new work methods resulted from comparison of actual work to estimated work.

There is much evidence to support the theory that improved management of maintenance can save money. As early as 1971, the City of Philadelphia Water Department instituted a systemized approach to maintenance with time standards and found an annual savings in excess of $318,000 after two years. An outside consultant was hired to develop time standards that were tailored to their plant. Both the Los Angeles County Flood Control District and Colorado Springs found that new maintenance management systems have been instrumental in reducing maintenance budgets without reducing services or output. The City of Wausau, Wisconsin found that, by hiring a professional firm to operate the plant and schedule maintenance, it was able to reduce down time and end a series of permit violations. Industry also has found that maintenance management is important. A metal processing facility, Monsanto and Chemplex chemical plants in England, and Corning Glass Works have all found that, by installing maintenance management systems, costs and equipment down times are reduced.
There has been some concern that, with the improved maintenance
management systems being implemented, it is possible to go overboard and
expend funds performing unnecessary maintenance. It has been reported that
an increased level of maintenance should reduce the costs incurred due to
failure. However, there is a point where a higher level of maintenance
does not result in a proportionate reduction in the costs due to failure and
total expenditures start to rise. Figure 1 graphically depicts the relative
relationship. The level of maintenance is based on the frequency of
maintenance. More frequent accomplishment of preventive maintenance
work, such as greasing and oil checks, is considered a higher level of
maintenance. As tasks are performed more frequently, the cost to
accomplish the maintenance rises, but the likelihood of failure of the
component will decrease. The costs due to failure decrease rapidly as the
level of maintenance is increased from zero to the manufacturers
recommended levels. Beyond that point it levels out. When both maintenance
costs and costs due to failure are added for a given level of maintenance, it
can be seen that there is a level of maintenance that will minimize costs.
Instrumentation equipment may be a type that is likely to be subject to over
maintenance.
Relation of Costs to Maintenance Levels
from Petroleum Engineer International
CONCLUSIONS

The purpose of this work was to develop a list of task statements that could be used by water and wastewater treatment plant managers to assist in setting maintenance budgets and determining staffing. A list of task statements has been presented and estimated labor hours and frequencies provided for many of the task statements. There is a serious need for an industry accepted set of standards for labor hours and frequencies. The numbers developed herein are a start, but much more work is necessary before they will be accepted as fact. The main impediment to this happening is not a lack of need, as most every computerized system requires that type of information in order to implement an effective maintenance system. What is needed, is a coordinated effort by one of the professional organizations in the field. It is recommended that a project similar to the Operations and Maintenance White Paper produced by the WPCF be conducted. The methodology and results presented herein can be used to expand the data base and, ultimately, accomplish the goal initially established. It is anticipated that more information will be available within the next two to five years because there are many automated maintenance management systems.
major factor influencing frequencies is the presence or lack of standby units. If there are standby units and the "on" unit is rotated periodically, then repair and replacement frequencies will be much different from normal. Other major influences on frequency of task accomplishment are exposure to weather, quality of craftsmen, quality of preventive maintenance, and suitability of the equipment for the application. The computer data base used has a provision for developing high and low factors that can be applied to the average frequency values, but this adjustment was not accomplished during this project because it would require a fairly substantial data sample to have meaningful results. There was very little information of this nature available at the time the study was conducted.
has seized to the shaft. Obviously, the necessary time to perform the task will be quite different in each case, but neither will be the same as the standard. The advantage of having standards is that they will provide an indication that further investigation is necessary. In some cases, the individuals may not be performing tasks as quickly as they should and more supervision or training may be necessary. In other cases, it may be a maintenance system that allows bearings to freeze to shafts that needs improvement. By using a system of standards, a good manager should be able to easily identify problems and thereby correct them sooner.

The EPS manuals that were used to determine labor hours for most of the task statements provide labor hour estimates with too many significant figures. Most tasks should be estimated to the nearest minute or five minutes and not to the nearest 0.36 second as is done in the manuals. The data input to the computer have been rounded off to the nearest 0.001 hour, but it is recognized that in actual practice standards probably will be written to the nearest 0.1 hour.

The frequencies that have been determined are average times for the particular task statement. Frequencies are very difficult to estimate because there are so many factors that have an effect on the values. The
DISCUSSION

The task statement outline, Appendix B, is not all inclusive. For some of the components (ie. pumps), the tasks listed are comprehensive and include almost all actions that would be necessary during the life of a component. However, for other components (ie. some of the sludge handling equipment) there is very little information available and many components have become prematurely obsolete due to changes in operating factors such as energy costs. There are some components where the only tasks listed are preventive maintenance, repairs, and replacement as no more detailed task statements could be determined. The list of tasks provided is as comprehensive as possible based on the information that is currently available.

Veteran mechanics or electricians may feel that the labor hour estimates do not provide enough time to perform the task. The estimates may seem low because they are average craft times and do not include time to get to the job site, go for parts or materials, and trouble shoot. Actual times to perform the tasks can vary dramatically depending on the conditions the craftsman is confronted with. As an example, a bearing may be removed quickly if it is just starting to go bad, but it may have to be torched out if it
TASK DATA FORM

Task Code: 081101

Component: TANK-LESS WATER CLOSET  System: SANITARY  Subsystem: FIXTURES

Task Description: M/R  REPLACE FLUSH VALVE

Unit of Measure: 1-CT  Frequency of Occurrence: H: 8.00  A: 10.00  L: 12.00

Persons per Team: 1  Task Duration: 0.117  Trade: 3

References: Labor: 2  Material: 1  Equipment: 1

Labor Resources

<table>
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<tr>
<th>Subtask Description</th>
<th>Labor Hrs</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
<th>Labor Hrs</th>
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<td>REMOVE OLD FLUSH VALVE</td>
<td>0.090</td>
<td>Material</td>
<td>0.00</td>
<td>0.00</td>
<td>0.11</td>
<td>0.0082</td>
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<td>INSTALL NEW FLUSH VALVE (QT-311 TWICE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Material Resources

<table>
<thead>
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<th>Quantity</th>
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<th>Total Cost</th>
<th>Labor Hrs</th>
</tr>
</thead>
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<td>Material</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
<td>0.0020</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SUMMARY

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<th>Resources</th>
<th>UOM</th>
<th>Direct</th>
<th>Indirect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>LH</td>
<td>0.090</td>
<td>0.027</td>
<td>0.117</td>
</tr>
<tr>
<td>Material</td>
<td>ELH</td>
<td>0.010</td>
<td>0.003</td>
<td>0.013</td>
</tr>
<tr>
<td>Equipment</td>
<td>ELH</td>
<td>0.117</td>
<td>0.117</td>
<td>0.117</td>
</tr>
</tbody>
</table>

Components Containing This Task:
### Figure 2

**NT-198**

Remove and Install Motor from Centrifugal Sump

Pump. Remove and install pump shaft packing, shaft bearing, or impeller in shop. Moving pump to shop not included.

<table>
<thead>
<tr>
<th>No. Reference</th>
<th>Work Unit Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remove 4 screws from switch cover plate.</td>
</tr>
<tr>
<td>2</td>
<td>Remove switch cover plate.</td>
</tr>
<tr>
<td>3</td>
<td>Disconnect wires at 3 terminals.</td>
</tr>
<tr>
<td>4</td>
<td>Remove 2 switch bracket screws.</td>
</tr>
<tr>
<td>5</td>
<td>Remove switch assembly.</td>
</tr>
<tr>
<td>6</td>
<td>Remove float rod spring retainer pin.</td>
</tr>
<tr>
<td>7</td>
<td>Un-screw motor from pump tube.</td>
</tr>
<tr>
<td>8</td>
<td>Insert float rod through motor end bell guide hole and float rod spring.</td>
</tr>
<tr>
<td>9</td>
<td>Install spring retainers over float rod end.</td>
</tr>
<tr>
<td>10</td>
<td>Engage spring coupling with slot in motor shaft.</td>
</tr>
<tr>
<td>11</td>
<td>Screw motor on to pump tube.</td>
</tr>
<tr>
<td>12</td>
<td>Install float rod retainer pin.</td>
</tr>
<tr>
<td>13</td>
<td>Install switch assembly.</td>
</tr>
<tr>
<td>14</td>
<td>Install 2 switch bracket screws.</td>
</tr>
<tr>
<td>15</td>
<td>Connect wires at 3 terminals.</td>
</tr>
<tr>
<td>16</td>
<td>Install switch cover plate.</td>
</tr>
<tr>
<td>17</td>
<td>Install 4 cover plate screws.</td>
</tr>
<tr>
<td>18</td>
<td>Remove impeller shaft drive pin.</td>
</tr>
<tr>
<td>19</td>
<td>Loosen impeller shaft coupling adapter collar set screw.</td>
</tr>
<tr>
<td>20</td>
<td>Remove impeller shaft coupling adapter collar.</td>
</tr>
<tr>
<td>21</td>
<td>Remove 4 screws on pump base to pump housing.</td>
</tr>
<tr>
<td>22</td>
<td>Remove pump base.</td>
</tr>
<tr>
<td>23</td>
<td>Remove 4 pump housing plate screws.</td>
</tr>
<tr>
<td>24</td>
<td>Remove pump housing plate.</td>
</tr>
<tr>
<td>25</td>
<td>Remove impeller shaft and impeller, shaft adapter and impeller shaft ball bearing.</td>
</tr>
<tr>
<td>26</td>
<td>Remove pump bearing.</td>
</tr>
<tr>
<td>27</td>
<td>Remove pump bearing packing gland retainer.</td>
</tr>
<tr>
<td>28</td>
<td>Remove pump bearing packing gland.</td>
</tr>
<tr>
<td>29</td>
<td>Remove pump bearing packing, spring and washer.</td>
</tr>
<tr>
<td>30</td>
<td>Assemble pump bearing packing gland with new packing (4 rings), spring and washer.</td>
</tr>
<tr>
<td>31</td>
<td>Install pump bearing packing gland and retainer into bearing.</td>
</tr>
<tr>
<td>32</td>
<td>Install pump bearing into pump tube.</td>
</tr>
<tr>
<td>33</td>
<td>Remove impeller pin.</td>
</tr>
<tr>
<td>34</td>
<td>Remove impeller from shaft.</td>
</tr>
<tr>
<td>35</td>
<td>Assemble impeller, impeller shaft and impeller pin.</td>
</tr>
<tr>
<td>36</td>
<td>Install impeller shaft into pump tube.</td>
</tr>
<tr>
<td>37</td>
<td>Install impeller shaft ball bearing retainer.</td>
</tr>
</tbody>
</table>

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Example of Engineered Performance Task
directly listed. Estimates were developed by using the estimated times for similar actions. The EPS manuals list a task and time and then break the time estimate into the several steps (each individually estimated) necessary to complete the task, see Figure 2 for an example. In many cases, all steps in the EPS task were not needed for the task statement being estimated, but the author was able to apply some of the steps to a water and wastewater task statement to develop an estimate. There is a memo field in every record in the data base that details and references how the estimated labor hours, frequency, equipment, or materials were determined. After all the information possible was gleaned from the EPS manuals, other sources were used to estimate labor hours. The author was not able to estimate labor hours for every task listed because the information necessary to accomplish this effort was not available. Frequencies for some of the task statements were estimated and documented in the same manner that the labor hours were done. However, due to lack of time, only approximately 10 percent of the task statements had frequencies estimated and no material or equipment estimates were developed. A sample task statement data form is shown in Figure 3.
estimated labor hours, equipment, or materials for any of the tasks and there are no industry accepted standards on the life expectancy of equipment.

Letters were sent to firms that provide automated maintenance systems; a sample letter is included in Appendix D, but no firm was able to list a reference that had been using its system long enough so that they considered their data to be of any value for use in this project. Most firms responded that their systems were new and had not been put in place yet.

Labor hours were selected as the first parameter to study in detail. Rather than trying to determine every unknown for every task statement, if all labor hours were estimated at once there would be more consistency and efficiency in providing this information. Labor hours for each task were estimated using several sources for guidance, a list of which is provided in Appendix E. The reference number for each source listed in Appendix E is the labor reference noted in the task statement record in the computer data base. Most of the estimates were developed using one or more of the Engineered Performance Standards (EPS) manuals written by the Department of Defense. See Appendix E for a list of the specific manuals used. These manuals were designed to aid in estimating labor hours for maintenance and repair of DOD's real property (buildings and grounds). There were very few tasks that were
There are more than six hundred task statements for the water and wastewater treatment plants. It would be very time consuming and tedious to keep track of all the information required without the use of a computerized data base. For this project, a relational data base called D-Base III by Ashton-Tate, Inc. was used. A routine developed by the Architectural Engineering Department of the Pennsylvania State University for the CERL project on plumbing and electrical systems was modified for use in this project. The routine develops reports in the format that CERL requires, but is flexible enough to allow output in a variety of formats. The computer used was an IBM-PC/XT with a 10 megabyte hard disk. Appendix C lists the directions for use of the system including input and output of data.

c. Frequency and Labor Hour Estimates.

For each task statement, the ultimate goal is to have an estimate for the labor hours, equipment, and materials necessary to accomplish the task and frequency of occurrence of the task. The only data the author found readily available for the tasks on water and wastewater treatment equipment were that for frequency of preventive maintenance. There are no published data on
the Army Civil Engineering Research Laboratory (CERL), the financial sponsor for this project. The first four digits refer to the type of treatment plant, i.e. 1616xxx is for water treatment plants and 1624xxx is for wastewater treatment plants. The fifth digit refers to the unit operation. The numbers one through nine were used for this, the sixth, and the seventh digits. The number zero was not used to avoid confusion in submittals to CERL. Because there were more than nine unit operations, after the number nine, letters were used sequentially starting with "A" and going to "Z". Letters were allowed to be used in any digit and were needed with most of them. The sixth digit refers to the component and values were assigned sequentially as the components were determined for the unit operation under study. Because of the number of components, it was not possible to always list motors as "1" and centrifugal pumps as "2", for example. The seventh digit refers to the task statement. Readers should note that the there are what may appear to be missing task statements in Appendix B. These apparent omissions were proposed tasks that were deleted during the study for lack of applicability. This numbering system is somewhat cumbersome to use and does not allow for grouping by level of treatment, i.e. primary, secondary, tertiary, etc., but was used because it was mandated by the project sponsor.
as motors, that are used in many different unit operations. They were listed only once per unit operation, but were included in every unit operation in which they are found. In this way, a complete list of components can be assembled if the unit operations to be used are known.

Each component listed was analyzed to determine the types of tasks that would have to be accomplished over the life of the component to keep it in operating condition. Sources of information used included manufacturer’s maintenance instructions, existing treatment plant operations and maintenance manuals, treatment plant mechanics (through interviews), manuals of practice, and personal inspection of some of the equipment by the author. Two water treatment plants and four sewage treatment plants were visited by the author to conduct interviews with mechanics, review equipment maintenance cards and conduct inspection of equipment. The tasks were compiled into a list on the basis of unit operation. This list is presented in Appendix B.

b. Numbering and Data Base System.

A seven digit numbering system was applied to the list giving each task statement a unique number. The numbering system used was one specified by
# List of Unit Operations to Be Considered

## Wastewater Treatment

### Primary
- Screening
- Grinding
- Flow Metering
- Primary Settling
- Sludge Handling
- Scum Removal

### Secondary
- Aeration
- Air Delivery
- Secondary Clarifiers
- Chemical Treatment
- Return Sludge
- Excess Sludge Handling
- Scum Removal
- Chlorination
- Effluent Water Sampling
- Effluent Water Metering
- Trickling Filter
- Rotating Biological Contactor Equipment
- Filtration

### Tertiary
- Nitrogen Removal
- Phosphorus Removal

### Sludge Handling
- Incinerators
- Vacuum Filtration
- Sludge Conditioning
- Chemical Treatment
- Sludge Thickening
- Sludge Digestors
- Centrifuge Equipment

### Water Treatment
- Pumping Equipment
- Mixing
- Flocculation
- Filtration
- Chlorination
- Ion Exchange
- Activated Carbon Column
treatment (Table 1) was compiled. Not all unit operations listed would be encountered in any one plant, but the list is inclusive of unit operations that have been and are being used to treat water and wastewater streams. Two areas that were not included are incineration of sludge and final disposal of sludge, i.e., landfilling or spraying on agricultural lands. It was felt that those areas are outside the basic scope of this study.

Each of the unit operations listed was reviewed in detail and any equipment or appurtenance that might be necessary for that operation was listed. For example, under the unit operation called sludge pumping, there were five different types of pumps listed (plunger, centrifugal, rotary, diaphragm, and grinder) because any of these pumps might be used for that purpose. In any one plant handling sludge, there often would be only one type of sludge pump installed, but that particular pump could be any of the five listed types depending on the characteristics of the sludge, volume of flow, head, and designer preferences. For the purposes of this study, each of the pieces of equipment and various appurtenances were defined as a component. Appendix A contains a list of the components considered in this study. One may note that there are many components that were listed more than once in Appendix A. That situation occurred because there are some components, such
Study Procedure

The goal of this project was to produce a set of labor hour and frequency standards that can be applied to maintenance, repair, and replacement of equipment and appurtenances used in water and wastewater treatment. As indicated in the previous section, a diligent search of the literature revealed no published reports that had accomplished such a task. A list of the tasks to be considered was compiled, a system to number and store the information was developed, and estimates of labor hours and frequency of occurrence were made.


Water and wastewater treatment consists of a series of unit operations designed to deliver an effluent with the desired qualities. The most logical way to compile the data is on the basis of unit operations. Different plants will have a different combination of unit operations and vessel sizes depending on the influent characteristics and effluent qualities desired, but the equipment necessary for each unit operation is basically the same.

A complete list of unit operations that are used in water and wastewater
collecting the data today.
Author's Observations

The Environmental Engineering profession must improve its public image. Much has been said in the technical literature and common press about how poorly treatment plants perform. The public is exposed to this poor record of performance almost daily and it is a black mark on our profession. This paper is an attempt to cause engineers to recognize that operations and maintenance play an important role in the performance of a treatment plant and that much work must be done to improve the management of operations and maintenance. It is the responsibility of all involved in the profession to take that extra step necessary to ensure that treatment plants perform as designed. It is very important that the public believe in the integrity and competence of the professionals in the field.
REFERENCES


3. Ibid, p.901.


<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Pages</th>
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<tr>
<td>Appendix A</td>
<td>List of Components</td>
<td>A-1 to A-7</td>
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<tr>
<td>Appendix B</td>
<td>Task Statement Outline</td>
<td>B-1 to B-25</td>
</tr>
<tr>
<td>Appendix C</td>
<td>Instructions for Data Base Access</td>
<td>C-1 to C-17</td>
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<td>Appendix D</td>
<td>Sample Letter</td>
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<tr>
<td>Appendix E</td>
<td>List of Estimating References</td>
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Appendix A

List of Components
APPENDIX A
LIST OF COMPONENTS

1616000 WATER TREATMENT PLANT

1616100 Pumping
1616110 Centrifugal Pump
1616120 Piping
1616130 Valves
1616140 Pump Motor

1616200 Rapid Mixer
1616210 Chamber
1616220 Mixing Tank
1616230 Mixer

1616300 Flocculation
1616310 Basin
1616320 Flocculator
1616330 Flocculator Motor

1616400 Clarification
1616410 Basin
1616420 Sludge Collector Mechanism
1616430 Sludge Collector Drive
1616440 Sludge Collector Drive Motor

1616500 Filtration, Ion Exchange, Activated Carbon
1616510 Concrete Basin
1616520 Steel Tank
1616530 Underdrain piping
1616540 Rate Control Valve
1616550 Backwash Pumps
1616560 Surface Wash System
1616570 Pump Motor
### APPENDIX A
### LIST OF COMPONENTS

**1616500 Chlorination and Flouridation**
- 1616610 Chlorine Injectors
- 1616620 Chlorinator
- 1616630 Pressure Reducing Valve
- 1616640 Automatic Controls
- 1616650 Injector Booster Pump

**1616700 Sludge Pumping**
- 1616710 Piping
- 1616720 Pump Motor
- 1616730 Adjustable Speed Drive
- 1616740 Centrifugal Pump

**1616800 Chemical Feed System**
- 1616810 Storage Bin and Cyclone
- 1616820 Vibrator
- 1616830 Screw Dry Chemical Feeder
- 1616840 Piping
- 1616850 Agitator/Mixer
- 1616860 Conveyor
- 1616870 Motor
- 1616880 Slaking Tank
- 1616890 Metering Pump

**1624000 SEWAGE TREATMENT PLANT**

**1624100 Raw wastewater Pumping**
- 1624110 Centrifugal Pump
- 1624120 Pneumatic Ejector
- 1624130 Piping
- 1624140 Sewage Pump Motor
# APPENDIX A

## LIST OF COMPONENTS

### 1624200 Comminution
- 1624210 Comminutor Motor
- 1624220 Gear Box
- 1624230 Cutting Bars and Screen
- 1624240 Channel

### 1624300 Screening
- 1624310 Bars
- 1624320 Rake Mechanism
- 1624330 Rake Mechanism Motor
- 1624340 Channel

### 1624400 Primary Settling
- 1624410 Basin
- 1624420 Sludge Collector Mechanism
- 1624430 Sludge Collector Drive
- 1624440 Scum Collector
- 1624450 Sludge Collector Drive Motor

### 1624600 Aeration Tank - Diffused Aeration
- 1624610 Basin
- 1624620 Air Distribution System
- 1624630 Air Blower
- 1624640 Blower Motor
- 1624650 Air Filter System

### 1624700 Aeration Tank - Mechanical Aerator
- 1624710 Aerator
- 1624720 Aerator Motor
- 1624730 Basin

### 1624800 Secondary Clarifier
- 1624810 Basin
- 1624820 Sludge Collector Mechanism
- 1624830 Sludge Collector Drive
APPENDIX A
LIST OF COMPONENTS

1624840 Scum Collector
1624850 Sludge Collector Drive Motor

1624900 Chlorination
1624910 Basin
1624920 Chlorine Injectors
1624930 Chlorinator
1624940 Pressure Reducing Valve
1624950 Automatic Controls
1624960 Booster Pump

1624A00 Sludge Pumping
1624A10 Piping
1624A20 Pump Motor
1624A30 Adjustable Speed Drive
1624A40 Plunger Pump
1624A50 Centrifugal Pump
1624A60 Rotary Positive Displacement Pump
1624A70 Diaphragm Pump
1624A80 Grinder Pump

1624B00 Aerobic Sludge Digestion
1624B10 Basin
1624B20 Air Distribution System
1624B30 Air Compressor
1624B40 Compressor Motor
1624B50 Mechanical Aerator
1624B60 Mechanical Aerator Motor

1624C00 Trickling Filter
1624C10 Retaining Structure
1624C20 Distributor
1624C30 Undrain System
APPENDIX A
LIST OF COMPONENTS

1624D00 Rotating Biological Contactor (RBC)
  1624D10 RBC Motor
  1624D20 Belt Drive
  1624D30 Gear Reducer
  1624D40 Chain Drive
  1624D50 Tank Enclosure
  1624D60 Rotating Plastic Media

1624E00 Stabilization Lagoon
  1624E10 Earthen Basin
  1624E20 Concrete Basin
  1624E30 Diffused Air Distribution System
  1624E40 Air Compressor
  1624E50 Compressor Motor
  1624E60 Mechanical Aerator
  1624E70 Aerator Motor

1624F00 Dosing Tank
  1624F10 Tank
  1624F20 Piping
  1624F30 Counter

1624G00 Flow Metering
  1624G10 V-Notch Weir
  1624G20 Float and Cable
  1624G30 Sending/Receiving Transmitters
  1624G40 Totalizer
  1624G50 Recorder/Indicator

1624H00 Automatic Sampling
  1624H10 Tubing
  1624H20 Sampler
APPENDIX A
LIST OF COMPONENTS

1624100 Sand Filtration
1624110 Backwash Pump
1624120 Pump Motor
1624130 Automatic Valve Operator and Valve
1624140 Surface Wash System
1624150 Underdrain System

1624J00 Sludge Drying Bed
1624J10 Piping/Channels
1624J20 Basin
1624J30 Underdrain
1624J40 Sand

1624K00 Anaerobic Digester
1624K10 Tank
1624K20 Tank Cover-Fixed
1624K30 Tank Cover-Floating
1624K40 Heat Exchanger
1624K50 Pressure and Vacuum Relief Valves
1624K60 Flame Arrestor
1624K70 Instrumentation
1624K80 Condensate Trap
1624K90 Recirculation Pump
1624KA0 Gas Compressor
1624KB0 Gas Meter

1624L00 Vacuum Filtration
1624L10 Sludge Vat
1624L20 Filter Drum
1624L30 Filter Cloth
1624L40 Agitator
1624L50 Vacuum Pump
1624L60 Filtrate Pump
1624L70 Vacuum Control Valve
1624L80 Sludge Cake Conveyor
APPENDIX A
LIST OF COMPONENTS

1624L90  Motor
1624LA0  Variable Speed Drive

1624M00  Centrifuge
1624M10  Rotating Bowl
1624M20  Rotating Conveyor
1624M30  Variable Speed Drive
1624M40  Motor

1624N00  Filter Press
1624N10  Filter Cloth
1624N20  Filter Plates
1624N30  Frame
1624N40  Closing Gear
1624N50  Motor
1624N60  Sludge Pump
1624N70  Piping

1624P00  Belt Pressure Filter
1624P10  Belt
1624P20  Scraping Blade
1624P30  Drive Mechanism
1624P40  Drive Motor
Appendix B

TASK STATEMENT OUTLINE
APPENDIX B
TASK OUTLINE

1624A44 replace check valve
1624A45 replace piston rings
1624A46 replace v-belts
1624A47 overhaul
1624A50 Centrifugal Pump
  1624A51 lubricate
  1624A52 replace seals and packing
  1624A53 replace coupling
  1624A54 replace v-belts
  1624A55 disassemble and check impeller
  1624A56 replace impeller
  1624A57 replace bearings
  1624A58 overhaul
1624A60 Rotary Positive Displacement Pump
  1624A61 lubricate
  1624A62 disassemble and check rotor clearance
  1624A63 replace rotor
  1624A64 replace coupling
  1624A65 replace bearings
  1624A66 replace v-belts
  1624A67 overhaul
1624A70 Diaphragm Pump
  1624A71 lubricate
  1624A72 disassemble and clean check valve
  1624A73 replace check valve
  1624A74 replace diaphragm
  1624A75 replace compressor air filters
  1624A76 repair air compressor
  1624A77 overhaul air compressor
  1624A78 overhaul pump
  1624A79 preventive maintenance on air compressor
1624A80 Grinder Pump
  1624A81 lubricate
  1624A82 resurface cutters
  1624A83 replace cutters
APPENDIX B
TASK OUTLINE

1624940 Pressure Reducing Valve
   1624941 clean and adjust
   1624942 replace diaphragm
   1624943 replace

1624950 Automatic Controls
   1624951 clean and calibrate
   1624952 replace

1624960 Booster Pump
   1624961 lubricate
   1624962 replace bearings and packing
   1624963 replace sleeve
   1624964 overhaul

1624A00 Sludge Pumping

1624A10 Piping
   1624A11 flush piping
   1624A12 disassemble and rod out
   1624A13 repair leaks
   1624A14 repack valves
   1624A15 replace valves
   1624A16 clean and paint

1624A20 Pump Motor
   1624A21 lubricate
   1624A22 clean, adjust, and calibrate controls
   1624A23 replace controls
   1624A24 replace/rewind motor

1624A30 Adjustable Speed Drive
   1624A31 lubricate
   1624A32 replace seals
   1624A33 replace lubricant
   1624A34 overhaul

1624A40 Plunger Pump
   1624A41 lubricate
   1624A42 replace packing
   1624A43 replace coupling
APPENDIX B
TASK OUTLINE

1624823 replace worn or broken chain link
1624824 replace bearings
1624825 replace worn/broken chain and sprockets
1624826 overhaul
1624830 Sludge Collector Drive
   1624831 replace lubricant
   1624832 lubricate
   1624833 paint
   1624834 replace oil seals
   1624835 replace shear pin
   1624836 overhaul
1624840 Scum Collector
   1624841 replace worn or broken flights
   1624842 replace corroded hopper
   1624843 unplug hopper
   1624844 replace
1624850 Sludge Collector Drive Motor
   1624851 lubricate bearings
   1624852 replace/rewind motor

1624900- Chlorination
1624910 Basin
   1624911 dewater, clean and repair
   1624912 dewater and clean
1624920 Chlorine Injectors
   1624921 disassemble and clean
   1624922 replace piping
   1624923 replace jets
   1624924 overhaul
1624930 Chlorinator
   1624931 clean, inspect and calibrate
   1624932 replace flexible tubing
   1624933 repair leaks
   1624934 replace
APPENDIX B
TASK OUTLINE

1624621 remove from tank, inspect and clean
1624622 repair leaks

1624630 Air Blower
   1624631 clean and check pressure relief valve
   1624632 lubricate bearings
   1624633 replace belts
   1624634 paint
   1624635 overhaul
   1624636 drain, flush, refill oil reservoir

1624640 Blower Motor
   1624641 lubricate bearings
   1624642 replace/rewind

1624650 Air Filter System
   1624651 clean/replace air filter elements

1624700 Aeration Tank - Mechanical Aerator
   1624710 Aerator
      1624711 lubricate
      1624712 repair/replace impellers
      1624713 replace bearings
      1624714 replace coupling

1624720 Aerator Motor
   1624721 lubricate bearings
   1624722 replace/rewind motor

1624730 Basin
   1624731 dewater, clean, repair cracks & spalling
   1624732 dewater and clean

1624800 Secondary Clarifier
   1624810 Basin
      1624811 dewater, clean, repair cracks & spalling
      1624812 dewater and clean

1624820 Sludge Collector Mechanism
   1624821 lubricate chain, bearings
   1624822 replace worn or broken flights
APPENDIX B
TASK OUTLINE

1624342 replace corroded gates
1624343 clean and flush channel

1624400 Primary Settling
1624410 Basin
   1624411 dewater, clean, repair cracks & spalling
   1624412 dewater and clean
1624420 Sludge Collector Mechanism
   1624421 lubricate chain, bearings
   1624422 replace worn or broken flights
   1624423 replace worn or broken chain link
   1624424 replace bearings
   1624425 replace worn/broken chain and sprockets
   1624426 overhaul
1624430 Sludge Collector Drive
   1624431 replace oil
   1624432 lubricate
   1624433 paint
   1624434 replace oil seals
   1624435 replace shear pin
   1624436 overhaul
1624440 Scum Collector
   1624441 replace worn or broken flights
   1624442 replace corroded hopper
   1624443 unplug hopper
   1624444 replace
1624450 Sludge Collector Drive Motor
   1624451 lubricate bearings
   1624452 replace/rewind motor

1624600 Aeration Tank - Diffused Aeration
1624610 Basin
   1624611 dewater, clean, repair cracks & spalling
   1624612 dewater and clean
1624620 Air Distribution System
APPENDIX B
TASK OUTLINE

1624220 Gear Box
  1624221 lubricate
  1624222 change lubricant
  1624223 replace gears
  1624224 replace coupler
  1624225 replace oil seals
  1624226 clean and paint housing

1624230 Cutting Bars and Screen
  1624231 inspect and adjust cutters
  1624232 sharpen cutting bars
  1624233 replace worn cutting bars
  1624234 unclog jammed mechanism

1624240 Channel
  1624241 clean, repair cracks & spalling
  1624242 replace corroded gates
  1624243 clean and flush channel

1624300 Screening

1624310 Bars
  1624311 repair broken/corroded bar
  1624312 replace bars

1624320 Rake Mechanism
  1624321 lubricate bearings and chain
  1624322 replace bearings
  1624323 replace worn/broken chain links
  1624324 replace worn/broken rake tines
  1624325 repair worn/broken screen
  1624326 overhaul

1624330 Rake Mechanism Motor
  1624331 clean and adjust controls
  1624332 lubricate bearings
  1624333 replace/rewind motor
  1624334 replace controls

1624340 Channel
  1624341 clean, repair cracks & spalling

B-9
APPENDIX B
TASK OUTLINE

1624000 SEWAGE TREATMENT PLANT

1624100 Raw wastewater Pumping
1624110 Centrifugal Pump
  1624111 lubricate bearings
  1624113 replace packing/seals
  1624114 replace coupling
  1624115 replace v-belts
  1624116 disassemble and inspect
  1624117 replace impeller
  1624118 replace bearings
  1624119 overhaul

1624120 Pneumatic Ejector
  1624121 lubricate pilot valve and linkage
  1624122 clean compressor air strainer
  1624123 PM air compressor
  1624124 overhaul air compressor
  1624125 clean and paint
  1624126 overhaul

1624130 Piping
  1624131 flush
  1624132 repair leaks
  1624133 repack valve
  1624134 replace valve
  1624135 replace check valve
  1624136 PM on check valve

1624140 Sewage Pump Motor
  1624141 lubricate bearings
  1624142 replace/rewind
  1624143 clean and adjust controls
  1624144 replace controls

1624200 Comminutation

1624210 Comminutor Motor
  1624211 lubricate bearings
  1624212 replace/rewind motor
APPENDIX B
TASKOUTLINE

1616850  Agitator/Mixer
  1616851  lubricate
  1616852  replace bearings
  1616853  replace eccentric gear
  1616854  repair framing
  1616855  repair blade
  1616856  replace blades
  1616857  overhaul

1616860  Conveyor
  1616861  lubricate
  1616862  replace bearings
  1616863  adjust and align belt
  1616864  repair conveyor belt
  1616865  replace conveyor belt
  1616866  repair framing
  1616867  overhaul

1616870  Motor
  1616871  lubricate
  1616872  replace/rewind

1616880  Slaking Tank
  1616881  clean and paint
  1616882  repair walls and bottom
  1616883  repair baffle
  1616884  replace

1616890  Metering Pump
  1616891  preventive maintenance
  1616893  repair
  1616894  replace

B-7
APPENDIX B
TASKOUTLINE

1616730 Adjustable Speed Drive
   1616731 lubricate
   1616732 replace seals
   1616733 replace lubricant
   1616734 overhaul

1616740 Centrifugal Pump
   1616741 lubricate
   1616742 replace seals and packing
   1616743 replace coupling
   1616744 replace v-belts
   1616745 disassemble and check impeller
   1616746 replace impeller
   1616747 replace bearings
   1616748 overhaul

1616800 Chemical Feed System
   1616810 Storage Bin and Cyclone
      1616811 clean and paint
      1616812 repair walls
      1616813 replace
   1616820 Vibrator
      1616821 lubricate
      1616822 replace bearings
      1616823 repair vibrating plate
      1616824 replace plate
   1616830 Screw Dry Chemical Feeder
      1616831 lubricate
      1616832 replace belts
      1616833 replace bearings
      1616834 replace
   1616840 Piping
      1616841 clean and flush
      1616842 repair
      1616843 replace
APPENDIX B
TASK OUTLINE

1616620 Chlorinator
   1616621 clean, inspect and calibrate
   1616622 replace flexible tubing
   1616623 repair leaks
   1616624 replace

1616630 Pressure Reducing Valve
   1616631 clean and adjust
   1616632 replace diaphragm
   1616633 replace

1616640 Automatic Controls
   1616641 clean and calibrate
   1616642 replace

1616650 Injector Booster Pump
   1616651 lubricate
   1616652 replace bearings and packing
   1616653 replace sleeve
   1616654 overhaul

1616700 Sludge Pumping
1616710 Piping
   1616711 flush piping
   1616712 disassemble and rod out
   1616713 repair leaks
   1616714 repack valves
   1616715 replace valves
   1616716 clean and paint

1616720 Pump Motor
   1616721 lubricate
   1616722 clean, adjust, and calibrate controls
   1616723 replace controls
   1616724 replace/rewind motor
APPENDIX B

TASK OUTLINE

1616540 Rate Control Valve
   1616541 lubricate and adjust
   1616542 calibrate control
   1616543 repack stem
   1616544 repair
   1616545 replace

1616550 Backwash Pumps
   1616551 lubricate
   1616552 disassemble and inspect
   1616553 replace impeller
   1616554 replace coupling
   1616555 replace shaft
   1616556 repair housin
   1616557 replace seals and packing
   1616558 overhaul

1616560 Surface Wash System
   1616561 repair piping
   1616562 replace piping
   1616563 repair nozzles
   1616564 replace nozzles
   1616565 repair controls
   1616566 replace controls
   1616567 replace

1616570 Pump Motor
   1616571 lubricate
   1616572 replace/rewind

1616600 Chlorination and Flouridation
   1616610 Chlorine Injectors
      1616612 replace piping
      1616613 replace jets

B-4
APPENDIX B
TASK OUTLINE

1616420 Sludge Collector Mechanism
   1616421 lubricate chain, bearings
   1616422 replace worn or broken flights
   1616423 replace worn or broken chain link
   1616424 replace bearings
   1616425 overhaul

1616430 Sludge Collector Drive
   1616431 replace oil
   1616432 replace shear pin
   1616433 paint
   1616434 replace oil seals
   1616435 overhaul
   1616436 lubricate

1616440 Sludge Collector Drive Motor
   1616441 lubricate bearings
   1616442 replace/rewind motor

1616500 Filtration, Ion Exchange, Activated Carbon
   1616510 Concrete Basin
      1616511 dewater, clean and patch
      1616512 dewater and clean
   1616520 Steel Tank
      1616521 clean and paint
      1616522 repair leaks
   1616530 Underdrain Piping
      1616532 repair leaks
      1616533 repack valves
      1616534 replace valves
      1616535 replace piping
APPENDIX B
TASKOUTLINE

1616230  Mixer
  1616231  lubricate
  1616232  repair mixing blades
  1616233  replace mixing blades
  1616234  replace mixing motor
  1616235  replace mixer

1616300  Flocculation
  1616310  Basin
    1616311  dewater, clean and patch
    1616312  dewater, clean
  1616320  Flocculator
    1616321  lubricate
    1616322  repair paddles
    1616323  replace paddles
    1616324  replace bearings
    1616325  replace v-belts
    1616326  repair variable speed drive
    1616327  replace variable speed drive lubricant
    1616328  replace
  1616330  Flocculator Motor
    1616331  lubricate
    1616332  replace/ rewind
    1616333  clean and adjust controls
    1616334  replace controls
    1616335  replace brushes/bearings

1616400  Clarification
  1616410  Basin
    1616411  dewater, clean, repair cracks & spalling
    1616412  repair baffles
    1616413  replace baffles
    1616414  dewater and clean
APPENDIX B
TASK OUTLINE

1616000 WATER TREATMENT PLANT

1616100 Pumping
  1616110 Centrifugal Pump
     1616111 lubricate
     1616112 replace coupling
     1616113 replace seals and packing
     1616114 replace v-belts
     1616115 disassemble and inspect impeller
     1616116 replace impeller
     1616117 replace housing
     1616118 replace bearings
     1616119 overhaul
  1616120 Piping
     1616122 repair leaks
     1616123 replace
  1616130 Valves
     1616131 repack
     1616133 replace
  1616140 Pump Motor
     1616141 lubricate
     1616142 replace/rewind
     1616143 clean and adjust controls
     1616144 replace controls

1616200 Rapid Mixer
  1616210 Chamber
     1616211 dewater and clean
     1616212 repair leaks
     1616213 repair orifice plate
     1616214 replace orifice plate
  1616220 Mixing Tank
     1616221 dewater, clean and repair
     1616222 dewater and clean
APPENDIX B
TASK OUTLINE

1624A84 replace seals and packing
1624A85 replace bearings
1624A86 overhaul pump

1624B00 Aerobic Sludge Digestion
1624B10 Basin
   1624B11 dewater, clean and repair
   1624B12 dewater and clean
1624B20 Air Distribution System
   1624B21 disassemble and unclog
   1624B22 repair leaks
   1624B23 replace nozzles
   1624B24 replace piping
1624B30 Air Compressor
   1624B31 lubricate
   1624B32 clean and check pressure relief valve
   1624B33 replace belts
   1624B34 paint
   1624B35 overhaul
   1624B36 drain, flush, refill oil
1624B40 Compressor Motor
   1624B41 lubricate bearings
   1624B42 replace/rewind
1624B50 Mechanical Aerator
   1624B51 lubricate
   1624B52 repair/replace impellers
   1624B53 replace bearings
   1624B54 replace coupling
1624B60 Mechanical Aerator Motor
   1624B61 lubricate bearings
   1624B62 replace/rewind motor

1624C00 Trickling Filter
1624C10 Retaining Structure
   1624C11 clean and patch structure
APPENDIX B
TASK OUTLINE

1624C12 repair leaks
1624C20 Distributor
   1624C21 lubricate
   1624C22 replace lubricant and adjust guy rods
   1624C23 flush nozzles and laterals
   1624C24 replace nozzles
   1624C25 replace bearings and seals
   1624C26 overhaul
1624C30 Undrain System
   1624C31 flush clean

1624D00 Rotating Biological Contactor (RBC)
   1624D10 RBC Motor
      1624D11 lubricate
      1624D12 replace/rewind
   1624D20 Belt Drive
      1624D21 lubricate
      1624D22 replace belts
      1624D23 replace sheaves
   1624D30 Gear Reducer
      1624D31 lubricate
      1624D32 replace seals
      1624D33 replace lubricant
      1624D34 overhaul
   1624D40 Chain Drive
      1624D41 lubricate
      1624D42 replace lubricant
      1624D43 replace chain and sprockets
      1624D44 replace chain link
      1624D46 overhaul
   1624D50 Tank Enclosure
      1624D51 repair leaks
      1624D52 dewater and clean
      1624D53 paint
APPENDIX B
TASK OUTLINE

1624D60 Rotating Plastic Media
  1624D61 lubricate bearings
  1624D62 replace bearings
  1624D63 repair shaft
  1624D64 replace shaft

1624E00 Stabilization Lagoon
  1624E10 Earthen Basin
    1624E11 repair basin walls
    1624E12 dewater and remove solids
  1624E20 Concrete Basin
    1624E21 repair basin walls
    1624E22 dewater and remove solids
  1624E30 Diffused Air Distribution System
    1624E31 remove from tank, inspect and clean
    1624E32 repair leaks
  1624E40 Air Compressor
    1624E41 clean and check pressure relief valve
    1624E42 lubricate bearings
    1624E43 replace belts
    1624E44 paint
    1624E45 overhaul
    1624E46 change lubricant
  1624E50 Compressor Motor
    1624E51 lubricate bearings
    1624E52 replace/rewind motor
  1624E60 Mechanical Aerator
    1624E61 lubricate
    1624E62 repair/replace impellers
    1624E63 replace bearings
    1624E64 replace coupling
  1624E70 Aerator Motor
    1624E71 lubricate bearings
    1624E72 replace/rewind motor
APPENDIX B
TASK OUTLINE

1624F00 Dosing Tank
   1624F10 Tank
      1624F11 drain and clean
      1624F12 repair leaks
   1624F20 Piping
      1624F21 flush
      1624F22 repair leaks
      1624F23 repack valve
      1624F24 replace valve
      1624F25 replace protective coating on piping and valves
      1624F26 overhaul
   1624F30 Counter
      1624F31 clean, oil and adjust
      1624F32 replace

1624G00 Flow Metering
   1624G10 V-Notch Weir
      1624G11 clean and level
      1624G12 replace
   1624G20 Float and Cable
      1624G21 clean, oil, adjust, and calibrate
      1624G22 replace
   1624G30 Sending/Receiving Transmitters
      1624G31 calibrate
      1624G32 replace
   1624G40 Totalizer
      1624G41 calibrate
      1624G42 replace
   1624G50 Recorder/Indicator
      1624G51 calibrate
      1624G52 replace pen and ink
      1624G53 replace
APPENDIX B
TASK OUTLINE

1624H00 Automatic Sampling
1624H10 Tubing
  1624H11 disassemble and flush
  1624H12 replace
1624H20 Sampler
  1624H21 PM by factory representative
  1624H22 repairs
  1624H23 replace

1624I00 Sand Filtration
1624I10 Backwash Pump
  1624I11 lubricate bearings
  1624I13 replace packing and seals
  1624I14 replace coupling
  1624I15 replace v-belts
  1624I16 disassemble and check impeller
  1624I17 replace impeller
  1624I18 replace bearings
  1624I19 overhaul
1624I20 Pump Motor
  1624I21 lubricate
  1624I22 replace/rewind
1624I30 Automatic Valve Operator and Valve
  1624I32 replace packing
  1624I33 rebuild operator
  1624I34 replace valve
1624I40 Surface Wash System
  1624I41 unclog orifices
  1624I42 replace orifices
  1624I43 repair leaking piping
1624I50 Underdrain System
  1624I52 replace
APPENDIX B
TASK OUTLINE

1624J00 Sludge Drying Bed
  1624J10 Piping/Channels
    1624J11 flush
    1624J12 repair
    1624J13 replace
  1624J20 Basin
    1624J21 clean
    1624J22 repair
  1624J30 Underdrain
    1624J31 flush
    1624J32 repair
    1624J33 replace
  1624J40 Sand
    1624J41 till and relevel
    1624J42 replace

1624K00 Anaerobic Digestor
  1624K10 Tank
    1624K11 empty and clean
    1624K12 repair walls
  1624K20 Tank Cover-Fixed
    1624K21 clean and inspect
    1624K22 repair and patch
  1624K30 Tank Cover-Floating
    1624K31 clean and inspect
    1624K32 repair and patch
    1624K33 renew side skirts
    1624K34 replace
  1624K40 Heat Exchanger
    1624K41 clean tubes
    1624K42 repair tubes
    1624K43 replace tube bundle
    1624K44 repair piping
    1624K45 replace piping
    1624K46 flush piping
APPENDIX B
TASK OUTLINE

1624K47 clean and calibrate temperature controls
1624K49 replace temperature control
1624K4A perform hydrostatic test and certification
1624K50 Pressure and Vacuum Relief Valves
   1624K51 clean and check operation
   1624K52 replace
1624K60 Flame Arrestor
   1624K61 clean and inspect
   1624K62 replace
1624K70 Instrumentation
   1624K71 clean and calibrate
   1624K72 repair
   1624K73 replace
1624K80 Condensate Trap
   1624K81 clean and inspect
   1624K82 repair
   1624K83 replace
1624K90 Recirculation Pump
   1624K91 lubricate
   1624K92 replace impeller
   1624K93 replace motor
   1624K94 replace pump
1624KA0 Gas Compressor
   1624KA1 preventive maintenance, inspection, alignment
   1624KA2 repair
   1624KA3 replace
1624KB0 Gas Meter
   1624KB1 preventative maintenance
   1624KB2 repair
   1624KB3 replace
## APPENDIX B
### TASK OUTLINE

<table>
<thead>
<tr>
<th>Task Code</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1624L00</td>
<td><strong>Vacuum Filtration</strong></td>
</tr>
<tr>
<td>1624L10</td>
<td>Sludge Vat</td>
</tr>
<tr>
<td>1624L11</td>
<td>dewater, clean and inspect</td>
</tr>
<tr>
<td>1624L12</td>
<td>repair</td>
</tr>
<tr>
<td>1624L13</td>
<td>overhaul</td>
</tr>
<tr>
<td>1624L20</td>
<td>Filter Drum</td>
</tr>
<tr>
<td>1624L21</td>
<td>preventive maintenance</td>
</tr>
<tr>
<td>1624L22</td>
<td>repair drum</td>
</tr>
<tr>
<td>1624L23</td>
<td>replace drum</td>
</tr>
<tr>
<td>1624L24</td>
<td>lubricate shaft bearings</td>
</tr>
<tr>
<td>1624L25</td>
<td>replace bearings</td>
</tr>
<tr>
<td>1624L26</td>
<td>repair shaft</td>
</tr>
<tr>
<td>1624L27</td>
<td>replace shaft</td>
</tr>
<tr>
<td>1624L30</td>
<td>Filter Cloth</td>
</tr>
<tr>
<td>1624L31</td>
<td>repair cloth</td>
</tr>
<tr>
<td>1624L32</td>
<td>replace</td>
</tr>
<tr>
<td>1624L40</td>
<td>Agitator</td>
</tr>
<tr>
<td>1624L41</td>
<td>preventive maintenance</td>
</tr>
<tr>
<td>1624L42</td>
<td>repair</td>
</tr>
<tr>
<td>1624L43</td>
<td>replace</td>
</tr>
<tr>
<td>1624L50</td>
<td>Vacuum Pump</td>
</tr>
<tr>
<td>1624L51</td>
<td>lubricate</td>
</tr>
<tr>
<td>1624L52</td>
<td>repair</td>
</tr>
<tr>
<td>1624L53</td>
<td>replace</td>
</tr>
<tr>
<td>1624L60</td>
<td>Filtrate Pump</td>
</tr>
<tr>
<td>1624L61</td>
<td>lubricate</td>
</tr>
<tr>
<td>1624L62</td>
<td>replace seals/packing</td>
</tr>
<tr>
<td>1624L63</td>
<td>replace coupling</td>
</tr>
<tr>
<td>1624L64</td>
<td>replace v-belts</td>
</tr>
<tr>
<td>1624L65</td>
<td>disassemble and check impeller</td>
</tr>
<tr>
<td>1624L66</td>
<td>replace impeller</td>
</tr>
<tr>
<td>1624L67</td>
<td>replace bearings</td>
</tr>
<tr>
<td>1624L68</td>
<td>overhaul</td>
</tr>
</tbody>
</table>
APPENDIX B
TASK OUTLINE

1624L70 Vacuum Control Valve
   1624L71 disassemble, clean and adjust
   1624L72 repair
   1624L73 replace

1624L80 Sludge Cake Conveyor
   1624L81 lubricate
   1624L82 replace bearings
   1624L83 adjust and align belt
   1624L84 repair conveyor belt
   1624L85 replace conveyor belt
   1624L85 replace conveyor belt
   1624L85 repair framing

1624L90 Motor
   1624L91 lubricate
   1624L92 replace/rewind

1624LA0 Variable Speed Drive
   1624LA1 lubricate
   1624LA2 replace lubricant
   1624LA3 replace seals
   1624LA4 overhaul

1624M00 Centrifuge
   1624M10 Rotating Bowl
      1624M11 lubricate
      1624M12 replace bearings
      1624M13 repair bowl walls
      1624M14 overhaul
   1624M20 Rotating Conveyor
      1624M21 preventive maintenance
      1624M22 repair
      1624M23 overhaul
   1624M30 Variable Speed Drive
      1624M31 lubricate
      1624M32 replace lubricant
      1624M33 replace seals
APPENDIX B
TASK OUTLINE

1624M34 overhaul
1624M40 Motor
  1624M41 lubricate
  1624M42 replace/rewind

1624N00 Filter Press
  1624N10 Filter Cloth
    1624N11 repair cloth
    1624N12 replace
  1624N20 Filter Plates
    1624N21 preventive maintenance
    1624N22 repair
    1624N23 replace
  1624N30 Frame
    1624N31 clean and paint
    1624N32 repair
    1624N33 replace
  1624N40 Closing Gear
    1624N41 lubricate
    1624N42 repair
    1624N43 replace gear
    1624N44 overhaul
  1624N50 Motor
    1624N51 lubricate
    1624N52 replace/rewind
  1624N60 Sludge Pump
    1624N61 lubricate
    1624N62 disassemble and inspect
    1624N63 replace impeller
    1624N64 replace motor
    1624N65 replace coupling
    1624N66 overhaul
    1624N67 replace seals/packing
APPENDIX B
TASK OUTLINE

1624N70 Piping
1624N71 flush
1624N72 repair leaks
1624N73 replace
1624N74 repack valves
1624N75 replace valves

1624P00 Belt Pressure Filter
1624P10 Belt
1624P11 repair belt
1624P12 replace belt
1624P13 lubricate drum bearings
1624P14 replace drum bearings
1624P15 adjust belt alignment
1624P16 repair drum
1624P17 replace drum
1624P18 overhaul
1624P20 Scraping Blade
1624P21 clean and adjust
1624P22 resurface edge
1624P23 replace

1624P30 Drive Mechanism
1624P31 lubricate
1624P32 replace lubricant
1624P33 replace seals
1624P34 overhaul

1624P40 Drive Motor
1624P41 lubricate
1624P42 replace/rewind motor
Appendix C

INSTRUCTIONS FOR DATA BASE ACCESS
INSTRUCTIONS FOR DATA BASE ACCESS

It is necessary for a potential user of the data base program used here to
be thoroughly familiar with the operating system of the computer and be able
to load and access D-Base III. Those instructions are beyond the scope of
this paper and are better learned from the manuals that accompany the
programs.

1. Load D-Base III. From the dot prompt (.) type “DO RN-MAIN”. A screen
will appear that asks for today’s date (Figure C-1). Type in the date
using the format month/day/year and hit the return key.

2. The next screen (Figure C-2) will give you four choices for functions to
perform and ask you to hit the appropriate number key. If you hit a key
that is not a choice, the screen will reappear. A “0” will bring you back
to the D-Base dot prompt.

3. If you want to add records, then you hit the “1” key. This action will
cause the next screen to appear (Figure C-3). This screen gives you the
option of adding records to the area file (1), the system file (2), the
subsystem file (3), the task data file (4), or return to the main menu (0)
by hitting the appropriate number key. The first three files were created
for use by CERL and probably are not of interest. To add input to the task
data file, hit the number “4” and the return key.

a. The next screen (Figure C-4) will ask you if you want to input data
(D), edit (E), or quit (Q). If you hit an "E", the program will put you into the edit mode (see that paragraph for details). If you hit the "Q", the program will bring you back to the previous screen. If you hit the "D", then it will continue in the add mode. Any other key will give you the screen back again.

b. Once you hit the "D" key, the program will ask you for the task code number (Figure C-5). Type in the seven digit number for the task code. The computer will use the first six digits to identify the component and ask you if it is correct (Figure C-6). If you type a "T" for yes it will proceed to the next menu (Figure C-7). If you type an "F" for no, it will go back to the previous menu.

c. If the computer does not find the component in the component file, it will generate a new screen (Figure C-8) that will ask you if you want to add ("A") to the component file, try ("T") another number or quit ("Q") to the main menu. Try will let you try another number and quit will bring you back to the main menu. Add will generate a new screen (Figure C-9) that asks you for the name of the component. When you type it in and hit the return key, the computer will go on with the next screen in the add mode (Figure C-7).

d. The screen shown in Figure C-7 asks you to input data to the task description code field, description of task field and unit of measure field. The task description code field is a code used to identify the task as preventive maintenance (PM), repairs (M/R), or replacement (REPLACE)
<table>
<thead>
<tr>
<th>Task Code: 0811102</th>
<th>Component: TANK-LESS WATER CLOSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsystem: FIXTURES</td>
<td>M/R UNPLUG CLOGGED LINE</td>
</tr>
<tr>
<td>Task Description:</td>
<td>FREQUENCY OF OCCURRENCE:</td>
</tr>
<tr>
<td>Unit of Measure:</td>
<td>1.33</td>
</tr>
<tr>
<td>Persons per Team:</td>
<td>A: 1.67</td>
</tr>
<tr>
<td>Trade:</td>
<td>E: 3.33</td>
</tr>
<tr>
<td>Equiv</td>
<td>L: 2.00</td>
</tr>
<tr>
<td>Labor Resources</td>
<td>Material Resources</td>
</tr>
<tr>
<td></td>
<td>Labor Hrs</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>SUMMARY</td>
<td>Resources</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Components Containing This Task:</td>
<td>1.</td>
</tr>
</tbody>
</table>

FIGURE C-16
<table>
<thead>
<tr>
<th>CASES</th>
<th>TASK</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>081101</td>
<td>REPLACE FLUSH VALVE</td>
<td></td>
</tr>
<tr>
<td>081102</td>
<td>UNPLUG CLOSET LINE</td>
<td></td>
</tr>
<tr>
<td>081103</td>
<td>OVERHAUL FLUSH VALVE</td>
<td></td>
</tr>
<tr>
<td>081104</td>
<td>REPLACE WATER CLOSET</td>
<td></td>
</tr>
<tr>
<td>081105</td>
<td>REPLACE FLUSH VALVE</td>
<td></td>
</tr>
<tr>
<td>081106</td>
<td>OVERHAUL FLUSH VALVE</td>
<td></td>
</tr>
<tr>
<td>081107</td>
<td>UNPLUG LINE</td>
<td></td>
</tr>
<tr>
<td>081108</td>
<td>REPLACE UTILITY</td>
<td></td>
</tr>
<tr>
<td>081109</td>
<td>REPLACE WASHER IN SPUD CONNECTION</td>
<td></td>
</tr>
<tr>
<td>081110</td>
<td>REPLACE WASHER IN FAUCET</td>
<td></td>
</tr>
<tr>
<td>081111</td>
<td>REPLACE SUPPORT RODS</td>
<td></td>
</tr>
<tr>
<td>081112</td>
<td>REPLACE FAUCETS</td>
<td></td>
</tr>
<tr>
<td>081113</td>
<td>CLEAN OUT STRAINER AND P TRAP</td>
<td></td>
</tr>
<tr>
<td>081114</td>
<td>REPLACE LAVATORY</td>
<td></td>
</tr>
<tr>
<td>081115</td>
<td>REPLACE WASHER IN SPUD CONNECTION</td>
<td></td>
</tr>
<tr>
<td>081116</td>
<td>REPLACE WASHER IN FAUCET</td>
<td></td>
</tr>
<tr>
<td>081117</td>
<td>REPLACE SUPPORT RODS</td>
<td></td>
</tr>
<tr>
<td>081118</td>
<td>REPLACE FAUCETS</td>
<td></td>
</tr>
<tr>
<td>081119</td>
<td>CLEAN OUT STRAINER AND P TRAP</td>
<td></td>
</tr>
<tr>
<td>081120</td>
<td>REPLACE LAVATORY</td>
<td></td>
</tr>
<tr>
<td>081121</td>
<td>REPLACE WASHER IN SPUD CONNECTION</td>
<td></td>
</tr>
<tr>
<td>081122</td>
<td>REPLACE WASHER IN FAUCET</td>
<td></td>
</tr>
<tr>
<td>081123</td>
<td>REPLACE SUPPORT RODS</td>
<td></td>
</tr>
<tr>
<td>081124</td>
<td>REPLACE FAUCETS</td>
<td></td>
</tr>
<tr>
<td>081125</td>
<td>CLEAN OUT STRAINER AND P TRAP</td>
<td></td>
</tr>
<tr>
<td>081126</td>
<td>REPLACE LAVATORY</td>
<td></td>
</tr>
<tr>
<td>081127</td>
<td>REPLACE WASHER IN SPUD CONNECTION</td>
<td></td>
</tr>
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<td>081128</td>
<td>REPLACE WASHER IN FAUCET</td>
<td></td>
</tr>
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<td>081129</td>
<td>REPLACE SUPPORT RODS</td>
<td></td>
</tr>
<tr>
<td>081130</td>
<td>REPLACE FAUCETS</td>
<td></td>
</tr>
<tr>
<td>081131</td>
<td>CLEAN OUT STRAINER AND P TRAP</td>
<td></td>
</tr>
<tr>
<td>081132</td>
<td>REPLACE LAVATORY</td>
<td></td>
</tr>
<tr>
<td>081133</td>
<td>REPLACE WASHER IN SPUD CONNECTION</td>
<td></td>
</tr>
<tr>
<td>081134</td>
<td>REPLACE WASHER IN FAUCET</td>
<td></td>
</tr>
<tr>
<td>081135</td>
<td>REPLACE SUPPORT RODS</td>
<td></td>
</tr>
<tr>
<td>081136</td>
<td>REPLACE FAUCETS</td>
<td></td>
</tr>
<tr>
<td>081137</td>
<td>CLEAN OUT STRAINER AND P TRAP</td>
<td></td>
</tr>
</tbody>
</table>

**BASIC TASK INFORMATION TABLE**

<table>
<thead>
<tr>
<th>INDEX NO. TO UNIT OF MEASURE</th>
<th>INDEX NO. TO TRADE</th>
<th>FREQUENCY OF OCCURRENCE</th>
<th>RESOURCES IN EQUIVALENT MAN HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Labor**
- **Material**
- **Equipment**
Basic Task Information Report for:

1) Water Treatment Plant
2) Sewage Treatment Plant
3) Flooring
4) All
0) Return to Previous Menu.

Enter Your Selection!
FIGURE C-12

Select the Data File You Wish to Use

1) System
2) Sub-System
3) Component
4) Task Data Information

0) Return to Previous Menu

Enter Your Selection

FIGURE C-13

Do you wish to print the:

1) Basic Task Information Table
2) Task Data Form

0) Return to Previous Menu

Enter your selection.
FIGURE C-11

FOR TASK CODE 9999999 :
Freq of Occur: H       Freq A:       Freq L:
Persons per team:     Trade-    Reference: Labor-
Reference: Equipment - Reference: Material-
Subtask Description:

Labor Hours:          .
Equp-Qu:              . UnCst:     . TtMtrCst:   . EquLbrHr:
% Comp Repl Cost:     .

Compts Cntng Task:
1st Component:        2nd Component:          3rd Component:
4th Component:        5th Component:
FIGURE C-9

COMPONENT

Today is 08/07/85

Task Code: 99999999
Compnt Dscr:

Enter the above requested information.

FIGURE C-10

Record No. 432
NOTES memo
TASK_DSCR
FIGURE C-7

Enter the following information:

Task Description Code
Description of Task
Unit of Measure

FIGURE C-8

TASK DATA FORM

08/07/85

TASK CODE NO :8888888:

Component not found. Enter <A>dd to Component Data File, <T>ry another number, or <Q>uit to Main Menu.
FIGURE C-5

TASK DATA FORM

08/07/85

+===================================================================================================+

TASK CODE NO : : :

+===================================================================================================+

FIGURE C-6

TASK DATA FORM

08/07/85

+===================================================================================================+

TASK CODE NO : 161611Y:
Component Descr : CENTRIFUGAL PUMP:

+===================================================================================================+

Is this the right component (T/F)? T

C-9
FIGURE C-3

Select the Data File you wish to use!

1. AREA
2. SYSTEM
3. SUBSYSTEM
4. TASK Data & Calculation
0. Return To Main Menu

Enter your selection!

FIGURE C-4

TASK DATA FORM

08/07/85

TASK CODE NO : :

Enter <D ata, <E dit Data, <Q uit to Main Menu

Enter -->
FIGURE C-1

* * * * * * * * * * * * * * * * * * * * * * * * * *
* DA CERL Program - WATER & WASTEWATER TREATMENT *
* COMPONENT AND TASK DATA BASE *
* * * * * * * * * * * * * * * * * * * * * * * * * *

Enter today's date:

/ /

FIGURE C-2

* * * * * * * * * * * * * * * * * * * * * * * * * *
* DA CERL Program - WATER & WASTEWATER TREATMENT *
* COMPONENT AND TASK DATA BASE *
* * * * * * * * * * * * * * * * * * * * * * * * * *

=== Select one of the following ===

0 EXIT to System Menu
1 Add Records
2 Search/Edit/Delete Records
3 Generate Reports
4 File Maintenance

Enter your selection here?

C-7
files. The re-index selection does not work and should not be selected. Re-indexing can be done directly from the dot prompt in D-Base.

b. Selection of the backup files option will generate a new screen (Figure C-18) that asks you which file you wish to backup. Note that the task data file has been divided in half because it will not all fit on one floppy disk. Follow the directions to obtain your backup floppy disk. It takes approximately ten minutes for the task data files to be copied.
a. The basic task information table provides columns of a few fields from the task data file for all task codes called. It can be obtained by hitting the "1" key of the screen shown in Figure C-13 which in turn will generate a new screen (Figure C-14). In this screen, the program asks you to select which report you want. Note that flooring is one of the other sections of the CERL project and selection of that choice will not generate any report as that particular file is empty. A sample of the basic information table is shown in Figure C-15.

b. The task data form provides an individual sheet for each task code number. The form is designed to provide the reader with all the pertinent information about any task statement. A sample is provided as Figure C-16. There will be one or two more screens after that shown in Figure C-13 that give you the opportunity to tailor the content of the report depending on your needs. You can get a report with sheets for only one task record, one with all, or one with a portion of the file.

6. File maintenance is an important function that is provided from the main menu. It allows you to back up your files onto floppy disks which can be put in a safe place. If anything were to happen to the hard disk in the computer, your backup copies could be used to replace those files lost. Backup has been done weekly for the CERL project.

a. Select the file maintenance mode by hitting the "4" key in the main menu. This action will generate a new screen (Figure C-17) which asks you if you wish to make backup copies of your files or re-index data.
the main menu (Figure C-2) and hit the "2" key. The screen that will be generated (Figure C-12) will ask you which file you wish to use: the system, sub-system, component, or task data information files. Whichever of the files you decide to enter, the next screen will ask you to enter the appropriate number of the record you want. For example, for the task data information file the program needs the seven digit task code number and for the component file the program needs the six digit component number. Refer to Appendices A and B if you do not have the appropriate number.

To revise information in a record, position the cursor over the incorrect information and type over it. The new information is not saved to the disk until the next screen is generated. Until that point you can revise as often as you wish without actually changing the record. But once you go to the next screen, it is necessary to leave the record and re-enter it if you decide the revision was incorrect.

5. Reports can be generated by returning to the main menu (Figure C-2) and hitting the "3" key. This action will call up a menu screen (Figure C-13) for the two types of reports available: basic task information table or a task data form. The format for both of the reports was dictated by CERL for its purposes and requires a 15 inch wide platen printer. It is possible that a program such as "Sidewinder", that turns a printed page sideways, could be used since the document produced while 14 inches wide is only 8.5 inches long. Use of such a program was not investigated.
action. The appropriate code should be entered. The description of task entry is self explanatory. The unit of measure field is limited to the following entries: one each (I-CT), per linear foot (I-LF), per square foot (I-SF), and per 1000 linear feet (3-LF).

d. After this information is entered, the next screen appears (Figure C-10). This screen repeats the task description entered previously and has a memo field. The memo field is represented by the word “memo” and is used to document how the estimates were arrived at. To enter the memo field, put the cursor over the word “memo” and hit the control-page down keys in combination. This action will bring up a blank page on which information can be entered, similar to that used in a word processor. When you are finished with the memo field, hit the combination of control - page up keys. Next, hit the page down key to generate the final screen in the add mode (Figure C-11).

e. Entry of information into this screen is self explanatory. It should be noted that much of the information only is entered for the purposes of the CERL project and can be omitted if not necessary for your purposes. Upon completion of this screen, the program will give you the chance to add another record or go back to the main menu.

4. The edit mode allows you to review and revise each record to correct errors and update information. It uses many of the same screens as the add mode, only there is information already entered in each of the fields. For example, in the task data information file edit will call up the screens shown in Figures C-7, C-10, and C-11. To edit a file, start from
FIGURE C-17

Do you wish to:

1) Make backup copies of your files?
2) Re-index data files?
3) Return to Previous Menu?

Enter Your Selection

FIGURE C-18

Select the file you wish to back-up:

1) Task Data File for >1624964
2) System Data File
3) Sub-Task Data File
4) Component Data File
5) Task Data File for <1624964

0) RETURN to Previous Menu

Enter Your Selection
Appendix D

SAMPLE LETTER
Robert Olt
Lotepro Corp.
1140 Ave of the Americas
New York, NY 10035

Dear Mr. Olt:

Civil Engineering personnel at The Pennsylvania State University are performing a study of water and sewage treatment plants to develop factors to be used in determining annual maintenance and repair costs over the life of a facility. In order to accomplish this task, it is necessary to compile industry accepted standards for maintenance, repair and replacement costs attributable to facilities and equipment normally found in water and sewage treatment plants. It is intended that task statements will be developed for each of the maintenance/repair actions required. Data on the frequency of occurrence and time necessary for completion of a task will be gathered. These data will be used to generate predicted maintenance and repair costs for treatment plants of various sizes.

A second aspect of this study is to review the various management systems used to coordinate maintenance and repair activities. The revolutionary hardware advances recently made in the microcomputer industry have created a strong market for off-the-shelf software packages that can be used to manage the limited resources available for maintenance of facilities. Products and services such as yours are rapidly becoming available and once in place are an indispensable tool for plant managers.

Your firm is being contacted to obtain information on the products and services that you offer and a list of plants that are using any of these products. The principal researcher for this study is Mr. Roland Moreau, an Environmental Engineering graduate student in the Department of Civil Engineering. He can be reached by writing to the above address or by calling 814/865-1226 during afternoon hours. If you have any information that could be of value to him or would like any of your products or services included in the study, please do not hesitate to contact him. All sources of information will be kept confidential if requested.

Your assistance in this matter is greatly appreciated.

Sincerely,

David A. Long, P.E.
Professor of Civil Engineering

DAL/ash
Appendix E

LIST OF ESTIMATING REFERENCES
Appendix E
List of Estimating References

15. Interview of Plant Personnel of Pennsylvania State University Wastewater Treatment Plant, University Park, Pennsylvania.
Appendix E
List of Estimating References

23. Interview of Plant Personnel of University Area Joint Authority Wastewater Treatment Plant, State College, Pennsylvania.

24. Interview of Plant Personnel of Mid Centre Authority Wastewater Treatment Plant, Milesburg, Pennsylvania.

25. Interview of Plant Personnel of Tyrone Regional Wastewater Treatment Plant, Tyrone, Pennsylvania.

30. Authors best engineering judgement.