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MICRO COMPUTER-ASSISTED PLANNING MODEL FOR SELECTION OF APPROPRIATE TECHNOLOGY IN WATER AND WASTE TREATMENT

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

MICRO COMPUTER-ASSISTED PLANNING MODEL FOR SELECTION OF APPROPRIATE TECHNOLOGY IN WATER AND WASTE TREATMENT

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

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BY

CLYDE LINCOLN ARNOLD, JR.

Norman, Oklahoma

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MICRO COMPUTER-ASSISTED PLANNING MODEL

FOR SELECTION OF APPROPRIATE TECHNOLOGY

IN WATER AND WASTE TREATMENT

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MICRO COMPUTER-ASSISTED PLANNING MODEL FOR SELECTION OF APPROPRIATE TECHNOLOGY IN WATER AND WASTE TREATMENT

CHAPTER I

INTRODUCTION

The United Nations has called for the expenditure of $133 billion[1] on water and waste treatment systems during the period 1981-1990, the "Water Decade." It is intended that the provision of safe water and adequate sanitation will significantly improve the health and well-being of the general population in developing countries. That intention will not be fulfilled unless treatment technology is selected which is maintainable, affordable, socially/culturally acceptable, and operable at the local site. Integral to the success of the investment are four major factors:

i. The technology selected must be appropriate[2] to local resource availability,

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[1]Unless otherwise noted all dollar values are 1977 U.S.

[2]A glossary of terms is included as Appendix Y.

2. the technology selected must be responsive to local health conditions and social/cultural customs,

3. the technology selection process must be subjected to extensive sensitivity analysis prior to final selection in order to reduce the probability that inappropriate investment will occur, and

4. the technology selection process must provide a common frame of reference to encourage interaction between engineers/planners/health professionals/economists in developing countries and international financial organizations.

In developing countries current practice often results in the selection of technology that is inappropriate. Available evidence indicates that a significant factor in this inappropriate investment is the lack, or inefficient use, of existing information and experience from both developing and developed countries. This research provides a model which places emphasis on developing country applications by utilizing a modification and synthesis of water supply/sanitation treatment technology selection models currently used in the United States. The model is tested using data previously collected by University of Oklahoma/United States Agency for International Development (OU/AID) projects in Panama and Indonesia. The research documented by this dissertation represents an attempt to fulfill the four success factors cited previously.

The nature of the health problem in developing countries is virtually linked to the provision of adequate quantities of safe water supply and adequate sanitation. It has been estimated that approximately 80 percent of mortality and morbidity in developing countries is related to the availability of adequate/safe water and sanitation. The lack of adequate water and sanitation is a significant contributing factor in the annual death of 13 million children. The United Nations, its affiliates (World Health Organization, Pan American Health Organization, etc.) and other international organizations (World Bank, International Development Research Center, Agency for International Development, etc.) have expended considerable effort in estimating the magnitude of the water/sanitation/health problem and the investment required to ameliorate the problem. To provide minimal water and sanitation to all of the world's people, only 38 percent currently have minimal service, will require an investment of $133 billion dollars. In theory the cost of the investment should be compared to the quantified benefits estimated for each alternative. Unfortunately, this type of infrastructure investment cannot be directly correlated to quantifiable benefits. In practice individual water/sanitation investment programs are compared on the basis of qualitative benefits and/or the engineering cost of the alternate treatment schemes. Neither of these selection criteria has the property of logically leading to the selection of appropriate technology and the second criteria, engineering cost analysis, may seriously miscalculate the economic cost of the project. Unless technology can be selected which is appropriate for local operation and cognizant of local health conditions an expenditure of $133 billion dollars will not significantly improve the human condition in developing countries.

This research documents are interdisciplinary planning model which is structured to select the most appropriate water and/or sanitation treatment technology for a local site. The selected technology will be responsive to local health conditions and the selection process strongly encourages extensive sensitivity analysis prior to selection. The planning model provides a common frame of reference where a multidisciplinary group (engineers, planners, health professionals, economists, etc.) can interdependently interact to seek the most appropriate treatment scheme for an individual project. The selection process uses a systematic cost effectiveness analysis to display the range of technology suitable to local conditions and select the most appropriate technology based on the available data. Finally, the planning model uses high level technology (but appropriate, i.e., microcomputer hardware and systems analysis software) to aid in the selection of appropriate technology (indicating neither high or low level) in the water supply and sanitation technology field.

CHAPTER II

LITERATURE REVIEW

Introduction

The literature reviewed during this research has concentrated on water/sanitation technology selection models and the interdependent links between these types of models and economic development. The first section of the review will concentrate on four water/sanitation technology selection models current in the literature. Next, the review investigates the relationship between water supply treatment/sanitation technology and the public's health. Finally, the review explores the connection between water/sanitation technology, health, and economics.

There are four major water/sanitation treatment technology models current in the literature:

i. CAPDET, jointly sponsored by the Corps of Engineers (COE) and the Environmental Protection Agency (EPA).[1]

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[1]Corps of Engineers and U.S. Environmental Protection Agency, Computer-assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems: Users Guide, Report 430/9-79-01, May 1979.

ii. EXEC-OP, an EPA/Lewis Rossman developed model.[2]

iii. USAID/Reid, development sponsored by the United States Agency for International Development (USAID) with Professor George W. Reid.[3]

iv. WBANK, a model developed by the International Bank for Reconstruction and Development/The World Bank.[4]

The original theoretical work in the optimization area were based on chemical engineering optimization routines developed in the mid to late 1950's. Lynn, et al., gave the first application of systems analysis to water treatment/sanitation technology selection in early 1962.[5] The late 1960's and early 1970's resulted in the development of various optimization applications using linear programming, integer programming, dynamic programming, geometric programming, and non-linear

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[2]Lewis A. Rossman, "Synthesis of Waste Treatment Systems by Implicit Enumeration", Journal of the Water Pollution Control Federation, (January 1980): 148-160.

[3]George W. Reid and Katherine Coffey, eds., Appropriate Methods of Treating Water and Wastewater in Developing Countries, (Norman: Bureau of Water and Environmental Resources Research, University of Oklahoma, 1979).

[4]International Banks for Reconstruction and Development/The World Bank, Appropriate Technology for Water Supply and Sanitation, studies in low-cost water supply and sanitation (Washington, DC, 1980).

[5]Walter R. Lynn, et al., "Systems Analysis for Planning Wastewater Treatment Plants", Journal of the Water Pollution Control Federation, Vol. 34, No. 6 (June 1962): 565-581.

programming.[6] By the mid 1970's, COE had developed considerable expertise at the Waterways Experimental Station in Mississippi with computer applications and mathematical modeling in the general area of water treatment/sanitation technology. A joint effort was launched by COE and EPA to provide a planning model that could be used by municipalities to investigate alternate treatment schemes. The model resulting from that effort, CAPDET, relied on kinetic/mass balance equations and design data in unit processing routines to take a limited data input (the Wastewater flow and constituents of pollutation at minimum) and provide output data, such as the physical size of pipes, pumps, etc; expected effluent in both qualitative and quantative detail; plus extensive economic parameters, such as capital cost, operation and maintenance cost, energy cost, manpower required, materials required, etc.[7] The CAPDET draft report became available in 1976 but the use of the system was initially impeded by its formidability. Although a participant in the development and extention of CAPDET, the EPA had maintained an interest in water treatment/sanitation technology modeling by developing a wastewater

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[6] D. E. Evenson G. T. Orlob, J. R. Monzer, "Preliminary Selection of Waste Treatment Systems", Journal of the Water Pollution Control Federation, Vol. 41, No. 11 (November 1969): 1845-1858. Chia S. Shih and P. Krishnan, "Dynamic Optimization for Industrial Waste Treatment Design", Journal of the Water Pollution Control Federation, Vol. 41, No. 10 (October 1969): 1787-1802. Paul M. Berthouex and Lawrence B. Polksowski, "Optimum Waste Treatment Plant Design Under Uncertainty," Journal of the Water Pollution Control Federation, Vol. 42, No. 9 (September 1970): 1589-1613. B. J. Adams and D. Panagiotakopoulos, "Network Approach to Optimal Wastewater Treatment Design", Journal of the Water Pollution Control Federation, Vol. 49, No. 4 (April 1977): 623-632; Hans J. Rasmusen, "Simplified Optimization of Water Supply Systems," Journal of the Environmental Engineering Division, American Society of Civil Engineers, Vol. 102, No. EE2 (April 1976): 313-327.

[7] See Appendix A for a CAPDET example output.

treatment plant simulator entitled EXECUTIVE.[8] In the same period USAID encouraged Professor George W. Reid to initiate modeling efforts toward selection of water treatment/sanitation technology in developing countries. The USAID/REID effort lead to a field test of the model in Panama and Indonesia plus the demonstration of the model and field results in Panama, Guatemala, Peru, the Philippines, Indonesia, and Thailand during late 1979 and early 1980.[9] The separate EPA modeling effort which produced EXECUTIVE lead to the development in early 1980 of a wastewater treatment selection model, EXEC-OP, which uses the EXECUTIVE simulation model as a subroutine.[10] Meanwhile, the World Bank had initiated a modeling effort toward the selection of appropriate technology in water treatmemt and sanitation for developing countries. The first draft of that effort became publicly available in 1981 with final results scheduled to be published in mid 1982.[11] Table 1 contrasts the major differences between the four models. CAPDET provides the user with a maximum amount of detail both engineering and economic; however, it does not respond to the concept of appropriate technology

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[8]R. G. Eilers and Robert Smith, "Applications of Computer Programs in the Preliminary Design of Wastewater Treatment Facilities - Section II," EPA-600/2-78-1856, U. S. Environmental Protection Agency, Municipal Environmental Research Laboratory (Cincinnati, Ohio, 1978).

[9]Reid and Coffey, eds., Appropriate Methods; George W. Reid, Clyde L. Arnold, and Leale E. Streebin, Workbooks for Appropriate Technology Workshop, Bureau of Water and Environmental Resources Research, University of Oklahoma (April 1980).

[10]Rossman, Synthesis of Water Treatment Systems.

[11]The International Bank for Reconstruction and Development/The World Bank, Appropriate Technology.

TABLE 1

Parameter	Model: CAPDET	EXEC-OP	USAID/REID	World Bank
1. Unit Processes Fixed?	Yes	Yes	Yes	Yes
2. Total Number of Unit Processes	5	22	27	12
3. Treatment Trains Fixed	No	No	Yes	No
4. Uses Mass Balance and Process Kinetics	Yes	Yes	No	No
5. Includes Multiple Design Criteria	No	Yes	No[1]	No[1]
6. Optimization Technique	Complete Enumeration	Partial Enumeration	Screening	Screening
7. Recycles Sidestreams	No	Yes	No	No
8. Design Detail Provided	Very High	Medium	Low	Low
9. Allows User to Input Local Cost	Yes	No	Yes	Yes
10. Screens Processes on the Basis of Available Resources	No	No	Yes	Yes
11. Relative Computer Cost	Very High	Medium Low	Very Low	None
12. Type of Computer System Required	Large, Main Frame or Time Sharing	Mini	Micro-computer, Programmable Calculator, None	None
13. Coverage	Wastewater	Wastewater	Water, Waste	Water[2]

[1]Variations in design criteria are not systematically included but may be investigated using sensitivity analysis at little additional cost.

[2]Water treatment is mentioned but the technical detail concentrates on waste treatment.

nor does it deal with water treatment.[12] In addition, CAPDET is not structured for sensitivity analysis as an integral part of the modeling effort. Both CAPDET and EXEC-OP are oriented toward wastewater treatment plant design in the U.S. with EXEC-OP concentrating on a smaller group of advanced technologies processes than does CAPDET.[13] EXEC-OP provides three major additions relative to CAPDET, namely:

1. The ability to explicitly recycle effluent sidestreams generated by certain unit processes such as sedimentation,

2. allows the inclusion of multiple design criteria such as reliability and the cost of energy, and

3. uses a branch and bound technique under linear programming to produce a partial enumeration of available unit processes.

Recycling of sidestreams represents an improvement in the completeness of the model while partial enumeration represents a more efficient modeling technique compared to CAPDET. In addition, EXEC-OP does not provide the level of design detail of CAPDET nor does it easily allow the user to input local cost data, although local cost may be used with some

---

[12]Conversations with individuals concerned with CAPDET indicate that the model is currently being expanded to handle water treatment.

[13]The unit processes contained in CAPDET and EXEC-OP are included as Appendix B and D respectfully. Appendix A and C present typical output examples for the two models.

difficulty. Both USAID/REID and WBANK are directly concerned with developing country applications, each is responsive to the concept of appropriate technology, both handle local cost input, and neither accepts multiple design criteria. USAID/REID is the only model to explicitly address technology selection in both water treatment and sanitation.[14] Neither USAID/REID nor WBANK provide the engineering design detail[15] of CAPDET, nor the attention to sidestream recycling or the multiple design criteria of EXEC-OP. In terms of an overview summary, CAPDET is reasonably flexible, except for sensitivity analysis, and provides a great quantity of engineering design detail and engineering cost analysis. EXEC-OP is most complete in the simulation mode, the most efficient in optimization technique, and the most conducive to sensitivity analysis. USAID/REID has the most complete coverage of technology appropriate to developing country water treatment and sanitation. The WBANK model has the clearest commitment to the relationship between public health and water treatment/sanitation technology selection. Since each model has strong points and disadvantages, the following sections explore the details of the separate models.

---

[14]The World Bank model deals slightly with water treatment, but does not explicitly include water treatment technology in the solution algorithm.

[15]Detailed design information is provided in the documentation for both USAID/REID and WORLD BANK.

Capdet

The philosophical set of CAPDET is to provide the knowledgeable user with sufficient engineering design and engineering cost data to compare alternative wastewater treatment designs. CAPDET was intended to meet the needs of the EPA Construction Grants Program and the COE Urban Studies Program.[16] Figure 1 presents the generic organization of a typical treatment scheme.[17] CAPDET used three major divisions for treatment processes: liquid division, primary sludge division, and secondary sludge division. As indicated in Figure 2, the wastewater enters the liquid treatment division and continues with liquid treatment processes and/or enters the primary sludge division. After additional liquid treatment processes, the transformed wastewater may enter the secondary sludge division or be discharged as liquid effluent. The intention is to take highly contaminated wastewater and use various treatment technologies to create safe residues, both liquid and solid, for disposal. The specific treatment processes included in CAPDET are listed in Appendix B. Figure 3 presents a typical problem construction for an investigation of alternate treatment schemes.[18] The waste stream enters

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[16]Corps of Engineers and Environmental Protection Agency, Computer-Assisted Procedure (1979): Acknowledgments.

[17]IBid.: 1-3.

[18]Corps of Engineers and Environmental Protection Agency, Computer-Assisted Procedure (1979): 2-3.

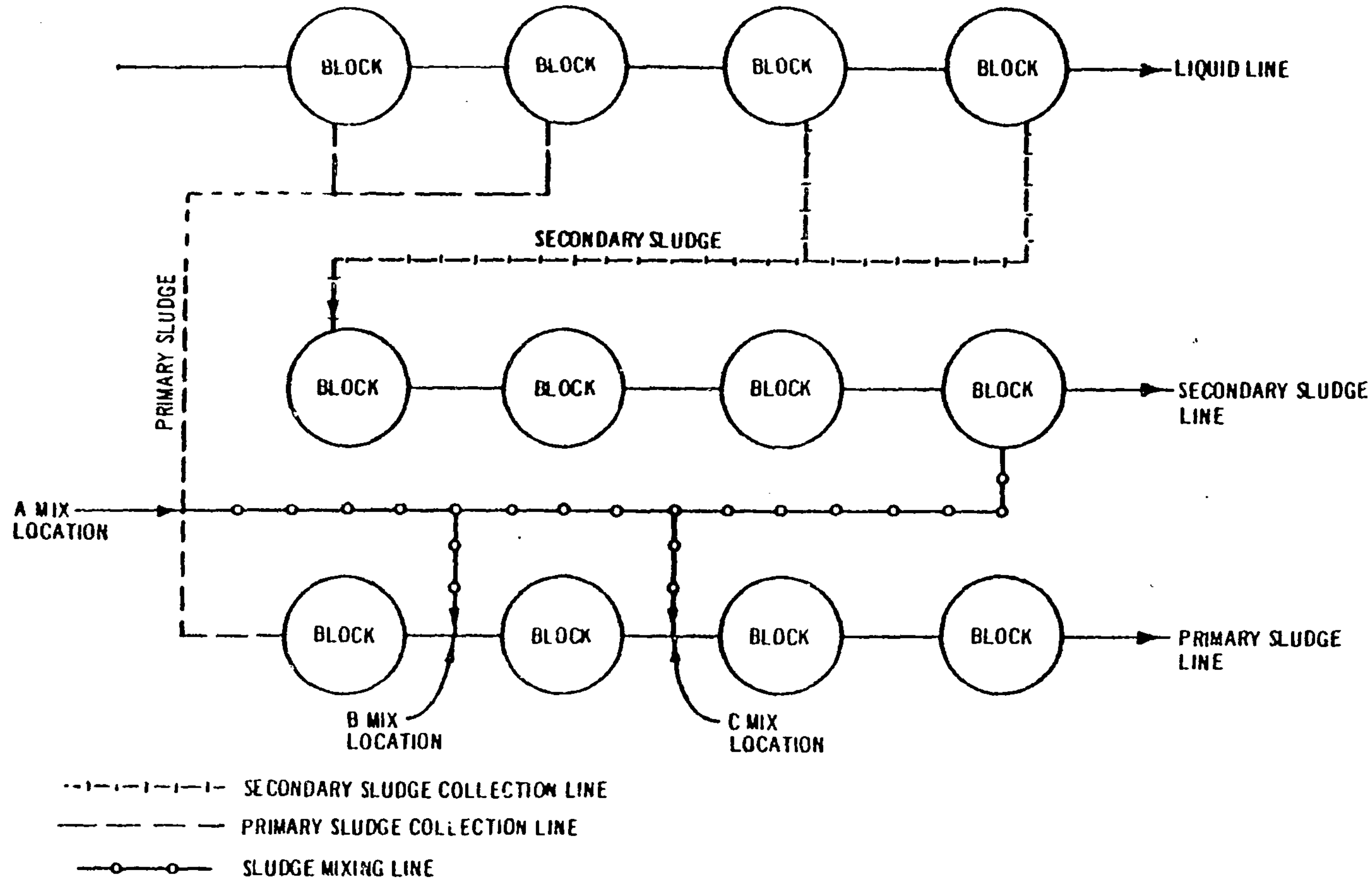

Figure 1. Generic organization of a typical treatment scheme.

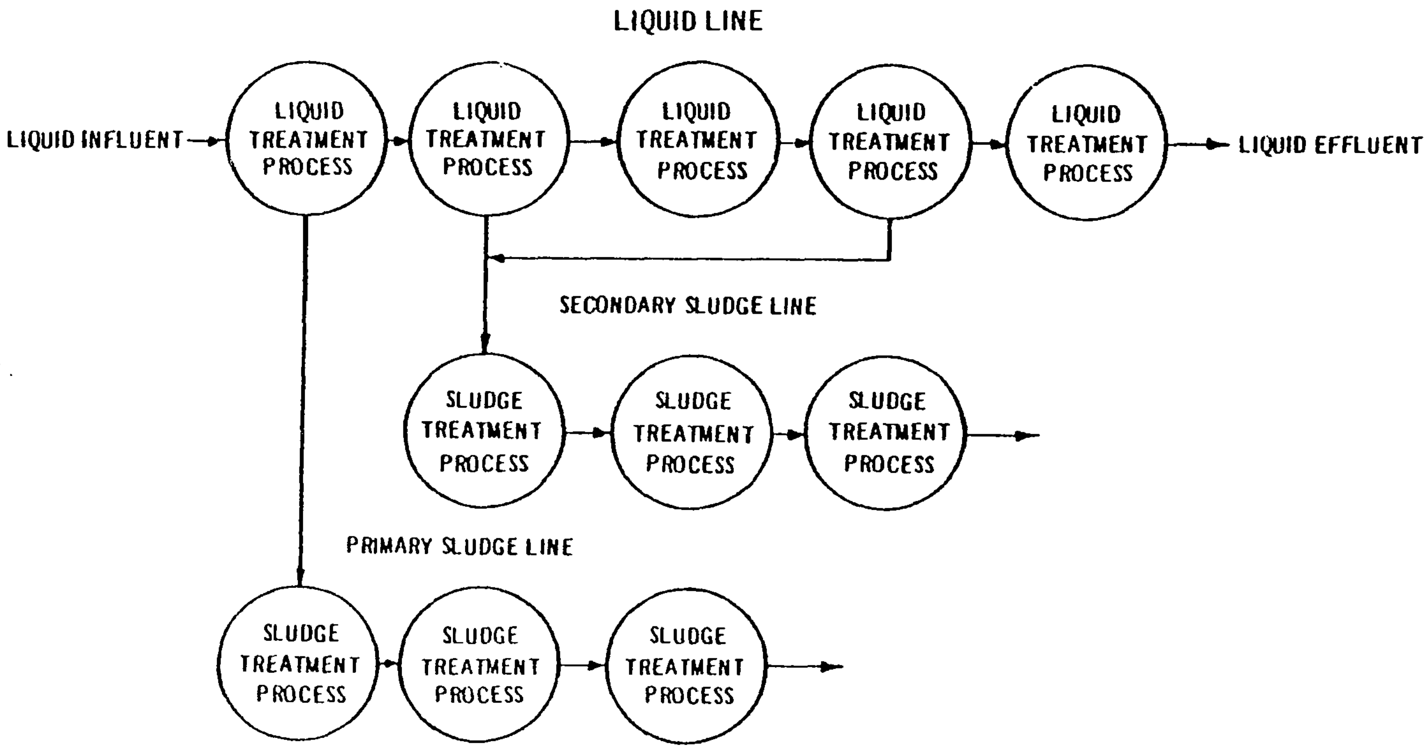

Figure 2. Typical problem construction.

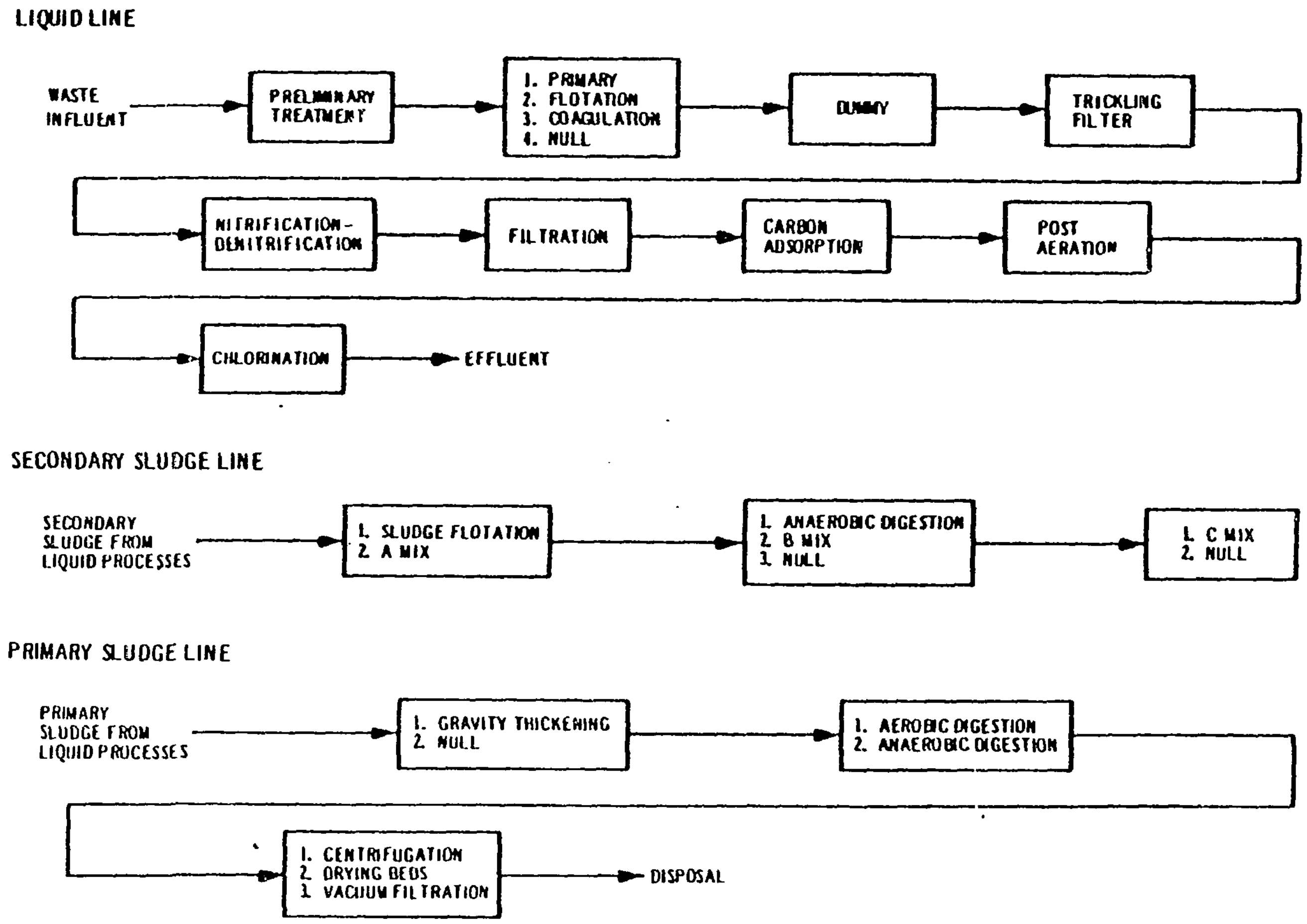

Figure 3. Typical treatment scheme with unit processes indicating 192 possible treatment train alternatives.

the preliminary treatment unit process, then exits to one of four unit processes (primary, flotation, etc.) followed by trickling filtration, filtration, and chlorination. As the selected unit processes produce sludge, the effluent is passed throught the two sludge divisions. This single treatment scheme represents 192 possible treatment trains combinations from the treatment scheme.[19]

The user selects the unit treatment processes to include in the treatment scheme and arrays the selected processes into proper block location. The user is expected to be sufficiently conversant with the tech nical details to not only select and array unit processes but also to evaluate and modify as necessary, the technical details included in the analysis, i.e., biological oxygen demand (BOD) loading, average daily flow, etc. The user may select either a large facility analysis, flow greater than or equal to 0.5 million gallons per day (mgd), or a small facility analysis, flow less then 0.5 mgd. This decision affects the number of unit processes available for inclusion in the analysis.[20] Once selection and array of unit treatment processes is complete CAPDET uses a complete enumeration approach to calculate cost and design details for all possible combinations of unit processes constructed into treatment trains.[21] The treatment cost is calculated by assuming a typical configuration and method of construction for each unit process. Unit

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[19]A treatment train includes a single unit process for each block in the treatment scheme.

[20]The CAPDET treatment processes for both large and small facility analysis are included as Appendix B.

[21]Detail is calculated for all combinations but only the 100 least cost treatment trains may be saved for display.

cost supplied by the user, or defaulted by CAPDET, are used in calculating treatment cost. This estimating technique gives the user the ability to easily alter unit cost to site/geographic specific cost analysis.[22] Where appropriate, the user may modify equipment and component service life to more closely simulate local conditions. All of the data entry and analysis are undertaken in a batch mode.[23] As can be seen in the sample CAPDET output, Appendix A, extensive engineering cost and design detail are provided to the user.

If a treatment train were to be selected only on the basis of engineering cost analysis CAPDET supplies sufficient information to discriminate between treatment train alternatives. For developing countries a simple engineering cost analysis is insufficient for planning purposes and selection of appropriate technology is vital. Therefore, CAPDET can be very useful but it has several drawbacks; namely:

1. Sensitivity analysis is not available except as repeated batch runs.

2. The selection of technology is not subjected to any con straint on manpower and/or resources.

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[22] Corps of Engineers and Environmental Protection Agency, Computer-Assisted Procedure, (1979): 3-1.

[23] In a batch mode all data and selections of unit treatment processes are entered as a single step. Output follows automatically with no recourse to sensitivity analysis unless a second batch run is undertaken.

3. The computer charges for a computer time sharing system are substantial.[24]

The first two disadvantages are by far the most important for planning in developing countries. The need to prevent inappropriate investment in water supply treatment/sanitation technology is well documented in the literature.[25]

The need for sensitivity analysis has been cited by several authors[26]. The level and application of the sensitivity analysis is left to the analyst to determine. Computer charges may be significant if it contributes to either inappropriate technology and/or insufficient sensitivity analysis. In summary, CAPDET represent the state-of-the-art

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[24]A typical problem could easily cost $500 per run. Although this cost is insignificant in relation to level of investment, the cost could rise significantly if sensitivity analysis were performed. In developing countries, such a rise would be likely to sharply curtail the sensitivity analysis.

[25]Robert J. Saunders and Jeremy J. Warford, Village Water Supply: Economics and Policy in the Developing World, (Baltimore: John Hopkins University Press c 1976). Asit K. Biswas, "Environment and Water Development in the Third World," Journal of the Water Resources Planning and Management Division, American Society of Civil Engineers, Vol. 106, No. WR1, pp 319-332. W. L. Reyes, "Research in the Development of Appropriate Technology for the Improvement of Environmental Health at the Village Level in the WHO South-East Asia Region", Paper presented at the National Workshop on Research and Sanitation Decade, 1981-1990, Neeri, Nagpur: 21-22 November 1979. Reid and Coffey, eds., Appropriate Methods. H. M. Neghassi, "U.N. Water Conference: Scope for Transfer of Knowledge in the Action Plan", Journal of the WaterResources Planning and Management Divisions, American Society of Civil Engineers, Vol. 106, No. WR1, March 1980: 351-363.

[26]Rossman, "Synthesis of Waste Treatment Systems": 149. Reid, Arnold, and Streebin, Workbook: 120-123, 281: International Bank for Reconstruction and Development/The World Bank, Appropriate Technology: A Planner's Guide, VOL.2: 1-5.

in terms of engineering design detail, engineering economic analysis, and complete enumeration of unit processes technology selection in water treatment and sanitation technology.

Exec-op

The philosphical set of EXEC-OP is very similar to CAPDET for unit process selection but differs significantly in the output produced and optimization technique employed. Figure 4 presents a typical block structure for EXEC-OP. Comparison to Figure 3, a typical CAPDET structure, indicates close similarity except that EXEC-OP includes recycling of sidestreams (R mode). Once the candidate unit processes are selected the input data is organized in a batch run very similar to CAPDET's input requirement. The level of detail to be provided by the user and the output produced during the EXEC-OP analysis are substantially smaller than CAPDET; however, the optimization technique used by EXEC-OP provides a more efficient analysis algorithm. The optimization technique used by EXEC-OP seeks an optimal but partial solution in contrast to a complete enumeration of all possible treatment trains.[27] Such a procedures results in a substantial decrease in computer cost compared to CAPDET. Whereas CAPDET uses life cycle cost as the design criteria EXEC-OP uses a system objective function composed of the weighted sum of individual criteria:[28]

---

[27] The solution technique employed by EXEC-OP, a "branch and bound" technique under linear programming, is covered in Appendix I.

[28] Lewis A. Rossman, EXEC-OP Reference Manual, Version 1.2, Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, (Cincinnati, Ohio: 1980): 8-9.

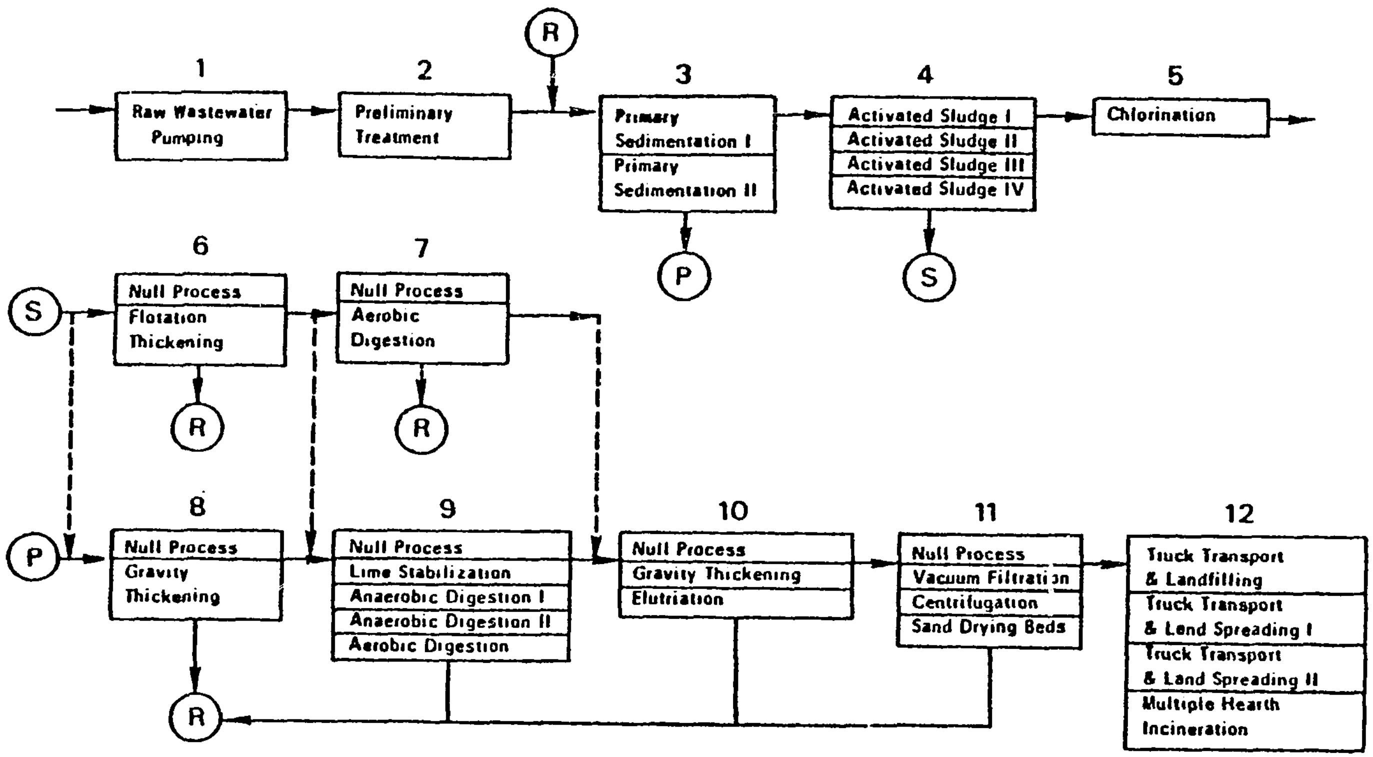

Figure 4. Block structure for EXEC-OP.

$$V = w_1c_1 + w_2c_2 + w_3c_3 + w_4c_4 - w_5c_5 + w_6c_6 + w_7c_7 + w_8c_8$$

where V = System objective function.

w_i = Weight for the ith criteria and i = 1 to 8.

c_1 = Total initial construction cost in million dollars.

c_2 = Total annual operation and maintenance cost in million dollars of system influent.

c_3 = Total equivalent annual life cycle cost, dollers/million gallons of system influent.

c_4 = Total gross energy consumption, kwh/million gallons of system influent.

c_5 = Total gross energy production, kwh/million gallons of system influent.

c_6 = Total net energy consumption, kwh/million gallons of system influent.

c_7 = Total sand area utilization, acres.

c_8 = Systems undesirability index.[29]

A combination of these criteria are then selected to form the system function. Once an objective function is constructed, the input data is assembled for a batch run. A typical output is shown as Appendix C and as can be seen the level of detail is much lower than CAPDET.[30] In summary the optimization technique employed by EXEC-OP and the multiobjective approach taken by EXEC-OP represent the state-of-the-art in the water treatment and sanitation technology selection models.

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[29]The undesirability index represents a summation of the individual undesirability values assigned to unit processes by the user.

[30]Rossman, "Synthsis of Waste Treatment Systems": 157-158.

USAID/REID

The USAID/REID model involves a significant shift in organization, optimization technique, and area of application. This model is developed primarily for use in developing countries in contrast to both CAPDET and EXEC-OP which have a developed country orientation.[31] The unit processes included in USAID/REID cover both the water and sanitation areas as can be seen in Appendix F. These unit processes are constructed into predetermined treatment trains which would provide a prescribed level of treatment criteria which must not be exceeded as a maximum. For example, if the coliform bacteria level of the raw water exceeds 200 most probable number (MPN) per 100 millimeter then water treatment process combinations W_1 and W_2 will not be available for use since the maximum level of coliform allowed by these combinations is exceeded. The treatment combinations are composed of unit treatment processes which are screened on the basis of availability in manpower and construction/maintenance resources. The USAID/REID screening process employs a questionnaire to identify the likely level of resources available to the local site. The levels are used to determine whether a particular resource, say professional labor, is available and, therefore, whether this availability/unavailability removes any unit treatment

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[31]The USAID/REID model has been tested for applicability in Oklahoma with qualified success in small towns and small, isolated, rural cities.

processes from consideration. All of this process is an attempt to identify those unit processes and, by default, those combinations of unit processes which would represent appropriate technology for the local site. Once the appropriate technology alternatives are selected by the screening process the alternatives are displayed by relative ranking cost ratios for both construction and maintenance.[32] Design detail is not available as an output from USAID/REID, however, the documentation supporting the model is very extensive with respect to design detail, cost equations, etc. USAID/REID can be solved manually, i.e., by pencil and paper, in addition to a computer solution. A sample computer run using the computer solution of USAID/REID is included as Appendix E. In summary USAID/REID provided the initial research effort in selection of appropriate technology for water treatment and sanitation technology in developing countries and represents the state-of-the-art in developing country selection models placing equal emphasis on water and sanitation technology. USAID/REID is lacking in the level of design and economic detail provided to the user. The computer cost associated with processing USAID/REID are minimal as can be seen in Appendix J. See Figures 12 and 13 for the USAID/REID solution process.

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[32]These relative cost ratios are responsive to both economics of scale and social-economic scaling. The cost data are presented as ratios due to the difficulties of using a general model for site specify cost estimates. A module exists within USAID/REID to respond to local input cost data during the computer analysis.

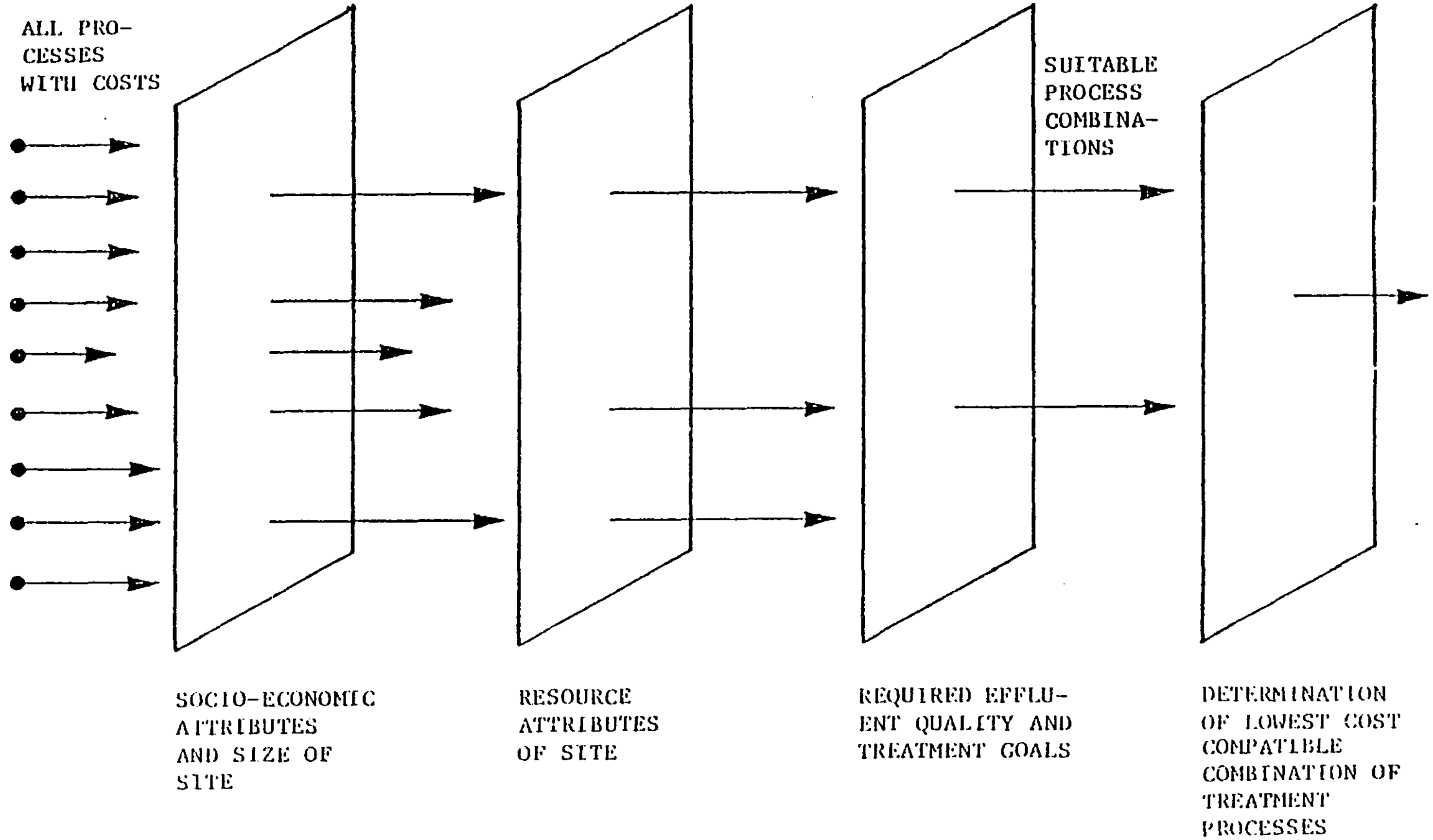

Figure 12. USAID/REID Screening Process.

Source: Raid and Coffey eds., Appropriate Methods: 18

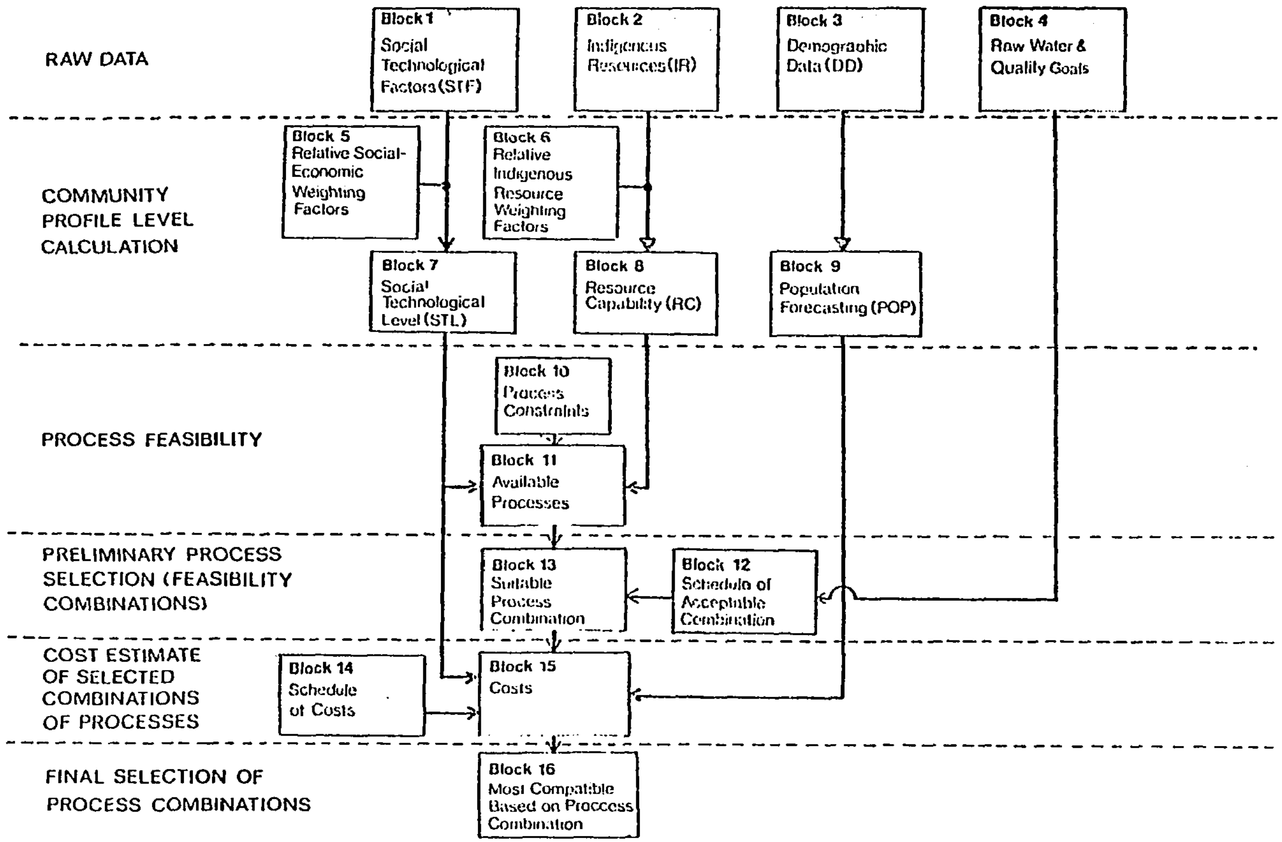

Figure 13. USAID/REID Solution Algorithm.
Source: Reid, Arnold, and Streebin, Workbook: 50

WBANK

The WBANK model is very similar in construction to USAID/REID, however, the emphasis shifts from engineering cost analysis to economic analysis. WBANK attempts to focus attention on the interdisciplinary nature of the investment, i.e., encompassing the areas of civil engineering, economics, internation finance, health and welfare, microbiology, and sociology. The model is intended specifically for developing countries and requires no computer for analysis. As Appendix G indicates the WBANK model is limited to sanitation only and the range of sanitation unit processes is heavily skewed toward the lower levels of technology in terms of complexity and resource requirements.[33] Since the model is intended for application in rural areas, or "urban" as Davidson has defined rural villages, this range of technology is very appropriate.[34]

The WBANK model differs significantly from the three previous models in several ways. First WBANK actively promotes an interdisciplinary approach to water and sanitation technology investments. As Figure 5 indicates the decision interaction should include sanitary

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[33]Documentation for the WBANK model mentions water provision in several places but water treatment processes are not included in the solution algorithm.

[34]Richard Feachem, Michael McGarry, and Duncan Mara, Water, Waste and Health in Hot Climates, eds., (Chichester: John Wiley and Sons, 1977): 216-217.

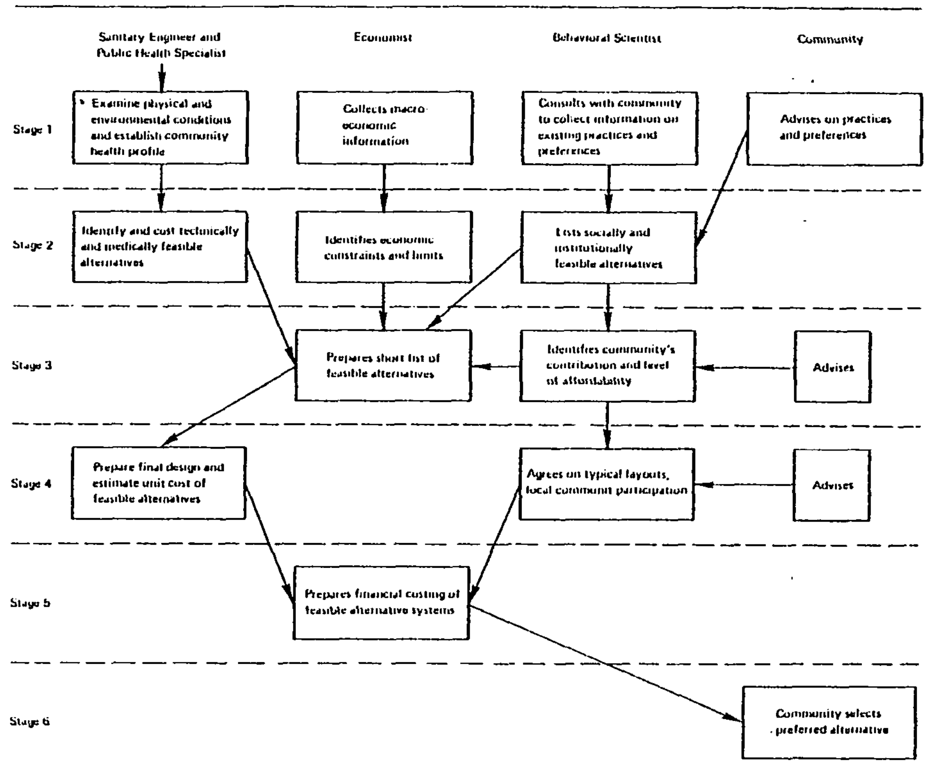

Figure 5. WBANK recommended structure for program planning.

engineer, public health specialist, economist, behavioral scientist, and community participation in an interdependent presentation of alternatives. The final decision should be made by the local community. Secondly, WBANK explicitely relates the provision of water treatment and sanitation technology to the health problems existing at the design site and to public health in general.[35] Thirdly, the WBANK model attempts to use economic costs as opposed to engineering cost analysis. Using economic costing requires that all cost to the economy be included in the analysis, each included cost must be evaluated using shadow prices, and that only future cost be included in the analysis rather than historical cost. WBANK specifically includes the cost of water for flushing and the cost of separate disposal for sullage where such disposal is required. The cost items subjected to shadow pricing include unskilled labor, foreign exchange, opportunity cost of capital, and other direct inputs such as water, land, etc. WBANK includes a procedure for discounting both cost and capacity utilization to remove the bias toward large economies of scale type treatment technology when a future "design" population is used in the analysis. WBANK notes that engineering cost analysis often size water/sanitation investment to meet future demand. WBANK proposes

$$AIC = \frac{\sum_{t=1}^{t=t} \frac{c_t + 0_t}{(1+r)^{t-1}}}{\sum_{t=1}^{t=T} \frac{N_t}{(1+r)^{t-1}}}$$

[35]The health aspect of water and sanitation are investigated later in this chapter.

using an average incremental cost approach:[36]

where AIC_t = The average incremental cost at time t.

t = Time in years.

T = Design lifetime in years.

C_t = Construction costs incurred in year t.

O_t = Incremental operation and maintenance cost incurred in year t.

N_t = Additional people or households served in year t.

r = Opportunity cost of capital expressed in percent times 10^2.

Such an approach amounts to a variant of cost-benefit analysis with the difference that in this case the discounting takes places for additional population to be served in the future. The solution algorithm for the WBANK model is shown in Appendix H.[37]

In summary, the WBANK model represents the state-of-the-art in suggesting the relationship between health and the selection of sanitation technology and in applying economic analysis to the selection of technology. WBANK is lacking in respect to coverage of both water and sanitation technology, in respect to the level of design detail presented as an output, and in respect to encouraging sensitivity analysis during selection.

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[36] International Banks for Reconstruction and Development. The World Bank, Appropriate Technology: 30-31.

[37] It should be noted that there is a single output for multiple unit processes, i.e., sewerage as an output represents selection of any type of sewerage unit process. Such a procedure does not represent selection of technology based on availability.

For selection models this literature review has included four state-of-the-art models; namely: CAPDET, EXEC-OP, USAID/REID, and WBANK.[38] Each model has been found to be superior in at least one aspect but flawed in its application to developing countries for one or more reasons. CAPDET is superior in the level of output provided and coverage of sanitation treatment technology. EXEC-OP is superior in the optimization technique employed during the analysis. USAID/REID is superior in terms of the coverage of both water and sanitation in addition to the attention devoted to the selection technology based on available resources. WBANK is superior in relating the selection of water/sanitation technology to public health and in advancing the use of economic policy analysis as opposed to engineering cost analysis, for decision making. Each model has been reviewed in sufficient detail to follow the operation of the model. In the next review section the relationship between public health and water/sanitation technology is investigated.

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[38] Table 1 presents a brief comparison of the four models.

Water Sanitation, and Health

The major reason for a developing country to invest in water treatment/sanitation technology is the expected effect on public health. It has been estimated that between 25,000 and 36,000 people die per day due to the lack of safe drinking water and safe human excreta disposal.[39] The majority of these deaths are children. Figure 6 graphically depicts the human survival comparison against age for both developed and developing countries. In developed countries (A) relatively few deaths occur until the individuals reach the age of 50 where diseases of the arteries begin to have a significant impact. In developing countries (B) the increased death rate in the early years is due in large part to infectious diseases and malnutrition. In many cases, there is a vicious circular relationship between water, disease, sanitation, and water. For example, starting with contaminated water individuals receive intestinal infection which acerbates the effects of an initial infection and malnutrition generally leads to high levels of infective organisms being excreted into the water supply - the completed circle. It is quite clear that the age group most effected by improvements in health; i.e., the young may well

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[39] Gene Dallaire, "U.N. Launches International Water Decade; U.S. Role Uncertain", Civil Engineer, American Society of Civil Engineers, Vol. 51, No. 3, March 1981: 59. J.T. Dale,"World Bank Shifts Focus on Third World Sanitation Projects", Journal of the Water Pollution Control Federation, Vol. 51, No. 4, April 1979: 663.

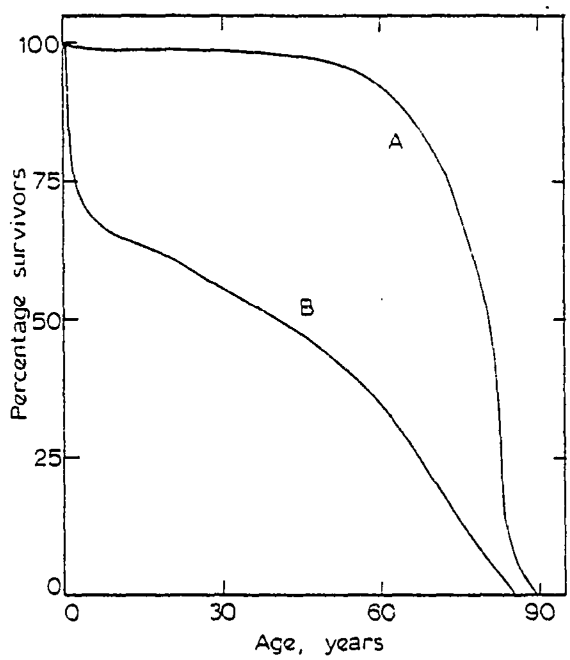

Figure 6. Human survival curves in (A) developed countries and (B) developing countries (Source: Feachem, McGarry, and Mara, Water, Waste and Health: 4).

lead to an increase in the population growth rate.[40] Thw World Health Organization (WHO) indicates that only 38 percent of the 1975 population was adequately served with safe water and only 33 percent of the 1975 population were adequately served with safe sanitation.[41] Table 2 summarizes the world situation in terms of service adequacy for both safe water and sanitation. Tables 3 and 4 provide summeries of water and sanitation service in developing countries. As can be seen from this small sample the variation among regions is large but the variation among countries is very large; i.e., total population with access varies between 20 and 75 percent for regions and between 1 and 77 percent for countries. In the following pages of this subsection, the health data are developed, the water/sanitation treatment technology linked to health is investigated, and a classification scheme for disease and water/sanitation is presented.

The links between water and health can be traced to the relating of certain fevers to marshy areas by Hippocrates. By the mid 1800's the relationship between water and several diseases (Cholera/Typhoid, Filariasis, Malaria, Guinea Worms, and Schistosomiasis) were reported in the health literature.[42] Today it is clearly understood that excreta is related to disease in two major ways. First, the agents of infection are passed in the excreta. Secondly, excreta encourages the breeding of insects which are vectors for diseases or transmit the infective agents

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[40]Saunders and Warford, Village Water Supply: 73.

[41]World Health Organizations, World Health Statistics Report: 570.

[42]Feachem, McGarry, and Mara, Water, Waste and Health: 5-6.

TABLE 2

Estimated Population Served by Adequate Water and Sanitation Facilities in 1975 (excludes China)

Item	Population Served		Increase Since 1970 (%)
	In Millions	AS (%)	
Water			
Urban	450	77	10
Rural	313	22	8
Total	763	38	9
Sanitation			
Urban	437	75	4
Rural	209	15	4
Total	646	33	6

Source: World Organization, World Health Statistics Report: Vol. 29, No. 10 (Geneva: 1976): 570.

TABLE 3

Community Water Service in Developing Countries, by Region
and Selected Countries, Excluding China, 1975 Data

Region or Country	Urban Population With Access			Rural Population With Access	Total Population With Access
	With House Connections (%)	With Public Stand Posts (%)	Total		
Africa	37	31	68	21	29
Americas	67	14	81	32	58
Eastern Mediterranean	52	28	80	16	34
Europe	67	14	81	63	71
South-East Asia	48	21	70	19	29
Western Pacific	75	16	90	30	54
Total	57	20	77	22	38
Number of Countries	79	79	79	75	75
Chad	7	36	43	23	26
Kenya	90	10	100	4	17
Upper Volta	19	31	50	23	25
Bolivia	30	51	81	6	34
Mexico	68	2	70	49	62
Panama	93	7	100	54	77
Bangladesh	6	16	22	61	56
Indonesia	30	11	41	4	11
Thailand	59	10	69	16	25

Source: World Health Organization, World Health Statistics Report, Vol. 29, No. 10 (Geneva: 1976): 571-579.

TABLE 4

Community Sanitation in Developing Countries, by Region and Selected Countries, Excluding China, 1975 Data

Region or Country	Urban Population With Access			Rural Population With Access	Total Population With Access
	Connected to Sewer-Systems (%)	With House-Hold Systems (%)	Total		
Africa	15	62	75	28	38
Americas	35	39	80	25	63
Eastern Mediterranean	10	53	63	14	27
Europe	21	17	38	18	27
South-East Asia	26	53	79	6	20
Western Pacific	24	57	81	43	58
Total	25	N/A	75	15	33
Chad	4	8	9	1	1
Kenya	42	56	98	48	55
Upper Volta	N/A	47	47	N/A	4
Bolivia	24	N/A	N/A	9	N/A
Mexico	29	N/A	N/A	14	N/A
Panama	72	6	78	76	77
Bangladesh	5	35	40	N/A	5
Indonesia	2	58	60	5	15
Thailand	N/A	58	58	36	40

Source: World Health Organization. World Health Statistics Report, Vol. 29. No. 10 (Geneva: 1976): 571-579.

mechanically. Any particular excreted load is subject to a group of transmission factors prior to providing an infective dose for a specific individual. These transmission factors include:

1. Latency - the delay interval between the excretion of an infective agent and its ability to infect. For example, many viruses, bacteria, and protozoa are immediately infective.

2. Persistency - interval between the excretion of an infective agent and it's death under normal conditions.

3. Multiplication - following excretion the reproductive ability of the infective agent in the environment.

The circular nature of this relationship is indicated in Figure 10.[43] A major element in this analysis is the varying nature of the levels necessary for an excreted load to be transmitted as infective. Additional complicating factors are the age of the individual exposed to the infective agent and immunity acquired over time. Age complicates transmission through the increased susceptability of the young and the benign attitude prevalent in many developing countries toward children's excreta. Water and sanitation technology is intended to interrupt the transmission by reducing the probability that an excreted load will be infective. It should be noted that regardless of the treatment prior to

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[43]Kalbermatten, Juluis, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: Technical and Economic Options: 64.

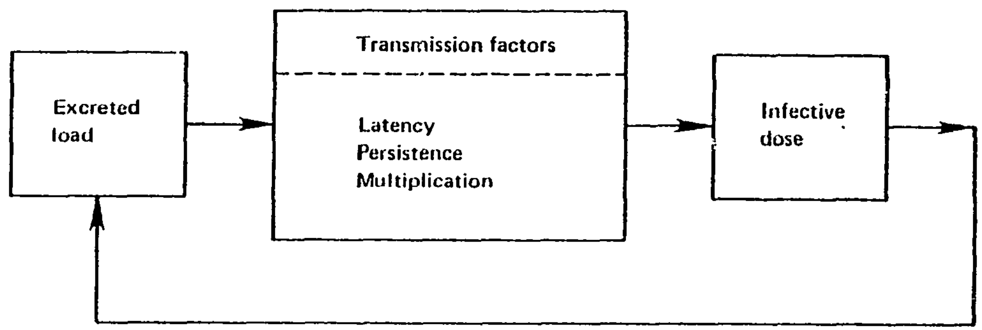

Figure 10. The relationship between excreta and infective dose for a given disease.

discharge of the final residual, either liquid or solid, many pathogens may survive for extended periods unless destroyed prior to discharge. Final residuals are often disposed as liquid or solid on soil, as liquid in a body of water, or as a liquid or solid on crops.

Table 5 indicates survival of the major pathogenic classifications in soil and applied on crops. The point being developed here in specific, i.e., treatment is a necessary condition for public health but may not be sufficient to ensure public health, is alluded, in general, by several authors and succinctly stated by Saunders and Warford, .."it is clear that while improved drinking is probably a necessary condition for the improvement of people's health, it is not a sufficient condition."[44]

The attempts to quantify the relationship between water supply/ sanitation technology and public health has not been successful for several reasons:[45]

1. A lack of knowledge concerning the underlaying processes and disease mechanisms.

2. A lack of specificity and knowledge concerning the role of exogenous variables.

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[44] Saunders and Warford, Village Water Supply: 35. Kalbermatten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Summary of Technical and Economical Options, Vol 1a: 21.

[45] Saunders and Warford, Village Water Supply: 35-39, 66-68. Feachem, McGarry, and Mara, Water, Waste and Health: 8, 240.

TABLE 5

Estimated Survival Time for Major Pathogenic Classifications

Pathogen	Survival Time
On Soil	
Virus	Up to 6 months (generally 3 months)
Bacteria	Up to 3 years (generally 2 months)
Protozoa	Up to 10 days (generally 2 days)
Helminths	Up to 7 years (generally 1 year)
On Crops	
Virus	Up to 2 months (generally 1 month)
Bacteria	Up to 6 months (generally 1 month)
Protozoa	Up to 5 days (generally 1 month)
Helminths	Up to 5 days (generally 1 month)

Source: Kalbermatten, Julius, Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Planners Guide, Vol. 2 (Washington, D. C.: 1980): 180.

3. Collinearity and interdependency among the social/cultural/economic variables.

4. Systematic bias introduced by better housing, better nutrition, etc. on both time series and cross-sectional studies.

5. Large sampling errors introduced in data gathering.

6. Various logistic problems, such as installation of technology neither implies adequate upkeep nor usage, seasonality, etc.

In addition, and possibly most important, it is not possible, nor would it be acceptable, to separately consider a disease relationship to either water or sanitation treatment while excluding the other. It is not possible to separate the interdependency between the two factors.[46] Although precise specification cannot be accomplished there exists a significant body of literature on the classification of infective agents and possible amelioration by water supply/sanitation technology. Two major classification schemes are useful in relating water supply/sanitation technology to public health; namely, (1) the mode of disease spread and (2) the pathogen causing the disease. Four elements comprise the pathogenic classifications:

1. Virus

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[46] Feachem, McGarry, and Mara, Water, Waste, and Health: 8.

2. Bacteria

3. Protozoa

4. Helminth

The mode of spread classification also includes four elements:[47]

1. Water-borne

2. Water-washed

3. Water-based

4. Water-related

Each pathogenic classification may exist within the separate "mode of spread" classification. A water-borne disease classification arises where an infection spreads through the water supply. A water-washed disease classification occurs where the disease can be traced to the lack of sufficient water for personal hygiene. A water-based disease classification occurs where a disease is transmitted through an aquatic invertebrate such as a snail. A water-related disease classification occurs when a disease is spread by insects that depend on the availability of water. Without water supply/sanitation technology fecal pollution from

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[47]Much of the effort in this classification scheme is due to the works of Feachem, et al., at the Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine.

individuals suffering from intestinal infections may contribute to infections by other individuals using the same water supply. Typhoid and cholera are devastating examples of this "common source outbreaks," classified as water-borne diseases.[48] The quantity of water available for personal hygiene is the critical criteria in water-washed diseases. Kalbermatten, Julius, and Gunnerson indicate that most health benefits from provisions of water will occur when delivery reaches the level of 30 to 40 liters per capita per day at the local site.[49] In water-based diseases parasite eggs, or larvae, reach water where a snail or crustacean serves as an intermediate host. The pathogenic agent is discharged from the intermediate host back to water which then causes a human disease. A typical example is schistosomiasis where the helminth resides in a snail intermediate to penetrating human skin during contact with snail infected water. Water-related diseases are indicated where insects such as flies or mosquitos breed in or near water. These insects are then vectors for a multitude of diseases. Typical examples are yellow fever caused by mosquitos and sleeping sickness caused by the tsetse fly. Tables 6 through 9 indicate the health aspects of each classification by both mode of spread and pathogen causing the disease. Each table gives both the disease name and the common name where appropriate in addition to the biological group and pathogenic agent. The percent reduction column indicates the expected reduction in frequency of occurrence given adequate treatment for the water supply, i.e., the water is

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[48]Feachem, McGarry, and Mara, Water Waste, and Health: 9.

[49]Kalbernatten, Julius and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Summary of Technical and Economic Options, Vol. 1a: 17.

TABLE 6

Water-Borne Diseases

Biological Group	Disease	Common Name	Pathogenic Agent	Reduction (%)	Transmission Mode	Reservoir	Physical Environment Preference or Comment
Virus	Viral Hepatitis	Infectious Hepatitis	Hepatitis virus type A	10	Fecal contamination of a single source - water, etc.	Man	Poor sanitation, poor personal hygiene
	Poliomyelitis	Polio	Poliovirus 1-3	10	Human contact, fecal contamination of a single source - water, etc.	Man	Poor sanitation, poor hygiene, warm climate
	Enteroviruses (some) infection		Coxsackieviruses type A and B, echovirus, enteroviruses	10	Human contact, fecal contamination of a single source	Man	Warm climate
	Gastroenteritis		Gastroenteritis, type A	50	Human contact, contamination of food or drink	Man	Poor sanitation, poor hygiene
	Gastroenteritis, infantile	Severe infantile diarrhea	Gastroeteritis virus type B or rotavirus		Unknown	Animal, man	Children, cool or cold weather
Bacteria	Cholera		_Vibrio cholera_	90	Human contact, fecal contamination of a single source	Man	Poor sanitation, poor hygiene, vibrios survive in water up to 3 weeks
	Typhoid	Typhoid or enteric fever	_Salmonella typhi_	80	Contamination of food or drink	Animal, man	Poor sanitation, poor hygiene
	Paratyphoid	Typhoid or enteric fever	_Salmonella paratyphi_	40	Contamination of food or drink	Animal, man	Poor sanitation, poor hugiene

Continued

TABLE 6 (Cont'd)

Water-Borne Diseases

Biological Group	Disease	Common Name	Pathogenic Agent	Reduction (%)	Transmission Mode	Reservoir	Physical Environment Preference or Comment
	Shigellosis	Bacillary dysentery	Shigella dysenteriae, Shigella Sp.	50	Contamination of food, fingers, feces flies	Man	Poor sanitation, poor hygiene
	Leptospirosis	Infectious jaundice, Weil's disease, marsh fever, etc.	Leptospirae Sp.	80	Animal contact, animal excreta contamination of food or drink	Animal	Animals include rats, mice, wild rodents, dogs, swine, cattle. Primarily animal disease
	Yersinosis	Tularaemia	Francisella tularensis	40	Paritally cooked wild rodents, wild animal excreta contamination of food or drink, deerfly bite	Rodents	Primarily an animal disease
Protozoa	Giardiasis	Flagellate diarrhea	Giardia lamblia		Cyst contamination of food or drink	Man	Common in young children
	Amebic dysentery		Entamoeba histolytica	50	Cyst contamination of food or drink, flies may contribute	Man	High-carbohydrated/low protein diet, favors development, poor sanitation, poor hygiene
	Balantidiasis	Balantidial dysentery	Balantidium coli		Cyst contamination of food or drink	Animals, man	

Source: Feachem, McGarry, and Mara, eds., Water, Waste and Health: 6-16, 75-95.

Kalbermatten, et al., Appropriate Technology for Water Supply and Sanitation: A Planner's Guide: 7-19.

E. Janetz, J. L. Melnick, E. A. Adelberg, Review of Medical Microbiology (Los Altos: Lange, 1976): 203-231 368-380, 454-460, 492-524.

TABLE 7

Water-Washed Diseases

Biological Group	Disease	Common Name	Pathogenic Agent	Reduction (%)	Transmission Mode	Reservoir	Physical Environment Preference or Comment
Bacteria	Rickettsosis	Typhus	*Rickettsia prowazekii*, *R. typhia*		Human bitten by Arthropods (tick, mite, etc.)	Man Rat	Poor hygiene
	Skin Sepsis and ulcers		*Staphylococci, sp.* *Streptococci sp.*	50	Human contact, air-bourne contamination	Animals, man	Poor hygiene
	Trachoma		*Chlamydiae trachomatis*	60	Human contact, shared shared cosmetics, bathroom towels		Poor hygiene
	Yaws	Frambesia	*Treponema pertenue*	70	Human contact with children under age 15		Hot, humid climate
	Relapsing Fever		*Borrelia recurrentis*	40	Rodent tick bite or crushing tick into bite	Rodent	Crowding, malnutrition, cold climate
	Leprosy		*Mycobacteria leprae*	50	Uncertain	Man	
Fungus	Tinea	Ringworm, Athlete's Foot	*Trichophyton sp.*, *Microsporum sp.*, *Epidermophton floccosum*	50	Human contact or transfer	Animal, man	Hot, humid climate, poor hygiene
Helminth	Ascariasis	Roundworm	*Ascaris lumbricoides*	40	Fecal contamination of food or drink		
Miscellaneous	Non-specific Dysentery		Various	50			

Continued

TABLE 7 (Cont'd)

Water-Washed Diseases

Biological Group	Disease	Common Name	Pathogenic Agent	Reduction (%)	Transmission Mode	Reservoir	Physical Environment Preference or Comment
	Non-specific conjunctivitis		Various	70			Poor hygiene
	Scabies		Various	80			

Source: Feachem, McGarry, and Mara, Water, Waste, and Health: 6-16, 75-95.

Kalbermatten, et al., Appropriate Technology for Water Supply and Sanitation: A Planner's Guide: 7-19.

Janetz, Melnick, Adelberg, Medical Microbiology: 169-184, 196-202, 225-244, 258-261, 492-512.

TABLE 8

Water-Based Diseases

Biological Group	Disease	Common Name	Pathogenic Agent	Reduction (%)	Transmission Mode	Reservoir	Physical Environment Preference or Comment
Helminth	Clonorchiasis	Chinese liver fluke	*Clonorchis sinensis*		Uncooked freshwater fish	Snail, fish	
	Diphyllobothriasis	Broad fish tapeworm	*Diphyllobothrim latum*		Uncooked freshwater fish	Copepod, fish	
	Draconitiasis	Guinea worm	*Dracunculus medinensis*	100	Drinking water inhabited by *Cyclops*	Crustacean	Rainy season
	Fasciolopsiasis	Giant intestinal fluke	*Fasciolopsis buski*		Man or pig-aquatic snail-aquatic vegetation-man	Pig, snail	
	Paragonimiasis	Lung fluke	*Paragonimus westermani*		Animal, man-aquatic snail-crab or crayfish-man	Animal, man	
	Schistosomiasis	Bilharzia	*Schistosoma haematobium*		Penetrates skin in snail infested water	Snail	Slowly flowing water with non-smooth banks
			S. japonicum		Penetrates skin in snail infested water	Snail	Slowly flowing water with non-smooth banks
			S. mansoni		Penetrates skin in snail infested water	Snail	Slowly flowing water with non-smooth banks

Source: Feachem, McGarry, and Mara, *Water, Waste and Health*: 6-16, 75-95, 299-309.

Kalbermatten, et al., *Appropriate Technology for Water Supply and Sanitation: A Planner's Guide*: 492-512.

TABLE 9

Water-Related Diseases

Biological Group	Disease	Common Name	Pathogenic Agent	Reduction (%)	Transmission Mode	Intermediate Host or Reservoir	Physical Environment Preference or Comment
Virus	Denegue fever	Breakbone fever	Arbovirus group B (Dengue virus type 1-4)		Bite of Mosquito (*Aedes aegypti*)	Mosquito, monkey	Rainy season, water storage containers, shade, warm climate
	Yellow fever	Jaundice	Arbovirus group B (yellow fever virus)	10	Bite of Mosquito (*A. aegypti*)	Mosquito, monkey	Rainy season, water storage container, shade, warm climate
	Non-specific arboviral infections		Arbovirus				
Protozoa	Malaria		*Plasmodia sp.*		Bite of Mosquito (*Anopheles*)	Mosquito	Warm, humid climate below 6,000 feet altitude
	Trypanosomiasis	Sleeping sickness	*Trypanosoma rhodesiense*, *T. gambiense*	80	Bite of Tsete Fly (*Glossina palpalis*)	Animals, man	River bank brush or lake shore brush
Helminth	Filariasis	Elephantitis	*Wuchereria bancrofti*, *Brugia malayi*		Bite of Mosquito (*Culicidae*)	Mosquito	
	Onchocerciasis	River blindness	*Onchocerca volvulus*	20	Buffalo gnat or black fly bite	Gnat, Fly	Rapidly flowing water

Source: Feachem, McGarry, and Mara, *Water, Waste and Health*, 6-16, 75-95, 299-309.

Kalbermatten, et al., *Appropriate Technology for Water Supply and Sanitation: A Planners Guide*: 7-19.

Janetz, Melnick, Adelberg, *Medical Microbiology*: 352-367, 492-512.

safe for use. In many cases a safe water supply means adequate sanitation. Where such information has been indicated in the literature, the mode of transmission, intermediate host/reservoir, and a comment have been added to the table. The comment column is intended to highlight those elements favored by the pathogenic agent, or a contributing factor in the onset of the disease. Table 10 uses the same form as Tables 6 through 9 to indicate the pathogens found in human excreta with the exception that the percent reduction column is omitted from Table 10. The percent reduction column is omitted due to the interdependent nature of water treatment and adequate sanitation. In summary this section has reviewed the health conditions in developing countries which relate to water treatment and sanitation. It has been found that a significant portion of the population in developing countries are without adequate water and/or sanitation. The following section attempts to trace the investment necessary to break the water-sanitation-disease-malnutrition cycle and to indicate the benefits to be derived in this type of infrastructure investment.

TABLE 10

Pathogens Found in Human Excreta

Biological Group	Disease	Common Name	Pathogenic Agent	Transmission Mode	Intermediate Host or Reservoir	Physical Environment Preference or Comment
Virus	Non-specific enterovirus infection		ECHO virus, coxsackievirus	Human contact, fecal contamination of food	Man	Warm climate
	Gastroenteritis, infantile	Infantile diarrhea	Gastroenteritis type B, rotavirus	Unknown		
	Poliomyelitis	Polio	Poliovirus 1-3	Human contact, fecal contamination of a single source - (water, etc.)	Man	Poor sanitation, poor hygiene, warm climate
	Viral Hepatitis	Infectious Hepatitis	Hepatitis virus Type A	Fecal contamination of a single source (water etc.)	Man	Poor sanitation, poor hygiene
Bacteria	Campylobacterial diarrhea	Infantile diarrhea			Animals, man	
	Cholera		_Vibrio cholerae_	Human contact, fecal contamination of a single source (water, etc.)	man	Poor sanitation, poor hygiene, vibrios survive in water up to 3 weeks
	Gastroenteritis		_Escherichia coli_	Fecal contamination of a single source (water, etc.)	Man	Poor sanitation, poor hygiene

Continued

TABLE 10 (Cont'd)

Pathogens Found in Human Excreta

Biological Group	Disease	Common Name	Pathogenic Agent	Transmission Mode	Intermediate Host or Reservoir	Physical Environment Preference or Comment
	Paratyphoid fever	Typhoid or enteric fever	Salmonella paratyphi	Contamination of food or drink	Animal, man	Poor sanitation, poor hygiene
	Salmonellosis	Food poisoning	S. typhimurium	Contamination of food or drink	Animal, man	Poor sanitation, poor hygiene
	Shigellosis	Bacillary Dysentery	Shigella dysenteriae, Shigella sp.	Contamination of food or drink	Man	Poor sanitation, poor hygiene
	Typhoid Fever	Typhoid or enteric fever	Salmonella typhi	Contamination of food or drink	Animal, man	Poor sanitation, poor hygiene
	Vibrial diarrhea	Diarrhea	Vibrio sp.	Contamination of food or drink	Animal, man	Poor sanitation, poor hygiene
	Yersinosis	Tularemia	Francisella tularensis	Partially cooked wild rodents, wild animal excreta, contamination of food or drink, deerfly bite	Rodents	Primarily an animal disease
	Non-specific yersinosis		Yersinia sp.	various	Animal, man	
Protozoa	Balantidiasis	Balantidial dysentery	Balantidium coli	Cyst contamination of food or drink	Animal, man	
	Amebic dysentery		Entamoeba histolytica	Cyst contamination of or drink, flies may may contribute	Man	High carbohydrate/low protein diet favors development, poor hygiene

Continued

TABLE 10 (Cont'd)

Pathogens Found in Human Excreta

Biological Group	Disease	Common Name	Pathogenic Agent	Transmission Mode	Intermediate Host or Reservoir	Physical Environment Preference or Comment
	Giardiasis	Flagellate diarrhea	Giardia lambia	Cyst contamination of food or drinks		Common in yound children
Helminth	Ascariasis	Roundworm	Ascaris lumbricoides	Fecal contamination of food or drink		
	Clonorchiasis	Chinese liver fluke	Clonorchis sinensis	Eating uncooked freshwater fish	Snail, fish	
	Diphyllobothriasis	Fish tapeworm	Diphyllobothrium latum	Eating uncooked freshwater fish	Fish, Copepod	Temperature, climate
	Enterobiasis	Pinworm	Enterobius vermicularis	Anal-oral, self contamination and internal recontamination	Man	
	Fascioliasis	Sheep liver fluke	Fasciola hepatica	From sheep to aquatic vegetation to man	Sheep, snail	
	Fasciolopsiasis	Giant intestinal fluke	Fasciolopsis buski	Man or pig to aquatic snail to aquatic vegetation to man	Man, pig, Snail	
	Gastrodiscoidiasis		Gastrodiscoides hominis	Pig to aquatic snail to aquatic vegetation to man	Pig, snail	
	Heterophyiasis	Intestinal fish fluke of man	Heterophyes heterophytes	Uncooked fish (mullet)	Fish	

Continued

TABLE 10 (Cont'd)

Pathogens Found in Human Excreta

Biological Group	Disease	Common Name	Pathogenic Agent	Transmission Mode	Intermediate Host or Reservoir	Physical Environment Preference or Comment
	Hookworm		Ancylostoma duodenale, Necator americanus	Through skin, infected soil, contaminated water	Soil	Warm, humid climates
	Hymenalepiasis	Dwarf tapeworm	Hymenolepis sp.	Infected insects from rats or mice	Rodent, man	
	Metagonimiasis	Intestinal fish fluke of man	Metagonimiasis yokogawai	Uncooked fish		
	Opisthorchiasis	Asian liver fluke	Opisthorchis Felineus, O. viverrini	Uncooked fish		
	Paragonimiasis	Lung fluke	Paragonimus westermani	Animal or man to aquatic snail to crab or crayfish	Animal, man snail, crab	
	Schistosomiasis	Bilharzia worm, blood fluke	Schistosoma haematobium	Larvae penetrate skin in snail-infested waters	Snail	Slowly flowing water with non-smooth banks
	Schistosomiasis	Japanese blood fluke	S. japonicum	Larvae penetrate skin in snail-infested water	Snail	Slowly flowing water with non-smooth banks
	Schistosomiasis	Manson's blood fluke	S. mansoni	Larvae penetrate skin in snail-infested water	Snail	Slowly flowing water with non-smooth banks

Continued

TABLE 10 (Cont'd)

Pathogens Found in Human Excreta

Biological Group	Disease	Common Name	Pathogenic Agent	Transmission Mode	Intermediate Host or Reservoir	Physical Environment Preference or Comment
	Strongyloidiasis	Threadworm	*Strongyloides stercoralis*	Larvae penetrate skin through human contact, possibly through dog-man contact		Warm humid climates
	Taeniasis	Beef tapeworm	*Taenia saginata*	Uncooked beef	Cattle	
	Taeniasis	Pork tapeworm	*T. solium*	Uncooked pork	Pig	
	Trichuriasis	Whipworm	*Trichuris trichiura*	Ingestion of worms from feces-contaminated soil		Soil

Source: Feachem, McGarry, and Mara, Water, Waste and Health: 6-16, 75-95, 299-309.

Kalbermatten, et al., Appropriate Technology for Water Supply and Sanitation: A Planner's Guide: 7-19.

Janetz, Melnick, Adelberg, Medical Microbiology: 169-184, 196-244, 258-261, 352-380, 454-460, 492-524.

The Economics of Water and/or Sanitation Investments

In the spring of 1977 the United Nations sponsored a conference at Mar del Plata, Argentina concerning the provision of safe water and adequate sanitation to those people without either or both. At the time the number of individuals without adequate water/sanitation was estimated at 1.07 billion excluding China. The provision of adequate water and sanitation was estimated to cost $60 billion for an adequate water supply and up to $600 billion for adequate sanitation.[50] The magnitude of this investment is large and it seems reasonable to ask what benefits will accrue from the proposed investment. Although history is replete with reference to the necessity of providing potable water and adequate sanitation there are great ambiguities concerning the benefits accruing to such provision. Since reliable benefit quantification is generally not available, water/sanitation investment programs are often compared on the basis of qualitative benefits and/or the life cycle cost of the alternate treatment schemes where the costs are estimated by engineering cost accounting. The qualitative benefits are generally considered to be improvements in health, economic development, and income redistribution. Since the benefit analysis basically reduces to a subjective judgement concerning improved health it becomes of paramount importance

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[50]Kalbermatter, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Planners Guide: 1.

that the selected technology be operable under local conditions and acceptable to local users. The World Bank has defined such technology as follows: "The most appropriate technology is defined as that which provides the most socially and environmentally acceptable level of service at the least economic cost."[51] If one looks at the historical development of water and sanitation treatment technology there has been an interdependent evolution of two factors: treatment goals and treatment technology. Over time treatment technology has become more sophisticated and treatment goals more stringent in addition to the identification additional pollution constituents to be removed from the wastewater. Treatment technology has followed the familiar S curve evolution of invention, innovation, displacement. Figure 7 applies the S curve analysis to water treatment using filtration technology as an example.[52] As increased efficiency of removal was required filtration technology moved from slow sand, then to rapid sand, and finally to multimedia/settling tubes/poly electrolytes filtration. Figures 8 and 9 indicate the movement that has taken place in water/sanitation pollution removal goals over time. Clearly both treatment goals and treatment efficiency can have a strong positive correlation with time; however, the point arises as to whether developed and developing countries are moving along the same time path or along a different time path with respect to development. If developing countries are moving along the same time path but merely displaced on the development curve then the use of treatment

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[51]Kalbermatten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Planners Guide: 3.

[52]Reid and Coffey, eds., Appropriate Methods: 30. See Chapter II and VI for a complete discussion of the technology issue.

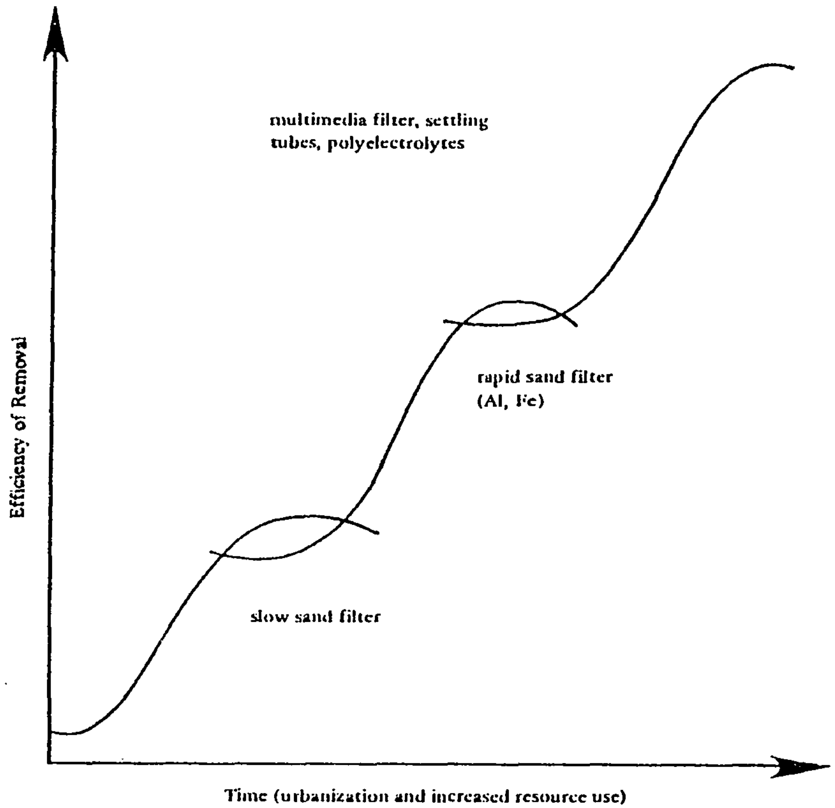

Figure 7. Development of water treatment technology.

Source: Reid and Coffey, eds., Appropriate Methods: 21.

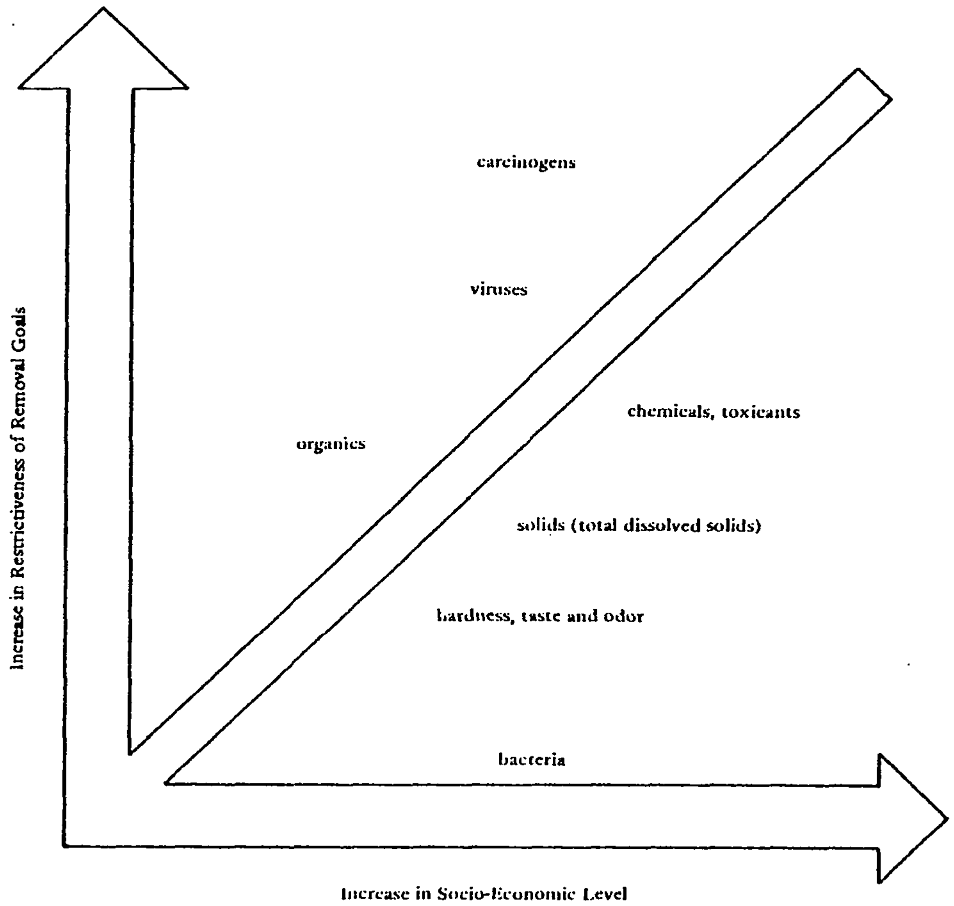

Figure 8. Constituents to be removed in water treatment.

Source: Reid and Coffey, eds., Appropriate Methods: 19.

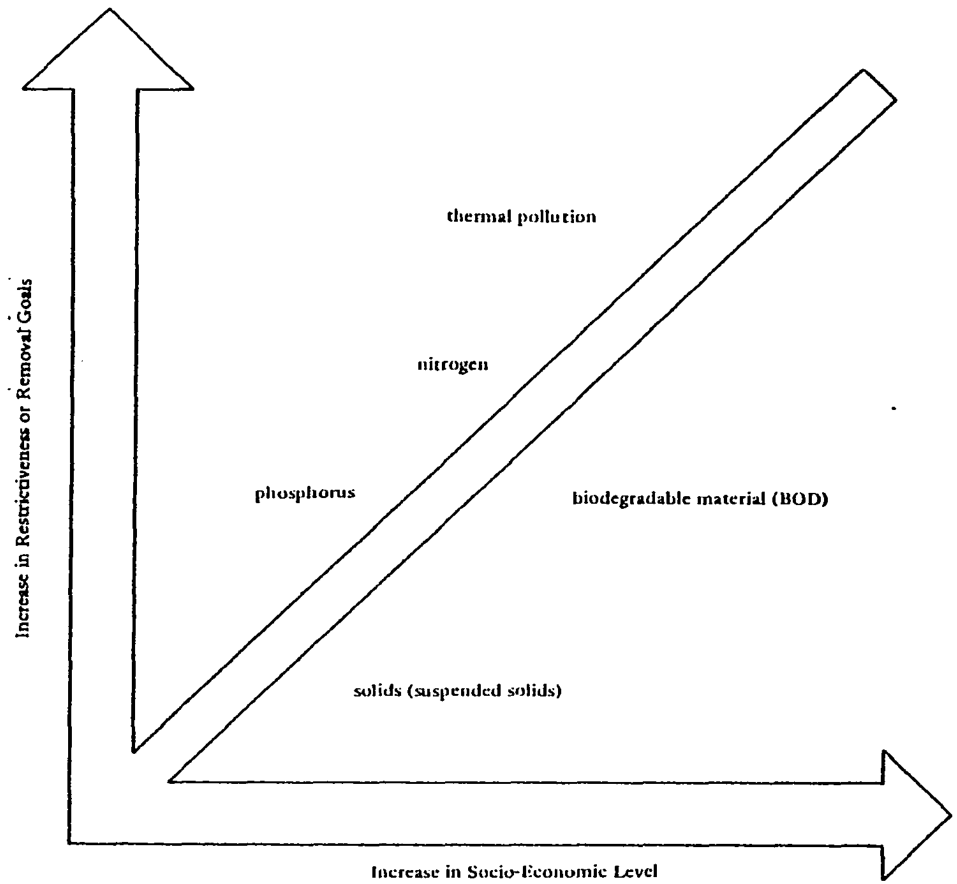

Figure 9. Constituents to be removed in wastewater treatment.

Source: Reid and Coffey, eds., Appropriate Methods: 18.

technology would be heavily oriented toward previous experiences in developed countries during their developing stage. If developing countries are moving along a different time path then regressive technology applications may not suffice as appropriate treatment. In displaced time path development, water/sanitation technology application might well find "high" technology as viable solutions for developing countries. In many developing countries the national economy has a dichotomous nature; i.e., there is one part of the economy developing in step with developed countries while a second part of the economy is developing in step with conditions existing over 50 years ago in the United States. Available evidence indicates that water treatment/sanitation technology selection in developing countries will require both "high" technology and retrogressive technology.[53] This analysis would indicate that a dual economy may have sectors which are proceeding along a continuous development time path while other sectors are moving along a discontinuous development time path. In either case the selection of technology must be appropriate to the local conditions if it will facilitate a development plan. The remainder of this section will focus on the data relative to the level of investment expected during the Water Decade, the nature of the relationship between water/ sanitation investment and the expected health benefits, and the economic impacts of the investment.

The level of investment required to adequately treat water and provide sanitation to the world's needy has been estimated by several

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[53]Reid and Coffey, eds., <u>Appropriate Methods</u>: 28-33. Kalbermatten, Julius and Gunnerson, <u>Appropriate Technology for Water Supply and Sanitation: A Planner's Guide</u>: 9.

groups; the World Bank, the World Health Organization (WHO), etc. Typical of the data is Table 11 which indicates the United Nation's estimate of the fund necessary to meet the Water Decade goals. As can be seen the WHO goals of 100% of population served would require a disbursement of $51.4 billion on water treatment and $32.3 billion on sanitation. The World Bank has placed the disbursement level at $60 billion for water treatment and between $300 and $600 billion for sanitation. Both of these calculations exclude the People's Republic of China (PRC) which may include an additional one billion people who must be supplied with water treatment and sanitation technology. It seems unreasonable that long-term planning in international organizations can ignore the needs of the PRC. It seems more reasonable that funding levels through the year 2,000 will address the issue of adequate water treatment and sanitation for PRC in addition to the remainder of the world. If the investment were undertaken during the Water Decade such an inclusion could double the investment levels needed to provide adequate water treatment and sanitation to the world. Regardless of the eventual level of investment in water and sanitation technology there is ample evidence, excluding the PRC, regarding historical data on disbursement of funds for water and sanitation investment.[54] Tables 12 and 13 indicate the investment undertaken in water and sanitation by selected regions and countries of the world. The data is displayed to emphasize the variation between internal and external financing in addition to the urban/rural split. The WHO report calls for an allocation

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[54]The data available from the PRC is not extensive. Perhaps the lack of data invites the exclusion of the PRC.

TABLE 11

Investment Required to Meet Targets in 1990 and Population Data
(Millions of 1977 U.S. $ and % of Population)

Item	Community Water Supply				Community Sanitation			
	Urban			Rural	Urban			Rural
	House Connection	Stand Pipe	Total	Total	House Connection	Home System	Total	Total
Percentage of Population Served in 1975	57	20	77	22	25	50	75	15
Percentage of Population Served in 1990	57	43	100	100	25	75	100	100
Investment Required to Meet Targets in 1990	34,500	16,900	51,400	40,800	13,900	18,440	32,340	8,400

Source: United Nations "Report on Community Water Supplies," United Water Conference, Mar Del Plata, Argentina, 14-25 March 1977, Report E/Conf. 70-14 (New York: 1977): 25.

of investment between urban and rural of 61 and 39 percent respectively. A glance at Tables 12 and 13, the percent urban to total investment columns, indicates that such a policy would be a deviation from practice for all regions except Africa and South-East Asia (mean = 23.1 rural, standard deviation = 14.4). Montanari estimates that the Word Bank disbursed just over one billion dollars on water and sanitation projects during the period 1963 to 1978.[55] The provision of the funds indicated above is a monumental task which will require international cooperation beyond a simple "call to arms." Such cooperation will occur only through an understanding of the likely economic effects. The next section of this review will investigate the economic effects of water/sanitation investment.

For development economics a fundamental question concerns effective quantification for the economic cost and benefits related to a particular investment in public goods. There are several ways to measure economic benefits as summarized in Table 14. None of the methods provide a flawless analysis procedure but there are four common problems inherent in the analysis.[56] First, there are multiple infective sources, or transmission modes, for many diseases. This multiplicity dilutes the ability to specify benefits occuring to a particilar health project. Second, there are a variety of physical and cultural factors at local sites which tend to compound the analysis of alternatives.

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[55]F. W. Montanari, "World water supply and sanitation decade -a multi-billion dollar public works program," American Public Works Reporter, (June 1979): 24.

[56]Saunders and Warford, Village Water Supply: 34-35.

TABLE 12

Investments in Community Water Supplies During 1971 - 1975
(In Millions of 1977 U.S. $)

Region or Country	National		External		Total	% External to Total	% Urban to Total
	Urban	Sub-total	Urban	Sub-total			
Africa	134.7	228.7	114.5	170.0	356.7	42.9	62.8
Americas	2,106.4	2.010.9	309.1	342.4	2,357.2	14.5	100.0
Eastern Mediterranean	1,337.1	1,793.8	53.8	138.8	1,932.6	7.2	73.0
Europe	889.4	1,157.2	1.0	1.0	1,155.5	.09	77.1
South-East Asia	593.9	1,074.9	111.4	142.9	1,217.7	11.7	57.9
Western Pacific	240.5	289.8	100.6	102.3	384.6	26.6	86.9
Total	5,302.0	6,555.3	690.4	897.4	7,444.3	12.1	80.4
No. of Countries	63	66	66	65	62	64	
Chad	.9	1.0	3.1	3.1	4.1	75.6	97.6
Kenya	10.1	22.3	8.0	10.0	32.3	24.8	56.0
Upper Volta	.6	1.1	9.0	13.0	14.1	63.8	68.1
Bolivia	9.4	11.3	31.4	32.1	43.4	72.4	94.0
Mexico	203.7	356.5	-	-	356.5	0.0	-
Panama	20.4	26.0	25.0	28.3	54.3	52.1	83.6
Bangladesh	51.1	72.0	15.0	31.8	103.8	31.6	63.7
Indonesia	43.4	53.3	20.0	23.8	77.1	30.9	82.2
Thailand	100.8	153.6	75.0	76.0	229.6	33.1	76.6

Source: World Health Organization, World Health Statistics Report, Vol. 29, No. 10 (Geneva 1976): 581-583.

TABLE 13

Investments in Excreta Disposal Facilities During 1971 - 1975
(In Millions of 1977 U. S. $)

Region or Country	National		External		Total	% External Regional to Total	% Urban Regional to Total
	Urban	Sub-total	Urban	Sub-total			
Africa	44.8	47.0	7.4	7.4	54.4	13.6	96.0
Americas	1,272.7	1,187.8	63.3	62.2	1,250.0	-	-
Eastern Mediterranean	805.1	749.1	8.9	26.6	775.7	-	-
Europe	448.4	504.6	2.0	2.0	500.4	.4	90.0
South-East Asia	53.5	59.2	6.4	6.6	65.8	10.0	91.0
Western Pacific	112.9	118.4	23.4	23.6	142.0	16.7	96.0
Total	2,737.4	2,666.2	111.4	128.4	2,788.4	4.6	98.2
No. of Countries	59	58	60	60	58		
Chad	-	-	-	-	-	-	-
Kenya	21.6	21.6	.9	.9	22.5	4.0	100.0
Upper Volta	-	-	-	-	-	-	-
Bolivia	7.4	10.4	.5	.5	10.9	4.6	72.5
Mexico	624.5	626.3	-	-	626.3	-	-
Panama	9.0	10.0	2.6	2.6	12.6	20.6	92.1
Bangladesh	.1	.8	5.0	5.2	6.0	86.7	85.0
Indonesia	.3	4.8	.6	.6	5.4	11.1	16.7
Thailand	52.8	53.3	-	-	53.3	-	-

Source: World Health Organization, World Health Statistics Report, Vol. 29, No. 10 (Geneva 1976): 584-587.

TABLE 14

Economic Benefit Measurement and Associated Analysis Problems

Valuation Measure	Analysis Problems
Willingness to pay	1. Demand is a function of education and income, both interdependent. 2. Water/sanitation is an investment and consumption good. 3. Questionnaire/interview may introduce bias through the structure of questions.
Economic value of increased, and/or healthier, lifespan	1. Considers income generation only, the value or quality of life is not included. 2. Assumes GNP maximization is society's goal.
Present value of output generated minus consumption	1. Considers only income generation (see above). 2. Assumes GNP maximization is society's goal.
Implicit value from previous governmental health programs	1. Politics generally most decisive factor in determining the quantity and location of health investments.
Aggregate death and disability premiums	1. Insurance may reflect value to beneficiaries. 2. Ignores those individuals without sufficient disposable income to participate in insurance.
Socio-economic quality of life index methods	1. Generally not suitable for micro or project level analysis. 2. Data is difficult to gather.
Cost effectiveness methods	1. Cannot get specific cost-benefit relationship.
Cost-benefit analysis	1. Cost, and/or service rates, maybe reduced for political reasons. 2. Macro-economic goals such as employment may not be reflected. 3. All benefits must be the same for all alternatives. 4. External benefits are often excluded in the analysis. 5. Misleading results may occur when projects are mutually exclusive.

Source: Saunders and Warford, Village Water Supply: 47-53. John A. Sinden and Albert C. Worrell, Unpriced Values: Decisions Without Market Prices, (New York: Wiley, 1979): 303-363.

Third, the removal of all pathogenic agents associated with water/ sanitation investments would be prohibitively expensive. This results in a compromise in terms of health and compounds the analysis of alternatives. Fourth, attempts to tradeoff between cost and benefits involves quantification of "better" health. At the present time such quantification is not possible. Saunders and Warford summarize the problem as follows:

> An improvement in water supply and sanitation can generate interrelated improvements in health, income, and social welfare. Although such benefits are used to justify massive investments expenditures, in practice they are hard to identify and harder to measure. While it is possible to make rational decisions about unquantifiable goals or benefits if their economic costs are known, even this information is often unavailable.[57]

These factors combined to prevent a direct analysis link between economic output and improved health. Several authors indicate that adequate water and sanitation is a necessary but not sufficient condition for economic development.[58] The Feachem, McGarry, and Mara study indicates there are immediate goals to be accomplished, three stages of benefits to be derived, and complementary inputs necessary for facilitating the goals/benefits (see Tables 15 and 16). Saunders and Warford separate

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[57]Saunders and Warford, Village Water Supply: 31.

[58]Feachem, McGarry and Mara, Water, Waste, and Health: 78, 137-8. Saunders and Warford, Village Water Supply: 61.

TABLE 15

Aims and Potential Benefits of Water Supply Improvement

Immediate Aims	Stage I Benefits	Stage II Benefits	Stage III Benefits
Improved Water:	Save time	Labor release	Higher cash incomes
Quality	Save energy	Crop innovation	Increased and more reliable subsistence
Quality	Improved health	Crop improvement	
Availability		Animal husbandry innovation	Improved health
Reliability		Animal husbandry improvement	Increased leisure

Source: Feachem, McGarry, and Mara, Water, Waste and Health: 79-80.

TABLE 16

Complementary Inputs Necessary for the Achievement of the Various Aims and Benefits Setout in Table 15

Aim or Benefit	Complementary Inputs or Prerequisite Conditions
Immediate Aims	Active community participation and support. Competent design. Adequate facilities for operation and maintenance. Appropriate technology utilized.
Stage I Benefits	New supply used in preference to old. New supply closer to dwellings than old. Water use patterns changes to take advantage of improved quantity, availability and reliability. Hygiene changed to utilize improved supply. Other environmental health measures taken. Supply must not create new health hazards (e.g., mosquitos breeding sites).
Stage III Benefits	Good advice and extension services must be provided by government personnel concerned with agriculture, animal husbandry, cooperatives, marketing, education, credit, etc.
Stage III Benefits	Water supply development must be just a single component of an integrated rural development program which has the active support of the local community.

Source: Feachem, McGarry, and Mara, Water, Waste, and Health: 77-80.

the macroeconomic effects into three areas: economic growth, redistribution of income, and balance of payments.[59] A water supply/sanitation program will lead to economic growth if the external funds would not have been received otherwise, if the country is not fully employing indigenous resources, and if the decrease in savings from within country increases aggregrate demand. Redistribution of income will occur if government revenues are derived from taxation. Balance of payments problems may arise in developing countries where capital is scarce and unskilled labor is relatively cheap. The positive short run effects are increased irrigation of vegetables, increased local fish farming, and increased livestock watering. If individuals must contribute funds to the cost of the project then disposable income may be reduced and a negative short run effect will be realized. The positive long run effects include direct economic effects, reduction in mortality, reduction in morbidity, reduction in disease spread, increased time for work and leisure, decrease labor cost due to disease averted, and decreased migration from rural to urban where rural investment is undertaken. The direct economic effects include increases in the economic infrastructure, increases in economic activity, and increases in property tax revenue. Unfortunately no direct link has been established between economic output and health at the project level. There are two ways to measure the effect of reduction in mortality. The first method stresses changes in gross output for a given untimely death. The second method attempts to measure the change in net output, gross output minus

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[59]Saunders and Warford, Village Water Supply: 56-61.

consumption, for a given untimely death. The first method stresses gross output as a societal goal while the second method stresses consumption as a social goal. Reduction in morbidity results from decreases in worker absentee rates, increased worker productivity, and decreased earnings due to home care. There is a synergic effect if investment in education is coordinated with the investment in water supply/sanitation. For developing countries the effect of underemployment and unemployment may negate the benefits due to reduction in morbidity. Reduction in disease spread occurs through two mechanisms: reduction in the level of pollution reduces transmission and increased body resistance to an infective dose. Once the disease spread is hampered the benefits are gained through reduction in mortality, etc. The provision of more convenient water supply/sanitation generally reduces the amount of time spent in collection of water for household usage. The collection of water is generally the work of women and children in developing countries with the result that increases in available time may not significantly affect benefits if there is substantial under/unemployment. Economic costs may be averted if the water supply/sanitation investment results in reduced expenditures on health or medical expenses. Rural migration to urban areas may be reduced if the water supply/sanitation is directed to rural areas. The World Bank study, in addition to Saunders and Warford, finds no evidence for health/medical cost averted or significant effects on migration. It is unfortunate that the practical aspects of benefit estimation are not possible. The situation is illustrated by the following:

> A major theme of this book is the extreme difficulty of predicting the effects of investment in rural water supply and sanitation. A satisfactory basis on which to allocate funds to the sector as a whole is therefore lacking, as well as a method of ranking projects within the sector. . . . but at the present intuition is the primary guide as to the merits of competing projects.[60]

The relationship of benefits to investment is not only tenuous but some ramifications are, in fact, distinctively negative (e.g., the provision of additional unskilled labor is likely to acerbate labor conditions in dual economies where unskilled labor is generally underemployed and over supplied). In summary, at the present time it is possible to discuss the theoretical aspect of the benefits resulting from the provision of adequate water and sanitation but it is not possible to quantify the basic relationships.

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[60]Saunders and Warford, Village Water Supply: 164.

Summary

This literature review has considered three main areas of investigation: technology selection models, the relationship between water supply/sanitation and health, and the relationship between investment water supply/sanitation and economic benefits. The four technology selection models individually provided both advantages and disadvantages. None of the current models were found perfectly tuned to conditions in developing countries. It is quite clear that a significant investment in water supply and sanitation will be undertaken in the 1980's. It cannot clearly be established what relationship exists between this type of investment and public health. In addition, even if the investment/public health data existed it would not be possible to segregate the effects so that economic benefits could be quantified in a meaningful fashion. It is quite clear that a link between adequate water supply and sanitation and public health exists in the aggregate. It is also clear that investments in this type of infrastructure provide a necessary but not sufficient condition for economic development. Until the separate linkages can be established a need exists to provide a technology selection model which facilitates planning in developing countries. Since benefit analysis basically reduces to a subjective judgement concerning public health it becomes of paramount importance that the selected technology be operable under local conditions (i.e., there is a need to encourage the selection of appropriate technology).

Since the selection will be based on qualitative benefits and estimates of life cycle cost associated with alternate treatment schemes, there is a need for the planning process to evaluate the sensitivity to design factors during the selection process. The following chapter develops a selection model which responds to these planning needs in developing countries.

CHAPTER III

MAPMAT METHODOLOGY

Introduction

MAPMAT represents an attempt to focus high technology, in the form of hardware and software (information, etc.), on the problem of selecting appropriate technology. Previous sections of this paper have indicated the need for the selection of appropriate technology in water treatment and sanitation technology and the investment necessary to mitigate the related health problems in developing countries. Several technology selection models have been reviewed to indicate the basis from which MAPMAT arises. MAPMAT intends to fulfill the following design criteria:

1. The selection of water treatment and/or sanitation technology which is appropriate to local resource availability.

2. The selection of water treatment and/or sanitation technology which is responsive to local health conditions and social/cultural customs.

3. The selection methodology includes interactive sensitivity analysis to facilitate the planning process.

4. The selection framework includes a common interaction reference for an interdisciplinary group of planners.

5. The selection methodology incorporates the technology appropriate to both urban and nucleated village conditions in developing countries.

6. The selection methodology addresses the issue of using economic cost analysis as opposed to engineering cost analysis.

7. The selection methodology provides engineering design level data using telecommunication.

8. The selection methodology incorporates multiobjective optimization rather than selection of the least cost alternative.

Criteria 1, 2, 3, 4, and 5 are fulfilled using an enhanced combination of the USAID/RE&D and WBANK selection models. Criteria 6 fulfills the philosophical intent of WBANK with respect to economic costing of alternatives. Criteria 7 is fulfilled using an automated telecommunications link to CAPDET. The fulfillment of Criteria 8 is closely connected to the optimization technique of EXEC-OP. The design of MAPMAT, and by implication the fulfillment of the design criteria, represents a logical extension of the previous work in the area and a merging of the elements into an intergrated system. The following paragraphs will discuss MAPMAT in terms of technology selection, optimization procedure and unit process cost, sensitivity analysis, telecommunication module and the statistical module.

MAPMAT Screening Algorithm

The thrust of MAPMAT is to provide a tool for knowledgeable planners. The planner is expected to be able to select combinations of treatment technology which will fulfill treatment and health goals. The telecommunication link to CAPDET allows a check of the engineering design to ensure that treatment and health goals are accomplished. MAPMAT considers four main areas of constraints: technical, social/cultural, resource, and health. Technical constraints include:

1. Population density.
2. Water quantity requirement.
3. Sludge disposal requirement.
4. Sewage connection requirement.
5. Sullage disposal requirement.
6. Height of groundwater restriction.
7. Water connection requirement.

The population density technical constraints attempts to eliminate technologies that become inappropriate as population growth occurs. In general this is due to the nature of the technology. For example, one of the lowest levels of sanitation technologies, ventilated improved pit laterine, becomes inappropriate as population density rises due to the inability, and rising unavailability, of land to adequately degrade the toxic materials. As the population density rises there would be less land available for digging laterines and the health hazard would rise as the available land must be reused sooner. The result is that some technologies become inappropriate after a certain population density.[1]

The water quantity technical constraint indicates the quantity of water required, in liters per capita per day (LPCD), to properly maintain the technology. This level varies based on the basic design of the technology with some technologies requiring no water while others may require 75 LPCD for proper operation.

The sludge disposal technical constraint indicates that the treatment technology will require the disposal of sludge at the local site. This disposal represents a need to access the treatment physically in addition to the need for adequate disposal following collection. As an example the septic tank technology requires periodic desludging to maintain proper operation while the nature of the ventilated improved pit laterine removes the need for sludge disposal.

The sewerage connection technical constraint indicates if the basic nature of the technology requires access to a conventional sewer

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[1]The technical constraints section follow closely the WBANK and USAID/REID formulations and the work by Feachem, McGarry, and Mara.

for proper operation. Certain technologies such as a sewered pour-flush toilet requires the existence of a sewer system while other technologies, such as the rotating biological contactor, assume the existing of water-bourne sewage collected to a central point. By implication, of course, the central collection would occur as a result of conventional sewerage connections.

The sullage disposal technical constraint indicates the necessity of providing on-site disposal of sullage. Certain technologies, e.g., septic tank treatment, can accommodate sullage disposal as an integral element of the operation of the technology while other technologies, e.g., pour-flush toilets may require the addition of separate sullage disposal ability to insure adequate operation.[2]

The height of groundwater technical constraint recognizes that certain sanitation technologies may create a problem of contamination if the effluent leaches into the local water supply. In general these possible contaminations will occur where the design of the technology uses the soil as a soakaway (see Figure 11 for examples of soakaways used with sanitation technology).

The final technical constraint, site water connection, indicates the level of water connection required for the proper operation of the technology. The levels are no water connection required, a standpipe connection in the near vicinity, a yard connection at the dwelling,

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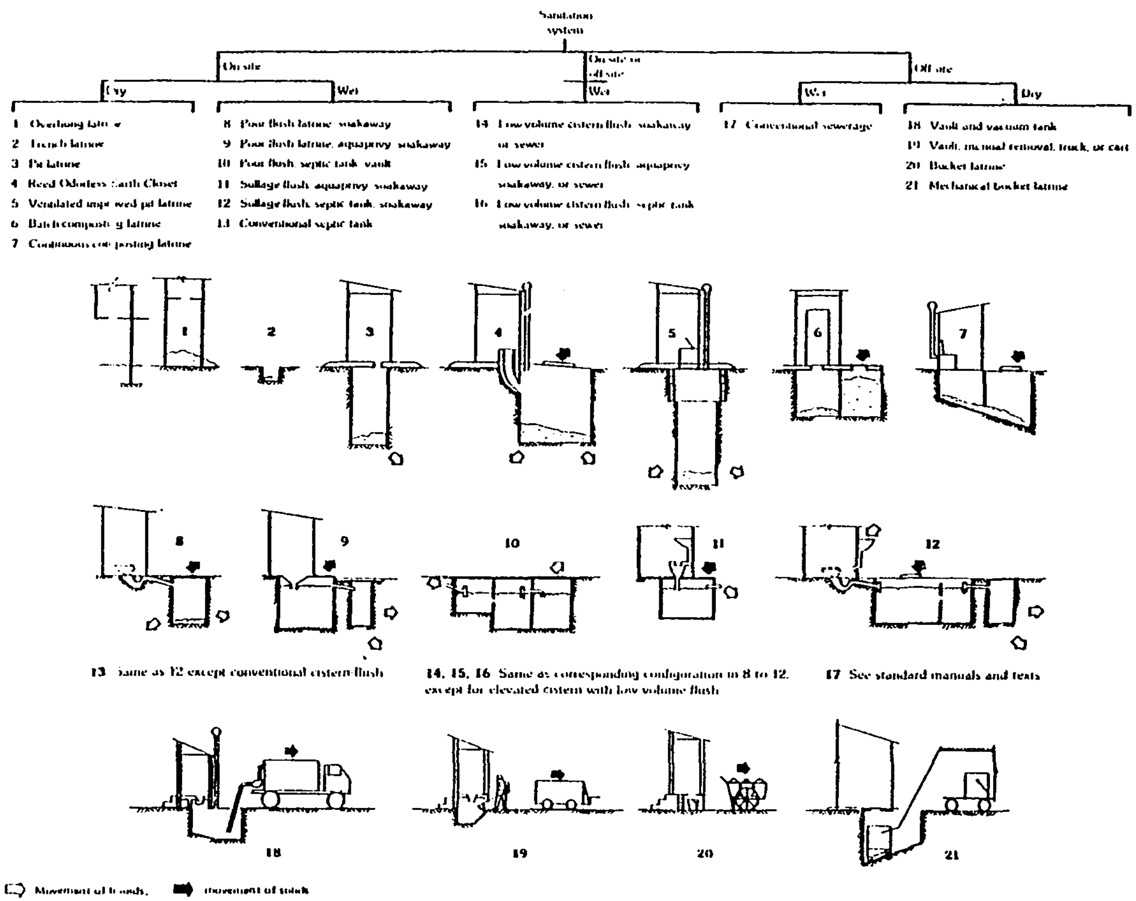
[2]The WBANK study indicates that the conveyence of conventional sewage is the primary advantage of conventional sewer technology over on-site disposal technology. The disposal of sullage represents much of this conveinience. See Kalbermattten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: Technical and Economic Options: 17-18.



Source: Kalbermatten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: a Summary of Technical and Economic Options: Annex.

Figure 11. The World Bank Generic Classification of Sanitation Systems Source.

and a house connection.

The second major technology constraint is the social and cultural area which includes the following subdivisions:

1. Anal material usage restriction.

2. Visible excreta restriction.

3. Fly or mosquito inhibitor restriction.

4. Humus handling, or reuse, restriction.

5. Level of user education required.

6. Level of infrastructure required to organize operation and maintenance.

The anal material usage social/cultural constraint indicates the effect of various commonly used materials on the operation of the technology. Several sanitation technologies cannot accommodate cleansing materials such as mudballs, corn cobs, grain or cement sacking, etc. The double-vault composting toilet cannot tolerate an excessive quantity of water usage. The WBANK study indicates a maximum of 10 LPCD for this type of technology. The use of water as an anal cleansing material would restrict the use of such technology in many developing countries where most anal cleansing is accomplished by water rinse.

The visible excreta social/cultural constraints indicates the disfavor which many societies, both developed and developing, have with visible excreta. If the viewing of adult excreta is objectional, individuals may refuse to use the technology even if the only alternative is defecation in the open. Objection to the sight of excreta would destroy the usefulness of an aquaprivy regardless of the nonviolation of other constraints.

The fly/mosquito inhibitor social/cultural constraint indicates those technologies which may provide especially favorable habitate for various water-related diseases such as yellow fever, etc. The technologies affected, e.g., ventilated improved pit laterines for sanitation and pretreatment for water supply, may produce favorable conditions for disease transmission unless an inhibitor, such as an insectcide or mechanical cover, can be included with the technology. The willingness and ability of the local user to effectively employ the inhibitor becomes critical to the success of the technology.

The humus handling, or reuse, social/cultural constraint indicates those technologies where the local individual is likely to be required to dispose of a residual generated by the technology. The sanitation technology ventilated improved double pit laterine represents a technology which could required local participation in removal/disposal of the residual produced during the composting. If there is local resistance to the use of the residual in agricultural endeavors then these technologies may not be viable alternatives. In addition if there is local resistance to the handling of the residual, the technologies are not likely to be appropriate to local conditions.

The level of user education social/cultural constraint indicates that some technologies will require a low level of instruction for local users while other technologies will require a high level of user education if the technology is to be adequate to local conditions.[3] Some technologies simply require a greater comprehension by the user of the health-treatment relationship to be useful. Conventional sewage represents a case where almost no significant education is required since the transport system moves the potential hazard to a concentrating location. The ventilated improved pit laterine requires a low level of education for adequacy, however, the design nature of the double-vault composting toilet requires a knowledge of the proper mix of organic materials to be supplied, etc., if the technology is to be successful.

The level of infrastructure social/cultural constraint indicates the necessity to provide a local organizational network, or induce individual responsibility, to operate and maintain the technology. In the case of an containment filter for water supply technology or a Reed Odorless Earth Closet for sanitation technology, once the user is properly educated in the usage the level of organization effort necessary to maintain the technology properly is low, however, a sanitation technology such as vault and cartage or a water supply technology such as chlorination require a high level of local infrastructure to operate and maintain the technology. This may indicate a higher operation cost but volunteerism could be a significant factor in offsetting such cost. The salient point is that it is the infrastructure which must exist as an effective network to support local development rather than the relatively higher cost of operation.

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[3]User education represents a complementary investment in this case, however, the critical emphasis here is not the additional investment which must be undertaken but the actual complexity, and therefore, precariousness, of the technology to the level of education provided to, and accepted by, locals.

The third major area of constraint is resources. The resource constraints can be subdivided into the following:

1. Labor

Construction	(Unskilled)
Operation and	(Semi-skilled)
Maintenance	(Skilled)
	(Professional)

2. Equipment

   Electrical
   Laboratory
   Electronic

3. Supplies

   Chemicals
   Process
   Operation and Maintenance
   Laboratory

4. Energy

   Electrical
   Other (gasoline, diesel, etc.)

5. Miscellaneous

   Land
   Organic Matter (straw, leaves, etc.)

The labor resource constraints indicates the necessity for four types of labor:

1. Unskilled, e.g., common laborer.

2. Semi-skilled, e.g., apprentice electrician.

3. Skilled, e.g., electrician

4. Professional, e.g., engineer

The technologies are constrained differently depending on the nature of the requirement: construction or operation and maintenance. In general sanitation and water supply technologies require a higher level of skill in construction compared to operation. The second resource constraint is equipment. The subdivisions of this constraint include:

1. Electrical equipment, e.g., pumps, motors, etc.

2. Laboratory equipment, e.g., balance, disk washer.

3. Electronic equipment, e.g., pH meter, calculator, computer.

Except for labor and land, all resource constraints are intended for operation and maintenance. This reflects the fact that construction materials are often available from the major urban areas, provided by the funding agency, or connected to the foreign exchange component of funding through an international lending organization. These subdivisions are based on the technical details of the various treatment technologies.

The supplies resource constraints indicate the major elements of supplies needed for the operation and maintenance of sanitation and water supply technology. The subdivisions for this constraint include:

1. Chemical supplies, e.g., lime, chlorine.

2. Process supplies, e.g., pipe, valves, tubing.

3. Operation and maintenance supplies, e.g., sand, gravel, water.

4. Laboratory supplies, e.g., test tubes, filter paper.

All of the operation and maintenance resources are expected to be readily available or will be continuously supplied by a central agency to the local site. The supplies resource constraint would be especially critical due to the high levels of continuing usage.

The energy resource constraint indicates the usage of electrical power or other energy medium such as gasoline, diesel, etc. for operating vehicles, etc. The levels of the electrical subdivision reflect an adaptation of the Metcalf and Eddy, Inc. analysis of pumping station design:[4]

Class	Capacity range
None	Lights only or none
Low (small)	200-700 gpm
Medium (intermediate)	700-10,000 gpm
High (large)	15 million gallons per day

The levels of the other energy subdivision indicate the likely need for the use of vehicles in the operation of the technology.

[4]Metcalf and Eddy, Inc., Wastewater Engineering: Collection, Treatment, Disposal (New York: McGraw-Hill, 1972): 204.

The miscellaneous resource constraint indicates the relative level of land required for the technology construction and operation in addition to the requirement for organic matter such as straw, leaves, etc., to be used in the operation of the technology. The land requirement reflects the general parameters of the separate technologies as follows:[5]

Class	Requirement for Land (acres)
Low	Less than one-tenth of an acre
Medium	Between one-tenth and one-half an acre
High	Greater than one-half acre

The organic matter subdivision of the miscellaneous resource constraint reflects the requirement for compost balancing materials in sanitation technologies.

The fourth and final major constraint classification relates to the possibility of certain technologies to favor the development of related health problems. There are three major subdivision in this classification: helminth, insect, and heavy metals. All of these restrictions are interdependent with social/cultural habits but rely primarily on the connection between a hazardous entity, unfavorable health

[5]These divisions are based loosely on the design recommendations for sand filters by Fair and Geyer, and the design of activated sludge processes by Metcalf and Eddy, Inc. See Gordon M. Fair and John C. Geyer, Elements of Water Supply and Waste-Water Disposal, (New York: John Wiley and Sons, 1958): 369. Also see Metcalf and Eddy, Wastewater Engineering: 519-522.

conditions in the local area, and technology design. For the helminth major classification there are three subdivisions:

1. Food transmission where the helminth related disease is transmitted by the human consumption of raw or partially cooked meat, i.e., fish, beef, pork, crab, etc. Examples of these diseases include clonorchiosis and diphyllobothriasis.

2. Water transmission where human contact with snail/host residing in water leads to the diseases; e.g., dracontiasis or schistosomiasis.

3. Soil transmission where human contact with excreta contaminated soil allows transmission. In general the helmiuth eggs mature in the soil until passage to the human. Examples of these deseases include ascariasis and hookworm.

Certain technologies, no treatment or pretreatment for water supply and aquaculture or land treatment for sanitation, may actually be hazardous to health if local sites experience specific health conditions. If in the local area raw or partially cooked meat, i.e., fish, beef, pork, crab, etc. will be consumed and there commonly exist helminth related diseases such as clonorchiosis and diphyllobothriasis then several sanitation and water supply technologies may acerbate local health conditions.[6] For example water supply technologies no treatment and pretreatment in addition to sanitation technologies, vault and cartage, aquaculture, land treatment, and trickling filtration provide excellent transmission mediums for the helminths or their eggs. The use of these technologies might easily be technically sufficient but inappropriate to local conditions.

The water transmission subdivision indicates the importance of the possible transmission of this helminth by several technologies. Schistosomiasis is transmitted by the penetration of human skin during contact with snail-infested waters where the snail serves as an intermediate host. These helminths prefer slowly flowing water/wastewater with non-smooth banks. If the helminths exist, or could easily be imported from other regions, certain sanitation technologies; e.g., aquaculture, and water supply technologies; e.g., no treatment, may improve the likelihood of transmission. Such transmission would mean inappropriate technology due to the health constraints.

The final helminth subdivision, soil transmission, indicates those technologies which might provide favorable habitat for the transmission of the related diseases. As an example the Ascaris lumbricoides helminth lays eggs which are excreted and mature in soil. Human contact with the soil, or fecal contamination of food or drinks, results in transmission of the desease ascariasis. The water supply technologies providing favorable conditions for transmission of these type of diseases are no treatment and pretreatment. Aquaculture, sludge drying

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[6]See Tables 6-9 for more complete coverage of these diseases.

beds, sludge lagoons, land treatment, and trickling filtration are sanitation technologies which may provide favorable habitat for the transmission of the eggs.

The second major health constraint relates to diseases arising from insect transmission. These deseases may be transmitted mechanically, i.e., the insect has physical contact with the contaminate then spreads the contaminate by physical contact with the human's body or food, or by biting the human. Houseflies and blowflies are examples of the mechanical transmission insects. The mosquitoes and gnats are examples of the insect bite transmission. The mechanical transmission insects may transmit any of the sanitation related diseases (see Table 10) with the genus Musca and genus Chrysomyia most important as vectors. The biting insects transmit several diseases such as yellow fever, malaria, elephantiasis, and sleeping sickness (see Tables 6 through 10). If environmental conditions are favorable to the insects, generally a warm humid climate is preferred, then certain water supply, e.g., no treatment, and sanitation technologies, e.g., ventilated improved pit latrine, sludge drying beds, will be inappropriate technologies for local conditions.

The final major classification under health constraints relates to the transmission of diseases by heavy metals being deposited in the soil and/or by vegetables produced for human consumption. Lead poisoning represents an example of this type of health problem. The sanitation technology land treatment could explicitly contribute to unhealthly conditions. If the compost is used for agricultural purposes such sanitation technologies as double-vault composting toilet and thermophilic composting could transmit heavy metals.

In summary MAPMAT uses a screening algorithm to indicate those technologies which may not be appropriate for local usage due to technical constraints, social/cultural constraints, resource constraints, and health constraints. The following section will discuss the technology selection algorithms, optimization technique, and development of the cost ratios.

MAPMAT Technology Selection Algorithm, Optimization Technique, and Cost Ratios

Having established the parameters to be included in the MAPMAT screening of technology it is necessary to establish the water supply and sanitation technology to be included, the optimization technique used in MAPMAT, and the cost ratios used during optimization. The water supply and sanitation technologies included in MAPMAT are shown in Table 17. Brief descriptions are included as Appendix K to provide sufficient information for comparison.[7] As can be seen in Table 17 MAPMAT includes 29 sanitation technologies and 11 water supply treatment technologies ranging from the lowest level; i.e., a pit latrine in sanitation and no treatment in water supply technology, to the highest technology level; i.e., rotating biological contactor in sanitation technology and desalting in water supply technology. Tables 18 through 21 correlate the sanitation technologies to the screening process used in the initial step of MAPMAT. Tables 22 through 25 correlate the water treatment technologies to the MAPMAT screening process. Tables 18 and 22 relates the technologies, sanitation and water treatment, to the technical constraints used in MAPMAT. For the first constraint there are three quantity breaks for maximum population density: less than or equal to

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[7]Figure 11 includes drawings for the lesser known sanitation technologies.

TABLE 17

Legend for Tables 18 Through 24

Acronym	Sanitation Technologies
VIPL	Ventilated Improved Pit Latrine
VIDPL	Ventilated Improved Double Pit Latrine
ROEC	Reed Odorless Earth Closet
ST	Septic Tank
DVCT	Double Vault Composting Toilet
PFT	Pour Flush Toilet
PFT.SEW.SB	Pour Flush Toilet, Sewered, Small Bore
PFT.ST	Pour Flush Toilet, Septic Tank
AP	Aquaprivy
AP.SULLAGE	Aquaprivy, Sullage
AP.SEW.SB	Aquaprivy, Sewered, Small Bore
V&C	Vault and Cartage
COMM	Communal Facilities
COMM.SEW	Communal Facilities, Sewered
AC	Aqua Culture
LAG.WSP	Lagoons, Waste Stabilization Ponds
TC	Thermophilic Composting
HRTC	High Rate Thermophilic Composting
PC	Primary Clarification
SDBED	Sludge Drying Beds
SDLAG	Sludge Drying Lagoons

Continued

TABLE 17 (Cont'd)

Acronym	Sanitation Technology
ALAG.Ext	Aerated Lagoons, Extended
CHLOR	Chlorination
LT	Land Treatment
RBC	Rotating Biological Contactor
AS	Activated Sludge
TF.STD	Trickling Filtration, Standard
TF.HR	Trickling Filtration, High Rate
IMHOFF	Imhoff Tank
	Water Supply Technologies
NT	No Treatment
PT	Pretreatment
SSF	Slow Sand Filter
RSF	Rapid Sand Filter
T&O	Taste and Odor
DFILT	Disinfection Filter
CFILT	Containment Filter
SOFT	Softening
DSALT1	Desalting, Softwater
DSALT2	Desalting, Brackish
	Tables 18 - 25 Mnemonics
NA	Not Applicable
Y	Yard connection for water
H	House connection for water
S	Standpost connection for water

TABLE 18

Sanitation Technology Technical Constraints

Sanitation Technology	Technical Constraints						
	Maximum Population Density, People/ Hectare	Water Required, LPCD	Site Sludge Disposal Required	Sewage Connection Required	Sullage Disposal Required	Height of Groundwater A Problem	Site Water Connection Required
VIPL	≦300	-	No	No	Yes	Yes	None
VIDPL	≦300	-	Yes	No	Yes	Yes	None
ROEC	≦300	-	Yes	No	Yes	Yes	None
ST	≦300	4.5	Yes	No	No	Yes	Y,H
DVCT	≦600	-	Yes	No	Yes	No	None
PFT	>600	6	Yes	No	Yes	No	None
PFT.SEW.SB	>600	4.5	Yes	Yes	No	No	None
PFT.ST	≦600	6	Yes	No	Yes	Yes	S,Y,H
AP	>600	4.5	Yes	No	Yes	Yes	S,Y,H
AP.SULLAGE	>600	4.5	Yes	No	No	Yes	Y,H
AP.SEW.SB	>600	4.5	Yes	Yes	No	No	Y,H
V&C	>600	10 (max)	Yes	No	Yes	No	None
COMM	>600	35	Yes	No	No	No	Yes
COMM.SEW	>600	75	No	Yes	No	No	Yes
AC	≦600	-	No	No	No	Yes	None
LAG.WSP	>600	-	Yes	No	No	No	None
TC	>600	-	Yes	No	No	No	None
HRTC	>600	250	Yes	No	No	No	None
PC	>600	250	Yes	yes	No	No	H
SDBED	>600	250	Yes	yes	No	NO	H
SDLAG	>600	250	Yes	Yes	No	No	H
A.LAG.EXT	>600	250	Yes	Yes	No	No	H
CHLOR	>600	250	Yes	Yes	No	No	H
LT	>600	250	Yes	Yes	No	No	H
RBC	>600	250	Yes	Yes	No	No	H
AS	>600	250	Yes	Yes	No	No	H
TF.STD	>600	250	Yes	Yes	No	No	H
TF.HR	>600	250	Yes	Yes	No	No	H
IMHOFF	>600	250	Yes	Yes	No	No	H

TABLE 19

Sanitation Technology Social/Cultural Constraints

Sanitation Technology	Anal Material Usage Restriction	Visible Excreta Restriction	Fly or Mosquito Inhibitor Required	Humus Handling or Reuse Restriction	Level of User Education Required	Level of Infrastructure Required to Organize Operation and Maintenance
VIPL	No	Yes	Yes	No	Medium	Low
VIDPL	No	Yes	Yes	Yes	Medium	Low
ROEC	No	No	Yes	No	Medium	Low
ST	No	No	No	No	Very Low	Medium
DVCT	Yes (H_2O)	Yes	No	Yes	High	High
PFT	Yes	No	No	No	Medium	Low
PFT.SEW.SB	Yes	No	No	No	Low	Low
PFT.ST	Yes	No	No	No	Low	Medium
AP	No	Yes	Yes	Yes	Medium	Low
AP.SULLAGE	No	Yes	No	No	Low	Medium
AP.SEW.SB	No	Yes	No	No	Low	Medium
V&C	No	Yes	Yes	Yes	Low	High
COMM	Yes	No	Yes	No	Medium	High
COMM.SEW	Yes	No	No	No	Low	High
AC	No	No	Yes	No	No	High
LAG.WSP	No	No	Yes	No	No	Medium
TC	No	No	Yes	Yes	No	High
HRTC	No	No	No	Yes	No	High
PC	No	No	No	No	No	Medium
SDBED	No	No	Yes	No	No	Medium
SDLAG	No	No	Yes	No	No	Medium
ALAG.EXT	No	No	Yes	No	No	Medium
CHLOR	No	No	No	No	No	High
LT	No	No	Yes	No	No	Medium
RBC	No	No	Yes	No	No	High
AS	No	No	No	No	No	High
TF.STD	No	No	Yes	No	No	Medium
TF.HR	No	No	Yes	No	No	Medium
IMHOFF	No	No	No	No	No	High

TABLE 20

Sanitation Technology Resource Constraints

Sanitation Technology	Resource Constraints																		
	Labor								Equipment			Supplies				Energy		Misc.	
	Construction				Operation & Maintenance														
	Unskilled	Semiskilled	Skilled	Professional	Unskilled	Semiskilled	Skilled	Professional	Electrical	Laboratory	Electronic	Chemical	Process	Operation & Maintenance	Laboratory	Electrical	Other	Land	Organic Matter
VIPL	x	x			x							x		x				low	
VIDRL	x	x			x							x		x				low	
ROEC	x	x	x		x							x		x				low	
ST	x	x	x	x	x	x								x			low	med	
DVCT	x	x	x		x	x								x				low	x
PFT	x	x	x		x									x				low	
PFT.SEW.SB	x	x	x	x	x	x	x	x	x					x		low		med	
PFT.ST	x	x	x	x	x	x								x			low	med	
AP	x	x	x		x	x						x		x			low	low	
AP.SULLAGE	x	x	x		x	x								x			low	med	
AP.SEW.SB	x	x	x	x	x	x	x	x	x					x		low	low	med	
V&C	x	x	x		x	x	x					x		x			med	low	

Continued

TABLE 20. Continued

	Resource Constraints																		
	Labor								Equipment			Supplies				Energy		Misc.	
	Construction				Operation & Maintenance														
Sanitation Technology	Unskilled	Semiskilled	Skilled	Professional	Unskilled	Semiskilled	Skilled	Professional	Electrical	Laboratory	Electronic	Chemical	Process	Operation & Maintenance	Laboratory	Electrical	Other	Land	Organic Matter
COMM	x	x	x	x	x	x			x			x		x			low	low	
COMM.SEW	x	x	x	x	x	x	x	x	x					x		low	low	med	
AC	x	x	x		x	x								x			low	high	
LAG.WSP	x	x	x		x	x			x				x	x		low		high	
TC	x	x	x		x	x								x		low	low	med	x
HRTC	x	x	x		x	x	x		x			x	x	x		med	low	med	x
PC	x	x	x	x	x	x	x		x			x	x	x		med		med	
SDBED	x	x	x		x	x			x				x	x		low	low	high	
SDLAG	x	x	x	x	x	x			x				x	x		low	low	high	
ALAG.EXT	x	x	x	x	x	x			x				x	x		med		high	
CHLOR	x	x	x	x	x	x	x		x	x	x	x	x	x	x	low		low	
LT	x	x	x		x	x	x		x	x	x		x	x	x	high	med	high	
RBC	x	x	x	x	x	x	x	x	x	x	x		x	x	x	high		med	
AS	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	high		med	
TF.STD	x	x	x	x	x	x	x		x				x	x		high		med	
TF.HR	x	x	x	x	x	x	x		x				x	x		high		med	
IMHOFF	x	x	x	x	x				x				x	x		med		med	

TABLE 21

Sanitation Technology Health Constraints

Sanitation Technology	Health Constraints: Helminth — Raw or Half-Cooked Meat Restriction (Fish, Beef, Pork, Crab, etc.)	Health Constraints: Helminth — Schistosomiasis Restriction	Health Constraints: Insect — Ascaris, Hookworm, Tapeworm Restriction	Health Constraints: Insect — Filariasis Restriction (Cockroach, Fly, Mosquito)	Health Constraints: Insect — Heavy Metal Restriction
VIPL				x	
VIDPL				x	
ROEC				x	
ST					
DVCT				x	x
PFT					
PFT.SEW.SB					
PFT.ST					
AP					
AP.SULLAGE					
AP.SEW.SB					
V&C	x		x		
COMM					
COMM.SEW					
AC	x	x	x	x	
LAG.WSP				x	
TC					x
HRTC					x
PC					
SDBED			x	x	
SDLAG			x	x	
ALAG.EXT					
CHLOR					
LT	x		x	x	x
RBC		x			
AS		x			
TF.STD	x		x		
TF.HR	x	x	x		
IMHOFF					

TABLE 22

Water Treatment Technology Constraints

Water Treatment Technology	Maximum Population Density, People/Hectare	Water Required, LPCD	Site Sludge Disposal Required	Sewage Connection Required	Sullage Disposal Required	Height of Groundwater a Problem	Site Water Connection Required
NT	>600	NA	No	NA	NA	NA	NA
PT	>600	NA	Yes	NA	NA	NA	NA
SSF	>600	NA	Yes	NA	NA	NA	NA
RSF	>600	NA	Yes	NA	NA	NA	NA
CHLOR	>600	NA	No	NA	NA	NA	NA
T&O	>600	NA	Yes	NA	NA	NA	NA
DFILT	>600	NA	Yes	NA	NA	NA	NA
CFILT	>600	NA	Yes	NA	NA	NA	NA
SOFT	>600	NA	Yes	NA	NA	NA	NA
DSALT1	>600	NA	Yes	NA	NA	NA	NA
DSALT2	>600	NA	Yes	NA	NA	NA	NA

TABLE 23

Water Treatment Technology Technical Constraints

Water Treatment Technology	Social and Cultural Constraints					
	Anal Material Usage Restriction	Visible Excreta Restriction	Fly or Mosquito Inhibitor Required	Humus Handling or Reuse Restriction	Level of User Education Required	Level of Infrastructure Required to Organize Operation & Maintenance
NT	NA	NA	Yes	NA	NA	Low
PT	NA	NA	Yes	NA	NA	Medium
SSF	NA	NA	No	NA	NA	Medium
RSF	NA	NA	No	NA	NA	Medium
CHLOR	NA	NA	No	NA	NA	High
T&O	NA	NA	No	NA	NA	High
DFILT	NA	NA	No	NA	Low	Low
CFILT	NA	NA	No	NA	Low	Low
SOFT	NA	NA	No	NA	NA	High
DSALT1	NA	NA	No	NA	NA	High
DSALT2	NA	NA	No	NA	NA	High

TABLE 24

Water Treatment Technology Resource Constraints

Water Treatment Technology	Resource Constraints																		
	Labor								Equipment			Supplies				Energy		Misc	
	Construction				Operation & Maintenance														
	Unskilled	Semiskilled	Skilled	Professional	Unskilled	Semiskilled	Skilled	Professional	Electrical	Laboratory	Electronic	Chemical	Process	Operation & Maintenance	Laboratory	Electrical	Other	Land	Organic Matter
NT	x	x			x									x			low		
PT	x	x	x		x	x			x			x	x	x		low	low		
SSF	x	x	x		x	x			x				x	x		med	med		
RSF	x	x	x	x	x	x	x	x	x	x		x	x	x	x	high	med		
CHLOR	x	x	x		x	x	x			x		x	x	x	x	-	low		
T&O	x	x	x		x	x	x		x	x	x	x	x	x	x	low	low		
DFILT	x	x	x	x	x				x			x	x	x		-	low		
CFILT	x	x			x	x			x				x	x		-	low		
SOFT	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	low	low		
DSALT1	x	x	x	x	x	x	x	x	x	x	x		x	x	x	med	med		
DSALT2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	high	med		

TABLE 25

Water Treatment Technology Health Constraints

Health Constraints					
Helminth			Insect		
Water Treatment Technology	Raw or Half-Cooked Meat Restriction (Fish, Beef, Pork, Crab, etc.	Schistosomiasis Restriction	Ascaris, Hookworm, Tapeworm Restriction	Filariasis Restriction (Cockroach, Fly, Mosquito)	Heavy Metal Restriction
NT	x	x	x	x	
PT	x	x	x	x	
SSF					
RSF		x			
CHLOR					
T&O					
DFILT					
CFILT					
SOFT					
DSALT1					
DSALT2					

300, less than or equal to 600, and greater than 600 persons per hectare. Most of the technologies require a population density greater than 600. To some extent this division reflects a movement from rural area technologies at the low density to the urban area technologies at the high density. The second constraint of both Tables 18 and 22 relate the technologies to the water required for proper operation. The V&C technology represents a maximum level of water rather than a minimum since a level of water usage greater than 10 lpcd will disrupt the proper operation of the technology. The water treatment technologies do not require a minimum amount of water. The sewered sanitation technologies such as LAG, WSP, SDBED, RBC, etc. require a certain water volume to maintain flow in the sewer, e.g., 250 to 500 lpcd, thus, the sewered technologies have been set at a minimum level of 250 lpcd. The third technical constraint relates the sanitation and water supply technologies to the necessity of on-site disposal/removal of sludge. As can be observed in Tables 18 and 22 most technologies require on-site sludge disposal/ removal, the exceptions being those technologies such as ventilated improved pit latrines and aquaculture which include disposal/ removal as an integral part of the technology. The communal facilities sewered represents an anomaly in this area since it would not of itself require desuldging but by implication the sanitation technology, other than aquaculture, chosen to treat the liquid wastewater would produce a sludge requirement. It would be expected that the cognizant planner would construct a treatment train which included a desludging requirement. The fourth technical constraint of Tables 18 and 22 relate the respective technologies to a requirement for a sewer connection. The water treatment technologies are not affected by this requirement but many sanitation technolgies explicity include the sewer, e.g., the small bore sewered aquaprivy, or imply the existence of a sewer system, e.g., a standard trickling filter. The fifth technical constraint of Tables 18 and 20 relate the sanitation and water treatment technologies to a requirement for a separate sullage disposal. Sullage, i.e., vegetable waste, laundry and dish water, etc., are handled as an integral part of a sewered sanitation system but the non-sewered technologies require local sullage disposal. The WBANK documentation indicates that the disposal of sullage is the prime reason for having sewered systems.[8] The sixth technical constraint of Tables 18 and 22 relate the height of the groundwater to the various technologies. The water treatment technologies do not adversely affect the groundwater by inducing contamination. Certain sanitation technologies are prone to contaminate the groundwater if the groundwater table is near the surface or soil conditions are conducive to contamination. In general these technology use the soil as a primary or secondary source of organic matter decomposition so that conditions conducive to groundwater contamination reduce the appropriateness of these technologies. The final technical constraint relates the water supply/sanitation technologies to the level of need for a water connection. Clearly the water supply technologies will not require a water connection, however, most of the sanitation technologies do require some type of water connection. The types of connections are

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[8]Kalbermatten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: Technical and Economic Options: 114.

none, standpost (S), yard (Y), and house (H).[9] If a technology requires Y or H, a septic tank for example, then local conditions must be able to support at least a yard water connection for proper operation of the technology. This would rule out the use of a septic tanks system in cases where local site water connections were likely to be none or a standpost.

The second major selection area of MAPMAT are the social and cultural constraints. These constraints are operative where a particular technology would be violating local customs. In such a case the technology may be technically adequate but totally inappropriate for local use.[10] Tables 19 and 23 indicate the dependency between the sanitation and water supply technologies, respectfully, and the social/ cultural constraints. The first social/cultural constraint indicates where the use of certain type anal cleansing material may impede the use of a particular sanitation technology.[11] Dry materials such as mudballs, sacking, and corncobs may clog certain technologies such as the pour flush toilet series. A common anal cleanser in many parts of the world is water, however, the double vault composting toilet would be intolerant to a high water volume. The result is that local usage of certain anal cleansers may be inappropriate for use with several sanitation technologies. The second social/cultural constraint relates the various

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[9] A standpost may serve a very small village or urban neighborhood while a yard connection brings water near the house but not inside. A house connection is obvious.

[10] Clearly the technology could be entirely viable in a different setting with different customs.

[11] Water supply technology would not be subject to this constraint.

sanitation technologies to local customs which shun the open presence of excreta. Many cultures place a very high negative value on the sight of excreta and any technology, such as a pit latrine., which subjects the user to continual awareness of the excreta will be less than effective in providing adequate sanitation. MAPMAT screens out those technologies which might be offensive to local customs based on the fact that some sanitation technologies include visible excreta as an integral part of operation. The third social/cultural constraint relates the necessity of providing fly or mosquito inhibitor for certain technologies. There are two elements to this constraint. First local users may be required to safely use an insecticide or other inhibitor to control certain insects. If the local population cannot or will not maintain this responsibility certain sanitation technologies such as the pit latrines and aquaprivy may not be viable. The second element of this constraint deals with certain technologies being conductive to insect breeding and the spread of disease through insect vectors. If local custom does not emphasize the hazards due to insect contaminant of food and/or drink, and a technology will provide favorable conditions for the propagation of the insect, then there is a high liklihood that the technology will be inappropriate to local conditions. The fourth social/cultural constraint deals with the use of humus produced by composting technologies. This constraint does not apply to the water supply technologies or most of the sanitation technologies, however, it is critical for those technologies which produce humus. Local individuals must be willing to handle the humus and, in general, the humus should be viewed as a valuable reclaimed resource by the local user. Unless these two conditions are fulfilled a technology which produces humus from composting will not be viewed with favor by the local user. MAPMAT considers this disfavor as likely to cause the technology to be inappropriate. The fifth social/cultural constraint is the level of user education required to operate the technology. For the sewered sanitation alternatives such as primary clarification and activated sludge, this constraint does not apply since these technology do not require user interaction. For the remaining technologies, a level of very low indicates that users will need at most a short introduction to using the technology. A user education level of low indicates that the user must not only understand how to use the technology but what must be done to avoid disrupting the operation of the technology. For example, a pour flush toilet septic tank cannot tolerate bulky materials such as corncobs, etc. to maintain proper conditions. A user education level of medium indicates that the relationship between the use of the technology and possible disease spread must be understood by the users. If an insufficient volume of water is used to maintain the water seal the pour flush toilet will not operate properly and insects may propagate diseases. A high level of user education is indicated where the user must clearly understand the operation and maintenance of the technology. The double vault composting toilet requires a limit on the volume of liquid added to the compost and the addition of organic materials to aid composting in a fairly fixed ratio. The user must be educated to deal with the proper carbon/nitrogen ratios, the various sources of these materials, etc. The final social/cultural constraint is the level of infrastructure required to operate and maintain the respective technologies. A low level of infrastructure indicates that local users, possibly with wide spaced central agency help, can adequately maintain the technology. A medium level of infrastructure indicates that a local individual or group must assume the responsibility of overseeing maintenance of the technology. For example if septic tanks are selected as the sanitation technology to be used in a rural village then a local group will need to assure desludging and disposal authority. Without the local infrastructure, MAPMAT considers that the technology has a high probability of being inappropriate. A high level of infrastructure indicates that a local individual, or group, will be required full time to assure the proper operation and maintenance of the technology.

The third major selection area of MAPMAT are the resource constraints. Details of the constraints have been covered previously, but Tables 20 and 24 relate the various resource constraints to the sanitation and water supply technologies, respectfully. Each technology which requires the listed resource is shown with an x, and a blank indicates that the resource is not normally required. MAPMAT compares local conditions to this resource requirement/technology matrix in order to screen out technologies which would be inappropriate to local conditions on the basis of resource availability.

The final major selection area of MAPMAT is the health constraints. The health constraints can be divided into three major subdivision: helminth, insect, and heavy metals. The helminth subdivision is further divided into food transmission, water transmission, and soil transmission. Tables 21 and 25 relate the water supply and sanitation technologies to the health constraints. If raw meat is consumed in the local area then the sanitation technologies V&C, AC, LT, and trickling filtration may encourage the helminths which can be transmitted in this fashion. The water supply technologies, no treatment and pretreatment, involve the same risk in terms of the food transmission health constraints. The same two water supply technologies in addition to RSF, DFILT, and CFILT are suspect when water transmission helminths are indicated in the local area. The slow sand filter has the advantage of removing helminth ova due to the extended time period between backwashing, but the rapid sand filtration requires a much quicker periodicity on backwashing. This quicker backwashing results in viable helminth transmission. The sanitation technologies aquaculture, rotating biological contactor, and activated sludge may provide a favorable environment for the water transmitted helminths. The soil transmitted health constraint applied to the sanitation technologies aquaculture, sludge drying beds, sludge drying lagoons, land treatment, standard trickling filtration, and high rate trickling filtration in addition to the water supply technologies of no treatment and pretreatment. The insect transmission health constraint applies to the two ventilated improved pit latrines, Reed Odorless Earth Closet, double vault composting toilet, vault and cartage, aquaculture, lagoons/waste stabilizations ponds, sludge drying beds, sludge drying lagoons, and land treatment sanitation technologies, in addition to the water supply technologies of no treatment and pretreatment. The heavy metal health constraint applies to the double vault composting toilet, thermophilic composting, and land treatment sanitation technologies.

The selection process of MAPMAT relies on a question/response algorithm to establish the appropriateness of a water supply and/or sanitation technology. For the technologies listed in Tables 20 through 25, MAPMAT asks one or more questions for each column to establish the on/off condition relative to the technology vector. If a technology is constrained by an on condition, or a level condition, which is not fulfilled, then MAPMAT considers that technology unavailable at the local site. For example, if the water available at a local site amounts to 12 lpcd or less, then such sanitation technologies as communal, primary clarifier, etc. would not be available. If the level of land available at the local site were to be medium, then all technologies which had high land requirements would be unavailable. MAPMAT expects the user to be acquainted with the local site and knowledgable concerning the water/sanitation field; however, it is not expected that the user be an engineer. The intent of MAPMAT is to eliminate those technologies which are inappropriate at a local site by a systematic analysis of local data. Once the basic data is collected, sensitivity analysis can be performed to check the analysis. The first step of MAPMAT is shown as Equation 1 below.[12]

$$\underline{A}\ \underline{N}' = \underline{N'N} \text{ for } B_{jkt} = 1 \qquad (1)$$

$$\text{otherwise } B_{jke} = \phi$$

where

$\underline{A}$ represents a row vector of resources available to the jth treatment technology as determined by the I questions. The vector element a_{ij}, indicates the Bernoeulli condition on resource availability for the jth treatment technology and ith question.

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[12]A summary of the equations used in MAPMAT is shown in Table 26.

$\underline{N}$ represents a raw vector of resources required by the jth treatment technology. The vector element n_{ij} indicates the Bernoulli condition on resource requirements for the jth treatment technology and the ith question.

$\underline{B}_{jkt}$ represents the Bernoulli condition of the j the treatment technology in kth stage at time t.

Equation 1 determines the availability of a treatment technology in respect to the local data, the A vector, and the technology requirement, the N vector. The result is either an on condition, $B_t = 1$, or an off condition, $B_t = 0$, based on the inner product comparisons. The second step of MAPMAT is to help the user construct alternate treatment schemes to be used in the analysis . Alternate treatment schemes are constructed by the user with available treatment technology being selected to fill blocks in a treatment scheme. The treatment scheme may include one or more treatment technologies. There must be at least one treatment technology selected for each stage included in the treatment train. This condition is expressed as Equation 2.

$$\sum_{j=1}^{J} B_{jkt} = 1 \text{ and } B_{jkt} = 0 \text{ or } 1 \qquad (2)$$

Equation 2 insures that a treatment technology will be used only once in a particular stage and that each stage included will have a treatment technology assigned to that stage. In the third step of MAPMAT the reduction of the waste constituent is calculated for each stage at a particular time period. At the present time there are two waste constituents to be calculated: biological oxygen demand (BOD) for sanitation technologies and the count of coliform bacteria for water supply technologies. In both cases these pollutants are used as a relative measure of the efficiency of the technology in comparisons to the rest of the technologies. The site disposal sanitation technologies: VIPL; VIDPL; ROEC; ST; DUCT; PFT; PFT; SEW.SB; PFT, ST; AP; AP.SULLAGE; AP.SEW.SB; V&C; COMM; COMM.SEW; AC are assumed to provide adequate disposal if all MAPMAT constraints are met and the technology is properly operated. The relative efficiencies of these technologies are 100% efficient. As a comparison the waste stabilization pond provides 50% reduction of BOD. The sanitation technology CHLOR provides a very low BOD reduction, maybe 1%, however, the primary reason for chlorine disinfection is to destroy coliform bacteria. Sludge drying beds and lagoons provide a negligible amount of BOD reduction although these technologies are valuable in respect to sludge dewatering. The coliform standard for water supply technologies results in the same type of situation with respect to the technologies T&O, DSALT1, and DSALT2. The primary purpose of these technologies is the removal of taste/odor and the desalting of water. Clearly the selection of a single criteria to measure efficiency results in exception to the reduction criteria. MAPMAT recognizes these technologies as being developed for special purposes within a treatment scheme and, as such, they are included in the list of alternatives unless they violate a MAPMAT constraint. During the third step MAPMAT allows the setting of a treatment goal on BOD removal and/or coliform removal which must not be exceeded. If a selected treatment scheme would not reduce one or both of the waste constituents below, the treatment goal MAPMAT flags that scheme as inappropriate. Equation 3 and 4 are used by MAPMAT to accomplish step three.

$$L_{\nu tk+1} = \sum_{j=1}^{J} B_{jkt}(1-R_{\nu j})\, L_{\nu tk} \tag{3}$$

$$Q_{\nu t} \leqq L_{\nu tk=0} - \sum_{K=0}^{k-1} (L_{\nu tk} - L_{\nu tk+1}) \tag{4}$$

where $L_{\nu tk}$ represents the νth waste load in the kth stage at time t. The two waste constituents are BOD, given in milligrams/liter, and coliform given in most probable number per 100 milliliters.

$R_{\nu j}$ represents the reduction efficiency, i.e., the percent reduction of the νth waste constituent by the jth treatment process. The waste remaining as a percentage is $1-R_{\nu j}$.

$Q_{\nu t}$ represents a treatment goal for the νth waste constituent at time t.

Equation 3 establishes the waste constituent load at each stage in the process. A selected technology which is available, the B_{jkt}, produces transformation by a fixed percentage, the $(1-R_{\nu j})$ term, for an initial waste load, $L_{\nu tk}$. The resultant waste load is $L_{\nu t\ k+1}$ following treatment. Equation 4 sets the treatment goal, $Q_{\nu t}$, constraint so that the k stages of waste removal must satisfy the goal. The fourth step of MAPMAT is the calculation procedure used in producing the value of an objective function for each treatment scheme. A cost effectiveness approach is taken during optimization to reflect the fact that at the present time an informed judgment represents the best available criteria for treatment scheme selection once inappropriate technology is removed from consideration.[13] MAPMAT allows the user to construct weighting factors, or cost effectiveness factors, to be used in evaluating the various alternate treatment schemes. A decision not to use weighting factors represents placing equal weights on the treatment schemes or placing equal weight on the effectiveness criteria for each treatment technology. Equations 5 and 6 fulfill the fourth step of MAPMAT.

$$O_j = \sum_{j=1}^{J} \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{z=1}^{Z} \frac{1}{M_i} \cdot B_{jkt} \cdot \frac{C_{zjkt}}{(1+D)^t} + \sum_{j=1}^{J} \sum_{t=1}^{T} \frac{1}{M_i} \cdot B_{jkt} \cdot \frac{P_{jt}}{(1+D)^t} \tag{5}$$

$$\sum_{l=1}^{I} M_i = 1 \text{ and } 0 \leqq D \leqq 1.00 \tag{6}$$

[13]Kalbermatten, Julius and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Summary of Economic and Technical Options: 85, 9, 13, 33-34. Saunders and Warford, Village Water Supply: 9, 55. Feachem, McGarry, and Mara, Water, Waste and Health: 94.

where

O_i represents the value of the objective function for the ith treatment scheme.

M_i represents the weighting or cost-effectiveness factor, for the ith treatment scheme.

C_{jktz} represents the zth cost element for the jth treatment technology used in the kth stage at time t. There are two cost elements: capital cost and operation/maintenance cost.

D represents the discount factor to be used during present value calculations. In general, this would be the economic opportunity cost of capital for the country.

P_{jt} represents a penalty cost for the jth treatment technology at time t. The penalty derives from a design flow in respect to complete treatment, i.e., the disposal of sullage, water used as a transport medium, disposal of a residual, etc.

Equation 5 indicates the objective function to be calculated for each user selected treatment scheme. For every technology which is selected in addition, not previously rejected by MAPMAT as inappropriate for the local site, i.e., the B_{jkt} equals one, the discounted present value of construction and operation/maintenance is calculated as the C_{zjkt} term. In like fashion, a discounted penalty cost term is calculated, the P_{jt} term. Certain technologies realize an external cost which must be appended to the capital and operation/maintenance cost if an economic cost analysis is to be prepared. If the nature of a technology does not provide for sullage disposal and sullage disposal will be required then a penalty cost must be added to the objective function. The water transport of waste in sewers represents a cost of sanitation for those technologies which are designed around sewers. Disposal of residuals, such as dried sludge and humus, may represent penalty cost if local conditions do not support reuse of these materials. During the questioning MAPMAT flags these types of events so that penalties may be appended if the technology is selected. Having calculated the basic cost ratios to be used in the comparison, MAPMAT activates the weighting, or cost-effectiveness technique to calculate the factor M_i. MAPMAT interrogate interactively until the M_i are established for all treatment alternatives. At this point all information needed to construct objective function values for each treatment scheme is available to MAPMAT. Equation 6 insures that the weighting factors add to unity and the discount factor is restricted to a reasonable value. MAPMAT finishes step four by displaying the objective function information for all user selected alternatives. The fifth step of MAPMAT allows the user to alter a condition within MAPMAT's analysis to check the results based on a new parameter value or a different response to a specific question. For example having MAPMAT perform the initial analysis, the user may be interested in the effect of a community education program which improves the local infrastructure and increases the awareness of

TABLE 26

$$\underline{A}\,\underline{N}' = \underline{N}'\underline{N} \text{ for } B_{jkt} = 1 \tag{1}$$

$$\text{otherwise } B_{jkt} = \phi$$

$$\sum_{j=1}^{J} B_{kjt} = 1 \text{ and } B \quad = \phi \text{ or } 1 \tag{2}$$

$$L_{\upsilon tk+1} = \sum_{j=1}^{J} B_{jkt}(1-R_{\upsilon k})\, L_{\upsilon tk} \tag{3}$$

$$Q_{\upsilon t} \leqq L_{\upsilon tk=0} - \sum_{k=0}^{K=1} (L_{\upsilon tk} - L_{\upsilon tk+1}) \tag{4}$$

$$O_i = \sum_{j=1}^{J} \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{z=1}^{Z} \frac{1}{M_i} \cdot B_{jkt} \cdot \frac{C_{zjkt}}{(1+D)^t} \tag{5}$$

$$+ \sum_{j=1}^{J} \sum_{t=1}^{T} \frac{1}{M_i} \cdot B_{jkt} \cdot \frac{P_{jt}}{(1+D)^t}$$

$$\sum_{i=1}^{I} M_i = 1 \text{ and } 0 \leqq D \leqq 1.00 \tag{6}$$

where $\underline{A}$ represents a raw vector of resources available to the jth treatment technology as determined by the I questions. The vector element a_{ij} indicates the Bernoulli condition on resource availability for the jth treatment technology and the ith question at time t.

$\underline{N}$ represents a raw vector of resources required by the jth treatment technology. The vector element n_{ij} indicates the Bernoulli condition on resource requirements for the jth treatment technology and the ith question at time t.

B_{jkt} represents the Bernoulli condition with respect to the availability of the jth treatment technology in the kth stage of the treatment scheme at time t.

$L_{\nu tk}$ represents the νth waste load in the kth stage at time t. The two waste constituents are BOD, given in milligrams per liter, and coliform, given in most probable number per 100 milliliter.

$R_{\nu j}$ represents the reduction efficiency; i.e., the percent reduction of the Vth waste constituent by the jth treatment process. The waste remaining as a percentage is $1-R_{\nu j}$.

$Q_{\nu t}$ represents a treatment goal for the νth waste constituent at time t.

M_i represents the weighting or cost-effectiveness factor for the ith treatment scheme.

C_{zjkt} represents the zth cost element for the jth treatment technology used in the kth stage at time t. There are two cost elements: capital cost and operation/maintenance cost.

D represents the discount factor to be used during present value calculations. In general this would be the economic opportunity cost of capital for the country.

P_{jt} represents a penalty cost for the jth technology at time t. The penalty derives from a design flow in the technology in respect to complete treatment, i.e., the disposal of sullage, water used as a transport medium, disposal of a residual, etc.

the health/water/sanitation trilogy. MAPMAT will automatically rerun the analysis given only this change to the social/cultural constraints. As a second example, if an initial solution were based on constructing all technology in the first three years and the user wished to investigate an additional treatment scheme with construction of a pour-flush toilet in year 1, addition of a septic tank system in year 5, and addition of a small bore sewer in year 10. MAPMAT would automatically generate an objective function for the new alternative. Once the sensitivity analysis is completed MAPMAT can provide two additional services. First, a commercial telecommunications package titled "ASCII Express II" may be used to link to CAPDET. Many of the technologies are part of the small facility wastewater treatment processes included in CAPDET.

The telecommunications module provides a empty buffer which can store the works session on CAPDET, list the work session to a printer, and execute a plethora of friendly telecommunication services. The second additional service provided by MAPMAT is a multiple regression package entitled "HSD Regress." The regression package provides the ability to handle up to 25 variables and 300 cases per variable in a single analysis. Data can be stored on diskette, edited, plotted, transformed, and/or submitted to the regression package. The cost ratio approach for MAPMAT will not be sufficient for actual comparison within a country. These ratios are intended for demonstration only and represent the best knowledge available for generic cost estimation. The regression package allows the user to get local data which can be substituted for the MAPMAT cost ratios once statistical analysis is completed on the data. Table 27 summarizes the literature dealing with cost estimating equations for water supply and wastewater treatment. Most of the equations take the form

$$\log Y = \log a + b \log Q$$

where Y is the cost to be estimated, Q is the design capacity, and regression parameters are a and b. MAPMAT uses cost ratios in the analysis procedures simply because an adequate way to provide generic cost

TABLE 27

Cost Functions for Regression Analysis

Emphasis	Model	Reference
1. Wastewater Treatment Plant	General Form: $Y = a X^b$ Estimator: $\log Y = \log a + \log X$ where Y = capital or operation and maintenance cost in dollars or manhours X = plant load in MGD or PE a, b = parameters	Michel, "Costs..."
2. Wastewater Conveyance System	Pipeline General Form: $C/L = K + \alpha D^{\beta}$ where C = total capital cost, \$ L = length of pipe, meters K = fixed cost D = diameter, meters β = parameter Pumping station $C = K' + \nu W \delta$ where K' = fixed cost, \$ W = horsepower ν, δ = parameters	Tyteca, "Cost functions..."
3. Waste Treatment Plants	General Form: $\ln y = b_o + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4$	Shah and Reid, "Techniques for..."

Continued

TABLE 27 (Cont'd)

Emphasis	Model	Reference
	where Y = construction cost per design MGD X_1 = design PE X_2 = design flow in MGD X_3 = design BOD of influent in MG/1 X_4 = BOD removal efficiency b_o through b_4 = parameters	
4. Water Supply	General Form: $C = a_o + a_1 P + a_2\ PD + a_3\ D + a_4\ SW + a_5\ S_o + A_6\ Q_1 + a_7\ Q_2$ where C = cost per 1,000 gallons of water P = population served PD = population density in person per square mile D = average daily demand, MGD SW = supplier of water, utility is primary or secondary source SO = source of water, surface or ground $A_o, a_1, a_2, a_3, a_4, a_5, a_6, a_7$ = parameters Q_1 and Q_2 = dummy variables which indicate a good or bad rating for utility	Clark and Goddard, cost..." Clark, "Cost and Pricing ..."

Continued

TABLE 27 (Cont'd)

Emphasis	Model	Reference
5. Water Supply	<u>Capital Cost</u> $ACC = a_Q \, AD^{b} \, Q^{c}$ <u>Operating Cost</u> $AOC = d \, (D_{mh})^{e} \, (M_{mg}) \, (Q)^{F}$ where ACC = annual capital cost, \$ AD = annual depreciation AOC = annual operating cost, \$ D_{mh} = labor cost, dollars per hour M_{mg} = productivity, manhours per 1,000,000 gals. a Through F = parameters	
6. Rural Wastewater and Water Supply	<u>Septic Tanks</u> $S_T\,(Q1) = a_o + a_1\,Q1 + a_2\,TK + a_3\,TF + a_4\,DW$ <u>Wells</u> $W_C\,(Q2) = b_o + b_1\,Q2 + b_2\,WD$ where ST (Q1) = Total septic tanks installation cost during quarter Q1, \$. Q1 = Quarter number, 1962 base year TK = Septic tank size, gallons TF = Tile feet, linear feet DW = Number of dry wells of 600 gallons each	Rajagopal, et.al., "Water..."

Continued

TABLE 27 (Cont'd)

Emphasis	Model	Reference
	WC(Q2) = Total well installation cost during Q2, \$ Q2 = Quarter number, 1958 base year WD = well depth, feet a_o through a_4 = parameters b_o through b_2 = parameters	
7. Wastewater Treatment	General Forms: $Y = a\ X^b$ Estimator: log Y log a + b log X where Y = construction or operation/maintenance cost in thousands of \$ per MDG X = Plant size, MGD a,b = parameters	Smith, "Costs..."
8. Water Treatment	General Form: $Y = a\ X^b$ Estimator: log Y = log a + log X where Y = construction or operation/maintenance cost in thousands of \$ per MDG X = plant size, MGD a,b = parameters <u>Construction, Operation/Maintenance for Plants and Truck Sewers</u>	Logan, et.al., "An Analysis..."
9. Wastewater Treatment	General Form: $Y = K\ X^{\alpha}$ or $\ln Y = a + b^1 \ln X$	Klemetson and Grenney, "Physical ..."

Continued

TABLE 27 (Cont'd)

Emphasis	Model	Reference
	where Y = total cost of capacity X, in \$ for treatment plants and lift stations, \$ per mile trunk sewers K = cost coefficient X = capacity, Mgd α = economics of scale parameters, $0 \leq \alpha \leq 1$ Power cost for lift and pumping $Y = K X^{\alpha} H$ where Y = cost of pumping a flow of X to a height of H, \$ K = cost coefficient X = flow rate, MGD α = economics of scale H = effective pumping head, ft.	
10. Small Water Systems	General Form: $C_c = \alpha Q_n^{B}$ where C_c = total capital cost, in 1,000 \$ Q_n = design capacity, MGD α,β = parameters	Clark, "Small Water..."
11. Water Supply and Wastewater Treatment	Construction and operation/maintenance cost for water supply, pipelines, and wastewater treatment General Form: $Y = \alpha Q\beta$ where Y = total cost in \$1,000 Q = design capacity, MGD α,β = parameters	Ocanas and Mays,

Continued

TABLE 27 (Cont'd)

Emphasis	Model	Reference
	<u>Pumping Operation/Maintenance Cost</u> General Form: $Y = \alpha H^{BQ\nu}$ where Y = annual pumping cost H = pumping heat, ft. Q = design flow, MGD α, B, ν = parameters	
12. Municipal Wastewater	General Form: $Y = a Q^b$ Estimator: $\log Y = \log a + b \log Q$ where Y = process cost, in millions \$ Q = design flow, MGD a, b = parameters	EPA, "Construction Costs for Municipal ..."
13. Wastewater Treatment	General Form: $Y = a Q^b$ Estimator: $\log Y = \log a + \log Q$ where Y = process cost, in thousands \$ Q = design flow, in MGD a, b = parameters	EPA, "Estimating Costs..."
14. Operation and Maintenance	General Form: $Y = a Q^b$ Estimator: $\log Y = \log a + \log Q$ where: Y = total of O&M cost, millions \$ Q = actual flow, MGD a, b = parameters	EPA, "Analysis of Operations..."

estimator for developing countries does not exist. The most extensive attempt to provide generic estimators is covered in the USAID/REID documentation.[14] Several authors indicate the cost estimation problem with respect to developing countries.[15] The cost ratios used in MAPMAT are based on U.S. data adjusted using best professional judgment concerning economics of scale to be expected in developing countries.[16] Tables 28 and 29 include the cost ratios used in MAPMAT. There are two sections of cost: (1) construction, and (2) operation and maintenance. Both sections are subject to two step function factors which may cause economies or diseconomies. The first economic/diseconomy factor relates to the level of infrastructure expected at the local site. The rationalization behind the use of this factor is that within a developing country there are four levels of communities in terms of infrastructure:[17]

1. Level I where the infrastructure is dependent on imported employment; agriculturally oriented with a very small or non-existent local market economy; and/or very low levels of education, few high school or college graduates unless

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[14] Reid and Coffey, Appropriate Methods: 97-166.

[15] Reid, Arnold, and Streebin: Appropriate Methods, Workbook: 208. Saunders and Warford, Village Water Supply: 123-138, 158-161.

[16] Kalbermatten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Summary of Technical and Economic Options: vi.

[17] The four levels of communities follows closely the development by USAID/REID. See Reid and Coffey, Appropriate Methods: 68-72.

TABLE 28

Sanitation Cost Ratios by Infrastructure and Population Levels

Sanitation Technology	Population Level	Infrastructure Level: Construction Cost Factor I	II	III	IV	Operation and Maintenance Cost Factor I	II	III	IV
VIPL	I	.44	.55	.69	.86	.02	.03	.03	.04
	II	.41	.51	.64	.80	.02	.02	.03	.04
	III	.38	.47	.59	.74	.02	.02	.03	.03
	IV	.35	.44	.55	.68	.02	.02	.03	.03
VIDPL	I	.88	1.10	1.38	.172	.04	.05	.06	.08
	II	.82	1.02	1.28	1.60	.04	.05	.06	.07
	III	.76	.95	1.19	1.48	.04	.04	.05	.07
	IV	.71	.89	1.10	1.38	.03	.04	.05	.06
ROEC	I	.87	.81	.75	.70	.04	.04	.04	.03
	II	.57	.53	.50	.46	.04	.03	.03	.03
	III	.38	.35	.33	.31	.03	.03	.03	.02
	IV	.25	.23	.22	.20	.03	.02	.02	.02
ST	I	.64	.60	.55	.52	.17	.16	.15	.14
	II	.60	.55	.52	.48	.16	.15	.14	.13
	III	.55	.52	.48	.45	.15	.14	.13	.12
	IV	.52	.48	.45	.41	.14	.13	.12	.11
DUCT	I	.79	.83	.86	.90	.17	.18	.19.	.19
	II	.54	.56	.59	.61	.12	.12	.13	.13
	III	.37	.38	.40	.42	.08	.08	.09	.09
	IV	.25	.26	.27	.28	.05	.06	.06	.06
PFT	I	.21	.19	.18	.17	.09	.09	.08	.08
	II	.19	.18	.17	.15	.08	.08	.08	.07
	III	.18	.17	.15	.14	.07	.08	.07	.07
	IV	.17	.15	.14	.13	.07	.07	.07	.06
PFT.SEW.SB	I	.51	.74	1.07	1.55	.21	.31	.45	.65
	II	.48	.69	1.00	1.44	.20	.29	.42	.60
	III	.44	.64	.93	1.34	.19	.27	.39	.56
	IV	.41	.60	.86	1.25	.17	.25	.36	.52
PFT.ST	I	.85	.79	.74	.68	.26	.24	.23	.21
	II	.79	.74	.68	.64	.24	.23	.21	.20
	III	.74	.68	.64	.59	.23	.21	.20	.18
	IV	.68	.64	.59	.55	.21	.20	.18	.17

Continued

TABLE 28. Continued

Sanitation Technology	Population Level	Infrastructure Level: Construction Cost Factor I	II	III	IV	Operation and Maintenance Cost Factor I	II	III	IV
AP	I	2.52	2.34	2.18	2.02	.10	.09	.09	.08
	II	2.34	2.18	2.02	1.88	.09	.09	.08	.07
	III	2.18	2.02	1.88	1.75	.09	.08	.07	.07
	IV	2.02	1.88	1.75	1.63	.08	.07	.07	.06
AP.SULLAGE	I	3.78	5.45	7.88	11.39	.15	.21	.31	.44
	II	3.51	5.07	7.33	10.59	.14	.20	.29	.41
	III	3.27	4.72	6.82	9.85	.13	.18	.27	.38
	IV	3.03	4.39	6.34	9.16	.12	.17	.25	.36
AP.SEW.SB	I	6.29	9.09	13.14	18.98	.25	.35	.51	.74
	II	5.85	8.45	12.22	17.65	.23	.33	.48	.69
	III	5.44	7.86	11.36	16.42	.21	.31	.44	.64
	IV	5.06	7.31	10.57	15.27	.20	.29	.41	.60
V&C	I	.28	.28	.28	.28	.30	.30	.30	.30
	II	.28	.28	.28	.28	.30	.30	.30	.30
	III	.28	.28	.28	.28	.30	.30	.30	.30
	IV	.28	.28	.28	.28	.30	.30	.30	.30
COMM	I	.38	.47	.59	.74	.15	.19	.24	.30
	II	.35	.44	.55	.69	.14	.18	.22	.28
	III	.33	.41	.51	.64	.13	.17	.21	.26
	IV	.30	.38	.47	.59	.12	.15	.19	.24
COMM.SEW	I	.94	1.36	1.97	2.84	.38	.55	.80	1.15
	II	.88	1.27	1.83	2.64	.36	.51	.74	1.07
	III	.81	1.18	1.70	2.46	.33	.48	.69	1.00
	IV	.76	1.09	1.58	2.29	.31	.44	.64	.93
AC	I	No cost data available							
	II								
	III								
	IV								
LAG.WSP	I	3.00	1.45	1.90	2.15	2.62	4.21	7.42	10.63
	II	1.17	1.67	2.07	2.35	2.50	4.10	7.21	10.31
	III	1.50	1.70	2.22	3.35	2.10	3.17	5.33	7.50
	IV	2.00	2.50	3.50	4.00	1.00	2.83	4.67	6.50
TC	I	No cost data available							
	II								
	III								
	IV								

Continued

TABLE 28. Continued

Sanitation Technology	Population Level	Infrastructure Level							
		Construction Cost Factor				Operation and Maintenance Cost Factor			
		I	II	III	IV	I	II	III	IV
HRTC	I	No cost data available							
	II								
	III								
	IV								
PC	I	2.89	3.13	3.38	3.62	10.31	12.21	14.10	16.00
	II	7.52	8.15	9.78	10.41	9.62	11.19	13.15	14.92
	III	9.07	9.94	10.70	11.00	9.17	10.86	12.56	14.52
	IV	10.55	11.18	11.45	11.82	9.08	10.57	11.33	14.10
SDBED	I	6.68	5.87	5.07	4.26	50.25	43.13	41.96	38.24
	II	9.57	8.04	7.21	6.98	46.46	43.13	34.58	32.85
	III	13.73	11.70	9.67	8.64	39.25	34.58	27.63	25.47
	IV	17.37	15.23	13.08	11.94	37.80	32.90	26.96	21.31
SDLAG	I	38.30	27.30	25.00	20.29	72.69	79.40	86.10	92.81
	II	30.73	25.82	20.91	16.00	39.54	46.77	54.00	61.23
	III	23.78	22.50	18.22	14.94	30.67	36.28	40.95	47.50
	IV	19.29	17.03	15.78	12.52	28.60	33.83	39.07	44.30
ALAG.EXT	I	12.33	14.48	16.00	17.00	20.56	29.75	37.94	45.13
	II	15.50	17.26	18.20	19.15	16.06	26.48	30.89	37.31
	III	17.16	18.40	19.64	21.88	10.50	14.72	18.95	23.17
	IV	17.23	19.57	20.90	23.24	8.40	10.30	14.27	15.20
CHLOR	I	1.32	1.21	1.11	1.00	18.62	19.26	20.66	26.86
	II	8.60	7.91	7.22	6.53	13.25	14.45	13.00	11.54
	III	10.23	11.37	15.20	16.84	6.19	6.88	9.24	10.18
	IV	16.84	13.50	10.17	9.18	5.80	5.07	5.33	3.60
LT	I	15.70	17.55	23.00	26.00	9.42	10.46	14.07	15.50
	II	12.67	14.08	18.94	20.86	7.69	10.30	11.29	12.35
	III	10.23	11.37	15.20	16.84	6.19	6.88	9.24	10.18
	IV	8.25	9.19	12.23	13.58	4.95	5.52	7.34	8.15
RBC	I	58.50	43.04	32.72	25.60	29.38	27.35	22.42	15.40
	II	49.50	39.40	31.70	21.90	27.15	23.36	18.75	13.45
	III	37.93	35.70	28.71	20.48	25.24	20.31	16.20	13.37
	IV	28.94	27.25	21.91	15.64	23.93	17.71	14.32	10.21

Continued

TABLE 28. Continued

Sanitation Technology	Population Level	Infrastructure Level: Construction Cost Factor I	II	III	IV	Operation and Maintenance Cost Factor I	II	III	IV
AS	I	48.10	37.24	30.00	25.00	17.88	22.75	27.63	32.50
	II	42.00	32.00	27.00	20.00	14.92	18.97	23.03	27.08
	III	30.30	29.00	23.22	18.00	13.90	17.67	21.43	24.83
	IV	23.31	21.82	18.34	15.85	13.67	17.39	21.11	24.20
TF.STD	I	34.64	34.97	35.30	38.63	8.75	14.00	19.25	24.50
	II	28.09	32.02	34.95	35.88	6.23	9.97	13.72	17.46
	III	27.99	29.50	30.90	31.00	5.33	8.53	11.72	14.92
	IV	23.32	24.27	25.21	26.16	5.10	8.13	11.17	14.20
TF.HR	I	53.85	40.03	23.78	20.25	32.00	33.00	34.00	36.00
	II	40.00	37.00	31.00	20.00	16.15	20.64	25.13	29.62
	III	27.11	23.51	19.90	17.68	14.20	16.44	21.14	25.83
	IV	20.11	18.86	17.62	16.37	11.75	16.07	17.93	19.80
IMHOFF	I	20.00	17.28	16.45	11.62	46.25	55.35	63.46	72.56
	II	24.52	19.52	19.02	18.53	39.38	45.87	53.36	61.85
	III	28.11	21.28	20.04	18.80	38.58	41.80	42.03	42.25
	IV	30.38	27.28	24.17	21.07	18.70	24.60	26.50	31.40

TABLE 29

Water Treatment Technology Cost Ratios by Infrastructure and Population Level

		Infrastructure Level							
Water Treatment Technology	Population Level	Construction Cost Factor				Operation and Maintenance Cost Factor			
		I	II	III	IV	I	II	III	IV
NT	I	3.16	2.94	2.15	1.50	2.51	2.80	5.04	4.00
	II	2.70	2.43	1.48	1.37	1.75	2.01	3.01	3.53
	III	1.64	1.47	1.51	1.14	1.42	1.95	2.50	2.75
	IV	1.44	1.38	1.21	1.10	1.00	1.78	1.95	2.43
PT	I	2.00	2.20	2.57	3.00	6.54	7.03	7.51	8.00
	II	2.20	2.50	3.00	3.25	6.74	7.17	7.67	8.15
	III	2.50	2.75	3.01	3.50	6.83	7.33	7.83	8.33
	IV	2.74	2.96	3.48	4.00	6.93	7.63	7.93	8.53
SSF	I	13.16	14.77	15.38	16.00	2.66	5.11	5.55	6.00
	II	11.29	13.48	14.68	15.00	2.94	5.71	6.05	6.45
	III	9.59	11.45	13.31	14.17	3.05	6.01	7.86	10.42
	IV	7.90	9.43	10.97	12.50	3.33	6.37	9.44	12.50
RSF	I	23.38	20.31	16.66	12.80	3.60	4.08	5.27	7.60
	II	22.00	19.89	14.45	11.00	4.90	8.27	9.93	10.45
	III	16.42	16.00	9.20	7.58	6.58	9.25	11.91	14.58
	IV	15.50	8.77	6.00	5.30	11.17	15.78	20.39	25.00
CHLOR	I	4.32	3.21	3.11	3.00	18.58	15.72	12.86	11.75
	II	3.81	3.57	2.94	2.80	18.47	15.65	12.54	11.42
	III	3.48	3.04	2.71	2.57	18.08	14.91	12.35	10.58
	IV	3.16	2.91	2.65	2.40	16.50	12.33	12.17	10.00
T&O	I	105.16	93.00	80.50	70.00	46.82	45.24	43.66	42.08
	II	91.34	80.44	70.53	59.63	51.00	49.28	47.56	45.84
	III	75.59	66.71	57.82	48.92	87.50	84.22	80.95	77.67
	IV	61.76	54.57	47.39	40.20	97.50	94.22	90.95	87.67
DFILT	I	31.60	29.17	26.94	24.31	28.08	25.92	23.76	21.60
	II	30.25	28.55	26.74	24.12	27.78	25.45	23.25	20.64
	III	29.95	28.26	26.38	24.01	27.13	25.17	22.89	20.19
	IV	29.32	28.10	26.23	23.75	26.98	24.98	22.56	20.04
CFILT	I	No data available at the present							
	II								
	III								
	IV								

Continued

TABLE 29. Continued

Water Treatment Technology	Population Level	Infrastructure Level: Construction Cost Factor I	II	III	IV	Operation and Maintenance Cost Factor I	II	III	IV
SOFT	I	150.99	110.47	70.95	41.43	29.86	28.85	27.85	26.84
	II	115.86	90.49	65.12	39.75	38.48	37.52	36.57	35.61
	III	60.79	52.01	48.23	25.45	44.50	42.67	40.83	39.00
	IV	47.90	30.87	27.83	22.80	54.50	52.69	50.87	49.06
DSALT1	I	163.71	158.11	116.00	105.00	16.46	15.91	15.35	14.80
	II	146.94	129.63	117.31	95.00	24.77	25.17	23.92	22.26
	III	127.70	112.88	97.06	84.24	32.67	31.22	29.78	28.33
	IV	83.52	73.95	65.37	57.80	42.67	41.22	39.73	38.33
DSALT2	I	153.24	118.00	103.00	82.35	31.32	30.27	29.21	28.16
	II	120.04	105.53	91.01	77.50	37.87	36.59	35.31	34.03
	III	106.50	95.42	81.31	69.21	65.10	62.97	60.78	58.58
	IV	80.78	75.17	66.46	56.80	66.33	70.72	65.11	59.50

from a "volunteer" type organization. Virtually 100% of local employment is agricultural. A rural village is an example.

2. Level II where the infrastructure is dependent on the imported employment of scientific and technical people, but produces managers, operators, low level teachers, etc. to support a low to medium size market economy. Approximately 50% of the local population derives a livelihood from agriculture. The secondary and primary schools are developed but the quality of instruction may be very variable. An example is the rural town or small city.

3. Level III where the infrastructure has available scientists, engineers, and other professionals, but imports almost all research professionals. Primary and secondary school systems are well developed with generally good teachers. There may be a local college available. Less than 25% of the population will be engaged in agriculture or agriculture related enterprise. An example is a large but isolated city, possibly a regional center of commerce.

4. Level IV where the infrastructure closely resembles a large city in a developed country. Significant portion of the population finish primary and secondary schools. Research professional are readily available and high technology is also available. An example is the national capital of a developing country.

The second economy/diseconomy factor relates to the population size of the design site. In general this factor reflects the effects of scale on the treatment cost. There are four scale levels utilized by MATMAT:

1. Level I: population $\leq 2{,}500$

2. Level II: $2{,}500 <$ population $\leq 15{,}000$

3. Level III: $15{,}000 <$ population $\leq 50{,}000$

4. Level IV: population $> 50{,}000$

In summary, MAPMAT uses cost ratios which may be useful for comparison and demonstration purposes but cannot be used for estimation purpose. Two sources exist to get around the cost estimation problem. First local cost data may be developed and substituted for MAPMAT's cost ratios. Secondly, local cost may be used with CAPDET once MAPMAT has been used to construct treatment schemes which are appropriate to the local site. In either case, the regression package and the telecommunications link to CAPDET should be useful to the user. A final note is that all cost should reflect economic cost which means that shadow prices may be required for labor (especially the unskilled usage rate), foreign exchange, opportunity cost of capital, and other direct inputs such as land, water, etc. The WBANK documentation deals at length with the use of shadow prices.[18] The technique is simple but the estimation of the shadow price factor is very difficult: "Given the data available in developing countries, no precise calculations can be made of shadow prices....[19] MAPMAT does not attempt to use shadow pricing for this reason.

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[18]Kalbermatten, Julius, and Gunnerson, Appropriate Technology for Water Supply and Sanitation: A Planner's Guide: 27-40.

[19]Feachem, McGarry, and Mara, Water, Waste and Health: 134.

Summary

This chapter has presented the details of a model designed to aid in the planning process in developing countries, MAPMAT. The area of interest is the selection of appropriate technology in water supply treatment and sanitation technology. The approach taken by MAPMAT is to use an interactive sequence of questions about local conditions to remove from consideration treatment technology which would be inappropriate for local use. Inappropriateness could occur due to the violation of technical, social/cultural, resource, or health constraints. The remaining treatment technologies are arrayed by the user into treatment schemes. MAPMAT then uses sensitivity analysis and cost effectiveness analysis to investigate the alternatives available to the user. MAPMAT has available a telecommunications link to CAPDET and a multiple regression package for the user's convenience. The design of MAPMAT concentrated on eight major criteria:

1. The selection of appropriate technology for water supply and/or sanitation.

2. The selection of water supply/sanitation technology which is responsible to local health conditions and social/cultured conditions.

3. Methodology which includes interactive sensitivity analysis.

4. The methodology provides a common framework of analysis for interdisciplinary planning.

5. The range of technology included must cover both rural nucleated villages and urban areas in developing countries.

6. The methodology uses an economic cost approach.

7. The methodology allows engineering design detail to be provided by telecommunications.

8. The methodology incorporates multiple objective optimization.

MAPMAT incorporates all of these criteria into its design. The foundation on which MAPMAT builds is the previous models developed in this area: (1) CAPDET and EXEC-OP for developed country applications, (2) USAID/REID and WBANK for developing countries applications. In the following chapter, data gathered by the USAID/REID project is used to verify the operation of MAPMAT.

CHAPTER IV

A TEST OF MAPMAT

Introduction

The intent of MAPMAT's design is an interactive framework for analysis of water supply and sanitation investment in developing countries. MAPMAT will have fulfilled that intent if planners in developing countries and members of international lending organizations find the approach taken by MAPMAT to be useful and to facilitate selection of appropriate technology. Thorough testing of MAPMAT will require extended usage in developing countries and a committment to collecting economic cost data to be used in analysis. A limited test, and insight into the application, of MAPMAT can be gained by comparison to a similar model, USAID/REID, which has been field tested in Panama and Indonesia. AID sponsored a four month field test of USAID/REID in both Panama and Indonesia in late 1979 and early 1980. Teams of University of Oklahoma engineers, under the direction of Professor George W. Reid, gathered data from varied test sites in Panama and Indonesia. The USAID/REID model was tested with this varied data and although there were minor definational problems the USAID/REID model was found to be an excellent first generation model. The USAID/REID model and the field test results were presented in one week seminars held in several countries: Panama, Indonesia, the Philippines, Peru, Thailand, etc. The data gathered in the USAID/REID field test is used to test MAPMAT and to compare the output of MAPMAT to the output of USAID/REID. The following sections will discuss the operation of MAPMAT, the results derived by using the Panama and Indonesia data as input to MAPMAT, and conclusions and recommendations.

Operation of MAPMAT

MAPMAT has six integral operating sections plus two utilities. The two utilities are intended to allow multiple regression analysis on cost data and provide a telecommunication link to CAPDET. Both of these utilities are peripheral to MAPMAT's operation and will not be discussed here. The central sections of MAPMAT are:

1. MAPMAT.MAIN

2. MAPMAT.AVAIL

3. MAPMAT.OPTIMIZE

4. MAPMAT.COST.RATIO

5. MAPMAT.EFFECTIVENESS

6. MAPMAT.SENSITIVITY

Initial entry into MAPMAT occurs via a greeting program called MAPMAT.HELLO. The greeting program automatically runs the main menu program called MAPMAT.MAIN. The purpose of the main menu program is to provide user interaction among the separate programs. The programs are written separately due to size of MAPMAT, approximately 95,000 bytes of code and cost ratio data, and to increase the efficiency of interactive usage. Once data is prepared by one of the programs MAPMAT automatically stores the data in a temporary file for further processing and, at user option, the file may be saved permanently. MAPMAT.MAIN guides the user to select a program for use. Appendix L includes the output generated by MAPMAT.HELLO and MAPMAT.MAIN.

MAPMAT.AVAIL second major section of MAPMAT, uses a questionnaire approach to identify technologies which may be inappropriate for the design site. There are 37 questions which correspond to the columns of Tables 18 through 21 for sanitation technology and Tables 22 through 25 for water supply technology. The answers to these questions determine whether a specific technology would be appropriate to local conditions and therefore is considered available by MAPMAT. Once the 37 questions are completed MAPMAT indicates the available technologies and, at the users option, the answers given to the questions and/or the questions which caused a particular technology to be unavailable. MAPMAT.AVAIL then produces a temporary disk file which contains the technology mnemonics, the technology availability, and response to questions. Appendix M contains the output generated by MAPMAT.AVAIL. The last four pages of Appendix M details the available technologies: ST,PFT.ST, and AP.SULLAGE for sanitation and SSF,DFILT, and CFILT for water supply. The technologies are arrayed against question numbers with an "x" indicating that the question response caused the particular technology to be unavailable. The zero or one preceeding the technology label indicates the on/off condition, 0 if off, one is on. The final section of Appendix M indicates the response given to the 37 questions.

The user has the option to permanently store the data generated by MAPMAT.AVAIL. The user finishes the MAPMAT.AVAIL section by returning to the main menu.

The third major section of MAPMAT is the optimization section, MAPMAT.OPTIMIZE. The purpose of this section is the construction of treatment trains from the available processes and checking to see that treatment goals, if set, are fulfilled. On entering MAPMAT.OPTIMIZE the user can select three options for data entry:

1. retrieve data stored temporarily by MAPMAT,

2. retrieve data stored permanently under a file name,

3. data which the user generates at this point.

The first two options use data stored on disks by MAPMAT.AVAIL. The data are retrieved from the disks and used to construct treatment trains. From the list of available technologies the user selects those technologies which will be used to construct treatment trains. Up to 99 stages can be included in a single treatment train and up to 999 treatment trains can be constructed. To allow for sequential investment programs MAPMAT.OPTIMIZE asks the user to specify the year in which a technology will be available. By specifying an entry in year 10 the user can investigate sequential investment starting in year one with an additional technology entered in year 10. Treatment goals and load can be entered by the user and MAPMAT will use internal percent reduction calculations to check each treatment train for compliance with the goal.

At the present time BOD reduction is the only goal of sanitation technology, while fecal coliform count is the only goal of water supply treatment. If a treatment train exceeds a goal, then the user is informed of both goal and existing load. The train may be included or excluded at the user's option. Finally a summary of the treatment train data is printed and the user is returned to the main menu. The treatment trains and year of availability are stored in a temporary data file and can be permanently stored at the user's option. A sample computer output is included as Appendix N.

The fourth section of MAPMAT is the cost ratio section, MAPMAT.COST.RATIO. The purpose of this section is to use the stored data to calculate per capita cost ratios for the selected treatment trains. Upon entry the user provides analysis data such as the existing population growth rate, the period of analysis to be used in discounting, and the opportunity cost of capital. The population values are used to establish economy/diseconomy information to be used by MAPMAT.COST.RATIO during the cost calculations. The average population over the life of the project is used in this analysis rather than the design population or the initial population. MAPMAT.COST.RATIO next presents descriptions of the four infrastructure levels which help to determine the economy/diseconomy data. The user must select an infrastructure level which is the best approximation of the design site. Once this information is entered MAPMAT.COST.RATIO moves to the cost calculations. Two options for data retrieval are using a temporary file stored by MAPMAT or data retrieval using a permanent file stored by MAPMAT. The indicated data is retrieved and the cost ratios are presented for each stage and for the train as a whole. Since the total values are presented as integers, the rounding error may cause values less than one to be reported as zero. Once MAPMAT.COST.RATIO completes printing the cost ratio data, the user is again returned to the main menu. A sample computer output for MAPMAT is the multi-objective optimization analysis using a pairwise comparison technique for cost effectiveness analysis. The purpose of this section is to allow the user to determine the relative importance of several factors which relate to the decision but cannot be quantified strictly in terms of cost. As an example, the data generated by Appendices L through O are used to demonstrate the technique. Four treatment trains have been stored and upon entry to MAPMAT.EFFECTIVENESS are identified as trains 1 through 4. Four effectiveness measures are selected for analysis:

1. the effectiveness of the alternative trains in using local labor,
2. reliability of the selected trains,
3. the social acceptance of the selected treatment trains,
4. the reliance on imported material of the selected trains.

Relative weights are assigned pairwise starting at the top of the list of effectiveness measures. For example, local labor use might be deemed twice as important as reliability. Reliability could be three times as important as social acceptance, etc. From these relative importance figures MAPMAT produces normalized relative weights for the included effectiveness measures. The same procedure is used for each effectiveness measure, but each alternative is ranked pairwise against the other alternatives. MAPMAT produces normalized relative rates for the alternate treatment trains for each selected effectiveness measure. MAPMAT uses the normalized weights between the effectiveness measures, and the normalized weights between the alternatives for each effectiveness measure, to construct a total weighted average effectiveness:

$$TE_j = \sum_{i=1}^{I} A_{ij} \cdot M_i$$

where TE_j = total effectiveness for the jth alternative,

A_{ij} = normalized weight for the jth alternative within the ith effectiveness measure,

M_i = normalized weight for the ith effectiveness measure.

The user has three options for cost data entry:

1. a temporary data file constructed by MAPMAT,

2. a permanent data file constructed by MAPMAT,

3. local entry of data.

Once the data are entered MAPMAT produces a summary of the cost effectiveness by dividing each cost by the TE_j calculated above. Appendix P includes a sample computer output for MAPMAT.EFFECTIVENESS.

The final major section of MAPMAT is the sensitivity analysis, MAPMAT.SENSITIVITY. The purpose of this section is to allow the user to modify a data element and investigate the effect of the change. Upon entry the user selects the area of data which will be modified. The modification takes place and the user receives the output appropriate to the solution. An example is included as Appendix Q. Inspection of the summary information in Appendix M indicated that question 12 caused several sanitation technologies such as VIPL to be inappropriate. Question 12 attempts to discover what level of training will be available at the design site. Several technologies require an extensive knowledge on the part of the user to be effective. If a local group, or a non-local group, will not supply that training then these technologies are likely to be inappropriate. For this example a low level of training was initially expected at the local site, but if an international lending organization will include funds for training then these technologies become available as shown in Appendix Q. The user could then link back using the main menu to rerun the optimization, cost ratio, and cost effectiveness sections.

In summary, the operation of MAPMAT is segmented into several sections which generate data files that are stored for further processing. A complete run of the model, excluding the communication and statistical utilities, is included as Appendices L through Q. In the following sections the use of MAPMAT is demonstrated using data from the USAID/REID field test in Panama and Indonesia.

MAPMAT Results for Panama and Indonesia, Data Gathered by the USAID/REID Project

Two member teams were dispatched from the University of Oklahoma to spend approximately three to four months in Panama and Indonesia. The major effort of these teams was to be the collection of data and analysis of the data using the USAID/REID model. The teams had daily contact and involved local government individuals in the collection and analysis of data. In Panama five test sites were selected for investigation:

	City	Province	1979 Population
1.	David	Chirique	50,890
2.	Santiago	Veraquas	21,840
3.	Penonome'	Cocle'	9,490
4.	Las Tablas	Los Santos	5,700
5.	Bocas del Toro	Bocas del Toro	2,700

Water supply treatment analysis was completed for David, Santiago, and Bocas del Toro. Wastewater treatment analysis was completed for David, Peneonome', and Las Tablas. The following output was derived from the USAID/REID model:

City	Unit Process Availability	Combinations Availability
David	No Treatment (NT)	1. RSF,c + D
	Pre-Treatment (PT)	2. RSF,a + D
	Slow Sand Filter (SSF)	3. PT + RSF,c + D

Cont'd.

City	Unit Process Availability	Combinations Availability
	Rapid Sand Filter, conventional (RSF,c) Rapid Sand Filter, Advanced (RSF,a) Softening (SOFT) Disinfection (D) Taste, Odor (T&O) Desalting - Salt (SALT1) Desalting - brackish (SALT2) Containment Filter (CFILT)	4. PT + RSF,a + D
Santiago	NT PT SSF D T&O CFILT	None

By making available professional operation and maintenance labor, the following process and combinations occur:

	RSF,c RSF,a	1. RSF,c + D 2. RSF,a + D 3. PT + RSF,c + D 4. PT + RFF,a + D
Bocas del Toro	PT D	None

By providing professional labor as above the same unit processes and combinations would be available.

Using data derived from the USAID/REID project MAPMAT provided the following output:

City	Technologies Available	Combinations Available
David	RSF CHLOR T&O	Any combination selected up to 99 stages and 999 treatment trains

Cont'd.

City	Technologies Available	Combinations Available
	DFILT	Examples:
	CFILT	1. CFILT + RSF + CHLOR
	SOFT	2. RSF + CHLOR
	DSALT1	3. RSF + DFILT
	DSALT2	4. DSALT1 + CHLOR
		5. CFILT + DFILT
		6. CFILT + RSF in year 1 + DFILT in year 5
Bocas del Toro	NT	Any combination
	DFILT	Examples:
	CFILT	1. DFILT in year 1 + DFILT in year 10
		2. NT + DFILT
		3. NT + CFILT

The Santiago output provided no significant information increase for the comparison and therefore is omitted from the analysis. In comparison, it can be seen that MAPMAT indicates fewer technologies available. Analysis of the MAPMAT.AVAIL output indicated that the prevalence of helminths in the local area was significant in reducing the number of available technologies. In addition the lack of professional labor for operation and maintenance reduced the number of technologies available.

This is in keeping with the intent of MAPMAT to flag inappropriate investment. Appendix R includes the summary information from MAPMAT.AVAIL, MAPMAT.OPTIMIZE, and MAPMAT.COST.RATIO. for David. The same information is included as Appendix S for Bocas del Toro. It should be noted that MAPMAT produces cost ratios of zero when data is not available. The wastewater output of USAID/REID field test in Panama included the following:

Wastewater Treatment

City	Unit Process Availability	Combinations Availability
David	Primary, conventional (PC)	1. OC + IMHOFF
	Primary, Stabilization Pond (SP)	2. SP + DILUT
	Sludge, conventional (S,c)	3. PC + S,c
	Sludge, advanced (S,a)	4. PC + IMHOFF + STD
	Sludge, combined (IMHOFF)	5. PC + EXT
	Secondary, standard filter (STD)	6. PC + S,c + STD
	Secondary, high rate filter (HR)	7. PC + S,c + HR
	Secondary, Activated Sludge (AS)	8. PC + S,c + AS
	Secondary, Extended Aeration (EXT)	9. Pc + IMHOFF + D
	Disinfection (D)	10. PC + S,c + D
	Aqua culture (AQ)	11. SP + D
	Dilution (DILUT)	12. PC + INHOFF + STD + D
	Individual (INDIV1)	13. PC + S,c + STD + D
	Individual, advanced (INDIV2)	14. PC + S,c + HR + D
		15. PC + D + EXT
Penonome'	PC	1. PC + IMHOFF
	SP	2. PC + S,c
	S,c	3. SP + DILUT
	S,a	4. PC + IMHOFF + STD
	IMHOFF	5. PC + EXT
	STD	6. PC + S,c + STD
	EXT	7. PC + IMHOFF + D
	D	8. PC + S,c + D
	AQ	9. SP + D
	DILUT	10. PC + IMHOFF + STD + D
	INDIV1	11. PC + S,c + STD + D
	INDIV2	12. PC + D + EXT

LAS TABLAS	Same as Penonome'	1. PC + IMHOFF + D 2. PC + S,c + D 3. SP + D 4. PC + IMHOFF + STD + D 5. PC + S,c STD + D 6. PC + EXT + D

Using the data from the USAID/REID project MAPMAT supplied the following output:

City	Technology Availability	Treatment Trains
David	ROEC ST PFT PFT.SEW.SB PFT.ST COMM COMM.SEW TC HRTC PC CHLOR RBC AS TF.STD TF.HR IMHOFF	Examples with year of construction under the technology 1. ROEC 1 2. ST 1 3. PFT + PFT.ST + PFT.SEW.SB 1 5 10 +PC +IMHOFF + TF.STD 10 10 10 4. PC + IMHOFF + TF.HR + CHLOR 1 1 1 10 5. PC + TF.STD + AS + CHLOR 1 1 5 1 6. PFT.SEW.SB + PC + IMHOFF + TF.STD 1 1 1 1 7. COMM.SEW + PC + IMHOFF + TF.STD 1 1 1 1
Penonome'	VIPL VIDPL ROEC PFT PFT.ST AP	Examples: 1. PFT + PFT.ST 1 5 2. VIPL 1 3. VIDPL 1 4. ROEC 1 5. PFT 1 6. AP 1 7. VIDPL + PFT + PFT.ST 1 5 10 8. ROEC + PFT + PFT.ST 1 5 10

Las Tablas is not included here since it did not provide significant additional information. As can be seen from the above, the technology available for David are substantially the same for MAPMAT and USAID/REID. The flexibility of MAPMAT in constructing treatment trains is apparent for both David and Penonome'. Appendices T and U include the summary output from MAPMAT. Certain treatment trains are eliminated from consideration due to faulty data input by the user, i.e., specifying a construction date beyond the analysis period, etc. The David output from MAPMAT is illustrative of the difference in comparison to USAID/REID. Treatment trains 4, 5, and 6 allow the user to investigate sequential investment, and in the case of train 4, the technology moves from on-site to sewered. In addition, MAPMAT includes a larger number of technologies than USAID/REID so that additional flexibility is provided. In the case of Penonome', the differences are quite striking. USAID/REID has available almost the full range of sanitation, while MAPMAT indicates only on-site alternatives be included as appropriate to local conditions. Analysis of the response to the questions indicates that several technologies were made unavailable on the basis of judgmental answers by the user. Since the pertinent information is not available, the output from MAPMAT cannot be verified. Clearly, MAPMAT is sensitive to the quality and quantity of the input data. This sensitivity is the intent of MAPMAT since the interactive flexibility allows rapid additional analysis that should be sensitive to local conditions. Of course, MAPMAT may be too sensitive, but only full information tests will decide this issue. It should be noted that at the time of the USAID/REID field tests, only communal septic tanks were in use at Penonome'.

The Indonesia field test of USAID/REID covered four sites in West Java:

Test Site	Location	District	Population
TS1	Desa Bongas	Bandung	11,175
TS2	Desa Nanjung	Bandung	5,236
TS3	Desas Wetan and Kulon	Majalengka	24,625
TS4	Four Desas in Karawang	Karawang	79,680

Two of the Indonesian test sites are selected for comparison, TS2 and TS4.

The USAID/REID model indicates the following output based on the test site data:

Test Site	Unit Process Availability	Combinations Available
TS2	NT	1. NT
	PT	2. NT + D
	SSF	3. SSF
	D	4. PT + SSF
	T&O	5. PT + SSF + D
	CFILT	6. CFILT
		7. T&O
TS4	NT	1. NT
	PT	2. NT + PT
	SSF	3. SSF
	RSF,c	4. PT + SSF
	RSF,a	5. CFILT
	SOFT	6. RSF,c + D
	D	7. PT + RSF,c + D
	T&O	8. RSF,a + D
	SALT1	9. PT + RSF,a D
	SALT2	
	CFILT	

Using the USAID/REID data, MAPMAT generated the following output.

Water Supply Treatment

Test Site	Technology Availability	Treatment Train
TS2	NT PT DFILT CFILT	Any combination of the available technologies
TS4	NT PT SSF RSF CHLOR T&O DFILT CFILT SOFT DSALT1 DSALT2	Any combination

As in the Panama test data, both USAID/REID and MAPMAT select approximately the same technologies for a large city. MAPMAT gives the user more flexibility in constructing alternate treatment trains. For rural villages and towns, MAPMAT tends to be conservative in selecting technology compared to USAID/REID.

The sanitation section of USAID/REID resulted in the following output for the Indonesian test sites:

Sanitation Technology

Test Site	Unit Process Availability	Combinations Available
TS2	PC SP S,c S,a IMHOFF STD EXT D	1. PC + IMHOFF 2. PC + S,c 3. SP 4. PC + IMHOFF + STD 5. PC + EXT 6. PC + S,c + STD 7. S,c 8. Any one of 1 to 7 + D

Sanitation Technology - Cont'd.

Test Site	Unit Process Availability	Combinations Available
	AQ DILUT INDIV1 INDIV2	9. AC 10. DILUT 11. SP + DILUT 12. INDIV1 13. INDIV2
TS4	All process available - see David, Waste section.	See David

Using the data from the USAID/REID project, MAPMAT produced the following output:

Sanitation Technology

Test Site	Technology Availability	Treatment Train
TS2	VIPL VIDPL ST PFT PFT.SF SP AP.SULLAGE	Any combination
TS4	PFT PFT.SEW.SB AP AP.SULLAGE AP.SEW.SB COMM COMM.SEW LAG.WSP TC HRTC PC SDBEDS SDLAG A.LAG.EXT CHLOR LT RBC AS TF.STD TF.HR IMHOFF	Any combination

These results confirm the previous findings that MAPMAT is more conservative than USAID/REID on technology availability for small towns and rural villages, but very similar on large cities. MAPMAT is more flexible in construction of treatment trains. Summary results from MAPMAT are included as Appendix V for TS2 and Appendix W for TS4.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The purpose of this research has been the synthesis of economics and civil engineering in a planning model which would be appropriate to developing countries. The model developed, MAPMAT, attempts to interface the areas of economic planning, economic cost effectiveness analysis, and public health economics with the civil engineering areas of water supply treatment and sanitation technology. The coming decade, i.e., the Water Decade, is likely to see a very large investment in water supply treatment and sanitation technology for developing countries. Unless the technology selected is appropriate to local conditions, the level of investment may not be effective in improving public health in developing countries. It is desirable in economic developmental planning that infrastructure investment funds be expended in an efficient manner and be allocated to maximize societal welfare. In general, quantifiable benefits are compared to project cost in choosing among competing investments. Unfortunately, the benefits which accrue to an investment in water supply/sanitation cannot be adequately quantified at the present time. In such circumstances, the appropriateness of technology to local conditions becomes critical. The model developed during this research represents a new economic planning model to be used in the selection of water supply treatment and sanitation technology. The following paragraphs will indicate the approach used in developing the model and recommendations on future research.

Since the intent of MAPMAT included a synthesis of civil engineering and economics the first step in the development of MAPMAT was a literature review pertinent to the areas of interest. The review concentrated on water supply treatment and sanitation selection models and the interdependent links between the provision of these technologies and economic development. The second step in the development of MAPMAT included the design of the model and implementation on a microcomputer. A test of MAPMAT, using data previously collected by a USAID/University of Oklahoma project, completed the development of the model. MAPMAT's basic technology selection structure is derived from the previous technology selection models: CAPDET, EXEC-OP, USAID/REID, and WBANK. Economic planning elements were added to MAPMAT to produce the final form. Once the design of MAPMAT was completed, a microcomputer was chosen for implementing MAPMAT's design. The hardware configuration selected for MAPMAT included an Apple II Plus microcomputer with approximately 64,000 bytes of random access memory, the Apple disk operating system version 3.3, and the BASIC language version called Applesoft. Peripheral hardware included a Sanyo monitor, two Micro-Sci disk drives, a Mountain Hardware CPS Multifunction board, a D.C. Hayes modem, and an Intragral Data Systems Model 560G printer. The implementation of MAPMAT required over 90,000 bytes of information be stored on magnetic diskette. The final step in the development of MAPMAT included a test of MAPMAT using data collected by the USAID/University of Oklahoma project. The test results from MAPMAT were compared to results generated by USAID/REID. That comparison indicated that MAPMAT included a broader range of options for planning purposes and a more conservative technology process for small towns and rural villages.

Although MAPMAT fulfills the intent of its design, there are several areas which would benefit from further research:

1. Sets of cost data should be developed for all planning units which intend to use MAPMAT for cost estimation. The cost data included in MAPMAT is useful for demonstration only.
2. MAPMAT, and it's developing country predecessors USAID/REID and WBANK, are sensitive to the definition and interpretation of terms used during the questionaire response and technology selection processes. Perhaps a universal set of questions/terms could be established rather than depend on the modeler's particular definition of terms.
3. The relationship between an investment in public water treatment and/or sanitation technology should be investigated thoroughly. No satisfactory method currently exists to quantify benefits related to these types of infrastructure investment.
4. The type of simulation included in EXEC-OP and CAPDET should be explicitly included in MAPMAT's design. Possibly one of the

new 16 bit microprocessor microcomputers with extended memory could be used to create a model which would not require a telecommunications link to CAPDET.

5. The concept of economic cost should be extended in MAPMAT's design to allow for additional policy options. This should be a joint or subsequent activity with the development of cost estimation data.
6. MAPMAT should be tested in several developing countries and its design altered to match conditions specific to each country where it is used for planning.

These recommendations for future research do not attempt to be an exhaustive list of possible alterations. Rather it is anticipated that these recommendations will provide a starting point for future research.

MAPMAT represents a significant addition to the interdisciplinary area that encompasses water treatment and sanitation technology from civil engineering and economic development from economics. MAPMAT encourages the selection of appropriate technology and provides the most comprehensive selective algorithm for water treatment/sanitation technology appropriate to developing countries. MAPMAT promotes systems analysis, cost effectiveness analysis, and multi-objective planning in an interactive sensitivity framework. MAPMAT systematically includes both economic costing and local health conditions in the technology selection process. In conclusion, MAPMAT represents a new model to be incorporated into economic development planning for developing countries.

Despite the fulfillment of design intent and the technical contribution to the interdisciplinary area covered by MAPMAT, only time and usage will indiciate if MAPMAT has fulfilled it's philosophical intent. Should this intent be fulfilled, then economic conditions and public health will be significantly improved by the Water Decade investment in water treatment and sanitation technology.

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APPENDIX A

CAPDET EXAMPLE PROBLEM OUTPUT

```
PRIMARY CLARIFICATION
SIDEWATER DEPTH     10.0 FEET
END
DRYING BEDS
RAINFALL             6.0 INCHES/MONTH
END
TITLE     EXAMPLE PROBLEM
LIQUID LINE
BLOCK     PRELIM
BLOCK     PRIMAR
BLOCK     STEP A TRICKL
BLOCK     CHLORI
SECONDARY SLUDGE LINE
BLOCK     A MIX
PRIMARY SLUDGE LINE
BLOCK     AEROBI ANAERO
BLOCK     DRYING
BLOCK HAULIN
```

WASTE INFLUENT	
AVERAGE FLOW	10.0 MGD
BOD5	300.0 MG/L
OIL AND GREASE	0.0 MG/L
DESIRED EFFLUENT CHARACTERISTICS	
UNIT COSTS	
BUILDING	42.0 \$/SQFT
EXCAVATION	1.75 \$/SQFT
WALL CONCRETE	275.00 \$/CUYD
SLAB CONCRETE	230.00 \$/CUYD
MARSHALL AND SWIFT	545.00
SMALL CITY EPA INDEX	140.00
END	
CONTROL CARDS	
LIST	4 TRAINS
PRINT TRAIN NO	1
OUTPUT QUANTITIES	
GO	I=6.625 30 YEARS

COST ANALYSIS INPUT PARAMETERS

INTEREST RATE	6.625 PERCENT
PLANNING PERIOD	30 YEARS
WAGE RATE	7.50 \$/HOUR

UNIT PRICES AND COSTS INDICES

I BUILDING	42.00	\$/SQ FT
I EXCAVATION	1.75	\$/CU YD
I WALL CONCRETE	275.00	\$/CU YD
I SLAB CONCRETE	230.00	\$/CU YD
I MARSHALL AND SWIFT INDEX	545.00	
D CRANE RENTAL	67.00	\$/HR
I EPA CONSTRUCTION COST INDEX	140.00	
D CANOPY ROOF	15.75	\$/SQ FT
D LABOR RATE	13.40	\$/HR
D OPERATOR CLASS II	7.50	\$/HR
D ELECTRICITY	.04	\$/KWHR
D CHEMICAL COSTS		
LINE	.03	\$/LB
ALUM	.04	\$/LB
IRON SALTS	.06	\$/LB
POLYMER	1.62	\$/LB
D ENGINEERING NEWS RECORD COST INDEX	2886.00	
D HANDRAIL	25.20	\$/FT
D PIPE COST INDEX	295.20	
D PIPE INSTALLATION LABOR RATE	14.70	\$/HR
D EIGHT INCH PIPE	9.08	\$/FT
D EIGHT INCH PIPE BEND	86.82	\$/UNIT
D EIGHT INCH PIPE TEE	128.49	\$/UNIT
D EIGHT INCH PIPE VALVE	1346.16	\$/UNIT

EXAMPLE PROBLEM

TRAIN NO 1

LIQUID PREL 0 PRIM 0 TRIC 0 CHLO 0

SECONDARY A MI 0

PRIMARY ANAE 0 DRYI 0 HAUL 0

CAPITAL COST $9,536,401.

OPERATING MAINTENANCE COST $343,240.

EQUIVALENT ANNUAL COST $1,202,058.

TRAIN NO 2

LIQUID PREL 0 PRIM 0 TRIC 0 CHLO 0

SECONDARY A MI 0

PRIMARY AERO 0 DRYI 0 HAUL 0

CAPITAL COST $9,232,032.

OPERATING MAINTENANCE COST $377,476.

EQUIVALENT ANNUAL COST $1,216,207.

TRAIN NO 3

LIQUID PREL 0 PRIM 0 TRIC 0 CHLO 0

SECONDARY A MI 0

PRIMARY AERO 0 DRYI 0 HAUL 0

CAPITAL COST $16,131,672.

OPERATING MAINTENANCE COST $891,186.

EQUIVALENT ANNUAL COST $2,332,480.

TRAIN NO 4

LIQUID PREL 0 PRIM 0 TRIC 0 CHLO 0

SECONDARY A MI 0

PRIMARY ANAE 0 DRYI 0 HAUL 0

CAPITAL COST $17,570,674.

OPERATING MAINTENANCE COST $901,397.

EQUIVALENT ANNUAL COST $2,469,677.

EXAMPLE PROBLEM TRAIN NO 1

INFLUENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	200.00	BOD5	300.00	TKN	45.00
AVERAGE	10.0000	VOLATILE	60.00 %	BOD5S	75.00	NH3	25.00
MINIMUM	10.0000	SETTLEABLE	15.00	COD	500.00	NO2	.00
				CODS	400.00	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	18.00		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

EXAMPLE PROBLEM TRAIN NO 1

* *

MECHANICALLY CLEANED BAR SCREEN

D BAR SIZE	.250+00 IN
D BAR SPACING	.150+01 IN
D SLOPE OF BARS FROM HORIZONTAL	.300+02 DEG
HEAD LOSS THROUGH SCREEN	.206-01 FT
D APPROACH VELOCITY	.250+C1 FPS
D AVERAGE FLOW THROUGH VELOCITY	.250+01 FPS
D MAXIMUM FLOW THROUGH VELOCITY	.300+01 FPS
SCREEN CHANNEL WIDTH	.616+01 FT
D AVERAGE CHANNEL DEPTH	.100+01 FT

* *

EXAMPLE PROBLEM TRAIN NO 1

* *

AERATED GRIT CHAMBER

	MAXIMUM FLOW	.154+02 CFS
	AVERAGE FLOW	.154+02 CFS
	MINIMUM FLOW	.154+02 CFS
	TEMPERATURE	.180+02 DEG C
D	MAXIMUM FLOW THROUGH VELOCITY	.113+00 FPS
D	AVERAGE FLOW THROUGH VELOCITY	.113+00 FPS
D	SIZE SMALL, PART, 100% REMOVED	.200+00 MM
D	SPECIFIC GRAVITY OF PARTICLE	.265+01
D	NUMBER OF UNITS	.200+01
	MAXIMUM FLOW/UNIT	.770+01 CFS
D	WIDTH OF CHANNEL	.170+02 FT
D	DEPTH OF CHANNEL	.400+01 FT
	LENGTH OF CHANNEL	.170+02 FT
	SETTLING VELOCITY OF PARTICLE	.785-01 FPS
D	DETENTION TIME	.250+01 MIN
	VOLUME OF GRIT	.400+02 CUFT/DAY
D	AIR SUPPLY	.300+01 CFM

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EXAMPLE PROBLEM TRAIN NO 1

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COMMINUTION

D NUMBER OF UNITS	.200+01 UNITS
DRUM DIAMETER	.250+02 INCHES
DRUM RPM	.250+02 REV/MIN
AVERAGE SLOT WIDTH	.380+00 INCHES
HORSEPOWER/UNIT	.150+01 HP
STANDARD WEIGHT	.579+01 FEET
STANDARD NET WEIGHT	.210+04 POUNDS

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LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	200.00	BOD5	300.00	TKN	45.00
AVERAGE	10.0000	VOLATILE	60.00 %	BOD5S	75.00	NH3	25.00
MINIMUM	10.0000	SETTLEABLE	15.00	COD	500.00	NO2	.00
				CODS	400.00	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	18.00		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

EXAMPLE PROBLEM TRAIN NO 1

* *

**** SUPERNATANT FROM ANAEROBIC DIGESTER ADDED TO LIQUID LINE ****

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	212.69	BOD5	312.19	TKN	49.25
AVERAGE	10.0000	VOLATILE	59.80 %	BOD5S	88.31	NH3	27.36
MINIMUM	10.0000	SETTLEABLE	15.00	COD	527.36	NO2	.00
				CODS	422.89	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	18.91		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

EXAMPLE PROBLEM   TRAIN NO 1

* *

PRIMARY CLARIFIER

CIRCULAR CLARIFIER

D SURFACE OVERFLOW RATE	.100+04	GAL/DAY/SQFT
SURFACE AREA	.100+05	SQ FT
I SIDE WATER DEPTH	.100+02	FEET
DETENTION TIME	.180+01	HOURS
SOLID LOADING	.177+01	LB/SQFT/DAY
D WEIR LOADING	.150+05	GAL/DAY/FT
WEIR LENGTH	.667+03	FEET
VOLUME OF SLUDGE PRODUCED	.294+05	GAL/DAY
D SUSPENDED SOLIDS REMOVAL	.580+02	PERCENT
D BOD REMOVAL	.320+02	PERCENT
D COD REMOVAL	.400+02	PERCENT
D TKN REMOVAL	.500+01	PERCENT
D P04 REMOVAL	.500+01	PERCENT

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EXAMPLE PROBLEM TRAIN NO 1

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QUANTITIES FOR SEDIMENTATION

CIRCULAR CLARIFIER

PRIMARY CLARIFIER

EXCESS CAPACITY FACTOR	.100+01
CALCULATED SURFACE AREA	.100+05 SQ FT
ADJUSTED SURFACE AREA	.100+05 SQ FT
AVERAGE DAILY WASTEWATER FLOW	.100+02 MGD
NUMBER OF CIRCULAR CLARIFIERS	2
NUMBER OF BATTERIES	1
SURFACE AREA PER UNIT	.500+04 SQ FT
DIAMETER OF UNIT	.800+02 FEET
EARTHWORK REQUIRED	.128+06 CU FT
SIDEWATER DEPTH	.100+02 FEET
THICKNESS OF THE SLAB	.104+02 INCHES
WALL THICKNESS	.120+02 INCHES
TOTAL WALL CONCRETE REQUIRED	.600+04 CU FT
TOTAL SLAB CONCRETE REQUIRED	.101+05 CU FT
MAINTENANCE MANPOWER REQUIRED	.564+03 MAN-HOURS/YR
OPERATION MANPOWER REQUIRED	.102+04 MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.101+05 KWHR/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	89.33	BOD5	240.55	TKN	48.16
AVERAGE	10.0000	VOLATILE	59.80 %	BOD5S	88.31	NH3	27.36
MINIMUM	10.0000	SETTLEABLE	.00	COD	485.57	NO2	.00
				CODS	422.89	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	17.96		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	29371.00	.00
% SOLIDS	4.00	.00
% VOLATILE	59.80	.00

EXAMPLE PROBLEM TRAIN NO 1

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TRICKLING FILTRATION

D SOLID PRODUCTION RATE .650+00 LB/LB BOD5

D HYDRAULIC LOADING RATE .750+00 GPM/SQ FT

D RASCHIG RINGS MEDIA (1-1/2 INCH)

D SPECIFIC SURFACE AREA .300+02 SQ FT/CU FT

REACTION RATE CONSTANT	.205=02
RECIRCULATION RATIO	.362+00
TOTAL HYDRAULIC LOADING RATE	.102+01 GPM/SQ FT
DEPTH OF FILTER TOWER	.238+02 FEET
NUMBER OF STAGES	2
SURFACE AREA OF FILTER	.926+04 SQ FT
MEDIA VOLUME	.440+06 CU FT

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR TRICKLING FILTER

NUMBER OF TOWERS	4
VOLUME PER FILTER TOWER	.116+06 CU FT
DIAMETER OF FILTER TOWER	.786+02 FEET
TOTAL NUMBER OF POSTS	345
TOTAL LENGTH OF PRECAST BEAMS	.105+05 FEET
TOTAL REINFORCED WALL CONCRETE	.395+05 CU FT
TOTAL REINFORCED SLAB CONCRETE	.130+05 CU FT
TOTAL EARTHWORK REQUIRED	.247+06 CU FT
ELECTRICAL ENERGY REQUIRED	.192+06 KWHR/YR
OPERATIONAL MANPOWER	.520+03 MAN-HOURS/YR
MAINTENANCE MANPOWER	.407+03 MAN-HOURS/YR

EXAMPLE PROBLEM TRAIN NO 1

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SECONDARY CLARIFIER

CIRCULAR CLARIFIER

	SOLIDS LOADING RATE	.107+02 LB/SQFT/DAY
D	SURFACE OVERFLOW RATE	.800+03 GAL/SQFT/DAY
	DETENTION TIME	.202+01 HOURS
D	WEIR OVERFLOW RATE	.150+05 GAL/FT/DAY
D	TANK SIDEWATER DEPTH	.900+01 FEET
	WEIR LENGTH	.908+03 FEET
	VOLUME OF WASTED SLUDGE	.160+05 GAL/DAY
D	UNDERFLOW CONCENTRATION	.300+01 PERCENT
	TOTAL SURFACE AREA	.125+05 SQ FT

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR SEDIMENTATION

CIRCULAR CLARIFIER

SECONDARY CLARIFIER

EXCESS CAPACITY FACTOR	.100+01
CALCULATED SURFACE AREA	.125+05 SQ FT
ADJUSTED SURFACE AREA	.125+05 SQ FT
AVERAGE DAILY WASTEWATER FLOW	.100+02 MGD

NUMBER OF CIRCULAR CLARIFIERS	2
NUMBER OF BATTERIES	1
SURFACE AREA PER UNIT	.625+04 SQ FT
DIAMETER OF UNIT	.900+02 FEET
EARTHWORK REQUIRED	.166+06 CU FT
SIDEWATER DEPTH	.900+01 FEET
THICKNESS OF THE SLAB	.101+02 INCHES
WALL THICKNESS	.115+02 INCHES
TOTAL WALL CONCRETE REQUIRED	.591+04 CU FT
TOTAL SLAB CONCRETE REQUIRED	.123+05 CU FT
MAINTENANCE MANPOWER REQUIRED	.646+03 MAN-HOURS/YR
OPERATION MANPOWER REQUIRED	.117+04 MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.105+05 KWHR/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	10.00	TKN	23.60
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	5.00	NH3	23.60
MINIMUM	10.0000	SETTLEABLE	.00	COD	15.00	NO2	.00
				CODS	7.50	NO3	10.11
TEMP	18.0 C	OIL & GREASE	.00	PO4	8.80		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	29371.00	1600.00
% SOLIDS	4.00	3.00
% VOLATILE	59.80	80.00

EXAMPLE PROBLEM TRAIN NO 1

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CHLORINATION

MAXIMUM FLOW	.100+02 MGD
AVERAGE FLOW	.100+02 MGD
D CONTACT TIME	.300+02 MIN
TOTAL VOLUME	.208+06 GAL
AVERAGE CHLORINE REQUIREMENT	.834+03 LB/DAY
PEAK CHLORINE REQUIREMENT	.834+03 LB/DAY
COLIFORM REDUCTION	.996+02 PERCENT

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR CHLORINATION

NUMBER OF CHLORINATORS AND EVAPORATORS	1
CHLORINATION BUILDING AREA	.220+03 SQFT

NUMBER OF CHLORINE CYLINDERS	13
AREA OF CHLORINE STORAGE BUILDING	.182+04 SQFT
AVERAGE DAILY WASTEWATER FLOW MGD	.100+02 MGD
VOLUME OF EARTHWORK REQUIRED	.144+05 CUFT
VOLUME OF R.C. FOR WALLS	.565+04 CUFT
VOLUME OF R.C. FOR SLAB	.307+04 CUFT
CHLORINE REQUIREMENT PER YEAR	.152+03 TONS/YR
OPERATIONAL LABOR	.145+04 MAN-HOURS/YR
MAINTENANCE MANPOWER REQUIRED	.363+03 MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.131+06 KWH/YR
CHLORINE REQUIREMENT	.834+03 LB/DAY
O & M MATERIAL AND SUPPLY COSTS	.313+01 PERCENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	10.00	TKN	23.60
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	5.00	NH3	23.60
MINIMUM	10.0000	SETTLEABLE	.00	COD	15.00	NO2	.00
				CODS	7.50	NO3	10.11
TEMP	18.0 C	OIL & GREASE	.00	PO4	8.80		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	29371.00	1600.00
% SOLIDS	4.00	3.00
% VOLATILE	59.80	80.00

EXAMPLE PROBLEM . TRAIN NO 1

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**** SECONDARY SLUDGE LINE MIXED INTO PRIMARY SLUDGE LINE ****

INFLUENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	10.00	TKN	23.60
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	5.00	NH3	23.60
MINIMUM	10.0000	SETTLEABLE	.00	COD	15.00	NO2	.00
				CODS	7.50	NO3	10.11
TEMP	18.0 C	OIL & GREASE	.00	PO4	8.80		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	45371.00	.00
% SOLIDS	3.65	.00
% VOLATILE	65.66	.00

EXAMPLE PROBLEM TRAIN NO 1

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ANAEROBIC DIGESTION

D PERCENT V. S. DESTROYED	.500+02	PERCENT
D SOLIDS CONCENTRATION IN DIGESTER	.500+01	PERCENT
D RAW SLUDGE TEMPERATURE	.700+02	DEG F
D DIGESTER TEMPERATURE	.100+03	DEG F
D AIR TEMPERATURE	.400+02	DEG F
DETENTION TIME	.965+01	DAYS
TOTAL VOLUME	.113+06	CU FT
GAS PRODUCED	.297+04	CU FT/HR
HEAT REQUIREMENT	.208+04	BTU/HR
DIGESTER GAS REQUIREMENT	.208+04	CU FT/HR
TOTAL NATURAL GAS REQUIRED	.000	CU FT/YR
DIGESTER DEPTH	.235+02	FEET
DIGESTER DIAMETER	.450+02	FEET

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR ANAEROBIC DIGESTION

DIAMETER OF TANK	.450+02 FEET
NUMBER OF DIGESTERS PER BATTERY	3
NUMBER OF BATTERIES	1
VOLUME OF EARTHWORK	.121+06 CU FT
SIDEWATER DEPTH OF DIGESTER	.235+02 FEET
WALL THICKNESS	.193+02 INCHES
REINFORCED WALL CONCRETE	.201+05 CU FT
SLAB THICKNESS	.993+01 INCHES
REINFORCED SLAB CONCRETE	.450+04 CU FT
SURFACE AND A/FLOOR OF 2-STORY CONTROL BLDG	.792+03 SQ FT
PIPING SIZE	.600+01 INCHES
LENGTH OF TOTAL PIPING SYSTEM	.728+03 FEET
NUMBER OF 90 DEGREE ELBOWS	39
NUMBER OF TEES	77
NUMBER OF PLUG VALVES	56
TOTAL DRY SOLIDS TREATED PER DAY	.725+01 TONS/DAY
ELECTRICAL ENERGY REQUIRED	.152+06 KWHR/HR
OPERATION MAN-HOUR REQUIREMENT	.173+04 MAN-HOURS/YR
MAINTENANCE MAN-HOUR REQUIREMENT	.144+04 MAN-HOURS/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	10.00	TKN	23.60
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	5.00	NH3	23.60
MINIMUM	10.0000	SETTLEABLE	.00	COD	15.00	NO2	.00
				CODS	7.50	NO3	10.11
TEMP	18.0 C	OIL & GREASE	.00	PO4	8.80	PH	7.60
CATIONS	160.00						
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	22231.14	.00
% SOLIDS	5.00	.00
% VOLATILE	48.88	.00

EXAMPLE PROBLEM TRAIN NO 1

* *

SLUDGE DRYING BEDS

TOTAL SURFACE AREA REQUIRED .492+06 SQ FT D INITIAL

DEPTH OF SLUDGE .120+02 INCHES D FINAL PERCENT

SOLIDS .500+02

BED HOLDING TIME .166+03 DAYS

EXAMPLE PROBLEM TRAIN NO 1

* *

QUANTITIES FOR DRYING BED

TOTAL DRYING BED SURFACE AREA	.492+06 SQ FT
NUMBER BEDS	165
SURFACE AREA OF EACH INDIVIDUAL BED	.298+04 SQ FT
LENGTH OF EACH BED	.149+03 FEET
VOLUME OF EARTHWORK REQUIRED	.242+07 CU FT
VOLUME CONCRETE FOR DIVIDING WALL	.159+06 CU FT
VOLUME OF R.C. IN-PLACE FOR TRUCK TRACKS	.738+05 CU FT
VOLUME OF SAND	.369+06 CU FT
VOLUME OF GRAVEL	.492+06 CU FT
CLAY PIPE DIAMETER	.600+01 INCHES
TOTAL LENGTH CLAY PIPE	.492+05 FEET
SLUDGE SOLIDS PER DAY	.464+01 TONS/DAY
OPERATION MANPOWER REQUIRED	.494+04 MAN-HOURS/YR
MAINTENANCE MANPOWER REQUIRED	.247+04 MAN-HOURS/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	10.00	TKN	23.60
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	5.00	NH3	23.60
MINIMUM	10.0000	SETTLEABLE	.00	COD	15.00	NO2	.00
				CODS	7.50	NO3	10.11

TEMP	18.0 C	OIL & GREASE	.00	PO4	8.80
PH	7.60	CATIONS	160.00		
		ANIONS	160.00		

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	5884.71	.00
% SOLIDS	17.00	.00
% VOLATILE	48.88	.00

EXAMPLE PROBLEM TRAIN NO 1

* *

SLUDGE HAULING AND LAND FILLING

	VOLUME OF SLUDGE HAULED	.291+02 CU YD/DAY
	TRUCK CAPACITY	.190+02 CU YD
D	ROUND TRIP TIME TO DISPOSAL SITE	.100+01 HRS
D	TRUCK LOADING TIME	.750+00 HRS
D	HOURS OF OPERATION PER DAY	.800+01 HRS
	NUMBER OF TRUCKS REQUIRED	1
	TONS OF SLUDGE HAULED PER DAY	.258+02 TONS
D	DISTANCE TO DISPOSAL SITE	.100+02 MILES

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EXAMPLE PROBLEM TRAIN NO 1

* *

QUANTITIES FOR SLUDGE HAULING AND LANDFILL

TOTAL SLUDGE VOLUME HAULED	.291+02 CUYD/DAY
MAXIMUM ANTICIPATED LANDFILL DOWNTIME	.300+02 DAYS
ANTICIPATED SLUDGE STORAGE HEIGHT	.800+01 FEET
SLUDGE STORAGE SHED AREA	.295+04 SQ FT
WIDTH OF SLUDGE STORAGE SHED SLAB	.384+02 FEET
LENGTH OF SLUDGE STORAGE SHED SLAB	.768+02 FEET
VOLUME OF EARTHWORK	.812+04 CU FT
VOLUME OF SLAB CONCRETE	.348+04 CU FT
SURFACE AREA OF CANOPY ROOF	.295+04 SQ FT
DISTANCE TO DISPOSAL SITE	.100+02 MILES
ROUND TRIP HAUL DISTANCE	.200+02 MILES
TONS OF SLUDGE HAULED PER DAY	.258+02 TONS/DAY
OPERATION MANPOWER REQUIRED	.456+03 MAN-HOURS/YR
ROUND TRIPS PER DAY PER TRUCK	.200+01
DISTANCE TRAVELED PER YEAR PER TRUCK	.100+05 MILES/YR
MAINTENANCE AND MATERIAL SUPPLY COST	.130+02 PERCENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	10.00	TKN	23.60
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	5.00	NH3	23.60

MINIMUM	10.0000	SETTLEABLE	.00	COD	15.00	NO2	.00
				CODS	7.50	NO3	10.11
TEMP	18.0 C	OIL & GREASE	.00	PO4	8.80		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

EXAMPLE PROBLEM TRAIN NO 1

* *

AVERAGE WASTEWATER FLOW 10.00 MGD

LIQUID PREL 0 PRIM 0 TRIC 0 CHLO 0

SECONDARY A MI 0

PRIMARY ANAE 0 DRYI 0 HAUL 0

* *

COST SUMMARY

UNIT	CAPITAL COST $	AMMORT COST $/YR	OPER LABOR COST $/YR	MAINT LABOR COST $/YR	POWER COST $/YR	MATERIAL COST $/YR	CHEMICAL COST $/YR	TOTAL O & M COST $/YR
PRELIMIN	159346	11018	13915	5907	1859	3983	0	25664
PRIM CLA	394444	25643	7445	3486	403	3944	0	15273
T SEC CL	441249	28686	8515	3994	419	4412	0	17340
PUMPING	210658	18917	5137	3686	36278	1472	0	46573
TRIC FIL	1272057	82699	3783	2518	7678	3108	0	17087
CHLORINA	175153	25951	10519	2247	5250	5477	17783	41276
ANAE DIG	1061131	82314	12611	7030	6083	8477	0	34201
DRY BEDS	2230988	246256	35960	15278	0	20078	0	71316
HAUL & LF	123617	68529	3314	0	0	14109	0	17423
TOTAL	6068348	590018	101203	44149	57974	65065	17783	286158

DIRECT COSTS

PROFIT/OVERHEAD 1335036 $

TOTAL 1335036 $ TOTAL CONSTRUCTION COST 7403384$

INDIRECT COSTS

MISC NON CONST COSTS	370169 $	
ADMIN/LEGAL	148067 $	
201 PLANNING	259118 $	
A/E DESIGN FEE	447267 $	(6.04 %)
INSPECTION	148067 $	
CONTINGENCIES	592270 $	
TECHNICAL COSTS	148067 $	
TOTAL	2113025 $	

LAND COSTS	19992 $	(20. ACRES)
ADMINISTRATIVE COST	28414 $/YR	
LABORATORY COST	28649 $/YR	
CAPITAL COST	9536401 $	
OPER/MAINT COST	343240 $/YR	
EQUIVALENT ANNUAL COST	1202058 $/YR	
PRESENT WORTH	15495965 $	

APPENDIX B

UNIT PROCESSES INCLUDED IN CAPDET

Large Treatment

	Treatment Process
Sludge	Aerobic digestion
	Anaerobic digestion
	Centrifugation
	Drying beds
	Filter press
	Fluidized bed incineration
	Gravity thickening
	Hauling and land filling
	Multiple hearth incineration
	Pressure filtration
	Sludge flotation
	Vacuum filtration
	Wet oxidation
Liquid	Aerated lagoon
	Anion exchange
	Attached growth denitrification

	Carbon absorption
	Cation exchange
	Chlorination
	Large Facility
	Treatment Process
Liquid	Coagulation
	Complete mix activated sludge
	Contact stabilization activated sludge
	Counter current ammonia stripping
	Cross current ammonia stripping
	Denitrification (suspended growth)
	User specified process
	Equalization
	Extended aeration activated sludge
	Filtration
	Flotation
	High rate activated sludge
	Lagoon
	Microscreening
	Neutralization
	Nitrification (suspended growth)

Nitrification (rotating
biological contactor)
Nitrification (trickling filter)
Overland flow land treatment
Oxidation ditch
Plug flow activated sludge
Post aeration

Large Facility
Treatment Process

Liquid

Preliminary treatment
Intermediate pumping
Pure oxygen activated sludge
Rapid infiltration land treatment
Raw sewage pumping
Rotating biological contactor
Recarbonation
Slow filtration land treatment
Step aeration activated sludge
Trickling filtration
Two stage lime treatment

Large Facility
Treatment Process

Pseudo	Secondary and primary sludge mixing, A
	Secondary and primary sludge mixing, B
	Secondary and primary sludge mixing, C
	No process
	Small Facility Treatment Process
Sludge	Drying beds
	Sludge drying lagoons
Liquid	Activated sludge (Package Plant)
	Aerated lagoon
	Bar screens
	Chlorination
	Coagulation
	User specified process
	Equalization
	Filtration
	Flotation
	Intermittant sand filtration
	Lagoons
	Overland flow land treatment

	Oxidation ditch
	Post aeration

	Small Facility Treatment Process
Liquid	Primary clarification
	Pumping
	Rapid infiltration land treatment
	Raw sewage pumping
	Septic tanks
	Slow infiltration land treatment
	Trickling filtration
Pseudo	Secondary and primary sludge mixing, A
	Secondary and primary sludge mixing, B
	Secondary and primary sludge mixing, C
	No process

APPENDIX C

EXEC-OP EXAMPLE OUTPUT

TABLE 1

Noninferior Cost/Energy Systems for Hypothetical Design Problem*

System	Air Flotation Thickening	Anaerobic Digestion I (15 days)	Lime Stabilization	Gravity Thickening	Centri-fugation	Sand Drying Beds	Incineration	Landfilling	System Cost ($/1,000 m^3)	System Net Energy (kWh/1,000 m^3)
No energy recovery										
1a		MIX		MIX		MIX	MIX		72.9	345
2a		MIX		MIX		MIX		MIX	73.4	324
3a			MIX		MIX			MIX	81.1	288
4a					MIX			MIX	83.2	273
5a			MIX			MIX		MIX	84.3	267
Recovery of methane										
1b		MIX		MIX		MIX	MIX		71.9	235
2b		MIX		MIX		MIX		MIX	72.1	213
3b	WAS	MIX		MIX		MIX		MIX	72.9	194

*PRI = primary sludge; WAS = waste activated sluge; MIX = PRI + WAS.

NOTE. All systems utilize the same wastewater treatment train--pumping, preliminary treatment, primary sedimentation II (60% solids removal), activated sludge III (3000 mg/l MLVSS and 30% recycle), and chlorination.

TABLE 2

Least-Cost and Least-Energy Systems for Hypothetical Problem Without Sand Drying Beds*

System	Air Flotation Thickening	Anaerobic Digestion 1 (15 days)	Gravity Thickening	Centrifugation	Land Spreading 1 (16 km)	Landfilling	System Cost ($/1,000 m^3)	System Net Energy (kWh/1,000 m^3)
No Energy Recovery								
Least-cost		MIX	MIX		MIX		73.4	334
Least-energy				MIX		MIX	83.2	273
Recovery of methane:								
Least-cost		MIX	MIX		MIX		72.1	224
Least-energy	WAS	MIX	MIX	MIX		MIX	78.2	202

*PRI = primary sludge; WAS = waste activated sludge; MIX = PRI + WAS.

TABLE 3

Unit Process Cost and Energy Consumption for Least-Cost and Least-Energy Systems With No Energy Recovery

Process	($/100 m^3)	(% of Total)	(kWh/1,000 m^3)	(% of Total)
Least-Cost System:				
Pumping	8.5	11.6	37	10.8
Preliminary treatment	4.2	5.8	1	0.4
Primary sedimentation	7.1	9.8	2	0.7
Activated sludge	22.2	30.4	166	48.2
Chlorination	6.6	9.1	32	9.3
Anaerobic digestion	5.8	8.0	79	22.9
Gravity thickening	1.1	1.4	0.3	0.1
Sand drying beds	8.2	11.2	0.3	0.1
Incineration	9.2	12.7	26	7.6
Least-Energy System:				
Pumping	8.5	10.0	37	14.0
Preliminary treatment	4.2	5.0	1	0.5
Primary sedimentation	7.1	8.5	2	0.9
Activated sludge	22.2	26.3	169	63.2
Chlorination	6.6	7.8	32	12.0
Lime stabilization	2.4	2.8	16	6.1
Sand drying beds	18.8	22.3	0.5	0.2
Truck transport /landfilling	14.5	17.2	8	3.1

APPENDIX D

UNIT PROCESS INCLUDED IN EXEC-OP

Liquid	Raw wastewater pumping Preliminary treatment Primary sedimentation Aeration and final settler (activated sludge) Primary sedimentation aeration, final settler with waste activated sludge returned to the primary settler Trickling filter Rotating biological contactor Chlorination
Sludge	Gravity thickening Air flotation thickening Anaerobic digestion Nonoxidative heat treatment Elutriation Sand drying beds Vacuum filtration Centrifugation Lime stabilization Multiple hearth incineration Truck transport/land spreading Truck transport/ landfilling Sludge holding tanks

APPENDIX E

USAID/REID Example Output

Sample Computer Printout

PLEASE CHOOSE A SYSTEM FOR DATA INPUT AS FOLLOWS:

ENTER 1 IF YOU WANT DATA INPUT IN BLOCKS OF QUESTIONS, IN ENGLISH ONLY. PRESS RETURN.

ENTER 2 IF YOU WANT DATA INPUT BY SINGLE QUESTION, IN ENGLISH ONLY. PRESS RETURN.

*?2

PUNCH IN DESIGN DATA IN THE FOLLOWING FORMAT:

YEAR OF THE AVAILABLE POPULATION, POPULATION VALUE IN THAT YEAR, POPULATION GROWTH RATE EXPRESSED AS A DECIMAL (1.8), BASE YEAR OF DESIGN, PROJECTED TERMINAL YEAR OF DESIGN

?1970,10181,1.7,1980,2000

PUNCH IN LOCATION DATA IN THE FOLLOWING FORMAT:

COMMUNITY, STATE OR PROVINCE, COUNTRY, PLANNING GROUP, ?SMALLVILLE, KANSAS, USA, AVERAGE LEVEL OF EDUCATION OBTAINED BY INHABITANTS LIVING IN THE COMMUNITY

* Answer(s) that follows "?" are (is) input data.

Educ. Level	None	Primary	High School	Technical Institute	College
1	95%	4%	1%	0%	0%
2	70%	19%	7%	3%	1%
3	55%	22%	14%	6%	3%
4	9%	34%	43%	8%	7%

?3

AVERAGE DISTRIBUTION OF LABOR FORCE IN THE COMMUNITY

LEVEL	UNSKILLED	SEMISKILLED	PROFESSIONAL
1	97%	2%	1%
2	80%	16%	4%
3	61%	27%	12%
4	45%	30%	25%

?2

ANNUAL AVERAGE INCOME PER FAMILY IN APPROXIMATE U.S. DOLLAR EQUIVALENT

1 LESS THAN $100

2 $100 TO $500

3 $500 TO $1000

4 $1000 TO $3000

5 GREATER THAN $3000

?3

AMONG THE HIGH SKILLED AND TECHNICAL WORKERS (ECONOMIST/ENGINEER/CHEMIST ETC.) WHAT PERCENTAGE OF THESE IS NONLOCAL OR NON-NATIVE PEOPLE?

1 LESS THAN 10%

2 10% TO 25%

3 25% TO 50%

4 50% TO 75%

5 75% TO 100%

?3

ARE THERE ANY PRIMARY OR SECONDARY SCHOOLS OPERATED BY VOLUNTARY OR MISSIONARY ORGANIZATIONS RATHER THAN THE GOVERNMENT ITSELF?

ENTER 1 IF YES

ENTER 2 IF NO

?2

WHAT IS THE HIGHEST GRADE OFFERED BY LOCAL SCHOOLS ON A REGULAR BASIS? (ENTER THE NUMBER. FOR 12+ ENTER 13.)

1 2 3 4 5 6 7 8 9 10 11 12 12+

?13

IF THE NUMBER SELECTED ON QUESTION 6 IS LESS THAN 12 HOW FAR AWAY IS THE NEAREST HIGH SCHOOL OFFEREING THE 12TH GRADE? ENTER THE NUMBER

1 IF LESS THAN 10 MILES (16 KILOMETERS)

2 IF 10 TO 30 MILES (16 TO 48 KM)

3 IF 30 TO 50 MILES (48 TO 80 KM)

4 IF GREATER THAN 50 MILES (80 KM)

?0

ARE THERE ANY TECHNICAL OR VOCATIONAL SCHOOLS IN THE COMMUNITY?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?1

HAS THE COMMUNITY ACHIEVED COMPULSORY PRIMARY EDUCATION OF AT LEAST 6 YEARS?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?2

ARE THERE ANY FORMAL IN SERVICE TRAINING PROGRAMS BY EITHER THE GOVERNMENT OR LOCAL INDUSTRY FOR THEIR EMPLOYEES?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?1

IS THERE A COLLEGE OR UNIVERSITY IN THE LOCAL COMMUNITY?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?1

DOES THE UNIVERSITY HAVE A CHEMISTRY DEPARTMENT OR LABORATORY?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?/

IS UNEMPLOYMENT WIDESPREAD?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?1

ARE ADVISORY SERVICES WIDELY AVAILABLE TO FARMERS FOR COMMUNITY DEVELOPMENT OR FOR OTHER PROGRAMS DESIGNED TO UPGRADE THE SKILLS AND ENLIST THE PARTICIATION OF THE INHABITANTS?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?2

DO MOST COLLEGE OR UNIVERSITY STUDENTS OF THE COMMUNITY RECEIVE THEIR EDUCATION IN NEIGHBORING COMMUNITIES OR NEIGHBORING COUNTRIES OR OTHER FOREIGN COUNTRIES?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?1

THE LEVEL OF TECHNOLOGY AVAILABLE CAN GENERALLY BE CLASSIFIED AS

1 HAND TOOLS ONLY

2 MECHANICAL TOOLS

3 CHEMICAL PRODUCTS

4 ELECTRONIC TECHNOLOGY

?2

DOES THE GOVERNMENT DOMINATE THE LABOR MARKET?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?2

ARE PUBLIC EMPLOYMENT SERVICES READILY AVAILABLE?

ENTER 1 IF THE ANSWER IS YES

ENTER 2 IF THE ANSWER IS NO

?1

(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR OPERATION EQUIPMENT HOW MANY OF THE FOLLOWING ARE NOT AVAILABLE IN THE COMMUNITY?

1 Meters; water, gas, thermostats

2 Sheet metal fabrication, etc.

3 Gauges; vacuum, flow, etc.

4 Laboratory equipment; test tubes

5 Portable power plants

6 Electric motors

7 Pumps, fans, etc.

?2

(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR PROCESS MATERIALS HOW MANY OF THEM FOLLOWING ARE NOT GENERALLY AVAILABLE IN THE LOCAL COMMUNITY?

1 Pipe (clay, asbestos, cement, etc.)

2 Pipe (cast iron, steel, copper)

3 Concrete, cement

4 Valves, pipe fittings

5 Tanks

6 Structural steel

7 Heat exchangers

?3

(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR OPERATION AND MAINTENANCE SUPPLIES WHICH OF THE FOLLOWING ARE NOT GENERALLY AVAILABLE IN THE LOCAL COMMUNITY?

1 Silica sand and gravel

2 Paint

3 Water sealing compound, epoxy

4 Petroleum

5 Electricity

?1

(COUNT EACH "NOT AVAILABLE" ANSWER LINE AS 1 AND EACH "AVAILABLE" ANSWER LINE AS 0. ENTER THE SUM OF THIS COUNT.)

FOR CHEMICAL SUPPLIES HOW MANY OF THE FOLLOWING ARE NOT GENERALLY AVAILABLE IN THE LOCAL COMMUNITY?

1 Aluminum sulfate (AL2(SO4)3);
ferric chloride (FECL3);

2 Soda ash (NA2CO3);
activated charcoal;
lime (CAO)

3 Chlorine (CL2);

ozone (03);

chlorindioxide;

bromine

4 HTH;

copper sulfate (CUS04)

?2

IS GROUNDWATER AVAILABLE?

1 YES

2 NO

?1

USING DATA INDICATED BY THE RAW WATER QUALITY SECTION OF YOUR QUESTIONNAIRE ANSWER THE FOLLOWING QUESTION

ENTER THE NUMBER OF COLIFORM BACTERIA
(MPN/100 ML)

?50

ENTER THE TURBIDITY (JACKSON TURBIDITY UNITS)

?50

ENTER THE HARDNESS (MG/L)

?100

ENTER THE TOTAL DISSOLVED SOLIDS (TDS)

?1000

ENTER FE AND MN (MG/L)

?.5

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE KEYBOARD. PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE.

0 INDICATES THAT YOU DO NOT WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.

1 INDICATES THAT YOU DO WISH TO USE THE WATER TREATMENT SECTION OF THE MODEL.

?1

ENTER THE NUMBER WHICH CORRESPONDS TO YOUR PREFERRENCE IN DISPLAYING THE COST DATA

1 REPRESENTS NO COST ANALYSIS NEEDED

2 REPRESENTS RELATIVE COST RATIOS BASED ON U.S. DOLLARS IN 1978 PRICES

3 REPRESENTS LOCAL COSTS WHICH YOU MUST SUPPLY TO THE COMPUTER AS DATA. IF YOU CHOOSE 3 INSTRUCTIONS WILL BE DISPLAYED ON YOUR DATA ENTRY.

E1

?2

WHAT DISCOUNT RATE AND TIME SPAN WOULD YOU LIKE TO USE IN THE PRESENT VALUE CALCULATIONS? ENTER DATA IN THE FOLLOWING FORMAT

DISCOUNT RATE EXPRESSED AS A DECIMAL VALUE (ENTER .0725 FOR A DISCOUNT RATE OF 7.25%.)

THE NUMBER OF YEARS TO BE USED FOR THE DISCOUNTING (20 FOR EXAMPLE)

*** NOTE ***

IF YOU DO NOT WISH TO DISCOUNT THE OPERATION AND MAINTENANCE COST THEN ENTER THE NUMBER ZERO FOR THE DISCOUNT RATE. ENTER THE NUMBER OF YEARS IN A NORMAL FASHION. A TYPICAL DATA ENTRY WOULD BE

.0725,20

?.0725.20

THE LDC WATER AND SEWAGE TREATMENT PLANNING MODEL

FOR THE COMMUNITY	SMALLVILLE
IN THE STATE OR PROVINCE OF	KANSAS
IN THE COUNTRY OF	USA
FOR THE PLANNING GROUP	
BASEYEAR =	1980

**** ENTER THE NUMBER 5 WHEN YOU WISH TO CONTINUED ****

?5

*** SUITABLE WATER TREATMENT PROCESSES FOR IMPLEMENTATION IN...1980...***

FEASIBLE PROCESS COMBINATIONS	INITIAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
W2	14.66	3.14
W5	17.66	7.13

*** ENTER 5 WHEN YOU WISH TO CONTINUE ***

?5

FEASIBLE PROCESS COMBINATIONS	TOTAL COST RATIO 20 YEAR	MANPOWER REQUIRED UNSKILLED	SKILLED	PROFESSIONAL
W2	77.53	2	0	0
W5	160.23	3	1	0

THE LOWEST TOTAL COST RATIO IS W2 AT A 20 YEAR SUM OF 77.53

```
*** ENTER 5 WHEN YOU WISH TO CONTINUE ***

?5

THE PROGRAM WILL NOT PROCEED UNTIL YOU PUNCH IN A NUMBER FROM THE
KEYBOARD.  PLEASE ENTER THE NUMBER WHICH INDICATES YOUR CHOICE
0  INDICATES THAT YOU DO NOT WISH TO USE THE WASTE TREATMENT SECTION OF
THE MODEL.

1  INDICATES THAT YOU DO WISH TO USE THE WASTE TREATMENT SECTION OF THE
MODEL.

?1

DO YOU PREFER THE DILUTION RATIO TO BE BASED ON BOD OR COLIFORM?

ENTER 1 IF YOU PREFER THE BOD BASE
ENTER 2 IF YOU PRESER THE COLIFORM BASE

?1

INPUT THE DILUTION RATIO

?15
```

*** SUITABLE WASTE TREATMENT PROCESSES
FOR IMPLEMENTATION IN ...1980...***

OUTPUT FOR THE SELECTION MODEL

FEASIBLE PROCESS COMBINATIONS	INITIAL CONSTRUCTION COST RATIO	AVERAGE MAINTENANCE COST RATIO
S3	2.07	3.75
S4	18.2	16.05
S9	28.72	12.7
S10	37.14	21.92

APPENDIX F

UNIT PROCESSES FOR USAID/REID

Water Treatment Process/Code Identifiers

Code	Process
PW 1	No Treatment
PW 2	Pre-Treatment
PW 3	Slow Sand Filtration
PW 4	Rapid Sand Filter-Conventional
PW 5	Rapid Sand Filter-Advanced
PW 6	Softening
PW 7	Disinfection
PW 8	Taste-Odor - Fe, Mn
PW 9	Desalting - Salt Water
PW 10	Desalting - Brackish Water
PW 11	Containment Filters
PW 12	Disinfection Filter

Wastewater Treatment Process/Code Identifiers

Code	Process
PS1	Primary - Conventional
PS2	Primary Stabilization Pond
PS3	Sludge - Conventional
PS4	Sludge - Advanced
PS5	Sludge Combined - Imhoff
PS6	Secondary - Standard Filter
PS7	Secondary - High Rate Filter
PS8	Secondary - Activated Sludge
PS9	Secondary Extended Aeration (Oxidation Pond)
PS10	Disinfection - Chlorine
PS11	Aqua-Culture
PS12	Dilution
PS13	Individual
PS14	Individual (Advanced)

TABLE 1

WATER TREATMENT

Acceptable Combinations of Treatment Processes, According to Raw Water Quality or Degree of Dilution Available to Waste Flows

Code for Process Combinations	Process Combinations	Criteria Levels Raw Water Concentration		
		Coliform Bacteria (MPN/100 ml)	Solids	
			Turbidity (JTU)	Other (mg/l)
W1	PW1	1-2*	10	
W2	PW3	200	100	
W3	PW11	300	800	
W4	PW1 + PW7	500	10	
W5	PW2 + PW3	1,000	800	
W6	PW2 + PW12	3,000	800	
W7	PW3 + PW7	5,000	100	
W8	PW2 + PW3 + PW7	10,000	1,000	
W9	PW4 + PW7	10,000	100	
W10	PW2 + OW4 + PW7	10,000	1,000	
W11	PW5 + PW7	10,000	100	
W12	PW2 + PW5 + PW7	10,000	1,000	
W13	(any one of W1 to W12)+PW6			300 hardness
W14	(any one of W1 to W12)+PW8			1-3 Fe & Mn
W15	(any one of W1 to W12)+PW9			3,000 TDS*
W16	(any one of W1 to W12)+PW10			2,000 TDS*

*This represents standards for developed countries; different standards may be more appropriate for developing countries, e.g., for W1 an alternate goal could be 20 MPN/100ml for coliform bacteria and 30 JTU for turbidity.

TABLE 2

SEWAGE TREATMENT

Acceptable Combinations of Treatment Processes, According to Raw Water Quality or Degree of Dilution Available to Waste Flows

Code for Process Combinations	Process Combinations	Receiving Water Volume 7-Day Low Flow Level/Waste Volume	
		Based on BOD*	Based on Coliform
S1	PS5	20	160
S2	PS1 + PS3	20	160
S3	PS2	10	16
S4	PS9	3	16
S5	S2 + PS10	5	32
S6	S2 + PS6	6	32
S7	S2 + PS7	5	32
S8	S2 + PS8	4	32
S9	PS1 + PS12	0	0
S10	S4 + PS12	0	0
S11	PS2 + PS13	5	16
S12	S1 + PS11	20	2
S13	S2 + PS11	20	2
S14	S3 + PS11	10	2
S15	S4 + PS11	3	2
S16	S5 + PS11	5	2
S17	S6 + PS11	6	2
S18	S7 + PS11	5	2
S19	S8 + PS11	4	2

*These represent standards for developed countries; different standards may be more appropriate for developing countries.

APPENDIX G

UNIT PROCESSES INCLUDED IN WBANK

Ventilated improved pit latrine

Recd Odorless Earth Closet

Pour-flush toilet

Double-vault composting toilet

Aquaprivy - self-topping

- sullage

Septic tanks, single and multi-stage

Vault toilet and cartage

Bucket laterine and cartage

Sewered - Both conventional and small bore septic tank

- Pour-flush toilet

- Aquaprivy

Sewerage - waste stabilization ponds

- aerated lagoons

- oxidation ditches

- rapid sand filtration

- slow sand filtration

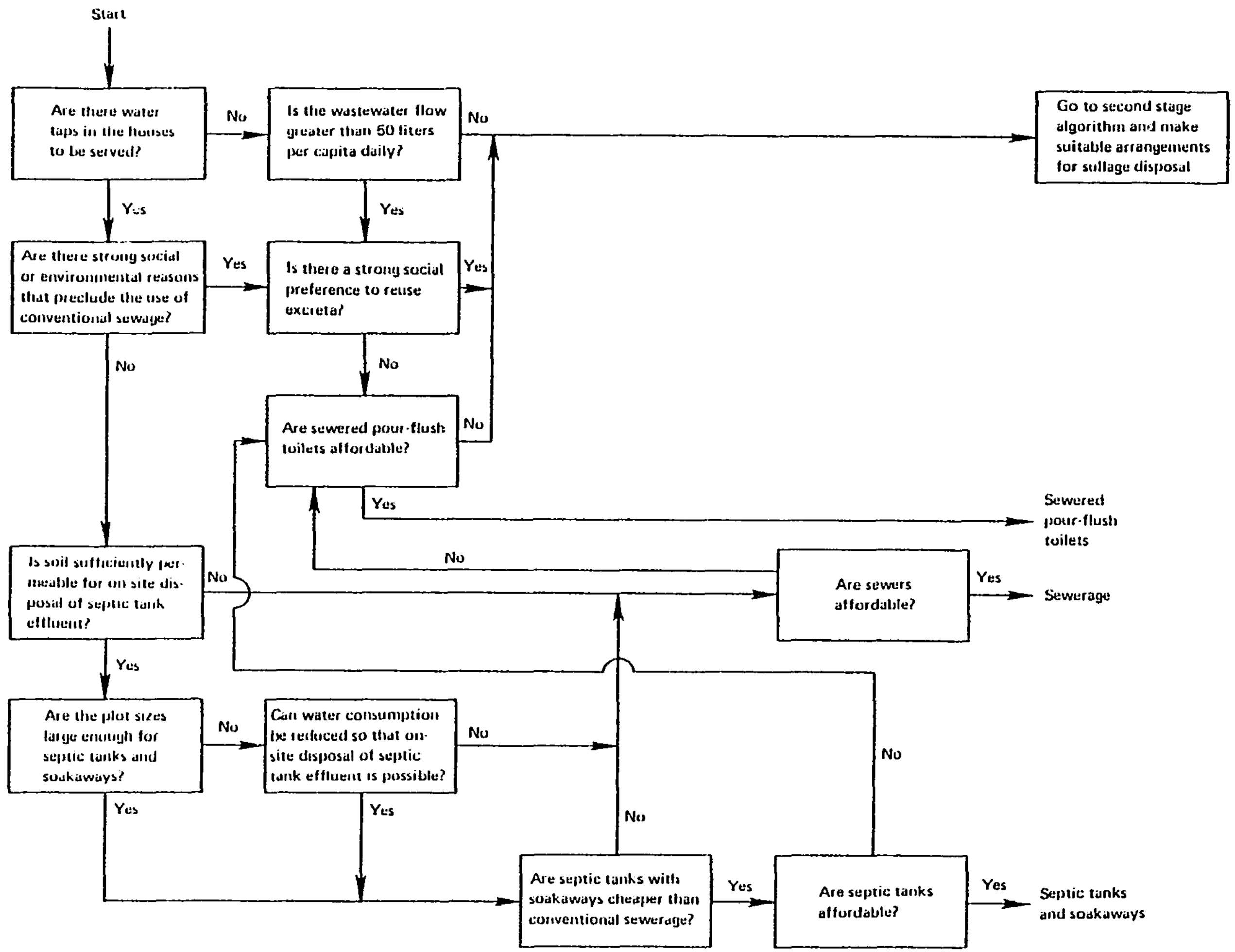
- land application

- chlorination

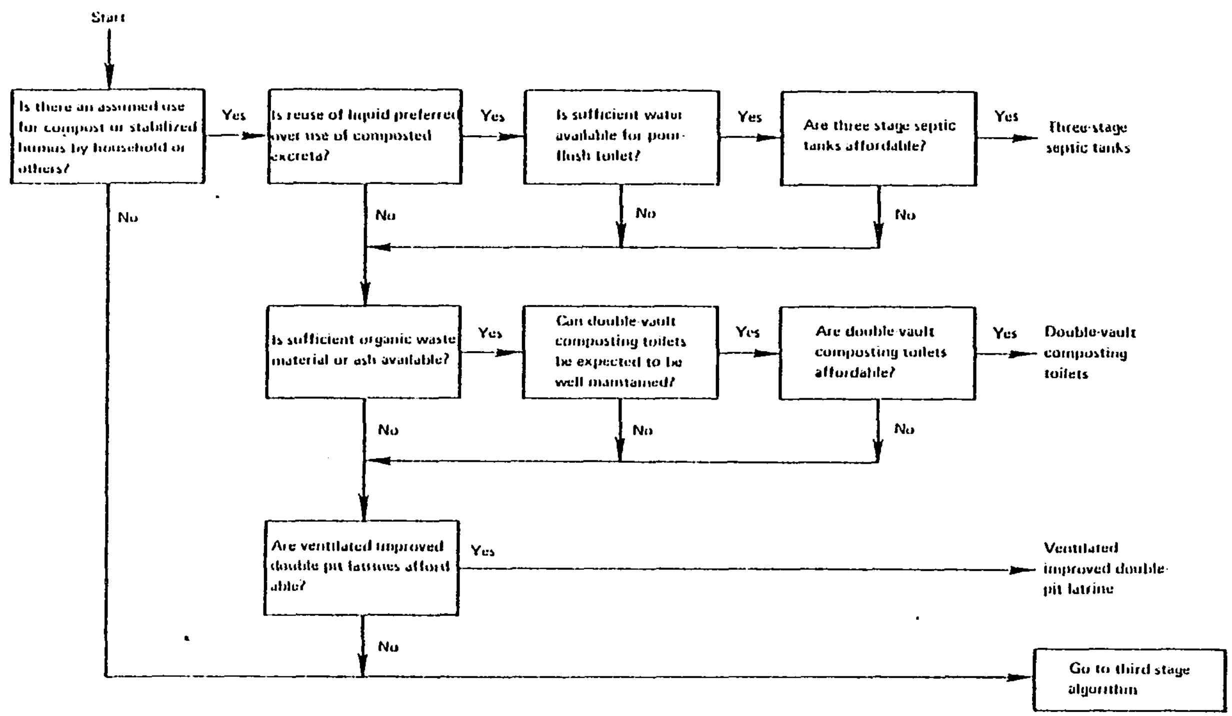
APPENDIX H

SOLUTION ALGORITHM FOR THE WBANK MODEL

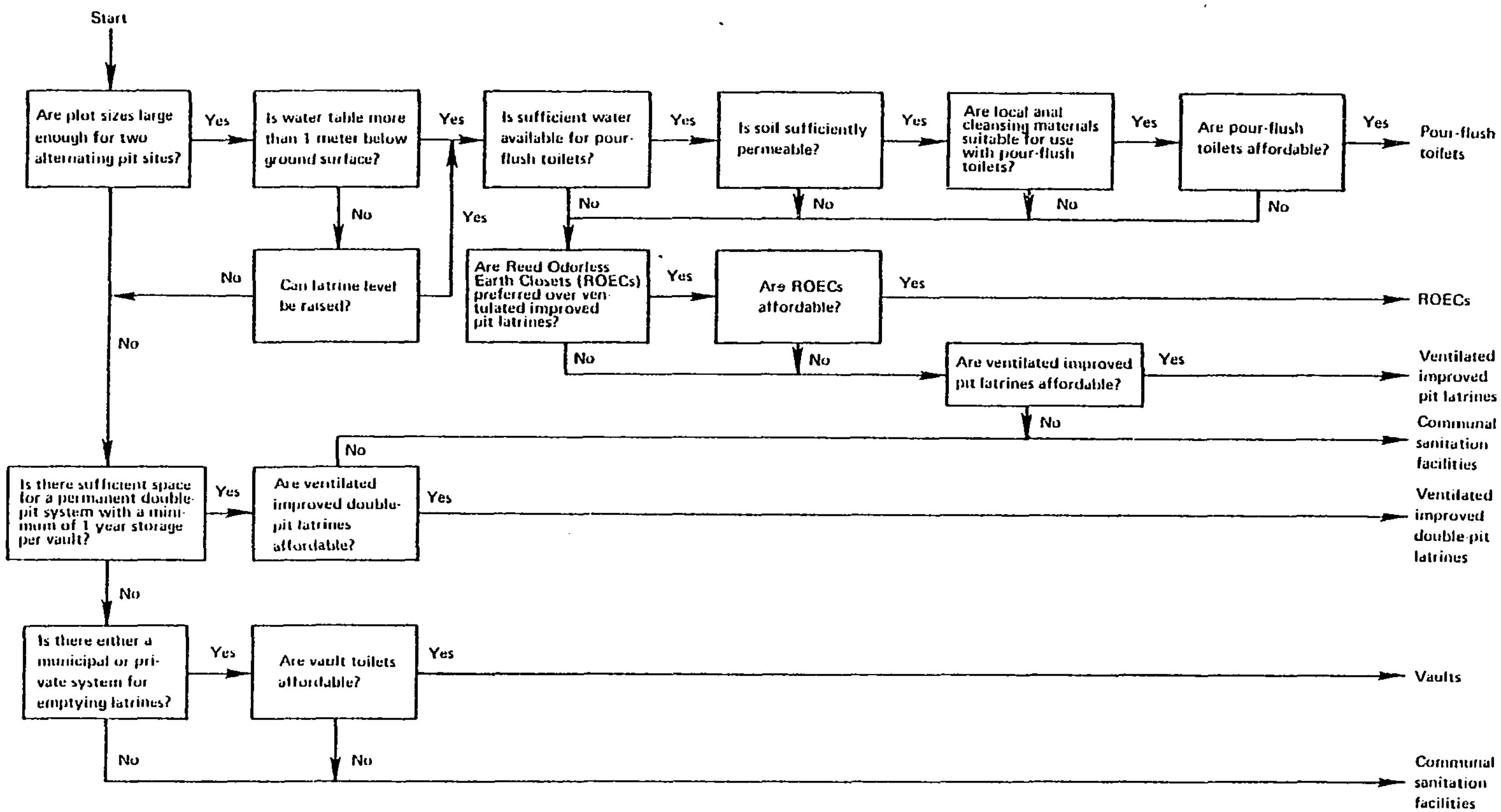
The WBANK model uses a three stage algorithm to select sanitation technology as follows:



WBANK solution algorithm, first stage.



WBANK solution algorithm, second stage.



WBANK solution algorithm, third stage.

APPENDIX I

EXEC-OP MATHEMATICAL FORMULATION

EXEC-OP uses a branch and bound application from interger programming as a solution algorithm. The mathematical formulation is:

Minimize $$v_k = \sum_{i=1}^{N} \sum_{j=1}^{J} z_{ij}\, C_{ijk}\, (X_i) \qquad (1)$$

Subject to $$k = \sum_{i=1}^{N} \sum_{j=1}^{J} z_{ij}\, C_{ijk}\, (X_i) \quad b_k \text{ for } K = 1,\ldots,K \qquad (2)$$

$$X_{i+1} = \sum_{j=1}^{J} z_{ij}\, f_{ij}(X_i) \text{ for } 1 = 1,\ldots,N \qquad (3)$$

$$S_i = \sum_{j=i}^{J} z_{ij}\, g_{ij}\, (X_i) \text{ for } i = 1,\ldots,N \qquad (4)$$

$$\sum_{j=1}^{J} z_{ij} = 1 \text{ and } z_{ij} = 0 \text{ or } 1 \text{ for } i = 1,\ldots,N;\ j = 1,\ldots,J \qquad (5) \text{ and } (6)$$

$$X_{L+1} = \sum_{i=1}^{L} S_i \tag{7}$$

$$X_1 = X_o + \sum_{i=L+1}^{N} S_i \tag{8}$$

where

K = the total number of different design criteria that must be satisfied.

b_k = target values for the kth design criteria that must not be exceeded.

C_{ijk} = The contribution that must not be exceeded choosing treatment process j at stage i, the C_{ijK} are positve and non-decreasing with respect to the x_{im}.

v_k = the value of the kth criteria.

X_o = influent waste stream.

J = total number of treatment processes.

N = total number of treatment stages.

L = 1 to Lth treatment stage belonging to liquid treatment train.

x_{im} = the volumetric flow rate of the mth pollutant component to the ith stage.

s_{im} = the volumetric flow rate of the mth pollutant component in the sidestream generated at stage i.

X_i = a vector of the m waste flows at stage i.

S_i = a vector of the m sidestream waste flows at stage i.

z_{ij} = a decision variable whose value is 1 if treatment process j is chosen at stage i and 0 otherwise.

f_{ij} = a vector valued function describing the transformation of the influent waste stream (X_i) to an effluent stream (X_{i+1}) when treatment process j is chosen.

g_{ij} = a vector valued function describing the transformation of the influent waste stream (X_i) to a sidestream (S_i) when treatment process j is chosen.

In describing the system Rossman says "Equations 1 and 2 represent the design criteria, Equations 3 and 4 express the stagewise transformation of influent waste flows and the generation of sidestreams, while Equations 5 and 6 ensure that only one process is chosen at each stage. Equation 7 expresses the influent to the sludge treatment train as the sum of the sludge sidestreams generated in the wastewater treatment train. Finally, Equation 8 closes the loop by adding the sludge treatment sidestreams to the plant influent."[1] Rossman replaces Equation 8 by augmenting Equations 1 and 2 with a penalty added to the objective function for generated sidestreams, i.e.,

Let

p_{km} = the increase in criterion k per unit increase in component m of the recycle stream.

then

$$v_k = \sum_{i=1}^{N} \sum_{j=1}^{J} z_{ij} \, c_{ijk} \, (X_i) + \sum_{i=L+1}^{N} \sum_{m=1}^{M} p_{km} \, s_{im} \quad (1')$$

and

$$v_k = \sum_{i=1}^{N} \sum_{j=1}^{J} z_{ij} \, c_{ijk} \, (X_i) + \sum_{i=L+1}^{N} \sum_{m=1}^{M} p_{km} \, s_{im} \, b_k \quad (2')$$

The branch and bound technique which provide the implicit enumeration assumes that a feasible system design, say Z_{ij} with criteria values v_k, has been determined. Then if at stage q of an alternative process r is proposed

---

[1]Rossman, "Synthesis of Waste Treatment": 151-152.

where

$$\sum_{i=1}^{q-1} \sum_{j=1}^{J} z_{ij} C_{ijk} + C_{qrk} \qquad \begin{matrix} v_1 \text{ For } K = 1 \\ \text{or} \\ b_K \text{ for any } K + r \end{matrix}$$

the process r and all stages past q can be eliminated from consideration.

APPENDIX J

DEVIATION OF THE UNIT COMPUTER COST OF USAID/REID

Purchase of Equipment		$4,000.
Operation and Maintenance	10% year 1	
	15% year 2	
	25% year 3	
	35% year 4	

Discount Rate 12%

Present Value of the Discounted Cost = $6,437.80

Time Available for Use:

8 hours per day; 5 day week, 52 weeks year = 124,800 minutes/year

Unit Cost:

$$\frac{\$6.437.80}{(4)\ (124,800)} = \$.0129 \text{ per minute}$$

Let USAID/REID take 2 hour computer time for analysis:

$$(120)\ (\$.0129) = \$1.55$$

APPENDIX K

WATER SUPPLY AND SANITATION TECHNOLOGY INCLUDED IN MAPMAT

Sanitation Technology	Description
VIPL	Ventilated Improved Pit Latrine. The VIPL include a slightly offset pit, a squatting plate or seat, an external vent pipe connected to pit, and a superstructure that covers the pit. When the pit fills to a predetermined level the structure is moved to a new pit and the old pit is filled with soil.
VIDPL	Ventilated Improved Double Pit Latrine. Same as a VIPL except that two pits are alternately used. When the first pit is full the squatting plate/seat is moved to

the second pit and the first pit is filled with dirt. When the second pit is full the first pit is emptied and used again. In a VIDPL the size of the superstructure, the amount of digging, and the number of seats reflect the doubling effect over the VIPL.

ROEC — Reed Odorless Earth Closet. A large pit is dug offset to the superstructure. Excreta enters the pit through a chute loading from the squat plate/seat. The pit is covered by a removable lid for desludging and a vent pipe is included for ventilation.

ST — Septic Tank. One or two chambers are placed just before ground level with a removal lid to allow periodic desludging. Excreta and flush water enter from the toilet and solids settle to the chamber bottom. Effluent is disposed in drainfields and/or soakaways.

DVCT — Double Vault Composting Toilet. Very similar to VIDPL except that vaults are sealed units. Superstructure may be movable so that as first vault reaches about 3/4 full it is topped with soil and allowed to compost. Ash and organic matter are added to encourage composting plus absorb odors and moisture.

PFT — Pour Flush Toilet. PFT uses a water seal below a squat plate or seat. The chamber may be directly under or offset from the superstructure. The chamber generally has walls and removable cover of concrete or ferrocement, while the bottom provides soakaway. Water or liquid sullage is poured into the squat plate/seat to provide the flushing action. Periodic desludging is necessary.

PFT.SEW.SB — Pour Flush Toilet, Sewered, Small Bore. Identical to a PFT except that the chamber is enclosed and has effluent disposal in a small bore (75-200 millimeter diameter) sewer. The system can alternately dispose of effluent in a septic tank or soakaway trenches. Periodic desludging is required.

PFT.ST — Pour Flush Toilet, Septic Tank. Identical to a PFT except an enclosed chamber is used as a septic tank. The chamber must be desludged periodically. Drainfields dispose of the liquid effluent. Readily adaptable to a sewered system.

AP — Aquaprivy. Squat plate/seat directly above an enclosed chamber. The squat plate/seat incorporates a straight drop pipe which provides a water seal. Water is added to maintain the water seal. Generally, a superstructure incorporates a vent pipe in addition to coverage. The chamber has a removable desludging access port and a soakaway pit may be incorporated.

AP.SULLAGE — Aquaprivy, Sullage. Identical to the AP except that household sullage is used to maintain the water seal. A sink is generally added to the outside of the toilet for convenient sullage disposal.

AP.SEW.SB — Aquaprivy, Sewered, Small Bore. Identical to the AP except that the chamber is connected to a small bore sewer.

V&C — Vault and Cartage. An enclosed chamber is placed below or offset from a squat plate/seat. The chamber is emptied regularly by a pump truck which discharges the contents using land-treatment, marine discharge, or conventional treatment such as waste stabilization ponds.

COMM — Communal Facilities. Includes any of the above technologies which are appropriate to provide a large public service. These large facilities may include shower, laundry, and fresh water for communal use. Generally, one toilet per 25 people is required to satisfy local sanitation demand, while one shower and a washtub per 50 people will be required to adequately provide these services.

COMM.SEW — Communal Facilities, Sewered. Identical to the COMM facility except the selected technology is connected to a sewer.

AC — Aquaculture. A pond or lagoon where excreta is deposited to be utilized as a food source for fish and/or plants.

LAG.WSP — Lagoons, Waste Stabilization Ponds. A single or series of ponds used to remove organic matter by microbial action include both algae and bacteria. These large shallow basins can provide both anaeorbic and aerobic condition for degradation.

TC — Thermophilic Composting. Organic matter is mixed with excreta for composting. The moisture content of the compost mixture must be below 60 percent. Aerobic conditions are maintained in the pile by daily or weekly turning of the pile depending on the size of the compost heap. Mechanical dewatering may be necessary for reaching a moisture content below 60 percent. Finished compost must be removed.

HRTC — High Rate Thermophilic Composting. Identical to the TC process except that perforated pipe connected to air blower is buried in the pile. Air is drawn through the pile to maintain highly aerobic conditions in the compost pile.

PC — Primary, Conventional. Settling tank or sedimentation basins which are used to remove suspended soilds and BOD in a quiescent state. Fluid movements cause flocculation during dentention in the unit.

SDBED — Sludge Drying Beds. Beds are open beds of layered sand and gravel over which a foot or more of sludge is spread to dry. The dried sludge cake may be placed in landfills or used as fertilizer.

SDLAG — Sludge Drying Lagoons. Shallow open lagoons are filled with sludge to allow aerobic and anaerobic decomposition. The dried sludge cake may undergo disposal much like SDBED processes.

ALAG.EXT — Aerated Lagoon, Extended. Very similar to LAG, WSP, except that certain units are floated on the surface of the basin to increase the aerobic conditions.

CHLOR — Chlorination. Chlorine is added to the effluent for a sufficient period of time to destroy pathogenic bacteria such as fecal coliforms.

LT — Land Treatment. Effluent is deposited on grassland, (or cultivated land) by irrigation, overland flow, or infiltration. The land acts as a biological filter prior to the effluent reaching groundwater. If crops are involved then the plants and associated ecosystems help to detoxify the effluent in concert with the LT.

RBC — Rotating Biological Contactor. A series of mechanically rotating discs are partially submerged in the wastewater to provide biological decomposition. As the disc rotates, the liquid is aerated and conditions are created on the surface of the disc to encourage biological degradation.

AS — Activated Sludge. Excreta are subjected to conditions which encourage the growth of microorganisms which decompose the organic material. The conditions, or unit design criteria may include aerobic, anoerobic, or a mix of the two in the unit reactor. In general, the containers may be open rectangular chambers which have sufficient flow and aeration to provide proper microbial activity.

IMHOFF — Imhoff. Tank incorporates the actived sludge biological process in a two-story tank with sedimentation occurring in the top compartment and digestion in the bottom. Gas from the sludge digestion can be collected for use or disposed.

TF.STD — Trickling Filter, Standard. A large bed of gravel is contained in an open unit where a slow turning rotor sprays effluent over the gravel. Microorganism attach to the gravel and decompose the organic material as the liquid passes over the stones. The filter may be very large, i.e., 200 feet in diameter and 20 feet deep. Underdrains are provided to support the filter media and collect the effluent.

TF.HR Trickling Filter, High Rate. Identical to the TF except that effluent from the TF is recycled for additional passes through the filter media. Substantial pumping may be required if high recirculation is desired.

Water Treatment Technology	Description
NT	<u>No Treatment</u>. Existing ground water or catchment water is provided with no treatment. Some minor structural works and maintenance are required.
PT	<u>Pretreatment</u>. Suspended matter and algae are removed using sand filters, thermocline control, and chemicals.
SSF	<u>Slow Sand Filter</u>. A large sand bed above a gravel base is used to remove suspended and organic matter. Water flows through the sand bed where microorganisms decompose impurities. With use, the filter will clog and a layer of top sand will be removed to return flow. Sand is periodically replaced.
RSF	<u>Rapid Sand Filter</u>. Water passes through sand bed under pressure. Several media such as gravel and anthracite may be layered to improve filtering. As the flow lessens the filter is backwashed to remove the microbes and trapped material.
CHLOR	Identical to sanitation technology CHLOR except lower dosage required in general.

T&O — Taste and Odor. Aeration, zeolite, chlorine, and/or absorbents are used to remove taste and odors present in the water.

DFILT — Disinflection Filter. A small water purification device using a porous filter containing a bactericide to destroy pathogenic organisms.

CFILT — Containment Filter. Removal of suspended material using locally available filter media such as coconut fiber, charred rice husks, charred pine needles, etc.

DSALT1 — Desalting, Saltwater. Reduction of salt concentration from 35,000 Mg/l to less than 1,000 Mg/l using pressure, evaporation, or freezing.

DSALT2 — Desalting, Brackish Water. Reduce the salt content in the range of 1,000 to 35,000 Mg/l below 1,000 Mg/l using electrodialysis, reverse osmosis, and chemicals.

Sources:

Metcalf and Eddy, Inc., Wastewater Engineering: 408-10, 446, 455, 533-535, 617, 628.

Reid, Arnold, and Streebin, Appropriate Technology: 141, 231.

Feachem, McGarry, and Mara, Water, Waste and Health: 276-277.

APPENDIX L

SAMPLE OUTPUT FROM
MAPMAT·HELLO AND
MAPMAT·MAIN

```
                 WELCOME

                   TO


                 MAPMAT


                  MODEL

                   AND

                 PROGRAM

                   BY

             CLYDE ARNOLD
MAPMAT REPRESENTS A PLANNING MODEL
ENTITLED MICROCOMPUTER ASSISTED
PLANNING MODEL FOR THE SELECTION OF
APPROPRIATE TECHNOLOGY IN WATER
TREATMENT AND SANITATION.


AS YOU USE MAPMAT YOU WILL RESPOND TO
QUESTIONS UNTIL MAPMAT HAS SUFFICIENT
INFORMATION TO PERFORM THE INDICATED
ANALYSIS.  YOU WILL BE PROVIDED WITH
SUFFICIENT INFORMATION TO USE MAPMAT IN
AN INTERACTIVE MODE; HOWEVER, YOUR
ANALYSIS MAY BE IMPROVED BY CONSULTING
THE MAPMAT INSTRUCTION MANUAL.

A QUESTION MARK FOLLOWED BY A BLINKING
SQUARE; I.E., THE CURSOR, INDICATES
THAT MAPMAT IS WAITING YOUR RESPONSE
TO A QUESTION.

PRESS RETURN WHEN YOU ARE READY TO
PROCEED TO THE NEXT STEP.
?

THERE ARE EIGHT SECTIONS TO THE MAPMAT
MODEL:

    MAIN------->THE PROGRAM WHICH YOU
                ARE CURRENTLY USING.
AVAIL.PROCESS->DETERMINES AVAILABLE
                WATER AND/OR SANITATION
                TECHNOLOGY BASED ON DATA
                WHICH YOU ENTER.
```

```
COST RATIO----)RELATIVE RANK OF COST
COMMUNICATE---)TELECOMMUNICATION LINK
               TO CAPDET MODEL.
SENSITIVITY---)SENSITIVITY ANALYSIS ON
               MAPMAT OUTPUT
OPTIMIZATION--)SELECT TREATMENT TRAINS
               AND SET TREATMENT GOALS.
EFFECTIVENESS-)PERFORM MULTI-OBJECTIVE
               ON COST DATA.
STATISTICS----)MULTIPLE REGRESSION
               ANALYSIS ON DATA WHICH
               YOU ENTER

PRESS RETURN TO PROCEED!!!
?
 1 . ./----)MAIN

 2..../----)AVAIL.PROCESS

 3..../----)COST RATIO

 4. ../----)COMMUNICATE

 5..../----)SENSITIVITY

 6..../----)OPTIMIZE

 7..../----)EFFECTIVENESS

 8..../----)STATISTICS

ENTER THE NUMBER OF THE PROGRAM WHICH
YOU WANT TO USE   IF YOU NEED TO
REREAD THE PREVIOUS DESCRIPTIONS TYPE
HELP AND PRESS RETURN  IF YOU ARE DONE
USING MAPMAT TYPE END AND PRESS RETURN.
?3
```

APPENDIX M

SAMPLE OUTPUT FROM
MAPMAT•AVAIL

```
DO YOU WANT THE PRINTER ON?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
WELCOME TO THE SECTION OF MAPMAT WHICH
DETERMINES WHICH TREATMENT TECHNOLOGIES
ARE APPROPRIATE AT A LOCAL SITE.  IF
YOU ARE IN THE WRONG SECTION OF MAPMAT
THEN TYPE IN WRONG AND PRESS RETURN.
YOU WILL BE RETURNED TO MAPMAT'S MAIN
MENU.  IF THIS IS THE RIGHT SECTION OF
MAPMAT, THEN TYPE IN RIGHT AND PRESS
RETURN.
?RIGHT
THE PROGRAM MUST SET DEFAULT VALUES FOR
SEVERAL VARIABLES.  MAPMAT WILL BE BACK
IN A MOMENT.


            PLEASE WAIT!!!
IN THE FOLLOWING ANALYSIS YOU WILL BE
ANSWERING 38 QUESTIONS CONCERNING THE
DESIGN SITE.  THE ANSWERS TO THESE
QUESTIONS MAY RESULT IN SOME OF THE
TECHNOLOGIES BEING CONSIDERED
INAPPROPRIATE TO LOCAL CONDITIONS BY
MAPMAT.  YOU WILL HAVE A CHANCE TO
REVISE THE TECHNOLOGY SELECTION DURING
THE SENSITIVITY SECTION OF MAPMAT.

PRESS RETURN TO PROCEED!!!
QUESTION 1:

WHAT IS THE POPULATION DENSITY
AT THE LOCAL SITE IN PEOPLE PER
HECTARE?  THERE ARE THREE POSSIBLE
ANSWERS:

 1------ POP. DENSITY <= 300
 2------ POP. DENSITY <= 600
 3------ POP. DENSITY >  600

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 2:

WHAT LEVEL OF WATER CAN BE EXPECTED AT
THE LOCAL SITE IN LITERS PER CAPITA PER
```

```
DAY (LPCD).  THERE ARE SIX POSSIBLE
ANSWERS:

   1------- LPCD ( 4.5
   2------- LPCD )=4.5 AND ( 6
   3------- LPCD )=6   AND ( 35
   4------- LPCD )=35  AND ( 75
   5------- LPCD )=75  AND ( 250
   6------- LPCD )=250

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?6

DO YOU EXPECT LOCAL WATER DISPOSAL IN
THE SANITATION TECHNOLOGY TO BE GREATER
THAN 10 LPCD?  ENTER Y FOR YES OR N FOR
NO
?Y
QUESTION 3
CAN THE LOCATION SITE OF THE SELECTED
TECHNOLOGY BE EXPECTED TO PROVIDE SAFE
DISPOSAL OF SLUDGE THAT MIGHT BE
GENERATED?  THERE ARE TWO POSSIBLE
ANSWERS:

   1------- YES
   2------- NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 4.

DOES THE LOCAL SITE PROVIDE A SEWAGE
CONNECTION?  THERE ARE TWO POSSIBLE
ANSWERS:

   1------- YES
   2------- NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
QUESTION 5.

DOES THE LOCAL SITE PROVIDE ADEQUATE,
AND SAFE, SULLAGE DISPOSAL AT THE
PRESENT TIME?  THERE ARE TWO POSSIBLE
ANSWERS.

   1------- YES
   2------- NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
```

QUESTION 6:

CERTAIN SANITATION TECHNOLOGIES USE THE
GROUND AS A SOAKAWAY FOR LIQUID
EFFLUENT. IN GENERAL THE HEIGHT OF THE
GROUNDWATER MAY PRESENT PROBLEMS IF THE
SOAKAWAY WILL LEACH INTO THE LOCAL
GROUNDWATER. SOIL CONDITIONS WILL
DETERMINE THE CRITICAL HEIGHT OF THE
GROUNDWATER. FOR LOCAL CONDITIONS DO
YOU EXPECT GROUNDWATER CONTAMINATION
TO BE A PROBLEM? THERE ARE TWO POSSIBLE
ANSWERS:

```
  1------- YES
  2------- NO
```

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
QUESTION 7:

WHAT TYPE OF WATER CONNECTION EXISTS,
OR WILL EXIST, AT THE LOCAL SITE?
THERE ARE FOUR POSSIBLE ANSWERS:

```
  1------- NONE
  2------- STANDPIPE IN NEIGHBORHOOD
  3------- YARD CONNECTION
  4------- HOUSE CONNECTION
```

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?4
QUESTION 8:

CERTAIN SANITATION TECHNOLOGIES WILL
NOT TOLERATE ANAL CLEANSING MATERIALS
WHICH WILL NOT EASILY DECOMPOSE OR
WHICH MIGHT CLOG THE DISCHARGE PIPE.
IN GENERAL SUCH MATERIAL AS CEMENT (OR
OTHER HEAVY) BACKING, CORNCOBS,
ROCKS/STICKS, ETC., WILL IMPEDE THE PROPER
OPERATION OF SEVERAL TECHNOLOGIES. AT
THE LOCAL DESIGN SITE WOULD YOU EXPECT
THE ABOVE MATERIALS TO BE USED AS ANAL
CLEANSERS? THERE ARE TWO POSSIBLE
ANSWERS.

```
  1------- YES
  2------- NO
```

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1

DO YOU EXPECT WATER TO BE USED AS AN

ANAL CLEANSER? THERE ARE
TWO POSSIBLE ANSWERS.

1------- YES
2------- NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 9.

SOME SOCIETIES WILL NOT FEEL AT EASE
WITH A SANITATION TECHNOLOGY WHICH
PERMITS THE PRESENCE OF VISIBLE
EXCRETA. WOULD YOU SAY THAT THE LOCAL
POPULATION WOULD NOT BE LIKELY TO USE
A TECHNOLOGY WHICH, AS A MATTER OF
OPERATION, EXPOSED EXCRETA TO VIEW?
THERE ARE TWO POSSIBLE ANSWERS.

1------- YES
2------- NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
QUESTION 10:

SEVERAL TECHNOLOGIES MAY PROVIDE A GOOD
BREEDING SPOT FOR MOSQUITOES AND/OR
FLIES UNLESS AN INHIBITOR IS UTILIZED
BY THE USER AND/OR THE MAINTENANCE
PEOPLE. THE INHIBITOR COULD BE EITHER
CHEMICAL OR A MECHANICAL DEVICE OF
SIMPLE DESIGN SUCH AS A COVER. WOULD
YOU EXPECT THE LOCAL USERS, OR
MAINTENANCE PEOPLE, TO RESIST THE USE
OF AN INHIBITOR? THERE ARE TWO POSSIBLE
ANSWERS.

1------- YES
2------- NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
QUESTION 11.

HUMUS PRODUCED IN COMPOSTING ACTIVITY
MAY BE USED AS AN ORGANIC FERTILIZER IF
THERE IS NOT RESISTENCE TO THE USE OF
THE HUMUS OR THE HANDLING OF THE HUMUS.
WOULD YOU EXPECT THE LOCAL POPULATION
TO RESIST THE USE OR HANDLING OF HUMUS?
THERE ARE TWO POSSIBLE ANSWERS:

1------- YES

2------ NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?2
QUESTION 12:

CERTAIN TECHNOLOGIES REQUIRE USER
TRAINING AT ONE OF THE FOLLOWING
LEVELS:

VERY LOW->BASIC USE TRAINING REQUIRED
LOW->VERY LOW + DISRUPT PREVENTATION
MEDIUM->LOW + USE/DISEASE TRANSMITTAL
HIGH->MEDIUM + MAINTENANCE/OPERATION

WHICH OF THE FOUR LEVELS BEST DESCRIBE
LOCAL TRAINING AVAILABILITY?

1------ VERY LOW
2------ LOW
3------ MEDIUM
4------ HIGH

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?2
QUESTION 13.

CRITICAL TO THE SUCCESSFUL OPERATION OF
MANY TECHNOLOGIES IS THE LEVEL OF LOCAL
INFRASTRUCTURE; I.E.,LOCAL NETWORK OF
SUPPORT FOR DEVELOPMENT.   WHICH
OF THE FOLLOWING THREE LEVELS BEST
DESCRIBES THE LOCAL SITE?

1--- LOW->USER CAN MAINTAIN
2--- MEDIUM->PART-TIME GROUP/PERSON
REQUIRED TO MAINTAIN
3--- HIGH->FULL TIME GROUP/PERSON
REQUIRED TO MAINTAIN

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
QUESTION 14 THROUGH 17:

LABOR IS REQUIRED FOR THE CONSTRUCTION
AS WELL AS THE OPERATION AND
MAINTENANCE OF THE TECHNOLOGIES. THERE
ARE FOUR TYPES OF LABOR INCLUDE IN THIS
ANALYSIS.

UNSKILLED------> COMMON LABORER
SEMISKILLED---> PLUMBERS HELPER
SKILLED-------> EXPERIENCED PLUMBER
PROFESSIONAL--> ENGINEER

```
QUESTION 14.

WHAT IS THE AVAILABILITY OF UNSKILLED
CONSTRUCTION LABOR AT THE LOCAL SITE?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 15.

WHAT IS THE AVAILABILITY OF SEMISKILLED
CONSTRUCTION LABOR AT THE LOCAL SITE?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 16:

WHAT IS THE AVAILABILITY OF SKILLED
CONSTRUCTION LABOR AT THE LOCAL SITE?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 17:

WHAT IS THE AVAILABILITY OF
CONSTRUCTION PROFESSIONALS AT THE SITE?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?1
QUESTION 18 THROUGH 21

LABOR IS REQUIRED FOR THE CONSTRUCTION
AS WELL AS THE OPERATION AND
MAINTENANCE OF THE TECHNOLOGIES.  THERE
ARE FOUR TYPES OF LABOR INCLUDE IN THIS
ANALYSIS.

   UNSKILLED------) COMMON LABORER
   SEMISKILLED---) PLUMBERS HELPER
   SKILLED--------) EXPERIENCED PLUMBER
  PROFESSIONAL--) ENGINEER
QUESTION 18:
```

```
WHAT IS THE AVAILABILITY OF UNSKILLED
OPERATION & MAINTENANCE LABOR LOCALLY?

   0------ UNAVAILABLE
   1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 19:

WHAT IS THE AVAILABILITY OF SEMISKILLED
OPERATION & MAINTENANCE LABOR LOCALLY?

   0------ UNAVAILABLE
   1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 20:

WHAT IS THE AVAILABILITY OF SKILLED
OPERATION & MAINTENANCE LABOR LOCALLY?

   0------ UNAVAILABLE
   1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?1
QUESTION 21:

WHAT IS THE AVAILABILITY OF O&M
PROFESSIONAL LABOR AT THE LOCAL SITE?

   0------ UNAVAILABLE
   1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 22 THROUGH 24

THREE TYPES OF EQUIPMENT MAY BE
REQUIRED FOR OPERATION AND MAINTENANCE
ACTIVITY.

 ELECTRICAL EQUIPMENT, E.G., A MOTOR,
 LABORATORY EQUIPMENT, E.G., A BALENCE,
 ELECTRONIC EQUIPMENT, E.G., A COMPUTER.
QUESTION 22.

DO YOU EXPECT ELECTRICAL EQUIPMENT TO
BE AVAILABLE WITHIN 24 HOURS IN THE
DESIGN AREA?
```

```
  0------ UNAVAILABLE
  1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
? 1
QUESTION 23

DO YOU EXPECT LABORATORY EQUIPMENT TO
BE AVAILABLE WITHIN 24 HOURS IN THE
DESIGN AREA?

  0------ UNAVAILABLE
  1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
? 1
QUESTION 24.

DO YOU EXPECT ELECTRONIC EQUIPMENT TO
BE AVAILABLE WITHIN 24 HOURS IN THE
DESIGN AREA?

  0------ UNAVAILABLE
  1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
? 0
QUESTION 25 THROUGH 28:

FOUR TYPES OF SUPPLIES MAY BE
REQUIRED FOR OPERATION AND MAINTENANCE
ACTIVITY:

 CHEMICAL SUPPLIES, E.G., CHLORINE,
 PROCESS SUPPLIES, E.G., PIPE,
 OPERATION AND MAINTENANCE SUPPLIES;
 E.G., PAINT
 LABORATORY SUPPLIES, E.G., TEST TUBES

QUESTION 25:

DO YOU EXPECT CHEMICAL SUPPLIES TO
BE AVAILABLE WITHIN 24 HOURS IN THE
DESIGN AREA?

  0------ UNAVAILABLE
  1------ AVAILABEL

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
? 1
QUESTION 26:
```

```
DO YOU EXPECT PROCESS SUPPLIES TO
BE AVAILABLE WITHIN 24 HOURS IN THE
DESIGN AREA?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 27:

DO YOU EXPECT OPERATION AND MAINTENANCE
SUPPLIES TO BE AVAILABLE WITHIN 24
HOURS IN THE DESIGN AREA?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 28.

DO YOU EXPECT LABORATORY SUPPLIES TO
BE AVAILABLE WITHIN 24 HOURS IN THE
DESIGN AREA?

   0------- UNAVAILABLE
   1------- AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 29 AND 30.
TWO TYPES OF ENERGY MAY BE REQUIRED
FOR OPERATION AND MAINTENANCE ACTIVITY:
ELECTRICAL ENERGY AND OTHER ENERGY
SOURCES SUCH AS DIESEL, GASOLINE, ETC.
THERE ARE FOUR LEVELS OF SUPPLY
AVAILIBILITY: NONE, LOW, MEDIUM, HIGH.
QUESTION 29.

FOR ELECTRICAL ENERGY THE LEVELS ARE
MEASURED IN PUMPING CAPACITY OF GALLONS
PER MINUTE (GPM) OR PER DAY (GPD):

 0---NONE ...RANGE: NONE OR LIGHTS ONLY
 1---LOW  ...RANGE: 700<= GPM
 2---MEDIUM .RANGE. 700<  GPM < 10,000
 3---HIGH....RANGE. GPM > 10,000 OR
                    GPD >= 15 MILLION

WHICH LEVEL INDICATES THE LOCAL SITE?
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
```

QUESTION 30:

FOR OTHER ENERGY THE LEVELS ARE
MEASURED AS FREQUENCY OF USE FOR
VECHICLES OR FUEL POWERED MOTORS:

0---NONE.....NO OR VERY LITTLE USE
1---LOW......WEEKLY OR INFREQUENT USE
2---MEDIUM...DAILY USE OR PART-TIME
3---HIGH.....FULL-TIME USE

HOW WOULD YOU RATE THE AVAILABILITY OF
FUEL FOR USE AT THE LOCAL SITE?
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
? 2
QUESTION 31:

LAND IS A NECESSARY PART OF ANY WATER
SUPPLY OR SANITATION TECHNOLOGY. THREE
LEVELS OF LAND AVAILABILITY ARE USED IN
THIS ANALYSIS:

1--LOW-----   AVAILABLE ACRES <= .1
2--MEDIUM-- .1 < AVAILABLE ACRES < .5
3--HIGH----   AVAILABLE ACRES >= .5

ON A PER CAPITA BASIS WHAT IS THE LAND
AVAILABILITY AT THE DESIGN SITE?

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
? 3
QUESTION 32:

ORGANIC COMPOSTING MATERIALS SUCH AS
STRAW, LEAVES, ETC., ARE REQUIRED FOR
CERTAIN SANITATION TECHNOLOGIES. DO
YOU EXPECT ADEQUATE AMOUNTS OF THESE
TYPE MATERIALS TO BE AVAILABLE AT THE
DESIGN SITE?

0------ UNAVAILABLE
1------ AVAILABLE

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
? 1
QUESTIONS 33 THROUGH 35:

CERTAIN TECHNOLOGIES MAY BE HAZARDOUS
TO LOCAL HEALTH IF PARTICULAR
CONDITIONS ARE MET. IN GENERAL THE
CONDITIONS RELATE THE SPREAD OF A
DISEASE TO FAVORABLE CONDITIONS
PRODUCED BY A TECHNOLOGY. THERE ARE

```
THREE MAJOR AREAS WHICH RELATE TO
HEALTH CONSTRAINTS ON TECHNOLOGY: HEAVY
METALS , INSECTS, AND HELMINTHS.

PRESS RETURN TO PROCEED!!!
QUESTION 33.

DOES THE LOCAL POPULATION CONSUME
PARTIALLY COOKED MEAT AND ARE HELMINTH
RELATED DISEASES WHICH ARE TRANSMITTED
BY FOOD CONSUMPTION, E.G ,
CLONORCHIOSIS AND DIPHYLOBOTHRIASIS
PREVALENT IN THE LOCAL AREA?

    1- ---- YES
    2------ NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E , 1. 2. ETC.
?2
QUESTION 34:

DO THE WATER TRANSMITTED HELMINTH
DISEASES SUCH AS SCHISTOSOMAISIS EXISTS
IN THE LOCAL AREA?

    1------ YES
    2------ NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
QUESTION 35:

DO THE SOIL TRANSMITTED DISEASES SUCH
AS ASCARAISIS EXIST IN THE LOCAL AREA?

    1------ YES
    2------ NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I E , 1. 2, ETC.
?2
QUESTION 36:

SEVERAL TECHNOLOGIES  MAY PROVIDE A
FAVORABLE HABITAT FOR THE BREEDING OF
INSECTS WHICH ARE VECTORS FOR MANY
DISEASES SUCH AS YELLOW FEVER, MALARIA,
ETC.  THESE DISEASES MAY BE TRANSMITTED
BY INSECT BITES OR BY THE INSECT HAVING
CONTACT WITH A HUMAN'S FOOD OR BODY.
IF LOCAL CONDITIONS PROVIDE A FAVORABLE
HABITAT FOR INSECTS THEN CERTAIN
TECHNOLOGIES MAY ENHANCE THE INSECT
POPULATION   DO YOU EXPECT INSECTS TO
BE A PROBLEM IN THE LOCAL AREA?
```

```
    1------ YES
    2------ NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
QUESTION 37:

THE SANITATION TECHNOLOGIES WHICH USE
COMPOSTING OR LAND TREATMENT
MAY CONTRIBUTE TO DISEASE IF THE
RESIDUAL IS USED IN AGRICULTURAL
ACTIVITIES.  THE DISEASES WOULD ARISE
FROM HEAVY METALS BEING TRANSMITTED TO
HUMAN FOOD OR HUMAN CONTACT.  WOULD YOU
EXPECT HEAVY METALS TO PRESENT A
PROBLEM IN THE LOCAL AREA?

    1------ YES
    2------ NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
MAPHAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

                  SANITATION
            ---------------------------
            ST
            PFT SF
            AP SULLAGE

PRESS RETURN TO PROCEED!!!
                WATER
            -----------
                SSI
                DFILT
                CFICT

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                      11111111112
           12345678901234567890
------------ --------------------
OVIPL                 X
SVIDPL                X
```

```
0HOCC                          X
1ST
0DVCF                     X    XX
0PFT                           X
0PFF SEW BD          X
1PFT.ST

               22222222233333333
               12345678901234567
-- ------- ------- --------------
0VIPL
0VIOPL
0HOCC
1BF
0DVCT
0PFF
0PIT SEW BB
1PFF SF
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
0AP                           X
1AP.SULLAGE
0AP SEW BD           X
0VSC               X          X
0COMM                        XX
0COMM BEW          X X        X
0AC                           X
0LAG VSP           X

               22222222233333333
               12345678901234567
---------- ----------------------
0AP
1AP SULLAGE
0AP SEW SD
0VSC
0COMM
0COMM BEW
0AC                            X
0LAG VSP
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
0IC                           X
0HRFC                         X
0PC                X X
```

```
OSDSEOB      X X
OSDLAG       X X
OA LAG EXT   X X
OCHLOR       X X         X
OLT          X X

            22222222233333333
            12345678901234567
----------  -----------------
OTC
OHNTC
OPC
OSDSEOS
OSDLAG
OA LAG EXT
OCHLOR         X
OLT            X     X
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
OHBC         X X         X
OAS          X X         X
OTF STD      X X
OTF HR       X X
OIMHOFF      X X         X
ONT
OPT
ISSF

            22222222233333333
            12345678901234567
----------  -----------------
OHBC           X     X     X
OAS            X     X     X
OTF STD              X
OTF HR               X     X
OIMHOFF
ONT                        X
OPT                        X
ISSF
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
OHSF
OCHLOR                   X
OT40                     X
IOFILE
```

```
ICFILT
OBOFF                      X
ODBALT1                    X
ODBALT2                    X

           22222222233333333
           12345678901234567
---------- -----------------
ORSF               X    X
SCHLON
QT6D          X
IDFILT
ICFILT
OSOFT         X
ODBALT1       X
ODBALT2       X    X
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?

?
  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?1
       Q1  - 1   Q19 - 1
       Q2  - 4   Q20 - 1
       Q3  - 1   Q21 - 1
       Q4  - 2   Q22 - 1
       Q5  - 1   Q23 - 1
       Q6  - 2   Q24 - 8
       Q7  - 4   Q25 - 1
       Q8  - 2   Q26 - 1
       Q9  - 2   Q27 - 1
       Q10 - 2   Q28 - 1
       Q11 - 2   Q29 - 2
       Q12 - 2   Q30 - 2
       Q13 - 2   Q31 - 3
       Q14 - 1   Q32 - 1
       Q15 - 1   Q33 - 2
       Q16 - 1   Q34 - 1
       Q17 - 1   Q35 - 2
       Q18 - 1   Q36 - 2
                 Q37 - 2

PRESS RETURN TO PROCEED!!!
MAPMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
```

```
WOULD YOU LIKE TO STORE THE DATA PERMANANTLY?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?2
THIS SECTION IS COMPLETE   YOU WILL BE
RETURNED TO THE MAIN MENU.


PRESS RETURN TO PROCEED!!!

THERE ARE EIGHT SECTIONS TO THE MAPMAT
MODEL:

     MAIN------->THE PROGRAM WHICH YOU
                 ARE CURRENTLY USING
AVAIL PROCESS->DETERMINES AVAILABLE
                 WATER AND/OR SANITATION
                 TECHNOLOGY BASED ON DATA
                 WHICH YOU ENTER
COST RATIO----->RELATIVE RANK OF COST.
COMMUNICATE--->TELECOMMUNICATION LINK
                 TO CAPDET MODEL.
SENSITIVITY--->SENSITIVITY ANALYSIS ON
                 MAPMAT OUTPUT
OPTIMIZATION-->SELECT TREATMENT TRAINS
                 AND SET TREATMENT GOALS.
EFFECTIVENESS->PERFORM MULTI-OBJECTIVE
                 ON COST DATA
STATISTICS---->MULTIPLE REGRESSION
                 ANALYSIS ON DATA WHICH
                 YOU ENTER.

PRESS RETURN TO PROCEED!!!
!
 1..../---->MAIN

 2... /---->AVAIL PROCESS

 3... /---->COST RATIO

 4.  ./---->COMMUNICATE

 5.. /---->SENSITIVITY

 6..../---->OPTIMIZE

 7..../---->EFFECTIVENESS

 8..../---->STATISTICS


ENTER THE NUMBER OF THE PROGRAM WHICH
YOU WANT TO USE   IF YOU NEED TO
```

APPENDIX N

SAMPLE OUTPUT FROM
MAPMAT·OPTIMIZE

```
WELCOME TO THE OPTIMIZATION SECTION OF
MAPMAT   THE PURPOSE OF THIS SECTION IS
TO CONSTRUCT TREATMENT TRAINS, DISCOVER
IF THE TREATMENT TRAINS WILL MEET THE
TREATMENT GOALS WHICH YOU SPECIFY, AND
LINK TO THE COST ESTIMATION SECTION,
THE COST EFFECTIVENESS SECTION, AND
THE SENSITIVITY SECTION   IF YOU ARE IN
THE WRONG SECTION OF MAPMAT THEN TYPE
WRONG AND PRESS RETURN   IF THIS IS THE
RIGHT SECTION THEN TYPE RIGHT AND PRESS
RETURN
?RIGHT
MAPMAT OFFERS THREE OPTIONS FOR
CONSTRUCTING TREATMENT TRAINS.

    1---DATA STORED TEMPORARILY BY
        YOUR USE OF MAPMAT
    2---DATA WHICH YOU HAD MAPMAT STORE
        PERMENTANTLY BY A FILENAME
    3---DATA WHICH YOU ENTER AT THIS TIME

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC
?1
MAPMAT WILL BE RIGHT BACK


                  PLEASE WAIT!!!
AVAILABLE TECHNOLOGIES ARE.
 4   ST
 8   PFT ST
 10  AP SULLAGE
 32  SSF
 34  DFILT
 37  CFILT
ENTER THE NUMBER OF YOUR TECHNOLOGY
CHOICE   * INDICATES PRIOR SELECTIONS.
?4
 4  *ST
 8   PFT ST
 10  AP SULLAGE
 32  SSF
 34  DFILT
 37  CFILT
ANOTHER CHOICE?  ENTER EITHER NO OR THE
NUMBER OF YOUR CHOICE AND PRESS RETURN.
?8
 4  *ST
 8  *PFT ST
 10  AP SULLAGE
 32  SSF
 34  DFILT
```

```
 37  CFILT
ANOTHER CHOICE?  ENTER EITHER NO OR THE
NUMBER OF YOUR CHOICE AND PRESS RETURN.
?10
  4  *ST
  8  *PFF.SF
 10  *AP.SULLAGE
 32   BSF
 36   DFILT
 37   CFILT
ANOTHER CHOICE?  ENTER EITHER NO OR THE
NUMBER OF YOUR CHOICE AND PRESS RETURN.
?NO
IN THE FOLLOWING SECTION MAFMAT WILL
ASSIST YOU IN ESTABLISHING TREATMENT
SCHEMES TO BE USED IN THE OPTIMIZATION
ANALYSIS   FOR THE TECHNOLOGIES WHICH
ARE AVAILABLE YOU MUST SELECT AT LEAST
ONE PROCESS FOR EACH STAGE THAT YOU USE
IN THE TREATMENT SCHEME   YOU MAY
SELECT UP TO 99 STAGES AND 999
TREATMENT SCHEMES.  TECHNOLOGIES CAN BE
CHOSEN TO BECOME OPERATIVE ALL AT THE
SAME TIME OR AT SOME FUTURE TIME.
TYPICALLY A TREATMENT SCHEME WILL
INCLUDE SEVERAL STAGES, I E , A THREE
STAGE TREATMENT SCHEME COULD COMPRISE:
       1
*************
*           *
*PFF SEW SS-)
*************
       2
*************
*           *
*   LAG.WSP-)'
*************
       3
*************
*           *
*         LT-)
*************

PRESS RETURN TO PROCEED!!!
DO YOU WANT TO SET TREATMENT GOALS?
ENTER Y FOR YES OR N FOR NO
?NY
ENTER BOD TREATMENT GOAL-SANITATION
TREATMENT ONLY.
?10

ENTER FECAL COLIFORM TREATMENT GOAL-
WATER TREATMENT ONLY
?2
ENTER BOD LOAD FOR WASTE TREATMENT IN
MG/L
?100
```

```
ENTER FECAL COLIFORM LOAD FOR WATER
TREATMENT IN MPN/100ML.
?12
HOW MANY STAGES ARE INCLUDED IN
TREATMENT SCHEME 1? (MAXIMUM = 99)
?1
AVAILABLE TECHNOLOGIES ARE:
 4  ST
 8  FFT ST
 10 AP SULLAGE
WHICH TECHNOLOGY IS YOUR CHOICE FOR
STAGE 1?
?4
AT WHAT YEAR WILL ST BE
AVAILABLE?  (CURRENT=1,MAX=99)
?1
ANOTHER TREATMENT SCHEME (ENTER Y FOR
YES OR N FOR NO AND PRESS RETURN
?Y
HOW MANY STAGES ARE INCLUDED IN
TREATMENT SCHEME 2? (MAXIMUM = 99)
?1
AVAILABLE TECHNOLOGIES ARE.
 4  ST
 8  FFT ST
 10 AP SULLAGE
WHICH TECHNOLOGY IS YOUR CHOICE FOR
STAGE 1?
?8
AT WHAT YEAR WILL FFT ST BE
AVAILABLE?  (CURRENT=1,MAX=99)
?1
ANOTHER TREATMENT SCHEME (ENTER Y FOR
YES OR N FOR NO AND PRESS RETURN.
?Y
HOW MANY STAGES ARE INCLUDED IN
TREATMENT SCHEME 3? (MAXIMUM = 99)
?1
AVAILABLE TECHNOLOGIES ARE:
 4  ST
 8  FFT ST
 10 AP SULLAGE
WHICH TECHNOLOGY IS YOUR CHOICE FOR
STAGE 1?
?10
AT WHAT YEAR WILL AP SULLAGE BE
AVAILABLE?  (CURRENT=1,MAX=99)
?1
ANOTHER TREATMENT SCHEME (ENTER Y FOR
YES OR N FOR NO AND PRESS RETURN.
?Y
HOW MANY STAGES ARE INCLUDED IN
TREATMENT SCHEME 4? (MAXIMUM = 99)
?1
AVAILABLE TECHNOLOGIES ARE:
 4  ST
```

```
  8  FFT ST
 10  AP SULLAGE
WHICH TECHNOLOGY IS YOUR CHOICE FOR
STAGE 1?
?10
AT WHAT YEAR WILL AP SULLAGE BE
AVAILABLE?  (CURRENT=1,MAX=99)
?1
AVAILABLE TECHNOLOGIES ARE:
  9  SF
  8  FFT ST
 10  AP SULLAGE
WHICH TECHNOLOGY IS YOUR CHOICE FOR
STAGE 2?
?8
AT WHAT YEAR WILL FFT ST BE
AVAILABLE?  (CURRENT=1,MAX=99)
?5
ANOTHER TREATMENT SCHEME (ENTER Y FOR
YES OR N FOR NO AND PRESS RETURN.
?N
TREATMENT TRAIN 1

   STAGE  TECHNOLOGY  YEAR BUILT
   -----  ----------  ----------
     1     SF             1

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

   STAGE  TECHNOLOGY  YEAR BUILT
   -----  ----------  ----------
     1     FFT.ST         1

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

   STAGE  TECHNOLOGY  YEAR BUILT
   -----  ----------  ----------
     1     AP SULLAGE     1

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 4

   STAGE  TECHNOLOGY  YEAR BUILT
   -----  ----------  ----------
     1     AP.SULLAGE     1
     2     FFT ST         5

PRESS RETURN TO PROCEED!!!
YOU ARE NOW READY TO LINK TO THE COST
CALCULATION SECTION ,OR ANY OTHER
SECTION OF MAPMAT  YOU WILL BE
RETURNED TO THE MAIN MENU OF MAPMAT.

PRESS RETURN TO PROCEED!!!
```

APPENDIX O

SAMPLE COMPUTER OUTPUT FOR
MAPMAT•COST•RATIO

```
DO YOU WANT THE PRINTER ON?

    1------YES
    2------NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
?2
WELCOME TO TO THE COST RATIO SECTION OF
MAPMAT.  THE PURPOSE OF THIS SECTION IS
TO CONSTRUCT RELATIVE COST RATIOS FOR
TREATMENT TRAINS PREVIOUSLY CONSTRUCTED
BY USING MAPMAT.  IF YOU ARE IN
THE WRONG SECTION OF MAPMAT THEN TYPE
WRONG AND PRESS RETURN.  IF THIS IS THE
RIGHT SECTION THEN TYPE RIGHT AND PRESS
RETURN.
?RIGHT
WHAT IS THE DESIGN LEVEL OF POPULATION
AT THE LOCAL SITE?
?11175
WHAT IS THE EXPECTED POPULATION GROWTH
RATE EXPRESSED AS AN INTEGER?  FOR
EXAMPLE ENTER 3 FOR A THREE PERCENT
RATE AND PRESS RETURN.
?2
WHAT IS THE PERIOD OF DESIGN TO BE USED
IN THE ANALYSIS? (MAXIMUM=100)
?25
WHAT IS THE OPPORTUNITY COST OF CAPITAL
OR DISCOUNT RATE TO BE USED IN THE
ANALYSIS?  ENTER AN INTEGER SUCH AS 10
FOR A TEN PERCENT COST OF CAPITAL.
?10
A CRITICAL CRITERIA IN EVALUATING THE
COST OF TECHNOLOGY IS THE LEVEL OF
SUPPORT AVAILABLE DURING THE USE OF THE
TECHNOLOGY.  IN GENERAL A GOOD MEASURE
OF THIS SUPPORT IS THE EXISTING LEVEL
OF THE INFRASTRUCTURE.  MAPMAT INCLUDES
FOUR LEVELS OF INFRASTRUCTURE.  WHICH
INFRASTRUCTURE LEVEL IS CLOSEST TO THE
DESIGN SITE?

 1--THE INFRASTRUCTURE IS DEPENDENT ON
    IMPORTED EMPLOYMENT, AGRICULTURALLY
    ORIENTED WITH A VERY SMALL OR NON-
    EXISTANT LOCAL MARKET ECONOMY, FEW
    HIGH SCHOOL OR COLLEGE GRADUATES
    ARE AVAILABLE TO HELP LOCALLY
    UNLESS FROM A VOLUNTEER TYPE
    ORGANIZATION.  ALMOST 100 PERCENT
```

OF LOCAL EMPLOYMENT IS AGRICULTURE.
A RURAL VILLAGE IS AN EXAMPLE.

PRESS RETURN TO PROCEED!!!
2--THE INFRASTRUCTURE IS DEPENDENT
ON THE IMPORTED EMPLOYMENT OF
SCIENTIFIC/TECHNICAL PEOPLE BUT
PRODUCES MANAGERS, OPERATORS, LOW
LEVEL TEACHERS, ETC. TO SUPPORT A
LOW TO MEDIUM SIZE MARKET ECONOMY.
APPROXIMATELY 50 PERCENT OF THE
LOCAL POPULATION DERIVES A
LIVELIHOOD FROM AGRICULTURE. THE
SECONDARY AND PRIMARY SCHOOLS ARE
DEVELOPED BUT THE QUALITY OF
INSTRUCTION MAY BE VERY VARIABLE.

PRESS RETURN TO PROCEED!!!
2-- . . . . .CONTINUED . . .

AN EXAMPLE IS A RURAL TOWN OR
SMALL CITY.

PRESS RETURN TO PROCEED!!!
3--THE INFRASTRUCTURE HAS AVAILABLE
SCIENTISTS, ENGINEERS, AND OTHER
PROFESSIONALS BUT IMPORTS ALMOST
ALL RESEARCH PROFESSIONALS. PRIMARY
AND SECONDARY SCHOOL SYSTEMS ARE
WELL DEVELOPED WITH GENERALLY GOOD
TEACHERS. A LOCAL COLLEGE MAY BE
AVAILABLE. LESS THAN 25 PERCENT OF
THE POPULATION PRIMARILY DEPENDS ON
AGRICULTURE RELATED ENTERPRISE.

PRESS RETURN TO PROCEED!!!
3-- . CONTINUED . . .

AN EXAMPLE IS A LARGE BUT ISOLATED
CITY, POSSIBLY A REGIONAL CENTER
OF COMMERCE.

PRESS RETURN TO PROCEED!!!
4--THE INFRASTRUCTURE CLOSELY
RESEMBLES A LARGE CITY IN A
DEVELOPED COUNTRY. SIGNIFICANT
PORTIONS OF THE POPULATION FINISH
PRIMARY AND SECONDARY SCHOOL.
RESEARCH PROFESSIONALS ARE READILY
AVAILABLE AND HIGH TECHNOLOGY IS
ALSO AVAILABLE. AN EXAMPLE IS THE
NATIONAL CAPITAL OF A DEVELOPING
COUNTRY.

PRESS RETURN TO PROCEED!!!
1--RURAL VILLAGE LEVEL
2--RURAL TOWN OR SMALL CITY LEVEL.

```
 3--LARGE BUT ISOLATED CITY LEVEL.
 4--NATIONAL CAPITAL LEVEL.

IF YOU NEED TO REVIEW THE DEFINATIONS
FOR THESE LEVELS ENTER HELP OTHERWISE
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
? 12
MAPMAT OFFERS TWO OPTIONS FOR
CONSTRUCTING RELATIVE COST RATIOS:

   1---TREATMENT TRAIN DATA STORED
        TEMPORARILY BY YOUR USE OF
        MAPMAT.

   2---TREATMENT TRAIN DATA WHICH YOU
        YOU HAD MAPMAT STORE
        PERMENTARILY BY A FILE NAME.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
? 1
MAPMAT WILL BE RIGHT BACK


              PLEASE WAIT!!!
TREATMENT TRAIN 1

S              B
T              YU             OPERATION
A              EI                AND
G              AL CAPITAL     MAINTENANCE
E  TECHNOLOGY  RT COST           COST
-- ----------- -- -------     -----------
1  SF          1    55        1.41723393

 TOTAL PRESENT VALUE COST RATIO= 2

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S              B
T              YU             OPERATION
A              EI                AND
G              AL CAPITAL     MAINTENANCE
E  TECHNOLOGY  RT COST           COST
-- ----------- -- -------     -----------
1  PFF SF      1    74        2.99641214

 TOTAL PRESENT VALUE COST RATIO= 3

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

S              B
T              YU             OPERATION
A              EI                AND
```

```
G                AL CAPITAL      MAINTENANCE
E  TECHNOLOGY  NT COST               COST
-- ----------- -- -------       -----------
1  AP SULLAGE  1   5 07         2.13633857

 TOTAL PRESENT VALUE COST RATIO= 7

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 4

S                #
T                YN              OPERATION
A                CI                 AND
G                AL CAPITAL      MAINTENANCE
E  TECHNOLOGY  NT COST               COST
-- ----------- -- -------       -----------
1  AP SULLAGE  1   5 07         2.13633857
2  FFT 81      5    .74         2.03927351

 TOTAL PRESENT VALUE COST RATIO= 10

PRESS RETURN TO PROCEED!!!
       ALTERNATIVE TREATMENT TRAIN
     TOTAL PRESENT VALUE COST RATIOS

                 TOTAL PRESENT
     TREATMENT       VALUE
       TRAIN      COST RATIO
     ---------   -------------
         1           2
         2           1
         3           7
         4          10

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN
COST RATIOS IN A TEMPORARY FILE.  DO
YOU WANT TO STORE THE DATA UNDER A
PERMENTANT FILE NAME?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
?2
YOU HAVE COMPLETED THE COST RATIO
SECTION OF MAPMAT.  YOU ARE READY TO
PROCEED TO ANOTHER SECTION OF MAPMAT.
YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!
```

APPENDIX P

SAMPLE COMPUTER OUTPUT FROM MAPMAT•EFFECTIVENESS

```
                    EFFECTIVENESS EVALUATION TECHNIQUE

                                  USING

                   A PAIRWISE DECISION WEIGHTING MODEL

IN THIS ANALYSIS A  ****  RESULT INDICATES A VERY SMALL NUMBER OR A NUMBER
SLIGHTLY GREATER THAN ONE IN THE CASE OF A NORMALIZED VALUE.  A BLANK
REPRESENTS A NUMBER EQUAL TO 0.


YOU NEED TO ESTABLISH THE NUMBER OF ALTERNATIVES   PLEASE ENTER THE NUMBER
OF ALTERNATIVES THAT YOU WISH TO CONSIDER (MAXIMUM=20)
?4
YOU HAVE ENTERED 4 ALTERNATIVES TO BE NUMBERED AS FOLLOWS:

                    ALTERNATIVES
                         A1
                         A2
                         A3
                         A4

DO YOU WISH TO CHANGE THE NUMBER OF ALTERNATIVES(Y=YES,N=NO)?
?N
```

```
DO YOU WISH TO NAME THE ALTERNATIVES(Y=YES,N=NO)?
?Y
          INPUT NAME FOR ALTERNATIVE A1 (MAXIMUM LENGTH=20 CHARACTERS).
?TRAIN 1
          INPUT NAME FOR ALTERNATIVE A2 (MAXIMUM LENGTH=20 CHARACTERS).
?TRAIN 2
          INPUT NAME FOR ALTERNATIVE A3 (MAXIMUM LENGTH=20 CHARACTERS).
?TRAIN 3
          INPUT NAME FOR ALTERNATIVE A4 (MAXIMUM LENGTH=20 CHARACTERS).
?TRAIN 4

DO YOU WISH TO CHANGE THE NAMES OF YOUR ALTERNATIVES(Y=YES,N=NO)?
?N
```

```
                    ALTERNATIVES

                      A1   TRAIN 1
                      A2   TRAIN 2
                      A3   TRAIN 3
                      A4   TRAIN 4

PRESS THE RETURN KEY TO PROCEED
?
```

```
NOW YOU NEED TO ESTABLISH THE NUMBER OF EFFECTIVENESS MEASURES THAT WILL BE
USED BY THE EVALUATION.  PLEASE ENTER THE NUMBER OF EFFECTIVENESS MEASURES
THAT YOU WISH TO USE(MAXIMUM=10).
? 4

YOU HAVE ENTERED 4 EFFECTIVENESS MEASURES AS FOLLOWS:

                          EFFECTIVENESS MEASURES
                                    M1
                                    M2
                                    M3
                                    M4

DO YOU WISH TO CHANGE THE NUMBER OF EFFECTIVENESS MEASURES(Y=YES,N=NO)?
? N
```

```
DO YOU WISH TO NAME THE EFFECTIVENESS MEASURES(Y=YES,N=NO)?
?Y
          INPUT NAME FOR EFFECTIVENESS MEASURE M1 (MAXIMUM LENGTH=20 CHARACTERS).
?LOCAL LABOR USE
          INPUT NAME FOR EFFECTIVENESS MEASURE M2 (MAXIMUM LENGTH=20 CHARACTERS).
?RELIABILITY
          INPUT NAME FOR EFFECTIVENESS MEASURE M3 (MAXIMUM LENGTH=20 CHARACTERS).
?SOVCIAL ACCEPATTANCE
          INPUT NAME FOR EFFECTIVENESS MEASURE M4 (MAXIMUM LENGTH=20 CHARACTERS).
?IMPORTED MATERIAL

DO YOU WISH TO CHANGE THE NAMES OF YOUR EFFECTIVENESS MEASURES(Y=YES,N=NO)?
?N
```

```
EFFECTIVENESS MEASURES

  M1  LOCAL LABOR USE
  M2  RELIABILITY
  M3  SOCIAL ACCEPTANCE
  M4  IMPORTED MATERIAL

PRESS THE RETURN KEY TO PROCEED
?
```

```
NOW YOU NEED TO DETERMINE THE RELATIVE WEIGHTS TO BE ASSIGNED TO EACH MEASURE
OF EFFECTIVENESS.  YOU MUST DO THIS IN PAIRWISE RANKINGS USING THE RELATIVE
IMPORTANCE OF ANY ITEM TO THE NEXT ITEM ON THE LIST.  FOR EXAMPLE IF MEASURE
M1 IS TWO AND ONE-HALF TIMES AS IMPORTANT AS MEASURE M2 THEN THE PAIRWISE RANK
OF M1 RELATIVE TO M2 IS 2.5.

ENTER THE RELATIVE IMPORTANCE OF M1 TO M2.
?2
ENTER THE RELATIVE IMPORTANCE OF M2 TO M3.
? 1
ENTER THE RELATIVE IMPORTANCE OF M3 TO M4.
? 1
```

```
EFFECTIVENESS MEASURES RANKING FROM FIRST TO LAST MEASURE

                    M1    LOCAL LABOR USE           1
                    M2    RELIABILITY               1
                    M3    SOCIAL ACCEPTANCE         1
                    M4    IMPORTED MATERIAL         1

**** NOTE ***  THE MEASURE M4 HAS A RANK OF 1 SINCE IT IS THE LAST ITEM
ON THE LIST.

DO YOU WISH TO CHANGE THE RELATIVE RANKS(Y=YES,N=NO)?
?N
```

YOUR FRIENDLY COMPUTER WILL BE RIGHT BACK. BUT IN THE MEAN TIME
PLEASE WAIT WHILE YOUR CALCULATIONS ARE BEING PROCESSED

EFFECTIVENESS MEASURES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
M1- LOCAL LABOR USE	2	2	.4
M2- RELIABILITY	1	1	.2
M3- SOCIAL ACCEPTANCE	1	1	.2
M4- IMPORTED MATERIAL	1	1	.2

PRESS THE RETURN KEY TO PROCEED
?

```
NOW YOU NEED TO DETERMINE THE RELATIVE IMPORTANCE TO BE ASSIGNED TO EACH
ALTERNATIVE.  YOU MUST DO THIS IN PAIRWISE RANKINGS USING THE RELATIVE
IMPORTANCE OF ANY ITEM TO THE NEXT ITEM ON THE LIST.  FOR EXAMPLE IF
ALTERNATIVE A1 IS ONE AND ONE-HALF TIMES AS IMPORTANT AS ALTERNATIVE A2 THEN
THEN THE PAIRWISE RANK OF A1 RELATIVE TO A2 IS 1.5.

FOR EFFECTIVENESS MEASURE M1 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A1 TO A2.
?2

FOR EFFECTIVENESS MEASURE M1 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A2 TO A3.
?1

FOR EFFECTIVENESS MEASURE M1 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A3 TO A4
?1
```

```
ALTERNATIVES RELATIVE RANK FROM FIRST TO LAST
                              EFFECTIVENESS MEASURE M1   (LOCAL LABOR USE)

TRAIN 1               2

TRAIN 2               1

TRAIN 3               1

TRAIN 4               1

**** NOTA ***    THE ALTERNATIVE A4 HAS A RANK OF 1 SINCE IT IS THE LAST ITEM ON
THE LIST.

DO YOU WISH TO CHANGE THE RELATIVE RANKINGS OF THE ALTERNATIVES(Y=YES,N=NO)?
?N

FOR EFFECTIVENESS MEASURE M1 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A1 TO A2.
?2

FOR EFFECTIVENESS MEASURE M1 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A2 TO A3.
?1

FOR EFFECTIVENESS MEASURE M1 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A3 TO A4.
?1
```

```
ALTERNATIVES RELATIVE RANK FROM FIRST TO LAST
                              EFFECTIVENESS MEASURE M2  (RELIABILITY)

TRAIN 1               21

TRAIN 2               1

TRAIN 3               1

TRAIN 4               1

**** NOTE ***   THE ALTERNATIVE A4 HAS A RANK OF 1 SINCE IT IS THE LAST ITEM ON
THE LIST.

DO YOU WISH TO CHANGE THE RELATIVE RANKINGS OF THE ALTERNATIVES(Y=YES,N=NO)?
? Y

FOR EFFECTIVENESS MEASURE M2 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A1 TO A2.
?2

FOR EFFECTIVENESS MEASURE M2 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A2 TO A3.
?1

FOR EFFECTIVENESS MEASURE M2 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A3 TO A4.
?1
```

```
ALTERNATIVES RELATIVE RANK FROM FIRST TO LAST
                                  EFFECTIVENESS MEASURE M2   (RELIABILITY)

TRAIN 1                 2

TRAIN 2                 1

TRAIN 3                 1

TRAIN 4                 1

**** NOTE ***    THE ALTERNATIVE A4 HAS A RANK OF 1 SINCE IT IS THE LAST ITEM ON
THE LIST.

DO YOU WISH TO CHANGE THE RELATIVE RANKINGS OF THE ALTERNATIVES(Y=YES,N=NO)?
?N

FOR EFFECTIVENESS MEASURE M3 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A1 TO A2.
?2

FOR EFFECTIVENESS MEASURE M3 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A2 TO A3.
?2

FOR EFFECTIVENESS MEASURE M3 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A3 TO A4.
?1
```

```
ALTERNATIVES RELATIVE RANK FROM FIRST TO LAST
                                 EFFECTIVENESS MEASURE M3  (SOCIAL ACCEPTANCE)

TRAIN 1              3

TRAIN 2              3

TRAIN 3              1

TRAIN 4              1

**** NOTE ***   THE ALTERNATIVE A4 HAS A RANK OF 1 SINCE IT IS THE LAST ITEM ON
THE LIST.

DO YOU WISH TO CHANGE THE RELATIVE RANKINGS OF THE ALTERNATIVES(Y=YES,N=NO)?
?N

FOR EFFECTIVENESS MEASURE M4 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A1 TO A2.
?.5

FOR EFFECTIVENESS MEASURE M4 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A2 TO A3.
?.5

FOR EFFECTIVENESS MEASURE M4 INPUT THE RELATIVE IMPORTANCE OF ALTERNATIVE
A3 TO A4.
?2
```

```
ALTERNATIVES RELATIVE RANK FROM FIRST TO LAST
                              EFFECTIVENESS MEASURE M4   (IMPORTED MATERIAL)

TRAIN 1                .5

TRAIN 2                .5

TRAIN 3               2

TRAIN 4               1

**** NOTE ***    THE ALTERNATIVE A4 HAS A RANK OF 1 SINCE IT IS THE LAST ITEM ON
THE LIST.

DO YOU WISH TO CHANGE THE RELATIVE RANKINGS OF THE ALTERNATIVES(Y=YES,N=NO)?
?N
```

YOUR FRIENDLY COMPUTER WILL BE RIGHT BACK BUT IN THE MEAN TIME
PLEASE WAIT WHILE YOUR CALCULATIONS ARE BEING PROCESSED

FOR IMPORTANCE MEASURE M1 - LOCAL LABOR USE

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	2	2	.4
A2- TRAIN 2	1	1	.2
A3- TRAIN 3	1	1	.2
A4- TRAIN 4	1	1	.2

PRESS THE RETURN KEY TO PROCEED
?

FOR IMPORTANCE MEASURE M2 -- RELIABILITY

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	2	2	.4
A2- TRAIN 2	1	1	.2
A3- TRAIN 3	1	1	.2
A4- TRAIN 4	1	1	.2

PRESS THE RETURN KEY TO PROCEED

?

FOR IMPORTANCE MEASURE M3 - SOCIAL ACCEPTANCE

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	2	4	.5
A2- TRAIN 2	2	2	.25
A3- TRAIN 3	1	1	.125
A4- TRAIN 4	1	1	.125

PRESS THE RETURN KEY TO PROCEED
?

FOR IMPORTANCE MEASURE M4 - IMPORTED MATERIAL

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	.5	.5	.111
A2- TRAIN 2	.5	1	.222
A3- TRAIN 3	2	2	.444
A4- TRAIN 4	1	1	.222

PRESS THE RETURN KEY TO PROCEED

?

MEASURES OF EFFECTIVENESS MP

ALTERNATIVES	M1	M2	M3	M4	TOTAL EFFECTIVENESS
A1	.400	.400	.500	.111	.362
A2	.200	.200	.250	.222	.214
A3	.200	.200	.125	.444	.234
A4	.200	.200	.125	.222	.189

PRESS THE RETURN KEY TO PROCEED

```
DO YOU WISH TO USE COST AS A DECISION VARIABLE(Y=YES,N=NO)?
? Y
```

```
DO YOU WANT TO USE DATA STORED BY
MAPMAT   ENTER Y FOR YES OR N FOR NO
AND PRESS RETURN.
? Y
```

```
DO YOU WANT TO USE:

   1---TEMPORARY COST DATA FILE STORED
       BY MAPMAT.
   2---PERMANENT COST DATA FILE STORED
       BY MAPMAT USING A FILENAME.
ENTER THE NUMBER FOR YOUR CHOICE.
? 1
```

```
ALTERNATIVES                    COST
 A1                              2
 A2                              3
 A3                              7
 A4                              10

DO YOU WISH TO CHANGE THE COST VALUES(Y=YES;N=NO)?
?N
```

ALTERNATIVES	COST	TOTAL EFFECTIVENESS	COST EFFECTIVENESS
A1- TRAIN 1	2	.342	6
A2- TRAIN 2	3	.214	14
A3- TRAIN 3	7	.234	30
A4- TRAIN 4	10	.189	53

PRESS THE RETURN KEY TO PROCEED
?

DO YOU WISH TO GET A PRINTED COPY OF YOUR RESULTS(Y=YES;N=NO)?
?Y
#ON

EFFECTIVENESS MEASURES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
M1- LOCAL LABOR USE	2	2	.4
M2- RELIABILITY	1	1	.2
M3- SOCIAL ACCEPTANCE	1	1	.2
M4- IMPORTED MATERIAL	1	1	.2

FOR IMPORTANCE MEASURE M1 - LOCAL LABOR USE

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	2	2	.4
A2- TRAIN 2	1	1	.2
A3- TRAIN 3	1	1	.2
A4- TRAIN 4	1	1	.2

FOR IMPORTANCE MEASURE M2 - RELIABILITY

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	2	2	.4
A2- TRAIN 2	1	1	.2
A3- TRAIN 3	1	1	2
A4- TRAIN 4	1	1	2

FOR IMPORTANCE MEASURE M3 - SOCIAL ACCEPTANCE

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	2	4	5
A2- TRAIN 2	2	2	25
A3- TRAIN 3	1	1	125
A4- TRAIN 4	1	1	.125

FOR IMPORTANCE MEASURE M4 - IMPORTED MATERIAL

ALTERNATIVES	RELATIVE IMPORTANCE WITH RESPECT TO NEXT ITEM ON LIST	RELATIVE IMPORTANCE WITH RESPECT TO LAST ITEM ON LIST	NORMALIZED RELATIVE WEIGHT
A1- TRAIN 1	5	5	.111
A2- TRAIN 2	5	1	222
[illegible]	[illegible]	[illegible]	[illegible]

ALTERNATIVES	MEASURES OF EFFECTIVENESS MI				TOTAL EFFECTIVENESS
	M1	M2	M3	M4	
A1	.400	.400	.500	.111	.362
A2	.200	.200	.250	.222	.214
A3	.200	.200	.125	.444	.234
A4	.200	.200	.125	.222	.189

ALTERNATIVES	COST	TOTAL EFFECTIVENESS	COST EFFECTIVENESS
A1- TRAIN 1	2	.362	6
A2- TRAIN 2	3	.214	14
A3- TRAIN 3	7	.234	30
A4- TRAIN 4	10	.189	53

IN THIS ANALYSIS A **** RESULT INDICATES A VERY SMALL NUMBER OR A NUMBER SLIGHTLY GREATER THAN ONE IN THE CASE OF A NORMALIZED VALUE. A BLANK REPRESENTS A NUMBER EQUAL TO 0.

```
DO YOU WANT ANOTHER COPY OF YOUR RESULTS(Y=YES;N=NO)?
?N
```

```
DO YOU WANT TO RUN THIS PROGRAM AGAIN(Y=YES;N=NO)?
?N

                    GOODBYE
```

APPENDIX Q

SAMPLE COMPUTER OUTPUT FOR
MAPMAT•SENSITIVITY

```
WELCOME TO THE SENSITIVITY SECTION OF
MAPMAT.  IN THIS SECTION YOU CAN
MODIFY PREVIOUS DATA TO INVESTIGATE
THE EFFECT OF ALTERNATE INFORMATION.
IF YOU HAVE ARRIVED AT THE WRONG POINT
THEN ENTER WRONG AND PRESS RETURN.  IF
THIS IS THE RIGHT SECTION OF MAPMAT
THEN TYPE RIGHT AND PRESS RETURN
?RIGHT
THERE ARE SIX ALTERNATIVE PARTS IN THE
SENSITIVITY SECTION OF MAPMAT.  YOU
WILL BE ABLE TO RUN ANY OR ALL OF THE
SECTIONS.  THE ALTERNATIVES ARE:

  1---CHANGE THE AVAILABLE TECHNOLOGY.
  2---CHANGE THE TREATMENT TRAINS OR
      TREATMENT GOALS
  3---CHANGE THE ANSWERS TO QUESTIONS
      WHICH DETERMINE THE AVAILABLE
      TECHNOLOGY.
  4---RERUN MAPMAT USING NEW DATA.
  5---CHANGE THE COST RATIO DATA
  6---CHANGE THE COST EFFECTIVENESS
      DATA.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
?3
MAPMAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

                SANITATION
        ----------------------
        {VIPL }
        {VIDPL}
        {ROEC }
         ST
        {PIT}
         PFT.ST
        {AP}
         AP.SULLAGE

PRESS RETURN TO PROCEED!!!
              WATER
          ---------
              SST
              DFILT
              CFILT

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
```

```
T1
                      1111111112
            12345678901234567890
----------- --------------------
IVIPL
IVIDPL
IROEC
IST
ODVCT              X   XX
IPFT
OPFT.SEW.SB    X
IPFT.ST

            22222222233333333
            12345678901234567
----------- -----------------
IVIPL
IVIDPL
IROEC
IST
ODVCT
IPFT
OPFT.SEW.SB
IPFT.ST
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEED!*
*         *
***********
IAP
IAP.SULLAGE
OAP.SEW.SB     X
OVSC        X          X
OCOMM                  X
OCOMM.SEW   X X        X
OAC                    X
OLAG.WSP    X

            22222222233333333
            12345678901234567
----------- -----------------
IAP
IAP.SULLAGE
OAP.SEW.SB
OVSC
OCOMM
OCOMM.SEW
OAC                     X
OLAG.WSP
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
```

```
*PROCEED!*
*        *
**********
0TC                        X
0HRFC                      X
0PC             X X
0SDBEDS         X X
0SDLAG          X X
0A.LAG.EXT      X X
0CHLOR          X X        X
0LT             X X

               22222222233333333
               12345678901234567
----------     -----------------
0TC
0HRTC
0PC
0SDBEDS
0SDLAG
0A.LAG.EXT
0CHLOR            X
0LT               X    X
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
0RBC            X X        X
0AS             X X        X
0TF.STD         X X
0TF.HR          X X
0IMHOLE         X X        X
0NF
0PT
1SSF

               22222222233333333
               12345678901234567
----------     -----------------
0RBC              X    X    X
0AS               X    X    X
0TF.STD                X
0TF.HR                 X    X
0IMHOFF
0NT                         X
0PF                         X
1SSF
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
```

```
*        *
**********
ORSE
OCHLOR                 X
OT&O                   X
IDFILT
ICFILT
OBOFT                  X
ODSALT1                X
ODSALT2                X

           22222222223333333
           12345678901234567
---------- -----------------
ORSF               X    X
ICHLOR
OT&O          X
IDFILT
ICFILT
OBOFT         X
ODSALT1       X
ODSALT2       X    X
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?


  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
        Q1  = 1   Q19 = 1
        Q2  = 4   Q20 = 1
        Q3  = 1   Q21 = 1
        Q4  = 2   Q22 = 1
        Q5  = 1   Q23 = 1
        Q6  = 2   Q24 = 0
        Q7  = 4   Q25 = 1
        Q8  = 2   Q26 = 1
        Q9  = 2   Q27 = 1
        Q10 = 2   Q28 = 1
        Q11 = 2   Q29 = 2
        Q12 = 3   Q30 = 3
        Q13 = 2   Q31 = 3
        Q14 = 1   Q32 = 1
        Q15 = 1   Q33 = 2
        Q16 = 1   Q34 = 1
        Q17 = 1   Q35 = 2
```

```
        Q18 = 1    Q36 = 1
                   Q37 = 2

PRESS RETURN TO PROCEED!!!
MAPMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMNANTLY?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
THIS SECTION IS COMPLETE.  YOU WILL BE
RETURNED TO THE MAIN MENU.


PRESS RETURN TO PROCEED!!!
```

APPENDIX R

MAPMAT COMPUTER OUTPUT FOR
DAVID WATER SUPPLY

```
NAPHAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

                SANITATION
          ------------------------
          PFT
          PFT.SEW.SB
          COMM
          COMM.SEW

PRESS RETURN TO PROCEED!!!
                WATER
          ----------
             RST
             CHLOR
             T&O
             DFILT
             CFILT
             SOFT
             DSALT1
             DSALT2

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                    11111111112
           12345678901234567890
---------- --------------------
0VIPL      X        X
0VIDPL     X        X
0RUEC      X
0ST        X
00VCT      X        X   X
1PFT
1PFT.SEW.SB
```

```
0PIT.61        X

               22222222223333333
               12345678901234567
-------------- -----------------
0VIPL                         X
0VIDPL                        X
0ROEC                         X
0ST
0DVCT                     X   X
1PFT
1PFT.SEW SD
0PFT.SF
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
0AP                    X
0AP.SULLAGE            X
0AP.SEW.SD             X
0VAC            X      X
1COMM
1COMM.SEW
0AC            X
0LAG.WSP        X

               22222222223333333
               12345678901234567
-------------- -----------------
0AP
0AP.SULLAGE
0AP.SEW SD
0VAC                          X
1COMM
1COMM.SEW
0AC                      X   XX
0LAG.WSP                 X    X
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
0TC
0HRTC
0PC             X
0SDBEOS         X
0SDLAG          X
0A LAG.EXT      X
0CHLOR          X
0LT             X
```

```
            22222222233333333
            12345678901234567
----------- -----------------
OTC                    X
OHRTC                  X
OPC
OBDBEDS               X   XX
OSDLAG                X   XX
OA.LAG.EXT            X
OCHLOR
OLT                   X   XX
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEED!*
*         *
***********
ORDC        X
OAS         X
OTI  STD    X
OFF.HR      X
OIMHOFF     X
ONF
OPT
OSSF

            22222222233333333
            12345678901234567
----------- -----------------
ORBC
OAS
OFF.STD                  X
OTF HR                   X
OIMHOFF
ONT                      XX
OPT                      XX
OSSF                 X
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEED!*
*         *
***********
1RSF
1CHLOR
1T&D
1OFILT
1CFILT
1SOFF
1DSALT1
1DSALT2
```

```
              22222222233333333
              12345678901234567
---------- -----------------
IRDF
ICHLOR
IFEO
IDFILT
ICFILT
ISOFT
IDSALT1
IDSALT2
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?


  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
        Q1  = 3    Q19 = 1
        Q2  = 5    Q20 = 1
        Q3  = 1    Q21 = 1
        Q4  = 1    Q22 = 1
        Q5  = 1    Q23 = 1
        Q6  = 2    Q24 = 1
        Q7  = 4    Q25 = 1
        Q8  = 2    Q26 = 1
        Q9  = 1    Q27 = 1
        Q10 = 2    Q28 = 1
        Q11 = 2    Q29 = 3
        Q12 = 3    Q30 = 1
        Q13 = 3    Q31 = 2
        Q14 = 1    Q32 = 0
        Q15 = 1    Q33 = 2
        Q16 = 1    Q34 = 2
        Q17 = 1    Q35 = 1
        Q18 = 1    Q36 = 1
                   Q37 = 2

PRESS RETURN TO PROCEED!!!
MAPMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMENANTLY?

  1-----YES
  2-----NO
```

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
THIS SECTION IS COMPLETE. YOU WILL BE
RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!

```
IF YOU NEED TO REVIEW THE DEFINATIONS
FOR THESE LEVELS ENTER HELP OTHERWISE
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
? 2
MAPHAT OFFERS TWO OPTIONS FOR
CONSTRUCTING RELATIVE COST RATIOS:

    1---TREATMENT TRAIN DATA STORED
        TEMPORARILY BY YOUR USE OF
        MAPHAT.

    2---TREATMENT TRAIN DATA WHICH YOU
        YOU HAD MAPHAT STORE
        PERMENTANTLY BY A FILE NAME.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
? 1
MAPHAT WILL BE RIGHT BACK


           PLEASE WAIT!!!
TREATMENT TRAIN 1

S            Q
T            YU            OPERATION
A            EI               AND
G            AL CAPITAL    MAINTENANCE
E  TECHNOLOGY RT COST          COST
-- ---------- -- -------   -----------
1  CFILT      1  0         0
2  RSF        1  8.77      141.779261
3  CHLOR      1  2.91      110.781894

 TOTAL PRESENT VALUE COST RATIO= 244

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S            Q
T            YU            OPERATION
A            EI               AND
G            AL CAPITAL    MAINTENANCE
E  TECHNOLOGY RT COST          COST
-- ---------- -- -------   -----------
1  RSF        1  8.77      141.779261
2  CHLOR      1  2.91      110.781894

 TOTAL PRESENT VALUE COST RATIO= 244

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

S            Q
T            YU            OPERATION
```

```
A                 EI                        AND
G                 AL  CAPITAL         MAINTENANCE
E   TECHNOLOGY    RT  COST                COST
--  ----------    --  -------         -----------
1   RSF           1   8.77            141.779261
2   DFILT         1   28.1            224.438906

 TOTAL PRESENT VALUE COST RATIO= 403

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 4

S                 D
T                 YU                  OPERATION
A                 EI                        AND
G                 AL  CAPITAL         MAINTENANCE
E   TECHNOLOGY    RT  COST                COST
--  ----------    --  -------         -----------
1   DSALT1        1   73.95           370.351149
2   CHLOR         1   2.91            110.781894

 TOTAL PRESENT VALUE COST RATIO= 557

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 5

S                 D
T                 YU                  OPERATION
A                 EI                        AND
G                 AL  CAPITAL         MAINTENANCE
E   TECHNOLOGY    RT  COST                COST
--  ----------    --  -------         -----------
1   CFILT         1   0               0
2   DFILT         1   28.1            224.438906

 TOTAL PRESENT VALUE COST RATIO= 252

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 6

S                 D
T                 YU                  OPERATION
A                 EI                        AND
G                 AL  CAPITAL         MAINTENANCE
E   TECHNOLOGY    RT  COST                COST
--  ----------    --  -------         -----------
1   CFILT         1   0               0
2   RSF           1   8.77            141.779261
3   DFILT         3   28.1            212.668022

 TOTAL PRESENT VALUE COST RATIO= 391

PRESS RETURN TO PROCEED!!!
        ALTERNATIVE TREATMENT TRAIN
     TOTAL PRESENT VALUE COST RATIOS

                  TOTAL PRESENT
```

```
TREATMENT       VALUE
  TRAIN       COST RATIO
---------   -------------
    1            244
    2            264
    3            403
    4            557
    5            252
    6            391

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN
COST RATIOS IN A TEMPORARY FILE.  DO
YOU WANT TO STORE THE DATA UNDER A
PERMENTANT FILE NAME?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
?2
YOU HAVE COMPLETED THE COST RATIO
SECTION OF MAPMAT.  YOU ARE READY TO
PROCEED TO ANOTHER SECTION OF MAPMAT.
YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!
```

APPENDIX S

MAPMAT COMPUTER OUTPUT FOR
BOCAS DEL TORO WATER SUPPLY

```
MAPMAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

               SANITATION
          ----------------------
          VIPL
          VIDPL
          ROEC
          PFT
          AP

PRESS RETURN TO PROCEED!!!
             WATER
          ----------
             NT
             DFILT
             CFILT

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                    11111111112
           12345678901234567890
---------- --------------------
1VIPL
1VIDPL
1ROEC
0ST                    X
0DVCT                 XX
1PFT
0PFT.SEW.SB   X
0PFT.ST                X

           22222222233333333
           12345678901234567
---------- -----------------
1VIPL
1VIDPL
1ROEC
0ST
0DVCT
1PFT
0PFT.SEW.SBX
0PFT.ST
```

```
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
IAP
OAP.SULLAGE              x
OAP SLW SB      x        x
OVEC          x          x
OCOMM                    x
OCOMM SEW     x x        x
OAC                      x
OLAG.WSP      x          x

             22222222233333333
             12345678901234567
------------ -----------------
IAP
OAP.SULLAGE
OAP.SEW.SB   x
OVEC
OCOMM
OCOMM.SLW    x
OAC
OLAG.WSP
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
OTC                      x
OHRTC                    x
OPC           x x  x     x
OSUBEDS       x x  x     x
OSOLAG        x x  x     x
OA.LAG.EXT    x x  x     x
OCHLOR        x x  x     x
OLT           x x  x     x

             22222222233333333
             12345678901234567
------------ -----------------
OTC
OHRTC                x
OPC                  x
OSUBEDS
OSOLAG
OA LAG EXT           x
OCHLOR        xx    x
OLT           xx    xx
**********
```

```
*          *
*   PRESS  *
*  RETURN  *
*    TO    *
*PROCEED!  *
*          *
************
ORBC        X X  X     X
OAS         X X  X     X
OFF STD     X X  X     X
OFF HR      X X  X     X
OIMHOFF     X X  X     X
INT
OPT                    X
OSSF                   X

           22222222233333333
           12345678901234567
---------- -----------------
ORBC       X XX   XX
OAS        X XX   XX
OFF STD            X
OFF HR             X
OIMHOFF            X
INT
OPT
OSSF               X
************
*          *
*   PRESS  *
*  RETURN  *
*    TO    *
*PROCEED!  *
*          *
************
ORSF                   X
OCHLOR                 X
OT&O                   X
IDFILT
ICFILT
OSOFT                  X
ODSALT1                X
ODSALT2                X

           22222222233333333
           12345678901234567
---------- -----------------
ORSF       X X    XX
OCHLOR       X    X
OT&O         XX   X
IDFILT
ICFILT
OSOFT      X XX   X
ODSALT1    X XX   XX
ODSALT2    X XX   XX
************
*          *
```

```
*   PRESS  *
*  RETURN  *
*    TO    *
*PROCEED!*
*          *
***********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?


   1---YES
   2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
          Q1  = 1    Q19 = 1
          Q2  = 4    Q20 = 1
          Q3  = 1    Q21 = 0
          Q4  = 2    Q22 = 1
          Q5  = 1    Q23 = 0
          Q6  = 2    Q24 = 0
          Q7  = 3    Q25 = 1
          Q8  = 2    Q26 = 1
          Q9  = 2    Q27 = 1
          Q10 = 2    Q28 = 0
          Q11 = 2    Q29 = 1
          Q12 = 3    Q30 = 3
          Q13 = 1    Q31 = 3
          Q14 = 1    Q32 = 1
          Q15 = 1    Q33 = 2
          Q16 = 1    Q34 = 2
          Q17 = 1    Q35 = 2
          Q18 = 1    Q36 = 2
                     Q37 = 2

PRESS RETURN TO PROCEED!!!
MATMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMANENTLY?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
THIS SECTION IS COMPLETE.  YOU WILL BE
RETURNED TO THE MAIN MENU.


PRESS RETURN TO PROCEED!!!
```

```
TREATMENT TRAIN 1

S                B
T                YU                OPERATION
A                EI                   AND
G                AL  CAPITAL       MAINTENANCE
E  TECHNOLOGY    RT  COST              COST
-- ----------    --  -------       -----------
1  DFILT         1   30.25         249.596189
2  DFILT         10  30.25         211.296889

 TOTAL PRESENT VALUE COST RATIO= 521

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S                B
T                YU                OPERATION
A                EI                   AND
G                AL  CAPITAL       MAINTENANCE
E  TECHNOLOGY    RT  COST              COST
-- ----------    --  -------       -----------
1  NT            1   2.7           15.7233021
2  DFILT         1   30.25         249.596189

 TOTAL PRESENT VALUE COST RATIO= 298

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

S                B
T                YU                OPERATION
A                EI                   AND
G                AL  CAPITAL       MAINTENANCE
E  TECHNOLOGY    RT  COST              COST
-- ----------    --  -------       -----------
1  NT            1   2.7           15.7233021
2  CFILT         1   0             0

 TOTAL PRESENT VALUE COST RATIO= 18

PRESS RETURN TO PROCEED!!!
```

```
PRESS RETURN TO PROCEED!!!
       ALTERNATIVE TREATMENT TRAIN
    TOTAL PRESENT VALUE COST RATIOS

                    TOTAL PRESENT
     TREATMENT         VALUE
       TRAIN        COST RATIO
     ---------     ------------
         1             521
         2             296
         3             18

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN
COST RATIOS IN A TEMPORARY FILE.  DO
YOU WANT TO STORE THE DATA UNDER A
PERMENTANT FILE NAME?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
?2
YOU HAVE COMPLETED THE COST RATIO
SECTION OF MAPMAT.  YOU ARE READY TO
PROCEED TO ANOTHER SECTION OF MAPMAT.
YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!
```

APPENDIX T

MAPMAT COMPUTER OUTPUT FOR DAVID SANITATION TECHNOLOGY

```
MAPMAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

               SANITATION
          ------------------------
          ROEC
          SF
          PIT
          PIT.SEW.SB
          PIT.SF
          COMM
          COMM.SEW
          TC
          HH.TC
          PC
          CHLOR
          RBC
          AS
          TF.STD
CF.HR
IMHOFF

PRESS RETURN TO PROCEED!!!
             WATER
          ----------
             NF
             FT
             HSF
             CHLOR
             C&O
             DFILT
             CFILT
             SOFT
             DSALT1
             DSALT2

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                          11111111112
             12345678901234567890
---------- --------------------
OVIPL              X
OVIDPL             X
IROEC
```

```
IST
0DVCT              X  X
IPIT
IPFT.SEW.SB
IPIT.ST

           22222222233333333
           12345678901234567
---------- -----------------
0VIPL
0VIOPL
IROLC
IST
0DVCT
IPFT
IPIT.SEW.SB
IPFT.ST
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
0AP                X
0AP.SULLAGE        X
0AP.SEW.SB         X
0V&C        X      X
ICOMM
ICOMM.SEW
0AC
0LAG.WSP

           22222222233333333
           12345678901234567
---------- -----------------
0AP
0AP.SULLAGE
0AP.SEW.SB
0V&C
ICOMM
ICOMM.SEW
0AC                 X
0LAG.WSP            X
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
ITC
IHRTC
IPC
030BEOS
```

```
0SDLAG
0A.LAG.EXT
1CHLOR
0LT

              22222222233333333
              12345678901234567
----------  -----------------
1PC
1HRTC
1PC
0SUBLDS                X
0SDLAG                 X
0A.LAG.EXT             X
1CHLOR
0LT                    X
**********
*        *
*  PRESS *
* RETURN *
*    TO  *
*PROCEED!*
*        *
**********
1RBC
1AS
1TF.STD
1CF.HR
1IMHOFF
1NT
1PT
0SSF

              22222222233333333
              12345678901234567
----------  -----------------
1RBC
1AS
1TF STD
1TF HR
1IMHOFF
1NT
1PC
0SSF                   X
**********
*        *
*  PRESS *
* RETURN *
*    TO  *
*PROCEED!*
*        *
**********
1RSI
1CHLOR
1T60
1DFILT
1CFILT
```

```
1BOFF
1DSALT1
1DSALT2

            22222222233333333
            12345678901234567
----- ----- -----------------
1RSF
1CHLOR
1F&O
1DFILT
1CFILT
1SOFT
1DSALT1
1DSALT2
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?


  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
        Q1  = 1   Q19 = 1
        Q2  = 6   Q20 = 1
        Q3  = 1   Q21 = 1
        Q4  = 1   Q22 = 1
        Q5  = 1   Q23 = 1
        Q6  = 2   Q24 = 1
        Q7  = 4   Q25 = 1
        Q8  = 2   Q26 = 1
        Q9  = 1   Q27 = 1
        Q10 = 2   Q28 = 1
        Q11 = 2   Q29 = 3
        Q12 = 3   Q30 = 3
        Q13 = 3   Q31 = 2
        Q14 = 1   Q32 = 1
        Q15 = 1   Q33 = 2
        Q16 = 1   Q34 = 2
[illegible] = 1   Q35 = 2
        Q18 = 1   Q36 = 2
                  Q37 = 2

PRESS RETURN TO PROCEED!!!
MATMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMANENTLY?
```

```
  1-----YES
  2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E , 1, 2, ETC.
?
```

```
        TEMPORARILY BY YOUR USE OF
        MAPMAT.

     2---TREATMENT TRAIN DATA WHICH YOU
        YOU HAD MAPMAT STORE
        PERMENTANTLY BY A FILE NAME.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC
? 1
MAPMAT WILL BE RIGHT BACK


             PLEASE WAIT!!!
TREATMENT TRAIN 1

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ----------   -- -------       -----------
1  ROEC         1   .23          .179494881

 TOTAL PRESENT VALUE COST RATIO= 0

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ----------   -- -------       -----------
1  ST           1    48          1.40162007

 TOTAL PRESENT VALUE COST RATIO= 1

PRESS RETURN TO PROCEED!!!




TREATMENT TRAIN 4
```

STAGE	TECHNOLOGY	YEAR BUILT	CAPITAL COST	OPERATION AND MAINTENANCE COST
1	PFT	1	.15	.628932083
2	PFT.ST	5	.64	1.70271275
3	PFT.SEW.SB	10	.6	1.90151988
4	PC	10	11.18	96.4755128
5	IMHOFF	10	27.28	224.531468
6	TF.STD	10	24.27	73.931093

TOTAL PRESENT VALUE COST RATIO= 443

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 5

STAGE	TECHNOLOGY	YEAR BUILT	CAPITAL COST	OPERATION AND MAINTENANCE COST
1	PC	1	11.18	113.962493
2	IMHOFF	1	27.28	245.229644
3	TF.HR	1	18.86	173.241804
4	CHLOR	10	13.5	46.2753679

TOTAL PRESENT VALUE COST RATIO= 669

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 6

STAGE	TECHNOLOGY	YEAR BUILT	CAPITAL COST	OPERATION AND MAINTENANCE COST
1	PC	1	11.18	113.962493
2	TF.STD	1	24.27	87.331712
3	AS	4	21.82	180.480953
4	CHLOR	1	13.5	54.4431827

TOTAL PRESENT VALUE COST RATIO= 507

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 7

STAGE	TECHNOLOGY	YEAR BUILT	CAPITAL COST	OPERATION AND MAINTENANCE COST
1	PFT.SEW.SB	1	.6	2.24418601

2	PC	1	11.18	113.962493
3	IMHOFF	1	27.28	265.229644
4	TF.STD	1	24.27	87.331712

TOTAL PRESENT VALUE COST RATIO= 532

PRESS RETURN TO PROCEED!!!

TREATMENT TRAIN 9

STAGE	TECHNOLOGY	SYUEIALRT	CAPITAL COST	OPERATION AND MAINTENANCE COST
1	COMM.SEW	1	1.09	4.74394485
2	PC	1	11.18	113.962493
3	IMHOFF	1	27.28	265.229644
4	TF.STD	1	24.27	87.331712

TOTAL PRESENT VALUE COST RATIO= 535

PRESS RETURN TO PROCEED!!!

ALTERNATIVE TREATMENT TRAIN
TOTAL PRESENT VALUE COST RATIOS

TREATMENT TRAIN	TOTAL PRESENT VALUE COST RATIO
1	0
2	1
4	443
5	669
6	507
7	532
9	535

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN

```
COST RATIOS IN A TEMPORARY FILE   DO
YOU WANT TO STORE THE DATA UNDER A
PERMENTANT FILE NAME?

    1-----YES
    2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
?2
YOU HAVE COMPLETED THE COST RATIO
SECTION OF MAPMAT.  YOU ARE READY TO
PROCEED TO ANOTHER SECTION OF MAPMAT.
YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!
```

APPENDIX U

MAPMAT COMPUTER OUTPUT FOR
PENONOME SANITATION TECHNOLOGY

```
MAPMAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

               SANITATION
         -----------------------
         VIPL
         VIDPL
         ROEC
         PFT
         PFT.ST
         AP

PRESS RETURN TO PROCEED!!!
            WATER
         ----------
            NC
            PT
            DFILT
            CFILT

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                    11111111112
           12345678901234567890
---------- --------------------
1VIPL
1VIDPL
1ROEC
0ST              X
0DVCT                 XX
1PFT
0PFT.SEW.SB   X
1PFT.ST

           22222222223333333
           12345678901234567
---------- -----------------
1VIPL
1VIDPL
1ROEC
0ST
0DVCT
1PFT
```

```
OPTT.SEW.SBX
IPFF.ST
***********
*         *
*   PRESS *
* RETURN  *
*    TO   *
*PROCEED!*
*         *
***********
IAP
OAP.SULLAGE       X
OAP.SEW.SB     X  X
OV&C         X          X
OCOMM                   X
OCOMM.SEW    X X        X
OAC                     X
OLAG WSP     X

            22222222233333333
            12345678901234567
----------- -----------------
IAP
OAP.SULLAGE
OAP.SEW.SB  X
OV&C
OCOMM
OCOMM.SLW   X
OAC
OLAG.WSP
***********
*         *
*   PRESS *
* RETURN  *
*    TO   *
*PROCEED!*
*         *
***********
OTC                    X
OHRTC                  X
OPC          X X  X
OSDBEDS      X X  X
OSDLAG       X X  X
OA LAG.EXT   X X  X
OCHLOR       X X  X    X
OLT          X X  X

            22222222233333333
            12345678901234567
----------- -----------------
OTC
OHRTC               X
OPC                 X
OSDBEDS
OSDLAG
OA LAG EXT          X
OCHLOR        XX   X
```

```
OLT            XX   XX
***********
*         *
*  PRESS  *
* RETURN  *
*    TO   *
*PROCEED!*
*         *
***********
ORBC          X X   X     X
OAS           X X   X     X
OTF.STD       X X   X
OTF.HR        X X   X
OIMHOFF       X X   X     X
INT
IPT
OSSF

             22222222233333333
             12345678901234567
------------ -----------------
ORBC         X XX   XX
OAS          X XX   XX
OTF.STD              X
OTF.HR               X
OIMHOFF              X
INT
IPT
OSSI                 X
***********
*         *
*  PRESS  *
* RETURN  *
*    TO   *
*PROCEED!*
*         *
***********
ORSF
OCHLOR                   X
OT60                     X
IDFILT
ICFILT
OSOFT                    X
ODSALT1                  X
ODSALT2                  X

             22222222233333333
             12345678901234567
------------ -----------------
ORSF         X X    XX
OCHLOR         X    X
OT60           XX   X
IDFILT
ICFILT
OSOFT        X XX   X
ODSALT1      X XX   XX
ODSALT2      X XX   XX
```

```
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?


  1----YES
  2----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
         Q1  = 1    Q19 = 1
         Q2  = 4    Q20 = 1
         Q3  = 1    Q21 = 0
         Q4  = 2    Q22 = 1
         Q5  = 1    Q23 = 0
         Q6  = 2    Q24 = 0
         Q7  = 2    Q25 = 1
         Q8  = 2    Q26 = 1
         Q9  = 2    Q27 = 1
         Q10 = 2    Q28 = 0
         Q11 = 2    Q29 = 1
         Q12 = 3    Q30 = 3
         Q13 = 2    Q31 = 3
         Q14 = 1    Q32 = 1
         Q15 = 1    Q33 = 2
         Q16 = 1    Q34 = 2
         Q17 = 1    Q35 = 2
         Q18 = 1    Q36 = 2
                    Q37 = 2

PRESS RETURN TO PROCEED!!!
MAPMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMENANTLY?

  1------YES
  2------NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
THIS SECTION IS COMPLETE.  YOU WILL BE
RETURNED TO THE MAIN MENU.


PRESS RETURN TO PROCEED!!!
```

```
        TEMPORARILY BY YOUR USE OF
        MAPMAT.

    2---TREATMENT TRAIN DATA WHICH YOU
        YOU HAD MAPMAT STORE
        PERMENTANTLY BY A FILE NAME.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC
? 1
MAPMAT WILL BE RIGHT BACK


            PLEASE WAIT!!!
TREATMENT TRAIN 1

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ----------   -- -------       -----------
1  PFT          1   .18           .718779523
2  PFT ST       5   .74           2.83927351

 TOTAL PRESENT VALUE COST RATIO= 4

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ----------   -- -------       -----------
1  VIPL         1   .51           .179694881

 TOTAL PRESENT VALUE COST RATIO= 0

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ----------   -- -------       -----------
1  VIDPL        1  1.02           .449237202

 TOTAL PRESENT VALUE COST RATIO= 1

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 4

S               B
```

```
T              YU              OPERATION
A              EI                 AND
G              AL CAPITAL     MAINTENANCE
E  TECHNOLOGY  RT COST            COST
-- ----------- -- -------     -----------
1  ROEC        1    53        .249542321

 TOTAL PRESENT VALUE COST RATIO= 0

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 5

S               B
T              YU              OPERATION
A              EI                 AND
G              AL CAPITAL     MAINTENANCE
E  TECHNOLOGY  RT COST            COST
-- ----------- -- -------     -----------
1  PFT         1   .18        .718779523

 TOTAL PRESENT VALUE COST RATIO= 0

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 6

S               B
T              YU              OPERATION
A              EI                 AND
G              AL CAPITAL     MAINTENANCE
E  TECHNOLOGY  RT COST            COST
-- ----------- -- -------     -----------
1  AP          1   2 18       .970352356

 TOTAL PRESENT VALUE COST RATIO= 3

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 7

S               B
T              YU              OPERATION
A              EI                 AND
G              AL CAPITAL     MAINTENANCE
E  TECHNOLOGY  RT COST            COST
-- ----------- -- -------     -----------
1  VIDPL       1   1.02       .449237202
2  PFT         5   .18        .681085099
3  PFT.SF      10  .74        2.53462752

 TOTAL PRESENT VALUE COST RATIO= 5

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 8

S               B
T              YU              OPERATION
A              EI                 AND
G              AL CAPITAL     MAINTENANCE
```

```
E   TECHNOLOGY RT COST            COST
--  ---------- -- ------       -----------
1   ROEC        1   53          .269542321
2   PFT         5  .18          .681065099
3   PFT ST     10   74          2.53462752

 TOTAL PRESENT VALUE COST RATIO= 4

PRESS RETURN TO PROCEED!!!
       ALTERNATIVE TREATMENT TRAIN
     TOTAL PRESENT VALUE COST RATIOS

                   TOTAL PRESENT
      TREATMENT        VALUE
        TRAIN        COST RATIO
      ---------    ------------
          1            4
          2            0
          3            1
          4            0
          5            0
          6            3
          7            5
          8            4

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN
COST RATIOS IN A TEMPORARY FILE.  DO
YOU WANT TO STORE THE DATA UNDER A
PERMENANT FILE NAME?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC
?2
YOU HAVE COMPLETED THE COST RATIO
SECTION OF MAPMAT   YOU ARE READY TO
PROCEED TO ANOTHER SECTION OF MAPMAT.
YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!
```

APPENDIX V

MAPMAT COMPUTER OUTPUT FOR
INDONESIAN TEST SITE TWO

```
MAPMAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

          SANITATION
     ------------------------
     VIPL
     VIDPL
     ROEC
     ST
     PFT
     PFT.ST
     AP
     AP.SULLAGE
```

```
PRESS RETURN TO PROCEED!!!
               WATER
              ----------
               NT
               PT
               DETET
               CTILT

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

  1---YES
  2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                     1111111112
           12345678901234567890
---------- --------------------
1VIPL
1VIDPL
1ROEC
1ST
0DVCT             X   XX
1PFT
0PFT.SEW.SB   X
1PFT.ST

           22222222233333333
           12345678901234567
---------- -----------------
1VIPL
1VIDPL
1ROEC
1ST
0DVCT
1PFT
0PFT.SEW.SB
1PFT.ST
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
1AP
1AP.SULLAGE
0AP.SEW.SB    X
0VSC       X           X
0COMM                  X
0COMM.SEW  X  X        X
0AC                    X
```

```
OLAG.WSP      X

             22222222233333333
             12345678901234567
----------- -----------------
IAP
IAP SULLAGE
OAP BEW.SB
OV&C
OCOMM
OCOMM.SEW
OAC
OLAC.WSP
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEEDI *
*         *
***********
OTC                     X
OHRTC                   X
OPC          X X  X
OSDBEDS      X X  X
OSDLAG       X X  X
OA.LAG.EXT   X X  X
OCHLOR       X X  X     X
OLT          X X  X

             22222222233333333
             12345678901234567
----------- -----------------
OTC
OHRTC                X
OPC                  X
OSDBEDS
OSDLAG
OA.LAG.EXT           X
OCHLOR         X
OLT            X     X
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEEDI *
*         *
***********
ORBC         X X  X     X
OAS          X X  X     X
OTF.STD      X X  X
OTF.HR       X X  X
OIMMOIF      X X  X     X
INT
IPT
OSSF
```

```
            22222222233333333
            12345678901234567
----------- -----------------
ORBC           X    X
#AB            X    X
OFF.STD             X
#TF.HR              X
OIMRUFF             X
INT
IPF
#BSF                X
***********
*         *
*   PRESS *
* RETURN  *
*    TO   *
*PROCEED! *
*         *
***********
#RSF
OCHLOR                  X
#T40                    X
IOFILF
IC#ILT
OSUFF                   X
#DSALT1                 X
ODSALT2                 X

            22222222233333333
            12345678901234567
----------- -----------------
ORSF                X
#CHLOR
OT40           X
IDIILT
ICFILF
OSOFT          X
ODSALT1        X    X
#DSALT2        X    X
***********
*         *
*   PRESS *
* RETURN  *
*    TO   *
*PROCEED! *
*         *
***********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS?

   1---YES
   2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
```

```
?1
        Q1  = 1    Q19 = 1
        Q2  = 4    Q20 = 1
        Q3  = 1    Q21 = 1
        Q4  = 2    Q22 = 1
        Q5  = 1    Q23 = 1
        Q6  = 2    Q24 = 0
        Q7  = 3    Q25 = 1
        Q8  = 2    Q26 = 1
        Q9  = 2    Q27 = 1
        Q10 = 2    Q28 = 1
        Q11 = 2    Q29 = 1
        Q12 = 3    Q30 = 3
        Q13 = 2    Q31 = 3
        Q14 = 1    Q32 = 1
        Q15 = 1    Q33 = 2
        Q16 = 1    Q34 = 1
        Q17 = 1    Q35 = 2
        Q18 = 1    Q36 = 1
                   Q37 = 2

PRESS RETURN TO PROCEED!!!
MAPMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMENANTLY?

  1-----YES
  2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
THIS SECTION IS COMPLETE.  YOU WILL BE
RETURNED TO THE MAIN MENU.


PRESS RETURN TO PROCEED!!!
```

```
WELCOME TO TO THE COST RATIO SECTION OF
MAPMAT.  THE PURPOSE OF THIS SECTION IS
TO CONSTRUCT RELATIVE COST RATIOS FOR
TREATMENT TRAINS PREVIOUSLY CONSTRUCTED
BY USING MAPMAT.  IF YOU ARE IN
THE WRONG SECTION OF MAPMAT THEN TYPE
WRONG AND PRESS RETURN.  IF THIS IS THE
RIGHT SECTION THEN TYPE RIGHT AND PRESS
RETURN.
?RIGHT
WHAT IS THE DESIGN LEVEL OF POPULATION
AT THE LOCAL SITE?
?5234
WHAT IS THE EXPECTED POPULATION GROWTH
RATE EXPRESSED AS AN INTERGER?  FOR
EXAMPLE ENTER 3 FOR A THREE PERCENT
RATE AND PRESS RETURN.
?1
WHAT IS THE PERIOD OF DESIGN TO BE USED
IN THE ANALYSIS? (MAXIMUM=100)
?25
WHAT IS THE OPPORTUNITY COST OF CAPITAL
OR DISCOUNT RATE TO BE USED IN THE
ANALYSIS?  ENTER AN INTERGER SUCH AS 10
FOR A TEN PERCENT COST OF CAPITAL.
?10
A CRITICAL CRITERIA IN EVALUATING THE
COST OF TECHNOLOGY IS THE LEVEL OF
SUPPORT AVAILABLE DURING THE USE OF THE
TECHNOLOGY.  IN GENERAL A GOOD MEASURE
OF THIS SUPPORT IS THE EXISTING LEVEL
OF THE INFRASTRUCTURE.  MAPMAT INCLUDES
FOUR LEVELS OF INFRASTRUCTURE.  WHICH
INFRASTRUCTURE LEVEL IS CLOSEST TO THE
DESIGN SITE?

 1--THE INFRASTRUCTURE IS DEPENDENT ON
    IMPORTED EMPLOYMENT; AGRICULTURALLY
    ORIENTED WITH A VERY SMALL OR NON-
    EXISTANT LOCAL MARKET ECONOMY; FEW
    HIGH SCHOOL OR COLLEGE GRADUATES
    ARE AVAILABLE TO HELP LOCALLY
    UNLESS FROM A VOLUNTEER TYPE
    ORGANIZATION.  ALMOST 100 PERCENT
    OF LOCAL EMPLOYMENT IS AGRICULTURE.
    A RURAL VILLAGE IS AN EXAMPLE.

PRESS RETURN TO PROCEED!!!
 2--THE INFRASTRUCTURE IS DEPENDENT
    ON THE IMPORTED EMPLOYMENT OF
    SCIENTIFIC/TECHNICAL PEOPLE BUT
    PRODUCES MANAGERS, OPERATORS, LOW
    LEVEL TEACHERS, ETC. TO SUPPORT A
    LOW TO MEDIUM SIZE MARKET ECONOMY.
    APPROXIMATELY 50 PERCENT OF THE
    LOCAL POPULATION DERIVES A
```

```
     LIVELIHOOD FROM AGRICULTURE.  THE
     SECONDARY AND PRIMARY SCHOOLS ARE
     DEVELOPED BUT THE QUALITY OF
     INSTRUCTION MAY BE VERY VARIABLE.

PRESS RETURN TO PROCEED!!!
 2-- ......CONTINUED.. ..

     AN EXAMPLE IS A RURAL TOWN OR
     SMALL CITY.

PRESS RETURN TO PROCEED!!!
 3--THE INFRASTRUCTURE HAS AVAILABLE
     SCIENTISTS, ENGINEERS, AND OTHER
     PROFESSIONALS BUT IMPORTS ALMOST
     ALL RESEARCH PROFESSIONALS. PRIMARY
     AND SECONDARY SCHOOL SYSTEMS ARE
     WELL DEVELOPED WITH  GENERALLY GOOD
     TEACHERS  A LOCAL COLLEGE MAY BE
     AVAILABLE   LESS THAN 25 PERCENT OF
     THE POPULATION PRIMARILY DEPENDS ON
     AGRICULTURE RELATED ENTERPRISE.

PRESS RETURN TO PROCEED!!!
 3--....CONTINUED. . ....

     AN EXAMPLE IS A LARGE BUT ISOLATED
     CITY, POSSIBLY A REGIONAL CENTER
     OF COMMERCE.

PRESS RETURN TO PROCEED!!!
 4--THE INFRASTRUCTURE CLOSELY
     RESEMBLES A LARGE CITY IN A
     DEVELOPED COUNTRY.  SIGNIFICANT
     PORTIONS OF THE POPULATION FINISH
     PRIMARY AND SECONDARY SCHOOL.
     RESEARCH PROFESSIONALS ARE READILY
     AVAILABLE AND HIGH TECHNOLOGY IS
     ALSO AVAILABLE.  AN EXAMPLE IS THE
     NATIONAL CAPITAL OF A DEVELOPING
     COUNTRY.

PRESS RETURN TO PROCEED!!!
 1--RURAL VILLAGE LEVEL.
 2--RURAL TOWN OR SMALL CITY LEVEL.
 3--LARGE BUT ISOLATED CITY LEVEL.
 4--NATIONAL CAPITAL LEVEL.

IF YOU NEED TO REVIEW THE DEFINATIONS
FOR THESE LEVELS ENTER HELP OTHERWISE
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
? 2
MAPMAT OFFERS TWO OPTIONS FOR
CONSTRUCTING RELATIVE COST RATIOS:

    1---TREATMENT TRAIN DATA STORED
```

```
        TEMPORARILY BY YOUR USE OF
        MAPMAT.

    2---TREATMENT TRAIN DATA WHICH YOU
        YOU HAD MAPMAT STORE
        PERMENTANTLY BY A FILE NAME.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
? 1
MAPMAT WILL BE RIGHT BACK


             PLEASE WAIT!!!
TREATMENT TRAIN 1

S               B
T              YU                 OPERATION
A              EI                    AND
G              AL CAPITAL         MAINTENANCE
E  TECHNOLOGY  RT COST             .  COST
-- ----------  -- -------         -----------
1  VIPL         1  .51            .179694801
2  PFT          5  .18            .481085099
3  PFT.ST       1  .74            2.99441214

 TOTAL PRESENT VALUE COST RATIO= 5

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S               B
T              YU                 OPERATION
A              EI                    AND
G              AL CAPITAL         MAINTENANCE
E  TECHNOLOGY  RT COST               COST
-- ----------  -- -------         -----------
1  ST           1  .55            1.61725393

 TOTAL PRESENT VALUE COST RATIO= 2

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

S               B
T              YU                 OPERATION
A              EI                    AND
G              AL CAPITAL         MAINTENANCE
E  TECHNOLOGY  RT COST         .     COST
-- ----------  -- -------         -----------
1  VIOPL        1  1.02           .449237202
2  AP           5  2.18            .919464884
3  AP.BULLAGE  10  5.07           1.82545909

 TOTAL PRESENT VALUE COST RATIO= 11

PRESS RETURN TO PROCEED!!!
```

TREATMENT TRAIN 4

STAGE	TECHNOLOGY	YEAR BUILT	CAPITAL COST	OPERATION AND MAINTENANCE COST
1	VIPL	1	.51	.179694881
2	PFT	3	.18	.701723222
3	PFT ST	8	.74	2.67518604
4	ST	13	.55	1.22644453

TOTAL PRESENT VALUE COST RATIO= 6

PRESS RETURN TO PROCEED!!!

ALTERNATIVE TREATMENT TRAIN
TOTAL PRESENT VALUE COST RATIOS

TREATMENT TRAIN	TOTAL PRESENT VALUE COST RATIO
1	5
2	2
3	11
4	6

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN COST RATIOS IN A TEMPORARY FILE. DO YOU WANT TO STORE THE DATA UNDER A PERMENANT FILE NAME?

1-----YES
2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR CHOICE, I.E., 1, 2, ETC.
?2
YOU HAVE COMPLETED THE COST RATIO SECTION OF MAPMAT. YOU ARE READY TO PROCEED TO ANOTHER SECTION OF MAPMAT. YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!

APPENDIX W

MAPMAT COMPUTER OUTPUT FOR INDONESIAN TEST SITE FOUR

```
MAPMAT HAS DETERMINED THAT THE
FOLLOWING TECHNOLOGIES ARE AVAILABLE:

                 SANITATION
           ----------------------
           PFT
           PFT.SEW.SB
           AP
           AP.SULLAGE
           AP.SEW.SB
           COMM
           COMM.SEW
           LAG.WSP
           TC
           HRTC
           PC
           SUBEDS
           SDLAG
           A.LAG.EXT
CHLOR
LT
RBC
AS
TF.STD
TF.HR
IMHOFF

PRESS RETURN TO PROCEED!!!
              WATER
           ----------
              NT
              PT
```

```
                  BSF
                  RSF
                  CHLOR
                  T&O
                  OFILT
                  CFILT
                  SOFT
                  DSALT1
                  DSALT2

PRESS RETURN TO PROCEED!!!
WOULD YOU LIKE TO SEE WHICH QUESTIONS
AFFECTED THE AVAILABILITY OF THE
TECHNOLOGIES?

   1---YES
   2---NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
                         11111111112
                12345678901234567890
--------------- --------------------
OVIPL           X
OVIDPL          X
OROEC           X
OST             X
ODVCT           X      X   X
IPFT
IPFT.SEW SB
OPFT.ST         X

                22222222223333333
                12345678901234567
--------------- -----------------
OVIPL
OVIDPL
OROEC
OSF
ODVCT
IPFT
IPFT.SEW.SB
OPFT.ST
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEED!*
*         *
***********
IAP
IAP.SULLAGE
IAP.SEW.SB
OV&C            X
ICOMM
```

```
ICOMM.SEV
#AC          X
ILAG.WSP

             22222222233333333
             12345678901234567
----------  -------------------
IAP
IAP.SULLAGE
IAP.SEW.SB
#V&C
ICOMM
ICOMM.SEV
0AC
ILAG.VEP
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
ITC
IHRTC
IPC
ISDBEDS
ISDLAG
IA.LP .EXT
ICHLOR
ILT

             22222222233333333
             12345678901234567
----------  -------------------
ITC
IHRTC
IPC
ISDBEDS
ISDLAG
IA.LAG.EXT
ICHLOR
ILT
**********
*        *
*  PRESS *
* RETURN *
*   TO   *
*PROCEED!*
*        *
**********
IRBC
IAS
ITF.STD
ITF.HR
ITMHOFF
INF
```

```
 IPT
 IBSF

             2222222222333333333
             1234567890123456 7
----------- -------------------
 IRBC
 IAS
 ITF.STD
 ITF.HR
 IIMHOFF
 INT
 IPT
 IBSF
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEED! *
*         *
***********
 IRSF
 ICHLOR
 IT60
 IDFILT
 ICFILT
 ISOFT
 IDSALT1
 IDSALT2

             2222222222333333333
             1234567890123456 7
----------- -------------------
 IRSF
 ICHLOR
 IT60
 IDFILT
 ICFILT
 ISOFT
 IDSALT1
 IDSALT2
***********
*         *
*  PRESS  *
* RETURN  *
*   TO    *
*PROCEED! *
*         *
***********
WOULD YOU LIKE TO SEE THE ANSWERS YOU
GAVE TO THE QUESTIONS!

  1---YES
  2---NO
```

```
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?1
        Q1  = 3    Q19 = 1
        Q2  = 6    Q20 = 1
        Q3  = 1    Q21 = 1
        Q4  = 1    Q22 = 1
        Q5  = 1    Q23 = 1
        Q6  = 2    Q24 = 1
        Q7  = 4    Q25 = 1
        Q8  = 2    Q26 = 1
        Q9  = 2    Q27 = 1
        Q10 = 2    Q28 = 1
        Q11 = 2    Q29 = 3
        Q12 = 3    Q30 = 1
        Q13 = 3    Q31 = 3
        Q14 = 1    Q32 = 1
        Q15 = 1    Q33 = 2
        Q16 = 1    Q34 = 2
        Q17 = 1    Q35 = 2
        Q18 = 1    Q36 = 2
                   Q37 = 2

PRESS RETURN TO PROCEED!!!
MAPMAT HAS JUST STORED YOUR TECHNOLOGY
AVAILABILITY DATA IN A TEMPORARY FILE.
WOULD YOU LIKE TO STORE THE DATA PERMENANTLY?

   1------YES
   2------NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE, I.E., 1, 2, ETC.
?2
THIS SECTION IS COMPLETE.  YOU WILL BE
RETURNED TO THE MAIN MENU.


PRESS RETURN TO PROCEED!!!
```

```
WELCOME TO TO THE COST RATIO SECTION OF
MAPMAT.  THE PURPOSE OF THIS SECTION IS
TO CONSTRUCT RELATIVE COST RATIOS FOR
TREATMENT TRAINS PREVIOUSLY CONSTRUCTED
BY USING MAPMAT.   IF YOU ARE IN
THE WRONG SECTION OF MAPMAT THEN TYPE
WRONG AND PRESS RETURN.   IF THIS IS THE
RIGHT SECTION THEN TYPE RIGHT AND PRESS
RETURN
?RIGHT
WHAT IS THE DESIGN LEVEL OF POPULATION
AT THE LOCAL SITE?
?79400
WHAT IS THE EXPECTED POPULATION GROWTH
RATE EXPRESSED AS AN INTERGER?  FOR
EXAMPLE ENTER 3 FOR A THREE PERCENT
RATE AND PRESS RETURN
?1
WHAT IS THE PERIOD OF DESIGN TO BE USED
IN THE ANALYSIS? (MAXIMUM=100)
?25
WHAT IS THE OPPORTUNITY COST OF CAPITAL
OR DISCOUNT RATE TO BE USED IN THE
ANALYSIS?  ENTER AN INTERGER SUCH AS 10
FOR A TEN PERCENT COST OF CAPITAL.
?10
A CRITICAL CRITERIA IN EVALUATING THE
COST OF TECHNOLOGY IS THE LEVEL OF
SUPPORT AVAILABLE DURING THE USE OF THE
TECHNOLOGY.   IN GENERAL A GOOD MEASURE
OF THIS SUPPORT IS THE EXISTING LEVEL
OF THE INFRASTRUCTURE.  MAPMAT INCLUDES
FOUR LEVELS OF INFRASTRUCTURE.  WHICH
INFRASTRUCTURE LEVEL IS CLOSEST TO THE
DESIGN SITE?

 1--THE INFRASTRUCTURE IS DEPENDENT ON
    IMPORTED EMPLOYMENT; AGRICULTURALLY
    ORIENTED WITH A VERY SMALL OR NON-
    EXISTANT LOCAL MARKET ECONOMY; FEW
    HIGH SCHOOL OR COLLEGE GRADUATES
    ARE AVAILABLE TO HELP LOCALLY
    UNLESS FROM A VOLUNTEER TYPE
    ORGANIZATION.   ALMOST 100 PERCENT
    OF LOCAL EMPLOYMENT IS AGRICULTURE.
    A RURAL VILLAGE IS AN EXAMPLE.

PRESS RETURN TO PROCEED!!!
 2--THE INFRASTRUCTURE IS DEPENDENT
    ON THE IMPORTED EMPLOYMENT OF
    SCIENTIFIC/TECHNICAL PEOPLE BUT
    PRODUCES MANAGERS, OPERATORS, LOW
    LEVEL TEACHERS, ETC. TO SUPPORT A
    LOW TO MEDIUM SIZE MARKET ECONOMY.
    APPROXIMATELY 50 PERCENT OF THE
    LOCAL POPULATION DERIVES A
```

```
     LIVELIHOOD FROM AGRICULTURE. THE
     SECONDARY AND PRIMARY SCHOOLS ARE
     DEVELOPED BUT THE QUALITY OF
     INSTRUCTION MAY BE VERY VARIABLE.

PRESS RETURN TO PROCEED!!!
 2-- ..... CONTINUED ....

     AN EXAMPLE IS A RURAL TOWN OR
     SMALL CITY.

PRESS RETURN TO PROCEED!!!
 3--THE INFRASTRUCTURE HAS AVAILABLE
     SCIENTISTS, ENGINEERS, AND OTHER
     PROFESSIONALS BUT IMPORTS ALMOST
     ALL RESEARCH PROFESSIONALS. PRIMARY
     AND SECONDARY SCHOOL SYSTEMS ARE
     WELL DEVELOPED WITH  GENERALLY GOOD
     TEACHERS. A LOCAL COLLEGE MAY BE
     AVAILABLE.  LESS THAN 25 PERCENT OF
     THE POPULATION PRIMARILY DEPENDS ON
     AGRICULTURE RELATED ENTERPRISE.

PRESS RETURN TO PROCEED!!!
 3--....CONTINUED  .  ..

     AN EXAMPLE IS A LARGE BUT ISOLATED
     CITY, POSSIBLY A REGIONAL CENTER
     OF COMMERCE.

PRESS RETURN TO PROCEED!!!
 4--THE INFRASTRUCTURE CLOSELY
     RESEMBLES A LARGE CITY IN A
     DEVELOPED COUNTRY.  SIGNIFICANT
     PORTIONS OF THE POPULATION FINISH
     PRIMARY AND SECONDARY SCHOOL.
     RESEARCH PROFESSIONALS ARE READILY
     AVAILABLE AND HIGH TECHNOLOGY IS
     ALSO AVAILABLE.  AN EXAMPLE IS THE
     NATIONAL CAPITAL OF A DEVELOPING
     COUNTRY.

PRESS RETURN TO PROCEED!!!
 1--RURAL VILLAGE LEVEL.
 2--RURAL TOWN OR SMALL CITY LEVEL.
 3--LARGE BUT ISOLATED CITY LEVEL.
 4--NATIONAL CAPITAL LEVEL.

IF YOU NEED TO REVIEW THE DEFINATIONS
FOR THESE LEVELS ENTER HELP OTHERWISE
ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
?2
MAPMAT OFFERS TWO OPTIONS FOR
CONSTRUCTING RELATIVE COST RATIOS:

   1---TREATMENT TRAIN DATA STORED
```

```
        TEMPORARILY BY YOUR USE OF
        MAPMAT.

    2---TREATMENT TRAIN DATA WHICH YOU
        YOU HAD MAPMAT STORE
        PERMENTANTLY BY A FILE NAME.

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC.
? 1
MAPMAT WILL BE RIGHT BACK


             PLEASE WAIT!!!
TREATMENT TRAIN 1

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ------------ -- -------       -----------
1  PFT.SEW.SB   1  .4            2 24418601
2  LAG.WSP      1  2.5           25.4248256

 TOTAL PRESENT VALUE COST RATIO= 30

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 2

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ------------ -- -------       -----------
1  COMM.SEW     1  1.07          4.74394485
2  FC           1  11.28         113 962493
3  IMHOFF       1  27 .8         265.229644
4  TF STD       1  24 27         87.331712
5  CHLOR        1  13 5          54.6431827

 TOTAL PRESENT VALUE COST RATIO= 403

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 3

S               B
T               YU               OPERATION
A               EI                  AND
G               AL CAPITAL       MAINTENANCE
E  TECHNOLOGY   RT COST             COST
-- ------------ -- -------       -----------
1  IMHOFF       1  27.28         265 229644
2  TF STD       1  24.27         87.331712

 TOTAL PRESENT VALUE COST RATIO= 404
```

```
PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 4

S               B
T               YU              OPERATION
A               EI                 AND
G               AL CAPITAL      MAINTENANCE
E  TECHNOLOGY   RT COST            COST
-- ----------   -- -------      -----------
1  PC           1   11.18       113.962493
3  A.LAG.EXT    1   19.57       111.051436

 TOTAL PRESENT VALUE COST RATIO= 255

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 5

S               B
T               YU              OPERATION
A               EI                 AND
G               AL CAPITAL      MAINTENANCE
E  TECHNOLOGY   RT COST            COST
-- ----------   -- -------      -----------
1  PFF SEW.38   1   .6          2.24618601
2  LAG.USP      1   2.5         25.4268254
3  CHLOR        1   13.5        54.4631827

 TOTAL PRESENT VALUE COST RATIO= 78

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 6

S               B
T               YU              OPERATION
A               EI                 AND
G               AL CAPITAL      MAINTENANCE
E  TECHNOLOGY   RT COST            COST
-- ----------   -- -------      -----------
1  PC           1   11.18       113.962493
2  TF.HR        1   18.86       173.241804
3  CHLOR        1   13.5        54.4631827

 TOTAL PRESENT VALUE COST RATIO= 385

PRESS RETURN TO PROCEED!!!
TREATMENT TRAIN 7

S               B
T               YU              OPERATION
A               EI                 AND
G               AL CAPITAL      MAINTENANCE
E  TECHNOLOGY   RT COST            COST
-- ----------   -- -------      -----------
1  PFF SEW.38   1   .6          2.24618601
2  IMHOFF       1   27.28       245.229644
3  TF.STD       1   24.27       87.331712
```

```
4  CHLOR        5  13.5        51.7965218

 TOTAL PRESENT VALUE COST RATIO= 472

PRESS RETURN TO PROCEED!!!
      ALTERNATIVE TREATMENT TRAIN
    TOTAL PRESENT VALUE COST RATIOS

                 TOTAL PRESENT
   TREATMENT         VALUE
     TRAIN       COST RATIO
   ---------    ------------
       1             30
       2             603
       3             404
       4             255
       5             98
       6             385
       7             472

PRESS RETURN TO PROCEED!!!
MAPMAT HAS STORED YOUR TREATMENT TRAIN
COST RATIOS IN A TEMPORARY FILE.  DO
YOU WANT TO STORE THE DATA UNDER A
PERMENTANT FILE NAME?

   1-----YES
   2-----NO

ENTER THE NUMBER WHICH REPRESENTS YOUR
CHOICE; I.E., 1, 2, ETC
?2
YOU HAVE COMPLETED THE COST RATIO
SECTION OF MAPMAT.  YOU ARE READY TO
PROCEED TO ANOTHER SECTION OF MAPMAT
YOU WILL BE RETURNED TO THE MAIN MENU.

PRESS RETURN TO PROCEED!!!
```

APPENDIX X

A LISTING OF THE
MAPMAT PROGRAMS

```
]LIST

1  REM                                        MAPMAT.HELLO
2  REM
3  REM
20  GOTO 1000
25  FOR LOC = 776 TO 798: READ BYTE: POKE LOC,BYTE: NEXT
30  FOR I = 1 TO 14: READ P,D: POKE 776,P: POKE 777,D: CALL 778: NEXT
35  RETURN
100  DATA  255,255,173,48,192,136,208,5,206,9,3,240,9,202,208,245,174,8,3,76,10,3,96
105  DATA  202,72,192,72,182,72,152,72,128,72
110  DATA  172,234,102,156,108,78,102,234,172,234,162,234,102,156,108,78,102,234
190  REM
191  REM
192  REM
199  REM
UBROUTINES SECTION
200  REM
201  REM
205  FOR I = 1 TO AG: NEXT : HOME : RETURN
210  PRINT : PRINT "PRESS RETURN WHEN YOU ARE READY TO ": PRINT "PROCEED TO THE NEXT STEP.": INPUT Y$: HOME : RETURN
220  FOR I = 1 TO 3: CALL - 1059: NEXT : RETURN
1000  HOME
1001 D$ =  CHR$ (4)
1002  VTAB 3
1100  PRINT  SPC( 14);"WELCOME"
1101  PRINT
1110  PRINT  SPC( 17);"TO"
1111  PRINT : PRINT : PRINT
1119  HTAB 16: INVERSE : SPEED= 70: FLASH
1120  PRINT "MAPMAT"
1122  SPEED= 255: PRINT : NORMAL
1124  PRINT : PRINT
1130  PRINT  SPC( 16);"MODEL"
1131  PRINT
1140  PRINT  SPC( 17);"AND"
1141  PRINT
1150  PRINT  SPC( 15);"PROGRAM"
1151  PRINT
1155  PRINT  SPC( 18);"BY"
1156  PRINT : SPEED= 35: INVERSE
1160  HTAB 13: PRINT "CLYDE ARNOLD"
1170  GOSUB 25
1200  NORMAL : SPEED= 255:AG = 1000: GOSUB 205
2000  PRINT "MAPMAT REPRESENTS A PLANNING MODEL "
2010  PRINT "ENTITLED MICROCOMPUTER ASSISTED"
2020  PRINT "PLANNING MODEL FOR THE SELECTION OF"
2030  PRINT "APPROPRIATE TECHNOLOGY IN WATER"
2040  PRINT "TREATMENT AND SANITATION.": PRINT : PRINT
2050  PRINT "AS YOU USE MAPMAT YOU WILL RESPOND TO"
2060  PRINT "QUESTIONS UNTIL MAPMAT HAS SUFFICIENT"
2070  PRINT "INFORMATION TO PERFORM THE INDICATED "
2080  PRINT "ANALYSIS.  YOU WILL BE PROVIDED WITH"
2090  PRINT "SUFFICIENT INFORMATION TO USE MAPMAT IN"
2100  PRINT "AN INTERACTIVE MODE; HOWEVER, YOUR "
2110  PRINT "ANALYSIS MAY BE INPROVED BY CONSULTING"
```

```
2120  PRINT "THE MAPMAT INSTRUCTION MANUAL "
2130  PRINT : PRINT "A QUESTION MARK FOLLOWED BY A BLINKING"
2140  PRINT "SQUARE; I.E., THE CURSOR, INDICATES "
2150  PRINT "THAT MAPMAT IS WAITING YOUR RESPONSE"
2160  PRINT "TO A QUESTION "
2200  GOSUB 210
2810  PRINT D$;"RUN MAPMAT.MAIN"
```

```
]PR#0
]LIST

1  REM                                           MAPMAT.MAIN

2  REM
3  REM
20  GOTO 1000
190  REM
191  REM
192  REM
199  REM
SUBROUTINES SECTION
200  REM
201  REM
205  FOR I = 1 TO AG: NEXT : HOME : RETURN
210  PRINT : PRINT "PRESS RETURN TO PROCEED!!!": INPUT Y$: HOME : RETURN
215  FOR I = 1 TO 5: CALL  - 1059: FOR J = 15 TO AF:AF = J * 1.5: NEXT : NEXT : RETURN
220  FOR I = 1 TO 3: CALL  - 1059: NEXT : RETURN
1000  HOME
1001 D$ =  CHR$ (4)
1100  HOME
2400  PRINT "THERE ARE EIGHT SECTIONS TO THE MAPMAT"
2410  PRINT "MODEL ": PRINT
2420  HTAB 5: PRINT "MAIN======>THE PROGRAM WHICH YOU"
2425  PRINT "                    ARE CURRENTLY USING."
2430  PRINT "AVAIL.PROCESS=>DETERMINES AVAILABLE"
2440  PRINT "                    WATER AND/OR SANITATION"
2450  PRINT "                    TECHNOLOGY BASED ON DATA"
2460  PRINT "                    WHICH YOU ENTER."
2470  PRINT "COST.RATIO====>RELATIVE RANK OF COST."
2480  PRINT "COMMUNICATE===>TELECOMMUNICATION LINK "
2490  PRINT "                    TO CAPDET MODEL "
2500  PRINT "SENSITIVITY===>SENSITIVITY ANALYSIS ON"
2510  PRINT "                    MAPMAT OUTPUT."
2520  PRINT "OPTIMIZATION==>SELECT TREATMENT TRAINS": PRINT  TAB( 16);"AND SET TREATMENT GOALS."
2525  PRINT "EFFECTIVENESS=>PERFORM MULTI-OBJECTIVE": PRINT  TAB( 16);"ON COST DATA "
2550  PRINT "STATISTICS====>MULTIPLE REGRESSION"
2560  PRINT "                    ANALYSIS ON DATA WHICH"
2570  PRINT "                    YOU ENTER."
2580  GOSUB 210
2590  PRINT " 1..../====>MAIN": PRINT
2600  PRINT " 2..../====>AVAIL.PROCESS": PRINT
2610  PRINT " 3..../====>COST.RATIO": PRINT
2620  PRINT " 4..../====>COMMUNICATE": PRINT
2630  PRINT " 5..../====>SENSITIVITY": PRINT
2640  PRINT " 6..../====>OPTIMIZE": PRINT
2645  PRINT " 7..../====>EFFECTIVENESS": PRINT
2650  PRINT " 8..../====>STATISTICS": PRINT
2700  PRINT : PRINT "ENTER THE NUMBER OF THE PROGRAM WHICH"
2710  PRINT "YOU WANT TO USE.  IF YOU NEED TO "
2720  PRINT "REREAD THE PREVIOUS DESCRIPTIONS TYPE"
2730  PRINT "HELP AND PRESS RETURN. IF YOU ARE DONE": PRINT "USING MAPMAT TYPE END AND PRESS RETURN."
2740  INPUT AA$: IF AA$ = "HELP" THEN  HOME : GOTO 2400
2745  IF AA$ = "END" GOTO 2900
2747 AA =  VAL (AA$)
2750  IF AA < 1 OR AA > 7 THEN  GOSUB 220: HOME : GOTO 2590
```

```
2790  ON AA GOTO 2810,2820,2830,2840,2850,2860,2880,2870
2810  PRINT D$;"RUN MAPMAT.MAIN"
2820  PRINT D$;"RUN MAPMAT.AVAIL"
2830  PRINT D$,"RUN MAPMAT.COST"
2840  HOME : PRINT "INSERT YOUR COMMUNICATIONS SOFTWARE AND": PRINT "PRESS RETURN."
2841  PRINT D$,"PR#4"
2850  PRINT D$,"RUN MAPMAT.SENSITIVITY"
2860  PRINT D$,"RUN MAPMAT.OPTIMIZE"
2870  HOME : PRINT "INSERT YOUR STATISTICAL SOFTWARE AND": PRINT "PRESS RETURN.": PRINT : PRINT D$;"PR#6"
2880  PRINT D$;"RUN MAPMAT.EFFECTIVENESS"
2900  END
```

```
]PR#0
]LIST

1  REM                                  MAPMAT.AVAIL
10  GOTO 15000
100  REM                                         DATA STATEMENTS
105  DATA  VIPL,VIDPL,ROEC,ST,DVCT
106  DATA  PIT,PFT.SEW.SB,PFT.ST,AP,AP.SULLAGE
107  DATA  AP.SEW.SB,V&C,COMM,COMM SEW,AC
108  DATA  LAG WSP,TC,HRTC,PC,SOULDS
109  DATA  SOLAG,A.LAG EXT,CHLOR,LT,RBC
110  DATA  AB,TF.STD,TF.HR.IMHOFF,HT
111  DATA  PT,SSF,RSF,CHLOR,TSD
112  DATA  DFILT,CFILT,SOFT,DSALT1,DSALT2
200  REM                                         SUBROUTINES
205  PRINT : INPUT "PRESS RETURN TO PROCEED!!!";AA$: RETURN
210  FOR I = 1 TO 3: CALL  - 1059: NEXT : RETURN
215  PRINT
216  PRINT "ENTER THE NUMBER WHICH REPRESENTS YOUR": PRINT "CHOICE, I E., 1, 2, ETC.": INPUT AA$
217 AA = 1000: IF AA$ = "1" OR AA$ = "2" OR AA$ = "3" OR AA$ = "4" OR AA$ = "5" OR AA$ = "6" OR AA$ = "0" THEN AA =  VAL (AA$)
219  RETURN
220  PRINT  TAB( 3);"0------ UNAVAILABLE"
225  PRINT  TAB( 3);"1------ AVAILABLE": RETURN
230  FOR I = AB TO AC:A3$(I,AD) = "X":A1(I) = 0: NEXT : RETURN
235  PRINT : PRINT  TAB( 12);"2222222223333333": PRINT  TAB( 12);"1234567890123456 7": PRINT "---------- -----------------"
237  FOR J = AB TO AC
239  PRINT A1(J);A1$(J); TAB( 12);A3$(J,21);A3$(J,22);A3$(J,23);A3$(J,24);A3$(J,25);A3$(J,26);A3$(J,27);A3$(J,28);A3$(J,29);A3$(J,30
);
241  PRINT A3$(J,31);A3$(J,32);A3$(J,33);A3$(J,34);A3$(J,35);A3$(J,36);A3$(J,37)
243  IF A1$(J) = "PFT.ST" THEN  GOSUB 255: HOME : RETURN
245  IF A1$(J) = "LAG.WSP" THEN  GOSUB 255: HOME : RETURN
247  IF A1$(J) = "LT" THEN  GOSUB 255: HOME : RETURN
248  IF A1$(J) = "SSF" THEN  GOSUB 255: HOME : RETURN
249  NEXT J
250  RETURN
255  POKE 34,16: POKE 33,11: POKE 32,29: HOME : PRINT "***********": PRINT "*         *": PRINT "*  PRESS *": PRINT "* RETURN *": PRIN
T "*   TO    *": PRINT "*PROCEED!*"
256  PRINT "*         *"
260  INPUT "***********";AA$: POKE 33,40: POKE 32,0: POKE 34,3: RETURN
265  HOME : PRINT "THE PROGRAM MUST SET DEFAULT VALUES FOR": PRINT "SEVERAL VARIABLES.  MAPMAT WILL BE BACK"
275  PRINT "IN A MOMENT.": PRINT : PRINT : PRINT  TAB( 10);"PLEASE WAIT!!!": RETURN
299  RETURN
300  REM     QUESTION SUBROUTINES
305  HOME : PRINT "QUESTION 1:": PRINT : PRINT "WHAT IS THE POPULATION DENSITY": PRINT "AT THE LOCAL SITE IN PEOPLE PER"
310  PRINT "HECTARE?  THERE ARE THREE POSSIBLE ": PRINT "ANSWERS:": PRINT : PRINT  TAB( 2);"1------ POP. DENSITY <= 300"
315  PRINT  TAB( 2);"2------ POP. DENSITY <= 600": PRINT  TAB( 2);"3------ POP. DENSITY >  600"
320  GOSUB 215: IF AA < 1 OR AA > 3 THEN  GOSUB 210: GOTO 305
325 A2(1) = AA: RETURN
330  HOME : PRINT "QUESTION 2:": PRINT : PRINT "WHAT LEVEL OF WATER CAN BE EXPECTED AT"
335  PRINT "THE LOCAL SITE IN LITERS PER CAPITA PER": PRINT "DAY (LPCD).  THERE ARE SIX POSSIBLE "
340  PRINT "ANSWERS:": PRINT
345  PRINT  TAB( 3);"1------ LPCD < 4.5": PRINT  TAB( 3);"2------ LPCD >=4.5 AND < 6": PRINT  TAB( 3);"3------ LPCD >=6   AND < 35"
350  PRINT  TAB( 3);"4------ LPCD >=35  AND < 75"
355  PRINT  TAB( 3);"5------ LPCD >=75  AND < 250": PRINT  TAB( 3);"6------ LPCD >=250"
360  GOSUB 215: IF AA < 1 OR AA > 6 THEN  GOSUB 210: GOTO 330
365 A2(2) = AA
370  PRINT : PRINT "DO YOU EXPECT LOCAL WATER DISPOSAL IN": PRINT "THE SANITATION TECHNOLOGY TO BE GREATER"
```

```
375  PRINT "THAN 10 LPCD?  ENTER Y FOR YES OR N FOR": PRINT "NO.": INPUT AA$: IF AA$ = "Y" THEN A1(12) = 0:A3$(12,2) = "X": RETURN
380  IF AA$ = "N" THEN  RETURN
385  GOSUB 210: GOTO 370: RETURN
390  HOME : PRINT "QUESTION 3": PRINT "CAN THE LOCATION SITE OF THE SELECTED": PRINT "TECHNOLOGY BE EXPECTED TO PROVIDE SAFE"
395  PRINT "DISPOSAL OF SLUDGE THAT MIGHT BE ": PRINT "GENERATED?  THERE ARE TWO POSSIBLE ": PRINT "ANSWERS:"
400  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
405  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 390
410 A2(3) = AA: RETURN
415  HOME : PRINT "QUESTION 4:": PRINT : PRINT "DOES THE LOCAL SITE PROVIDE A SEWAGE": PRINT "CONNECTION?  THERE ARE TWO POSSIBLE"
420  PRINT "ANSWERS:": PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
425  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 415
430 A2(4) = AA: RETURN
435  HOME : PRINT "QUESTION 5:": PRINT : PRINT "DOES THE LOCAL SITE PROVIDE ADEQUATE,": PRINT "AND SAFE, SULLAGE DISPOSAL AT THE "
440  PRINT "PRESENT TIME?  THERE ARE TWO POSSIBLE": PRINT "ANSWERS:"
442  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
445  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 435
450 A2(5) = AA: RETURN
455  HOME : PRINT "QUESTION 6:": PRINT
460  PRINT "CERTAIN SANITATION TECHNOLOGIES USE THE": PRINT "GROUND AS A SOAKAWAY FOR LIQUID"
465  PRINT "EFFLUENT.  IN GENERAL THE HEIGHT OF THE": PRINT "GROUNDWATER MAY PRESENT PROBLEMS IF THE"
470  PRINT "SOAKAWAY WILL LEACH INTO THE LOCAL": PRINT "GROUNDWATER.  SOIL CONDITIONS WILL "
475  PRINT "DETERMINE THE CRITICAL HEIGHT OF THE": PRINT "GROUNDWATER.  FOR LOCAL CONDITIONS DO"
480  PRINT "YOU EXPECT GROUNDWATER CONTAMINATION": PRINT "TO BE A PROBLEM? THERE ARE TWO POSSIBLE"
485  PRINT "ANSWERS:"
490  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
495  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 455
500 A2(6) = AA: RETURN
505  HOME : PRINT "QUESTION 7:": PRINT
510  PRINT "WHAT TYPE OF WATER CONNECTION EXISTS, ": PRINT "OR WILL EXIST, AT THE LOCAL SITE?"
515  PRINT "THERE ARE FOUR POSSIBLE ANSWERS:": PRINT
520  PRINT  TAB( 3);"1------ NONE": PRINT  TAB( 3);"2------ STANDPIPE IN NEIGHBORHOOD"
525  PRINT  TAB( 3);"3------ YARD CONNECTION": PRINT  TAB( 3);"4------ HOUSE CONNECTION"
530  GOSUB 215: IF AA < 1 OR AA > 4 THEN  GOSUB 210: GOTO 505
535 A2(7) = AA: RETURN
540  HOME : PRINT "QUESTION 8:": PRINT
545  PRINT "CERTAIN SANITATION TECHNOLOGIES WILL ": PRINT "NOT TOLERATE ANAL CLEANSING MATERIALS"
550  PRINT "WHICH WILL NOT EASILY DECOMPOSE OR": PRINT "WHICH MIGHT CLOG THE DISCHARGE PIPE."
555  PRINT "IN GENERAL SUCH MATERIAL AS CEMENT (OR": PRINT "OTHER HEAVY) SACKING, CORNCOBS, "
560  PRINT "MUDBALLS, ETC., WILL IMPEDE THE PROPER": PRINT "OPERATION OF SEVERAL TECHNOLOGIES.  AT"
565  PRINT "THE LOCAL DESIGN SITE WOULD YOU EXPECT": PRINT "THE ABOVE MATERIALS TO BE USED AS ANAL"
570  PRINT "CLEANSERS?  THERE ARE TWO POSSIBLE ": PRINT "ANSWERS:": PRINT
575  PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
580  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 540
585 A2(8) = AA
590  PRINT : PRINT "DO YOU EXPECT WATER TO BE USED AS AN ": PRINT "ANAL CLEANSER?  THERE ARE"
595  PRINT "TWO POSSIBLE ANSWERS:"
600  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
605  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 590
610  IF AA = 1 THEN A1(5) = 0:A3$(5,8) = "X"
615  RETURN
620  HOME : PRINT "QUESTION 9:": PRINT
625  PRINT "SOME SOCIETIES WILL NOT FEEL AT EASE ": PRINT "WITH A SANITATION TECHNOLOGY WHICH "
630  PRINT "PERMITS THE PRESENCE OF VISIBLE": PRINT "EXCRETA.  WOULD YOU SAY THAT THE LOCAL"
635  PRINT "POPULATION WOULD NOT BE LIKELY TO USE": PRINT "A TECHNOLOGY WHICH, AS A MATTER OF"
640  PRINT "OPERATION, EXPOSED EXCRETA TO VIEW?": PRINT "THERE ARE TWO POSSIBLE ANSWERS:"
645  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
650  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 620
```

```
655 A2(9) = AA: RETURN
660  HOME : PRINT "QUESTION 10:": PRINT
665  PRINT "SEVERAL TECHNOLOGIES MAY PROVIDE A GOOD": PRINT "BREEDING SPOT FOR MOSQUITOES AND/OR"
670  PRINT "FLIES UNLESS AN INHIBITOR IS UTILIZED": PRINT "BY THE USER AND/OR THE MAINTENANCE"
672  PRINT "PEOPLE.  THE INHIBITOR COULD BE EITHER"
675  PRINT "CHEMICAL OR A MECHANICAL DEVICE OF ": PRINT "SIMPLE DESIGN SUCH AS A COVER.  WOULD"
680  PRINT "YOU EXPECT THE LOCAL USERS, OR ": PRINT "MAINTENANCE PEOPLE, TO RESIST THE USE"
685  PRINT "OF AN INHIBITOR? THERE ARE TWO POSSIBLE": PRINT "ANSWERS:"
690  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
695  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 660
700 A2(10) = AA: RETURN
705  HOME : PRINT "QUESTION 11:": PRINT
710  PRINT "HUMUS PRODUCED IN COMPOSTING ACTIVITY": PRINT "MAY BE USED AS AN ORGANIC FERTILIZER IF"
715  PRINT "THERE IS NOT RESISTENCE TO THE USE OF": PRINT "THE HUMUS OR THE HANDLING OF THE HUMUS."
720  PRINT "WOULD YOU EXPECT THE LOCAL POPULATION": PRINT "TO RESIST THE USE OR HANDLING OF HUMUS?"
725  PRINT "THERE ARE TWO POSSIBLE ANSWERS:"
730  PRINT : PRINT  TAB( 3);"1------ YES": PRINT  TAB( 3);"2------ NO"
735  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 705
740 A2(11) = AA: RETURN
745  HOME : PRINT "QUESTION 12:": PRINT
750  PRINT "CERTAIN TECHNOLOGIES REQUIRE USER ": PRINT "TRAINING AT ONE OF THE FOLLOWING"
755  PRINT "LEVELS:": PRINT : PRINT  TAB( 2);"VERY LOW->BASIC USE TRAINING REQUIRED"
760  PRINT  TAB( 2);"LOW->VERY LOW + DISRUPT PREVENTATION": PRINT  TAB( 2);"MEDIUM->LOW + USE/DISEASE TRANSMITTAL"
765  PRINT  TAB( 2);"HIGH->MEDIUM + MAINTENANCE/OPERATION": PRINT
770  PRINT "WHICH OF THE FOUR LEVELS BEST DESCRIBE": PRINT "LOCAL TRAINING AVAILABILITY?"
775  PRINT : PRINT  TAB( 3);"1------ VERY LOW": PRINT  TAB( 3);"2------ LOW": PRINT  TAB( 3);"3------ MEDIUM": PRINT  TAB( 3);"4----
-- HIGH"
800  GOSUB 215: IF AA < 1 OR AA > 4 THEN  GOSUB 210: GOTO 745
805 A2(12) = AA: RETURN
810  HOME : PRINT "QUESTION 13:": PRINT
820  PRINT "CRITICAL TO THE SUCCESSFUL OPERATION OF": PRINT "MANY TECHNOLOGIES IS THE LEVEL OF LOCAL"
825  PRINT "INFRASTRUCTURE: I.E.,LOCAL NETWORK OF ": PRINT "SUPPORT FOR DEVELOPMENT.  WHICH"
830  PRINT "OF THE FOLLOWING THREE LEVELS BEST": PRINT "DESCRIBES THE LOCAL SITE?"
835  PRINT : PRINT  TAB( 2);"1--- LOW->USER CAN MAINTAIN"
840  PRINT  TAB( 2);"2--- MEDIUM->PART-TIME GROUP/PERSON": PRINT  TAB( 2);"           REQUIRED TO MAINTAIN"
845  PRINT  TAB( 2);"3--- HIGH->FULL TIME GROUP/PERSON": PRINT "          REQUIRED TO MAINTAIN"
850  GOSUB 215: IF AA < 1 OR AA > 3 THEN  GOSUB 210: GOTO 810
855 A2(13) = AA: RETURN
860  HOME : PRINT "QUESTION 14 THROUGH 17:": PRINT
865  PRINT "LABOR IS REQUIRED FOR THE CONSTRUCTION": PRINT "AS WELL AS THE OPERATION AND "
870  PRINT "MAINTENANCE OF THE TECHNOLOGIES.  THERE": PRINT "ARE FOUR TYPES OF LABOR INCLUDE IN THIS"
875  PRINT "ANALYSIS:": PRINT
880  PRINT  TAB( 3);"UNSKILLED=====> COMMON LABORER"
885  PRINT  TAB( 3);"SEMISKILLED===> PLUMBERS HELPER"
890  PRINT  TAB( 3);"SKILLED=======> EXPERIENCED PLUMBER"
895  PRINT  TAB( 3);"PROFESSIONAL==> ENGINEER"
900  POKE 34,13: RETURN
910  HOME : PRINT "QUESTION 14:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF UNSKILLED"
920  PRINT "CONSTRUCTION LABOR AT THE LOCAL SITE?": PRINT
930  GOSUB 220
950  GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 910
955 A2(14) = AA
960  HOME : PRINT "QUESTION 15:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF SEMISKILLED"
965  PRINT "CONSTRUCTION LABOR AT THE LOCAL SITE?": PRINT
970  GOSUB 220
975  GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 960
980 A2(15) = AA
```

```
985  HOME : PRINT "QUESTION 16:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF SKILLED"
990  PRINT "CONSTRUCTION LABOR AT THE LOCAL SITE?": PRINT
995  GOSUB 220
1000  GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 985
1005 A2(16) = AA
1010  HOME : PRINT "QUESTION 17:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF "
1015  PRINT "CONSTRUCTION PROFESSIONALS AT THE SITE?": PRINT
1020  GOSUB 220
1025  GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1010
1030 A2(17) = AA: TEXT : RETURN
1035  HOME : PRINT "QUESTION 18:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF UNSKILLED"
1040  PRINT "OPERATION & MAINTENANCE LABOR LOCALLY?": PRINT
1050  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1035
1055 A2(18) = AA
1060  HOME : PRINT "QUESTION 19:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF SEMISKILLED"
1065  PRINT "OPERATION & MAINTENANCE LABOR LOCALLY?": PRINT
1070  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1060
1075 A2(19) = AA
1080  HOME : PRINT "QUESTION 20:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF SKILLED"
1085  PRINT "OPERATION & MAINTENANCE LABOR LOCALLY?": PRINT
1090  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1080
1095 A2(20) = AA
1100  HOME : PRINT "QUESTION 21:": PRINT : PRINT "WHAT IS THE AVAILABILITY OF O&M"
1105  PRINT "PROFESSIONAL LABOR AT THE LOCAL SITE?": PRINT
1110  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1100
1115 A2(21) = AA: TEXT : RETURN
1120  HOME : PRINT "QUESTION 22 THROUGH 24:": PRINT
1125  PRINT "THREE TYPES OF EQUIPMENT MAY BE": PRINT "REQUIRED FOR OPERATION AND MAINTENANCE"
1130  PRINT "ACTIVITY:": PRINT
1135  PRINT  TAB( 2);"ELECTRICAL EQUIPMENT; E.G., A MOTOR,"
1140  PRINT  TAB( 2);"LABORATORY EQUIPMENT; E.G., A BALENCE,"
1145  PRINT  TAB( 2);"ELECTRONIC EQUIPMENT; E.G., A COMPUTER."
1150  POKE 34,11
1160  HOME : PRINT "QUESTION 22:": PRINT
1165  PRINT "DO YOU EXPECT ELECTRICAL EQUIPMENT TO": PRINT "BE AVAILABLE WITHIN 24 HOURS IN THE "
1170  PRINT "DESIGN AREA?": PRINT
1180  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1160
1185 A2(22) = AA
1190  HOME : PRINT "QUESTION 23:": PRINT
1195  PRINT "DO YOU EXPECT LABORATORY EQUIPMENT TO": PRINT "BE AVAILABLE WITHIN 24 HOURS IN THE"
1200  PRINT "DESIGN AREA?": PRINT
1205  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1190
1210 A2(23) = AA
1215  HOME : PRINT "QUESTION 24:": PRINT
1220  PRINT "DO YOU EXPECT ELECTRONIC EQUIPMENT TO": PRINT "BE AVAILABLE WITHIN 24 HOURS IN THE"
1225  PRINT "DESIGN AREA?": PRINT
1230  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1215
1235 A2(24) = AA: TEXT : RETURN
1240  HOME : PRINT "QUESTION 25 THROUGH 28:": PRINT
1245  PRINT "FOUR TYPES OF SUPPLIES MAY BE": PRINT "REQUIRED FOR OPERATION AND MAINTENANCE"
1250  PRINT "ACTIVITY:": PRINT
1255  PRINT  TAB( 2);"CHEMICAL SUPPLIES; E.G., CHLORINE."
1260  PRINT  TAB( 2);"PROCESS SUPPLIES; E.G., PIPE."
1265  PRINT  TAB( 2);"OPERATION AND MAINTENANCE SUPPLIES; ": PRINT  TAB( 2);"E.G., PAINT."
1267  PRINT  TAB( 2);"LABORATORY SUPPLIES; E.G., TEST TUBES": PRINT
1270  POKE 34,11
1275  HOME : PRINT "QUESTION 25:": PRINT
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1280  PRINT "DO YOU EXPECT CHEMICAL SUPPLIES TO": PRINT "BE AVAILABLE WITHIN 24 HOURS IN THE "
1285  PRINT "DESIGN AREA?": PRINT
1290  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1275
1295 A2(25) = AA
1300  HOME : PRINT "QUESTION 26:": PRINT
1305  PRINT "DO YOU EXPECT PROCESS SUPPLIES TO": PRINT "BE AVAILABLE WITHIN 24 HOURS IN THE"
1310  PRINT "DESIGN AREA?": PRINT
1315  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1300
1320 A2(26) = AA
1325  HOME : PRINT "QUESTION 27:": PRINT
1330  PRINT "DO YOU EXPECT OPERATION AND MAINTENANCE": PRINT "SUPPLIES TO BE AVAILABLE WITHIN 24 "
1335  PRINT "HOURS IN THE DESIGN AREA?": PRINT
1340  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1325
1345 A2(27) = AA
1350  HOME : PRINT "QUESTION 28:": PRINT
1355  PRINT "DO YOU EXPECT LABORATORY SUPPLIES TO": PRINT "BE AVAILABLE WITHIN 24 HOURS IN THE"
1360  PRINT "DESIGN AREA?": PRINT
1365  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1350
1370 A2(28) = AA: TEXT : RETURN
1380  HOME : PRINT "QUESTION 29 AND 30:"
1385  PRINT "TWO TYPES OF ENERGY MAY BE REQUIRED": PRINT "FOR OPERATION AND MAINTENANCE ACTIVITY:"
1395  PRINT "ELECTRICAL ENERGY AND OTHER ENERGY": PRINT "SOURCES SUCH AS DIESEL, GASOLINE, ETC."
1400  PRINT "THERE ARE FOUR LEVELS OF SUPPLY ": PRINT "AVAILIBILITY: NONE, LOW, MEDIUM, HIGH."
1405  POKE 34,0
1410  HOME : PRINT "QUESTION 29:": PRINT : PRINT "FOR ELECTRICAL ENERGY THE LEVELS ARE "
1413  PRINT "MEASURED IN PUMPING CAPACITY OF GALLONS": PRINT "PER MINUTE (GPM) OR PER DAY (GPD):": PRINT
1414  PRINT  TAB( 2);"0---NONE....RANGE: NONE OR LIGHTS ONLY"
1415  PRINT  TAB( 2);"1---LOW.....RANGE: 700<= GPM"
1420  PRINT  TAB( 2);"2---MEDIUM..RANGE: 700<  GPM < 10,000"
1425  PRINT  TAB( 2);"3---HIGH....RANGE. GPM > 10,000 OR": PRINT  TAB( 2);"                    GPD >= 15 MILLION"
1430  PRINT : PRINT "WHICH LEVEL INDICATES THE LOCAL SITE?"
1435  GOSUB 216: IF AA < 0 OR AA > 3 THEN  GOSUB 210: GOTO 1408
1440 A2(29) = AA
1445  HOME : PRINT "QUESTION 30:": PRINT :: PRINT "FOR OTHER ENERGY THE LEVELS ARE"
1446  PRINT "MEASURED AS FREQUENCY OF USE FOR": PRINT "VECHICLES OR FUEL POWERED MOTORS:"
1449  PRINT : PRINT  TAB( 3);"0---NONE....NO OR VERY LITTLE USE"
1450  PRINT  TAB( 3);"1---LOW.....WEEKLY OR INFREQUENT USE"
1455  PRINT  TAB( 3);"2---MEDIUM..DAILY USE OR PART-TIME"
1460  PRINT  TAB( 3);"3---HIGH....FULL-TIME USE."
1463  PRINT : PRINT "HOW WOULD YOU RATE THE AVAILABILITY OF": PRINT "FUEL FOR USE AT THE LOCAL SITE?"
1465  GOSUB 216: IF AA < 0 OR AA > 3 THEN  GOSUB 210: GOTO 1445
1470 A2(30) = AA: TEXT : RETURN
1475  HOME : PRINT "QUESTION 31:": PRINT
1480  PRINT "LAND IS A NECESSARY PART OF ANY WATER": PRINT "SUPPLY OR SANITATION TECHNOLOGY.  THREE"
1485  PRINT "LEVELS OF LAND AVAILABILITY ARE USED IN": PRINT "THIS ANALYSIS:": PRINT
1490  PRINT  TAB( 2);"1--LOW-----       AVAILABLE ACRES <= .1"
1495  PRINT  TAB( 2);"2--MEDIUM-- .1 < AVAILABLE ACRES <  .5"
1500  PRINT  TAB( 2);"3--HIGH----       AVAILABLE ACRES >= .5"
1505  PRINT : PRINT "ON A PER CAPITA BASIS WHAT IS THE LAND": PRINT "AVAILABILITY AT THE DESIGN SITE?"
1510  PRINT : GOSUB 215: IF AA < 1 OR AA > 3 THEN  GOSUB 210: GOTO 1475
1515 A2(31) = AA: RETURN
1520  HOME : PRINT "QUESTION 32:": PRINT
1525  PRINT "ORGANIC COMPOSTING MATERIALS SUCH AS": PRINT "STRAW, LEAVES, ETC., ARE REQUIRED FOR"
1530  PRINT "CERTAIN SANITATION TECHNOLOGIES.  DO": PRINT "YOU EXPECT ADEQUATE AMOUNTS OF THESE"
1535  PRINT "TYPE MATERIALS TO BE AVAILABLE AT THE": PRINT "DESIGN SITE?": PRINT
1540  GOSUB 220: GOSUB 215: IF AA < 0 OR AA > 1 THEN  GOSUB 210: GOTO 1520
1545 A2(32) = AA: RETURN
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1550  HOME : PRINT "QUESTIONS 33 THROUGH 35:": PRINT
1555  PRINT "CERTAIN TECHNOLOGIES MAY BE HAZARDOUS": PRINT "TO LOCAL HEALTH IF PARTICULAR "
1560  PRINT "CONDITIONS ARE MET.  IN GENERAL THE ": PRINT "CONDITIONS RELATE THE SPREAD OF A "
1565  PRINT "DISEASE TO FAVORABLE CONDITIONS ": PRINT "PRODUCED BY A TECHNOLOGY.  THERE ARE "
1570  PRINT "THREE MAJOR AREAS WHICH RELATE TO ": PRINT "HEALTH CONSTRAINTS ON TECHNOLOGY: HEAVY"
1575  PRINT "METALS , INSECTS, AND HELMINTHS."
1580  POKE 34,2: GOSUB 205
1585  HOME : PRINT "QUESTION 33:              ": PRINT
1590  PRINT "DOES THE LOCAL POPULATION CONSUME  ": PRINT "PARTIALLY COOKED MEAT AND ARE HELMINTH"
1595  PRINT "RELATED DISEASES WHICH ARE TRANSMITTED": PRINT "BY FOOD CONSUMPTION, E G., "
1600  PRINT "CLONORCHIOSIS AND DIPHYOBOTHRIASIS "
1601  PRINT "PREVALENT IN THE LOCAL AREA?": PRINT : PRINT  TAB( 4);"1------ YES": PRINT  TAB( 4);"2------ NO"
1605  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 1585
1610 A2(33) = AA: RETURN
1615  HOME : PRINT "QUESTION 34:": PRINT
1620  PRINT "DO THE WATER TRANSMITTED HELMINTH ": PRINT "DISEASES SUCH AS SCHISTOSOMAISIS EXISTS"
1625  PRINT "IN THE LOCAL AREA?": PRINT
1630  PRINT  TAB( 4);"1------ YES": PRINT  TAB( 4);"2------ NO"
1635  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 1615
1640 A2(34) = AA: RETURN
1645  HOME : PRINT "QUESTION 35:": PRINT
1650  PRINT "DO THE SOIL TRANSMITTED DISEASES SUCH": PRINT "AS ASCARAISIS EXIST IN THE LOCAL AREA?": PRINT
1652  PRINT  TAB( 4);"1------ YES": PRINT  TAB( 4),"2------ NO"
1655  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 1645
1660 A2(35) = AA: TEXT : RETURN
1665  HOME : PRINT "QUESTION 36:": PRINT
1670  PRINT "SEVERAL TECHNOLOGIES  MAY PROVIDE A ": PRINT "FAVORABLE HABITAT FOR THE BREEDING OF"
1675  PRINT "INSECTS WHICH ARE VECTORS FOR MANY ": PRINT "DISEASES SUCH AS YELLOW FEVER, MALARIA,"
1680  PRINT "ETC.  THESE DISEASES MAY BE TRANSMITTED": PRINT "BY INSECT BITES OR BY THE INSECT HAVING"
1685  PRINT "CONTACT WITH A HUMAN'S FOOD OR BODY ": PRINT "IF LOCAL CONDITIONS PROVIDE A FAVORABLE"
1690  PRINT "HABITAT FOR INSECTS THEN CERTAIN ": PRINT "TECHNOLOGIES MAY ENHANCE THE INSECT"
1695  PRINT "POPULATION.  DO YOU EXPECT INSECTS TO": PRINT "BE A PROBLEM IN THE LOCAL AREA?": PRINT
1700  PRINT  TAB( 4);"1------ YES": PRINT  TAB( 4),"2------ NO"
1705  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 1665
1710 A2(36) = AA: RETURN
1715  HOME : PRINT "QUESTION 37:":: PRINT
1720  PRINT "THE SANITATION TECHNOLOGIES WHICH USE ": PRINT "COMPOSTING OR LAND TREATMENT"
1725  PRINT "MAY CONTRIBUTE TO DISEASE IF THE ": PRINT "RESIDUAL IS USED IN AGRICULTURAL "
1730  PRINT "ACTIVITIES.  THE DISEASES WOULD ARISE ": PRINT "FROM HEAVY METALS BEING TRANSMITTED TO"
1735  PRINT "HUMAN FOOD OR HUMAN CONTACT.  WOULD YOU": PRINT "EXPECT HEAVY METALS TO PRESENT A "
1740  PRINT "PROBLEM IN THE LOCAL AREA?": PRINT
1745  PRINT  TAB( 4);"1------ YES": PRINT  TAB( 4);"2------ NO"
1750  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 1715
1755 A2(37) = AA: RETURN
1998  REM
2000  REM   AVAILIBILITY/QUESTIONS SUBROUTINES
2010  FOR I = 1 TO 4:A3$(I,1) = "X":A1(I) = 0: NEXT : RETURN
2015 A3$(5,1) = "X":A3$(6,1) = "X":A3$(15,1) = "X":A1(5) = 0:A1(6) = 0:A1(15) = 0: RETURN
2020 A3$(4,2) = "X":A3$(7,2) = "X":A3$(9,2) = "X":A3$(10,2) = "X":A3$(11,2) = "X"
2025 A1(4) = 0:A1(7) = 0:A1(9) = 0:A1(10) = 0:A1(11) = 0
2030 A3$(6,2) = "X":A3$(8,2) = "X":A1(6) = 0:A1(8) = 0
2035 A3$(13,2) = "X":A1(13) = 0
2040 A3$(14,2) = "X":A1(14) = 0
2045 A3$(16,2) = "X":A1(16) = 0: FOR I = 19 TO 29:A3$(I,2) = "X":A1(I) = 0: NEXT : RETURN
2050  FOR I = 2 TO 13:A3$(I,3) = "X":A1(I) = 0: NEXT :A3$(17,3) = "X":A3$(18,3) = "X":A1(17) = 0:A1(18) = 0
2055  FOR I = 31 TO 33:A3$(I,3) = "X":A1(I) = 0: NEXT
2060  FOR I = 35 TO 40:A3$(I,3) = "X":A1(I) = 0: NEXT : RETURN
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2065 A3$(7,4) = "X":A3$(11,4) = "X":A3$(14,4) = "X": FOR I = 19 TO 29:A3$(I,4) = "X":A1(I) = 0: NEXT
2070 A1(7) = 0:A1(11) = 0:A1(14) = 0: RETURN
2075  FOR I = 1 TO 3:A3$(I,5) = "X":A1(I) = 0: NEXT : FOR I = 5 TO 6:A3$(I,5) = "X":A1(I) = 0: NEXT : FOR I = 8 TO 9:A3$(I,5) = "X":
A1(I) = 0: NEXT :
2080 A3$(12,5) = "X":A1(12) = 0: RETURN
2090  FOR I = 1 TO 4:A3$(I,6) = "X":A1(I) = 0: NEXT : FOR I = 8 TO 10:A3$(I,6) = "X":A1(I) = 0: NEXT :A3$(15,6) = "X":A1(15) = 0: RE
TURN
2095 A3$(8,7) = "X":A3$(9,7) = "X":A1(8) = 0:A1(9) = 0:A3$(13,7) = "X":A3$(14,7) = "X":A1(13) = 0:A1(14) = 0
2100 A3$(4,7) = "X":A1(4) = 0:A3$(10,7) = "X":A1(10) = 0:A3$(11,7) = "X":A1(11) = 0
2105  FOR I = 19 TO 29:A3$(I,7) = "X":A1(I) = 0: NEXT : RETURN
2110  FOR I = 6 TO 8:A3$(I,8) = "X":A1(I) = 0: NEXT :A3$(13,8) = "X":A1(13) = 0: RETURN
2115  FOR I = 1 TO 2:A3$(I,9) = "X":A1(I) = 0: NEXT :A3$(5,9) = "X":A1(5) = 0: FOR I = 9 TO 12:A3$(I,9) = "X":A1(I) = 0: NEXT : RETU
RN
2120  FOR I = 1 TO 3:A3$(I,10) = "X":A1(I) = 0: NEXT :A3$(9,10) = "X":A1(9) = 0: FOR I = 12 TO 13:A3$(I,10) = "X":A1(I) = 0: NEXT
2125  FOR I = 15 TO 17:A3$(I,10) = "X":A1(I) = 0: NEXT : FOR I = 20 TO 22:A3$(I,10) = "X":A1(I) = 0: NEXT
2130  FOR I = 24 TO 25:A3$(I,10) = "X":A1(I) = 0: NEXT : FOR I = 27 TO 28:A3$(I,10) = "X":A1(I) = 0: NEXT : FOR I = 30 TO 31:A3$(I,1
0) = "X":A1(I) = 0: NEXT : RETURN
2135 A3$(2,11) = "X":A1(2) = 0:A3$(5,11) = "X":A1(5) = 0:A3$(9,11) = "X":A1(9) = 0:A3$(12,11) = "X":A1(12) = 0:A3$(17,11) = "X":A1(1
7) = 0
2140 A3$(18,11) = "X":A1(18) = 0: RETURN
2145  FOR I = 7 TO 8:A3$(I,12) = "X":A1(I) = 0: NEXT : FOR I = 10 TO 12:A3$(I,12) = "X":A1(I) = 0: NEXT : FOR I = 34 TO 37:A3$(I,12)
 = "X":A1(I) = 0: NEXT :A3$(14,12) = "X":A1(14) = 0
2150  FOR I = 1 TO 3:A3$(I,12) = "X":A1(I) = 0: NEXT :A3$(6,12) = "X":A1(6) = 0:A3$(9,12) = "X":A1(9) = 0:A3$(13,12) = "X":A1(13) =
0
2152 A3$(5,12) = "X":A1(5) = 0: RETURN
2155 A3$(4,13) = "X":A1(4) = 0:A3$(8,13) = "X":A1(8) = 0:A3$(10,13) = "X":A1(10) = 0:A3$(11,13) = "X":A1(11) = 0:A3$(14,13) = "X":A1
(14) = 0
2160  FOR I = 19 TO 22:A3$(I,13) = "X":A1(I) = 0: NEXT :A3$(24,13) = "X":A1(24) = 0: FOR I = 27 TO 28:A3$(I,13) = "X":A1(I) = 0: NEX
T : FOR I = 31 TO 33:A3$(I,13) = "X":A1(I) = 0: NEXT
2165 A3$(5,13) = "X":A1(5) = 0: FOR I = 12 TO 15:A3$(I,13) = "X":A1(I) = 0: NEXT : FOR I = 17 TO 18:A3$(I,13) = "X":A1(I) = 0: NEXT
:A3$(23,13) = "X":A1(23) = 0
2170  FOR I = 25 TO 26:A3$(I,13) = "X":A1(I) = 0: NEXT :A3$(29,13) = "X":A1(29) = 0: FOR I = 34 TO 35:A3$(I,13) = "X":A1(I) = 0: NEX
T
2175  FOR I = 38 TO 40:A3$(I,13) = "X":A1(I) = 0: NEXT : RETURN
2180 AB = 7:AC = 7:AD = 29: GOSUB 230:AB = 11:AC = 11:AD = 29: GOSUB 230:AB = 14:AC = 14:AD = 29: GOSUB 230
2185 AB = 16:AC = 17:AD = 29: GOSUB 230:AB = 20:AC = 21:AD = 29: GOSUB 230:AB = 23:AC = 23:AD = 29: GOSUB 230
2190 AB = 31:AC = 31:AD = 29: GOSUB 230:AB = 35:AC = 35:AD = 29: GOSUB 230:AB = 38:AC = 38:AD = 29: GOSUB 230
2195 AB = 18:AC = 19:AD = 29: GOSUB 230:AB = 22:AC = 22:AD = 29: GOSUB 230:AB = 29:AC = 29:AD = 29: GOSUB 230
2200 AB = 32:AC = 33:AD = 29: GOSUB 230:AB = 37:AC = 37:AD = 29: GOSUB 230
2205 AB = 24:AC = 28:AD = 29: GOSUB 230:AB = 33:AC = 33:AD = 29: GOSUB 230:AB = 40:AC = 40:AD = 29: GOSUB 230: RETURN
2210 AB = 4:AC = 4:AD = 30: GOSUB 230:AB = 8:AC = 11:AD = 30: GOSUB 230:AB = 13:AC = 15:AD = 30: GOSUB 230
2215 AB = 17:AC = 18:AD = 30: GOSUB 230:AB = 20:AC = 21:AD = 30: GOSUB 230
2220 AB = 12:AC = 12:AD = 30: GOSUB 230:AB = 24:AC = 24:AD = 30: GOSUB 230: RETURN
2225 AB = 4:AC = 4:AD = 31: GOSUB 230:AB = 7:AC = 8:AD = 31: GOSUB 230:AB = 10:AC = 11:AD = 31: GOSUB 230
2230 AB = 14:AC = 14:AD = 31: GOSUB 230:AB = 17:AC = 19:AD = 31: GOSUB 230:AB = 25:AC = 29:AD = 31: GOSUB 230:AB = 33:AC = 33:AD = 3
1: GOSUB 230
2235 AB = 39:AC = 40:AD = 31: GOSUB 230
2240 AB = 15:AC = 16:AD = 31: GOSUB 230:AB = 20:AC = 22:AD = 31: GOSUB 230:AB = 24:AC = 24:AD = 31: GOSUB 230
2245 AB = 32:AC = 32:AD = 31: GOSUB 230: RETURN
2500  PRINT D$,"OPEN";F$
2505  PRINT D$,"DELETE";F$
2510  PRINT D$;"OPEN";F$;",L20"
2515  FOR I = 1 TO 40:B = 0
2520  PRINT D$,"WRITE";F$;",R";I;",B";B
2525  PRINT A1$(I): PRINT A1(I): PRINT A2(I)
2530  NEXT
2535  PRINT D$;"CLOSE";F$
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2540  RETURN
2550  HOME : PRINT "DO YOU NEED AT CATALOG OF THE DISK?": PRINT : PRINT "   1-----YES": PRINT "   2-----NO"
2555  GOSUB 215: IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 2550
2560  IF AA = 2 GOTO 2570
2565  PRINT D$;"CATALOG"
2566  GOSUB 205
2570  RETURN
25000  REM                                        MAIN PROGRAM
25020 D$ =  CHR$ (4):I$ =  CHR$ (9):W$ =  CHR$ (23): REM    CONTRL DFOR DOS, CONTROL I AND W FOR PRINTER
25030  HOME : PRINT "DO YOU WANT THE PRINTER ON?": PRINT : PRINT  TAB( 3);"1-----YES": PRINT  TAB( 3);"2-----NO"
25033  GOSUB 215
25034  IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 25030
25036  IF AA = 2 GOTO 25054
25040  PRINT D$;"PR#1"
25045  PRINT W$;I$;"I"
25054  HOME
25055  PRINT "WELCOME TO THE SECTION OF MAPMAT WHICH": PRINT "DETERMINES WHICH TREATMENT TECHNOLOGIES"
25060  PRINT "ARE APPROPRIATE AT A LOCAL SITE   IF ": PRINT "YOU ARE IN THE WRONG SECTION OF MAPMAT"
25065  PRINT "THEN TYPE IN WRONG AND PRESS RETURN.": PRINT "YOU WILL BE RETURNED TO MAPMAT'S MAIN"
25070  PRINT "MENU.  IF THIS IS THE RIGHT SECTION OF": PRINT "MAPMAT, THEN TYPE IN RIGHT AND PRESS"
25075  PRINT "RETURN.": INPUT AA$
25080  IF AA$ = "RIGHT" GOTO 25100
25085  IF AA$ = "WRONG" GOTO 25095
25090  GOSUB 210: GOTO 25054
25095  PRINT D$;"RUN MAPMAT.MAIN"
25100  DIM A1(40),A1$(40),A2(40),A3$(40,37)
25105  GOSUB 265
25115  FOR I = 1 TO 40: FOR J = 1 TO 37:A3$(I,J) = " ": NEXT J: NEXT I
25130  FOR I = 1 TO 40:A1(I) = 1: NEXT
25135  FOR I = 1 TO 38:A2(I) = 0: NEXT
25140  FOR I = 1 TO 40: READ A1$(I): NEXT
25145  HOME : PRINT "IN THE FOLLOWING ANALYSIS YOU WILL BE"
25150  PRINT "ANSWERING 38 QUESTIONS CONCERNING THE": PRINT "DESIGN SITE.  THE ANSWERS TO THESE ": PRINT "QUESTIONS MAY RESULT IN SO
ME OF THE"
25155  PRINT "TECHNOLOGIES BEING CONSIDERED ": PRINT "INAPPROPRIATE TO LOCAL CONDITIONS BY": PRINT "MAPMAT.  YOU WILL HAVE A CHANCE
TO "
25160  PRINT "REVISE THE TECHNOLOGY SELECTION DURING": PRINT "THE SENSITIVITY SECTION OF MAPMAT."
25163  REM      TECHNICAL CONSTRAINTS
25165  GOSUB 205: GOSUB 305
25170  GOSUB 338
25175  GOSUB 390
25180  GOSUB 415
25185  GOSUB 435
25190  GOSUB 453
25195  GOSUB 505
25205  REM    SOCIAL/CULTURAL CONSTRAINTS
25206  REM
25210  GOSUB 540
25215  GOSUB 620
25220  GOSUB 660
25225  GOSUB 705
25230  GOSUB 745
25235  GOSUB 910
25237  REM
25240  REM     RESOURCE CONSTRAINTS
25250  GOSUB 840: GOSUB 910
25255  HOME : PRINT "QUESTION 18 THROUGH 21": PRINT : GOSUB 865: GOSUB 1035
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25260   GOSUB 1120
25265   GOSUB 1240
25270   GOSUB 1360
25275   GOSUB 1475
25280   GOSUB 1520
25285   REM
25288   REM
25290   GOSUB 1550
25295   GOSUB 1615
25300   GOSUB 1645
25305   GOSUB 1665
25310   GOSUB 1715
25317   REM
25400   REM        AVAILABILITY/QUESTION SECTION
25450   REM  Q1
25455   IF A2(1) > 1 THEN  GOSUB 2010
25460   IF A2(1) > 2 THEN  GOSUB 2015
25465   REM
25470   REM  Q2
25475   IF A2(2) = 1 THEN  GOSUB 2020
25480   IF A2(2) = 2 THEN  GOSUB 2030
25485   IF A2(2) = 3 THEN  GOSUB 2035
25490   IF A2(2) = 4 THEN  GOSUB 2040
25495   IF A2(2) = 5 THEN  GOSUB 2045
25500   REM
25505   REM     Q3
25510   IF A2(3) = 2 THEN  GOSUB 2050
25515   REM
25520   REM     Q4
25525   IF A2(4) = 2 THEN  GOSUB 2065
25530   REM
25535   REM     Q5
25540   IF A2(5) = 2 THEN  GOSUB 2075
25545   REM
25550   REM     Q6
25555   IF A2(6) = 1 THEN  GOSUB 2090
25560   REM
25565   REM  Q7
25570   IF A2(7) = 1 THEN  GOSUB 2095
25575   IF A2(7) = 2 THEN  GOSUB 2100
25580   IF A2(7) = 3 THEN  GOSUB 2105
25585   REM
25590   REM     Q8
25595   IF A2(8) = 1 THEN  GOSUB 2110
25600   REM
25605   REM     Q9
25610   IF A2(9) = 1 THEN  GOSUB 2115
25611   REM
25612   REM      Q10
25615   IF A2(10) = 1 THEN  GOSUB 2120
25620   REM
25625   REM     Q11
25630   IF A2(11) = 1 THEN  GOSUB 2135
25635   REM
25636   REM     Q12
25640   IF A2(12) = 1 THEN  GOSUB 2145
25645   IF A2(12) = 2 THEN  GOSUB 2150
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25650  IF A2(12) = 3 THEN  GOSUB 2152
25655  REM
25660  REM    Q13
25665  IF A2(13) = 1 THEN  GOSUB 2155
25670  IF A2(13) = 2 THEN  GOSUB 2165
25675  REM
25680  REM   Q14
25685  IF A2(14) = 0 THEN AB = 1:AC = 40:AD = 14: GOSUB 230
25690  REM
25695  REM    Q15
25700  IF A2(15) = 0 THEN AB = 1:AC = 40:AD = 15: GOSUB 230
25705  REM
25710  REM     Q16
25715  IF A2(16) = 0 THEN AB = 3:AC = 29:AD = 16: GOSUB 230:AB = 31:AC = 36:AD = 16: GOSUB 230:AB = 38:AC = 40:AD = 16: GOSUB 230
25720  REM
25725  REM    Q17
25730  IF A2(17) = 0 THEN AD = 4.AC = 4:AD = 17: GOSUB 230:AB = 7:AC = 8:AD = 17: GOSUB 230:AB = 11:AC = 11:AD = 17. GOSUB 230
25735  IF A2(17) = 0 THEN AB = 13:AC = 14:AD = 17: GOSUB 230:AB = 19:AC = 19:AD = 17: GOSUB 230:AB = 21:AC = 23:AD = 17: GOSUB 230:A
B = 25 AC = 29:AD = 17: GOSUB 230
25740  IF A2(17) = 0 THEN AB = 33:AC = 33:AD = 17: GOSUB 230:AB = 36:AC = 36:AD = 17: GOSUB 230:AB = 38:AC = 40:AD = 17: GOSUB 230
25745  REM
25750  REM    Q18
25755  IF A2(18) = 0 THEN AB = 1:AC = 40:AD = 18: GOSUB 230
25760  REM
25765  REM    Q19
25770  IF A2(19) = 0 THEN AB = 4:AC = 5:AD = 19: GOSUB 230:AB = 7:AC = 28:AD = 19: GOSUB 230:AB = 31:AC = 35:AD = 19: GOSUB 230:AD =
 37:AC = 40:AD = 19: GOSUB 230
25775  REM
25780  REM    Q20
25785  IF A2(20) = 0 THEN AB = 7:AC = 7:AD = 20: GOSUB 230:AB = 11:AC = 12:AD = 20: GOSUB 230:AB = 14:AC = 14:AD = 20: GOSUB 230:AB
= 16:AC = 19:AD = 20: GOSUB 230
25790  IF A2(20) = 0 THEN AB = 33:AC = 28:AD = 20: GOSUB 230:AB = 33:AC = 35:AD = 20: GOSUB 230:AB = 38:AC = 40:AD = 20: GOSUB 230
25795  REM
25800  REM    Q21
25805  IF A2(21) = 0 THEN AB = 7:AC = 7:AD = 21: GOSUB 230:AB = 11:AC = 11.AD = 21: GOSUB 230:AB = 14:AC = 14:AD = 21. GOSUB 230
25810  IF A2(21) = 0 THEN AB = 25:AC = 26:AD = 21: GOSUB 230:AB = 33:AC = 33:AD = 21: GOSUB 230:AB = 38:AC = 40:AD = 21: GOSUB 230
25815  REM
25820  REM    Q22
25825  IF A2(22) = 0 THEN AB = 7:AC = 7:AD = 22: GOSUB 230:AB = 11:AC = 11:AD = 22: GOSUB 230:AB = 13:AC = 14:AD = 22: GOSUB 230
25830  IF A2(22) = 0 THEN AB = 16:AC = 16:AD = 22: GOSUB 230:AB = 18:AC = 29:AD = 22: GOSUB 230:AB = 31:AC = 33:AD = 22: GOSUB 230:A
B = 35:AC = 40.AD = 22: GOSUB 230
25835  REM
25840  REM    Q23
25845  IF A2(23) = 0 THEN AB = 23:AC = 26:AD = 23: GOSUB 230:AB = 33:AC = 35:AD = 23: GOSUB 230:AB = 38:AC = 40:AD = 23: GOSUB 230
25850  REM
25855  REM    Q24
25860  IF A2(24) = 0 THEN AB = 23:AC = 26:AD = 24: GOSUB 230:AB = 35:AC = 35:AD = 24: GOSUB 230:AB = 38:AC = 40:AD = 24: GOSUB 230
25865  REM
25870  REM    Q25
25875  IF A2(25) = 0 THEN AB = 1:AC = 3:AD = 25  GOSUB 230:AB = 9:AC = 9:AD = 25: GOSUB 230:AB = 12:AC = 13:AD = 25: GOSUB 230
25880  IF A2(25) = 0 THEN AB = 19:AC = 19:AD = 25: GOSUB 230:AB = 23:AC = 23:AD = 25: GOSUB 230:AB = 26:AC = 26:AD = 25: GOSUB 230
25885  IF A2(25) = 0 THEN AB = 31:AC = 31:AD = 25: GOSUB 230:AB = 33:AC = 36:AD = 25: GOSUB 230:AB = 38:AC = 38:AD = 25: GOSUB 230:A
B = 40:AC = 40:AD = 25: GOSUB 230
25890  REM
25895  REM    Q26
25900  IF A2(26) = 0 THEN AB = 16:AC = 16:AD = 26: GOSUB 230:AB = 18:AC = 27:AD = 26: GOSUB 230:AB = 31:AC = 40:AD = 26: GOSUB 230
25905  REM
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25910  REM    Q27
25915  IF A2(27) = 0 THEN AB = 1:AC = 40:AD = 27: GOSUB 230
25920  REM
25925  REM       Q28
25930  IF A2(28) = 0 THEN AB = 23:AC = 26:AD = 28: GOSUB 230:AB = 33:AC = 35:AD = 28: GOSUB 230:AB = 38:AC = 40:AD = 28: GOSUB 230
25935  REM
25940  REM    Q29
25945  IF A2(29) = 0 THEN  GOSUB 2180
25950  IF A2(29) = 1 THEN  GOSUB 2195
25955  IF A2(29) = 2 THEN  GOSUB 2205
25975  REM
25980  REM    Q30
25985  IF A2(30) = 0 THEN  GOSUB 2210
25990  IF A2(30) = 1 THEN  GOSUB 2220
25995  REM
26000  REM    Q31
26005  IF A2(31) = 1 THEN  GOSUB 2225
26010  IF A2(31) = 2 THEN  GOSUB 2240
26020  REM    Q32
26025  IF A2(32) = 0 THEN AB = 5:AC = 5:AD = 32: GOSUB 230:AB = 17:AC = 17:AD = 32: GOSUB 230:AB = 18:AC = 18:AD = 32: GOSUB 230
26030  REM    Q33
26035  IF A2(33) = 1 THEN AB = 12:AC = 12:AD = 33: GOSUB 230:AB = 15:AC = 15:AD = 33: GOSUB 230:AB = 24:AC = 24:AD = 33: GOSUB 230
26040  IF A2(33) = 1 THEN AB = 27:AC = 28:AD = 33: GOSUB 230:AB = 30:AC = 31:AD = 33: GOSUB 230:
26045  REM    Q34
26050  IF A2(34) = 1 THEN AB = 15:AC = 15:AD = 34: GOSUB 230:AB = 25:AC = 26:AD = 34: GOSUB 230:AB = 28:AC = 28:AD = 34: GOSUB 230
26055  IF A2(34) = 1 THEN AB = 30:AC = 31:AD = 34: GOSUB 230:AB = 33:AC = 33:AD = 34: GOSUB 230
26060  REM    Q35
26065  IF A2(35) = 1 THEN AB = 15:AC = 15:AD = 35: GOSUB 230:AB = 20:AC = 21:AD = 35: GOSUB 230:AB = 24:AC = 24:AD = 35: GOSUB 230:A
B = 30:AC = 31:AD = 35: GOSUB 230
26068  IF A2(35) = 1 THEN AB = 27:AC = 28:AD = 35: GOSUB 230
26070  REM    Q36
26075  IF A2(36) = 1 THEN AB = 1:AC = 3:AD = 36: GOSUB 230:AB = 5:AC = 5:AD = 36: GOSUB 230:AB = 12:AC = 12:AD = 36: GOSUB 230:AB =
15:AC = 16:AD = 36: GOSUB 230
26080  IF A2(36) = 1 THEN AB = 20:AC = 21:AD = 36: GOSUB 230:AB = 24:AC = 24:AD = 36: GOSUB 230:AB = 30:AC = 31:AD = 36: GOSUB 230
26085  REM    Q37
26090  IF A2(37) = 1 THEN AB = 5:AC = 5:AD = 37: GOSUB 230:AB = 17:AC = 18:AD = 37: GOSUB 230:AB = 24:AC = 24:AD = 37: GOSUB 230
26095  REM
26100  HOME : PRINT "MAPMAT HAS DETERMINED THAT THE ": PRINT "FOLLOWING TECHNOLOGIES ARE AVAILABLE:"
26101  PRINT :J = 0:AB = 18
26105  PRINT  TAB( 15);"SANITATION": PRINT  TAB( 10);"----------------------"
26110  FOR I = 1 TO 29
26115  IF A1(I) = 0 GOTO 26123
26120 J = J + 1: IF J = 15 THEN AB = 1: POKE 34,5: POKE 33,13: POKE 32,22: HOME
26122  PRINT  TAB( AB);A1$(I)
26123  NEXT
26125  GOSUB 205
26127  POKE 34,3: POKE 32,0: POKE 33,40
26130  HOME : PRINT  TAB( 13);"WATER": PRINT  TAB( 10);"----------"
26140  FOR I = 30 TO 40
26145  IF A1(I) = 0 GOTO 26155
26150  PRINT  TAB( 13);A1$(I)
26155  NEXT
26160  GOSUB 205
26165  TEXT
26200  REM       FINAL SECTION
26205  HOME : PRINT "WOULD YOU LIKE TO SEE WHICH QUESTIONS": PRINT "AFFECTED THE AVAILABILITY OF THE ": PRINT "TECHNOLOGIES?"
26210  PRINT : PRINT  TAB( 3);"1---YES": PRINT  TAB( 3);"2---NO": GOSUB 215
```

```
24215  IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 24205
24220  IF AA = 1 THEN  GOSUB 31500: GOSUB 255: TEXT : GOTO 24225
24222  GOSUB 255: TEXT
24225  HOME : PRINT "WOULD YOU LIKE TO SEE THE ANSWERS YOU": PRINT "GAVE TO THE QUESTIONS?": PRINT
24230  PRINT : PRINT  TAB( 3);"1---YES": PRINT  TAB( 3);"2---NO": GOSUB 215
24235  IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 24225
24237  IF AA = 2 GOTO 24250
24238  HOME
24240  FOR I = 1 TO 18: PRINT  TAB( 8);"Q";I; TAB( 12);"= ";A2(I); TAB( 18);"Q";I + 18; TAB( 22);"= ";A2(I + 18): NEXT : PRINT  TAB(
 18);"Q37 = ";A2(37)
24245  GOSUB 205
24250 F$ = "MAPMAT.DATA.1": GOSUB 2500
24255  HOME : PRINT "MAPMAT HAS JUST STORED YOUR TECHNOLOGY": PRINT "AVAILABILITY DATA IN A TEMPORARY FILE."
24260  PRINT "WOULD YOU LIKE TO STORE THE DATA PERMENANTLY?
24265  PRINT : PRINT  TAB( 3);"1-----YES": PRINT  TAB( 3);"2-----NO": GOSUB 215
24270  IF AA < 1 OR AA > 2 THEN  GOSUB 210: GOTO 24255
24273  IF AA = 2 GOTO 24300
24274  GOSUB 2550
24275  HOME : PRINT "ENTER THE FILE NAME (30 CHARACTERS ": PRINT "MAXIMUM).": INPUT F$
24280  GOSUB 2510
24300  HOME : PRINT "THIS SECTION IS COMPLETE.  YOU WILL BE": PRINT "RETURNED TO THE MAIN MENU.": PRINT : GOSUB 205
24305  PRINT D$;"RUN  MAPMAT.MAIN"
30000  END
31500  HOME : PRINT  TAB( 21);"11111111112": PRINT  TAB( 12);"12345678901234567890"
31502  PRINT "---------- -------------------"
31505  POKE 34,3
32000  FOR I = 1 TO 40: PRINT A1(I);A18(I); TAB( 12);A38(I,1);A38(I,2);A38(I,3);A38(I,4);A38(I,5);A38(I,6);A38(I,7);
32005  PRINT A38(I,8);A38(I,9);A38(I,10);A38(I,11);A38(I,12);A38(I,13);A38(I,14);A38(I,15);A38(I,16);
32010  PRINT A38(I,17);A38(I,18);A38(I,19);A38(I,20)
32018  IF A18(I) = "PFF.ST" THEN AB = 1:AC = 8: GOSUB 235
32020  IF A18(I) = "LAC.VSP" THEN AB = 9:AC = 16: GOSUB 235
32021  IF A18(I) = "LF" THEN AB = 17:AC = 24: GOSUB 235
32022  IF A18(I) = "SSF" THEN AB = 25:AC = 32: GOSUB 235
32023  IF A18(I) = "DUALFL" THEN AB = 33:AC = 40: GOSUB 235
32025  NEXT : TEXT : RETURN
32500  END
```

```
]PR#0
]LIST

1  REM
100  GOTO 20000
105  DATA     .001,1,.001,1,.001,1, .001,1,.001,1
106  DATA      .001,1,.001,1,.001,1                  , .001,1,.001,1
107  DATA      .001,1,.001,1,.001,1                  . .001,1,.001,1
108  DATA   .2,1, 5,1,.5,1,.7,1,1,                   1
109  DATA    1,1,.15,1,.99,.0001,.1,1,.15,1
110  DATA   .1,1,.2,1,.1,1,.7,1,1,                   1
111  DATA   1,.0002,1,.005,1,.001,                   1,.0001,1,1
112  DATA   1,.0004,1,.0033,1,.1,1                   .1,1,1
200  REM                                             SUBROUTINE SECTION
201  REM
205  FOR L = 1 TO 3: CALL  - 1059: NEXT : RETURN
210  PRINT : INPUT "PRESS RETURN TO PROCEED!!!";Y$: RETURN
215  PRINT
216  PRINT "ENTER THE NUMBER WHICH REPRESENTS YOUR": PRINT "CHOICE; I.E., 1, 2, ETC.": INPUT AA$
217  IF AA$ = "1" OR AA$ = "2" OR AA$ = "3" OR AA$ = "0" OR AA$ = "4" OR AA$ = "5" OR AA$ = "6" OR AA$ = "7" OR AA$ = "8" THEN AA =
 VAL (AA$): GOTO 219
218 AA = 1000
219  RETURN
220  PRINT : PRINT "   1-----YES": PRINT "   2-----NO": GOSUB 215: RETURN
225  PRINT D$,"OPEN";F$;", L30"
230  FOR I = 1 TO 40:B = 0
235  PRINT D$;"READ";F$;",R";I;",B";B
240  INPUT A1$(I),A3$(I),A2$(I)
245  NEXT
250  PRINT D$;"CLOSE";I$: RETURN
254 AC = 0: FOR I = 1 TO 40:A3$(I) = "0": NEXT
255  TEXT : HOME : FOR I = 1 TO 20:AA = I + 20
256  IF A3$(I) = "1" THEN A4$(I) = "*"
257  IF A3$(I + 20) = "1" THEN A4$(I + 20) = "*"
258  PRINT I; TAB( 4);A4$(I); TAB( 5);A1$(I); TAB( 18);AA; TAB( 21);A4$(AA); TAB( 22);A1$(AA): NEXT
260  POKE 34,20: IF AC = 1 GOTO 280
265  HOME : PRINT "ENTER THE NUMBER OF YOUR TECHNOLOGY": PRINT "CHOICE.  * INDICATES PRIOR SELECTIONS.": INPUT AB
270  IF AB < 1 OR AB > 40 THEN  GOSUB 205: GOTO 265
275 A3$(AB) = "1":AC = 1: GOTO 255
280  HOME : PRINT "ANOTHER CHOICE?  ENTER EITHER NO OR THE". PRINT "NUMBER OF YOUR CHOICE AND PRESS RETURN.": INPUT AA$
285  IF AA$ = "NO" GOTO 300
290 AB =  VAL (AA$): GOTO 270
295  GOTO 255
300  TEXT : RETURN
305  HOME : PRINT "AVAILABLE TECHNOLOGIES ARE:":AC = 0
310  FOR I = 1 TO 40:A4$(I) = " ": NEXT
315  FOR I = 1 TO 40
320  IF A3$(I) = "0" GOTO 350
321  IF AC = 0 GOTO 325
325  PRINT  TAB( 2);I; TAB( 5);A5$(I); TAB( 6);A1$(I)
330  IF I = 20 THEN  POKE 33,16: POKE 32,23: POKE 34,1: HOME : IF AC = 1 THEN  POKE 34,0: HOME
350  NEXT
365  POKE 34,21: POKE 32,0: POKE 33,40: HOME : IF AC = 1 GOTO 385
370  HOME : PRINT "ENTER THE NUMBER OF YOUR TECHNOLOGY": PRINT "CHOICE.  * INDICATES PRIOR SELECTIONS.": INPUT AB
375  IF AB < 1 OR AB > 40 THEN  GOSUB 205: GOTO 370
376  IF A3$(AB) = "0" THEN  GOSUB 205: GOTO 378
380 A4$(AB) = "*":A3$(AB) = "1":AC = 1: TEXT : HOME : GOTO 315
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385  HOME : PRINT "ANOTHER CHOICE?  ENTER EITHER NO OR THE": PRINT "NUMBER OF YOUR CHOICE AND PRESS RETURN.": INPUT AA$
390  IF AA$ = "NO" GOTO 405
395 AB =  VAL (AA$): GOTO 375
400  GOTO 415
405  TEXT : RETURN
410  HOME
415 AB$ = "**************":AC$ = "*              *":AD$ = "*":AE$ = "*)*              *"
420  PRINT  TAB( 7);AG: PRINT AB$: PRINT AC$: RETURN
425 AA =  LEN (A1$(AB)):AA = 10.0 - AA
430  PRINT AD$; SPC( AA);A1$(AB);AE$: RETURN
435  PRINT AB$: RETURN
440  POKE 33,13: POKE 32,LL: POKE 34,TT: RETURN
445  HOME : PRINT "AVAILABLE TECHNOLOGIES ARE:"
450  FOR K = 1 TO 40
452  IF K = 21 THEN  POKE 33,14: POKE 32,23: POKE 34,1: HOME
455  IF A4$(K) = " " GOTO 470
460  PRINT  TAB( 2);K; TAB( 5);A1$(K)
470  NEXT K
475  POKE 34,21: POKE 32,0: POKE 33,40: HOME
480  PRINT "WHICH TECHNOLOGY IS YOUR CHOICE FOR": PRINT "STAGE ";AJ;"?": INPUT AB
485  IF A4$(AB) = " " THEN  GOSUB 205: GOTO 480
490  HOME : PRINT "AT WHAT YEAR WILL ";A1$(AB);" BE": PRINT "AVAILABLE?  (CURRENT=1,MAX=99)": INPUT AI
491  IF AI < 1 OR AI > 100 THEN  GOSUB 205: GOTO 490
495  TEXT : RETURN
500  PRINT D$;"OPEN";F$: PRINT D$;"DELETE";F$: RETURN
501  IF R = 2 THEN  GOSUB 500
502  PRINT D$;"OPEN";F$;",L10"
503 R = R - (AF + 1):B = 0: FOR M = R TO R + AF + 1
505  PRINT D$;"WRITE";F$;",R";M;",B";B
510  PRINT A5$(M): PRINT A6$(M): NEXT
512 R = M - 1
515  PRINT D$;"CLOSE";F$: RETURN
520  PRINT D$;"OPEN";F$;",L10": PRINT D$;"WRITE";F$;",R";C;",B";B
525  PRINT A5$(1): PRINT A6$(1)
530  PRINT D$;"CLOSE";F$: RETURN
535 C = 1: PRINT D$;"OPEN";F$;",L10"
540  PRINT D$;"READ";F$;",R";C;",B";B
545  INPUT B1$(C),B2$(C)
550 C = 2:AG =  VAL (B1$(1))
554  PRINT D$;"READ";F$;",R";C;",B";B
555  INPUT B1$(C),B2$(C)
560 AF =  VAL (B2$(C))
565  FOR I = C + 1 TO C + AF
570  PRINT D$;"READ";F$;",R";I;",B";B
571  INPUT B1$(I),B2$(I)
575  NEXT
580  HOME : PRINT "TREATMENT TRAIN ";B1$(C): PRINT
581  PRINT  TAB( 3);"STAGE"; TAB( 10);"TECHNOLOGY"; TAB( 22);"YEAR BUILT": PRINT  TAB( 3);"-----"; TAB( 10);"----------"; TAB( 22);"
----------"
584 AD = 0
585  FOR I = C + 1 TO C + AF:AD = AD + 1
586 AI =  VAL (B2$(I)):AB =  VAL (B1$(I))
590  PRINT  TAB( 5);AD; TAB( 10);A1$(AB); TAB( 26);AI
591  NEXT
592 AG = AG - 1: PRINT D$;"CLOSE";F$: GOSUB 210
595 C = C + AF + 1: IF AG = 0 GOTO 599
596  PRINT D$;"OPEN";F$;",L10": GOTO 554
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599  TEXT : RETURN
600  FOR I = 1 TO 40
605  READ AA,AC
610 A7(I) = AA:A8(I) = AC
615  NEXT : RETURN
625  GOSUB 205: HOME : PRINT "A TREATMENT GOAL IS NOT FULFILLED FOR": PRINT "THIS TREATMENT SCHEME!!!  DO YOU WANT "
630  PRINT "TO MAINTAIN THE SCHEME REGARDLESS OF ": PRINT "THE VIOLATION?  ENTER Y FOR YES OR N "
635  PRINT "FOR NO AND PRESS RETURN "
636  PRINT : PRINT "BOD GOAL=";AL: PRINT "BOD LOAD=";AN: PRINT : PRINT "COLIFORM GOAL=";AM: PRINT "COLIFORM LOAD=";AO: INPUT AA$
640  IF AA$ = "Y" THEN  GOTO 655
645  IF AA$ = "N" THEN R = R - (AI + 1):AG = AG - 1: GOTO 655
650  GOSUB 205: GOTO 625
655  RETURN
20000  REM
20005  REM
20010  REM                                          MAIN PROGRAM
20020  REM
20100  DIM A3$(40),A1$(40),A2$(40),A4$(40),A5$(100),A6$(100),A7(40),A8(40),B1$(100),B2$(100)
20101  GOSUB 600
20105 D$ =  CHR$ (4):I$ =  CHR$ (9):W$ =  CHR$ (23)
20200  HOME : PRINT "WELCOME TO THE OPTIMIZATION SECTION OF": PRINT "MAPMAT.  THE PURPOSE OF THIS SECTION IS"
20205  PRINT "TO CONSTRUCT TREATMENT TRAINS, DISCOVER": PRINT "IF THE TREATMENT TRAINS WILL MEET THE"
20210  PRINT "TREATMENT GOALS WHICH YOU SPECIFY, AND": PRINT "LINK TO THE COST ESTIMATION SECTION,"
20215  PRINT "THE COST EFFECTIVENESS SECTION, AND ": PRINT "THE SENSITIVITY SECTION.  IF YOU ARE IN"
20220  PRINT "THE WRONG SECTION OF MAPMAT THEN TYPE ": PRINT "WRONG AND PRESS RETURN.  IF THIS IS THE"
20225  PRINT "RIGHT SECTION THEN TYPE RIGHT AND PRESS": PRINT "RETURN.": INPUT AA$
20230  IF AA$ = "RIGHT" GOTO 20300
20235  IF AA$ = "WRONG" GOTO 20250
20240  GOSUB 205: GOTO 20200
20250  PRINT D$;"RUN MAPMAT.MAIN"
20300  REM
20305  HOME : PRINT "MAPMAT OFFERS THREE OPTIONS FOR ": PRINT "CONSTRUCTING TREATMENT TRAINS:": PRINT
20310  PRINT "   1---DATA STORED TEMPORARILY BY ": PRINT "        YOUR USE OF MAPMAT"
20315  PRINT "   2---DATA WHICH YOU HAD MAPMAT STORE": PRINT "        PERMENTANTLY BY A FILENAME"
20320  PRINT "   3---DATA WHICH YOU ENTER AT THIS TIME"
20325  GOSUB 215
20330  IF AA = 1000 THEN  GOSUB 205: GOTO 20305
20335  IF AA < 1 OR AA > 3 THEN  GOSUB 205: GOTO 20305
20340  IF AA = 3 GOTO 20380
20345  IF AA = 1 THEN  GOTO 20380
20350  HOME : PRINT "DO YOU NEED A CATALOG OF THE DISK TO ": PRINT "LOCATE YOUR FILENAME?":
20355  GOSUB 220
20360  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20350
20365  ON AA GOTO 20370,20375
20370  PRINT D$;"CATALOG": GOSUB 210
20375  PRINT : PRINT "ENTER THE FILE NAME": INPUT F$: GOTO 20385
20380 F$ = "MAPMAT DATA.1"
20385  HOME : PRINT "MAPMAT WILL BE RIGHT BACK": PRINT : PRINT : PRINT  TAB( 15);"PLEASE WAIT!!!": GOSUB 225
20390  IF AA = 3 THEN  GOSUB 254
20400  GOSUB 305
20405  REM
20410  HOME : PRINT "IN THE FOLLOWING SECTION MAPMAT WILL ": PRINT "ASSIST YOU IN ESTABLISHING TREATMENT"
20415  PRINT "SCHEMES TO BE USED IN THE OPTIMIZATION": PRINT "ANALYSIS   FOR THE TECHNOLOGIES WHICH"
20420  PRINT "ARE AVAILABLE YOU MUST SELECT AT LEAST": PRINT "ONE PROCESS FOR EACH STAGE THAT YOU USE"
20425  PRINT "IN THE TREATMENT SCHEME.  YOU MAY ": PRINT "SELECT UP TO 99 STAGES AND 999"
20430  PRINT "TREATMENT SCHEMES.  TECHNOLOGIES CAN BE": PRINT "CHOSEN TO BECOME OPERATIVE ALL AT THE": PRINT "SAME TIME OR AT SOME F
UTURE TIME."
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20435  PRINT "TYPICALLY A TREATMENT SCHEME WILL ": PRINT "INCLUDE SEVERAL STAGES, I.E., A THREE": PRINT "STAGE TREATMENT SCHEME COUL
D COMPRISE."
20440  FOR I = 0 TO 0
20445  FOR J = 0 TO 2
20450 AD = AD + 1:AB = 7:LL = J * 13:TT = 15
20451  IF J = 1 THEN AB = 16
20452  IF J = 2 THEN AB = 24
20455  GOSUB 440: GOSUB 410: GOSUB 425: GOSUB 435
20460  NEXT J
20465  NEXT I
20470  POKE 32,0. POKE 33,40: GOSUB 210
20475  TEXT
20480  HOME : PRINT "DO YOU WANT TO SET TREATMENT GOALS?  ": PRINT "ENTER Y FOR YES OR N FOR NO.": INPUT AA$:AC = 0
20481  IF AA$ = "N" GOTO 20488
20482  IF AA$ = "Y" THEN AC = 1: GOTO 20485
20483  GOSUB 205: GOTO 20480
20485  HOME : PRINT "ENTER BOD TREATMENT GOAL-SANITATION ": PRINT "TREATMENT ONLY.": INPUT AL
20486  PRINT : PRINT "ENTER FECAL COLIFORM TREATMENT GOAL-": PRINT "WATER TREATMENT ONLY.": INPUT AM
20488  HOME : PRINT "ENTER BOD LOAD FOR WASTE TREATMENT IN": PRINT "MG/L.": INPUT AN
20489  PRINT : PRINT "ENTER FECAL COLIFORM LOAD FOR WATER ": PRINT "TREATMENT IN MPN/100ML.": INPUT AO
20494 AG = 1:R = 2:F$ = "MAPMAT.DATA.2": GOSUB 500
20495  HOME : PRINT "HOW MANY STAGES ARE INCLUDED IN ": PRINT "TREATMENT SCHEME ";AG;"? (MAXIMUM = 99)": INPUT AF
20500  IF AF < 1 OR AF > 99 THEN  GOSUB 205: GOTO 20495
20502 A5$(R) =  STR$ (AG):A6$(R) =  STR$ (AF)
20503 R = R + 1.AJ = 1
20505  FOR I = R TO AF - 1 + R
20520  GOSUB 445
20525 A5$(I) =  STR$ (AB).A6$(I) =  STR$ (AI)
20526  IF AI > 1 GOTO 20529
20527 AN = AN * A7(AB):AO = AO * A8(AB)
20529 R = R + 1:AJ = AJ + 1
20530  NEXT I
20534  IF AC = 0 GOTO 20545
20535  IF AN > AL THEN  GOSUB 625
20540  IF AO > AM THEN  GOSUB 625
20545 F$ = "MAPMAT DATA 2": GOSUB 501
20555  HOME . PRINT "ANOTHER TREATMENT SCHEME (ENTER Y FOR": PRINT "YES OR N FOR NO AND PRESS RETURN.": INPUT AA$
20560  IF AA$ = "N" GOTO 20580
20565  IF AA$ = "Y" THEN AG = AG + 1: GOTO 20495
20570  GOSUB 205. GOTO 20555
20580 A5$(I) =  STR$ (AG):A6$(I) =  STR$ (AG)
20585 C = 1. GOSUB 520
20590 F$ = "MAPMAT DATA 2": GOSUB 535
20600  HOME : PRINT "YOU ARE NOW READY TO LINK TO THE COST". PRINT "CALCULATION SECTION ,OR ANY OTHER"
20605  PRINT "SECTION OF MAPMAT.  YOU WILL BE ": PRINT "RETURNED TO THE MAIN MENU OF MAPMAT."
20610  GOSUB 210
20615  PRINT D$,"RUN MAPMAT.MAIN"
29999  END
30000  PRINT D$;"PR#1"
30005  FOR I = 1 TO 40
30010  PRINT A1$(I);" ";A3$(I);" ";A2$(I)
30015  NEXT
30020  PRINT D$;"PR#0"
30025  RETURN
30050 AD = 23: INPUT "AB";AB: GOSUB 410: GOSUB 425: GOSUB 435: RETURN
30100  GOSUB 410: FOR I = 1 TO 40:AD = 23:AB = I: GOSUB 425: NEXT
30105  GOSUB 435. RETURN
```

```
30150  FOR I = 1 TO 40:AN = 1000:AO = 2000
30151 AN = AN * A7(I):AO = AO * A8(I)
30152  PRINT I; TAB( 4);A7(I);" ";AN;" ";A8(I);" ";AO
30153  NEXT
30154  RETURN
30200  FOR I = 1 TO 20: PRINT "R=";I;" ";A5$(I); TAB( 10);"AI=";A6$(I): NEXT : RETURN
30250  FOR I = 1 TO 40. PRINT I; TAB( 4);A7(I); TAB( 15);A8(I): NEXT
30300 R = R - (AF + 1). FOR I = R - (AF + 1) TO R + AF + 1
30305  PRINT I; TAB( 4);A5$(I); TAB( 20);A6$(I)
30310  NEXT : RETURN
30399 F$ = "MAPMAT DATA 2".D$ =  CHR$ (4)
30400  PRINT D$;"OPEN";F$;",L10"
30405  FOR I = 1 TO 20
30406  PRINT D$;"READ";F$;",R";I;",B";B
30408  INPUT B1$,B2$
30410  PRINT I," ",B1$," ";B2$
30420  NEXT
30425  PRINT D$,"CLOSE",F$
30450  END
30500  PR# 1
30505  PRINT W$;I$,"T"
30510  FOR I = 1 TO 20. PRINT  TAB( 4);I; TAB( 8);B1$(I); TAB( 20);B2$(I): NEXT
30515  RETURN
```

```
]PR#0
]LIST

1  REM                                        MAPMAT.COST.RATIO
2  REM
20  HOME : PRINT "DO YOU WANT THE PRINTER ON?": GOSUB 220
21  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20
100  GOTO 20000
200  REM                                        SUBROUTINE SECTION
201  REM
205  FOR L = 1 TO 3: CALL  - 1059: NEXT : RETURN
210  PRINT : INPUT "PRESS RETURN TO PROCEED!!!";Y$: RETURN
215  PRINT
216  PRINT "ENTER THE NUMBER WHICH REPRESENTS YOUR": PRINT "CHOICE; I.E., 1, 2, ETC.": INPUT AA$
217  IF AA$ = "1" OR AA$ = "2" OR AA$ = "3" OR AA$ = "0" OR AA$ = "4" OR AA$ = "5" OR AA$ = "6" OR AA$ = "7" OR AA$ = "8" THEN AA =
 VAL (AA$): GOTO 219
218 AA = 1000
219  RETURN
220  PRINT : PRINT "    1-----YES": PRINT "    2-----NO": GOSUB 215: RETURN
225  PRINT D$;"OPEN";F$;", L20"
230  FOR I = 1 TO 40:B = 0
235  PRINT D$;"READ";F$;",R";I;",B";B
240  INPUT A1$(I),A3$(I),A2$(I)
245  NEXT
250  PRINT D$,"CLOSE";F$: RETURN
254 AC = 0: FOR I = 1 TO 40:A3$(I) = "0": NEXT
255  TEXT : HOME : FOR I = 1 TO 20:AA = I + 20
256  IF A3$(I) = "1" THEN A4$(I) = "*"
257  IF A3$(I + 20) = "1" THEN A4$(I + 20) = "*"
258  PRINT I, TAB( 4);A4$(I); TAB( 5);A1$(I); TAB( 18);AA; TAB( 21);A4$(AA); TAB( 22);A1$(AA): NEXT
260  POKE 34,20: IF AC = 1 GOTO 280
265  HOME : PRINT "ENTER THE NUMBER OF YOUR TECHNOLOGY": PRINT "CHOICE.  * INDICATES PRIOR SELECTIONS.": INPUT AB
270  IF AB < 1 OR AB > 40 THEN  GOSUB 205: GOTO 265
275 A3$(AB) = "1":AC = 1: GOTO 255
280  HOME : PRINT "ANOTHER CHOICE?  ENTER EITHER NO OR THE": PRINT "NUMBER OF YOUR CHOICE AND PRESS RETURN.": INPUT AA$
285  IF AA$ = "NO" GOTO 300
290 AB =  VAL (AA$): GOTO 270
295  GOTO 255
300  TEXT : RETURN
305  HOME : PRINT "AVAILABLE TECHNOLOGIES ARE:":AC = 0
310  FOR I = 1 TO 40:A4$(I) = " ": NEXT
315  FOR I = 1 TO 40
320  IF A3$(I) = "0" GOTO 350
321  IF AC = 0 GOTO 325
325  PRINT  TAB( 2);I; TAB( 5);A4$(I); TAB( 6);A1$(I)
330  IF I = 20 THEN  POKE 33,16: POKE 32,23: POKE 34,1: HOME : IF AC = 1 THEN  POKE 34,0: HOME
350  NEXT
365  POKE 34,21: POKE 32,0: POKE 33,40: HOME : IF AC = 1 GOTO 385
370  HOME : PRINT "ENTER THE NUMBER OF YOUR TECHNOLOGY": PRINT "CHOICE.  * INDICATES PRIOR SELECTIONS.": INPUT AB
375  IF AB < 1 OR AB > 40 THEN  GOSUB 205: GOTO 370
376  IF A3$(AB) = "0" THEN  GOSUB 205: GOTO 370
380 A4$(AB) = "*":A3$(AB) = "1":AC = 1: TEXT : HOME : GOTO 315
385  HOME : PRINT "ANOTHER CHOICE?  ENTER EITHER NO OR THE": PRINT "NUMBER OF YOUR CHOICE AND PRESS RETURN.": INPUT AA$
390  IF AA$ = "NO" GOTO 405
395 AB =  VAL (AA$): GOTO 375
400  GOTO 415
405  TEXT : RETURN
```

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410  HOME
415 AB$ = "**************":AC$ = "*              *":AD$ = "*":AE$ = "-)*            *"
420  PRINT  TAB( 7);AD: PRINT AB$: PRINT AC$: RETURN
422 LI = 1
425 AA =  LEN (A1$(AB)):AA = 10.0 - AA
430  PRINT AD$; SPC( AA);A1$(AB);AE$: RETURN
435  PRINT AB$: RETURN
440  POKE 33,13: POKE 32,LL: POKE 34,TT: RETURN
445  HOME : PRINT "AVAILABLE TECHNOLOGIES ARE:"
450  FOR K = 1 TO 40
452  IF K = 21 THEN  POKE 33,16: POKE 32,23: POKE 34,1: HOME
455  IF A4$(K) = " " GOTO 470
460  PRINT  TAB( 2);K; TAB( 5);A1$(K)
470  NEXT K
475  POKE 34,21: POKE 32,0: POKE 33,40: HOME
480  PRINT "WHICH TECHNOLOGY IS YOUR CHOICE FOR": PRINT "STAGE ";AJ;"?": INPUT AB
485  IF A4$(AB) = " " THEN  GOSUB 205: GOTO 480
490  HOME : PRINT "AT WHAT YEAR WILL ";A1$(AB);" BE": PRINT "AVAILABLE?  (CURRENT=1,MAX=99)": INPUT AI
491  IF AI < 1 OR AI > 100 THEN  GOSUB 205: GOTO 490
495  TEXT : RETURN
500  PRINT D$;"OPEN";F$: PRINT D$;"DELETE";F$: RETURN
501  IF R = 2 THEN  GOSUB 500
502  PRINT D$,"OPEN";F$;",L10"
503 R = R - (AF + 1):B = 0: FOR M = R TO R + AF + 1
505  PRINT D$;"WRITE";F$;",R";M;",B";B
510  PRINT A5$(M): PRINT A6$(M): NEXT
512 R = M - 1
515  PRINT D$;"CLOSE";F$: RETURN
520  PRINT D$;"OPEN",F$;",L10": PRINT D$;"WRITE";F$;",R";C;",B";B
525  PRINT A5$(I): PRINT A6$(I)
530  PRINT D$;"CLOSE";F$: RETURN
535 C = 1: PRINT D$;"OPEN";F$;",L10":D8 = 1
540  PRINT D$;"READ";F$;",R";C;",B";B
545  INPUT B1$(C),B2$(C)
550 C = 2:AG =  VAL (B1$(1)):D7 = AG
554 L = 10:F$ = "MAPMAT.DATA.2": PRINT D$;"READ",F$;",R";C;",              B";B
555  INPUT B1$(C),B2$(C)
560 AF =  VAL (B2$(C))
565  FOR I = C + 1 TO C + AF
570  PRINT D$;"READ";F$;",R";I,",B";B
571  INPUT B1$(I),B2$(I)
572  NEXT
574  HOME : PRINT "TREATMENT TRAIN ";B1$(C): PRINT
575  PRINT "S"; TAB( 16);"B": PRINT "T"; TAB( 15);"YU"; TAB( 29);"OPERATION": PRINT "A"; TAB( 15);"EI"; TAB( 32);"AND": PRINT "G"; T
AB( 15);"AL"; TAB( 18);"CAPITAL"; TAB( 29);"MAINTENANCE"
576  PRINT "E"; TAB( 4),"TECHNOLOGY"; TAB( 15);"RT"; TAB( 18);"COST"; TAB( 32);"COST"
577  PRINT "--"; TAB( 4);"----------"; TAB( 15),"--", TAB( 18);"-------"; TAB( 29);"-----------"
584 AD = 0
585  FOR I = C + 1 TO C + AF:AD = AD + 1
586 AI =  VAL (B2$(I)):AB =  VAL (B1$(I))
587  GOSUB 1000
588 D4 = D4 + A5(I) + A6(I)
590  PRINT AD; TAB( 4),A1$(AB); TAB( 15);AI; TAB( 18);A5(I); TAB( 29);A6(I)
591  NEXT : GOSUB 1300:D4 = 0
592 AG = AG - 1: PRINT D$,"CLOSE";F$: GOSUB 310
595 C = C + AF + 1: IF AG = 0 GOTO 599
596  PRINT D$;"OPEN";F$;",L10": GOTO 554
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599  GOSUB 1350: TEXT : RETURN
600  REM
601  IF C7 > 5000 THEN A5(I) = 0:A6(I) = 0: GOTO 665
605 F$ = "MAPMAT.COST.ONE":L = 40:B = 0
620  PRINT D$;"OPEN";F$;",L";L
621  PRINT D$;"READ";F$;",R";C7;",B";B
622  INPUT X1,X2,X3,X4,X5
623  PRINT D$;"CLOSE";F$
640 A5(I) = X1:A6(I) = X2
645 D2 = C3 - A1
650 D3 = (1 - ((1 + C4) ^  - D2)) / C4
655 D4 = (P1 * A6(I) * .1) + (P2 * .15 * A6(I)) + (P3 * .2 * A6(I))
660 A6(I) = (A6(I) + D4) * (D3)
665 D4 = 0:P1 = 0:P2 = 0:P3 = 0: RETURN
700  HOME : PRINT "WHAT IS THE DESIGN LEVEL OF POPULATION": PRINT "AT THE LOCAL SITE?": INPUT C1
705  HOME : PRINT "WHAT IS THE EXPECTED POPULATION GROWTH": PRINT "RATE EXPRESSED AS AN INTERGER?  FOR "
710  PRINT "EXAMPLE ENTER 3 FOR A THREE PERCENT": PRINT "RATE AND PRESS RETURN ": INPUT C2
715 C2 = C2 / 100
720  HOME : PRINT "WHAT IS THE PERIOD OF DESIGN TO BE USED": PRINT "IN THE ANALYSIS? (MAXIMUM=100)": INPUT C3
725  HOME : PRINT "WHAT IS THE OPPORTUNITY COST OF CAPITAL": PRINT "OR DISCOUNT RATE TO BE USED IN THE "
730  PRINT "ANALYSIS?  ENTER AN INTERGER SUCH AS 10": PRINT "FOR A TEN PERCENT COST OF CAPITAL.": INPUT C4
735 C4 = C4 / 100
740  HOME : PRINT "A CRITICAL CRITERIA IN EVALUATING THE": PRINT "COST OF TECHNOLOGY IS THE LEVEL OF "
750  PRINT "SUPPORT AVAILABLE DURING THE USE OF THE": PRINT "TECHNOLOGY.  IN GENERAL A GOOD MEASURE"
755  PRINT "OF THIS SUPPORT IS THE EXISTING LEVEL": PRINT "OF THE INFRASTRUCTURE.  MAPMAT INCLUDES"
760  PRINT "FOUR LEVELS OF INFRASTRUCTURE.  WHICH": PRINT "INFRASTRUCTURE LEVEL IS CLOSEST TO THE": PRINT "DESIGN SITE?": PRINT
765  PRINT " 1--THE INFRASTRUCTURE IS DEPENDENT ON": PRINT  TAB( 5);"IMPORTED EMPLOYMENT; AGRICULTURALLY"
770  PRINT  TAB( 5);"ORIENTED WITH A VERY SMALL OR NON-": PRINT  TAB( 5);"EXISTANT LOCAL MARKET ECONOMY; FEW": PRINT  TAB( 5);"HIGH
SCHOOL OR COLLEGE GRADUATES"
772  PRINT  TAB( 5);"ARE AVAILABLE TO HELP LOCALLY "
775  PRINT  TAB( 5);"UNLESS FROM A VOLUNTEER TYPE   ": PRINT  TAB( 5);"ORGANIZATION.  ALMOST 100 PERCENT"
780  PRINT  TAB( 5);"OF LOCAL EMPLOYMENT IS AGRICULTURE.": PRINT  TAB( 5);"A RURAL VILLAGE IS AN EXAMPLE."
785  GOSUB 210: POKE 34,10
790  HOME : PRINT " 2--THE INFRASTRUCTURE IS DEPENDENT": PRINT  TAB( 5);"ON THE IMPORTED EMPLOYMENT OF "
795  PRINT  TAB( 5);"SCIENTIFIC/TECHNICAL PEOPLE BUT": PRINT  TAB( 5);"PRODUCES MANAGERS, OPERATORS, LOW"
800  PRINT  TAB( 5);"LEVEL TEACHERS, ETC. TO SUPPORT A": PRINT  TAB( 5);"LOW TO MEDIUM SIZE MARKET ECONOMY."
805  PRINT  TAB( 5);"APPROXIMATELY 50 PERCENT OF THE": PRINT  TAB( 5);"LOCAL POPULATION DERIVES A": PRINT  TAB( 5);"LIVELIHOOD FROM
AGRICULTURE.  THE"
810  PRINT  TAB( 5);"SECONDARY AND PRIMARY SCHOOLS ARE": PRINT  TAB( 5);"DEVELOPED BUT THE QUALITY OF": PRINT  TAB( 5);"INSTRUCTION
MAY BE VERY VARIABLE "
815 : GOSUB 210: HOME
820  PRINT " 2--......CONTINUED.....": PRINT : PRINT  TAB( 5);"AN EXAMPLE IS A RURAL TOWN OR ": PRINT  TAB( 5);"SMALL CITY."
825  GOSUB 210
830  HOME : PRINT " 3--THE INFRASTRUCTURE HAS AVAILABLE": PRINT  TAB( 5);"SCIENTISTS, ENGINEERS, AND OTHER ": PRINT  TAB( 5);"PROFES
SIONALS BUT IMPORTS ALMOST"
835  PRINT  TAB( 5);"ALL RESEARCH PROFESSIONALS. PRIMARY": PRINT  TAB( 5);"AND SECONDARY SCHOOL SYSTEMS ARE": PRINT  TAB( 5);"WELL D
EVELOPED WITH  GENERALLY GOOD"
840  PRINT  TAB( 5);"TEACHERS. A LOCAL COLLEGE MAY BE": PRINT  TAB( 5);"AVAILABLE.  LESS THAN 25 PERCENT OF"
845  PRINT  TAB( 5);"THE POPULATION PRIMARILY DEPENDS ON": PRINT  TAB( 5);"AGRICULTURE RELATED ENTERPRISE."
847  GOSUB 210: HOME : PRINT " 3--....CONTINUED........": PRINT
850  PRINT  TAB( 5);"AN EXAMPLE IS A LARGE BUT ISOLATED": PRINT  TAB( 5);"CITY, POSSIBLY A REGIONAL CENTER": PRINT  TAB( 5);"OF COMM
ERCE."
855  GOSUB 210
860  HOME : PRINT " 4--THE INFRASTRUCTURE CLOSELY": PRINT  TAB( 5);"RESEMBLES A LARGE CITY IN A": PRINT  TAB( 5);"DEVELOPED COUNTRY.
  SIGNIFICANT"
865  PRINT  TAB( 5);"PORTIONS OF THE POPULATION FINISH": PRINT  TAB( 5);"PRIMARY AND SECONDARY SCHOOL.  ": PRINT  TAB( 5);"RESEARCH
PROFESSIONALS ARE READILY"
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870  PRINT  TAB( 5);"AVAILABLE AND HIGH TECHNOLOGY IS": PRINT  TAB( 5);"ALSO AVAILABLE.  AN EXAMPLE IS THE": PRINT  TAB( 5);"NATIONA
L CAPITAL OF A DEVELOPING": PRINT  TAB( 5);"COUNTRY."
872  GOSUB 210
875  HOME : PRINT " 1--RURAL VILLAGE LEVEL.": PRINT " 2--RURAL TOWN OR SMALL CITY LEVEL.": PRINT " 3--LARGE BUT ISOLATED CITY LEVEL.
": PRINT " 4--NATIONAL CAPITAL LEVEL."
880  PRINT : PRINT "IF YOU NEED TO REVIEW THE DEFINATIONS": PRINT "FOR THESE LEVELS ENTER HELP OTHERWISE": GOSUB 216
885  IF AA$ = "HELP" THEN  TEXT : GOTO 240
890  IF AA ( 1 OR AA ) 4 THEN  GOSUB 205: GOTO 875
895 C4 =  VAL (AA$)
899  TEXT : RETURN
1000  REM
1005 C9 = 0:C7 = 0:D1 = C1
1020  ON AD GOSUB 1101,1102,1103,1104,1105,1106,1107,1108,1109,1110,1111,1112,1113,1114,1115,1116,1117,1118,1119,1120,1121,1122,1123
,1124,1125,1126,1127,1128,1129,1130,1131,1132,1133,1134,1135,1136,1137,1138,1139,1140
1021  IF A2$(4) = "1" THEN P2 = 0
1022  IF A2$(5) = "1" THEN P1 = 0
1025  REM
1030  ON C6 GOSUB 1151,1152,1153,1154
1035  FOR C8 = 1 TO C3
1040 D1 = (D1) * (1 + C2):C9 = D1 + C9
1045  NEXT
1050 C9 = C9 / C3
1055  IF C9 (  = 2500 THEN C5 = 0
1060  IF C9 ) 2500 AND C9 (  = 15000 THEN C5 = 1
1065  IF C9 ) 15000 AND C9 (  = 50000 THEN C5 = 2
1070  IF C9 ) 50000 THEN C5 = 3
1075 C7 = C7 + C5:D2 = C3 - A1
1076  IF D2 = 0 THEN D2 = 1
1080 D3 = (1 - ((1 + C4) ^  - D2)) / C4
1085  GOSUB 600
1099  RETURN
1100  REM
1101 C7 = 369:P1 = 1: RETURN
1102 C7 = 385:P1 = 1: RETURN
1103 C7 = 401:P1 = 1: RETURN
1104 C7 = 417:P3 = 1: RETURN
1105 C7 = 433:P1 = 1: RETURN
1106 C7 = 449:P1 = 1: RETURN
1107 C7 = 465:P2 = 1: RETURN
1108 C7 = 481:P1 = 1:P2 = 1: RETURN
1109 C7 = 497:P1 = 1:P3 = 1: RETURN
1110 C7 = 513:P3 = 1: RETURN
1111 C7 = 529:P2 = 1:P3 = 1: RETURN
1112 C7 = 545:P1 = 1: RETURN
1113 C7 = 561:P3 = 1: RETURN
1114 C7 = 577:P2 = 1:P3 = 1: RETURN
1115 C7 = 10000: RETURN
1116 C7 = 193: RETURN
1117 C7 = 10000: RETURN
1118 C7 = 10000: RETURN
1119 C7 = 177:P2 = 1:P3 = 1: RETURN
1120 C7 = 209:P2 = 1:P3 = 1: RETURN
1121 C7 = 225:P2 = 1:P3 = 1: RETURN
1122 C7 = 305:P2 = 1:P3 = 1: RETURN
1123 C7 = 337:P2 = 1:P3 = 1: RETURN
1124 C7 = 353:P2 = 1:P3 = 1: RETURN
1125 C7 = 321:P2 = 1:P3 = 1: RETURN
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1126 C7 = 209:P2 = 1:P3 = 1: RETURN
1127 C7 = 257:P2 = 1:P3 = 1: RETURN
1128 C7 = 273:P2 = 1:P3 = 1: RETURN
1129 C7 = 241:P2 = 1:P3 = 1: RETURN
1130 C7 = 1: RETURN
1131 C7 = 17: RETURN
1132 C7 = 33: RETURN
1133 C7 = 49: RETURN
1134 C7 = 97: RETURN
1135 C7 = 113: RETURN
1136 C7 = 161: RETURN
1137 C7 = 10000: RETURN
1138 C7 = 81: RETURN
1139 C7 = 129: RETURN
1140 C7 = 145: RETURN
1145  REM
1151 C7 = C7 + 0: RETURN
1152 C7 = C7 + 4: RETURN
1153 C7 = C7 + 8: RETURN
1154 C7 = C7 + 12: RETURN
1200  FOR I = 1 TO 100:A5(I) = 0:A6(I) = 0: NEXT : RETURN
1300  REM
1305 D4 =  INT (D4):F$ = "MAPMAT DATA.3"
1310  PRINT : PRINT  TAB( 2);"TOTAL PRESENT VALUE COST RATIO= ";D4
1315 D8 = D8 + 1:E2 = E2 + 1
1330  PRINT D$;"OPEN";F$;", L20"
1335  PRINT D$;"WRITE";F$;",R";D8;",B";B
1340  PRINT E2: PRINT D4
1345  PRINT D$;"CLOSE";F$: RETURN
1350 F$ = "MAPMAT DATA.3": PRINT D$;"OPEN";F$;", L20"
1355  PRINT D$;"WRITE";F$;",R1";",B";B
1360  PRINT D7: PRINT D7
1365  PRINT D$;"CLOSE";F$: RETURN
1400 F$ = "MAPMAT DATA.3": PRINT D$;"OPEN";F$;", L20"
1405 AA = 1: PRINT D$;"READ";F$;",R";AA;",B";B
1410  INPUT AG,D4
1415  HOME : PRINT  TAB( 7);"ALTERNATIVE TREATMENT TRAIN": PRINT  TAB( 5);"TOTAL PRESENT VALUE COST RATIOS": PRINT
1420  PRINT  TAB( 18);"TOTAL PRESENT": PRINT  TAB( 6);"TREATMENT"; TAB( 21);"VALUE": PRINT  TAB( 8);"TRAIN"; TAB( 18);"COST RATIO":
PRINT  TAB( 6);"---------"; TAB( 18);"------------"
1421  POKE 34,7
1425  FOR I = 2 TO AG + 1
1430  PRINT D$;"READ";F$;",R";I;",B";B
1435  INPUT AA,D4
1445  PRINT  TAB( 10);I - 1; TAB( 20);D4
1447 E1 = E1 + 1:E3 = E3 + 1
1448  IF E3 = 12 THEN  GOSUB 210:E3 = 0
1450  NEXT
1465  PRINT D$;"CLOSE";F$
1499  GOSUB 210: TEXT : RETURN
1500  RETURN
20000  REM
20005  REM
20010  REM                                    MAIN PROGRAM
20020  REM
20100  DIM A1$(40),A2$(40),A3$(40),A4$(40),A5(100),A6(100),A7(40),A8(40),B1$(100),B2$(100)
20105 D$ =  CHR$ (4):I$ =  CHR$ (9):W$ =  CHR$ (23)
20110  IF AA = 2 GOTO 20120
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20115  PRINT D$;"PR#1": PRINT W$;I$;"T"
20120 F$ = "MAPMAT DATA 1": GOSUB 225
20125 F$ = "MAPMAT DATA 3": PRINT D$;"DELETE";F$
20130 F$ = "MAPMAT DATA 3"
20199  REM
20200  HOME : PRINT "WELCOME TO TO THE COST RATIO SECTION OF": PRINT "MAPMAT   THE PURPOSE OF THIS SECTION IS"
20205  PRINT "TO CONSTRUCT RELATIVE COST RATIOS FOR": PRINT "TREATMENT TRAINS PREVIOUSLY CONSTRUCTED"
20210  PRINT "BY USING MAPMAT   IF YOU ARE IN"
20220  PRINT "THE WRONG SECTION OF MAPMAT THEN TYPE ". PRINT "WRONG AND PRESS RETURN.  IF THIS IS THE"
20225  PRINT "RIGHT SECTION THEN TYPE RIGHT AND PRESS": PRINT "RETURN.": INPUT AA$
20230  IF AA$ = "RIGHT" GOTO 20275
20235  IF AA$ = "WRONG" GOTO 20250
20240  GOSUB 205. GOTO 20200
20250  PRINT D$;"RUN MAPMAT.MAIN"
20275  GOSUB 700
20300  REM
20305  HOME : PRINT "MAPMAT OFFERS TWO OPTIONS FOR": PRINT "CONSTRUCTING RELATIVE COST RATIOS:": PRINT
20320  PRINT "   1---TREATMENT TRAIN DATA STORED ": PRINT "       TEMPORARILY BY YOUR USE OF ": PRINT "       MAPMAT.": PRINT
20321  PRINT "   2---TREATMENT TRAIN DATA WHICH YOU": PRINT "       YOU HAD MAPMAT STORE"
20322  PRINT "        PERMENTANTLY BY A FILE NAME "
20325  GOSUB 215
20330  IF AA = 1000 THEN  GOSUB 205: GOTO 20305
20335  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20305
20345  IF AA = 1 THEN  GOTO 20380
20350  HOME . PRINT "DO YOU NEED A CATALOG OF THE DISK TO ": PRINT "LOCATE YOUR FILENAME?":
20355  GOSUB 220
20360  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20350
20365  ON AA GOTO 20370,20375
20370  PRINT D$;"CATALOG": GOSUB 210
20375  PRINT : PRINT "ENTER THE FILE NAME": INPUT F$: GOTO 20385
20380 F$ = "MAPMAT DATA 2"
20385  HOME : PRINT "MAPMAT WILL BE RIGHT BACK": PRINT : PRINT : PRINT  TAB( 12);"PLEASE WAIT!!!": GOSUB 535
20400  GOSUB 1400
20410  HOME . PRINT "MAPMAT HAS STORED YOUR TREATMENT TRAIN": PRINT "COST RATIOS IN A TEMPORARY FILE.  DO"
20415  PRINT "YOU WANT TO STORE THE DATA UNDER A ": PRINT "PERMENTANT FILE NAME?"
20420  GOSUB 220
20425  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20410
20427  IF AA = 2 GOTO 20500
20430  HOME : PRINT "DO YOU NEED A CATALOG OF THE DISK TO ": PRINT "LOCATE YOUR FILENAME?"
20435  GOSUB 220
20440  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20430
20441  ON AA GOTO 20442,20445
20442  PRINT D$,"CATALOG". GOSUB 210
20445  PRINT . PRINT "ENTER THE FILE NAME": INPUT F$
20500  HOME : PRINT "YOU HAVE COMPLETED THE COST RATIO ": PRINT "SECTION OF MAPMAT   YOU ARE READY TO "
20505  PRINT "PROCEED TO ANOTHER SECTION OF MAPMAT.": PRINT "YOU WILL BE RETURNED TO THE MAIN MENU."
20510  GOSUB 210
20515  PRINT D$,"RUN  MAPMAT.MAIN"
29999  END
30000  PRINT D$;"PR#1": PRINT W$;I$;"T"
30005  FOR I = 1 TO 40
30010  PRINT  TAB( 3);I; TAB( 5);A1$(I); TAB( 17);"A=";A3$(I); TAB( 24);"Q= ",A2$(I)
30015  NEXT
30020  PRINT D$,"PR#0"
30025  RETURN
30050 AD = 23: INPUT "AB";AB. GOSUB 410: GOSUB 425: GOSUB 435  RETURN
30100  GOSUB 410: FOR I = 1 TO 40:AD = 23:AB = I: GOSUB 425: NEXT
```

```
30105  GOSUB 435: RETURN
30150  FOR I = 1 TO 40:AN = 1000:AO = 1000
30151 AN = AN * A7(I):AO = AO * A8(I)
30152  PRINT I; TAB( 4);A7(I);" ";AN;" ";A8(I);" ";AO
30153  NEXT
30154  RETURN
30200  FOR I = 1 TO 20: PRINT "R=";I;" ";A5$(I); TAB( 10);"AI=";A6$(I): NEXT : RETURN
30250  FOR I = 1 TO 40: PRINT I, TAB( 4);A7(I); TAB( 15);A8(I): NEXT
30300 R = R - (AI + 1): FOR I = R - (AF + 1) TO R + AF + 1
30305  PRINT I; TAB( 4);A5$(I); TAB( 20);A6$(I)
30310  NEXT : RETURN
30399 F$ = "MAPMAT DATA.2":D$ =  CHR$ (4)
30400  PRINT D$,"OPEN";F$;",L10"
30405  FOR I = 1 TO 20
30406  PRINT D$;"READ";F$;",R";I;",B",B
30408  INPUT B1$,B2$
30410  PRINT I;" ";B1$;" ";B2$
30?40  NEXT
30?25  PRINT D$;"CLOSE";F$
30450  END
30500  PR# 1
30505  PRINT W$;1$;"F"
30510  FOR I = 1 TO 20: PRINT  TAB( 4);I; TAB( 8);B1$(I); TAB( 20);B2$(I): NEXT
30515  RETURN
30600 C1 = 10000: FOR I = 1 TO 10:C1 = (C1) * (1.10):C2 = C1 + C2
30605  PRINT I, TAB( 4),C1; TAB( 20);C2
30610  NEXT : RETURN
30700 AB = 37.C4 = 1.C3 = 10:C1 = 100:C2 = .1
30705  GOSUB 1000
30710  PRINT "R=";C7; TAB( 8);"AVE POP=";C9; TAB( 30);"C5=";C5
30750  END
30800 A2 =  1.A3 = 15.A4 = (1 - ((1 + A2) ^  - A3)) / A2: PRINT A4
30805  INPUT AA: PRINT AA * A4. GOTO 30800
30900 D6 = 0:P1 = 1:P2 = 1:P3 = 1:I = 1:A6(I) = 1:D3 = 1
30901  GOSUB 655. PRINT D6,A6(I): STOP
30905 D6 = P1 * A6(I) * .1 + P2 * .45 * A6(I) + P3 * .2 * A6(I)
30910 A6(I) = ((A6(I)) * (D3)) + D6
30920  PRINT D6,A6(I)
```

```
]PR#0
]LIST

1  REM                                MAPMAT SENSITIVITY
2  REM
20  HOME : PRINT "DO YOU WANT THE PRINTER ON?": GOSUB 220
21  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20
100  GOTO 20000
200  REM                                SUBROUTINE SECTION
201  REM
205  FOR L = 1 TO 3: CALL  - 1059: NEXT : RETURN
210  PRINT : INPUT "PRESS RETURN TO PROCEED!!!";Y$: RETURN
215  PRINT
216  PRINT "ENTER THE NUMBER WHICH REPRESENTS YOUR": PRINT "CHOICE; I.E., 1, 2, ETC.": INPUT AA$
217  IF AA$ = "1" OR AA$ = "2" OR AA$ = "3" OR AA$ = "0" OR AA$ = "4" OR AA$ = "5" OR AA$ = "6" OR AA$ = "7" OR AA$ = "8" THEN AA =
 VAL (AA$): GOTO 219
218 AA = 1000
219  RETURN
220  PRINT : PRINT "    1-----YES": PRINT "    2-----NO": GOSUB 215: RETURN
225  PRINT D$;"OPEN",F$;",L20"
230  FOR I = 1 TO 40:B = 0
235  PRINT D$;"READ";F$;",R";I;",B";B
240  INPUT A1$(I),A3$(I),A2$(I)
245  NEXT
250  PRINT D$;"CLOSE";F$: RETURN
254 AC = 0: FOR I = 1 TO 40:A3$(I) = "0": NEXT
255  TEXT : HOME : FOR I = 1 TO 20:AA = I + 20
256  IF A3$(I) = "1" THEN A4$(I) = "*"
257  IF A3$(I + 20) = "1" THEN A4$(I + 20) = "*"
258  PRINT I; TAB( 4);A4$(I); TAB( 5);A1$(I); TAB( 18);AA; TAB( 21);A4$(AA); TAB( 22);A1$(AA): NEXT
260  POKE 34,20: IF AC = 1 GOTO 280
265  HOME : PRINT "ENTER THE NUMBER OF YOUR TECHNOLOGY": PRINT "CHOICE.  * INDICATES PRIOR SELECTIONS.": INPUT AB
270  IF AB < 1 OR AB > 40 THEN  GOSUB 205: GOTO 265
275 A3$(AB) = "1":AC = 1: GOTO 255
280  HOME : PRINT "ANOTHER CHOICE?  ENTER EITHER NO OR THE": PRINT "NUMBER OF YOUR CHOICE AND PRESS RETURN.": INPUT AA$
285  IF AA$ = "NO" GOTO 300
290 AB =  VAL (AA$): GOTO 270
295  GOTO 255
300  TEXT : RETURN
305  HOME : PRINT "AVAILABLE TECHNOLOGIES ARE:":AC = 0
310  FOR I = 1 TO 40:A4$(I) = " ": NEXT
315  FOR I = 1 TO 40
320  IF A3$(I) = "0" GOTO 350
321  IF AC = 0 GOTO 325
325  PRINT  TAB( 2);I; TAB( 5);A4$(I); TAB( 6);A1$(I)
330  IF I = 20 THEN  POKE 33,16: POKE 32,23: POKE 34,1: HOME : IF AC = 1 THEN  POKE 34,0: HOME
350  NEXT
365  POKE 34,21: POKE 32,0: POKE 33,40: HOME : IF AC = 1 GOTO 385
370  HOME : PRINT "ENTER THE NUMBER OF YOUR TECHNOLOGY": PRINT "CHOICE.  * INDICATES PRIOR SELECTIONS.": INPUT AB
375  IF AB < 1 OR AB > 40 THEN  GOSUB 205: GOTO 370
376  IF A3$(AB) = "0" THEN  GOSUB 205: GOTO 370
380 A4$(AB) = "*":A3$(AB) = "1":AC = 1: TEXT : HOME : GOTO 315
385  HOME : PRINT "ANOTHER CHOICE?  ENTER EITHER NO OR THE": PRINT "NUMBER OF YOUR CHOICE AND PRESS RETURN.": INPUT AA$
390  IF AA$ = "NO" GOTO 405
395 AB =  VAL (AA$): GOTO 375
400  GOTO 415
405  TEXT : RETURN
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410  HOME
415 AB$ = "**************":AC$ = "*                *":AD$ = "@":AE$ = "*)*          *"
420  PRINT  TAB( 7),AD: PRINT AB$: PRINT AC$: RETURN
422 EI = 1
425 AA =  LEN (A1$(AB)):AA = 10.0 - AA
430  PRINT AD$, SPC( AA),A1$(AB);AE$: RETURN
435  PRINT AD$: RETURN
440  POKE 33,13  POKE 32,LL: POKE 34,TT: RETURN
445  HOME : PRINT "AVAILABLE TECHNOLOGIES ARE:"
450  FOR K = 1 TO 40
452  IF K = 21 THEN  POKE 33,14: POKE 32,23: POKE 34,1: HOME
455  IF A4$(K) = " " GOTO 470
460  PRINT  TAB( 2);K; TAB( 5);A1$(K)
470  NEXT K
475  POKE 34,21: POKE 32,0: POKE 33,40: HOME
480  PRINT "WHICH TECHNOLOGY IS YOUR CHOICE FOR": PRINT "STAGE ";AJ;"?": INPUT AB
485  IF A4$(AB) = " " THEN  GOSUB 205: GOTO 480
490  HOME : PRINT "AT WHAT YEAR WILL ",A1$(AB);" BE": PRINT "AVAILABLE?  (CURRENT=1,MAX=99)": INPUT AI
491  IF AI < 1 OR AI > 100 THEN  GOSUB 205: GOTO 490
495  TEXT : RETURN
500  PRINT D$;"OPEN";F$: PRINT D$;"DELETE",F$: RETURN
501  IF R = 2 THEN  GOSUB 500
502  PRINT D$,"OPEN";F$;",L10"
503 R = R - (AF + 1):B = 0: FOR M = R TO R + AF + 1
505  PRINT D$,"WRITE";F$;",R";M;",B";B
510  PRINT A5$(M): PRINT A6$(M): NEXT
512 R = M - 1
515  PRINT D$;"CLOSE";F$: RETURN
520  PRINT D$;"OPEN";F$;",L10": PRINT D$;"WRITE";F$;",R";C;",B";B
525  PRINT A5$(I)  PRINT A6$(I)
530  PRINT D$;"CLOSE",F$  RETURN
535 C = 1: PRINT D$,"OPEN";F$,",L10":D8 = 1
540  PRINT D$,"READ",F$;",R",C;",B",B
545  INPUT B1$(C),B2$(C)
550 C = 2:AG =  VAL (B1$(1)):D7 = AG
554 L = 10:F$ = "MAPMAT.DATA.2": PRINT D$;"READ";F$;",R";C;",              B",B
555  INPUT B1$(C),B2$(C)
560 AI =  VAL (B2$(C))
565  FOR I = C + 1 TO C + AF
570  PRINT D$,"READ",F$;",R";I;",B";B
571  INPUT B1$(I),B2$(I)
572  NEXT
574  HOME : PRINT "TREATMENT TRAIN ";B1$(C): PRINT
575  PRINT "S"; TAB( 14);"B": PRINT "T"; TAB( 15);"VU"; TAB( 29);"OPERATION": PRINT "A"; TAB( 15);"EI"; TAB( 32);"AND": PRINT "G"; T
AB( 15);"AL"; TAB( 18);"CAPITAL"; TAB( 29);"MAINTENANCE"
576  PRINT "E", TAB( 4),"TECHNOLOGY"; TAB( 15);"RT"; TAB( 18);"COST"; TAB( 32),"COST"
577  PRINT "--"; TAB( 4);"----------"; TAB( 15);"--"; TAB( 18),"-------"; TAB( 29),"-----------"
584 AD = 0
585  FOR I = C + 1 TO C + AI:AD = AD + 1
586 AI =  VAL (B2$(I)):AB =  VAL (B1$(I))
587  GOSUB 1000
588 D4 = D4 + A5(I) + A6(I)
590  PRINT AD, TAB( 4),A1$(AB), TAB( 15);AI; TAB( 18),A5(I); TAB( 29);A6(I)
591  NEXT : GOSUB 1300 D4 = 0
592 AG = AG - 1: PRINT D$;"CLOSE";F$: GOSUB 210
595 C = C + AF + 1: IF AG = 0 GOTO 599
596  PRINT D$;"OPEN";F$;",L10": GOTO 554
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599  GOSUB 1350: TEXT : RETURN
600  REM
605 F$ = "MAPMAT COST ONE":L = 40:B = 0
620  PRINT D$;"OPEN";F$;",L";L
621  PRINT D$;"READ";F$;",R";C7;",B";B
622  INPUT X1,X2,X3,X4,X5
623  PRINT D$;"CLOSE";F$
640 A5(I) = X1:A6(I) = X2
645 D2 = C3 - A1
650 D3 = (1 - ((1 + C4) ^  - D2)) / C4
655 D6 = (P1 * A6(I) * .1) + (P2 * .45 * A6(I)) + (P3 * .2 * A6(I))
660 A6(I) = (A6(I) + D6) * (D3)
665 D6 = 0:P1 = 0:P2 = 0:P3 = 0: RETURN
700  HOME : PRINT "WHAT IS THE DESIGN LEVEL OF POPULATION": PRINT "AT THE LOCAL SITE?": INPUT C1
705  HOME : PRINT "WHAT IS THE EXPECTED POPULATION GROWTH": PRINT "RATE EXPRESSED AS AN INTERGER?  FOR "
710  PRINT "EXAMPLE ENTER 3 FOR A THREE PERCENT": PRINT "RATE AND PRESS RETURN.": INPUT C2
715 C2 = C2 / 100
720  HOME : PRINT "WHAT IS THE PERIOD OF DESIGN TO BE USED": PRINT "IN THE ANALYSIS? (MAXIMUM=100)": INPUT C3
725  HOME : PRINT "WHAT IS THE OPPORTUNITY COST OF CAPITAL": PRINT "OR DISCOUNT RATE TO BE USED IN THE "
730  PRINT "ANALYSIS?  ENTER AN INTERGER SUCH AS 10": PRINT "FOR A TEN PERCENT COST OF CAPITAL.": INPUT C4
735 C4 = C4 / 100
740  HOME : PRINT "A CRITICAL CRITERIA IN EVALUATING THE": PRINT "COST OF TECHNOLOGY IS THE LEVEL OF "
750  PRINT "SUPPORT AVAILABLE DURING THE USE OF THE": PRINT "TECHNOLOGY.  IN GENERAL A GOOD MEASURE"
755  PRINT "OF THIS SUPPORT IS THE EXISTING LEVEL": PRINT "OF THE INFRASTRUCTURE.  MAPMAT INCLUDES"
760  PRINT "FOUR LEVELS OF INFRASTRUCTURE.  WHICH": PRINT "INFRASTRUCTURE LEVEL IS CLOSEST TO THE": PRINT "DESIGN SITE?": PRINT
765  PRINT " 1--THE INFRASTRUCTURE IS DEPENDENT ON": PRINT  TAB( 5);"IMPORTED EMPLOYMENT; AGRICULTURALLY"
770  PRINT  TAB( 5);"ORIENTED WITH A VERY SMALL OR NON-": PRINT  TAB( 5);"EXISTANT LOCAL MARKET ECONOMY; FEW": PRINT  TAB( 5);"HIGH
SCHOOL OR COLLEGE GRADUATES"
772  PRINT  TAB( 5);"ARE AVAILABLE TO HELP LOCALLY "
775  PRINT  TAB( 5);"UNLESS FROM A VOLUNTEER TYPE   ": PRINT  TAB( 5);"ORGANIZATION.  ALMOST 100 PERCENT"
780  PRINT  TAB( 5);"OF LOCAL EMPLOYMENT IS AGRICULTURE.": PRINT  TAB( 5);"A RURAL VILLAGE IS AN EXAMPLE."
785  GOSUB 210: POKE 34,10
790  HOME : PRINT " 2--THE INFRASTRUCTURE IS DEPENDENT": PRINT  TAB( 5);"ON THE IMPORTED EMPLOYMENT OF "
795  PRINT  TAB( 5);"SCIENTIFIC/TECHNICAL PEOPLE BUT": PRINT  TAB( 5);"PRODUCES MANAGERS, OPERATORS, LOW"
800  PRINT  TAB( 5);"LEVEL TEACHERS, ETC. TO SUPPORT A": PRINT  TAB( 5);"LOW TO MEDIUM SIZE MARKET ECONOMY."
805  PRINT  TAB( 5);"APPROXIMATELY 50 PERCENT OF THE": PRINT  TAB( 5);"LOCAL POPULATION DERIVES A": PRINT  TAB( 5);"LIVELIHOOD FROM
AGRICULTURE.  THE"
810  PRINT  TAB( 5);"SECONDARY AND PRIMARY SCHOOLS ARE": PRINT  TAB( 5);"DEVELOPED BUT THE QUALITY OF": PRINT  TAB( 5);"INSTRUCTION
MAY BE VERY VARIABLE."
815 : GOSUB 210: HOME
820  PRINT " 2-- ...  CONTINUED.....": PRINT : PRINT  TAB( 5);"AN EXAMPLE IS A RURAL TOWN OR ": PRINT  TAB( 5);"SMALL CITY."
825  GOSUB 210
830  HOME : PRINT " 3--THE INFRASTRUCTURE HAS AVAILABLE": PRINT  TAB( 5);"SCIENTISTS, ENGINEERS, AND OTHER ": PRINT  TAB( 5);"PROFES
SIONALS BUT IMPORTS ALMOST"
835  PRINT  TAB( 5);"ALL RESEARCH PROFESSIONALS. PRIMARY": PRINT  TAB( 5);"AND SECONDARY SCHOOL SYSTEMS ARE": PRINT  TAB( 5);"WELL D
EVELOPED WITH  GENERALLY GOOD"
840  PRINT  TAB( 5);"TEACHERS. A LOCAL COLLEGE MAY BE": PRINT  TAB( 5);"AVAILABLE.  LESS THAN 25 PERCENT OF"
845  PRINT  TAB( 5);"THE POPULATION PRIMARILY DEPENDS ON": PRINT  TAB( 5);"AGRICULTURE RELATED ENTERPRISE."
847  GOSUB 210: HOME : PRINT " 3--....CONTINUED... ... ": PRINT
850  PRINT  TAB( 5);"AN EXAMPLE IS A LARGE BUT ISOLATED": PRINT  TAB( 5);"CITY, POSSIBLY A REGIONAL CENTER": PRINT  TAB( 5);"OF COMM
ERCE."
855  GOSUB 210
860  HOME : PRINT " 4--THE INFRASTRUCTURE CLOSELY": PRINT  TAB( 5);"RESEMBLES A LARGE CITY IN A": PRINT  TAB( 5);"DEVELOPED COUNTRY.
  SIGNIFICANT"
865  PRINT  TAB( 5);"PORTIONS OF THE POPULATION FINISH": PRINT  TAB( 5);"PRIMARY AND SECONDARY SCHOOL.  ": PRINT  TAB( 5);"RESEARCH
PROFESSIONALS ARE READILY"
870  PRINT  TAB( 5);"AVAILABLE AND HIGH TECHNOLOGY IS": PRINT  TAB( 5);"ALSO AVAILABLE.  AN EXAMPLE IS THE": PRINT  TAB( 5);"NATIONA
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L CAPITAL OF A DEVELOPING": PRINT  TAB( 5);"COUNTRY "
872  GOSUB 210
875  HOME : PRINT " 1--RURAL VILLAGE LEVEL.": PRINT " 2--RURAL TOWN OR SMALL CITY LEVEL.": PRINT " 3--LARGE BUT ISOLATED CITY LEVEL.
". PRINT " 4--NATIONAL CAPITAL LEVEL "
880  PRINT : PRINT "IF YOU NEED TO REVIEW THE DEFINATIONS". PRINT "FOR THESE LEVELS ENTER HELP OTHERWISE": GOSUB 216
885  IF AA$ = "HELP" THEN  TEXT : GOTO 740
890  IF AA < 1 OR AA > 4 THEN  GOSUB 205: GOTO 875
895 C6 =  VAL (AA$)
899  TEXT . RETURN
1000  REM
1005 C9 = 0.C7 = 0.D1 = C1
1020  ON AD GOSUB 1101,1102,1103,1104,1105,1106,1107,1108,1109,1110,1111,1112,1113,1114,1115,1116,1117,1118,1119,1120,1121,1122,1123
,1124,1125,1126,1127,1128,1129,1130,1131,1132,1133,1134,1135,1136,1137,1138,1139,1140
1021  IF A2$(4) = "1" THEN P2 = 0
1022  IF A2$(5) = "1" THEN P1 = 0
1025  REM
1030  ON C6 GOSUB 1151,1152,1153,1154
1035  FOR C8 = 1 TO C3
1040 D1 = (D1) * (1 + C2):C9 = D1 + C9
1045  NEXT
1050 C9 = C9 / C3
1055  IF C9 <  = 2500 THEN C5 = 0
1060  IF C9 > 2500 AND C9 <  = 15000 THEN C5 = 1
1065  IF C9 > 15000 AND C9 <  = 50000 THEN C5 = 2
1070  IF C9 > 50000 THEN C5 = 3
1075 C7 = C7 + C5.D2 = C3 - A1
1076  IF D2 = 0 THEN D2 = 1
1080 D3 = (1 - ((1 + C4) ^  - D2)) / C4
1085  GOSUB 600
1099  RETURN
1100  REM
1101 C7 = 369:P1 = 1: RETURN
1102 C7 = 385:P1 = 1: RETURN
1103 C7 = 401:P1 = 1: RETURN
1104 C7 = 417:P3 = 1: RETURN
1105 C7 = 433:P1 = 1. RETURN
1106 C7 = 449:P1 = 1: RETURN
1107 C7 = 465:P2 = 1: RETURN
1108 C7 = 481:P1 = 1:P2 = 1: RETURN
1109 C7 = 497:P1 = 1:P3 = 1: RETURN
1110 C7 = 513:P3 = 1. RETURN
1111 C7 = 529:P2 = 1 P3 = 1. RETURN
1112 C7 = 545:P1 = 1. RETURN
1113 C7 = 561:P3 = 1: RETURN
1114 C7 = 577:P2 = 1 P3 = 1: RETURN
1115 C7 = 10000. RETURN
1116 C7 = 193: RETURN
1117 C7 = 10000: RETURN
1118 C7 = 10000  RETURN
1119 C7 = 177:P2 = 1.P3 = 1: RETURN
1120 C7 = 209:P2 = 1.P3 = 1: RETURN
1121 C7 = 225:P2 = 1 P3 = 1: RETURN
1122 C7 = 305:P2 = 1 P3 = 1: RETURN
1123 C7 = 337:P2 = 1:P3 = 1: RETURN
1124 C7 = 353:P2 = 1 P3 = 1: RETURN
1125 C7 = 321:P2 = 1 P3 = 1: RETURN
1126 C7 = 289:P2 = 1:P3 = 1: RETURN
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1127 C7 = 257:P2 = 1:P3 = 1: RETURN
1128 C7 = 273:P2 = 1:P3 = 1: RETURN
1129 C7 = 241:P2 = 1:P3 = 1: RETURN
1130 C7 = 1: RETURN
1131 C7 = 17: RETURN
1132 C7 = 33: RETURN
1133 C7 = 49: RETURN
1134 C7 = 97: RETURN
1135 C7 = 113: RETURN
1136 C7 = 161: RETURN
1137 C7 = 10000: RETURN
1138 C7 = 81: RETURN
1139 C7 = 129: RETURN
1140 C7 = 145: RETURN
1145  REM
1151 C7 = C7 + 0: RETURN
1152 C7 = C7 + 4: RETURN
1153 C7 = C7 + 8: RETURN
1154 C7 = C7 + 12: RETURN
1200  FOR I = 1 TO 100:A5(I) = 0:A6(I) = 0: NEXT : RETURN
1300  REM
1305 D4 =  INT (D4):F$ = "MAPMAT.DATA.3"
1310  PRINT : PRINT  TAB( 2);"TOTAL PRESENT VALUE COST RATIO= ";D4
1315 D8 = D8 + 1:E2 = E2 + 1
1330  PRINT D$;"OPEN";F$;", L20"
1335  PRINT D$;"WRITE";F$;",R";D8;",B";B
1340  PRINT E2: PRINT D4
1345  PRINT D$;"CLOSE";F$: RETURN
1350 F$ = "MAPMAT.DATA.3": PRINT D$;"OPEN";F$;", L20"
1355  PRINT D$;"WRITE";F$;",R1";",B";B
1360  PRINT D7: PRINT D7
1365  PRINT D$;"CLOSE";F$: RETURN
1400 F$ = "MAPMAT.DATA.3": PRINT D$;"OPEN";F$;", L20"
1405 AA = 1: PRINT D$;"READ";F$;",R";AA;",B";B
1410  INPUT AC,D4
1415  HOME : PRINT  TAB( 7);"ALTERNATIVE TREATMENT TRAIN": PRINT  TAB( 5);"TOTAL PRESENT VALUE COST RATIOS": PRINT
1420  PRINT  TAB( 18);"TOTAL PRESENT": PRINT  TAB( 6);"TREATMENT"; TAB( 21);"VALUE": PRINT  TAB( 8);"TRAIN"; TAB( 18);"COST RATIO":
PRINT  TAB( 6);"---------"; TAB( 18);"-------------"
1421  POKE 34,7
1425  FOR I = 2 TO AC + 1
1430  PRINT D$;"READ";F$;",R";I;",B";B
1435  INPUT AA,D4
1445  PRINT  TAB( 10);I - 1; TAB( 20);D4
1447 E1 = E1 + 1:E3 = E3 + 1
1448  IF E3 = 12 THEN  GOSUB 210:E3 = 0
1450  NEXT
1465  PRINT D$;"CLOSE";F$
1499  GOSUB 210: TEXT : RETURN
1500  RETURN
20000  REM
20005  REM
20010  REM                                        MAIN PROGRAM
20020  REM
20100  DIM A1$(40),A2$(40),A3$(40),A4$(40),A5(100),A6(100),A7(40),A8(40),B1$(100),B2$(100)
20105 D$ =  CHR$ (4):I$ =  CHR$ (9):W$ =  CHR$ (23)
20110  IF AA = 2 GOTO 20120
20115  PRINT D$;"PR#1": PRINT W$;I$;"C"
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20120 F$ = "MAPMAT.DATA.1": GOSUB 225:F$ = "MAPMAT.DATA.2"
20130  REM F$ = "MAPMAT.DATA.3"
20199  REM
20200  REM
20220  HOME : PRINT "WELCOME TO THE SENSITIVITY SECTION OF": PRINT "MAPMAT.  IN THIS SECTION YOU CAN": PRINT "MODIFY PREVIOUS DATA T
O INVESTIGATE"
20221  PRINT "THE EFFECT OF ALTERNATE INFORMATION "
20222  PRINT "IF YOU HAVE ARRIVED AT THE WRONG POINT": PRINT "THEN ENTER WRONG AND PRESS RETURN. IF "
20223  PRINT "THIS IS THE RIGHT SECTION OF MAPMAT ": PRINT "THEN TYPE RIGHT AND PRESS RETURN.": INPUT AA$
20230  IF AA$ = "RIGHT" GOTO 20255
20235  IF AA$ = "WRONG" GOTO 20250
20240  GOSUB 205: GOTO 20200
20250  PRINT D$;"RUN MAPMAT.MAIN"
20255  HOME : PRINT "THERE ARE SIX ALTERNATIVE PARTS IN THE ": PRINT "SENSITIVITY SECTION OF MAPMAT.  YOU "
20260  PRINT "WILL BE ABLE TO RUN ANY OR ALL OF THE ": PRINT "SECTIONS.  THE ALTERNATIVES ARE:": PRINT
20265  PRINT  TAB( 3);"1---CHANGE THE AVAILABLE TECHNOLOGY ": PRINT  TAB( 3);"2---CHANGE THE TREATMENT TRAINS OR"
20266  PRINT  TAB( 7);"TREATMENT GOALS.": PRINT  TAB( 3);"3---CHANGE THE ANSWERS TO QUESTIONS"
20267  PRINT  TAB( 7);"WHICH DETERMINE THE AVAILABLE ": PRINT  TAB( 7);"TECHNOLOGY."
20268  PRINT  TAB( 3);"4---RERUN MAPMAT USING NEW DATA.": PRINT  TAB( 3);"5---CHANGE THE COST RATIO DATA."
20269  PRINT  TAB( 3);"6---CHANGE THE COST EFFECTIVENESS": PRINT  TAB( 7);"DATA."
20275  GOSUB 215
20276  IF AA < 1 OR AA > 6 THEN  GOSUB 205: GOTO 20255
20280  IF AA = 3 THEN  PRINT D$;"RUN MAPMAT.AVAIL"
20285  IF AA = 4 THEN  PRINT D$;"RUN MAPMAT.MAIN"
20290  IF AA = 6 THEN  PRINT D$;"RUN MAPMAT.EFFECTIVENESS"
20295  IF AA = 1 GOTO 20600
20296  IF AA = 2 GOTO 20700
20300  REM
20350  HOME : PRINT "DO YOU NEED A CATALOG OF THE DISK TO ": PRINT "LOCATE YOUR FILENAME?":
20355  GOSUB 220
20360  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20350
20365  ON AA GOTO 20370,20380
20370  PRINT D$;"CATALOG": GOSUB 210
20375  PRINT : PRINT "ENTER THE FILE NAME": INPUT F$
20380  GOSUB 700
20385  HOME : PRINT "MAPMAT WILL BE RIGHT BACK": PRINT : PRINT : PRINT  TAB( 12);"PLEASE WAIT!!!": GOSUB 535
20400  GOSUB 1400
20410  HOME : PRINT "MAPMAT HAS STORED YOUR TREATMENT TRAIN": PRINT "COST RATIOS IN A TEMPORARY FILE.  DO"
20415  PRINT "YOU WANT TO STORE THE DATA UNDER A ": PRINT "PERMENTANT FILE NAME?"
20420  GOSUB 220
20425  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20410
20427  IF AA = 2 GOTO 20500
20430  HOME : PRINT "DO YOU NEED A CATALOG OF THE DISK TO ": PRINT "LOCATE YOUR FILENAME?"
20435  GOSUB 220
20440  IF AA < 1 OR AA > 2 THEN  GOSUB 205: GOTO 20430
20441  ON AA GOTO 20442,20445
20442  PRINT D$;"CATALOG": GOSUB 210
20445  PRINT : PRINT "ENTER THE FILE NAME": INPUT F$
20500  HOME : PRINT "YOU HAVE COMPLETED THE COST RATIO ": PRINT "SECTION OF MAPMAT.  YOU ARE READY TO "
20505  PRINT "PROCEED TO ANOTHER SECTION OF MAPMAT.": PRINT "YOU WILL BE RETURNED TO THE MAIN MENU."
20510  GOSUB 210
20515  PRINT D$;"RUN  MAPMAT.MAIN"
20600  PRINT D$;"RUN MAPMAT.OPTIMIZE"
20700  PRINT D$;"RUN MAPMAT.OPTIMIZE"
29999  END
```

APPENDIX Y

GLOSSARY

1. Appropriate technology . . . . technology which is suited to local conditions on the basis of resource availability, technical constraints, the economic infrastructure, and cultural factors.
2. Contaminated water . . . . . . water which is generally unfit for human use due to level of pollutants which it contains, i.e., coliform bacteria, DDT, heavy metals, etc.
3. Turbid water . . . . water which contains suspended materials such as dirt, solids, etc.
4. Clean water . . . . water free from significant amounts of contaminants and/or turbidity.

5. Waterborne diseases . . . . . those diseases which are contacted through the consumption of water.

6. Water wash related diseases . . . . those diseases which are generally correlated with the unavailability of clean water to rinse vegtables, etc.

7. Water related insect vector diseases . . . . those diseases which are generally contacted when water stands untreated in open catchment for significant periods of time.

8. Infrastructure . . . . the institutions, forward and economic backward linkages, public services, and public works supporting economic development.

9. MGD . . . . million gallons per day.

10. Modem . . . . a telecommunications device to link one computer to another over telephone lines.

11. Kinetics and mass balance equations . . . . . . those physical, chemical, and/or mathematical relationships which define how a particular process will react during the treatment of water/wastewater flow.

12. Treatment goals . . . . the specification of the standard levels to be allowed for certain pollutants; i.e., biological oxygen demand (BOD), most probable number (MPN) of coliform, chemical oxygen demand (COD), etc.