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Water Engineering Research
Laboratory
Cincinnati OH 45268

Research and Development

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Project Summary

Computer Assisted Preliminary Design for Drinking Water Treatment Process Systems

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A computer program known as WATER MAID was developed for use in estimating the performance and costs of existing and proposed drinking water treatment systems. Design procedures and cost-estimating relationships for 25 individual drinking water treatment processes are contained within the computer model. The unit processes were selected on the basis of their applicability to the removal of contaminants included in the National Interim Primary Drinking Water Regulations or to the treatment and disposal of sludges and brines produced by these treatment processes.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Estimating the performance efficiency and cost of water supply systems is of considerable interest to Federal, State, and local agencies, as well as to consulting engineers and planners. The computer program developed as part of this project can be used to calculate the expected contaminant removal performance and associated construction and operation/maintenance costs of drinking water treatment systems consisting of various unit treatment processes arranged in multiple configurations. The technology used in sizing unit processes, estimating removal efficiencies, and determining treatment cost is the best that is known to be currently available for preliminary design. Since the technology for each process is contained in individual subroutines of the computer program, improving and updating the technology as it becomes available is easily accomplished. The structure of the program allows the inclusion of additional unit process models if desired. The final report for this project also serves as a user's guide for the computer program.

Scope

The program name is WATER MAID, with MAID being an acronym for microcomputer assisted interactive design. WATER MAID consists of a number of support subprograms and a design/cost subprogram for each of 25 unit treatment processes.

The user must provide the influent concentrations or values for a list of 55 contaminants and other parameters that characterize the raw water stream enter- process is also displayed after each unit processes to be used, which are arranged in a specific flow diagram. The program then computes one or more effluent stream vectors and cost estimates for each process based on design input decisions supplied by the user. WATER MAID is an interactive program, and design decision parameters are entered from the computer keyboard in response to screen prompts.

The following unit processes are included in WATER MAID:

1. Sludge drying beds
2. Basin air stripping
3. Sludge centrifugation
4. Filtration

5. Flocculation
6. Sludge filter pressing
7. Finished water pumping
8. Granular carbon adsorption
9. Ion exchange
10. Disinfection with chlorine
11. Sludge lagoons
12. Land disposal of sludge
13. Lime softening
14. Stream mixer
15. Presedimentation
16. Lime sludge recalcination
17. Rapid mixing (chemical addition)
18. Reverse osmosis
19. Raw water pumping
20. Sedimentation
21. Stream splitter
22. Clearwell storage
23. Sludge gravity thickening
24. Tower air stripping
25. Sludge vacuum filtration

The following water parameters and contaminants are included in the stream vector (trihalomethane concentrations are in units of μg/L; all other concentrations are in mg/L unless otherwise specified):

1. Design plant flow rate, mgd
2. Water temperature, °C
3. pH
4. Turbidity, ntu
5. Color, pcu
6. Coliform organisms, #/100 mL
7. Total dissolved solids
8. Total suspended solids
9. Volatile suspended solids
10. Carbonate alkalinity
11. Noncarbonate alkalinity
12. Calcium ion
13. Magnesium ion
14. Sodium ion
15. Copper
16. Ferrous ion
17. Ferric ion
18. Bivalent manganese
19. Quadravalent manganese
20. Chloride
21. Sulfate ion
22. Nitrate ion
23. Total organic carbon
24. Nonpurgeable organic carbon
25. Pentavalent arsenic
26. Trivalent arsenic
27. Barium
28. Cadmium
29. Hexavalent chromium
30. Trivalent chromium
31. Lead
32. Mercury
33. Organic mercury
34. Quadravalent selenium
35. Hexavalent selenium
36. Silver
37. Fluoride
38. Endrin
39. Lindane
40. Toxaphene
41. 2,4-D
42. Silvex
43. Methoxychlor
44. Gross alpha particle, pCi/L
45. Radium-226, pCi/L
46. Radium-228, pCi/L
47. THM formation precursors
48. $CHCl_3$ (THM)
49. $CHBrCl_2$ (THM)
50. $CHBr_2Cl$ (THM)
51. $CHBr_3$ (THM)
52. Aluminum hydroxide
53. Ferric hydroxide
54. Calcium carbonate
55. Magnesium hydroxide

Purposes and Objectives

WATER MAID was developed to provide an efficient, interactive process design tool for consulting engineers, students, etc. The primary purpose is to evaluate any proposed system of drinking water treatment processes with respect to treatment effectiveness and cost with a minimum of engineering effort. Technology used in the development of individual process models is consistent with the state of the art. However, in many cases, the need for additional research is clear. Updating the technology when improved performance, cost, and design information becomes available can be done by the user.

Cost estimating data used in WATER MAID came from technical literature, equipment manufacturer's information, previous EPA research projects, etc. Treatment plant capacity limits for these data have been set at 1 to 200 mgd. A secondary purpose of WATER MAID is to provide a more flexible, preliminary, cost-estimating tool than that provided by graphical or tabular cost data. Cost-estimating procedures or data bases are often presented at a number of specific design parameter levels such as pumping heads or hauling distances for sludge, thus limiting their general applicability. When a cost-estimating algorithm is known, it can be used in WATER MAID in place of mathematical representations of tabular data, thus providing more accurate cost estimates. Some of the design procedures used in the program are limited by the availability of cost information.

Approach to Program Development

WATER MAID was written in the BASI computer language for use on the IBM P microcomputer. Because of system mem ory requirements, it was necessary t store the program on two floppy disks.

The general philosophy used in deve oping WATER MAID was to allow the use to input every possible design decision, t display the results of each design com putation as it is made, and to inform th user when design decisions are made b the program. The user is given th opportunity to change the raw wate stream vector or to change any of the co variables or chemical prices when a ne case is initiated. Recycling capability provided. The raw water stream vect and process flow diagram are stored ar can be used in the next case if desire Stream vectors for influent and effluer streams are displayed after each proces computation. A cost report for eac processs is also displayed after each un process computation. An overall cost ar parameter summary report is displaye after each case. Design flow is used compute construction cost and buildir energy requirements, and operating flo is used to calculate operation/maint nance costs. The user may also delete unit process from the flow diagram replace any unit process with anoth after each process computation. Th allows the user to consider alternati processes without rerunning the pr gram.

Conclusions

WATER MAID represents a mathema ical modeling effort that is a significa improvement on the hand calculati method of process design still commor used today. The principal deterrents better process design are usually th manual effort required in computing th expected performance and cost of alte native designs and the labor required accumulate and correlate the lar amount of experimental process desi performance data that is often availab The computer model can minimize t computational work required for exami ing alternative designs, and assumi that the model has been correctly dev oped, it will reflect the best experimen and scientific information obtainab WATER MAID provides the process d signer with a tool for quantitatively sele ing the most cost-effective system of u processes to achieve any drinking wa

treatment goal. The use of computer design techniques is a significant aid in achieving better treatment at a minimum cost.

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***Richard G. Eilers** is the EPA Project Officer (see below).*
The complete report consists of two parts, entitled "Computer Assisted Preliminary Design for Drinking Water Treatment Process Systems:"
Paper copy only (Order No. PB 86-181 112/AS; Cost: $22.95)
Software for Computer Program (2 diskettes) (Order No. PB 86-181 120/AS; Cost: $90.00, this price includes the paper copy as well)
The above will be available only from: (cost subject to change)
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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