Rest Area Wastewater Disposal

A STUDY PREPARED FOR THE

WASHINGTON STATE HIGHWAY COMMISSION • DEPARTMENT OF HIGHWAYS

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON

JANUARY 1972

REST AREA WASTEWATER DISPOSAL

A Study

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WASHINGTON STATE HIGHWAY COMMISSION

DEPARTMENT OF HIGHWAYS

by

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February 2, 1972

Mr. H. R. Goff, Assistant Director for
Planning, Research and State Aid
Washington State Highway Commission
Department of Highways
Highway Administration Building
Olympia, WA 98504

Re: Rest Area Wastewater Disposal Study

Dear Mr. Goff:

It is a pleasure to transmit herewith the study report by Professor Robert W. Seabloom and myself, "Rest Area Wastewater Disposal", in conformance with Agreement Y-1423, "Wastewater Disposal Research", between the Washington State Highway Commission and the University of Washington. A preliminary draft of the report was reviewed within the Department of Highways, by the Washington Department of Ecology and by the Washington Department of Social and Health Services, Health Division. Comments in these reviews have been carefully considered by the writers. These comments are reflected in this final draft when considered appropriate and where concurred in by the writers.

We hope that the Department finds this report of value in the continuing development of Washington's outstanding rest area facilities.

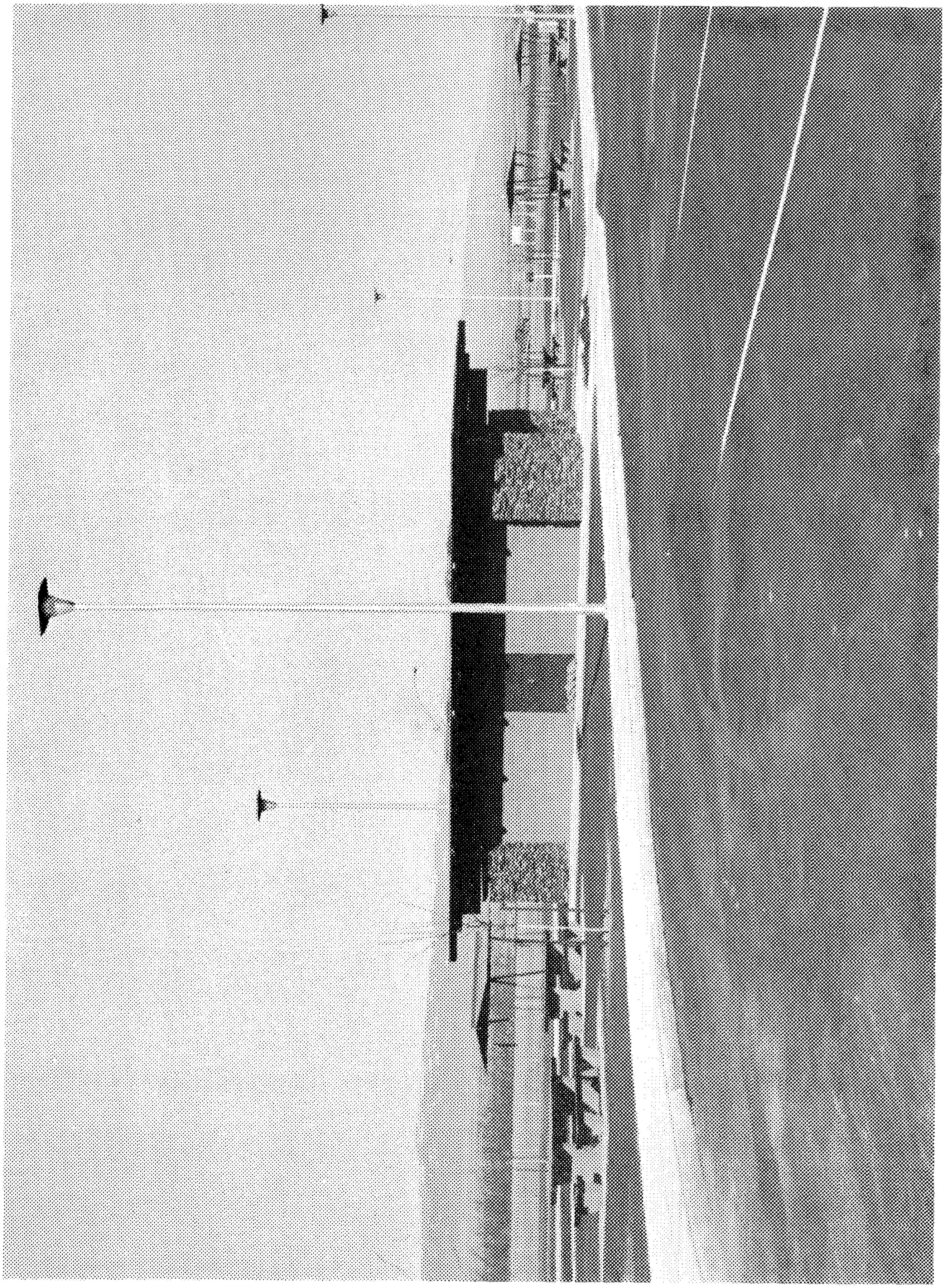
Yours truly,

ROSylvester

Robert O. Sylvester
Professor and Head, Water
and Air Resources Division

ROS:vs

Enclosure



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I. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A study was conducted of rest area wastewater disposal problems and related factors for the Washington State Highway Commission during the period of June - December, 1971. This report on the study is intended to present an evaluation of present rest area wastewater systems together with feasibility analyses of alternative methods of waste handling. It is not intended to be a preliminary engineering design report.

Data are presented on rest area problems as reported to or observed by the writers on field visitations. This is followed by discussions of criteria and standards presently used in rest area design together with data on water usage for those rest areas where "complete" data were available. Laboratory analyses were made on rest area wastewaters and on a certain additive, "Bacterial Waste Disposer", that has been used in some of the rest areas. A discussion is included on possible future trends and uses of rest areas and the need to minimize water usage. Chapter XII contains the principal thrust of the report in its discussion of possible rest area wastewater disposal methods with an evaluation and some relative cost data.

With increasingly stringent requirements for wastewater disposal, it seems apparent that rest area wastewaters must continue to be disposed of on highway property. If not, the Department would find itself, in most instances, with the task of operating continuously and effectually some rather complicated treatment systems that require trained operators, operational reports and effluent analyses, and systems that are not usually amenable to the flow characteristics of rest area wastewaters. Since much national attention is being given to these problems, it is hoped that new or improved treatment schemes may be developed in the future that will be appropriate for rest areas. An intent of this study has thus been to suggest means of wastewater disposal, presently available, that would offer an improvement to the septic tank drainfield method of disposal.

Conclusions and recommendations drawn from the study are as follows:

1. There is no question but that septic tank-drainfield disposal systems would, because of their simplicity, be the prefered method of disposal if their installation were applicable to most rest areas and if they would, from past experiences here and elsewhere, give some assurance of a freedom from operating difficulties over a period of just a few years.

Such, however, has usually not been the case and thus septic tank-drainfield installations are recommended only for those areas where soil porosity is high and extensive in area and when the ground water table is low.

2. Where topography and location will permit, rest area wastewater disposal in Eastern Washington should be through use of evaporative, non-overflow ponds, incorporating where possible, selective spray irrigation from the last pond in the series.

3. In Western Washington and in the mountain areas and foothills, wastewater might best be handled at this point in time by use of recycling toilets with vaults to store periodic discharge from the recycle unit holding tanks. As an alternative, it may be feasible to design and operate a recycle system using the present flush toilet units. In either case, the storage vault or tank would be pumped as necessary for transport to a suitable municipal wastewater treatment facility.

It is suggested that the Department install a recycle facility at the next appropriate opportunity in order to gain experience with and evaluate such a system for possible more widespread adaption.

4. Where the rest area location would permit spray irrigation, use of non-overflow ponds might be suitable for Western Washington and their use should be considered in each instance. Additional information is needed as to allowable rates of spray irrigation in areas of Western Washington and regulatory agency approval must be sought.

5. Operation and maintenance of rest area wastewater disposal systems and the water supply should be a clearly delineated responsibility at both the headquarters and the district level. These designated personnel should receive specific instruction on their responsibilities through special course attendance and interaction with the staff of the Department of Ecology and the Division of Health, DSHS. Their attendance at Washington State University and/or the University of Washington operator training short courses should be encouraged.

6. Each rest area building should have posted in the utility room, as built plans of the wastewater and water supply facility together with operating instructions. Septic tank and diversion box manholes should be readily accessible and identified.

7. Trailers or campers with their holding tanks are increasing in number with a corresponding increase in the need for holding tank content disposal facilities. Consideration should be given to the installation of holding tank dumping and washing facilities at those rest areas where they can be accomodated without construction of special holding or disposal facilities. Where a septic tank system or evaporative pond is used, these holding tank contents can be discharged to the septic tank or pond unless present facilities are near their operating capacity.

8. In the case of freeways, since they are being designed to by-pass municipalities, where feasible it would be desirable to locate rest areas in the near vicinity of a municipality so that water and sewerage service can be obtained from the municipality on a contract basis. This may also be feasible in many instances on the intrastate highway system.

9. Cooperative facilities (rest areas-parks-campgrounds-lake access areas, etc.) between the Department of Highways, Parks and Recreation Commission, and other State Agencies are to be encouraged since the combined service rendered can exceed the sum of the individual services at a reduced cost.

10. Wastewater disposal problems relate directly to the volume of used water generated. Where conventional flush toilets are installed, consideration should be given to the selection of toilet bowls that require less flushing water. Rest area designers should continue to follow the literature to be aware of new developments such as vacuum toilets as well as other methods of water conservation.

11. Prepared cultures of bacteria or enzymes, such as "bacterial waste disposers", that allegedly cure or prevent septic tank disposal system problems have been shown to have little if any beneficial effect. Their use is therefore not recommended.

12. Pumping of the water supply from wells at a low rate into storage reservoirs and then repumping to the rest area is to be encouraged as it minimizes sand pumping, excessive well drawn down, pump problems, sand clogging of flushometer valves, and pressure tank problems. Consideration should be given to the use of constant pressure pumps in lieu of pressure tanks.

13. No recommendations are made on the type of general purpose cleansers to be used by the rest area attendants. If used in accordance with manufacturers instructions they should have no appreciable deliterious effect on the wastewater disposal system.

14. Additional research by appropriate agencies is recommended on the following:

a. Toilet tissue to specify for rest areas. Paper accumulations are a problem and data could not be obtained on their relative bio-degradeable characteristics.
b. Means of reducing water usage.
c. Optimum rates of spray application for treated wastewater disposal in humid and arid areas of Washington.
d. Rate of solids (dissolved and suspended) build-up in recycle of treated wastewater through conventional flush toilets together with determination of possible operation problems.
e. Septic tank drainfield sizing. This is presently done using a soil percolation test with an empirical curve that is used for any and all soils, bearing no other relationship to the soil or wastewater characteristics. A study of existing rest area soils where drainfields are functioning could provide valuable information for future use.

15. In the selection of rest area sites, prior determination of water supply and wastewater disposal adequacy is now a prerequisite in site approval. It is believed that this requirement will prevent some of the problems previously experienced in water supply and wastewater disposal.

16. Widely fluctuating rates of water usage pose a problem in design. Design for the mean flow in the peak month ten years in the future would seem to be a reasonable design parameter at present.

17. Wastewater generated in rest room buildings is significantly different from domestic sewage in that it has a preponderance of urine and lacks the kitchen and laundry wastes. It does have a very high paper content. From a biological treatment standpoint, it would be classified as a somewhat weak sewage and one that should present no particular biological treatment problems. A low feces or solids content in the wastewater does not necessarily indicate easy disposal by subsurface irrigation. The purpose of the septic tank itself is to remove settleable and floatable solids and provide some

degradation of the wastewater components. Septic tank drainfield clogging, after a properly functioning septic tank, is due more to the development of biological flocs (growth or sludges) in the nutritious septic tank effluent than it is to the carry over of solids from the tank.

18. These conclusions would not be complete without noting the overall excellency of location, design, construction and maintenance of the State's rest areas. It was observed that they have widespread public approval.

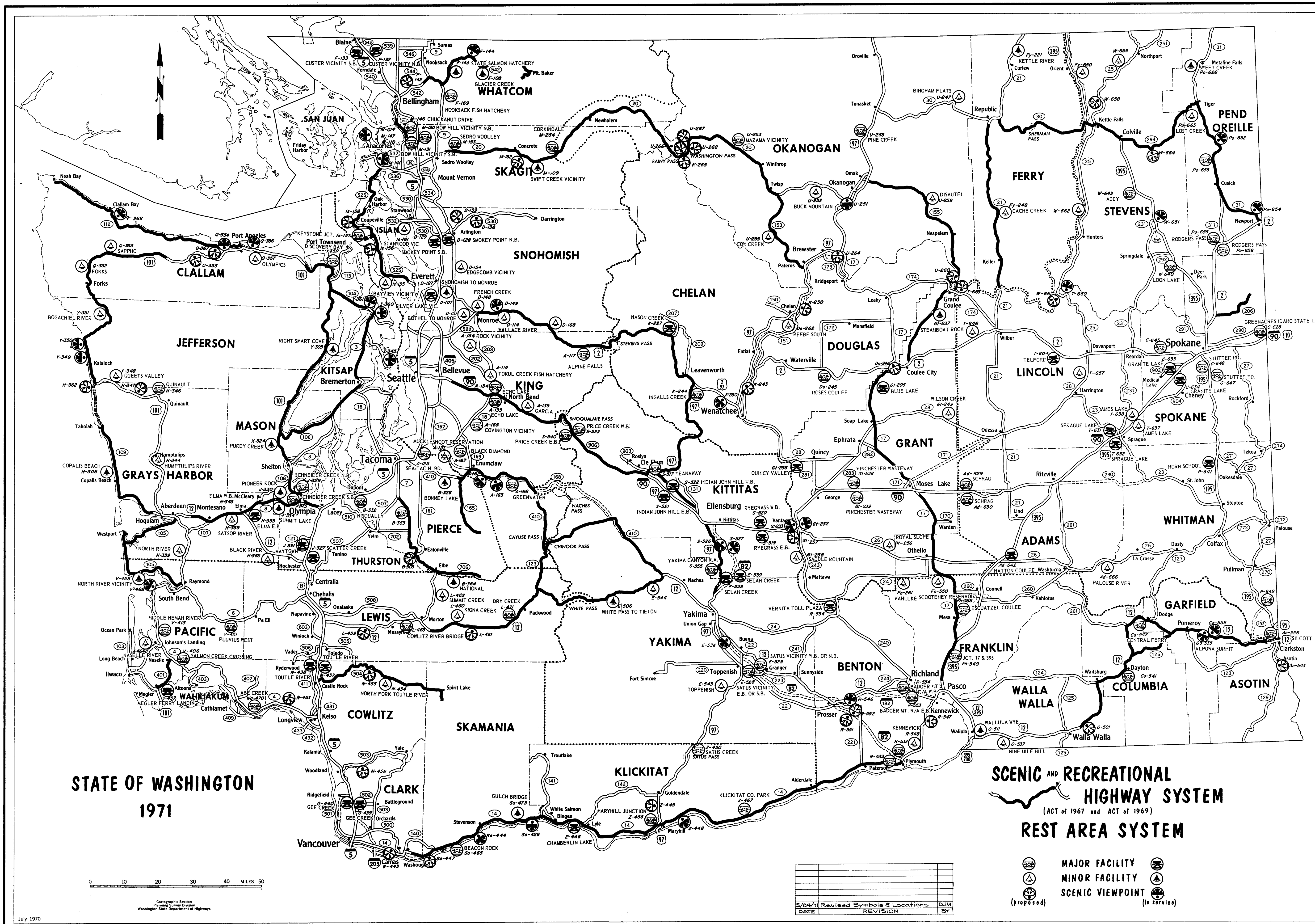
II. INTRODUCTION

This study on highway rest area wastewater disposal was sponsored by the Washington State Highway Commission, Department of Highways (1). Its principal objective was to evaluate the wastewater disposal problem and related factors and to make recommendations for future wastewater control methods. As such, it is not intended to be a preliminary engineering design report.

Twenty-six of the major rest areas were visited for the purpose of obtaining operating data and problems, construction methods, and maintenance procedures. The writers were impressed with the overall design, construction, maintenance and operation of the rest areas. They are indeed a credit to the Department and the State of Washington.

The primary reason for rest areas on interstate highways is safety. They are generally intended and designed for short occupancy; to provide a few minutes of relaxation for the motoring public. Perhaps the most important service provided for the convenience and comfort of the motorists at these safety rest areas is the rest-rooms. A water supply that meets health regulations must also be supplied. In addition receptacles for garbage and trash are provided in sufficient number to encourage their use. Picnic tables, drinking fountains, tourist information, an emergency telephone, and attractive landscaping are included for the convenience and enjoyment of the traveler. A sizable maintenance responsibility results because it is essential that these facilities be well maintained and kept clean at all times by properly trained and equipped crews.

The Washington State Department of Highways has 236 rest areas in the State's highway network. Of these, 77 are major rest areas, in operation, under construction, or planned as shown in Figure 1. The rest areas are located in regions that differ somewhat as to climate, topography, geology, and hydrology, and are in locations where municipal sewerage facilities are not available. Varying quantities of wastewater are generated at the rest areas depending upon the facilities provided, the average daily traffic, the time of day, week or year, and the location of the facilities. The wastewater disposal facilities provided have been based on the volume of


STATE OF WASHINGTON
1971
SCENIC AND RECREATIONAL
HIGHWAY SYSTEM
(ACT of 1967 and ACT of 1969)
REST AREA SYSTEM
MAJOR FACILITY
MINOR FACILITY
SCENIC VIEWPOINT
(proposed)
(in service)
5/24/71 Revised Symbols & Locations DJM
DATE REVISION BY
MILES 50
Cartographic Section
Planning Survey Division
Washington State Department of Highways
July 1970
WHATCOM
SAN JUAN
SKAGIT
OKANOGAN
FERRY
STEVENS
PEND OREILLE
ISLAND
SNOHOMISH
CLALLAM
JEFFERSON
CHELAN
DOUGLAS
LINCOLN
SPOKANE
KITSAP
KING
MASON
GRAYS HARBOR
GRANT
KITTITAS
PIERCE
THURSTON
ADAMS
WHITMAN
PACIFIC
LEWIS
YAKIMA
FRANKLIN
GARFIELD
BENTON
WALLA WALLA
COLUMBIA
ASOTIN
WAHKIAKUM
COWLITZ
SKAMANIA
KLICKITAT
CLARK
Seattle
Tacoma
Spokane
Olympia
Vancouver
Yakima
Wenatchee
Bellingham
Everett
Walla Walla
Richland
Pasco
Kennewick

flow, soil types, climate, and available land area. It is important that the sewage disposal facilities be capable of preventing contamination of adjacent ground and surface waters. They must be free from odor, not cause unsightly conditions, and be easily maintained and operated. Surveillance of these sanitary facilities comes under the State Division of Health, Department of Ecology and local health departments. Past or present methods of wastewater handling and disposal have included chemical toilets, septic tank and drainfield systems and waste stabilization ponds. A number of the present systems have experienced operating difficulties for a variety of reasons. Because increased usage is tending to aggravate some of the operational problems and because plans are being made for many additional rest areas in the State, it was deemed desirable that the entire subject of wastewater disposal at rest areas be evaluated.

Similar problems of waste handling are experienced by other State agencies as well as the many isolated private service areas encountered along the freeways and the intrastate highway network. For example, the Washington State Parks and Recreation Commission has 178 recreation areas and is acquiring more; the Department of Game has a large number of public access areas to bodies of water; and the Department of Natural Resources has some 53 camp and picnic sites, many of the so-called primitive type. Wherever feasible, it is desirable that state agencies cooperate on problems of waste handling to minimize cost and maximize service.

Data for the study reported herein were obtained through: Field visits to most of the major rest areas in the State and several in Oregon; discussions with WSDH maintenance, design, and research personnel, Oregon Department of Highways and Board of Health, Washington Department of Ecology and Health Division; field sampling of rest area wastewater characteristics; laboratory analysis; literature survey; and a compilation of proprietory and other wastewater treatment and disposal schemes.

III. THE PROBLEMS

Several years ago when the Department was planning their rest areas in locations well removed from centers of population, it was necessary to develop on site sources of water supply and on site methods of wastewater disposal. Even though streams or lakes were nearby, ground water development through the use of wells was necessary to avoid costly and complicated methods of water supply treatment. For wastewater disposal, the septic tank and subsurface percolation drainfield appeared to be the best alternative as they are used elsewhere and seem to require a minimum of attention for operation and maintenance. Subsequent problems with septic tank systems led to experimentation with waste stabilization ponds of the evaporative or non-overflow type in Eastern Washington.

Operational problems that have been experienced with the water supply - wastewater systems at rest areas have included:

1. Inadequate septic tank capacity for the loads experienced.

2. Inadequate drainfield capacity because of underdesign or site limitations.

3. Drainfield failures due to:

   a. Poor soil porosity
   b. High ground water table
   c. Heavy equipment passing over drainfield
   d. Uneven hydraulic loading of drain tile and lack of dosing units
   e. Diversion boxes not maintained
   f. Earth hauled in to provide a soil of proper porosity which cannot, by itself, accommodate the large volume of wastewater due to its limited volume.

4. Sticking flushometer valves (grain of sand from well in flushometer valve) resulting in the flushing of septic tank contents into the drainfield and subsequent clogging and overflow or break-out.

5. Pump motor failures due to inadequate pressure tank air cushion.

6. Clogging of septic tank inlet tees with paper.

7. Some maintenance personnel had not been adequately instructed as to the location of, and maintenance of the septic tank and drainfield system.

8. Sand pumping from wells; clogging of flushometer valves, water meters, and wearing of pumps.

9. Septic tank access manholes and diversion box covers under soil or pavement - no access.

10. High alkalinity in some well supplies reported to precipitate $CaCO_3$ with clogging of tile drainfield joints.

11. Undersized evaporative ponds.

12. Bacterial cultures purchased for improving septic tank drainfield performance - usefulness doubted.

13. Infrequent high rates of peak usage - sometimes difficult to anticipate in design or hard to justify as a design standard.

14. Vandalism.

15. Maintenance of air cushion in pressure tanks.

IV. LOCATION CRITERIA

The primary purpose of rest areas is for safety; to provide the highway traveler with a public facility where he can leave the right-of-way proper to rest, relax, take a stroll with or without pets, and use rest-room facilities. Drinking fountains, picnic tables, refuse cans, and attractive landscaping enhance the service provided by the facility. They are not, however, intended to be a public park as such and occupancy is intended to be brief.

Location criteria now include:

1. Separation by about 30 minutes driving time.

2. Before site is finally selected, the determination of a suitable water supply and method of wastewater disposal.

3. Where appropriate, a site that offers a view or other scenic amenities.

4. A site that does not compete with other state or private facilities of a similar nature, unless these can be combined into a joint facility.

V. DESIGN CRITERIA

The design criteria for major rest areas now used by the Washington Department of Highways, as related to the problem of wastewater, are given in Table 1. Water supply and wastewater disposal facilities must meet with the approval of the appropriate regulatory agency: Department of Ecology; Department of Social and Health Services, Health Division and/or the local health department. If a separate source of water supply is used for irrigation, it must be plainly identified as such and not be interconnected with the potable supply system.

Table 1. Rest Area Design Criteria, WSDH

Average Daily Traffic (ADT) projected for 20 years hence.	
Rest area on interstate; percent of average daily traffic (ADT) entering	12
Rest area near parks, resorts or towns; percent of ADT entering	5
Percent of people stopping using rest-rooms	80
Average number of people per vehicle	3.2
Average water use per person (gallons)	3.5
Peak hour; as percent of ADT	12
Percent of people stopping on Social-Recreation type trip	88

Water Usage:

Using the data from Table 1 the formula for the peak hourly water usage is as follows:

Gallons used during peak hour = A x B x C x D x E x F

where A = Average Daily Traffic (ADT)

B = Percent vehicles entering rest area

C = Peak hour; as percent of ADT

D = Number of persons per vehicle

E = Percent people using rest-rooms

F = Water use per person

and substituting numerical values from Table 1 it becomes

Gallons used during peak hour = (ADT) (0.12) (0.12) (3.2) (0.80) (3.5)

" " " " " = (ADT) (0.129)

In computing the number of rest-room facilities needed, it is assumed that one fixture will serve 30 persons per hour (2).

To determine the minimum size of septic tank required for 24-hour detention, the maximum fixture use per hour is multiplied by 3.5 gallons per person and divided by 12 percent, the peak hour as percent of (ADT),

or; $30(3.5) \div 0.12 = 875$ gallons per fixture per day. For a rest area building with 6 fixtures, these give a minimum septic tank size of 5250 gallons (use 6000); 8000 gallons for 8 fixtures and 10,000 gallons for 12 fixtures. The drainfield size is determined from field percolation tests and use of the Public Health Service Manual of Septic Tank Practice (3) chart giving the allowable rate of sewage application in gallons per square foot per day. (Additional discussion of septic tank design criteria will be found in following pages under the subject of wastewater disposal methods and critique.)

Evaporative ponds have been designed on the basis of BOD_5 loadings; 0.007 lbs/person and 40 lbs BOD_5 per acre per day which gives the surface area requirement. Pond depths are set at five feet. This size is then presumably checked for detention time and evaporation loss. (Additional disucssion of pond design will be found under the subject of wastewater disposal methods and critique).

VI. REST AREA USE AND PROJECTIONS

In order to provide adequate rest area facilities for the highway traveler it is necessary to know and project the rest area usage. Table 2 shows the summertime average day, peak day and minimum day rest area usage for the places and time periods listed. Complete data are not available for year around individual rest area use but as will be shown by water consumption records the maximum month is August and the minimum January. The daily distribution of vehicles entering the Indian John Hill rest area (both west bound and east bound) on an average and peak summer day is shown on Figure 2. With reference to Figure 2 it can be seen that there are very large hourly and daily variations in the number of vehicles entering the rest area.

Table 3 illustrates the approximate rest area building use, based on 3.5 gallons per person, using Maytown water meter readings as the example. Building facility use ranges from a low of 100 visitors per day in January to a high of 2740 per day in August. Summing the number of visitors per month for the year 1970, gives a total of approximately 368,500. This is indeed a large number of visitors that attests to the popularity of the rest areas and the service they are providing.

In Table 4 it is indicated that in general the summer minimum use is about half of the average use and the peak use is over twice the average use. Table 5 shows the projected rest area peak day usage for the years 1975 to 1990 in five-year increments. As indicated, the expected increase in usage will vary from around 38% at Chamberlain Lake to 78% at Vernita.

FIGURE 2: Hourly Traffic, Indian John Hill Rest Area

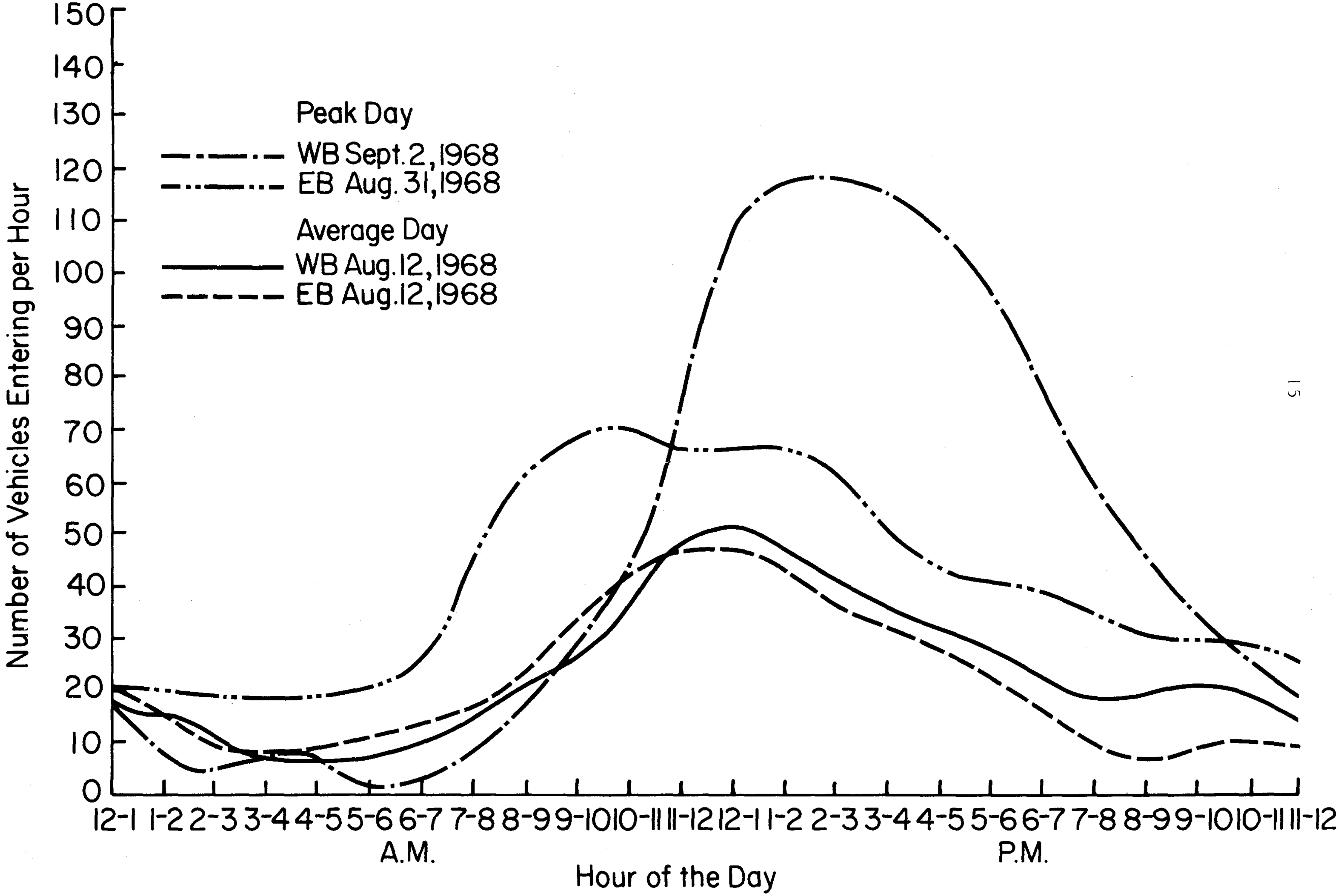


Table 2. Rest Area Summer Usage for Average, Peak and Minimum Days (for indicated study period)(Data from WSDH)

Rest Area Name	Location	Average Day		Peak Day		Minimum Day	
		Vehicles	Persons	Vehicles	Persons	Vehicles	Persons
Nason Creek [1]	SR-2	130	410	(9-2-68)* 290	930	50	160
Vernita [2]	SR-24	170	550	(9-2-68)* 410	1,350	80	260
Blue Lake [3]	SR-17	90	350	(9-1-68)* 170	630	40	150
Indian John Hill (E.B.) [4]	I-90	490	1,420	(8-31-68)* 950	2,760	300	870
Indian John Hill (W.B.) [5]	I-90	480	1,440	(9-2-68)* 1,180	3,540	320	960
Elma [6]	SR-12	440	1,360	(7-13-69)* 960	3,000	210	650
Chamberlain Lake [7]	SR-14	140	430	(7-13-69)* 250	780	90	280

* Date on which peak day occurred

[1] August 10 to September 12, 1968

[2] August 10 to September 15, 1968

[3] August 2 to September 5, 1968

[4] August 10 to September 18, 1968

[5] August 10 to September 17, 1968

[6] July 3 to July 21, 1969

[7] July 12 to July 31, 1969

Table 3. Water Use and Related Visitor Use -- Maytown Rest Area, 1970

	Jan.	Feb.	Mar.	Apr.	May	June	July**	Aug.	Sept.	Oct.	Nov.	Dec.
Cu. Ft. Water	7,610	11,270	15,430	11,540	15,690	21,740	23,410	28,790	18,100	12,250	9,660	8,750
No. Visitors/Mo.	15,200	22,500	30,900	23,100	31,400	43,500	46,800	57,600	36,200	24,500	19,300	17,500
Min. Day Cu. Ft.	50	170	210	240	210	*320	600	680	370	220	50	100
No. Visitors Per Day Min.	100	340	420	480	420	640	1,200	1,360	740	440	100	200
Max. Day Cu. Ft.	550	860	1,280	620	820	*870	1,320	1,370	1,230	780	900	900
No. Visitors Per Day Max.	1,100	1,720	2,560	1,240	1,640	1,740	2,640	2,740	2,460	1,560	1,800	1,800

Compiled from WSDH data. Visitor use calculated from water usage in rest area building divided by 3.5 gal/capita/use. (Use 0.5 cu. ft.)

* June, 1971, data; 15,850 cu. ft. total (for a wet Spring).
** Rest area closed 11-15 July, pump failure.

Table 4. Rest Area Usage; Vehicles Entering; Ratio of Minimum to Average Day and Peak to Average Day - Summer Months

Rest Area Name	Ratio Minimum to Average Day	Ratio Peak to Average Day
Nason Creek	0.38	2.22
Vernita	0.47	2.41
Blue Lake	0.44	1.89
Indian John Hill (E.B.)	0.61	1.93
Indian John Hill (W.B.)	0.67	2.46
Elma	0.48	2.18
Chamberlain Lake	0.64	1.78
Mean	0.53	2.13

Table 5. Projected Rest Area Usage for Peak Day

Rest Area Name	Estimated Number of Persons Using Restroom During Peakday				Ratio 1990 to 1975
	1975	1980	1985	1990	
Nason Creek	1070	1220	1390	1570	1.47
Vernita*	900	1140	1370	1600	1.78
Blue Lake*	620	730	860	1020	1.65
Indian John Hill (E.B.)	3130	4040	4650	5130	1.64
Indian John Hill (W.B.)	3720	4810	5530	6090	1.63
Elma*	2550	2950	3380	3790	1.48
Chamberlin Lake	780	870	970	1070	1.38

*Actual use in 1968 already exceeds this figure as shown in Table 2.

Prepared by: Department of Highways
Planning, Research and State Aid
September 24, 1971

VII. WATER USAGE

The majority of people stop at rest areas to use the rest-room facilities. The amount of water used for flushing toilets and urinals plus that used for washing is of course a function of the number of people stopping at the facility. All of this water must be handled as wastewater. As previously shown, the rest area usage varies mainly with the time of day, day of week, month of year, weather, and the rest area's location. In 1968, the Washington State Department of Highways made a study of water usage at various rest areas (2). As shown in Table 6 the water use in August of 1968 varied from a low of 1.9 to a high of 5.1 gallons per person. The report indicated that both the minimum and maximum values were influenced by weather conditions. As a result of this study, the WSDH design criteria was set at 3.5 gallons per person. Figures 3 and 4 show the water consumption at the Toutle River rest areas in two hour increments for a maximum and minimum summer day use. It indicates that there are wide fluctuations in both water use and in the time of occurence of such use when contrasting a maximum and minimum summer day.

Water Use at Specific Rest Areas

A special gaging of the water consumption in two hour increments between 6 a.m. and 7 p.m. at Toutle River (I-5) rest areas (south and north bound) made on the Labor day weekend of 1971 is shown in Figures 5a and 5b. These graphs indicate that the water use peaked around noon on Saturday at both areas, diminished considerably on Sunday and then peaked again on Monday.

Data on daily water use are available from the Maytown and Scatter Creek rest areas (S.B. and N.B. on I-5). The 1970 monthly water use for the Maytown rest area is tabulated in Table 7 and shown graphically on Figure 6. The seasonal variation is quite apparent, with the maximum in August and minimum in January. The water used for irrigation also follows a typical seasonal pattern. Since the water used for sprinkling does not influence the wastewater flow, it is not considered in designing the wastewater treatment units. Operational procedures at rest areas limit the use of irrigation over septic tank drain fields. Table 8 lists the 1970 monthly water use at Scatter Creek rest area, northbound across I-5 from Maytown. The monthly water use patterns for these two rest areas are clearly similar. Since wastewater treatment units are susceptible to both low and peak flows, these data for the Maytown are

Table 6. Water Usage, Rest Areas

Location		Date	Number of people using restrooms	Gallons Used	Gallons per person	
SR-395	Hatton-Coulee	8-11-68	637	2377.5	3.7	(1)
	" "	8-12-68	377	1912.5	5.1	(1)
I-90	Indian John Hill (E.B.)	8-16-68	579	1984.0	3.4	(1)
	" "	8-17-68	685	2342.0	3.4	(1)
I-90	Indian John Hill (W.B.)	8-18-68	1090	2113.5	1.9	(2)
	" "	8-19-68	521	996.7	1.9	(2)

(1) Warm weather

(2) Cool weather

illustrated in Figures 6, 7 and 8. As indicated, the average maximum daily flow at Maytown rest area is 930 cubic feet per day which is about 4 times the average minimum daily flow of 245 cubic feet per day. Similarly the average maximum daily flow at Scatter Creek, 715 cubic feet per day is almost 5 times the average low daily flow of 150 cubic feet per day. If, however, at the Maytown rest area the maximum daily flow of 1370 is compared to the minimum daily flow of 50 cubic feet per day the ratio is about 27 to 1. At Scatter Creek the ratio of maximum to minimum is approximately 18 to 1. The average daily flow (Figure 7) during the peak month (930 cubic feet per day or 6,960 gallons per day) is high for the 6,000 gallon septic tank to provide a desired 24-hour detention time.

Table 7. Monthly Water Usage, Maytown Rest Area, 1970

Month	Restrooms (cu.ft.)	Irrigation (cu.ft.)
Jan	7,610	0
Feb	11,270	40
Mar	15,430	100
Apr	11,540	130
May	15,690	240
June	21,740	6,080
July**	23,410	500
Aug	28,790	9,880
Sept	18,100	1,320
Oct	12,250	180
Nov	9,660	490
Dec	8,750	0
Total	184,240	18,960

**Closed 4 days for pump repair

Restroom - Max. Daily Use 1370 cu.ft./day on 8-15-70
Min. Daily Use 50 cu.ft./day on 1-27 & 11-17-70.

Irrigation - Max. Daily Use 1050 cu.ft./day on 8-25-70
Min. Daily Use 0 cu.ft./day

Table 8. Monthly Water Usage, Scatter Creek Rest Area, 1970 (Both Buildings 1 and 2)*

Month	Restrooms (cu.ft.)	Irrigation (cu.ft.)
Jan	4,700	0
Feb	10,040	100
Mar	8,880	350
Apr	10,530	120
May	9,040	240
June	16,370	8,220
July	20,860	8,690
Aug	21,420	2,780
Sept	12,810	2,110
Oct	9,010	210
Nov	8,540	80
Dec	5,610	0
Total	137,810	22,900

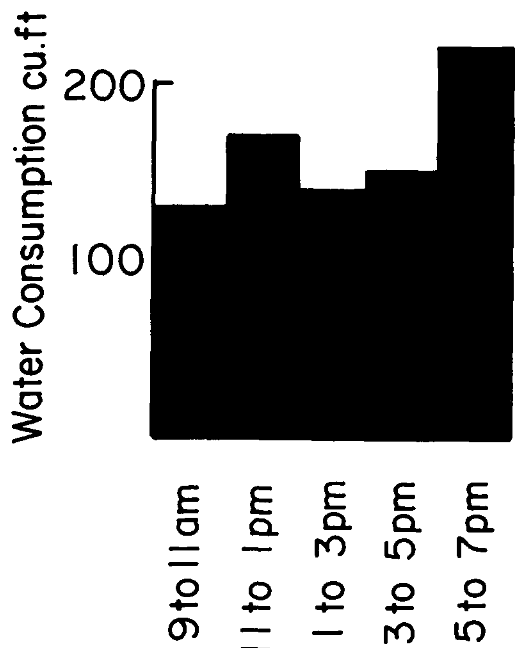
*Building No. 2 Closed for winter on 12-4-70.

Restroom - Max. Daily Use 1060 cu.ft./day on 8-3-70
Min. Daily Use 60 cu.ft./day on 12-15-70

Irrigation - Max. Daily Use 1800 cu.ft./day on 7-14 & 7-15-70.
Min. Daily Use 0

FIGURE 3: Water Consumption, Toutle River Rest Area (Northbound)

a) Sunday Aug. 1, 1971 (Maximum Summer Day)



b) Water Consumption on Thursday July 22, 1971 (Minimum Summer Day)

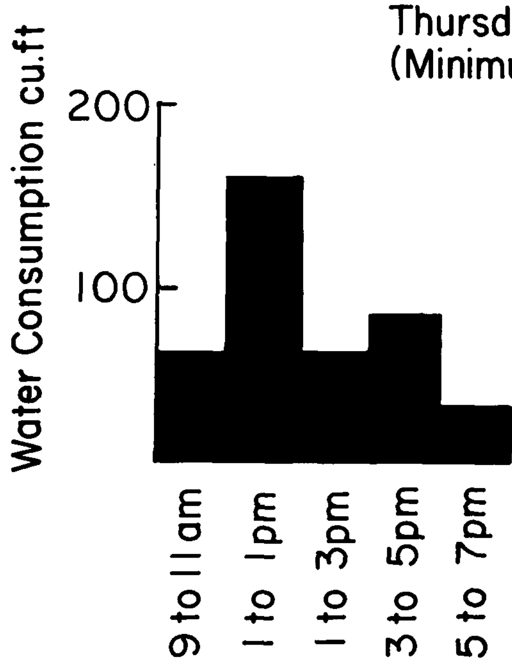
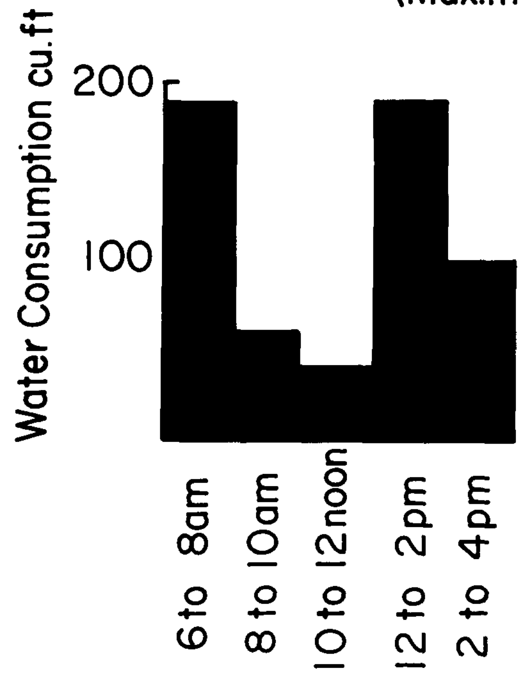


FIGURE 4: Water Consumption, Toutle River Rest Area (Southbound)

a) Sunday Aug. 1, 1971 (Maximum Summer Day)



b) Water Consumption on Thursday July 22, 1971 (Minimum Summer Day)

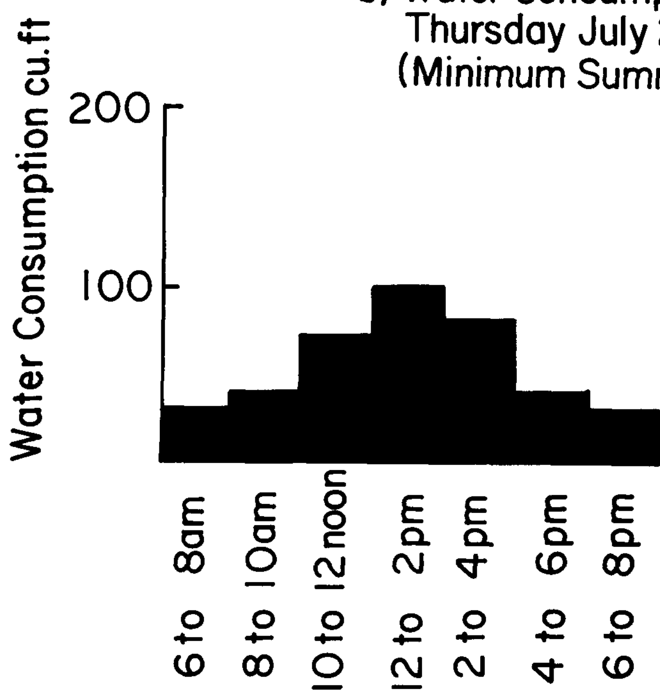
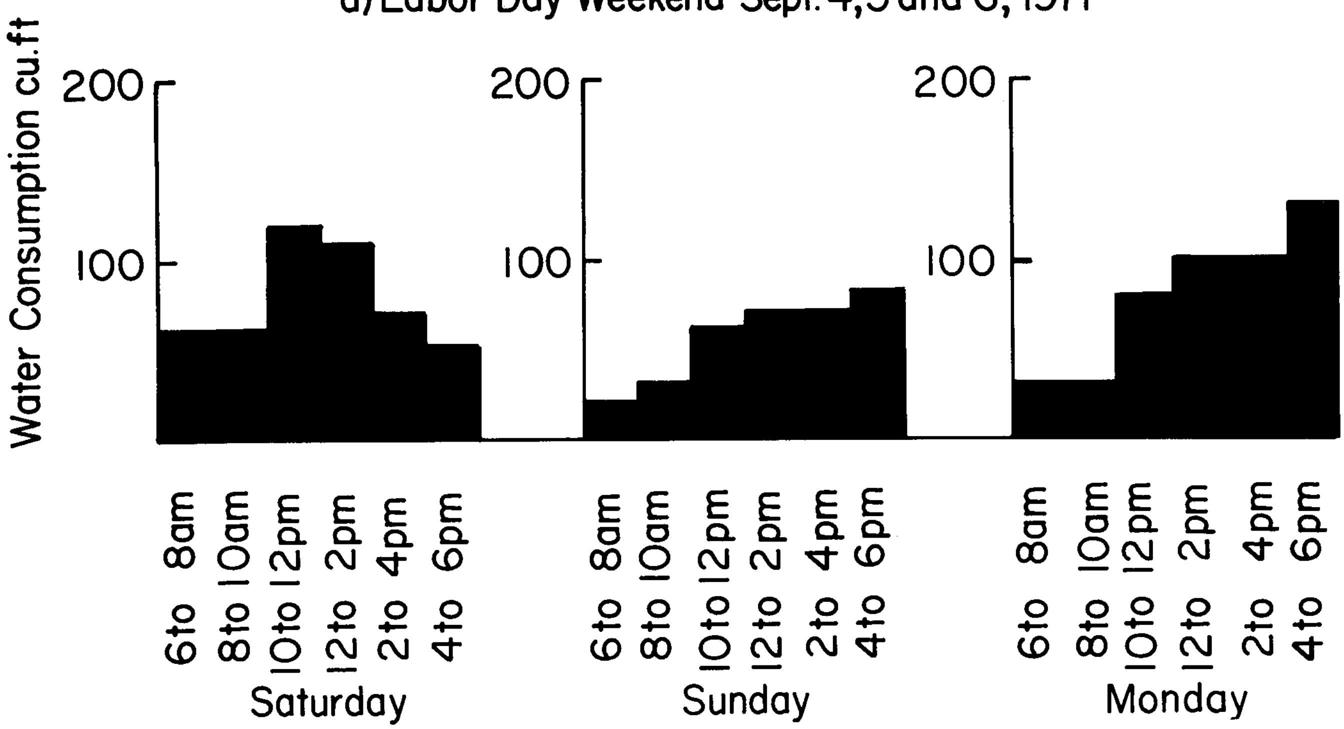


FIGURE 5: Water Consumption, Toutle River Rest Area (Southbound)
a) Labor Day Weekend Sept. 4, 5 and 6, 1971



Water Consumption, Toutle River Rest Area (Northbound)
b) Labor Day Weekend Sept. 4, 5 and 6, 1971

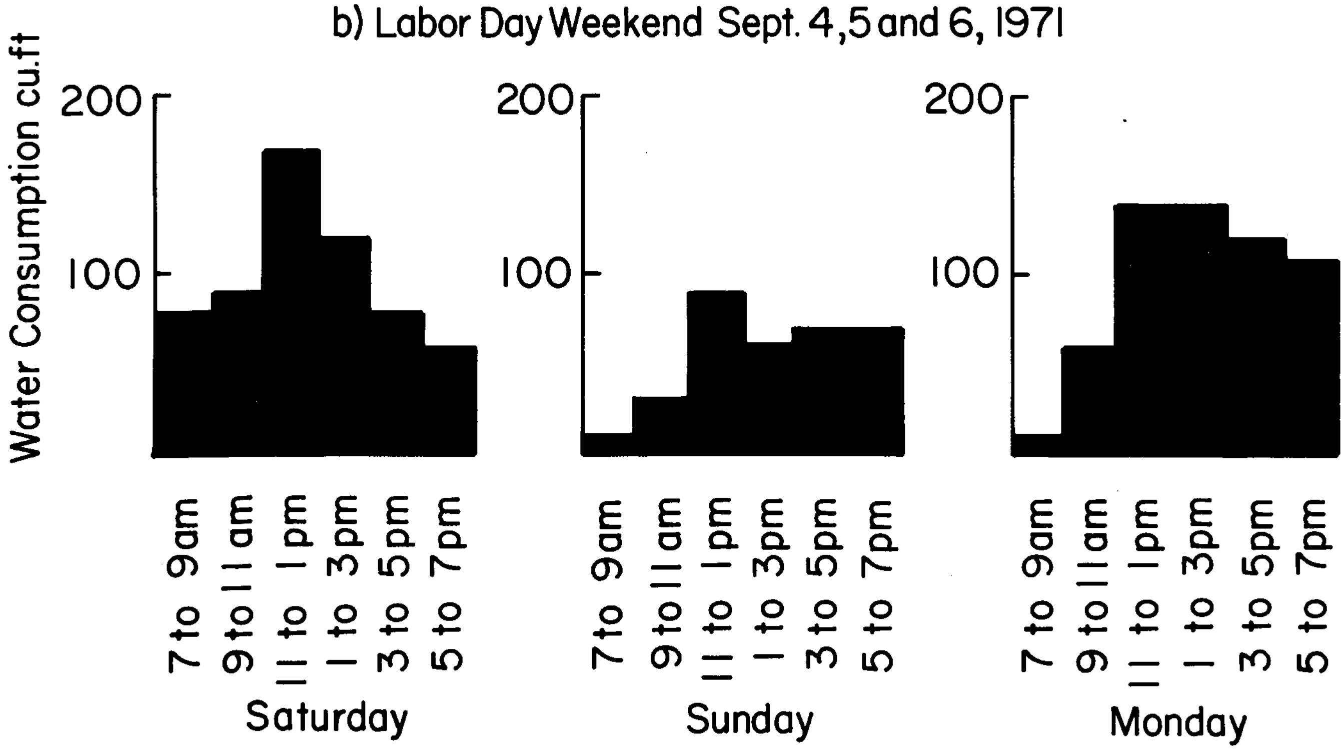


FIGURE 6: Monthly Water Consumption
Maytown Rest Area

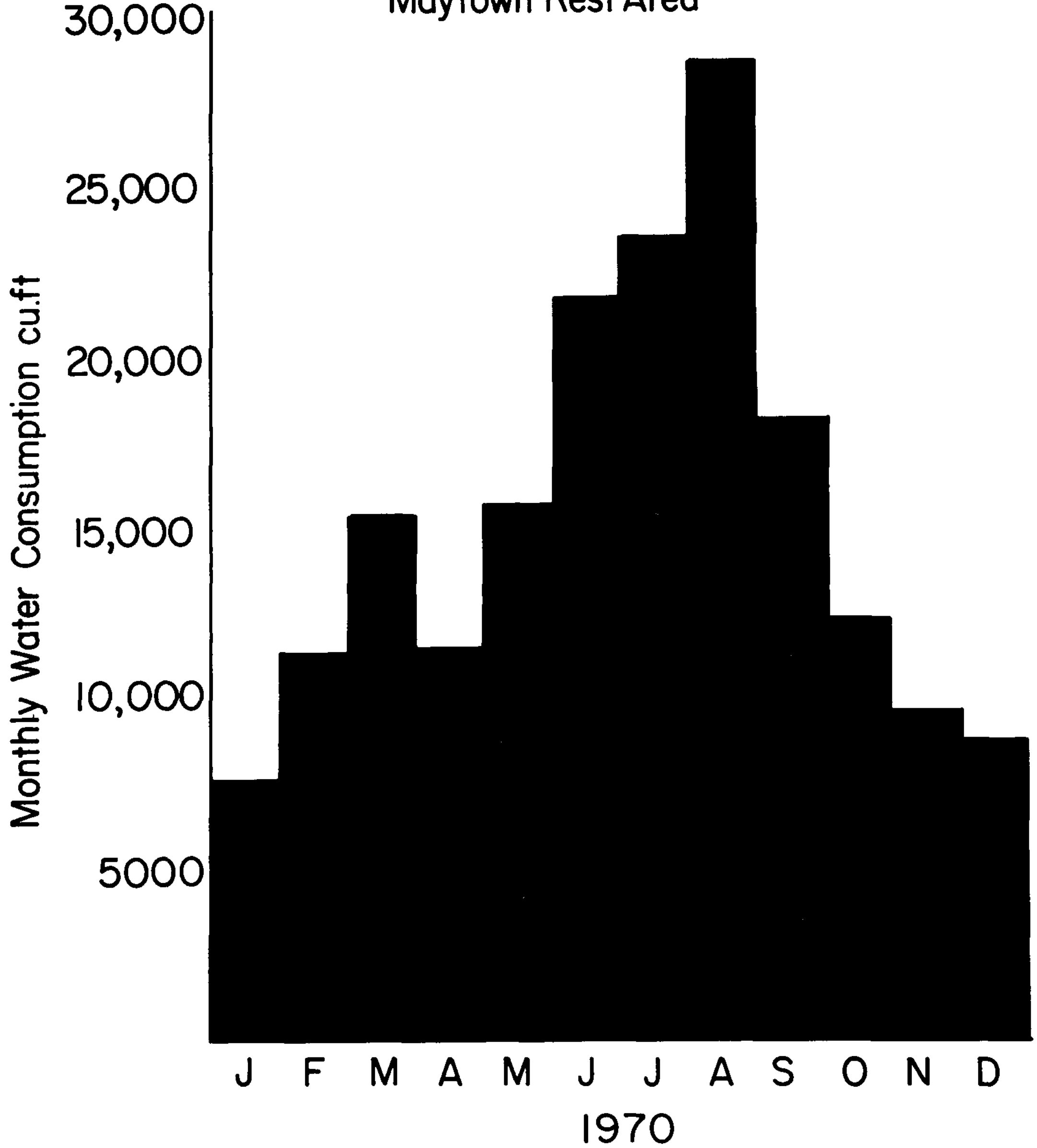
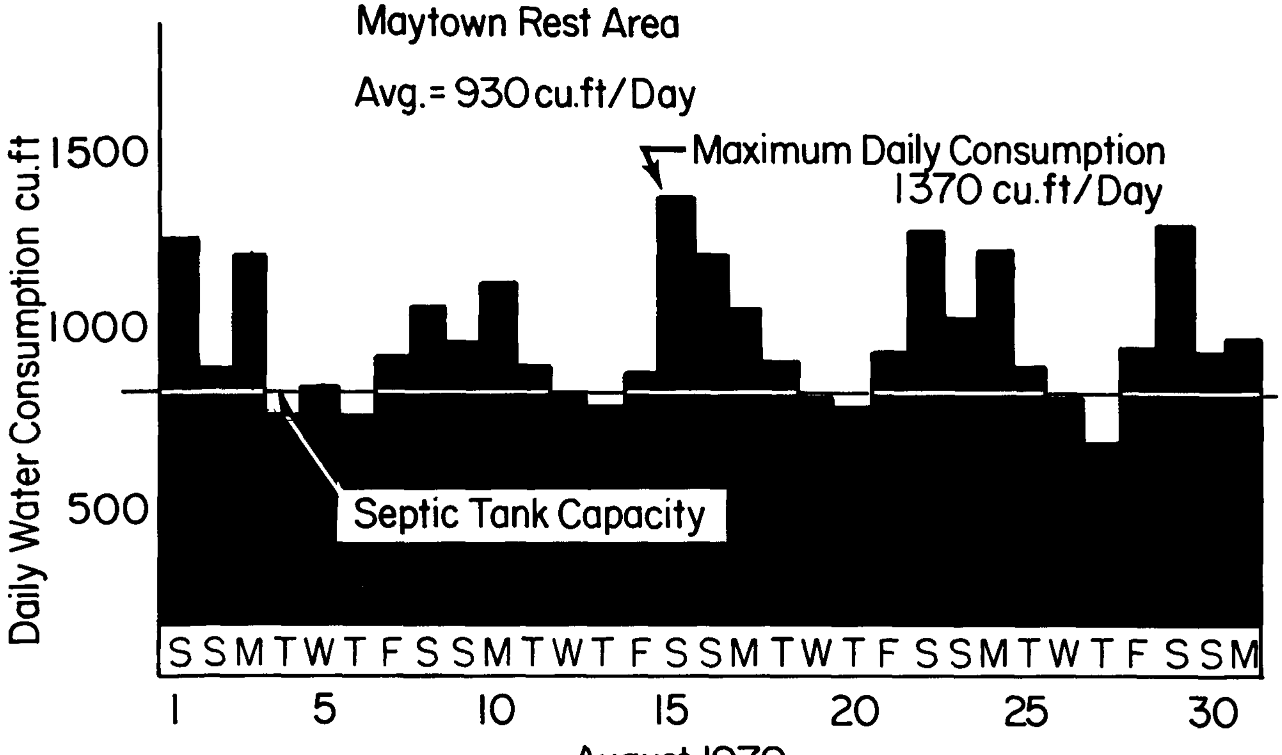


FIGURE 7: Daily Water Consumption During Maximum Month. Maytown Rest Area



Meter read 1PM daily, thus some of the maximum readings appear to fall on Mondays.

FIGURE 8: Daily Water Consumption During Minimum Month
Maytown Rest Area

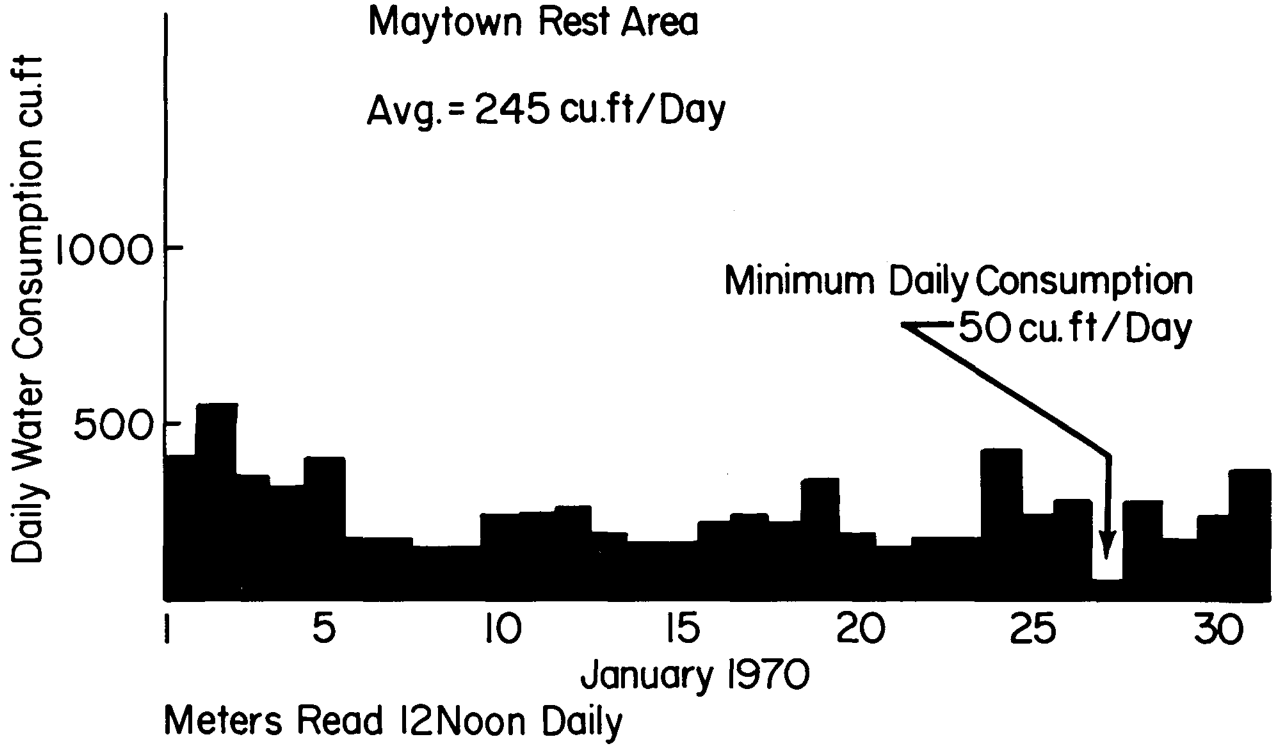
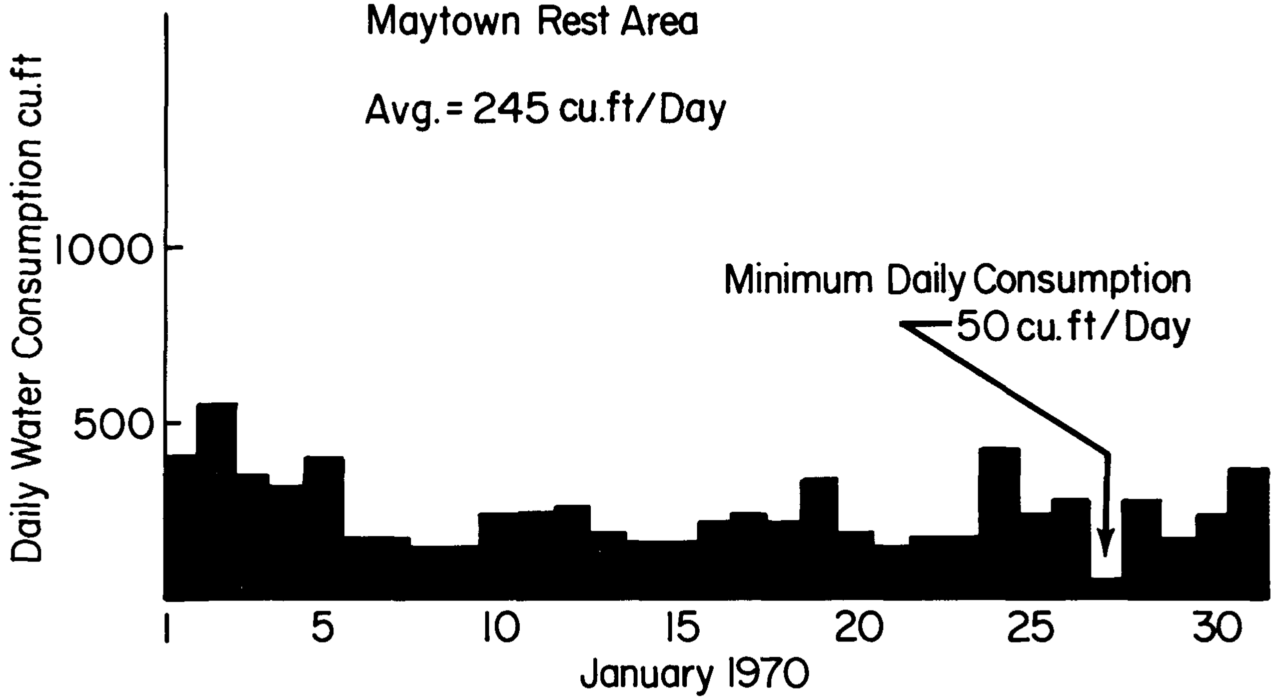


FIGURE 8: Daily Water Consumption During Minimum Month
Maytown Rest Area



Meters Read 12Noon Daily

VIII. LABORATORY INVESTIGATIONS

If wastewater treatment will be involved prior to final disposal, it is necessary that the wastewater characteristics be known for treatment plant design and prediction of treatment effluent quality. Ordinary domestic wastewater characteristics cannot be assumed for the rest areas since they lack the kitchen and laundry wastes, infiltration dilution water, and most rest area usage is for urination only. Also, the proportion of paper in rest area wastewater is disproportionately high.

For these reasons wastewater characteristics were sampled at the I-5 rest areas; Maytown, Scatter Creek and Toutle River, N.B. and S.B. Septic tank influent samples were collected from these four rest areas in three separate week days near the end of August. Each of the 12 samples represented a composite of individual samples collected over a 5-30 minute period, depending upon the frequency of flow pulses. On one of the collection days, samples of septic tank effluent were collected and the septic tanks were sounded for depth of scum blanket and sludge deposits. Samples were iced prior to delivery to the Food, Chemical, and Research Laboratory in Seattle for analysis using Standard Methods (4).

The Toutle River Rest Areas had been in operation only two months so as expected the septic tanks contained little scum or sludge. Rest areas at Scatter Creek and Maytown had been in operation two and three years respectively so some solids accumulation might be expected in the septic tanks. Both of these tanks had a very heavy mass of undecomposed paper floating on the surface but very little sludge accumulated on the tank bottoms, attesting to the special character of rest area wastewater. The floating paper may be a blessing in disguise since if it were comminuted prior to entry, it might pass into the drainfield, causing clogging problems. Comminution would, however, greatly assist in biodegradation of the paper.

Septic tank influent and effluent samples were analyzed for pH, total Kjeldahl nitrogen, nitrate, suspended solids, chemical oxygen demand (COD), biochemical oxygen demand (BOD), and phosphate before and after filtering. Sample analyses varied widely due to differences in paper content and the variable slug flow resulting from different usage of the facilities. Table 9 lists the mean values of some of the most important waste water characteristics of the septic tank influent. The results of these analyses indicated that when contrasted to ordinary domestic sewage the septic tank influent:

1. Had essentially no grease or scum materials.
2. Was high in nitrogen indicating the preponderance of urine.
3. Contained suspended solids and BOD_5 between a weak and average domestic sewage.
4. Had a chemical oxygen demand of a strong sewage because of the paper present.
5. Evidenced settleable solids much greater than domestic sewage because of the high paper content.
6. Had a phosphate content corresponding to a weak sewage.

Table 9. Septic Tank Influent Characteristics, Mean of Three Values*

Rest Area	pH	Kjeldahl Nitrogen as N	Nitrate as N	Sus. Solids mg/l	COD mg/l	BOD_5 mg/l	Sett. Solids ml/l	PO_4 before	PO_4 after
Toutle River (N.B.)	7.6	98	0.73	179	423	132	77	25.0	18.2
Toutle River (S.B.)	8.1	201	0.73	196	364	154	72	41.5	33.4
Maytown	8.8	144	0.38	138	355	166	46	23.6	20.5
Scatter Creek	8.7	124	0.53	145	478	204	36.8	27.3	23.8
Mean	8.3	140	0.6	165	405	165	60	29	24

*Sampling dates August 19, 23, 25, 1971.

Table 10 lists the analyses of the septic tank effluents (samples collected on one day only) and shows a significant reduction in suspended solids, COD, BOD_5, and settleable solids as the wastewater passed through the septic tanks. The reason for the increase in nitrogen and phosphate through the septic tanks is not readily apparent but may be due to anaerobic release of P and N substances not previously responsive to analytical techniques that were used.

In essence, these analyses indicate that wastewater from a rest area should present no particular quality characteristics that would make it difficult to treat.

Table 10. Septic Tank Effluent Characteristics**

Rest Area	pH	Kjeldahl Nitrogen as N	Nitrate as N	Sus. Solids mg/1	COD mg/1	BOD_5 mg/1	Sett. Solids mg/1	PO_4 before	PO_4 after
Toutle River (N.B.)	8.70	237.2	0.25	49.0	217	103	0.1	37.0	26.5
Toutle River (S.B.)	8.70	272.8	0.45	66.2	233	135	0.1	40.0	39.0
Maytown	7.78	221.1	0	58.4	221	133	0.1	34.0	25.0
Scatter Creek	7.50	163.6	0.1	78.8	264	160	0.4	34.0	33.0
Mean	8.2	223	0.2	63.2	233	133	0.2	36.4	30.8

**Sampling date Aug. 19, 1971

IX. BACTERIAL WASTE DISPOSER

A laboratory study was made of the efficiency of a "Bacterial Waste Disposer" additive which was purported to result in the liquefaction and digestion of the organic matter in sewage, inhibit and eliminate the offensive odors, and provide low-cost, trouble-free maintenance. Samples of septic tank sludge were collected from Maytown, Scatter Creek and both north and south bound Toutle River rest areas. One sample of septic tank scum was collected from the Toutle River south bound rest area.

In accordance with the manufacturers instructions, 750 ml samples of these sludges were dosed with the bacteria slurry and buffer solution, and then incubated in 1000 ml beakers in the dark at room temperature. Identical samples of the same sludges but without the bacteria slurry and buffer solution were observed and stirred daily thereafter for a period of 6 days, with no discernable difference being apparent between those that were bacteria dosed and those that were not. The same amount of surface scum and settleable solids were observed in the sludges dosed as contrasted to those that did not receive the bacteria slurry and buffer. A 1000 ml sample of the septic tank scum was innoculated with the bacteria slurry and buffer and after 21 days of incubation in the dark at room temperature still remained undigested. A second series of sludge samples from the same rest areas were dosed with a bacteria slurry concentration five times the manufacturers recommendation, and incubated as before. Again daily inspection revealed no visible difference between the generated surface scum, turbidity and settled sludge.

The data from these experiments suggest that the addition of the "Bacterial Waste Disposer" had no effect on the sludge digestion, one way or the other. Also, the results of this brief study parallel the observations and conclusions reported in the literature, that the addition of biocatalytic additives had no significant beneficial effect on sludge digestion or liquefaction (5,6). A report from the U.S.P.H.S. sums it up and states the following (3):

> "Some 1,200 products, many containing enzymes, have been placed on the market for use in septic tanks, and extravagant claims have been made for some of them. As far as is known, however, none has been proved of advantage in properly controlled tests."

Consequently, it is recommended that the Department of Highways discontinue use of the bacterial additives in its highway rest area septic tank systems.

X. FUTURE OUTLOOK

There is every liklihood that rest area usage will increase in the near future, in excess of highway vehicular traffic increases, as more travelers learn of the areas and their facilities. Public acceptance of the rest areas has been very good. Whether or not vehicular traffic will continue to increase beyond the next ten years is, of course, subject to question. There does not seem at this time much justification in future consideration for the provision of food, lodging, or vehicular services at the rest areas as these are suitably provided by private enterprise. Two additional services in Washington, however, must be considered; these are trailer holding tank dump facilities and limited overnight trailer or camper parking, both of which would add to the wastewater disposal problem.

Trailer-Camper Parking

There has been a rapid increase in the number of camper-trailer units on the highways posing a problem of where do they park enroute. Private trailer parks have accommodated some of the load, public campgrounds have taken some, while many search for a spot along the highways. Permitting a limited number of these to park in rest areas during nightime off peak hours would promote safety, provide a service, and be a deterrent to vandalism, most of which occurs between 10:00 p.m. and 6:00 a.m. when maintenance personnel are not on duty.

Holding Tanks

A number of states, such as Idaho and Montana, now provide camper holding tank dump facilities at their rest areas. Installation of these facilities not only supplies a needed service but will reduce the dumping of holding tanks along the roadways. It is estimated that the average holding tank will discharge up to 30 gallons of wastes frequently containing zinc sulfate or formaldehyde as the bactericidal agent together with small amounts of wetting agents, dye and perfume. Assuming 6 uses/day/person, 2 qts/use including dish washing and showers and a BOD_5 contribution of 0.2 lbs/day/person, the total BOD_5 discharged with a 30-gallon dump would approximate 2 lbs. BOD_5 values as high as 100,000 mg/l could be expected from a small holding tank with the non-flushing type of toilet.

Various agents added to the holding tanks are usually degradable and thus of no particular concern with the possible exception of zinc sulfate, used in some preparations. Zinc sulfate may be found in concentrations of 0.1-0.3 ounces per gallon (750-2250 mg/l). This zinc sulfate, when diluted in a treatment plant, will not have harmful effects on the treatment process. Foster (7) concluded that no detrimental effect on sewage disposal facilities results from the proper and normal use of chemicals in waste holding tanks used on mobile trailers and campers. This observation has been corroborated from laboratory and field experiences (7). Zinc, however, will pass through a treatment plant and into the receiving waters. Drinking Water Standards (8) limit the concentration of Zn to 5 mg/l (12.4 mg/l as $ZnSO_4$). The toxicity of zinc to aquatic life is related to the concentration of calcium and magnesium, pH, dissolved oxygen, and temperature and is not well understood (9). Toxicity in sea water is much less than in fresh water for a given concentration. A diluted fresh water Zn concentration of not over 0.1 mg/l would appear at present to be a tolerable value. Research is needed on this subject as well as the development of better bactericidal agents for use in holding tanks. It should be pointed out that these holding tanks are now being dumped into municipal and other systems. Provision of a facility by the Department of Highways does not change the amount generated.

The State of Montana assumes that five per cent of the vehicles stopping at their rest areas in the future will use the trailer disposal facility (10). They use a standard septic tank of 1000 gallon capacity with drainfield for disposal. The disposal facility also includes a concrete platform sloping to a capped drain with adjacent hose on tower for flushing and washing.

Assuming 30 gallons per holding tank, including flushing and washing water, a storage vault capacity of 21,000 gallons would be required for bi-weekly pumpouts for an average vehicle rest area stop of 1000 vehicles per day with five per cent using the trailer dump. This would amount to an assumed BOD_5 of about 1400 pounds. Providing for this storage capacity with subsequent hauling is considered impracticable. By comparison using the present average water usage of 3.5 gallons/person and a BOD_5 of 165 mg/l, 125,500 gallons of wastewater with a BOD_5 of 172 lbs would be generated in two weeks with an average vehicle rest stop of 1000 vehicles per day, and 80% of the people using the rest rooms. Thus, the trailer dump would add 17 per cent to the present rest area wastewater volume and would increase the BOD_5 by a factor of nine.

Provision of holding tank dumping facilities by the Department of Highways would provide a worthy service to the traveling public and should be given serious consideration for those locations where wastewater disposal is not a problem, i.e., when evaporative ponds have the capacity or when very porous soil lends itself to septic tank drainfields such as Scatter Creek or Elma.

XI. MISCELLANEOUS

In relation to the general study of rest area wastewater disposal, there are several allied topics that require consideration.

Paper

Rest areas in different localities use electric hand dryers, roller cloth towels, or paper towels, each area seeming to have their own preference. All have drawbacks. Paper towels would seem to present an invitation for toilet system clogging, thievery, and fire setting.

An effort was made to determine what kinds of toilet tissue (or paper) were the most biodegradable. This search was not fruitful with reference to the literature and the paper "experts." Since the use of toilet related papers in the rest areas is heavy, it is most desirable that proper tissues be used. This subject requires further study. At least, the paper used should be as soft and as easily mascerated as possible, consistent with its other required properties.

Water Use Reduction

It is desirable that the quantity of water used in the rest area building be kept to a minimum as a means of reducing disposal costs and problems. In a flush toilet, the amount of water required to flush is a function of the toilet bowl size and design and not of the delivery unit. With the usual design, 4 to 4-1/2 gallons of water at a flow rate of 20 to 25 gallons per minute is required per flush. A flushmeter valve can be set to deliver this amount regardless of the pressure. A tank closet will use more water for the same bowl flush because as soon as the handle is tripped, water starts to flow through the toilet bowl as well as the overflow tube with the result that 5 to 5-1/2 gallons are used per flush.

In future rest area installations using flush toilets, consideration should be given to using some new designs in toilet bowls that require less water per flush.

In addition, the Department should keep abreast of new developments in water saving toilet devices, such as the Swedish "Liljendahl System" vacuum toilet system which has been used in hotels, motels, apartments and other large buildings in Sweden. The stated advantage of this system is that air rather than water is used as the transport fluid and is purported to require only 0.5 gallon of water per flush. Correspondence (11) with the U.S. representative of this Swedish system indicates that it is not yet acceptable for general use.

Water Supply

Nearly all of the rest areas are provided with drilled wells as a source of water supply. The new design, of pumping at a low rate from the well into a storage tank and then repumping to the pressure tanks, is considered to be a distinct improvement over direct pumping from the well. This not only provides storage but reduces the chance of sand pumping due to a lower pumping rate from the well and it also permits the trapping of sand grains in the storage tank that might otherwise clog flushometer valves. An elevated storage tank functionally is superior to a buried tank but may cost more and not be pleasing aesthetically.

Pressure tanks have proven troublesome because of loss of the air cushion and excessive recycling of the supply pump. Consideration should be given to the use of constant pressure pumps in lieu of the pump-pressure tank combination. While these pumps are more expensive than the normal constant speed pump, they may be more trouble free and no more expensive when pressure tanks and their servicing can be eliminated.

XII. WASTEWATER DISPOSAL METHODS AND CRITIQUE

A. Final Disposal Methods

There are five basic possibilities for final wastewater disposal from rest areas. They are:

1. Percolation into the ground
2. Discharge into a stream or ditch
3. Evaporation including transpiration
4. Discharge to a community sewerage system
5. Storage and intermittent hauling to a community sewerage system

The first requires a porous soil, natural to the area, low groundwater table, and no immediately adjacent water wells. It also requires a carefully constructed system and pre-treatment of the wastewater.

The second requires a stream whose minimum rate of flow is many times that of the effluent discharged unless a reliable method of near complete treatment is employed. Nutrient removal may also be required. Only three of the present rest areas in the State are located near a stream of any magnitude.

Number three, on a yearly basis, requires that the rate of evaporation greatly exceeds the rate of precipitation, unless evaporation and transpiration are utilized through spray irrigation from a non-overflow pond.

Discharge to a community sewerage system, the fourth possibility, has not been previously used since rest areas are usually built well away from community sewerage systems. However, with the growing development of service centers around interchanges and access roads, it is quite probable that before long in many areas, trunk sewers will be built along the highway right-of-way connecting several of these centers to a common wastewater treatment plant. Connection of a rest area to one of these trunk sewers, or to a community sewer, would generally be the best of all solutions.

The fifth possibility, storage and intermittent hauling, depends upon water conservation and a maximum of water recycling or exclusion of the flush toilet. This method has a low first cost, is simple, and leaves options open for possible future improvements without having to scrap a large investment.

For the succeeding discussion on disposal methods, data were collected from some 55 manufacturers' bulletins, technical reports, or articles in the literature. To this information was added the experience of the authors.

B. Rest Area Wastewaters

Table 11. Disposal Loadings, Conventional Flush Toilets

	Rest Area Usage - Persons per Day				
	250	500	1000	3000	6000
Gallons/day[1]	875	1750	3500	10,500	21,000
BOD_5, lbs/day[2]	1.20	2.4	4.8	14.4	28.8
Susp. solids, lbs[3]	1.20	2.4	4.8	14.4	28.8

[1]Per capita usage flow: 3.5 gpc mean (WSHD field observations).

[2]BOD_5, mean estimate: 165 mg/l at 20°C (see Table 9) = 0.0048 lbs.

[3]Suspended solids, estimate: 165 mg/l (see Table 9).

In the table above, BOD_5 and suspended solids are identical in value, as determined by the laboratory tests previously discussed. While this happened by chance, it should be indicated herein that these values are usually quite close for normal domestic wastewater.

The rate of wastewater flow is dependent upon the frequency of facility usage. With six units flushed nearly simultaneously (unlikely), 4 gallons per flush and a flush cycle of 10 seconds, the maximum rate of flow would be 144 gpm or 0.32 cfs. Since there are prolonged periods of no flushing or wash basin use, the minimum rate of flow would be zero.

C. Criteria for Selection

The selection of a wastewater disposal system for highway safety rest areas should be based on the following criteria:

1. Simplicity in design, construction, operation and maintenance -- is a specially skilled and trained operator required?
2. Provision for final disposal of effluent and sludge accumulations
3. Treatment or disposal effectiveness
4. Freedom from odors, noise, insects and not unsightly
5. Ability to operate in extremes of weather

6. Ability to accommodate widely fluctuating hydraulic and organic loading

7. Ability to accommodate occasional extreme loadings

8. Suitability for usage at most rest areas so as to provide a near-uniform disposal method, or provides a regional least cost solution

9. Reasonable first and operating cost

10. Adequate freedom from corrosion, opportunities for vandalism, and hazards in operation.

11. Acceptability by water quality control and health agencies

12. Does not produce local stream or ground water pollution possibility.

D. Disposal Method Discussion

There are a number of alternative conventional methods for wastewater handling at rest areas that require consideration. These are listed below as to general category names and following, there is a critique of each in consideration of criteria for selection shown above.

1. General methods of wastewater handling

a. Pit privy

b. Chemical toilet

c. Holding tank (or vault)

d. Septic tank and drainfield or seepage pits

e. Ponds (waste stabilization ponds or lagoons); evaporative or non-overflow; quiescent; with or without spray irrigation

f. Recycle system with holding tanks and storage vault

g. Chemical precipitation, filtration, and adsorption (physical-chemical processes)

h. Biological treatment processes - package type

Activated sludge, contact stabilization or conventional

Activated sludge, completely mixed

Extended aeration

Rotating biological discs - "bio-disc"

Trickling filter

Oxidation ditch

i. Other

Anaerobic filter and chemical precipitation

Combustion and evaporation

Enzyme treatment

2. Pit Privy

The pit privy is judged to be unacceptable for any highway rest area as its only attributes are simplicity, low cost, and the fact that it does not require a water carriage system. It remains, however, a practicable device for certain "remote" areas. Public health agencies generally disapprove of pit privies.

3. Chemical Toilet

The chemical toilet represents a compromise between the pit privy and a flush toilet. These may be utilized on a rental basis or purchased and serviced by the owner. Service is usually on a once-a-week basis which involves pumping out the receptacle, cleaning, and recharging with water to which a bactericidal-odor masking agent has been added. A special two-tank truck with pump and hoses is used for servicing. The service truck discharges its content of wastes to a community sewerage system through pre-arrangement. Servicing also includes a general cleanup, renewal of paper, and painting as needed. Charges in the Seattle-Metro area are, for example, \$28.50/month/unit which includes delivery, servicing once-a-week, and pickup if use is transitory. The Municipality of Metropolitan Seattle (Metro) charges a fee of \$450/year/ service truck for discharge of pumped out wastes into their sewerage system.

The chemical toilet meets all the "criteria for selection" with the exception of large usage accommodation which could only be done with a series of units, at which point other methods of disposal become more feasible. Thus for view points and minor rest areas, the chemical toilet appears at this time to be the best solution. In some instances, duplicate units (two male and two female) or twice-a-week service may be desirable, depending upon the use factor and relative cost.

Unless several State agencies would combine their chemical toilet maintenance operations in a given region, it would appear economically desirable at this time for the Department of Highways to operate their units on a rental-service basis.

4. Holding Tank

The holding tank or vault as herein defined is a large tank (similar to pit privy) designed to receive directly, the wastes of the users. Surfaces of the direct-use tank are coated to make it impervious, to prevent the accumulation of odorous material, and to permit easy cleaning. In addition, the direct-use tank must be well-ventilated and the vault must receive frequent dosages of bactericidal agents for odor control. The direct-use holding tank presents a design and maintenance problem in the control of odors, insects, washwater inflow, pumping, and adequate cleaning. Its further use should be considered only after more experience is gained from the Granite Lake installations.

5. Septic tank and drainfield

A septic tank and drainfield system is intended to dispose of wastewater through sub-surface percolation with retention of the separable solids in the septic tank and their subsequent reduction in volume through anaerobic decomposition. The drainfield system probably will be unsatisfactory if any of the following conditions prevail: a) if the soil is dense; b) the water table is high; c) imported pervious soil has to be brought in, or d) the disposal area is inadequate in size. It will also be unsatisfactory if solids pass into the drainfield, the drainfield is not of the proper design or construction (length, slope, gravel in trench, backfilling, etc.), if natural porosity has been reduced due to soil compaction or smearing, if drainfield dosing is uncontrolled, or if soil clogging occurs due to soil swelling or biological growths. Drainfield failure is evidenced by sewage appearing on the ground surface or back-up in plumbing systems. This surfacing sewage is usually odorous and dark in color, constituting a distinct nuisance and a violation of State Board of Health regulations.

Despite their wide use, septic tank systems have not usually performed in a satisfactory manner, in fact, the majority of them become unsatisfactory sooner or later after being placed in use. Their widespread use has been due largely to the lack of an acceptable alternative. An extensive investigation of both the septic tank and the associated drainfield made by Cotteral and Norris in 1969, gave the following picture of septic tank performance (12).

> "The septic tank system, though simple in concept, is actually a complex physical, chemical and biological system which once constructed, functions virtually without controls of any kind. System performance is a function of the design of the system components, the construction techniques employed, the strength and chemical characteristics of the wastes, the rate of hydraulic loading, the areal geology and topography, the physical and chemical composition of the soil mantle, and the care given to periodic maintenance."

a. Septic tank design parameters

The septic tank size has been based upon the hydraulic loading. Generally a detention time of 24 hours is used. Some authorities recommend that with flows greater than 1,500 gallons per day, the minimum effective tank capacity should equal 1,125 gallons plus 75 percent of the daily sewage flow (3). The Washington State Department of Highways computes the size of septic tanks for rest areas as follows:

Septic tank size (gallons) = A x B x D x E x F

where A, B, D, E and F are as previously explained in Table 1 and by substituting appropriate numerical values it becomes

$$\text{Septic tank size (gallons)} = (\text{ADT})(0.12)(3.2)(0.80)(3.5)$$
$$= (\text{ADT})(1.075)$$

As used in practice, this results (13) in the usual specification of a 6,000 gallon capacity septic tank for a six-fixture rest area building; 8,000 gallon for eight fixtures, and 10,000 gallons for twelve fixtures. The tendency is to use larger tank sizes than normal design standards may indicate necessary. This tendency is good since the additional cost is small and septic tanks are traditionally undersized.

The fundamental purpose of the septic tank itself is to provide gravity separation of the floatable and settleable solids so that the effluent will be less apt to clog the drainfield. A secondary function is the anaerobic digestion of solids and scum which reduces the amount of necessary clean-out. The efficiency of this gravity separation, or sedimentation, is a function of tank surface area and not of volume. The larger the tank surface area, for a given volume, the more effective will be the sedimentation, providing the surface area is in one tank and not the sum of others in series. Many tanks are divided into two sections with a baffle to confine most of the sludge and scum to the first compartment. If a particular septic tank is too small, adding another in series will provide additional sludge and scum storage but will not increase the theoretical settling capability. If a particle would not settle in the first tank, it would not settle in an identical tank in series unless very rapid digestion with gasification hindered settling in the first unit.

Septic tanks should be provided with inlet and outlet baffles, rather than tees, since the baffle (extending across the tank and above and below the surface) will reduce inlet and outlet flow velocities and will not be so apt to clog as the tee. Also the control baffle should be a wall with many ports, rather than a solid wall with tee.

b. Drainfield percolation tests

Experience has demonstrated that the drainfield is the part of the system most likely to fail. Drainfield capacity is based upon a percolation test. When using the percolation test results it is assumed that the ability of soil to absorb septic tank effluent is directly related to its initial capacity to absorb fresh water. Unfortunately this is not the case as will be explained later. Generally on-site percolation tests are made and then the drainage seepage system is sized by reference to an empirical graph in the Public Health Services' Manual of Septic-Tank Practice (3). In addition, use of this graph requires the assumption that it is applicable to all soil types, which again is obviously not true. The percolation test cannot predict the effects of physical clogging due to suspended solids in the septic tank effluent, or from chemical and microbiological influences.

For example, using the PHS graph showing the relation between percolation rate and allowable rate of sewage application (3), with a field test percolation rate of 30 minutes per inch (an average value), the graph indicates that the allowable rate of sewage application is 0.95 gallons per sq. ft. per day. This is equivalent to 1.5 inches of rain per day or, if one considers trenches two feet wide, spaced on six foot centers, an application rate equivalent to at least 0.5 inches per day of rainfall. It would indeed require a very pervious soil with clean water to receive this application daily and not become saturated.

Physical clogging of drainfield (12)(14):

Suspended solids in the effluent physically clog the pore space in the soil thus reducing its permeability. In addition, certain operations of heavy equipment that tend to vibrate the soil cause compaction and migration of the soil fines so that they are more or less fitted around larger ones to form a more impervious soil. Smearing of the soil by equipment operation will also reduce its permeability.

Chemical clogging of drainfields (12)(14):

Ion exchange and swelling of colloids are the most important chemical factor in changing the porosity of a soil; for example, a septic tank effluent high in sodium content would very likely reduce the infiltrative capacity of the soil by this phenomenon.

Microbiological Clogging of Drainfields (12)(14):

Because of the abundance of nutrients and organic matter in the septic tank effluent the microbiological activity will be very high. The subsequent microbial populations are so enormous that just by their very presence, the extent of their bodies and gases they produce may effectively clog the soil until endogenous respiration, with resting of the drainfield, reduces their mass.

c. Drainfield dosing:

To make effective use of the entire length of the drainfield, it is necessary that it be dosed through a pump or dosing siphon arrangement. Dosing should be about once every three or four hours to permit some resting between doses. This dosing volume should not exceed 75 percent of the interior capacity of the drain lines being dosed at one time (3). Alternate dosing units discharging to separate portions of a drainfield provides flexibility in operation and reduces the size of individual dosing units.

d. Conclusion

Although septic tank systems are simple and require little attention, they are not recommended as the standard disposal units for future rest areas because: 1) of their history of failure with expensive maintenance; 2) unsuitability of most soils for effective operation; 3) cost; 4) large land areas required; and 5) difficulty of properly constructing extensive drainfield areas that will not have a weak point.

6. Wastewater Ponds

Ponds for the treatment of wastewaters are known as lagoons, oxidation ponds or waste stabilization ponds. They may consist of a single aerobic pond, several aerobic ponds in series, an anaerobic pond preceding an aerobic pond, a pond with mechanical agitators for aeration, and they may be of the overflow or non-overflow type. For rest area usage, the following types will not be considered: The anaerobic because of danger of odors due to wide fluctuations in loadings; the aerated type because they are not considered to be necessary and because of their expense and operating requirements; and the overflow type because of the problems attendant to effluent disposal at most rest area locations. Consideration is given herein then to only the aerobic, quiescent, non-overflow (evaporative) type of pond.

a. Aerobic quiescent pond

The aerobic quiescent pond is really a facultative pond with aerobic conditions prevailing in the upper layers and anaerobic in the bottom. These ponds "treat" wastewater through biological processes that are similar to other biological treatment methods with perhaps one exception, that of large scale algal and other macroscopic plankton growth. In a small non-overflow pond the influent would be admitted near the pond center from whence it would disperse radially as affected by wind action. Settleable solids are digested anaerobically on the pond bottom and the non-settleable and dissolved solids are digested or degraded by aerobic or anaerboic bacteria, depending upon their depth in the pond. These bacteria utilize the organics for food (synthesis of cell tissue and as a source of energy), releasing metabolic by-products and gases such as carbon dioxide. Algae are able to grow in the ponds because of the long detention period and the availability of large amounts of food (mineralized decomposition products and carbon dioxide produced by the bacteria). During daylight hours the algae respire oxygen and this, together with surface aeration, provides the dissolved oxygen necessary for aerobic bacterial action in the surface layer. Thus, much of the original wastewater constituents are transferred to algal protoplasm which, in an overflow pond, are discharged in the effluent. In a non-overflow pond, the algal cells mature, die, and settle to the bottom where they undergo decomposition. The build-up of solids in the bottom of a pond is a slow process and it would be many years before cleaning might be required. Also, in a non-overflow pond there will be a gradual build-up in dissolved salts that will, over a period of time, change the algal species composition. At some point in time, the salt concentration would inhibit bacterial and algal growth. This would require many years and is not considered to be a vital factor in the selection of ponds for rest areas.

These oxidation ponds have been widely adopted throughout the United States during the past 25 years in smaller communities because of their simplicity, low capital cost in most instances, ease of maintenance, and because they can produce adequate treatment of the wastewaters.

b. Aerobic evaporative pond design

Aerobic pond design is on a rather unrefined basis, usually being based upon a surface loading of so many people per acre or the equivalent BOD_5 loading of so many pounds per acre. In the Dakotas where the winters are cold, a conservative loading of 100 persons/acre has been used. This would correspond to a loading of 17 pounds of BOD_5/acre/day if one took a hypothetical municipal wastewater of 100 gallons/person/da y with a BOD_5 of 200 mg/l (values which could be very much in error in many circumstances). Other ponds have been loaded up to 60 or more pounds of BOD_5 per acre, depending on climate, pond location and effluent requirements.

The other criteria for pond design is the depth, shape being of little importance except that circulation is necessary and it is desirable to orient a long axis parallel with the prevailing wind to enhance aeration and mixing. To prevent the development of rooted vegetation, side walls should be steep and the depth sufficient to prevent light penetration to the bottom, usually at least three feet. Sidewalls should be ripraped, of concrete, or soil cement, to prevent erosion and the growth of vegetation. Steepness reduces the amount of exposed sediment (sludge) with fluctuation in liquid level.

The non-overflow, non-percolating pond should be designed on a surface area basis as related to the inflow, rate of evaporation and rate of rainfall. Following this design basis, BOD_5 loading can be checked to see if it is acceptable. Table 12 lists mean precipitation and evaporation data for selected stations using U.S. Weather Bureau data. Evaporation was measured in pans which usually over-estimate the evaporation rate from a natural water surface. Pan data should be multiplied by a factor of 0.7 to 0.8 (depending upon type of pan used) to obtain a more realistic value. As would be expected, the rainfall exceeds the evaporation in Western Washington and in the mountain areas, ruling out strictly evaporative ponds for these regions. In Eastern Washington, the annual evaporation exceeds the annual rainfall in a range of about 22-38 inches per year. These evaporation-rainfall differences are due to local differences in rainfall, wind speed, temperature, and vapor pressure. The greater the wind speed and temperature and the lower the actual air vapor pressure, the greater is the rate of evaporation. Rest areas in Eastern Washington would of course be expected to have a similar range in evapora tion-rainfall differences. A rest area in the same general locality of evaporation measurements might have greater or lesser evaporation rates due to local wind effects etc. Thus, unless specific data are available or experience is gained to prove otherwise, evaporative ponds in Eastern Washington should be designed for an evaporation-rainfall difference of not over 24 inches/year or, 87,120 cu. ft/acre/year.

Although the Department of Ecology may allow a sub-surface percolation rate of one-quarter inch per day (this amounts to about 7.5 inches per month, exceeding most evaporation rates) from ponds, this allowable percolation should not be included in the basic design since ponds will tend to seal themselves with use.

Complete yearly water usage data in the rest area building were available

Table 12. Precipitation-Evaporation Data, Mean in Inches
(U. S. Weather Bureau Records through 1960)

Location	Data	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Rain-fall Total	Total Evap[1]	Adjusted Evap-oration[2]	Rainfall Evaporation Difference
Seattle	Precip	4.73	4.08	3.60	2.12	2.64	1.30	0.58	0.88	1.65	3.32	4.55	5.68	33.93			
	Evap	0.57	0.88	1.74	3.14	4.64	5.05	6.67	5.28	3.48	1.65	0.70	0.52		29.91	24	-
Walla Walla	Precip	1.68	1.58	1.52	1.24	1.26	1.21	0.28	0.34	0.86	1.48	1.86	1.81	16.12			
	Evap			2.64	4.25	6.27	7.77	11.10	9.73	5.59	2.58				47.29	39	23
Prosser	Precip	1.06	0.81	0.63	0.58	0.58	0.85	0.14	0.24	0.34	0.90	1.10	1.11	8.34			
	Evap			2.55	4.24	5.65	6.69	7.85	6.57	4.13	2.30	0.94			37.43	31	22.5
Ephrata[3]	Precip	0.99	0.68	0.61	0.55	0.72	0.99	0.22	0.28	0.43	0.73	1.00	1.17	7.37			
	Evap				5.93	7.99	9.33	11.99	10.07	6.27	2.96				54.54	45	38
Lake Kachess	Precip	8.71	6.93	5.77	2.73	2.19	1.93	0.65	0.69	1.89	5.13	7.87	9.43	54.92			
	Evap				2.70	3.95	4.77	6.48	5.24	2.92	1.40				27.46	23	-
Lind.	Precip	1.05	0.93	0.83	0.68	0.85	1.10	0.30	0.26	0.55	1.14	2.13	1.35	10.17			
	Evap			2.96	5.22	7.49	8.30	11.00	9.44	5.67	3.01				47.12	39	29
Spokane	Precip	1.72	1.51	1.34	0.99	1.04	1.17	0.36	0.49	0.93	0.57	1.88	2.21	14.92			
	Evap				4.1	6.7	-	13	12.8	8.4					60[4]	49	34

1. Total Evaporation, inches, April - October, unadjusted pan.
2. " " " entire year, using pan coef. = 0.70
   and taking April - October evaporation as 85 percent of total yearly.
3. Evaporation data taken at nearby Quincy.
4. Estimated.

only for the Maytown and Scatter Creek Rest Areas at the time of this writing. These are shown by the month for the year 1970 in Tables 7 and 8. Months of high water usage correspond with months of high evaporation and vice versa. Using Maytown water usage as an example, the 1970 total was 184,240 cu. ft. Assuming a 40 percent future increase in usage as a design parameter, there would be 258,000 cu. ft. yearly of wastewater to be evaporated which would require (at 87,120 cu. ft./ac./yr.) about three acres of pond area. This usage estimate of 258,000 cu. ft. included 40,000 cu. ft. for August, the month of maximum usage. If a less conservative net evaporation rate of 36 inches/year and a pan coefficient of 0.8 had been selected, the total required pond area for the example would have been about 1.7 rather than three acres.

By comparing a septic tank drainfield system designed for the month of August (40,000 ft^3 of wastewater) with an assumed average allowable percolation rate of 0.95 $gal/ft^2/day$, a drainfield width of 2 ft. and 9 foot spacing between draintile lines (as at Gee Creek), would require about an acre of drainfield. Evaporative ponds may thus require relatively large land areas. The actual pond area required would be subject to local conditions and whether or not a portion of the wastewater is disposed of through spray irrigation. Likewise, the actual size of drainfields required is also subject to local conditions and it may be considerably larger than in the example above.

c. Recommendations on design and operation

It is recommended that evaporative ponds for Eastern Washington be designed and operated as follows:

Depth: Maximum of five feet, minimum of three feet, and mean operating of four feet, controlled by stop logs or other devices at the point of overflow to a succeeding pond.

Surface area: To be based on a net water loss through evaporation of 87,120 cu. ft./ac./yr.

Configuration: The total surface area required would be divided to provide up to four near equal area ponds to be operated in series.

Operation: Initially to observe operating characteristics, only the first two ponds would be built, with space reserved for two additional ponds if required at a later date. When the first pond reached a depth of five feet, it would be drawn down to three feet through discharge into the second pond in series. The first pond depth would be maintained at three feet until both were at a depth of three feet from whence both would be allowed to fill to four feet in depth. Having a liquid depth in the ponds of at least two feet will insure adequate water depth to control odor and help control aquatic weeds until pond depths increase.

It would require, on this design and operation basis, about 0.8 of a year to fill the first pond and about 1.5 years to fill both ponds to a depth of four feet.

With an input BOD_5 of 165 mg/l, the BOD_5 loading on the first pond would be at the rate of about 9.85 lbs/ac/day for a yearly average. Using Maytown water usage again as an example, the August, 1970, water usage in the rest rooms was 87 percent greater than the yearly average. Thus, the BOD_5 loading in August might average 18.4 lbs/ac./day, a very conservative rate of loading.

d. Spray irrigation:

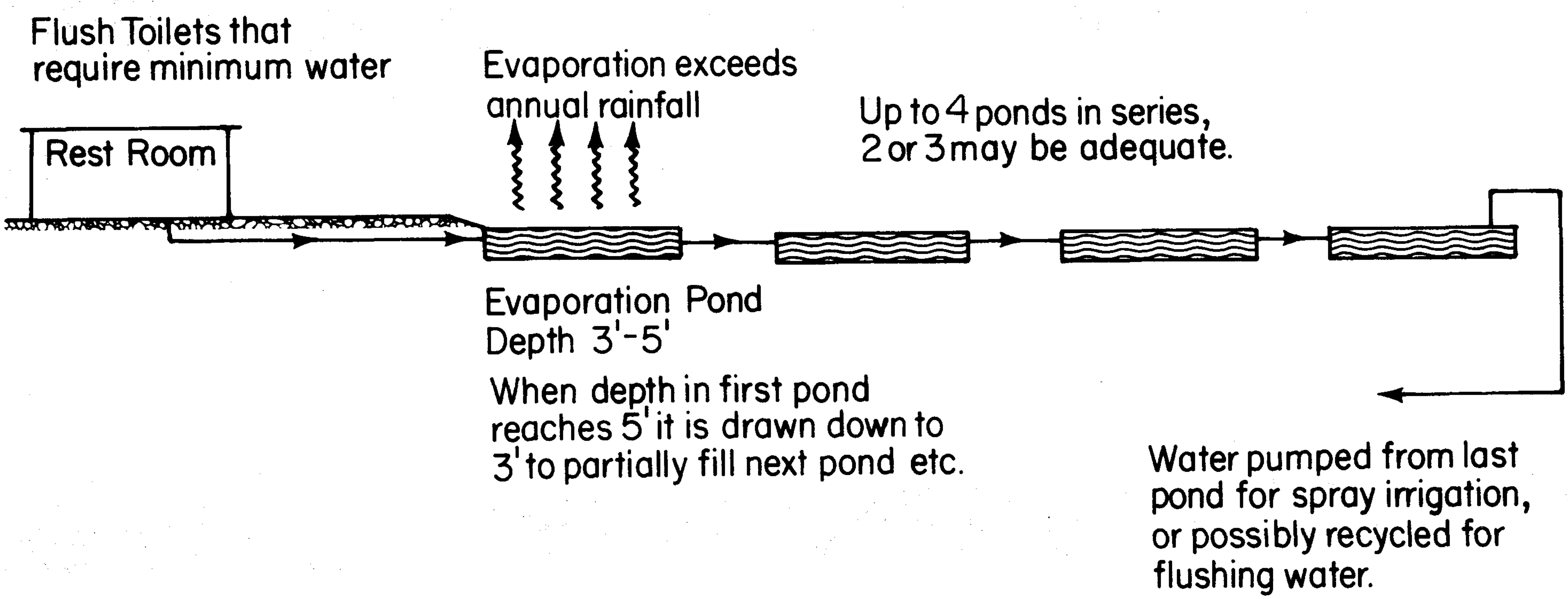
Two ponds in series at the loading rate recommended above should produce a high degree of treatment. An effluent from the second pond would be quite stable, essentially odor free, have little public health significance unless ingested, and would contain varying seasonal populations of phytoplankton and zooplankton, plus the mineralized decomposition products. To reduce the pond area required, to make some use of the wastewater and entrained nutrients and to control the dissolved solids build-up in the ponds, it is recommended that water be pumped from the final pond for spray irrigation as necessary to maintain liquid depths of about four feet in the ponds. Before the onset of freezing weather, the pond depths could be drawn down to 2.5 - 3 feet to permit storage during freezing weather.

In most Eastern Washington rest areas, an evapo-transpiration rate of at least 4 Ac-Ft/Ac, April to October, could be used. Thus the evapo-transpiration area required would be about the same as the area of one of the ponds.

e. Spray irrigation discussion:

Reuse of wastewater through land surface application will become increasingly popular or necessary with the stringent wastewater treatment requirements now being required or formulated. Site selection for spray irrigation at rest

FIGURE 9: Waste Water Pond (Evaporation)



areas should include an examination of the soil conditions to insure that there will be no surface urnoff from the application area. Prior approval is necessary from the Department of Ecology and the appropriate health jurisdiction. Application areas would be fenced to exclude the general public. Since lawn irrigation is practiced at the rest areas, it is unlikely that the public would be aware that this particular irrigation was an example of water reuse. If they were, it is unlikely that they would disapprove, since they are now recycle conscious. Disinfection of the water to be spray irrigated except in unusual cases, is considered unnecessary.

f. Conclusion, evaporative ponds

Evaporative ponds are recommended for Eastern Washington where the terrain is suitable and sufficient land area is available. Where this is not the case, consideration should be given to the installation of recycle flush toilets. Rest areas like Indian John Hill would be questionable for pond use because of the local terrain and rate of precipitation.

Ice formation on the ponds during the winter months will reduce algal growth, evaporation, and bacterial action but will not render the ponds inoperable. When the ice melts, there may be a few days of odor until the symbiotic system reestablishes itself. Otherwise, there should be no odor problems with the ponds properly maintained.

Non-overflow ponds can be used in Western Washington provided suitable land area is available for final disposal by spray irrigation. Loading rates here would depend greatly upon the local rainfall characteristics, soil and vegetation types. Additional study is required to determine appropriate irrigation rates for Western Washington.

With two ponds in series, the effluent from the final pond is suitable, after some pre-treatment, for recycling through the sewerage system. This would make an excellent solution but should be deferred at this time pending the availability of more design data.

7. Recycle system with holding tank:

a. Description

The type of wastewater handling system considered herein consists of a recirculating flush toilet actuated by a foot pump, air pressure, or electrically (12-volt battery or 110V AC)(urinals are not included so that male and female rest area facilities would be the same). Included with this self-contained system is a recirculation reservoir, filter system, and chemical reservoir. Different models are available for indoor or outdoor use and they vary as to recirculation use capacity. The units described herein are similar to those now used on aircraft and are manufactured by Monogram Industries, Inc., 6357 Arizona Circle, Los Angeles, California, 90045. They are manufactured using primarily fiberglass, stainless steel and plastic.

The model most appropriate for rest area usage, according to the manufacturer (15) would be the Model 1000 M-PA, having a capacity for approximately 1,000 uses (manufacturer claims 1,150 uses) before cleaning and recharging. This would be air activated; weigh 75 pounds; be 33" high, 36" wide and 24" deep; have a tank capacity of 62 gallons; adaptable to placing in existing rest area toilet stalls; be dumped through bottom discharge valve to a vault, or by pumping out tank through a side access port; and the units can be fitted for a pressure water connection to facilitate cleaning after the 1000 uses.

The unit is charged with about 14.5 gallons of water, 1/2 pint of chemical, and the chemical reservoir is filled. After approximately 1000 uses, the unit will contain about 62 gallons of waste material. This waste material is dumped or pumped out and the unit filled with clean water for rinsing and flushing. After removing the cleaning water the unit is recharged. Thus, about 1000 uses will generate approximately 125 gallons of wastewater for disposal versus about 5000 gallons using the conventional flush toilet.

Each time the toilet is flushed, a deodorant chemical is automatically metered into the system from the chemical reservoir. The purposes of this chemical compound are to: act as a deodorant; disinfectant; inhibit anaerobic bacterial growth, act as a detergent-surface tension reducing agent; and to provide an aesthetic coloring effect. The active ingredients in the chemical compound are formaldehyde, a wetting agent, blue food coloring dye, and a perfume. These compounds are biodegradable and should not interfere with biological treatment processes after dilution in a municipal system. Calcium chloride is added to prevent freezing during cold weather.

The manufacturer reports (1972) that the cost of their units to the State of Washington could be approximated as follows:

Recycle toilet unit - delivered, each $700

Bottom drain valve	$20
Vent	4
Level indicator for holding tank	5
Pressure water fill unit and vacuum breaker	25
Total each unit	$754
Small air compressor to serve all units	$100

b. Operating experiences:

The State of California has installed six of these units of the foot pedal activated type in a rest area on a trial basis. After two months of service they reported that (16) their initial problems had been paper clogging from seat covers and failure of users to flush the toilets. They propose converting to an air pressure-activated flush system and perhaps the elimination of paper seat covers if this continues to be a problem.

The U.S. Forest Service conducted both laboratory and field evaluation tests (17) on these recirculatory chemical toilets with the following findings:

Battery operation provided some electrical problems
Acceptance by the public and maintenance personnel was good
Satisfactory odor control was achieved
They are no more subject to vandalism than conventional type toilets
Regular inspection and maintenance is necessary
The need for an automatic chemical dispensing reservoir is questioned.

c. Washington Department of Highways Usage

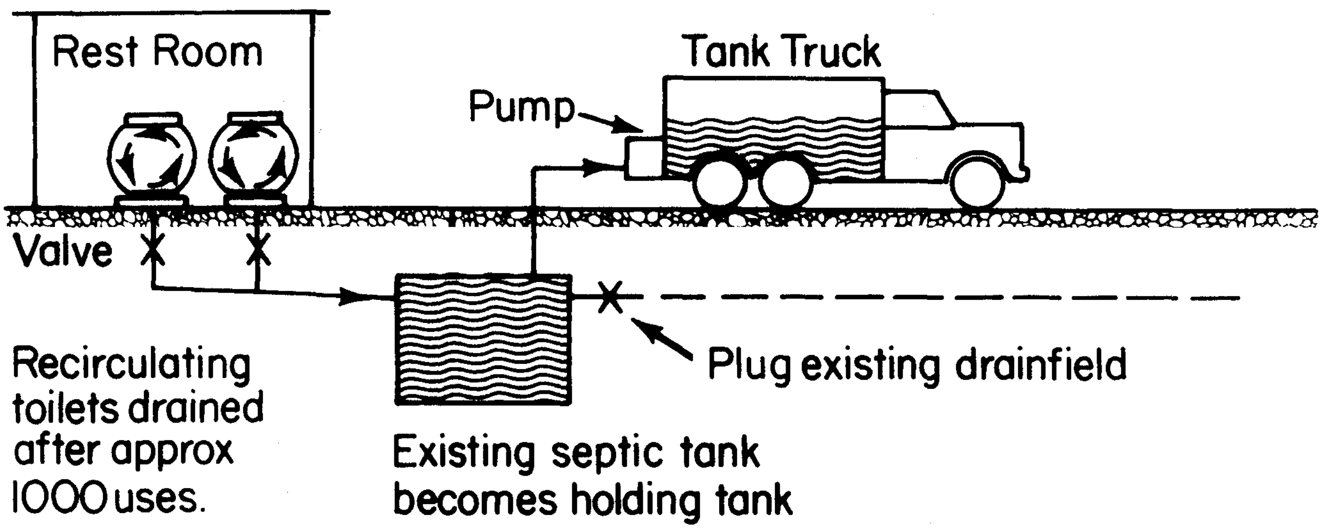
If the Highway Department were to use the Jet-O-Matic type of recirculating chemical toilet on an experimental basis it would involve:

On existing installations: the removal of conventional flush toilets and urinals with substitution of the recycle unit connected through a floor drain into the holding tank. The old septic tank manholes would be made accessible for easy removal and tank pump-out. If the drain slope between the toilet units and the tank is shallow, an access might be needed to facilitate flushing. Care must be taken that the old dewatered septic tank will not tend to float if the water table is high.

On new installations: the women's and men's restrooms would be identical with all toilets and basins discharging to a 10,000 gallon holding tank (or

FIGURE 10: Recycle System

Removal of conventional flush toilets and urinals and replacement with recirculating chemical toilets.



3000 gallon if incineration were used). Drinking fountains should discharge to dry wells. The holding tank would have one large pump-out manhole; no baffling; no effluent drain; and be located to prevent floating, provide a good fall for the drain, and be accessible for truck pump-out.

A 10,000 gallon holding tank would provide storage for 26,700 restroom users based on 1000 uses per recycle toilet generating 125 gallons of wastewater plus one-fourth gallon wastewater per user from basins. A use factor of 26,700 represents 9 and 27 days of storage before pump-out is required on total user days of 3000 and 1000 persons per day respectively. By comparison, with the present conventional system, 26,700 restroom users would generate 100,000 gallons of wastewater requiring disposal. With six recycle toilets and 3000 total users per day (a high rate of use), the toilets would require draining and flushing on the average of once every other day. If the wash basin drainage were taken to a sediment trap followed by a leaching pit, the frequency of required holding tank pump-out would be reduced by a factor of three.

There are four alternatives for pump-out and disposal for the recycle toilet systems:

i. Direct pumping from the recycle toilet itself using a 55 or 275 gallon capacity trailer-mounted tank with pump and hose. This unit would be trailered behind a highway maintenance truck. Two units might be pumped out per day and hauled by the maintenance man for disposal near the end of his shift.

ii. Purchase by the Highway Department of a tank truck with pump having a tank capacity of 2400-5000 gallons. This truck could service a large number of rest areas depending upon their location and use factor.

iii. Contract with a local septic tank pumping service.

iv. On-site evaporation and incineration of the holding tank contents. The holding tank should be sized to accommodate about three times the peak daily flow anticipated. A 3000 gallon tank would accommodate the wastewater generated for three days @ 3000 users per day. Evaporation and incineration systems for similar installations have been designed and manufactured by "Wastco," 20675 S. W. 105th St., Tualatin, Oregon, 97062. An evaporator-incinerator unit with accessories for a rest area might cost, according to Wastco (1972), in the neighborhood of $160,000 with fuel costs around $4.00/hr. when operating.

As an alternative, units can be designed with treatment systems for water recycle (reuse), incinerating and evaporating only the solids and entrained water that was removed. These treatment systems could be applied to conventional or recycle type toilet units and would be quite expensive in either instance. Further details should be obtained from the manufacturer.

If conventional urinals are desired in a recycle system, Monogram Industries has reported that it is a fairly simple matter to convert a conventional urinal into a recycling urinal. It is interesting to note that last summer, Mr. W. P. Mott, California State Director of Parks and Recreation issued an order marking the end of men's urinals at all state operated camping sites as part of a campaign to get more efficient use from toilet facilities.

Although there is no device on the recycle toilets to indicate the number of uses, a water level indicator can be installed to indicate when the units are nearly full. It is expected that after initial experiences, the rest area operator would quickly develop a holding tank dumping and cleaning routine based on his observations of area usage.

d. Alternative Design

A possible alternative to the proprietary recycle toilet is to use the conventional flush toilets and urinals operating out of a central holding tank equipped with the necessary devices for filtering and chemical addition. Whether or not existing simple filtering devices could be adapted to this larger liquid flow is uncertain as a system of this type has not been designed and operated to the knowledge of this writer. It is our understanding that such a system is being discussed between the WSDH and Monogram Industries. This scheme essentially involves wastewater recycling with intermediate treatment and solids removal. The design problem is: What treatment may be required; how long can the liquid be recycled; will flushometer values remain functional; how will the solids be removed and what disposal method will be most suitable; and what is to be done with the recycled water after it is spent? Design of such a unit is not difficult and its practicality is dependent upon whether or not the simple Monogram filtering unit can be employed which can be answered only by the Monogram people at this time. (Operation of present day wastewater treatment units in a recycle system is not considered practicable for rest areas by the writers).

e. Disposal of Contents

Disposal of the holding tank contents could be by contract with a suitable municipality wherein the Highway Department would install a tank, in the case of a small municipality, to receive the tank truck contents. This wastewater would be bled into the small municipal sewage treatment plant influent at a slow rate during off-peak flow periods. In a biological treatment plant, this loading during the hours of 10:00 p.m. to 6:00 a.m. would actually be beneficial to the plant operation and not constitute any overload. In a large municipality, because of the large dilution available, the truck could pump its contents directly into the treatment plant influent. The decision on the method of discharge to use could only be made in light of the tank truck size, frequency of discharge, municipal wastewater flow rate, and relative sewage treatment plant capacity. For purposes of evaluation, a 2400 gallon tank truck (other sizes would be in direct proportion) containing the recycle toilet contents plus wash basin discharge, would contain a BOD_5 of about 31 pounds representing a population equivalent of 235 persons based on a municipal wastewater flow of 90 gpcd and BOD_5 of 175 mg/l, and a holding tank content of 0.375 gallons/capita of usage with a BOD_5 contribution of 0.0048 lbs/capita; BOD_5 = 92 lbs., population equivalent of 700, without wash basin discharge.

f. Conclusions

A recycle toilet installation satisfies the criteria for wastewater disposal evaluation and it has the added advantages of: Low first cost, leaving options open for future developments; easy expansion; small land area required; greatly reduced fresh water requirements; and reduced operation problems with pumps and pressure tanks. Chemical additives should be largely spent by the time of discharge and have little if any effect on wastewater treatment plants. A possible disadvantage could be difficulty in obtaining a satisfactory contract with a local municipality to accept the tank truck discharge at a reasonable price. The writers forsee no real difficulty herein however since septic tank pumpers and chemical toilet service companies are operating throughout the State. An alternative to municipal dumping of sludge is State operation of a treatment plant(s) centrally located in a region to treat the wastes from various state agencies.

8. Chemical Precipitation and Adsorption

This treatment process involves the addition of a coagulant (like alum) under conditions of pH control wherein the coagulant feed is proportional to the rate of inflow. Following a period of flocculation, the wastewater is subjected to quiescent sedimentation which should remove most of the suspended solids and floatables. It can also be used for phosphorus removal. To secure near complete removal of suspended solids, the wastewater is then passed through a mixed media filter which is cleaned periodically through backwashing. Dissolved solids are then removed by passing the wastewater through a bed of granular carbon. This carbon can be regenerated by burning in a furnace.

The physical-chemical process, although capable of producing a high quality effluent, is not suitable for rest area usage because of: a) rest area wastewater flow is intermittant and varies widely in quantity making accurate chemical feed most difficult; b) relatively large quantities of chemical-organic sludge would be generated posing a disposal problem; c) carbon regeneration would be impractical; d) first cost would be high; and 5) skilled operation is required.

9. Biological Treatment Processes, Package Type

There are a large number of variations in the biological treatment process that are marketed as proprietary devices of the so-called "package" type. They all depend upon the development of a biomass than can utilize the organics in the wastewater for cell synthesis and as a source of energy. The biomass may be unattached and made to circulate through the liquor by induced agitation (activated sludge and oxidation ditch) or it may be attached to some type of media (trickling filter and bio-disc) where the settled sewage is passed over the media. All of these processes are followed by sedimentation for sludge removal. In the activated sludge processes, careful attention must be given the return of sludge to the aeration compartment so that treatment will be effective and so that the sludge will settle in a settling basin and not pass out with the effluent.

The extended aeration process consists of a mechanical aeration compartment followed by a sedimentation compartment. Solids settled in the sedimentation unit are returned to the plant influent and they thus go round and round with the sludge excess being continuously discharged along with the effluent in contrast with the activated sludge units whose excess sludge is usually taken to a digestion unit. While the extended aeration process is the simplist and most foolproof of the units, it does not produce an effluent whose quality is comparable with a well-operated activated sludge plant.

For continuous and effective performance, the biological treatment processes are dependent upon a fairly uniform inflow and organic load, the antithesis of the conditions found at the usual rest area. Of these processes, the extended aeration process would seem the best for rest area usage, with a fixed media process such as the trickling filter a second choice. Where the extended aeration process is followed with a settling basin to improve its BOD and solids removal characteristics, it will also require some type of solids disposal. These treatment units would all require trained operators and effluent recycle or discharge into seepage beds unless the rest area is located adjacent to a relatively large stream. If this stream was in a National Forest or discharged into a lake or impoundment, regulatory requirements would stipulate advanced waste treatment.

The effluent from a biological treatment process could also be disposed of in ways other than discharge to a water course. A most logical method is through use of spray irrigation as with pond effluent. Recycling, from say an extended aeration unit, would involve the addition of odor masking and coloring agents, filtration or fine screening, an equalizing reservoir, and bleed-off to prevent the accumulation of solids and salts.

A biological treatment "package" unit that seemed superior to others reviewed for possible rest area use by the writer is the unit manufactured by Bio-Pure Inc., 10510 S.W. Industrial Drive, Tualatin, Oregon, 97062. These units are designed for automatic operation to receive intermittent and peak flows through a "batch" type process. Treatment effectiveness would vary with flow variations and automatic operation does not remove the necessity of having operators familiar with the care and servicing of the unit.

10. Other Treatment Methods

The process using an anaerobic filter and chemical precipitation following a septic tank is considered to be too complicated operation-wise for consideration herein. It also would produce an effluent and large sludge disposal problem.

Evaporation and combustion requires a large expenditure of fuel for the evaporation of the liquid and the destruction of the solids. Ash remains as a residue. Careful design and operation would be required to prevent odors and to care for the large fluctuation in loading.

Enzyme treatment depends upon the addition of enzymes and other additives to correct or improve a particular disposal method. There is no evidence found by the authors in the literature or through their experience that would lead them to believe that these enzyme additives are effective as claimed by the numerous suppliers.

11. Costs of Wastewater Treatment

a. Conventional Treatment Units

Studies on the costs associated with building and operating wastewater treatment facilities are available from the literature (18)(19). As with most studies of this nature, assumptions vary among the cost estimators. Consequently, differences may result particularly if an attempt is made to relate the cost of the process with effectiveness in removing water contaminants. To assist Washington State Department of Highways engineers and planners in comparing the various methods of wastewater treatment processes, costs from two principal sources have been summarized in Tables 13 and 14. These data are presented to indicate how costs vary with the type and size of the treatment facility. Thus, should it be necessary for the Highway Department to build and operate a central trickling filter plant to handle a waste volume of say 0.1 MGD, it would cost approximately $90,000 for construction and $5,010 per year for operation and maintenance (if part-time) in terms of 1967 funds. The economy of operation of the waste stabilization pond is very noticeable in Table 13. It should be pointed out that the smallest unit shown in these tables is about 10 times the size of a unit that might be used for an individual rest area.

Table 15 was prepared using data taken from a study of comparative costs of wastewater treatment for a 500-man military camp in S.E. Asia (20). Costs shown are capital and operating in $/1000 gal., with the capital cost amortized over a 5-year period at 5 percent interest. While these costs would not be directly applicable to a rest area, they do reflect relative values for secondary wastewater treatment processes. Using their waste loading assumptions, a 500-man camp would produce a daily flow of 32,500 gallons.

Table 13. Wastewater Treatment Plant Operation and Maintenance Costs (18)

Type of Plant	Total Annual Cost for Average Daily Flow* (Dollars)			
	0.1 MGD	0.5 MGD	1.0 MGD	2.5 MGD
Conventional primary	5,540	14,300	21,400	26,600
Primary with oxidation lagoon	2,130	4,410	6,050	-
Waste stabilization pond	964	2,350	3,450	5,730
Standard-rate trickling filter	4,570	11,500	17,100	28,900
High-rate trickling filter	5,010	13,600	20,000	37,000
High-rate trickling filter, with oxidation lagoon	2,670	8,400	13,800	26,400
Activated sludge	5,940	19,200	31,900	62,300
Extended aeration	5,550	15,100	23,200	41,000
Contact aeration	6,480	16,000	23,700	39,600

*Includes salaries and wages, electricity, chemicals and other supplies and miscellaneous for 1965-1968 period.

Table 14. Wastewater Treatment Platn Construction Cost* (19)

Type of Plant	Total Construction Cost for Average Daily Flow (Dollars)			
	0.1 MGD	0.5 MGD	1.0 MGD	2.5 MGD
Primary treatment	$ 70,000	$200,000	$350,000	$625,000
Activated sludge	100,000	350,000	600,000	1,250,000
Trickling filter	90,000	350,000	600,000	1,250,000

*Costs are for 1967

Capital costs include equipment costs and accessaries, shipping, and labor costs for placing in service; land costs are not included. Operating costs include labor, repairs, power and chemicals.

Table 15. Capital and Operating Costs for Wastewater Treatment Alternatives in a 500-man Military Camp (20).

Treatment Process	Cost, $/1000 gal. Treated		
	Capital	Operating	Total
Biological Processes:			
Aerated Lagoon (a)	0.13	0.43	0.56
Completely Mixed Activated Sludge (a)	0.63	0.74	1.37
Contact Stabilization (b)	0.56	0.57	1.13
Extended Aeration (c)	0.55	0.48	1.03
Oxidation Ditch	0.30	0.40	0.70
Oxidation Pond	0.08	0.31	0.39
Bio-disc	0.90	0.19	1.09
Trickling Filter	0.53	0.77	1.30
Ultrafiltration	1.18	1.72	2.90
Chemical Processes:			
Chemical Precipitation	0.35	0.58	0.93
Electrochemical Flotation	1.46	1.02	2.48

(a) Mean of two manufacturers' systems
(b) Mean of three manufacturers' systems
(c) Mean of five manufacturers' systems

b. Recycle Toilets

These cost estimates are compared with a septic tank drainfield with dosing siphons or pumps and diversion boxes. For an eight unit rest area building, the drainfield and dosing equipment is estimated to cost $50,000 or $8,000/year in a seven-year life ($7000 for replacement plus $1000 per year operation and maintenance) exclusive of land cost. The cost of the septic tank itself is not included since a similar unit would be needed for the recycle system if individual pump-outs are not used. This is considered to be a low estimate of costs.

Recycle toilets delivered cost \$754 each with accessories and with an assumed installation cost of \$300/unit, the cost for eight replacement units installed would be \$8,430 (\$6,030 if a new installation is being compared). This gives an estimated cost of \$1,600 per year for operation, maintenance and replacement in a seven-year life. Credit is not given in the foregoing for reduced operation and maintenance on the water supply system.

For purposes of pumping and hauling comparisons, the following figures are used (tank truck cost and life was obtained from a company operating a fleet of tank trucks):

Tank truck of 2,400 gallons capacity, \$10,000 for chassis with 5-year life and \$10,000 for tank and pumping equipment with 20-year life.

Truck cost 10¢/ton mile for operation, maintenance, replacement, and driver. For 2,400 gallons, this is \$1.00/mile.

Mobile, 275 gallon tank with trailer and electric or gasoline pump and hose, \$1,320. This can be hauled behind a maintenance vehicle.

Average of 2,000 visitors per day in peak month @ 125 gallons of recycled waste/1000 users gives 250 gallons/rest area/day. With washbasin drainage = 750 gallons per day.

Wash basin drainage goes to small septic tank and drainfield, 1/20th size of units now serving flush toilets; cost \$5,000.

One tank truck serves I-5 rest areas including Elma on a 10-day turn around, 750 miles or \$1,800/mo = \$22,500/year. If the same truck also serves I-90 to Indian John Hill, this would be an additional 250 miles, or a total of \$2,500/month = \$30,000/year. This is \$1500 per rest area per year for 20 areas.

Discharge facilities at Olympia, Kelso, Arlington and Bellingham (Cle Elum and Snoqualmie if I-90 served). Each facility, including discharge fee plus prorated cost of discharge equalizing tank, at \$750 per year, or total of \$5250/year for the seven discharge locations. The 275 gallon mobile tank trailer would not require a discharge equalizing tank at the point of disposal.

Using a tank truck serving I-5 and I-90 with straight-line depreciation of the truck chassis over the first five year period, the annual cost of the recycle system per rest area is approximated at $\$2{,}000 + \$1{,}500 + \frac{5250}{20} + 1{,}300 + 500 = \underline{\$5{,}560}$ including \$500 per year for the small septic tank and drainfield. The first and operating cost of the recycle toilets has been included in this annual cost as \$1,300 per year in excess of conventional toilet units with the septic tank system.

If the maintenance personnel at each rest area were to clean and pump out two recycle units each day maximum (no vault for storage and each unit pumped directly through a valved manifold serving the eight units) and haul the mobile trailer to a municipal treatment plant on their way home, the annual cost should be no more than $1000 for hauling and disposal if they travel to and from work in a Department truck.

While these cost comparisons are not refined, they do show that the recycle system would cost no more than the septic tank-drainfield system and might be considerably less expensive if all costs are considered.

12. Evaluation and Recommendation

Table 16 presents a comparison of wastewater disposal methods rated against the criteria for "disposal method selection" discussed earlier in this chapter. Each criterion is given a weight of 8 or 10 points with the disposal methods subjectively rated against each other in a scale of 1 to 8 with 8 being judged the best. Rating weights assigned were based on usual field conditions, not on an idealized situation. While there is much room for argument on certain of the criteria, the overall results clearly indicate that evaporative ponds and recycle holding tanks are the two preferred methods of rest area wastewater disposal, at least in the subjective view of the writers.

This evaluation is not meant to be exclusive. For example, certain locations might not be as suitable for ponds or for recycle systems as they would be for a septic tank drainfield system.

It is therefore recommended that:

a) The Department of Highways install a recycle toilet system with holding tanks in one of the rest areas on a trial basis.

b) If the trial shows this system to be superior to other disposal alternatives, it is further recommended that:

c) Recycle systems with holding tank or mobile trailer pump-out be the standard disposal system for Western Washington, the mountain areas, and those areas of Eastern Washington where evaporative ponds are not suitable because of terrain or space limitations. They would be installed in new rest areas and in old rest areas experiencing septic tank drainfield problems. In addition, unless the prospects for private hauling are good, the Department of Highways consider the use of their own equipment for holding tank pump-out and hauling.

Table 16. Comparison of Wastewater Disposal Methods
(Refer to previous discussion)

DISPOSAL METHOD	Simplicity	Provides Entire Treatment and Disposal Required	Treatment or Disposal Effectiveness, in Practice	Aesthetic Qualities, in Practice	Effect of Weather Extremes	Accommodate Load Fluctuations	Accommodate Extreme Loadings	Suitability for Use in Most Rest Areas	Cost	Corrosion; Vandalism; Hazards	Acceptability to Regulatory Agencies	Local Pollution Possibility	Summation Criteria Ratings	Rating
Chemical Toilet	7	5	8	1	5	4	4	1	7	2	6	6	56	5*
Holding Tank (Dry)	8	4	6	2	8	5	7	7	8	5	7	7	74	3*
Septic Tank System	6	8	4	3	7	6	5	4	4	8	8	4	67	4
Ponds (evaporative)	5	7	9	5	4	8	8	5	5	7	9	5	77	2
Recycle & Holding Tank	4	6	10	8	6	7	6	8	6	6	10	8	85	1
Physical-Chemical Treatment	2	3	5	7	3	2	3	3	2	3	4	3	40	7
Biological Tr't (Package)	3	2	7	6	1	3	1	6	3	4	5	1	42	6
Proprietary Processes	1	1	3	4	2	1	2	2	1	1	3	2	23	8
Weight assigned criterion	8	8	10	8	8	8	8	8	8	8	10	8	100	

*These methods are unsuitable for most major rest areas.

d) New rest areas or those experiencing septic tank drainfield problems in Eastern Washington be provided with evaporative ponds and sprinkler irrigation systems, as discussed in previous pages. A recycle system with holding tank or mobile trailer pump-out would be used where the pond and/or septic tank system is not appropriate.

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