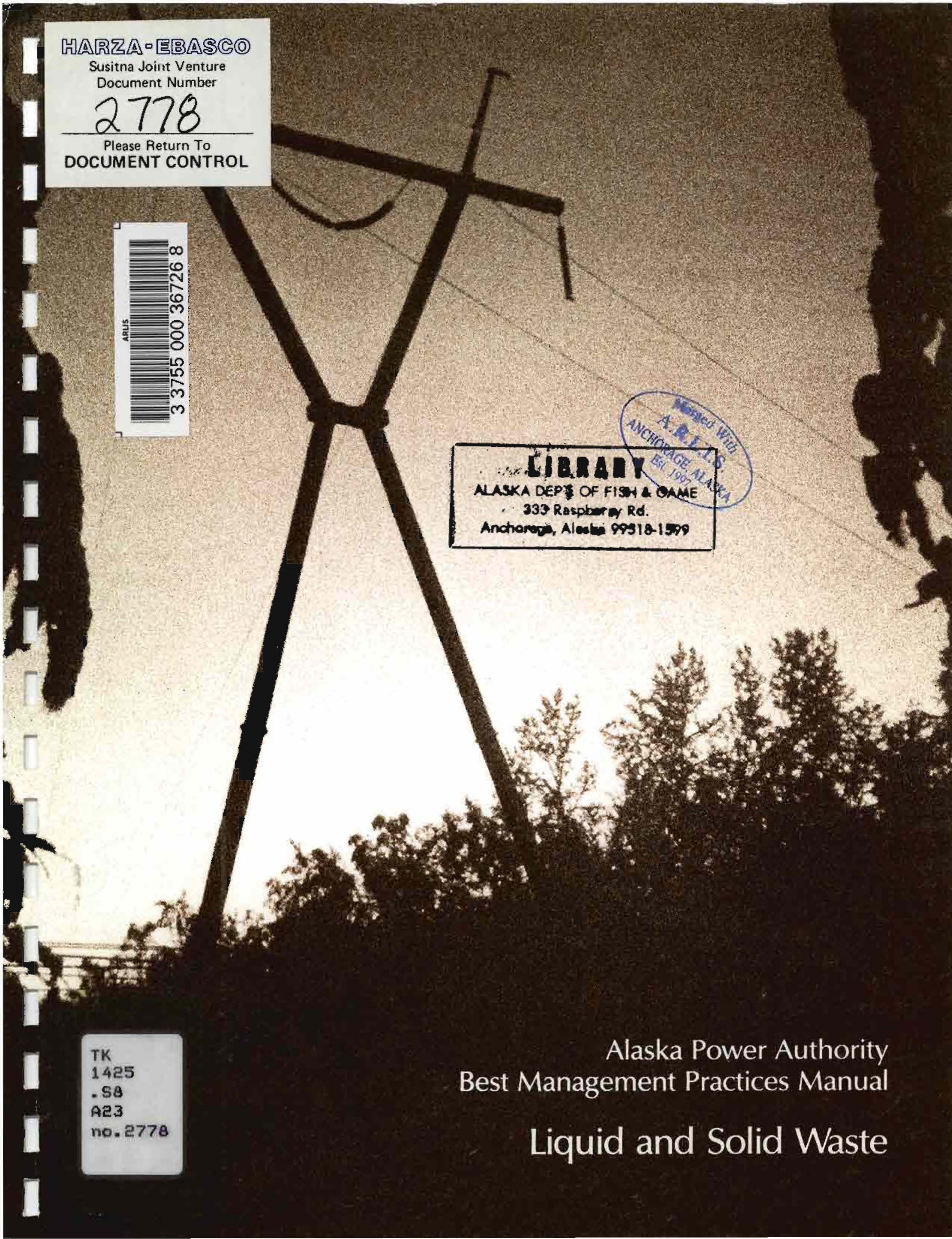

Alaska Power Authority
Best Management Practices Manual

Liquid and Solid Waste

ALASKA POWER AUTHORITY

BEST MANAGEMENT PRACTICES MANUAL

LIQUID AND SOLID WASTE MANAGEMENT

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Prepared by Frank Moolin & Associates, Inc.
under contract to Harza-Ebasco
Susitna Joint Venture

PREFACE

This manual is one of a series of "best management practices" manual to be used in the design, construction, and maintenance of Alaska Power Authority projects. It represents a coordinated effort involving federal, state and local government agencies, and special interest groups.

The Alaska Power Authority intends that applicable guidelines and state-of-the-art techniques contained in the manuals will be incorporated where appropriate into the contractual documents for projects constructed, maintained, or operated by or under the direction of the Alaska Power Authority.

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CHAPTER 1 - INTRODUCTION

This manual has been prepared by the Alaska Power Authority as one of a series of best management practices (BMP) manuals for projects constructed or operated by the Power Authority in Alaska. The ultimate goal of this manual on liquid and solid waste management is to assure that Power Authority waste management activities are conducted in an efficient and cost-effective manner in compliance with applicable federal, state and local laws.

This manual was prepared in recognition of the fact that waste management techniques must relate to an infinite variation in environmental conditions. This manual thus sets forth a wide range of liquid and solid waste management practices. Not all techniques will be appropriate for a particular site. In addition, federal, state, and local laws may impose specific requirements on particular Power Authority projects or activities. This manual is not a substitute for case-by-case identification and compliance with all laws and regulations applicable to the construction and operation of Power Authority projects.

This manual addresses liquid and solid wastes: what they are, how they are collected, and how they are treated. Chapter 2 discusses liquid wastes and Chapter 3 discusses solid wastes. Regulatory authorities and agencies are listed in Chapter 4. While hazardous materials and hazardous wastes, as defined by either EPA or Alaska regulations, are mentioned in this manual as possibly used at or generated from a Power Authority project, discussion of the special handling required for these materials is contained in a companion BMP manual entitled "Fuel and Hazardous Materials."

CHAPTER 2 - LIQUID WASTE

This chapter discusses liquid waste: what is it, how is it collected, and how is it treated in a chronological and order of magnitude approach. Smaller systems, such as those used at short-term exploratory or fly camps, are discussed before larger systems used at long-term camps. The evolution of most projects goes through a similar evolution of size and duration.

Some of the variables acting in a waste treatment design have been grouped in Table 1 to facilitate discussion in terms of phasing the design effort; identifying levels of complexity; placing relative costs for system construction, operation and maintenance; and evaluating the projected degree of treatment.

2.1 PROJECT PARAMETERS

On many occasions, a project is either a later phase or a repeat of a similar effort in a new location. Even though it does not appear such at the outset, there are sometimes enough dissimilar ingredients so that the same application of technology does not yield success.

Design of treatment facilities for liquid wastes should not be an isolated design procedure developed from data supplied by others. An environmental/sanitary engineer should be an integral member of the project team from the early stages. The following list presents typical projects tasks that should have participation or review from an environmental/sanitary engineer.

TABLE 1
LIQUID WASTE TREATMENT VARIABLES

CAMP SIZE & DURATION

TYPE	NUMBER OF RESIDENTS	YEARS OF DURATION
Exploratory	3 to 50	Varies
Short Term	3 to 50	0 to 10
Intermediate	50 to 300	3 to 10
Long Term	300 to 4000	10 to 30

NOTE: Residents and duration can be found in numerous combinations.

LOCATION COMPLEXITY
(Assumes coal, gas or hydro power project)

Alaska Project Location	Miles Distant From Major Supply & Distribution Center	Waste Treatment	Water Supply	Supply Transport System
Urban	0 to 30	Public	Public	Truck
Suburban	30 to 100	Combination or camp	Combination camp	Truck
Wilderness	100 to 160	Camp system	Camp system	Combination truck & airplane
Remote Wilderness	160 or more	Camp system	Camp system	Limited trucking, airplane or barge likely.
Remote Arctic	160 or more	May require camp system or haul out	May require haul in or camp supply.	Airplane or barge.

COLLECTION SYSTEMS

TYPE		DESCRIPTION
honey buckets	-	individual collection at generation source
pit toilets	-	disposal site at out-house
tank trucks	-	collects from storage tanks or buckets
sewers in ground	-	where climate and soils permit pipe in trenches
utiliducts above ground or below ground	-	cold climates require insulated pipe systems
piping in utilidors above ground or in ground	-	arctic climates require pipe chases heated and insulated
pump stations		

TREATMENT SYSTEMS

Field Tested

small camp
short duration

- haul to dump station or connect to public system
  land disposal (absorption field)
- seepage pits
- existing swamps, ponds or lakes (become lagoons)
- man-made facultative lagoons
- physical/chemical treatment
- activated sludge (extended aeration)
- rotating biological contactors
- incineration of sludge

Need Additional Study

- surface application of wastewater
  - o spray irrigation
  - o surface injection into plowed furrows
- aerated facultative lagoons
- aerobic sludge digesters
- anaerobic sludge digesters
- composting of sludge with shredded paper and garbage

TYPICAL PROJECT TASKS

- Exploratory survey
- Exploratory core boring
- Exploratory geology and soils sampling
- Stream flow monitoring
- Quality and quantity of water supply source
- Identification, classification and quantification of flora and fauna
- Route selection of haul roads and material storage areas
- Final siting of the structure (earth dam, concrete dam, coal fired generator, gas fired generator, etc.) and appurtenances
- Design of the structure
- Siting of early stage and final support facilities (water supply for camp, camp, waste treatment facility, shops, power and heat sources, fuel and supply depots)
- Design of support facilities
- Permitting of support facilities
- Operation and maintenance of support facilities
- Construction of project structures
- Removal of support facilities
- Site cleanup, restoration and revegetation
- Maintenance and operation of permanent or long-term facilities
- Monitoring for the long term (defined in the permit) all landfills, waste dumps and lagoons for possible pollution after covering

The environmental/sanitary engineer should be familiar with conceptual design drawings and how the project is to be situated on the premises, including such features as approximate limits of work, excavation, material storage, sedimentation and erosion control. Comparing topographic features with the limits of work and property lines will aid in determining what areas are available for camp siting and, therefore, the placement of adequate wastewater collection and treatment systems. Studying the topography, geology, meteorology, surface and groundwater records of the area will assist in making preliminary judgements as to the best location and orientation of dwelling units, supply and collection lines, pump stations, treatment and discharge locations.

The projected phases of development and related camp populations including any provisions for overlapping of staff at shift change and vacation will be needed to calculate peak loading. Early exploration may have as few as 5 to 10 men in a drilling operation moving nomadically through the project area and never staying more than a few days at any one location. First-phase camp erection will see several more men and concentrations of materials and equipment stockpiled in various locations. Large projects can have upwards of 3000 men at peak work schedules, all of whom are housed at a single location. Treatment systems must be flexible to take the surges and droughts which can and do occur.

The actual selection of distribution, collection, and treatment facilities is extremely dependent upon how quickly they must be operational and how soon they need to be unplugged and moved on. Long-term facilities can be built with an eye to efficient operation (low power consumption), durable semi-permanent materials, and efficient design based upon a more reliable projection of demand. Short-term portable facilities are more controlled by the results needed than the cost to get those results. Some parts of the system such as pumps may be actually disposables. The challenge to the design engineer is to obtain the correct mix of both while considering the remoteness of the camp and difficulty of resupply.

An evaluation of total project cost is reasonable if one alternative is compared to another. Actual treatment costs may be incidental and of little consequence due to environmental restraints and total project value. A team effort, including input from federal and state agencies, will be needed to establish reasonable limits of treatment. On-site population and construction cost of the project are the primary factors needed to estimate conceptual treatment costs and their percent of the total picture. Comparison with similar projects and effluent requirements can be a guide to the cost effectiveness of a given approach.

A review of project permit requirements is also important at the planning stage. Applicable regulations and permitting requirements may determine the kind of waste treatment measures and facilities selected for individual projects. The following are important factors that should be an integral part of Power Authority waste management project planning:

- o Identify project goals and describe proposed construction and other activities to implement goals.

- o Determine projects impact on environment.

- o Identify statutes, regulations and agencies which regulate either the proposed activity or its impacts. In particular, determine whether existing Power Authority permits control the activities or impacts involved.

- o Compare burdens imposed by regulations and/or permits for proposed activities and alternatives (including costs associated with modifying activities to reduce or eliminate requirements).

- o Develop and implement permitting strategy to obtain timely issuance of permits.

2.2 LIQUID WASTE STREAM CONSTITUENTS

2.2.1 Classification

The types of liquid substances or wastes anticipated at a Power Authority project site are listed in Table 2. Those items which are also identified as hazardous are addressed in a companion BMP manual on fuel and hazardous materials. Table 2 is intended only as general guidance. The classification of wastes listed in Table 2 is not a substitute for case-by-case waste stream analysis to assure that hazardous and non-hazardous wastes are segregated and managed in accordance with federal and state hazardous waste laws as more fully described in the fuel and hazardous materials BMP manual. Basically, the liquid and semi-liquid wastes which are likely to be found in camp situations can be separated into three categories:

TABLE 2

CAMP GENERATED CONTAMINANTS

DESCRIPTION OF WASTES	WORK CAMP TYPE			LIQUID WASTE TYPE			
	Exploratory	Intermediate	Long Term	Domestic	Industrial	Construction	Hazardou
WASTEWATER							
water treatment backwash		X	X	X			
excrement	X	X	X	X			
sink water	X	X	X	X			
bath/shower water	X	X	X	X			
kitchen food waste	X	X	X	X			
kitchen grease and oil	X	X	X	X			
laundry wastewater	X	X	X	X			
hospital wastes (limited)		X	X	X			X
pesticides (trace amounts)	X	X	X				X
disinfectants (controlled)	X	X	X	X			X
detergents (bio degradable)	X	X	X	X			
cleaning solvents (limited)	X	X	X	X	X	X	X
CONSTRUCTION WASTEWATER							
drilling slurry	X	X	X			X	
sediment	X	X	X			X	
acids	X	X	X			X	X
caustics	X	X	X			X	X
sealants		X	X			X	X
material coatings		X	X			X	X
paint		X	X			X	X
clean up of concrete mixing and finishing equipment		X	X			X	
MAINTENANCE & OPERATION							
petroleum	X	X	X		X	X	X
oil	X	X	X		X	X	X
grease	X	X	X		X	X	X
vehicle wash water		X	X		X	X	X
solvents	X	X	X		X	X	X
machine shop							

- Wastewater related to domestic uses
- Construction waste related to fabrication, erection, and finishing of the project
- Maintenance and operation wastes related to petroleum, oil, and lubrication products as well as other hazardous materials.

As practicable, the various materials will be separated at the point of origin. Mixing of waste generally complicates the classification and treatment process and in certain instances prevents treatment.

2.2.2 Wastewater Sources and Strengths

2.2.2.1 Water Treatment Backwash

Most fly camps or short-duration exploratory operations will provide treatment as dictated by their raw water source. Generation of water treatment by-products is limited. Larger camps that obtain drinking water from local sources may produce sludges from filter backwash containing algae, sediment, debris and chemical flocculants. The quantity of waste produced is a function of the turbidity and chemical composition of the raw water. Reverse osmosis can produce wastewater with high salinity. So also do softeners using ion exchange and sodium chloride as the degenerate. Flocculants generally are aluminum sulfate, ferrous sulfate, ferric sulfate, ferric chloride and coppers. Activated carbon is also used, and unless recharged, becomes disposable. Lime and soda ash, if used as a softener, will cause a precipitate to settle out in the contact tank and in the filter bed. Every water treatment process except chlorination will produce a wastewater or sludge which may hinder or enhance a sewage treatment process. It may be beneficial to operate the water and sewage treatment systems independently until the steady-state parameters of each are known before combining sludges.

2.2.2.2 Domestic Waste

The strength of waste and quantity generated are very closely tied to the size of the operation and the availability of potable water. Fly camps may use "honey buckets", priveys, incinolets, and pit toilets. Large 3,000-man facilities with a 5- to 10-year life may have all of the modern conveniences. The strength of workcamp wastewater is characteristically higher than normal domestic wastewater, although per capita flow rates may be only slightly less. BOD_5 and suspended solids can typically average 400 to 600 mg/l. While flow rates at Alyeska camps were calculated at about 66 gal/cap/day (250 l/cap/day) in 1979, average water use in camps today approximates 100 gal/cap/day (378 l/cap/day). Flow rates at the lower level may cause problems in meeting regulations with secondary treatment because of the higher strength wastewater. The more milligrams per liter of suspended solids and BOD_5 in a wastewater, the higher percent removal that is required to meet fixed criteria.

There are several explanations for the strength of camp wastewater. These include:

- Limited water supply
- High per capita food consumption and waste generation

- High grease content in kitchen wastewater
- Entry of cleaning compounds, used in camp maintenance, into the sewerage system
- Lack of groundwater infiltration into the sewers.

Flow Rates and Constituents

Per-person sewage flows are quite variable among camps and communities in cold regions. Tables 3 through 5 are representative of the current available data. In general, institutional facilities such as military stations and construction camps, tend to have strong flow variations because a large portion of the population responds to the same schedule. The peak flow will usually occur in late afternoon when personnel are using the bath and laundry. Two such peaks will occur at those installations operating on a continuous two-shift, 24-hour cycle. The peak daily flow rate for design purposes should be three times the average daily rate for institutional facilities. In general, the average rate for camps will be 100 gal/cap/day. For non-resident day workers, an allowance of 15 gal/cap/day per 8-hour shift should be made.

Civilian communities and similar residential areas have less sharply defined flow variations. In general, a single major peak, approximately at mid-day, will occur. The time is dependent on transmission distance from the homes to the treatment system. The daily peak flow rate of these communities should be taken as two times the average daily rate. The U.S. Public Health Service uses a factor of 3.5 people per residence for designs in small communities.

TABLE 3

TYPICAL AVERAGE PER PERSON SEWAGE FLOW [1]

Permanent Military Bases and Civilian Communities

a) greater than 1000 population with conventional piped water and sewage:

Average	300	l/person/d
	79	gal/cap/d

b) less than 1000 with conventional piped water and sewage:

Average	240	l/person/d
	63	gal/cap/d

c) with truck haul systems, conventional internal plumbing:

Average	140	l/person/d
	37	gal/cap/d

d) with truck haul systems, low flush toilets:

Average	90	l/person/d
	24	gal/cap/d

e) no household plumbing, water tanks and honeybucket toilet:

Average	1.5	l/person/d
	0.4	gal/cap/d

f) same as (e) above BUT with central bathhouse and laundry:

Average	15	l/person/d
	4	gal/cap/d

Construction Camps

Average	220	l/person/d
	58	gal/cap/d

Remote Military with Limited Availability of Water

Average	130	l/person/d
	34	gal/cap/d

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1) Source: Smith, et al (1979).

TABLE 4

CAMP WATER USE AND WASTEWATER CHARACTERISTICS [1)]

CAMP LOCATION	WATER CONSUMPTION (l/cap/day)	(gal/cap/day)	BOD_5 (mg/l)	COD (mg/l)	SUSPENDED SOLIDS (mg/l)	OTHER
	AVERAGE OF RESULTS					
1. Five camps in Alaska	320	84	626	1790	1180	
2. Alyeska-Chandalan Camp			609			
3. Alyeska-Pump Station No. 1			541		395	
4. Alyeska-Coldfoot Camp	280	74				
5. BP-Prudhoe Bay Drilling Camp	132	35	610		375	
6. BP-Prudhoe Bay Base Camp	200	53	590	2057	670	pH/7.3 6.2-9.3 Temp/28.0°C 16.5-36.9°C
7. Crazyhorse Camp	258	68	686		552	
8. Happy Horse Camp			509		357	
9. Isabel Camp			490		316	
10. Glennallen Camp			622		894	
11. Pump Station 4			770		712	
12. Valdez Terminal Camp			931		512	
13. Nine Pump Stations	240	63				
14. ADGO-F28, Mackenzie Bay, N.W.T.	130	34	1900	2800	1100	Oil & Greases 416 mg/l
15. Arctic Red River, N.W.T. SITE 1	110	29		3315	2048	Oil & Greases 386 mg/l
SITE 2	120	31		862	314	36 mg/l
16. 30 construction camps in Alaska	265	70	456	1078	491	Oil & Greases 100-150mg/l

1) Source: Givens and Ellis (1979)

TABLE 5

TYPICAL WASTEWATER DESIGN PARAMETERS IN CANADA AND USA [1)]

Community	gal/ cap/day	liters/ cap/day	lb BOD/ cap/day	mg BOD/ cap/day	lb SS/ cap/day	mg SS/ cap/day
Construction Camp	50	189	0.15	68,100		
Average Subdivision	80	303	0.17	77,180		
Hospitals	200	757	0.30	136,200		
Major Cities	135	511	0.20	90,800	0.23	104,420
Values Most [2)] Frequently Quoted	100	378	0.17	77,180	0.20	90,800

1) Source: Grainge et al (1973)

2) These values yield a BOD_5 concentration in raw sewage near 200 mg/l, and a suspended solids concentration of 230 mg/l.

Minimum flow rates are important to the design of grit chambers, monitoring devices, dosing equipment, etc. A minimum rate equal to 40 percent of the average rate should be used for design purposes.

Table 6 summarizes the sanitary facilities provided at several institutional installations. It should be noted that OSHA regulations will determine the minimum number of fixtures for a system.

TABLE 6
INSTITUTIONAL SANITARY FACILITIES IN COLD CLIMATES [1)]

	(units per person)			
	Toilets	Urinals	Sinks	Showers
Thule AFB, Greenland	1/10	1/27	-	-
P Mountain Radar, Thule Greenland	1/15	1/45	1/8	1/14
50-Man Winter Camp Tuto, Greenland	1/10	1/25	1/6	1/10
Wainwright, AK [2)]	1/47	0	1/94	1/47

1) Source: Smith et al (1979)
2) The gray water/black water concept is used at the Wainwright, AK, central facility and should be considered wherever water conservation is an issue. Black water is considered to be that related to human wastes from toilets, urinals, etc. Gray water (the remaining wastewater from showers, sinks, laundries) is recycled for the toilets.

The percentages of daily flow from community sewage sources, as presented in Table 7, have been averaged from numerous studies. Table 8 presents similar data for military field bases. The percentage of daily flow at army field bases for washracks (12 percent) is similar to flows at camps for equipment washing.

TABLE 7
DOMESTIC SEWAGE SOURCES
(% of average daily flow)

Category	%
Toilet, Urinal	37
Shower, Sinks	32
Kitchen	12
Laundry	19
	100

TABLE 8
ARMY FIELD BASES (1000-6000 pop)
(% of average daily flow)

Category	%
Photographic	5
Aircraft Washrack	9
Vehicle Washrack	3
Hospital	1
Toilets, Showers, Sinks	60
Kitchen	6
Laundry	16
	100

The concentrations of wastewater constituents will vary with the amount of water used and the type of facilities employed. However, the actual mass loading of organics and related substances should be relatively constant on a per person basis. Table 9 gives estimated mass values for the major domestic wastewater sources. The values are based on a comparative analysis of a number of data sources. The final item, "institutional garbage grinders", reflects the common practice at military stations and many construction camps of grinding most of the kitchen wastes for inclusion in the wastewater stream. The treatment system must be designed specifically for garbage if it is to be accepted. Disposal of cooking oils, animal fats, crisco, butter, etc. down sink drains can plug up sewers. Skimming devices may be required to reduce constant back-up and maintenance.

TABLE 9

ESTIMATED SOURCES OF SEWAGE POLLUTANTS

(per person per day)

Source	BOD_5		SS		Total Nitrogen		Total Phosphorus	
	Grams	Pounds	Grams	Pounds	Grams	Pounds	Grams	Pounds
Toilet	60.8	0.13	85.2	0.19	14.7	.0323	1.67	0.0037
Bath/Shower	5.33	0.01	5.12	0.01	0.31	.0007	0.04	0.0001
Laundry	7.92	0.02	7.70	0.02	0.23	.0005	0.67	0.0015
Kitchen	16.8	0.04	10.0	0.02	0.49	.0011	0.49	0.0011
Subtotal	90.8	0.20	109	0.24	15.7	.0346	2.83	0.0064
Institutional Garbage Grinders	59.0	0.13	58.8	0.13	1.31	.0029	0.95	0.0021
Total	150	0.33	165	0.37	17.0	.0375	3.78	0.0085

All the values in Table 9 are independent of the amount of water used for a particular activity and below the strengths of many camps. Combining these values with data in Tables 2 and 6 or other sources will allow determination of concentrations for a particular case. The following two examples, based on 58 and 24 gal/cap/day (220 and 90 l/cap/day), demonstrate systems that will require tertiary treatment. A flow rate of 100 gal/cap/day (378 l/cap/day) would be more realistic of current conditions.

Example 1:

200-man construction camp, all conventional facilities, central dining and kitchen with garbage grinder.

From Table 3: Assume flow = 58 gal/person/day (220 l/person/day)

From Table 9: grams/person/day

	BOD_5	SS	N	P
Totals include toilets, baths, laundry, kitchen, garbage grinders	150	165	17	3.8
x 200 people =	30,000	33,000	3,400	755

Total Flow: 220 x 200 = 44,000 l/day.

Concentrations:

BOD_5	30,000 ÷ 44 =	680 mg/l
SS	33,000 ÷ 44 =	750 mg/l
N	3,400 ÷ 44 =	77 mg/l
P	755 ÷ 44 =	17 mg/l

Example 2:

Small community, truck haul, internal plumbing,low-volume flush toilets (assume 100 people).

Table 3: flow = 24 gal/person/day (90 l/person/day)

Table 9: grams/person/day

BOD_5	SS	Total N	Total P
91	109	16	3

Design concentrations:

mg/l = grams/person/day ÷ l/person/day x 100 mg/g

BOD_5	1011 mg/l
SS	1211 mg/l
N	177 mg/l
P	33 mg/l

Temperature

The temperature of the raw wastewater entering the sewage treatment plant can strongly influence efficiency of most unit operations and processes. Temperature control is also necessary to prevent unwanted freezing either in the system or at the point of final discharge.

The energy level presented by moderate (50°F) to high incoming sewage temperatures should be considered as a resource. The treatment system and its protective elements should be designed to take full advantage of this available energy. For example, the municipal treatment plant in Fairbanks extracts energy from the effluent via a heat pump and this is used to heat the entire facility.

The seasonal temperature of the body of water which ultimately receives the wastewater is an important factor depending upon its relative size and the existing use of the water for fisheries, recreation, water supply, etc.

The temperature of raw wastewater is a function of the raw water temperature, the use of electric heat trace and insulation on sewers, the water and sewage system design and characteristics (utiliducts, utilidors, transport distance), the use, number and plumbing (hot water) of buildings serviced, and the ambient temperatures. Some values of raw wastewater temperature are presented in Table 10.

2.2.2.3 Construction Wastewater

Drilling operations often make use of a drilling mud (bentonite and water) slurry to assist in reducing the heat of the bit, seal sides of the hole, and carry tailings to the top. Generally it is injected, recirculated at a site, then abandoned in an approved disposal site. Exploratory drilling for projects recovers cores; any wastewater for hard rock drilling is discharged for overland percolation or, if required, to settling ponds prior to discharge.

TABLE 10

RAW SEWAGE TEMPERATURES AT TREATMENT FACILITY (°F) [1)]

Location	Winter		Summer	Notes
Fairbanks, AK	0		37	Individual wells
Fairbanks, AK	53		52	Water main at 59°C
College, AK	66		65	Sewers in heated utilidor
Eielson AFB, AK	70		69	Sewers in heated utilidor
Juneau, AK	36		48	
Kenai, AK	46		50-57	
Homer, AK	37-41		48-50	
Dillingham, AK		37-39		April
Craig, AK		41		January
Kake, AK		39		December
Soldotna, AK	37		46-48	
Eagle River, AK		41		Initial operation, few services
Eagle River, AK		48		After 4 years
Inuvik, NWT			73	
Whitehorse, YT		37-59		Water main bleeders
Clinton Creek, YT	63		72	
Emmonak, AK		82		Central facility, grey water only
Alaska		68-75		Construction camps (Alyeska)
Hay River, NWT		50-59		Airport facility

1) Source: Smith et al (1979)

Wastewater generated during camp construction usually consists of pressure testing water (if used in lieu of air) and the chlorinated water resulting from disinfection of the potable water system.

Another source of potential wastewater is surface runoff and associated sediments from construction activities. Proper design or location of control devices such as settling ponds is required to maintain state water quality standards for the receiving waters. These control devices are addressed in a companion BMP manual on erosion and sedimentation control.

Similarly, the batching of concrete can produce waste slurries that require treatment and/or disposal. Batch plant operators and truckers hauling concrete will usually require an area for disposal of their wastes and "wash down" waters. These wastes require special treatment and an approved disposal area away from wetlands and waterways.

2.2.2.4 Maintenance and Operation

An operational camp requires support facilities similar to those of the construction camp. Maintenance activities require garages, washing and steaming of equipment prior to repair, use of solvents, antifreeze, petroleum products, lubricants, incineration, etc. which may produce hazardous wastes. Care must be taken to segregate these materials from non-hazardous materials and prevent their entry into the domestic wastewater stream.

2.3 CONCEPTUAL CAMP LAYOUT, COLLECTION AND TREATMENT SYSTEMS

At this stage of the design process, preferences will be developed for certain types of collection and treatment based on project data and field reconnaissance. Liaison with state, federal, and local government personnel whose jurisdiction covers wastewater treatment, plan review and/or treatment requirements should be ongoing.

2.3.1 Water Supply Requirements

The quality and quantity of potable water should be verified by researching project records on stream data, exploratory drilling, any well water draw-down data, changes due to various seasons and weather conditions, etc. Evaluation of the raw water source should consider that its chemical and physical characteristics may add backwash water (more to treat) and/or treatment residues (change of wastewater characteristics).

Alternative water sources should be considered should water availability become a limiting factor in wastewater treatment feasibility. In many instances, a dependable water source such as a well system or impoundment may be required to size a treatment facility which will effectively treat the wastewater within the parameters of state or federal permits.

2.3.2 Wastewater Collection and Treatment

All siting of waste collection and treatment is a function of the location of the water supply, minimization of length of collection and delivery lines, location of ultimate receiving body, soils, ground water, surface water, and terrain of the area.

Gently sloping high ground with free draining soils would be the optimum site even if the location is less convenient than others to the work or water supply. Core boring will be needed on large sites to verify subsoil conditions and insure foundation stability as well as to identify the presence of permafrost or bedrock which could interfere with installation of sewers and other utilities.

Waste collection and treatment facilities should not be located in floodplains, wetlands, in the path of natural drainageways, or near waterbodies. Nor should they be located where they could cause odor problems at camp, or attract wildlife.

A minimum of three alternative systems should be considered for each project site. These alternatives are a function of the following:

- Size - phases of camp size and development
- Duration - length of camp usefulness
- Location - variables of camp location
- Cost - relative construction operation and maintenance of collection and treatment facilities

Two systems are usually fairly easy to develop but the third may require a more detailed investigation which often results in a better idea or modification. Modular units that can be plugged in and out or multiplied to obtain the ultimate treatment are desirable. Transportation and installation, which could take place in the most remote of locations and in the most severe weather, are important considerations. Other aspects to consider are the flexibility or durability of the system if the loading rate is different or the time it is in service changes, and the degree of sophistication required for the training of wastewater treatment facilities operators. Costs also need to be developed at this time in enough detail to comparatively rank the possibilities.

2.4 DESIGN OF COLLECTION SYSTEMS

This section discusses the characteristics of collection systems by camp and system characteristics. Table 11 summarizes the characteristics of typical collection systems in remote camp areas.

2.4.1 Characteristics by Type of Camp

2.4.1.1 Exploratory and Fly Camps

With a collection system relying on the individual users to bring their wastes to a disposal point, the important considerations are the types of containers in which the waste is transported and the facilities at the point of discharge.

Containers used by individuals for transporting wastes will vary from conventional oil drums to porta-can pails. The containers should be sized for the way they will be transported and should be covered.

TABLE 11
CHARACTERISTICS OF WASTEWATER COLLECTION SYSTEMS[1)]

TYPE	SOIL CONDITIONS	TOPOGRAPHY	ECONOMICS	OTHER
Gravity	Non-frost susceptible or slightly frost susceptible with gravel backfilling material.	Gently sloping to prevent deep cuts and lift station.	Initial construction costs high but operational costs low unless must go above ground or use lift stations.	Low Maintenance. High health and convenience improvements. Must hold grades. Flushing of low use lines may be necessary. Large diameter pipes necessary.
Vacuum	Most useful for frost susceptible or bedrock conditions, but can be used with any soil conditions.	Level or gently sloping.	Initial construction cost moderately high.	"Traps" every 300 feet. Low water use. High health and convenience improvements. Must have central holding tank for each 30 to 50 services with additional pumps to pump waste to treatment facilities.
			Operational costs moderate.	Can separate gray and black water. Use small pipes. No exfiltration.
Pressure	Most useful for frost susceptible or bedrock conditions, but can be used with any soil conditions.	Level, gently sloping or hilly.	Initial construction costs moderate. Operational costs moderately high.	Low water use if low water use fixtures are installed. High health and convenience improvements. No central facility necessary - units are in individual buildings. Number of services are not limited. No infiltration. Use small pipes.
Vehicle-Haul	Year-round roads must be available.	Level, gently sloping or hilly.	Initial construction cost low. Operational costs very high.	Low water use and moderate health and convenience improvements. Operational costs must be subsidized.
Individual Haul	Used with any soil conditions but boardwalks are necessary in extremely swampy conditions.	Level, gently sloping or hilly.	Initial construction cost and operational costs very low.	Low usage by inhabitants and thus low health and convenience improvements.

1) Source: Smith et al (1979)

2.4.1.2 Small and Intermediate Camps

Camp-haul sewage collection involves the collection of wastewater from each point of generation and its transportation by a contractor-operated track or wheel vehicle to a treatment and/or disposal facility. Facilities at camp dwellings generally consist of holding tanks located on or beneath the floors of buildings into which wastes from sinks, lavatories, toilets, and kitchens drain by gravity. The tanks are then emptied into a collection vehicle by pumping. With any haul system, low water use plumbing fixtures are necessary to reduce water consumption and to minimize wastewater generation.

The efficiency and operational costs of this type of collection system are dependent partly on the sizing of the holding tanks. For most circumstances, tanks should be around 260 gallons, but at least 100 gallons larger than the water storage tank provided. The size of the collection, reliability of the service, and climatic conditions should be considered in sizing wastewater storage tanks. It is also important to provide for the structural support in any building required to carry this additional load.

The tank must be constructed with a large manhole with removable cover so it can be cleaned and flushed out at least yearly. Fill alarms and volume metering ports should be provided. It must be well insulated, kept within the heated portion of the building and/or heat must be added using heating coils or circulating hot water to prevent any ice formation. While holding tanks have sometimes been buried in the ground beside or beneath facilities, this should not be done in permafrost areas. The tanks must be placed so they are emptied from the outside of buildings.

The hose connection should be of the quick-disconnect type and be a different size and color than that of the water delivery hose, to eliminate the possibility of a cross-connection. The pumpout connection at the building must be sloped to drain back into the tank after pumping so sewage does not drain outside or stand in the wind and freeze. The tanks must be properly vented to provide adequate air exchange during filling and emptying.

Two methods of emptying the holding tanks are in use in the north. With one, a pressure tank is used on the vehicle. The tank is held under a vacuum using a small compressor and a three-way valve. The contents of the holding tank are withdrawn into the truck tank under vacuum. At the disposal point the valve is turned to pressurize the tank, forcing the wastewater out. The other method is similar except that sewage pumps are used instead of a compressor and the vehicle tank does not have to be pressure rated.

2.4.1.3 Intermediate and Large Camps

Large facilities are designed for the convenience and sanitation which accompany piped sewage collection. Whenever the duration of the camp site will exceed 5 years, a piped system deserves consideration. There are several variations of piped sewage collection systems. Normally, a conventional gravity system has the lowest life-cycle cost and should be used whenever feasible. However, the layout of the site and/or the soil conditions may make a vacuum or pressure sewage collection system necessary. An additional advantage of a gravity system is that a freezeup seldom causes pipes to break. The freezeup is gradual and in layers, in contrast to pressure lines which are full when freezing takes place.

When soil conditions do not allow burying collection lines, they must be placed on or above the surface of the ground. In most locations, the topography and building layout would dictate above-ground lines on pilings (or gravel berms) to hold the grades necessary for gravity sewage flow. Above-ground lines are undesirable because of transportation hinderance, high heat losses, blocked drainage, vandalism, and the cluttered look they create. It may be preferable to use a pressure or vacuum collection system so that the lines can be placed on the ground surface to minimize the above problems.

Sewage collection lines may be placed in utilidors with other utilities, depending on the local circumstances. Assuming the same design, heat losses (and thus operation and maintenance costs) of above-ground facilities are nearly three times as high as for the same line placed below-ground because of the greater temperature differential between the inside and outside of the line.

Sewage temperatures are also an important design consideration. In camps or villages where the individual buildings have hot water heaters, sewage temperatures usually range between 50° and 59°F. Where hot water heaters are not used and any hot water must be obtained by heating water on a cook stove, sewage temperatures range from 39° to 52°F. Heated utilidors, utiliducts, and sewer lines can deliver sewage at temperatures upwards of 60° to 65°F. A greater percentage of this heat will be lost between the users and the point of treatment with a gravity system (without heat tracing) than with a utilidor, pressure or vacuum system because the sewage is longer in transit and there is air circulation above the sewage in the pipes. It is often necessary to use electric heat trace at the ends of little-used laterals or throughout the collection piping in a gravity system to eliminate freezing problems caused by the lines slowly icing up. Also, a greater percentage of the heat will be lost if the lines are above ground. Sewage heat losses will vary considerably from summer to winter with buried lines, depending upon the presence of permafrost. The presence of permafrost, however, requires an entirely different approach to the design and placement of underground utilities.

2.4.2 Collection Systems

The following paragraphs discuss design considerations for three types of systems used in remote, northern climates. Common to each system are the following considerations:

- o Storm water or melt water runoff should not be included in sewers. The waters could lower wastewater temperature, overload treatment facilities hydraulically, and deposit sand and grit in collection lines.

- Insulated pipe should always be used in cold regions unless lines can be buried well below the active layer and not in permafrost.

- Flex couplings must be provided in facilities designed for use in areas subjected to frost heaving or subsidence.

- In providing wastewater and water lines through the use of a common utilidor, care must be taken to ensure that no cross connections can occur or that the potable water line is protected from any sewage in the utilidor as in the case of a sewer line break.

- It is better to design the sewer system so there is at least one large user near the end of each lateral to eliminate the need for flushing.

- All fixtures should be placed on inside walls which are warm on both sides. If possible, the sink should be placed on the opposite side of the bathroom plumbing wall to reduce the length of drain lines.

- All fixtures and lines should be installed so that they can be drained or otherwise protected from freezing. Drainable P-traps should be used and the user should be aware that antifreeze solution should be added to the toilet and sewer line low spots if there is a danger of freezing during non-use.

- Vents should be constructed of low conductivity material and should increase in size as they go into the unheated atmosphere. One and one-half inch vents should be increased to 3 inches and 3-inch vents should be increased to 4 inches.

2.4.2.1 Conventional Gravity Collection Lines

If lines can be buried and the layout of the site is sloping, a gravity sewage collection system will have lower operation and maintenance costs than other types of systems.

The most important design consideration with gravity sewers is the minimum grades necessary to ensure adequate velocities in the pipelines. Building service lines should have a nominal pipe size of 4 to 6 inches and a minimum slope of 1 percent. The following minimums for main collection lines should be used with stable ground conditions (frost-susceptible and permafrost areas have additional design controls):

Nominal Pipe Size (inches)	Minimum Slope (percent)
6	0.6
8	0.5
10	0.4
12	0.3
14	0.22
15	0.17

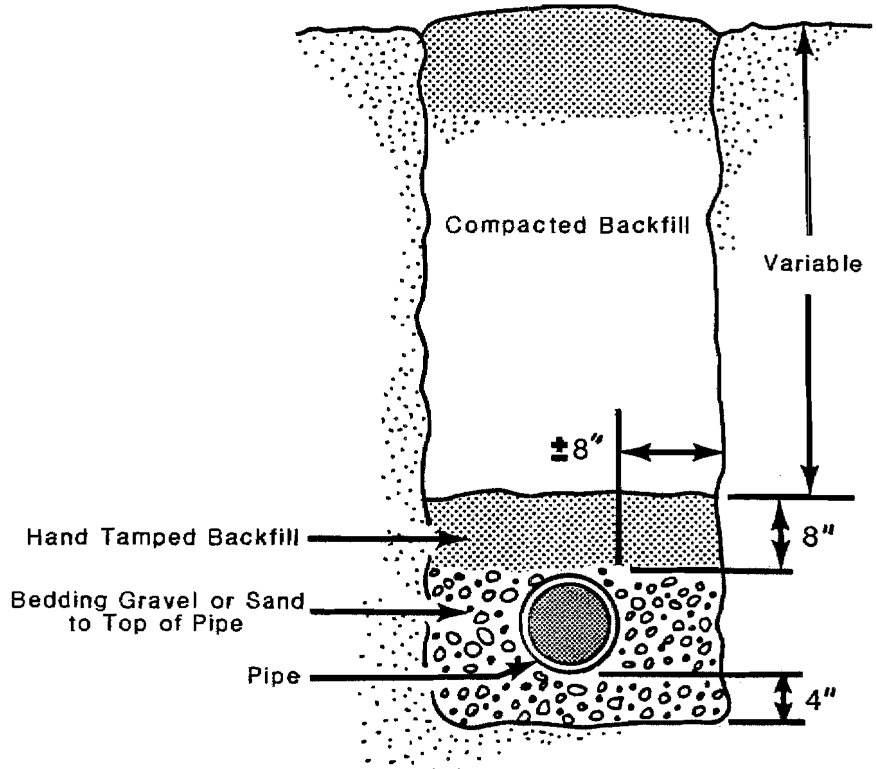
If soil stability is uncertain (i.e., a small amount of settling or heaving is likely), a minimum slope of 1 percent should be used for all collection lines. They should be backfilled with non-frost susceptible sand or gravel at least 12 inches at the bottom and sides of the pipe (Figure 1). The 4-inch service lines should be placed the same way with a 2-percent minimum slope. Higher slopes than those above should be used if possible because the longer the sewage is in the collection system, the more heat it will lose. In small camps, minimum sewage collection line sizes could be 6 inches instead of the normal 8 inches.

Lines usually should be buried at least 2 feet to prevent damage from surface loading. Less depth could be allowed in areas with no roads or vehicular traffic.

In addition to the steeper slopes listed above, provisions should be made to adjust the slope of a line if it traverses an area where movement is likely. With lines on piling, blocks are placed between the piling and the pipeline and act as shims. They can be removed or added to adjust the slope. A utilidor can be suspended with adjustable turnbuckles or placed on adjustable yokes or supports.

Gravity sewer lines should be checked regularly and when the depth of flow indicates sedimentation or blockage. All cleanouts should be inside of a lift station.

Figures 2 and 3 show typical service line connections to a building for a cold region gravity sewage collection system. They should slope at least 1 to 2 percent to the collection main, depending on soil stability. Of the two examples shown, the method of going through the wall is preferable to going through the floor. The former will allow for more movement of the



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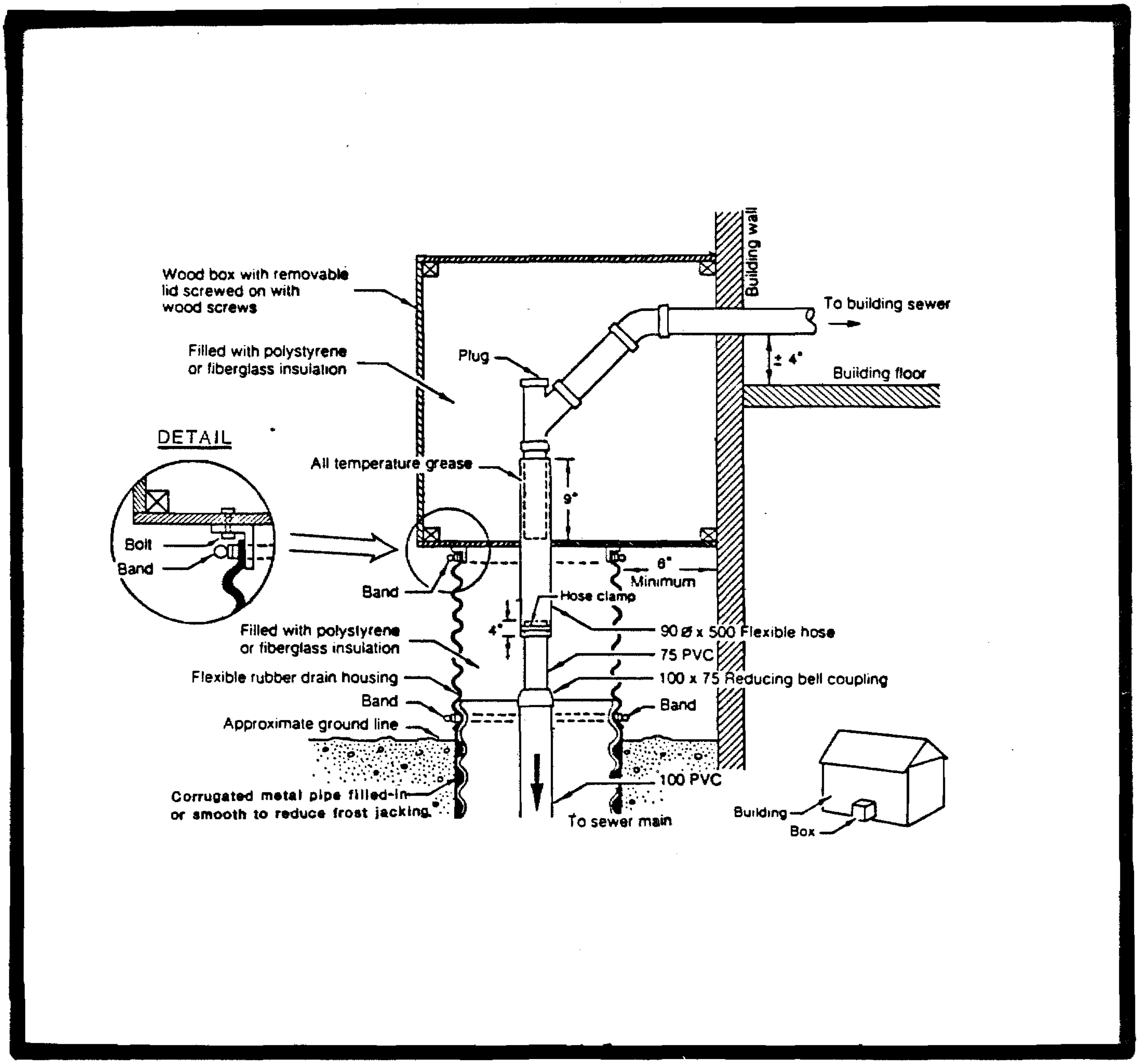
TYPICAL SEWER AND WATER BEDDING DETAILS

FIGURE 1



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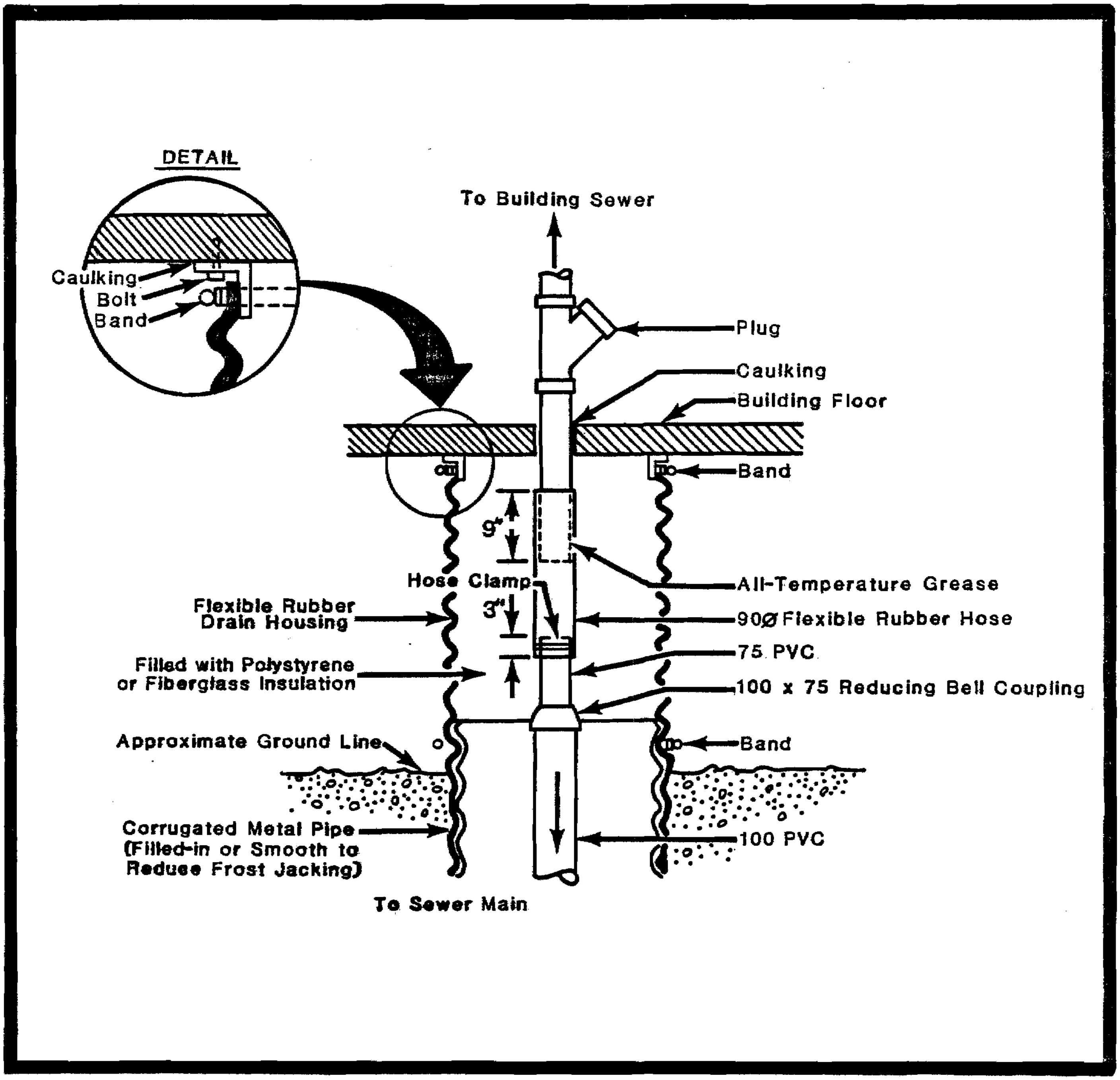
SEWER WALL CONNECTION

FIGURE 2



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SEWER FLOOR CONNECTION

FIGURE 3

building without damage to the sewer service line. It also permits all plumbing to be kept above the building floor.

2.4.2.2 Pressure Sewage Collection Systems

If soil conditions and camp layout make a gravity collection system impractical, a pressure system may be considered. A small pump-grinder unit in or near each building provides the force for the pressure system. While construction costs would probably be lower than either a gravity or vacuum system, operation and maintenance costs would be greater than for a gravity or vacuum system because of the pump-grinder units in each building.

The largest advantage of this system is that it is not necessary to maintain grades. Pipelines or utilidors do not have to be on piling or up off the ground. They can be at the surface or buried. Small movements due to frost heave or thawing will not affect operation nor will there be problems with infiltration of groundwater because the lines are under pressure. A disadvantage is that pressure lines lay full which allows sedimentation and freezing.

The collection lines must be sized to maintain a minimum of 1 foot per second scour velocity. The minimum size collection line is 1¼ inch, which would be the size for one unit. If more units are added than were originally planned for, velocities will increase down the line. The effect of this velocity increase is an increase in head loss. Pressures should be held below 40 psi in the layout. The lines should be slightly undersized (higher velocity) rather than oversized if the correct size (for 1 foot per second) is not available. In the design of a pressure system, an assumption that 33 percent of the pumps will be operating at once is recommended for sizing pipes.

The collection lines should be designed to be safely drained if the system has to be shut down during the winter for maintenance. Grades should not undulate with the terrain as this would establish a need for air and vacuum relief valves as well as dips which will freeze. The pressure collection lines should be heated, if required, by heat tape, hot air in utiliducts, circulating glycol, steam, etc. Air relief valves should be installed at all high points in the line to allow filling and pressure testing at start-up as well as for operation.

The pump-grinder units can be situated in each building or several buildings could drain into one unit by gravity. The units should be designed to pump against the design head in the main plus a 40 percent overload (with 33 percent of the pumps operating at once). Each unit should have complete duplication of controls, sump pumps, and pumps or compressor, for standby. The extra unit would take over if the primary unit is inoperable and, at the same time, set off a warning device (audible and visual) to alert the operator that repairs are required. Standby power should be available in case of a power outage for units serving several buildings. The pumping units should be well insulated and installed on a stable foundation if they are placed outside or in the ground. As with lift stations, they must be protected from frost jacking forces. Double-check valves should be provided on inlets and outlets to prevent backflow. Weighted check valves have proven more satisfactory than spring-loaded valves.

The pump-grinder units designed to serve individual buildings are equipped with positive displacement pumps which have a nearly constant pumping rate over a wide range of heads. The grinder unit reduces all foreign objects to 0.26 inches before they go into the pump. The unit must be able to handle unusual items flushed down the toilets such as rock, wash rags, utensils, etc. Positive displacement pumps require a lower power input to purge the system of any air pockets. The units must be small and light enough that they can be easily removed from the sump and repaired while the standby unit continues to operate.

The sump or tank from which the pump draws must be designed so that it is cleaned by scouring as the pump operates. The outlet check valves should be located in a horizontal run to prevent solids from settling in them when the pump is not running. Pressure sensors should be used to control pumps and alarms (rags and grease tend to foul float switches). The sump should be sized to provide several days' storage in case of a temporary power outage or other problem. It should be constructed of fiberglass or plastic for protection from corrosion.

The pressure system can also be modified by using conventional submersible sewage pumps in holding tanks at each building. The tanks are similar to septic tanks where the solids settle, biodegrade anaerobically, and are pumped out by truck occasionally. The submersible pump pumps the relatively clear effluent into the pressure sewer lines to a treatment facility.

Some of the advantages of this type of operation are:

- Problems with the grinder on the pump plugging up are eliminated.
- There are no solids to settle in the collection lines.
- The treatment facility is not as complicated as for conventional sewage.

Pressure sewer lines should be tested as any pressure water line would be. If using water or liquid, use 1½ times the working pressures with an allowable loss of 3 gallons in 24 hours. If using air, use 1½ times the working pressure with an allowable loss of 103 psi in 24 hours. Great care must be exercised when using compressed air because of the possibility of explosion. Air testing must be used at below freezing temperatures.

2.4.2.3 Vacuum Sewage Collection Systems

As with pressure systems, a vacuum sewage collection system should be designed only if soil conditions and camp layout negate a gravity collection system. Vacuum systems are not limited to holding grades, but are limited to 15 to 20 feet in elevation differences because they are operated at 8 to 10 psi vacuum. Vacuum systems are limited to 30 to 50 services on a given collection line.

Toilet wastes, with a small amount of water, are transported in the pipes by the differential pressure between the atmosphere (air admitted to the system with the flushing action) and a partial vacuum in the pipe created by a central vacuum pump. The flow conditions are slug-type, but the friction in the pipe breaks down the water slug. To reform the slug flow, transport pockets are required at intervals of about 200 to 300 feet. The vacuum toilets only require 0.3 gallons of water to flush and the collection lines are small (2 inches). The requirement for transport pockets (traps) is a disadvantage of the vacuum system. Because the traps will have liquid standing in them for extended periods of time, they must be inside a heated utilidor or be well insulated. They should also be provided with drains.

The collection line sizes will depend on the number of fixtures on a line and the estimated number that will be operating simultaneously. Usually 2- to 2½-inch lines are used with the traps dipping at least one and one-half pipe diameters. Tests have shown that head losses increase about 1 inch of mercury for each 984 feet of collection line velocities of 15 feet per second or less. Because the lines carry a combination of air and water, head losses are nearly impossible to compute. However, when going uphill, the increase in head loss is only about 20 percent of the actual elevation increase. Most fixtures will not flush if there is less than 6 to 7 psi vacuum in the collection lines. Thus, if several are flushing simultaneously and the vacuum drops to 6 to 7 psi, additional fixtures will not flush until the vacuum builds back up. Gray water (sink, shower and tub wastes) can be separated from black water (toilet wastes) for treatment purposes or water reuse, by having the toilets on a different collection line than the gray water fixtures. In low use lines where it is not desirable to have sewage stand in the traps for extended periods, an automatic or timed valve can be installed to bleed air into the end of the line and keep the wastewater moving. Full opening ball valves should be installed approximately every 200 feet so that sections of the lines can be isolated to check for leaks or plugs.

A collection tank is located at the end of the collection lines. The tank is held under a vacuum at all times by liquid-ring vacuum pumps which must be sized to evacuate the air and liquid admitted to the system by the users with a safety factor of two. (In Noorvik, Alaska, the design figures used were six flushes per person per day for the toilets and 30 gallons per person per day for sinks and showers. For 50 houses, pumps were selected which were capable of evacuating 64 cubic feet per minute at a vacuum of 16 inches of mercury.) The collected wastes are pumped out of the tank to the treatment facility using conventional centrifugal pumps. They must be designed to pump with a negative suction head equal to the maximum vacuum under which the tank must operate. The collection tank is sized similar to the pressure tank in a hydro-pneumatic system. One-half of the tank capacity is used for liquid storage and the other half is space (vacuum) serving as a buffer for the vacuum pumps. Several alarms should be included in the tank to give warning of high levels of sewage in the holding tanks, low incoming sewage temperature, and low vacuum in the system.

2.4.2.4 Lift Stations

Sewage lift stations are used mainly with gravity collection systems but could be used with pressure sewage collection systems, and even vacuum systems (to pump the waste from the collection tank to the treatment facility). The advantages and disadvantages of several types of lift stations are shown on Table 12.

TABLE 12
TYPES OF LIFT STATIONS

	TYPE	ADVANTAGES	DISADVANTAGES
1.	Submersible	Low initial cost; low maintenance requirements; does not require installation of appurtenances such as heaters, dehumidifers, sump pump, etc.; station can easily be expanded and increased in capacity; available for wide range of capacities. Little of the structure is above ground so heat losses are greatly reduced.	Difficult to make field repair of pump, requires specialized lifting equipment to remove pump.
2.	Dry Well	Pumping equipment located away from wet well; low cost per gallon capacity; good reliability; high efficiency; desirable for large installations; easily maintained.	High initial costs; requires larger construction site.
3.	Wet Well	Low initial cost; high efficiency; wide range of capacity available.	Requires explosion proof electrical motors and connections; difficult to maintain pump.
4.	Suction Lift	Good reliability; available for wide range of capacity.	Suction lift limited to 15 feet; decrease in priming efficiency as pump ages.
5.	Pneumatic Ejector	For low capacity (40 gpm) low head, short distances; generally nonclogging; 100 gpm maximum usually.	Somewhat more complex than other types of stations; high maintenances; low efficiency.

The outside of the station should be insulated with at least 3 inches of urethane or styrofoam with an outer protective covering to protect the insulation from moisture. Insulation should be placed underneath the station to prevent settling due to the thaw of frozen ground. Visqueen (plastic) or some other bond breaker should always be used to reduce frost jacking in the active layer. If thawing and settling under the station is anticipated, pile foundations extending well into the permafrost are recommended. All stations must be attached to concrete slabs to provide sufficient weight to overcome the buoyancy of the station itself if it were completely submerged in water. Pressure coupling (flexible) type connections are recommended at the inlet and outlet of the stations to prevent differential movement from breaking the lines.

Alarms are necessary in any lift station. All critical components, such as pumps and compressors, should be duplicated in each station. The controls should allow the operator to specify operation of the pump or compressor, with the identical standby unit taking over if one or the other does not start. An alarm (both visual from the surface and audible) would then warn the operator that one unit is malfunctioning. The alarms can also be set for the temperature and water level in the station. These alarms should be tied back into a central alarm panel in the pumphouse or to the treatment plant. Standby electrical power should be provided for each major lift station.

Inlet screens must be provided to remove items that would clog pumps or check valves. Each lift station should be checked by the operator and the inlet screen cleaned daily. Submersible types or those without a heated dry well in which to work should be housed in a heated surface structure with the electrical controls and alarms.

2.4.2.5 Force Mains

Force mains are pressure lines into which the pumps in the lift station discharge. They should be designed to have scour velocities during pumping ($2\frac{1}{2}$ to 3 feet per second) and to drain between pumping cycles. The line should be placed in a heated utilidor or heat traced in some way should climatic conditions dictate. Another option would be to time the pumping cycle so the sewage stays in the line for a calculated period, and to size the holding tank at the lift station to hold at least the volume of the force main. The mains should be pressure tested and meet all the criteria of pressure water transmission pipelines.

2.5 DESIGN OF TREATMENT SYSTEM

The selection of the best wastewater treatment and disposal alternatives depends upon many factors, as shown on Table 13. Some of the most important factors include:

- Wastewater characteristics and flows
- Degree of treatment required
- Receiving water
- Operators

TABLE 13

COMPARISON OF WASTEWATER TREATMENT SYSTEMS FOR CAMPS

TREATMENT SYSTEM & APPLICATION	ADVANTAGES	DISADVANTAGES
Septic tank with tile field and/or leach pit - Non-permafrost areas and small camps where suitable soil conditions exist for infiltration of septic effluent. Septic tank might also be used ahead of secondary treatment plant.	1. No direct discharge to surface water. 2. No operating requirements except for septic tank pump out and sludge disposal at completion of project. 3. Low operating cost.	1. Use limited to non-permafrost areas. Also, potential freezing problem during cold weather. 2. Potential groundwater contamination problems. 3. Probably not suitable for large camps. Suggested maximum size of 5,000 gal/day.
Short retention lagoon - Areas where primary effluent may be discharged with no risk to public and with negligible environmental impact.	1. Very simple and dependable. 2. Operator requirement minimal if properly designed and constructed. 3. Separate sludge handling, treatment and disposal systems not required. 4. Low capital operating costs.	1. Potential severe odor problems. 2. Potential groundwater contamination problems. 3. Stricter requirements for effluent discharge. 4. Require regular effluent sampling and analysis where effluent is discharged directly to a receiving water body (less frequent sampling might be permitted where effluent is discharged indirectly.
Long retention lagoon - Area where large relatively flat land space is available, winter retention is desirable and impervious soils exist.	1. Very simple, dependable, and flexible if sized adequately. Discharge can be timed to protect the receiving stream during critical periods. 2. Instant start-up. 3. Operator requirement minimal if properly designed and constructed. 4. Separate sludge handling, treatment and disposal systems not required. 5. Low capital cost if geotechnical conditions favorable. Low operting cost, low energy cost. 6. Eliminate need for regular effluent sampling and analysis except when discharging.	1. May require 2-year or longer holding period to achieve secondary level of treatment. 2. Potential odor problems. 3. Potential groundwater contamination problems. 4. Large land requirement. 5. Require suitable geotechnical conditions, preferably non-permafrost and impervious soils and low water table. 6. Land reclamation may be delayed until after project completion.
Aerated lagoon - Probably more applicable to long-term construction camps but could be used instead of long retention lagoon where land area is limiting or where continuous discharge is acceptable.	1. Simple to operate. 2. Only routine maintenance required. 3. Separate sludge handling, treatment and disposal systems not required. 4. Less land area requirement than for long retention lagoon.	1. Potential problem with clogging of fine-bubble air diffusers maintained. 2. Require regular sampling and analysis if effluent is discharged directly to receiving water. 3. Higher capital and operating costs than for most long retention lagoons.

TABLE 13 (CONTINUED)
COMPARISON OF WASTEWATER TREATMENT SYSTEMS FOR CAMPS

TREATMENT SYSTEM & APPLICATION	ADVANTAGES	DISADVANTAGES
Extended aeration - Non-permafrost and permafrost regions where continuous surface water discharge is permitted and where adequate power generation capacity is available.	1. Proven technology. 2. Can produce a highly nitrified effluent. 3. Excellent results if well designed (e.g., flow equalization, adequate aeration capacity, parallel units) and well operated. 4. Low quantity of sludge generated. Some in-system sludge storage capacity, eliminating need for continuous sludge wasting, treatment and disposal. 5. Capital cost lower than for RBC and P/C plants.	1. Bulking sludge, hydraulic surges, poor operating control, etc., could result in high effluent suspended solids level. 2. Long start-up time; therefore, special steps must be taken (e.g., seed plant with sludge, recycle unsatisfactory effluent). 3. Require skilled operator (biological and mechanical training). 4. Operating cost greater than for RBC (but less than for P/C plant).
Rotating biological contactor - Non-permafrost and permafrost regions where continuous surface water discharge is permitted and where moderate power generation capacity is available.	1. Quick recovery from organic and hydraulic overloads. 2. RBC process control is simple. 3. Low energy requirement compared to extended aeration.	1. Start-up time could be long, particularly if toxic chemicals in waste. 2. Require skilled operator (mechanical) for associated processes. 3. Require continuous sludge wasting and/or disposal. 4. High continuous sludge wasting and/or disposal. 5. Poor treatment when overloaded, even for short time periods.
Physical/Chemical - Permafrost and non-permafrost regions where highly variable wastewater characteristics are expected, where highly trained operators are available and a high quality effluent is required. In particular, could be downstream from a biological treatment plant to produce a very high quality effluent.	1. Proven technology (after extensive modifications). 2. Not affected by toxic constituents such as cleaning solvents nor significantly affected by temperature extremes. 3. Instant start up.	1. Extremely complex. 2. Require highly skilled operator 3. High capital and O & M costs. 4. Large quantities of chemical sludge generated, requiring additional handling and disposal.

- o Duration, size and location of operation
- o Climate
- o Geotechnical considerations

Capital and operating costs for a camp system do not command as much attention as they might in a permanent facility due to many other variables such as location, unit size, receiving stream, effluent requirements, and limited time to set up and move on.

It is reasonable to anticipate that no less than secondary treatment will be required at all camp sites. The major requirements (18 AAC 72) which need to be met to achieve secondary treatment are as follows.

- o $\underline{BOD_5}$--The arithmetic mean of the values for effluent samples collected in 30 consecutive days may not exceed 30 milligrams per liter; the arithmetic mean of the values for effluent samples collected in seven consecutive days may not exceed 45 milligrams per liter; and the arithmetic mean of the values for effluent samples collected in a 24-hour period may not exceed 60 milligrams per liter.

- o Suspended Solids--The arithmetic mean of the values for effluent samples collected in 30 consecutive days may not exceed 30 milligrams per liter; the arithmetic mean of the values for effluent samples collected in seven consecutive days may not exceed 45 milligrams per liter; the arithmetic mean of the values for effluent samples collected in a 24-hour period may not exceed 60 milligrams per liter; and for effluent from a lagoon, the arithmetic mean of the values for effluent samples collected in 30 consecutive days may not exceed 70 milligrams per liter.

- pH--The values for effluent pH must be kept between 6.0 and 9.0 unless it is shown that inorganic chemicals are not added to the waste stream as part of the treatment process.[1)]

- Fecal Coliform--The arithmetic mean of the values for a minimum of five effluent samples collected in 30 consecutive days may not exceed 200 fecal coliform/100 ml; and the arithmetic mean of the values for effluent samples collected in seven consecutive days may not exceed 400 fecal coliform/100 ml.[1)]

2.5.1 Exploratory and Fly Camps

Small operations will normally use porta-can pails or other similar containers to receive and transport waste. The disposal point for such containers must be designed for easy access; otherwise the wastes may not be deposited according to facility design. The disposal point could be a landfill site, a facultative lagoon or pond, a wastewater treatment plant, or a holding tank where the waste is then transported to a treatment facility by tank truck. Figure 4 illustrates four low-cost treatment systems.

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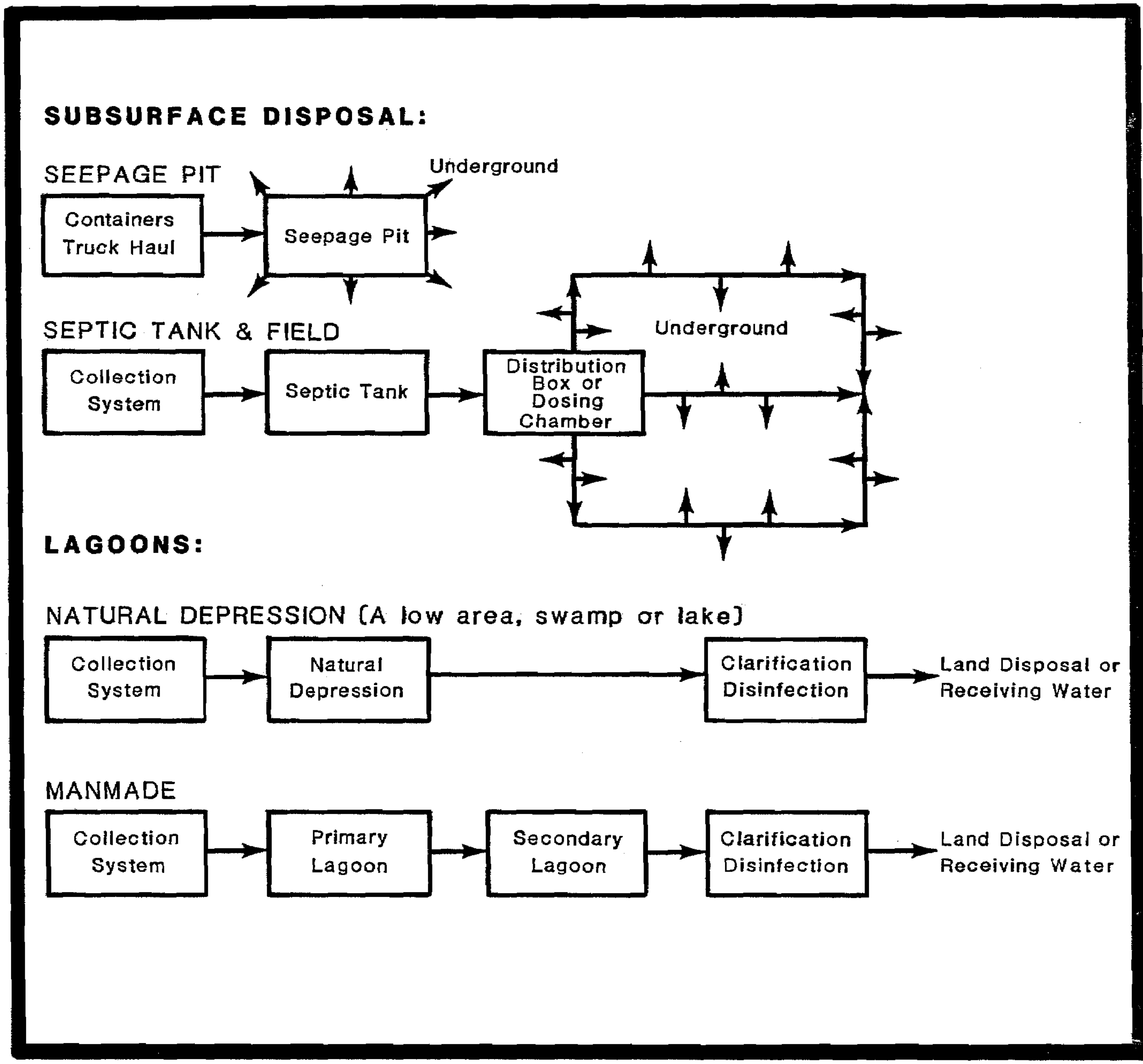
[1] Both pH and fecal coliform limits vary depending on receiving water characteristics.



ALASKA POWER AUTHORITY

LOW COST TREATMENT SYSTEMS (SIMPLE)

FIGURE 4

Where container wastes are dumped at a landfill site approved by the Alaska Department of Environmental Conservation (ADEC), they must be covered daily. If the wastes are deposited in a lagoon or pond, the dumping point should be designed to prevent erosion of the lagoon dikes and yet allow for easy access so the waste is deposited in the lagoon and not on the dikes.

Waste disposal pits are constructed by cribbing a hole in the ground and covering it with a platform containing a disposal hole covered with a fly-tight, hinged lid. When the pit is full, the platform is removed and the bunker is covered with the material excavated from a new pit. As with privies, waste pits are not a desirable form of waste disposal if the soil is frozen, in areas of fine-grained silts, or when there is a high groundwater table.

The most satisfactory disposal for container wastes would be at a central facility where the wastes are a small part of the total waste load to the facility. A fly-tight closeable box, which is convenient to use, should be provided on the outside of the building. It must be vandal proof and capable of being thoroughly washed down and cleaned daily. Above all, it must be aesthetically acceptable and easy to use.

The type of waste dumped at a disposal point could be an important consideration in treatment plan design even though the quantity (by comparison to the facility waste) may be small. The waste quite often contains a high concentration of deodorizers such as formaldehyde and phenols, which could affect biological treatment processes. It also may contain plastic bags and other solid wastes and will be very high in BOD (up to 1000 mg/l) and low in hydraulic loading.

The break even point when the loading or facility requires more sophisticated treatment is summarized in Table 14.

2.5.2 Small and Intermediate Camps

Small and intermediate camp wastewater disposal systems generally range from truck-haul, lagoon-disposal systems to more complex piped-collection and treatment plant facilities. The majority of the discussion on treatment system options follows in Section 2.5.3. This section addresses primarily disposal of truck-hauled wastewater.

The disposal point for truck hauled waste should be in a heated building with a "drive through" design to make the unloading time as short as possible. The building should also provide heated storage for the vehicles while not in use or for repairs. Where the disposal point is at a landfill or lagoon, a ramp or splash pad should be provided to prevent erosion and still allow the vehicle to deposit the wastes well within the lagoon or landfill. Any plastic bags used to contain wastes should go through a slitter to empty the contents. The contents then flow to a wet well where they can be pumped to a lagoon or to a treatment plant. The bags can be incinerated or land filled depending upon state approval.

The building in which the vehicles are stored and/or emptied should also be equipped with water for flushing and cleaning the tanks. The washwater

TABLE 14

WASTEWATER DISPOSAL

ADEC GUIDELINES

	Man Day Per Site (MD/S) - Nonrecurring Use 6/			
	0 - 10 MD/S	11 - 30 MD/S	301 - 1000 MD/S	1001 MD/S & ABOVE
GRAYWATER				
Pressurized	Land Disposal 1/	Land Disposal 1/	Plan Review 5/	-
Non-pressurized	Land Disposal 1/	Land Disposal 1/	Disposal 1/	Plan Review 5/
SEWAGE				
Nonwaterborne	Cat-Hole 2/ Alternate 4/	Burial 3/ Alternate 4/	Burial Alternate 4/	Plan Review 5/
Waterborne Chemically Treated	Approved Wastewater Dump Station. Burial and Land Disposal Prohibited.	Plan Review 5/	Plan Review 5/	Plan Review 5/

Footnotes: 1/ LAND DISPOSAL - Land disposal of graywater is permitted as shown subject to the following conditions:

a. Discharges must be at least 100 feet, measured horizontally, from any natural or man-made lake, river, slough, stream or coastal water of the state.

b. There is no drainage to water courses or standing water.

c. No puddling ocurs on the surface after 15 minutes.

d. Discharges should, to the extent possible, be limited to already disturbed and/or gravel areas.

2/ CAT-HOLE - Cat-holes are for individual one-time use and should be located in remote areas at least 100 feet from any streams or water bodies and well away from campsites or other areas frequented by people. All fecal material and tissues should be buried in a small hole, covered with soil and packed down. The vegetation, sod, tundra mat, etc., should then be replaced and the area left as if no one had used it.

3/ BURIAL - Slit trenches, latrines, straddle trenches, pit privies, etc., are permitted where site-specific and seasonal conditions allow. The type and size should meet the anticipated use. Use of these facilities is subject to the following conditions:

a. Located at least 100 feet, measured horizontally, from any natural or man-made lake, river, slough, stream or coastal water.

b. Constructed so that surface water drainage is away from the pit or trench.

c. Vertical separation between the bottom of the trench or pit and the highest water table elevation is 4 feet.

d. May not be constructed within 75 feet of the top, measured horizontally, of a cut or fill bank exceeding 6 feet in height.

e. Pits and trenches should be located, where possible, in already disturbed areas.

f. Pits or trenches filled with wastes to a point 1 foot from the surface must be closed out.

g. All pits or trenches must be disinfected with lime (or equivalent) prior to close out.

h. Close out requires filling to ground level with successive layers of earth packing each layer down before adding the next one. The filled pit should then be mounded over with at least 1 foot of dirt.

i. Pits and trenches not needed for overwinter use must be closed out prior to freeze-up.

4/ ALTERNATE - Alternate disposal methods not requiring permits or approvals include:

a. Backhauling in holding tanks or suitable containers to approved camp stations or wastewater treatment systems. Examples: Vault toilets; porta-johns; camper holding tanks; chemical toilets.

b. Incinerator type toilets. Electric or propane.

c. Use of existing approved wastewater systems.

TABLE 14 (Continued)

52 5/ PLAN REVIEW - As indicated on the chart, this is the level at which plans for wastewater disposal must be submitted to the department and reviewed on a case-by-case basis. This includes, but is not limited to, subsurface and surface discharge system, septic tanks, infiltration systems, french drains, lagoons, soakage pits, stack injection, etc.

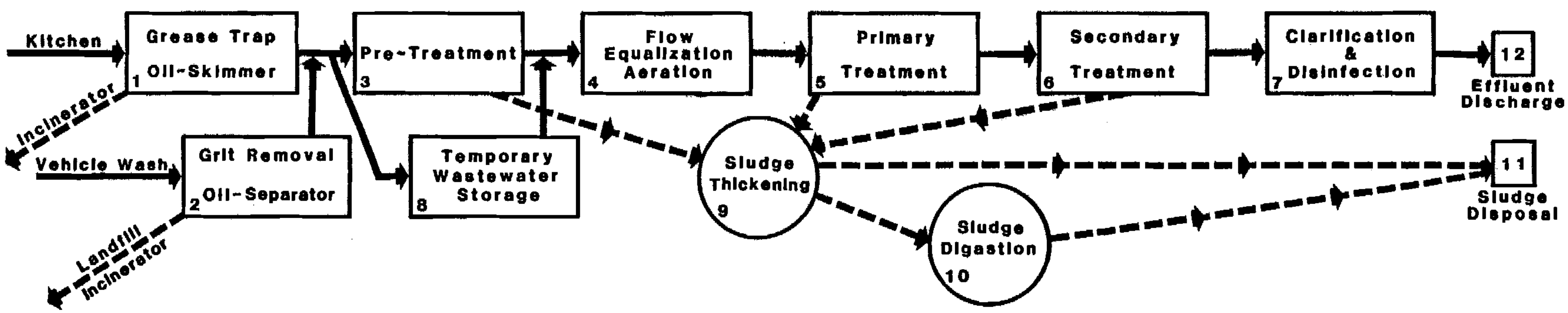
6/ NONRECURRING USE - Permanent facilities or repeated use of the same site requires plan review by ADEC.

should drain to the wet well where it can proceed to treatment. Extreme care must be taken to prevent a cross-connection with the water system.

2.5.3 Intermediate and Large Camps

The following sections discuss the various components (illustrated on Figure 5) necessary to complete the treatment process for intermediate and large camps and end up with a safe effluent. Units will be presented from the raw water end to the polishing end. Changing the order of placement of some units will affect the treatment efficiency and dictate design modifications accordingly. For instance, it may be preferrable to aerate a flow equalization tank prior to comminution so that less settling will take place. Or, screening prior to equalization may eliminate a greater amount of solids prior to treatment. Or, comminution followed by aeration in the equalization tank may enhance an activited sludge process. Use of a lagoon for treatment may eliminate the need for any pre-treatment. The selected procedure will depend upon the appearance of the wastewater as it enters the plant, its relative elevation, the extremes of flow variation and need for process pumping.

Elevation differences due to natural topography should be maximized in order to minimize the need for pumping. Extreme care must be taken during the design process to stabilize flows and not overdesign pumps for peak situations. It may be preferrable to use several equivalent pumps in parallel rather than to use one or two very large pumps. Several pumps are more flexible, provide backup during maintenance, and are more cheaply replaced or repaired.



TREATMENT OPTIONS

1 Grease Trap, Oil-Skimmer

2 Grit Removal, Oil-Separator

3 *Screens, Bar Racks, *Microstrainer, Comminutor, Aeration

4 Mixing, Aeration

5 6 Physical/Chemical, Activated Sludge, Extended Aeration, *Rotating Biological Contactors

7 Chlorine, *Ozone

8 Tank, Lagoon

9 Decant, Filter Press, *Vacuum, *Centrifuge

10 Aerobic, *Anaerobic

11 Incinerate, Burial, *Composting

12 Land Disposal, Discharge to Receiving Water

*Needs Study for Camp Application

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HIGH-COST TREATMENT SYSTEMS (COMPLEX)

FIGURE 5

The system should be designed to accommodate peak flows. The necessary equipment and bypasses should be incorporated to continue operation in the event a portion of the system fails. Redundancy in pumping, treatment and storage are essential.

2.5.3.1 Pre-treatment

Pre-treatment is considered to be any method of treating or conditioning raw wastewater in order to improve its treatability or to protect equipment. Pre-treatment processes applicable to camps include grease removal, screening, comminution and pre-aeration. The required types of pre-treatment facilities are determined by the requirements of the main treatment facility. For example, lagoons may not require any type of pre-treatment, whereas physical/chemical plants may require grease removal and screening.

Grease removal facilities are particularly important for efficient operation of mechanical treatment plants. Grease traps, septic tanks and/or air flotation tanks are necessary, since large quantities of grease can seriously overload downstream treatment facilities as well as contribute to breakdowns of mechanical equipment.

The first unit operation encountered in wastewater treatment plants, assuming grit chambers, grease traps and oil skimmers are in place upstream, is the filtering operation or screening. Coarse screening devices in sewage treatment consist mainly of bar racks, which are used to protect pumps, valves, pipelines, and other appurtenances from damage or clogging by rags and large objects.

Suspended particles greater than ¼ inch can be removed more economically by screening than by other unit operations. Fine screens of the disk or drum type are generally used. The high content of oil, grease, cooking fats, etc. at camps frequently interferes with the success of fine screening devices. They may warrant additional consideration, depending upon camp influent quality, since they are simple devices and low energy users. Sufficient elevation difference may allow gravity straining or sieving before any pumping is required. The minimum rotary screening opening should not be so small as to clog quickly and require frequent maintenance. Screen openings of 2 millimeters appear to be desirable. Alternatively, a screen with automatic cleaning (perhaps backwash) could be considered.

Comminution is another alternative. With comminution, larger solids are ground into smaller pieces which remain in the treatment system but are small enough so as not to adversely affect downstream equipment. Comminution is commonly used with extended aeration plants.

Pre-aeration is a process which may be used to make septic or high strength wastes more amenable to subsequent treatment by reducing the initial high oxygen uptake rate of the wastes. Aerated flow equalization tanks can serve this purpose. Pre-aeration is not required for physical/chemical systems.

2.5.3.2 Temporary Wastewater Storage

Provisions for emergency storage for mechanical treatment plants may be required by regulation for the following reasons:

- o To retain satisfactory wastewater effluent during periods of plant malfunction. This effluent can be recycled to the plant at a controlled rate once the cause of malfunction has been rectified.

- o To receive the entire raw wastewater flow if, for some reason, the plant is not functioning.

- o To further assist with the smooth operation of a biological treatment plant during start-up by permitting recycle of organics to the plant.

A minimum holding period of 5 days is recommended for emergency holding ponds. Longer than 5 days may be desirable in some cases after consideration of a number of factors such as geotechnical conditions, season(s) of operation, dependability of the operator and treatment process, length of operating time, and the condition and downstream uses of the receiving water.

2.5.3.3 Flow Equalization

One of the most important design considerations for any mechanical treatment plant is flow equalization. Because treatment plants function best over given flow ranges, it is desirable to dampen peak hydraulic loadings which commonly occur in the morning and evening and at such other times as may be characteristic of a particular camp. It is suggested that flow equalization tanks should provide 12 hours retention at the average daily flow; however, this could vary depending on the expected diurnal flow variations. The tanks must be aerated to prevent solids deposition and to keep the contents homogeneous and aerobic. Transfer of the liquid from the flow equalization tank to the downstream treatment units should be accomplished at a uniform rate (set at average daily flow or, for physical/chemical plants, at the plant capacity). Many sewage pumps provide flows much in excess of the average flows expected at camps. If special precautions, such as a progressive cavity pump with variable speed drive or an air lift pump in a constant head tank, are not taken, the purpose of flow equalization will be undermined.

2.5.3.4 Primary Treatment

Primary treatment substantially removes all floating and settleable solids from wastewater by such means as flotation and settling. Flotation is used primarily in the treatment of wastewater containing large quantities of industrial wastes that carry heavy loads of finely divided suspended solids and grease. For camp wastewater, the degree of solids reduction achievable by primary treatment is not well documented. Typically, normal domestic wastewater would be reduced 50 to 65 percent in suspended solids and 25 to 40 percent in BOD_5 by primary settling. It is expected that BOD_5 reductions for camp wastewater might be at the lower end of this range because of the higher-than-normal soluble BOD_5 fraction in camp wastewater.

Primary treatment as the only level of treatment is generally not acceptable in Alaska. A permit variance would have to be requested. The permit application would need considerable documentation as to the ability of the receiving water or land mass to assimilate all of the waste in an environmentally acceptable fashion.

The simplest primary treatment facility is the short retention lagoon, with a retention time ranging from 3 to 30 days, and depth varying from 10 to 20 feet. The liquid and accumulated sludge in this type of lagoon undergo anaerobic decomposition and consequently can be malodorous at times. Particularly obnoxious odors can occur when the water supply has a high sulfate content resulting in reduction of sulfates to hydrogen sulfide under anaerobic conditions. Consequently, it is usually advisable to site short retention ponds in the prevailing downwind direction and as far as practicable (at least 100 feet) from the serviced population.

2.5.3.5 Secondary Treatment

Secondary treatment means that method of removal of dissolved and colloidal materials which produces an effluent with the characteristics described in Section 2.5. Secondary treatment can be accomplished by means of long retention lagoons, aerated lagoons or by various types of mechanical treatment plants. Mechanical treatment plants discussed in this manual are limited to extended aeration, rotating biological contractors (RBC) and physical/chemical (P/C) processes.

Lagoons

Wastewater lagoons can provide one of the simplest, most cost-effective methods of wastewater treatment. The capital cost of constructing a lagoon is low provided that geotechnical conditions are suitable. The operating cost is low since specially trained personnel are not required, little time is required for operational control, and power requirements are very low or nil (except for aerated lagoons).

Lagoons must be water-tight unless the effect of seepage can be shown not to adversely affect any groundwater or nearby waterbodies. Furthermore, water-tightness is desirable for protection of inlet appurtenances against freezing due to low water levels during cold weather. The interior of the lagoon should be lined with *in situ* clay, or compacted mixed (off site) bentonite, or an impervious membrane.

There are two basic types of secondary lagoons applicable to workcamps: long retention and aerated. The long retention lagoons are also often termed facultative lagoons or oxidation ponds. Since the ponds are often covered by ice and are anaerobic for such a long period of time, the term "long retention" more accurately describes such lagoons.

The following design suggestions should be considered for long retention lagoons treating camp wastewater:

- A separate, short primary retention pond, preceding the long retention lagoon, would improve the overall performance by removing readily settleable and floatable organic solids. Suggested holding time for the primary cell is 5 days.

- Minimum of two long retention cells would be preferred.

- In terms of BOD, a loading of 0.5 pounds per day per 1000 square feet should not be exceeded.

- Complete winter retention plus at least 3 months or longer operation of the long retention cells under aerobic conditions are necessary to produce a secondary quality effluent. The ponds must have full sunlight throughout the day to promote effective treatment.

- Long retention lagoons should be over-sized by as much as 50 percent to ensure that complete winter retention is provided in case of flow under-estimation.

- Maximum cell depth should be 7 to 10 feet considering ice cover, freeboard and liquid operating depth.

- o The lagoon should be sited as far away from human habitation as possible, preferably at least 1000 feet downwind because of potential odor problems.

- o Provisions for flow measurements should be provided.

There appears to be no precedent for this type of lagoon system treating camp wastes. However, there are a great many Canadian villages, large and small, that have demonstrated good low-cost results. A lagoon system is less subject to fluctuations in flow but toxins can still cause upset to the biological stability.

Aerated lagoons are another type of secondary lagoon. Winter conditions in Alaska at the remote camp sites could create such difficult conditions that treatment by normal lagoon process may not lag far behind the more expensive aeration system in producing acceptable quality effluent. It is suggested that a minimum of two cells with a total of 30 to 40 days retention time, followed by a polishing pond, are required. The aeration system for the lagoon must be selected carefully to handle the maximum oxygen demand, which usually occurs in the springtime when water temperatures warm up and accumulation of undigested winter sludge exert an internal oxygen demand in addition to the applied demand.

<u>Extended Aeration</u>

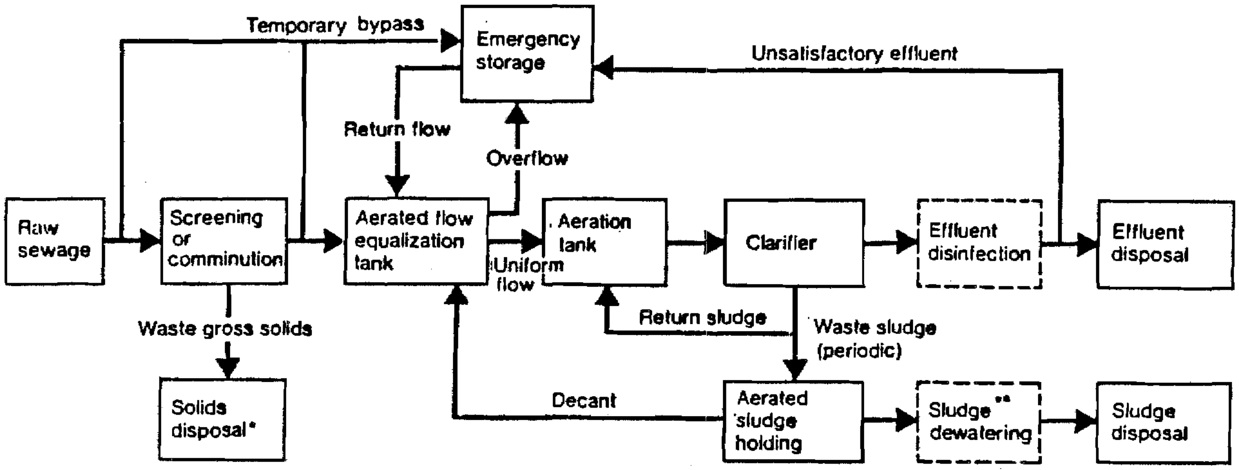
Extended aeration is a modification of the activated sludge treatment process. It has been used extensively in treating workcamp wastewater because of its high degree of stability for a wide variation in wastewater flow rate and strength. This biological process requires a trained operator or close supervision to avoid upset. A schematic diagram of a package extended aeration plant is shown on Figure 6.

Package extended aeration plants have been used at a number of construction camps in Canada and the U.S.A. Performance data on some of these are summarized in Table 15. Suggested design criteria and operating requirements for extended aeration plants are outlined in Table 16.

It should be noted that the recommended aeration tank loadings in Table 16 would result in an average retention time of 60 hours. The much less conservative approach taken at camps in Alaska (tanks provided 24 hours retention at the design average daily flow rate) is not recommended.

A characteristic problem with extended aeration plants is their long start-up time, which is usually 30 days before an adequate biological mass is built up in the aeration tank. This problem can be minimized or circumvented by applying one or a combination of the following procedures:

- Operate the aeration tank with no aeration for 1 week or as long as generated odors remain bearable. Biological solids will settle out and be effectively retained in the system. Aeration tends to break solids up, producing a pin-point, hard-to-settle floc when mixed liquid suspended solids (MLSS) concentration is low. By accumulating solids in the aeration tank before the aeration system is turned on, better flocculation of solids is promoted and start-up time is decreased.



*Not required with comminution

Note: Dotted lines indicate optional processes

** Required if incineration is used for sludge disposal

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SCHEMATIC OF EXTENDED AERATION PROCESS

FIGURE 6

TABLE 15
PERFORMANCE OF EXTENDED AERATION PLANTS TREATING CAMP WASTEWATER

Camp Location	Plant Design Capacity gal/d	Number of Samples	Parameter	Influent (mg/l)	Effluent (mg/l)	Removal %	Problems and Comments
Mackenzie Bay, N.W.T.	2500	18 influent 11 effluent	BOD_5 COD SS	1900 2790 1095	400 1095 315	79 61 71	1. Clarifier required frequent scraping each day to avoid anaerobic sludge. 2. Plant organically overloaded. 3. Some scum and floating grease balls. 4. Skimmer plugged once.
Mackenzie Bay, N.W.T.	2500 (2 plants)	-	-	-	-	-	1. Plants were located on a barge and inaccessible for proper maintenance. 2. Skimmers plugged.
Deadhorse, Alaska	2500	-	BOD_5 SS	- -	696 291	- -	
Galbraith, Alaska	19,000	1	BOD_5 COD	800 3600	33 -	96 -	1. Grab sample of influent from mixed surge tank.
Happy Valley, Alaska	24,000	-	COD SS	- -	324 147	- -	
Prudhoe, Alaska	15,000	1	BOD_5 COD SS	733 2510 1547	153 371 106	79 85 93	1. Grab sample of influent from mixed surge tank. 2. Long retention lagoon following plant resulted in further substantial improvements in effluent quality.
Crazyhorse, Alaska	10,000	7	BOD_5 SS	- -	27 39	93 82	1. Mixed liquor: Temp = 22°C, SS = 5000 mg/l, DO = 0.6 mg/l 2. Hydraulic loading averaged 50% greater than design loading (average 16 retention in aeration tank). 3. About 530 gal. sludge wasted every 2 weeks.

TABLE 16

SUGGESTED DESIGN CRITERIA AND OPERATING REQUIREMENTS FOR EXTENDED AERATION PLANTS TREATING CAMP WASTEWATER[1]

DESIGN		
Aeration tank loading - (dual units)	-	0.24 kg BOD_5/m^3 daily average @ 20°C 0.48 kg BOD_5/m^3 daily maximum @ 20°C
Flow equalization	-	Separate or in-system flow equalization
Oxygen requirement	-	2 kg O_2 transferred/kg BOD_5 applied
Oxygen transfer efficiency	-	3-5% depending on air diffusers, tank geometry, etc.
Mixing requirement	-	Sufficient air or energy must be supplied for aeration tank mixing
Clarifier surface loading rate	-	16 m^3/m^2 daily average 29 m^3/m^2 hourly peak
Positive sludge return	-	20 - 200% of average daily influent flowrate (normally set at 100%)
Sludge handling facilities	-	0.5 kg suspended solids per kg BOD_5 removed

OPERATION

- Measure mixed liquor dissolved oxygen, settleability and note color daily.
- Adjust air flowrates as required.
- Scrape hopper-type clarifier daily to ensure solids do not hang-up on the walls.
- Waste sludge as required to maintain mixed liquor suspended solids (MLSS) in the 3000 - 6000 mg/l range, approximately.

- Design a variable capacity unit or dual units sized to keep the food-to-microorganism ratio in a favorable range for start-up.

- Discharge poor quality effluent to the emergency holding pond and recycle settled solids to the head of the plant.

- Import activated sludge solids from a mature treatment plant.

- Add an artificial substrate to build-up the bacterial population faster.

Through prudent start-up procedures, it should be possible to achieve 80 percent BOD_5 reduction after a 1-week operating period and 90 percent after a 2-week period.

Rotating Biological Contactor

Rotating biological contactors (RBC) usually consist of plastic discs mounted on a horizontal shaft across a tank. The discs are slowly rotated with approximately 40 percent of their surface area submerged in wastewater in the tank. Biomass adheres to the discs, grows in the presence of oxygen and metabolizes organic matter in the wastewater. When the attached biomass on the discs becomes thick, portions of it slough off the discs into the wastewater. The wastewater effluent from the RBC tank is clarified to remove the sloughed biological solids. These solids must be removed regularly as sludge and treated and/or disposed of separately. A schematic diagram for an RBC and auxiliary components is presented on Figure 7. RBC systems have not been used extensively at campsites. Additional study is needed to take advantage of the concept's simplicity and low energy demand.

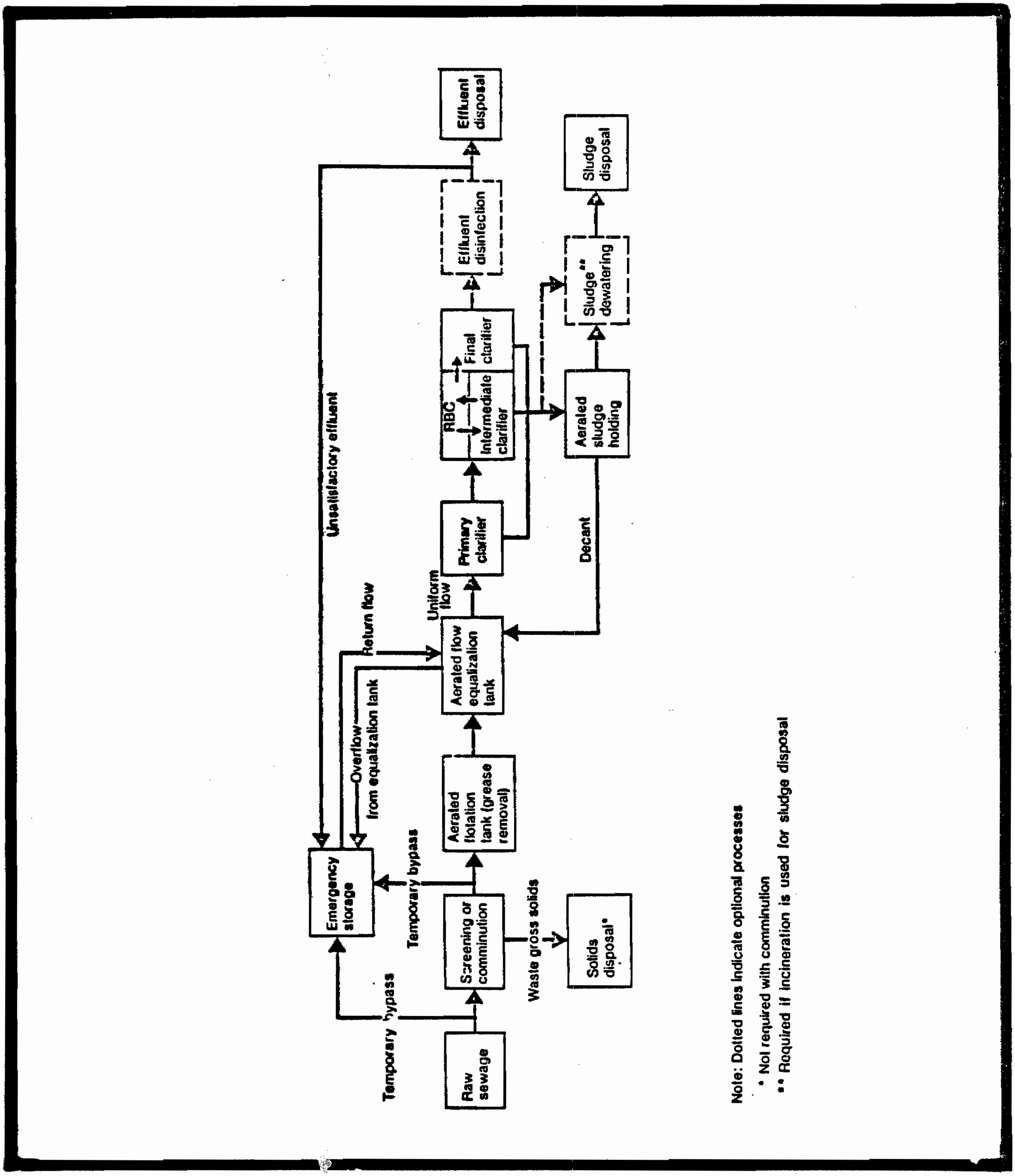
Pretreatment of the raw wastewater before addition to the RBC is essential to remove grease which could coat the discs and decrease performance; to remove larger solids which could clog the discs; and to remove smaller, but settleable, solids which are not efficiently removed by the discs themselves.

RBC plants, excluding auxiliary equipment, are simpler and more economical to operate than extended aeration plants. However, they usually have higher capital costs than the equivalent extended aeration plants and auxiliary equipment requirements may be more extensive than for extended aeration.

As shown from the limited data on Table 17, experience with RBC's in treating camp wastewater is limited. Tentative design criteria for RBC plants treating camp wastewater are presented in Table 18. Typical RBC problems are attributed to:

- o Organic overloading due to a higher-than-expected camp population.

- o Cleaning compounds in the raw sewage.



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SCHEMATIC OF ROTATING BIOLOGICAL CONTACTOR

FIGURE 7

TABLE 17

PERFORMANCE OF RBC PLANTS TREATING CONCENTRATED WASTEWATER

Type of Waste	Type of Pre-treatment	Type of Evaluation	Disc Diam (m)	Disc Total Area (m^2)	Disc Rotation (rpm)	Number of Stages	Parameter	Performance Influent (mg/l)	Effluent (mg/l)	Removal (%)	Total Organic Loading $g/m^2/d$	Total Hydraulic Loading $l/m^2/d$
Workcamp	Hydro-Screen	On-site plant	2.0	790	1.5	4	COD	3315[a]	956	72	39[b]	12
							SS	2048[a]	422	79		
							VSS	1748[a]	276	84		
							Oil & Grease	386[a]	16	96		
					1.5	4	COD	862[a]	291	66	11[b]	13
							SS	314[a]	71	77		
							VSS	222[a]	51	77		
							Oil & Grease	36[a]	10	72		
Workcamp							BOD_5	643-1080	25-86	92-97		
							COD	1271-1753	66-256	92-96		
							SS	252-600	32-114	55-94		
							VSS	252-560	32-114	55-93		

[a] Influent strength before pre-treatment

[b] Actual loading on discs would be less because effect of pre-treatment not included

TABLE 18

TENTATIVE DESIGN CRITERIA AND OPERATING REQUIREMENTS FOR RBC PLANTS TREATING CAMP WASTEWATER

DESIGN	
Heated enclosure	- essential
Flotation tank for grease removal	- consider
Primary settling (or equivalent)	- essential
Intermediate clarification	- desirable
RBC hydraulic loading	- 40 l/m^2 hourly peak - 20 l/m^2 daily average (for 600 mg/l waste)
RBC organic loading	- 24 g BOD/m^2 hourly peak - 12 g BOD/m^2 daily average
Intermediate clarifier overflow rate	- 40 - 80 m^3/m^2/day
Final clarifier overflow rate	- 24 m^3/m^2 daily average - 32 m^3/m^2 hourly peak
Number of stages	- 4 minimum

OPERATION

Must ensure that excess grease or cleaning compounds do not enter plant.

- Grease content of the wastewater can be considerably higher than 200 mg/l (causes coating of discs with excessive grease).

Possible remedial action that can be taken during design includes:

- Provisions for recycling some of the effluent.

- Provisions for adding influent to both the first and second stages to reduce the shock of high BOD loading.

- Pre-aeration in an aerated flow equalization tank to reduce oxygen demand.

Physical/Chemical Plants

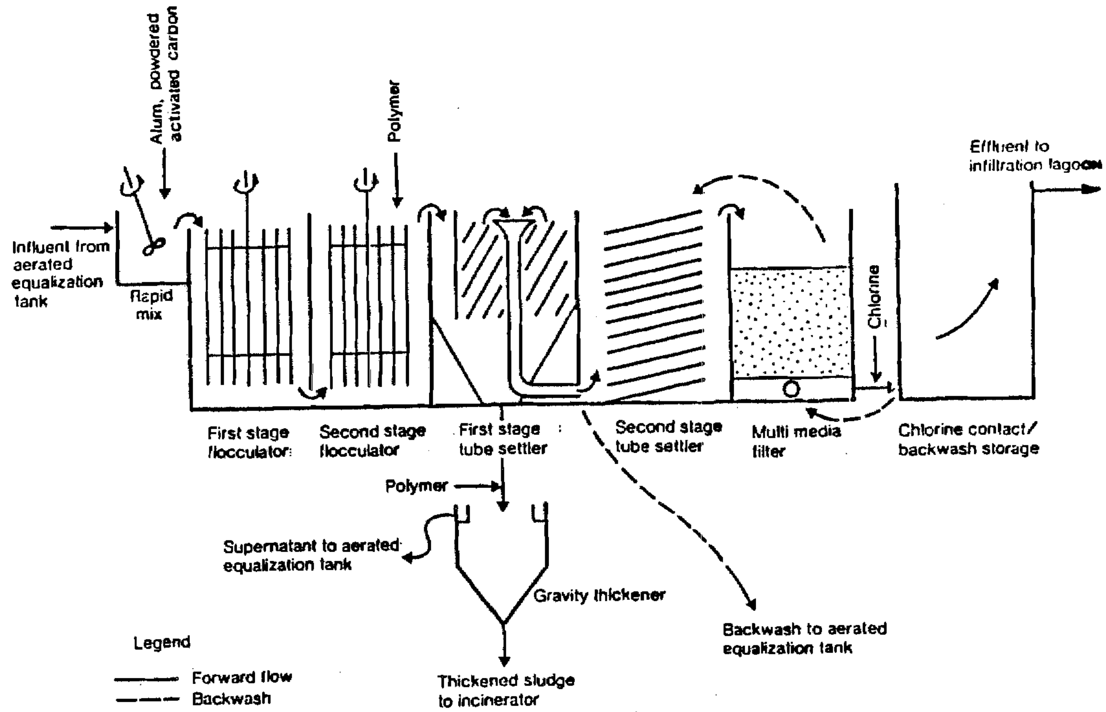
Physical/chemical (P/C) treatment plants, as the name implies, rely on physical and chemical processes to achieve organic reductions. P/C plants include various combinations of the following processes: comminution, screening, clarification, flocculation, coagulation, filtration, carbon adsorption and pH adjustment. P/C plants require large quantities of chemicals and produce large quantities of chemical sludges requiring further treatment and disposal. The main advantage of P/C units is their ability to handle a wide range of wastewater characteristics without plant upsets, provided that chemical additions and reaction times are sufficient. Toxic chemicals have little or no effects.

Considerable experience has been gained with P/C treatment plants, but they require continuous operator attention. Figure 8 illustrates one design for removal of organics with a packaged treatment plant. Table 19 summarizes the design parameters for the unit.

An essential part of any chemical or chemically aided precipitation system is stirring or agitation to increase the opportunity for particle contact (flocculation) after the chemicals have been added. If the agitation is too vigorous, the shear forces that are set up will break up the floc into smaller particles.

Chemical precipitation in wastewater treatment involves the addition of chemicals for the expressed purposes of improving plant performance and removing specific components contained in the wastewater. In the past, chemical precipitation was used to enhance the degree of suspended solids and BOD removal (1) where there were seasonal variations in the concentration of the sewage, (2) where an intermediate degree of treatment was required, and (3) as an aid to the sedimentation process.

More recently, interest in chemical precipitation has been renewed because (1) it can be used effectively for the removal of phosphorus, and (2) it can be combined with activated-carbon adsorption to provide complete wastewater treatment, bypassing the need for biological treatment and, at the same time, providing more effective removal of the organics in wastewater that are resistant to biological treatment. For example, the residual COD after chemical precipitation and carbon adsorption is about 10 to 20 mg/liter, whereas the residual COD after biological treatment is about 100 to 300 mg/liter.



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SCHEMATIC OF P/C TREATMENT PLANT

FIGURE 8

TABLE 19

SUMMARY OF DESIGN PARAMETERS FOR P/C UNIT

UNIT OPERATION	DESIGN PARAMETERS
Gross Solids Reduction and/or Removal	Comminutor or Rotary Screen
Aerated Equalization Tank	
- Blower Capacity	100 $l/m^3/min.$
- Minimum Detention Time	5 hours
Rapid Mix Chamber	Air-agitated with 6-second detention time
Flocculator	Two units in series each containing a variable speed vertical shaft paddle mixer - 20 minute detention time
First Stage Clarifier	Overflow rate through 60° tube settlers of 94 $l/m^2/min$
Second Stage Clarifier	Overflow rate through 7½° settlers of 61 $l/m^2/min$
Multi-Media Filter	
- Filtration Rate	200 $l/m^2/min$
- Backwash Rate	770 $l/m^2/min$
Chlorine Contact/Backwash	
- Storage Tank Detention Time	30 minutes
- Sludge Dewatering Device	Center feed gravity thickener with surface loading rate of 69.3 $kg/m^2/day$ and with a sludge blanket detention time of 8 hours.
Sludge Incinerator	Pathological Burner

Many different substances have been used as precipitants. The most common ones are listed on Table 20. The degree of clarification obtained depends on the quantity of chemicals used and the care with which the process is controlled. It is possible by chemical precipitation to obtain a clear effluent, substantially free from matter in suspension or in the colloidal state.

The chemicals added to sewage in chemical precipitation react with substances that are either normally present in the sewage or are added for this purpose.

Many reactions with other substances in sewage may take place. Each site-specific wastewater will have its own characteristic anomalies. Once they are identified, remedial action can be taken. The repeating indicators will give adequate notice of upcoming problems.

2.5.3.6 Disinfection

The final stage in treatment prior to releasing the effluent is disinfection, the selective destruction of disease-causing organisms. All of the organisms are not destroyed during the process. This differentiates disinfection from sterilization, which is the destruction of all organisms.

In the field of wastewater treatment, disinfection most commonly is accomplished through the use of (1) chemical agents, (2) physical agents, (3) mechanical means, and (4) radiation.

TABLE 20

CHEMICALS USED IN WASTEWATER TREATMENT

Chemical	Formula	Molecular Weight
Alum	$Al_2(SO_4)_3 \cdot 18H_2O^*$	666.7
Ferrous sulfate (copperas)	$FeSO_4 \cdot 7H_2O$	278.0
Lime	$Ca(OH)_2$	56 as CaO
Sulfuric acid	H_2SO_4	98
Sulfur dioxide	SO_2	64
Ferric chloride	$FeCl_3$	162.1
Ferric sulfate	$Fe_2(SO_4)_3$	400

*Number of bound water molecules will vary from 13 to 18.

An ideal disinfectant would have to possess a wide range of characteristics. It is also important that the disinfectant be safe to handle and apply, and that its strength or concentration in treated waters be measurable so that the presence of a residual can be determined.

Chemical agents that have been used as disinfectants include phenol and phenolic compounds, alcohols, iodine, chlorine and its compounds, bromine, ozone, heavy metals and related compounds, dyes, soaps and synthetic detergents, quaternary ammonium compounds, hydrogen peroxide, and various alkalies and acids.

Chlorine is the most commonly used disinfectant throughout the world. In dry powdered compounds (HTH) it can be mixed with water for use at camp sites; chlorine residual limits are based on the characteristics of the receiving water. Liquid chlorine gas, although efficient, could be too hazardous to transport and store at remote locations.

2.5.3.7 Sludge Thickening

Depending upon the treatment process, it may be necessary to dewater the sludge to some cost-effective level. Decanting, which merely amounts to letting the sludge settle quietly in its own tank until the water rises and then drawing off the mixed liquor suspended solids and sludge separately, is the most economical beginning point. Other alternatives to review are vacuum filtration, filter press, and centrifuge.

2.5.3.8 Sludge Digestion and Disposal

Continued aeration of the sludge in an activated sludge process will digest it to relatively safe condition. The by-product water generated can be recirculated and portions of the sludge may be needed to maintain biological reactions in the system during low camp population periods. Anaerobic digestion of sludge has not been investigated in field situations. Perhaps the advantages of further volume reduction, stable solids, and methane gas production do not offset its space requirements and need for heat. The inert products of anaerobic digestion could possibly provide a nutrient rich revegetation material.

Standard practice finds most sludges, greases, residues, etc. burned in the camp incinerator with the ash disposed of at a landfill.

2.5.3.9 Effluent Disposal

Several methods of wastewater disposal into soil are or have been practiced, including absorption field disposal of septic tank or aerobic treatment effluents, direct burial in pits, disposal in ice crypts or snow sumps, and dumping and covering in a landfill. The presence of, and depth and thickness of, permafrost, the type of soil and its percolation rates, and the frost penetration depth will influence the possibility of land application of effluent.

Land application of wastewater requires maintenance of the soil permeability. In some cold climate areas this may be possible through special design. However, many areas are unsuitable. The presence of permafrost will limit vertical movement of the wastewater, and winter freezeback of the active layer may prevent horizontal movement. It may be possible to design a suitable system in areas of thawed zones which do not completely freeze. Thermal protection for an absorption field should be designed for the worst winter conditions, minimum or no snow, and low temperatures.

Another approach warranting consideration is the use of a retention-land disposal system, making use of land disposal during the warmer parts of the year and retention through the winter. In general, land disposal is similar and subject to the same constraints as land treatment. The major difference is that land disposal systems are mainly concerned with getting the effluent into the ground and away from the site. The major concern is that the effluent moves in an acceptable direction and does not present a hazard to public health.

Discharge of treated wastewater into wetlands, lakes, ponds, or rivers requires detailed site evaluation to determine potential impacts on aquatic resources. The type of receiving waterbodies and the effluent standards which pertain to each specific operation are also important factors in the type of outfall structure designed.

Ponds are generally shallow, with depths up to 7 feet. Surface areas range from a few 1,000 to a few 10,000 square feet, and retention times are often extremely long, 1 to 6 months. Freeze depths may vary from 2 to 5 feet. Ice thickness can be estimated mathematically by assuming worst conditions of no snow cover and minimum heat input. The use of a pond to receive treated wastewater would effectively convert it to a polishing lagoon.

Fencing and posting to that effect is required. Regulatory agencies must be consulted before this approach is pursued.

Lakes may have the ability to absorb a greater volume of wastewater. Important considerations include surface area, depth, volume-inflow relationships, nutrients, flora and fauna, and benthic populations. Effluent quality, especially with regard to microorganisms, must be high if there is a potential for fishery or recreational use of the lake.

Northern streams and rivers are the most common receiving waters for wastewater. Flow, ice depth and movement are the most important factors to be considered. Dissolved oxygen conditions through the winter and downstream uses are of particular importance in selection of the type of outfall structure to be used.

The use of natural swamps for treating or polishing wastewater has received considerable attention in recent years. Swamp discharge has been practiced in several places in the North; however, detailed studies have been limited. It is important to design the outfall diffuser for maximum dispersion into the swamp.

Where possible, ocean discharge is desirable. Normally, the ability to absorb quality variations is very great. If initial dispersion by outfall design and tidal movement is not obtained, however, wastewater will concentrate on the surface, because fresh water and sewage are less dense than salt water. The result is a visible slick. The major advantage of sea disposal is dilution. The design of the outfall must consider ice movement due to tidal action, currents, nearby rivers and wind action.

CHAPTER 3 - SOLID WASTE

Solid wastes generated during the construction of Power Authority projects will vary from domestic refuse to large bulky items such as discarded equipment parts. Early planning for the management of solid wastes, including handling, storage, and disposal, is essential to minimize health hazards and adverse environmental impacts.

The basic objectives of the solid waste management program for a project include:

- Preventing or minimizing the environmental impacts associated with the management and disposal of solid wastes (land, water and air pollution, worker health and safety, aesthetics, etc.)
- Resource conservation (reclamation, reuse, minimization of land requirements, etc.)
- Sound engineering practices
- Compliance with governing regulations
- Response to public attitudes
- Achieving these objectives in the most economical manner for a given situation.

Factors to be considered during the planning phase for project waste management include:

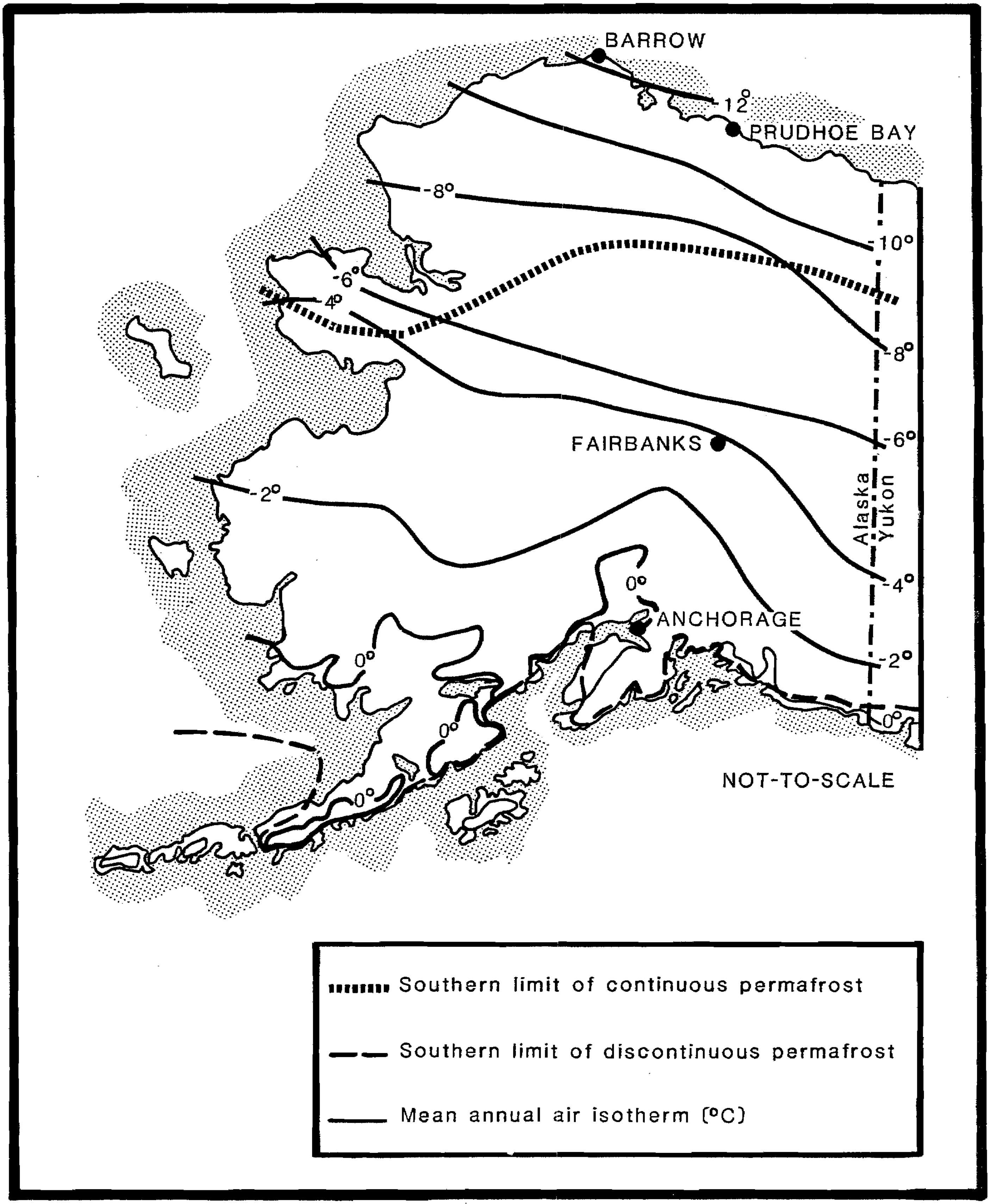
- Types of wastes
- Volumes of wastes

- o Method of treatment and disposal
  - Incineration
  - Landfill
  - Storage for salvage
  - Reuse on site
  - Public solid waste facilities
- o Soil type
- o Climatology
- o Permafrost conditions (Figure 9)
- o Size and life of the facility
- o Economics of alternative waste management systems
- o Environmental concerns or constraints
- o Geographic location
- o Regulatory constraints

Project permitting requirements should be reviewed at the planning stage of solid waste management projects. This review should contain the elements set out in Section 2.1.

To implement a solid waste management plan, an organizational structure will be developed that will define the individuals and their delegated responsibilities to ensure that the project will be in compliance with applicable permits, codes, and regulations.

Federal law prohibits "open dumping" as that term is defined in the Solid Waste Management Act. The act imposes minimum solid waste regulations pertaining to



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PERMAFROST IN ALASKA

FIGURE 9

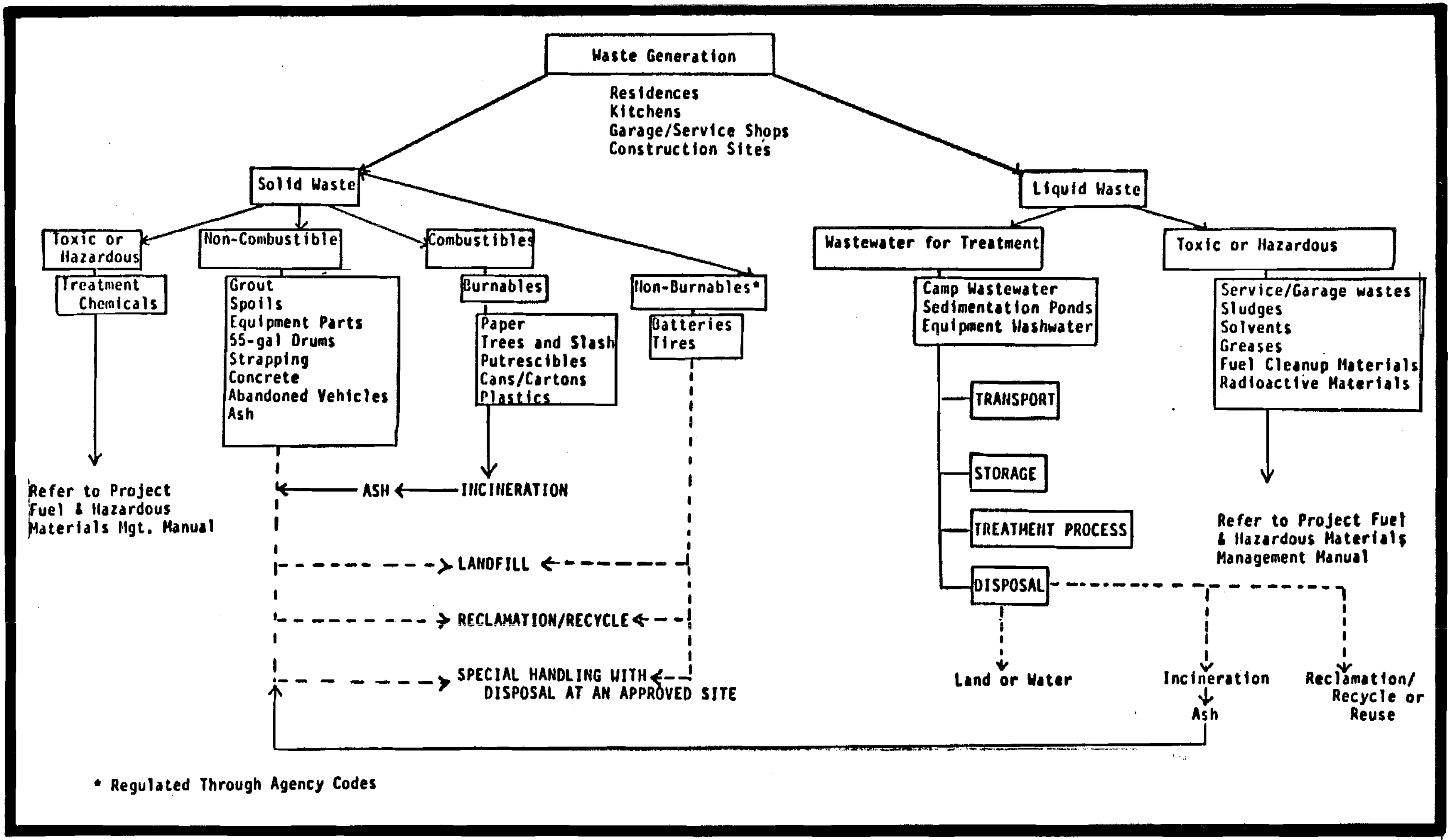
open dumping (40 CFR 257). These regulations must be satisified in addition to any state solid waste requirements.

3.1 TYPES OF WASTES

The sources of solid wastes generated during exploration, construction, or operation of a project are readily identifiable during the planning phase of the activities. Figure 10 displays one method of delineating types of waste products. Special note should be made of the project location when determining waste types since activities at a remote, controlled-access project will differ from those where workers have access to public services. Wastes for personnel support are usually institutional wastes generated by controlled use of products and commissary services. A 500 to 700-man camp at a remote site in Alaska will generate 2 to 3 tons per day of diverse waste products (not including clearing debris or overburden/spoil materials). The typical physical composition for these wastes is as follows:

1200-1500 lb/day	Municipal type (paper, cardboard, food and beverage cans, bottles, etc.)
200-500 lb/day	Food scraps and cooking wastes
2000-4000 lb/day	Garage, warehousing and repair wastes (equipment repair metals, pallets, strapping, form lumber, etc.)

The Alaska Department of Environmental Conservation uses a camp-generated solid waste rate of 7.9 lbs/person/day for design review purposes. Camp



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CRITERIA FOR WASTE MANAGEMENT ANALYSIS

FIGURE 10

wastes can be further classified as 86 percent combustible and 14 percent non-combustible.

3.2 TREATMENT ALTERNATIVES

There are four general practices for solid waste treatment and disposal in Alaska: incineration, landfill, reclamation for reuse, and salvage (haul back). Table 21 shows waste products with storage and disposal techniques. This table is intended only as general guidance. Waste classification and appropriate storage and disposal practices should be determined on a case-by-case basis in accordance with applicable federal, state, and local laws.

3.2.1 Incineration

Incineration is the acceptable method of treating putrescible wastes at remote sites to prevent food products from attracting wildlife. The objective of the incineration process is to control combustion of the waste to produce a residue which is not degradable and contains no combustible material. The residue (ash) then requires disposal. Advantages and disadvantages associated with this disposal technique are as follows:

Advantages:

- o Proven acceptable method in Alaska
- o Provides an inert, environmentally-acceptable, end product for disposal
- o Treats wastes as generated -- less storage space required
- o Eliminates leachate of organics at sites

TABLE 21

SOLID WASTE
DISPOSAL TECHNIQUES

SOLID WASTE	CATEGORY	STORAGE	DISPOSAL ALTERNATIVES
Paper	C3	S3	D1, 2, 6
Plastics	C3	S3	D1, 2, 6
Cardboard	C3	S3	D1, 2, 6
Wood	C3	S2	D1, 2, 6
Food Bottles & Cans	C1, 4	S1	D1, 2, 5
Food Packaging	C1, 3, 4	S1	D1, 2
Food Wastes	C4	S1	D1, 2
Tires	C2	S2	D1, 3, 5
Batteries	C2,5	S4	D5, 8
Equipment Parts	C1	S2	D3, 5
Oil Drums	C2,5	S4	D3, 4, 5, 8
Incinerator Ash	C1	S3	D1
PVC Pipe	C2	S2	D1
Oil Filters	C3,5	S4	D2,8
Trees & Slash	C3	S2	D1, 6, 7
Solvents & Paints	C3,5	S4	D2, 8
Greases	C2	S4, 5	D1, 3, 5
Used Oils	C3,5	S4, 5	D2, 3, 5, 8
X-ray Wastes	C3,5	S4, 5	D4, 8

Categories
C1 - Non-combustible
C2 - Non-burnable (regulated by codes)
C3 - Combustible
C4 - Putrescible
C5 - Toxic/hazardous (as defined by either federal or state regulations)

Storage
S1 - Animal proof container
S2 - Open container
S3 - Covered container
S4 - Leak proof container (area)
S5 - Drums

Disposal
D1 - Landfill
D2 - Incineration
D3 - Storage at landfill
D4 - Return to vendor
D5 - Salvage, reuse
D6 - Open burn
D7 - Chip
D8 - Special regulations

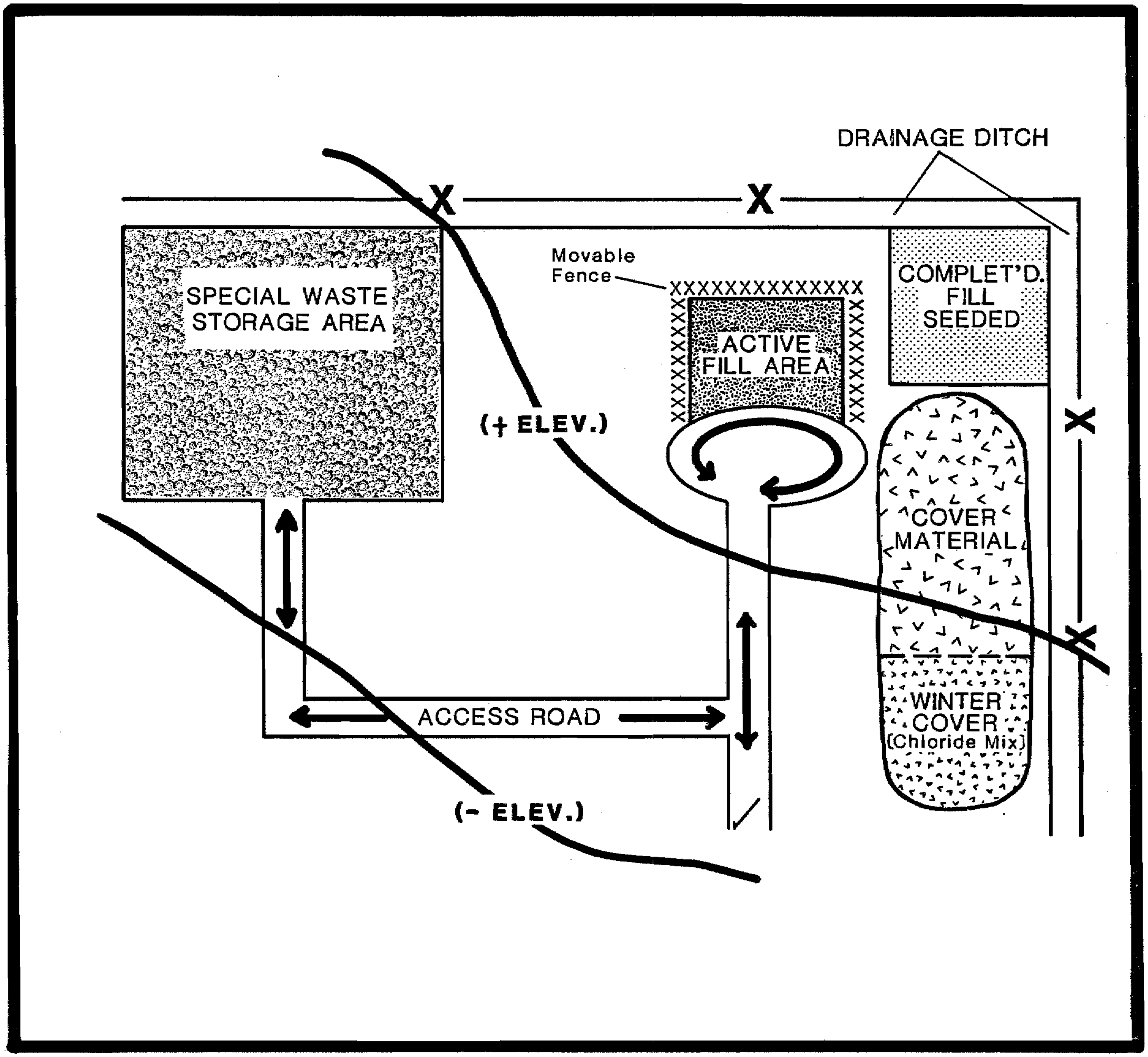
- Waste reduction (70 to 75 percent reduction of camp wastes)
- Reduces animal and bird scavenging

Disadvantages:

- Most expensive of processing systems in terms of capital and operating costs
- Labor intensive
- Requires trained operators
- High energy demand
- May contribute to air quality degradation
- Hazardous due to combustion of unknown solid wastes
- Heated building required in areas of extreme low temperatures and/or adverse climatic conditions
- Segregation of wastes required
- Incinerator ashes require special handling, hauling, etc.

3.2.2 Landfill

Figure 11 depicts a typical site design for a landfill and Figures 12 through 14 illustrate three common operational plans for the placement of solid wastes. The area method (Figure 12) is used when trenches cannot be excavated. Wastes are spread in long, narrow strips on the surface of the land in a series of layers that vary in depth from 16 to 30 inches. An earthen levee or berm is constructed against which wastes are compacted. The ramp method (Figure 13) is employed when cover material is scarce. Additional soil cover must be hauled in for both the area and ramp methods. The trench method (Figure 14) is suited to areas where an adequate depth of



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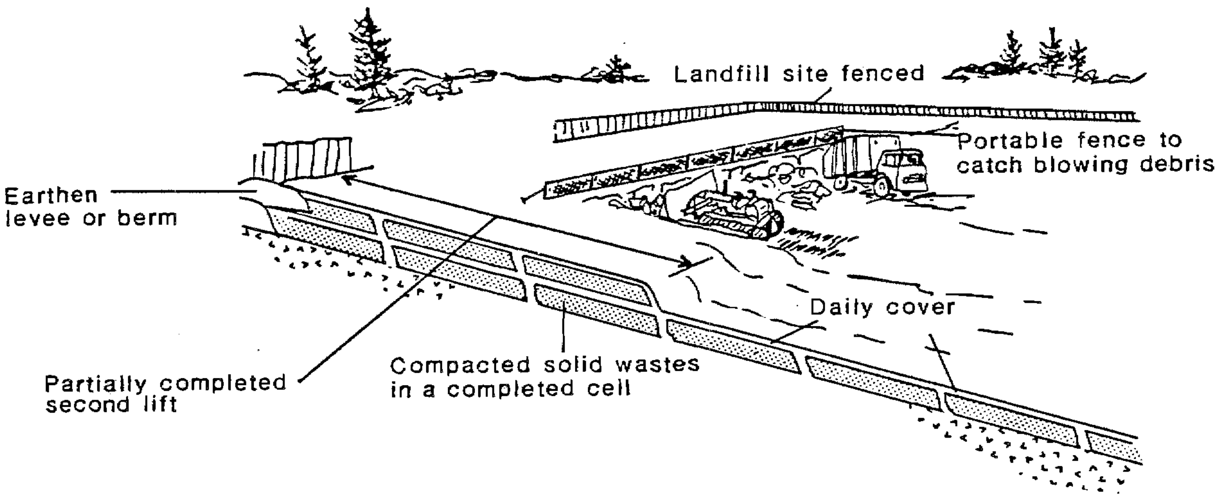
TYPICAL LANDFILL DISPOSAL SITE

FIGURE 11



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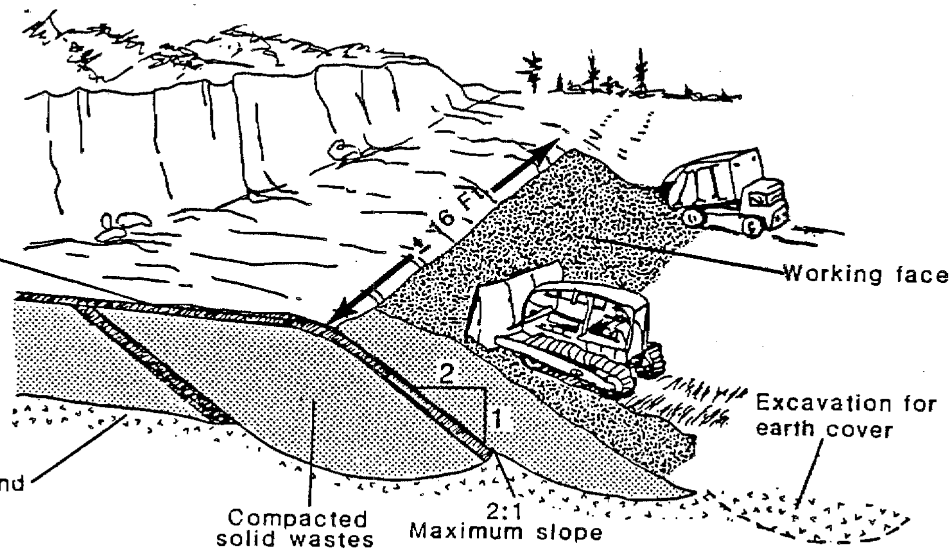
SANITARY LANDFILLING AREA METHOD

FIGURE 12



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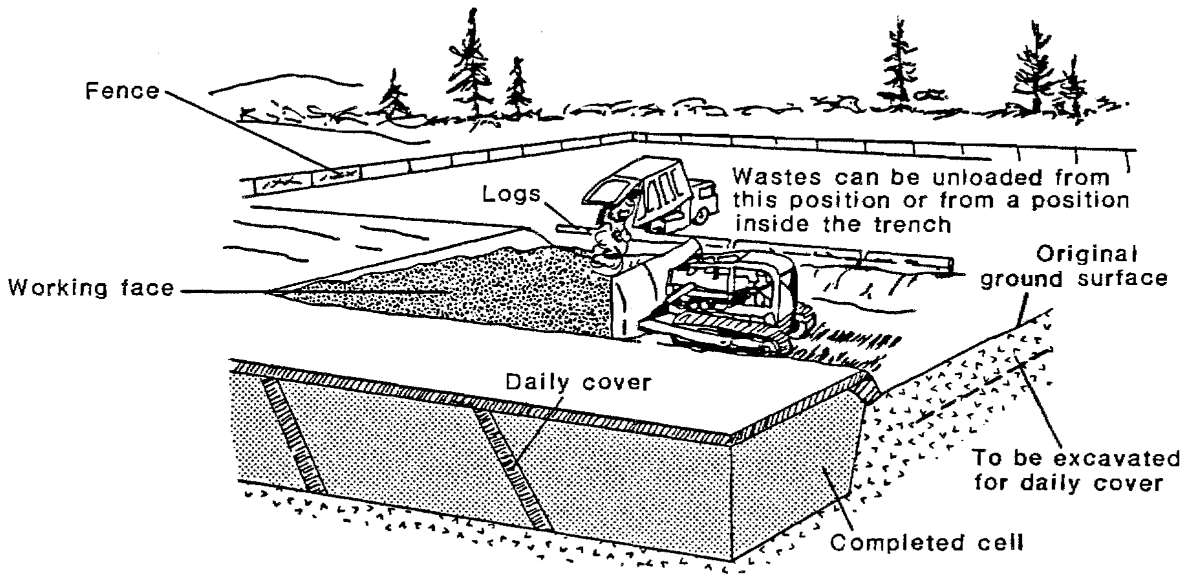
SANITARY LANDFILLING RAMP METHOD

FIGURE 13



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SANITARY LANDFILLING TRENCH METHOD

FIGURE 14

cover material is readily available. Cover material is obtained by excavating an adjacent trench.

3.2.2.1 Site Selection and Design

Preliminary screening and ultimate selection of a landfill site should be based on the results of a site(s) survey(s), results of engineering design and cost studies, and an environmental assessment. The selection team should be comprised of the design engineer, biologist, hydrologist, geologist, sanitary engineer, and regulatory personnel. Factors that must be considered include:

- Land Availability--The use of the land area around a project site may be affected by zoning restrictions, public resistance or project boundaries. Usually landfill sites are located on lands designated by a project for use as a borrow site, material storage area, etc. to permit the maximum use of an area without expanding demands on the land.

- Haul Distance--The shorter the haul the more economical the solid waste transport costs. Although minimal haul distances are desirable, project policies to use previously disturbed sites may negate this cost-effectiveness criterion.

- Soil Conditions--The soil at the site is the most important single aspect for judging site suitability because of its role as the interface between the waste and the groundwater. The soil's characteristics and availability as cover material must also be considered.

There is usually information on file with a local resource agency on soils in an area. However this data may be scarce or not available in Alaska. Soil borings can provide data prior to design. This data can be reviewed using soil interpretation sheets such as found in Tables 22 through 24 from the U.S. Department of Agriculture, Soil Conservation Service.

Approximately 1 cubic yard of cover material will be required for every 4 to 6 cubic yards of solid wastes. Table 25 provides a guide for cover material requirements. The cover material should be less permeable than the soil under the landfill (Figure 15).

- Climate--Winds, rainfall and snow cover must be known to adequately assess a landfill site with respect to area requirements, design parameters and physical layout.

- Ground and Surface Water Data--The control of site drainage and the protection of surface/ground water is important in the selection process. Prospective sites must be appraised for the ability to control drainage to and from the area to prevent leaching of waste constituents to ground or surface water and to maintain all-weather access roads. The site must be designed to prevent the washout of cover wastes.

TABLE 22

APPLICATION OF SOIL INFORMATION

DAILY COVER FOR LANDFILL

	PROPERTY	LIMITS GOOD	FAIR	POOR	RESTRICTIVE FEATURE
1.	USDA TEXTURE	---	---	ICE	PERMAFROST
2.	DEPTH TO BEDROCK (IN)	60	40-60	40	DEPTH TO ROCK
3.	DEPTH TO CEMENTED PAN (IN)	60	40-60	40	CEMENTED PAN
4.	[1]UNIFIED	---	---	SP, SW SP-SM, SW-SM, GP, GW, GP-GM, GW-GM	SEEPAGE
5.	[1),2),3)]USDA TEXTURE	---	CL, SICL, SC	SIC, C	TOO CLAYEY
6.	[1]USDA TEXTURE	---	LCOS, LS, LFS, VFS	S, FS, COS, SG	TOO SANDY
7.	[1),2)]UNIFIED	---	---	OL, OH, CH, MH	HARD TO PACK
8.	[1),4)]COARSE FRAGMENTS (PCT)	25	25-50	50	SMALL STONES
9.	[1), 4)]FRACTION 3 IN (WT PCT)	25	25-50	50	LARGE STONES
10.	SLOPE (PCT)	8	8-15	15	SLOPE
11.	DEPTH TO HIGH WATER TABLE (FT)	--- 3.5	--- 1.5-3.5	+ 1.5	PONDING WETNESS
12.	[1]UNIFIED	---	---	PT	EXCESS HUMUS
13.	LAYER THICKNESS (IN)	60	40-60	40	THIN LAYER
14.	[1]SOIL REACTION (pH)	---	---	3.6	TOO ACID
15.	[2]SALINITY (MMHOS/CM) (0-60")	---	---	16	EXCESS SALT
16.	[1),2)]SODIUM ADSORBTION RATIO OR GREAT GROUP OR PHASE	---	---	12 (HALIC, NATRIC, ALKALI PHASES)	EXCESS SODIUM
17.	CARBONATES	---	---	5)	EXCESS LINE

1) Thickest layer between 10 and 60 inches.
2) Disregard (1) in all Aridisols except Salorthids and Aquic subgroups, (2) all Aridic subgroups, and (3) all Torri great groups of Entisols except Aquic subgroups.
3) If in kaolinitic family, rate one class better if experience confirms.
4) Sum (100-% passing No. 10 sieve) and fraction less than 3 in. Use dominant condition for restrictive feature.
5) If amount of carbonate s so high that is restricts the growth of plants, rate "POOR-EXCESS LIME".

TABLE 23

APPLICATION OF SOIL INFORMATION

SANITARY LANDFILL (TRENCH)

PROPERTY	LIMITS GOOD	FAIR	POOR	RESTRICTIVE FEATURE
1. USDA TEXTURE	---	---	ICE	PERMAFROST
2. FLOODING	NONE	RARE	COMMON	FLOODING
3. DEPTH TO BEDROCK (IN)	---	---	72	DEPTH TO ROCK
4. DEPTH TO CEMENTED PAN (IN)				CEMENTED PAN
THICK	---	---	72	
THIN	---	72	---	
5. 1)PERMEABILITY (IN/HR) (BOTTOM LAYER)	---	---	2.0	SEEPAGE
6. DEPTH TO HIGH WATER TABLE (FT):	---	---	+	PONDING
APPARENT	---	---	6	WETNESS
PERCHED	4	2-4	2	WETNESS
7. SLOPE (PCT)	8	8-15	15	SLOPE
8. 1),2),3)USDA TEXTURE	---	CL, SC, SICL	SIC, C	TOO CLAYEY
9. 3)USDA TEXTURE	---	LCOS, LS, LFS, LVSF	COS, S PS, VPS, SG	TOO SANDY
10. 3)UNIFIED	---	---	OL,OH,PT	EXCESS HUMUS
11. 4)FRACTION 3 IN (WT PCT)	20	20-35	35	LARGE STONES
12. 1)SODIUM ADSORPTION RATIO (0-40") OR GREAT GROUP OR	---	---	12 (HALIC, NATRIC, ALKALI PHASES)	EXCESS SODIUM
13. SOIL REACTION (pH) (ANY DEPTH)	---	---	3.6	TOO ACID
14. SALINITY (MMHOS/CM) (ANY DEPTH)	---	---	16	EXCESS SALT
15. DOWNSLOPE MOVEMENT	---	---	5)	SLIPPAGE
16. DIFFERENTIAL SETTLING	---	---	6)	UNSTABLE FILL

1) Disregard (1) in all Aridisols except Salorthids and Aquic subgroups, (2) all Aridic subgroups, and (3) all Torri great groups of Entisols except Aquic subgroups.
2) If in kaolinitic family, rate one class better if experience confirms.
3) Thickest layer between 10 and 60 inches.
4) Weighted average to 60 inches.
5) If the soil is susceptible to movement downslope when loaded, excavated, or wet, rate "SEVERE-SLIPPAGE".
5) If the soil is susceptible to differential settling, rate "SEVERE-UNSTABLE FILL".

TABLE 24

APPLICATION OF SOIL INFORMATION

SANITARY LANDFILL (AREA)				
PROPERTY	LIMITS GOOD	FAIR	POOR	RESTRICTIVE FEATURE
1. USDA TEXTURE	---	---	ICE	PERMAFROST
2. FLOODING	NONE	RARE	COMMON	FLOODING
3. [1]DEPTH TO BEDROCK (IN)	60	40-60	40	DEPTH TO ROCK
4. [1]DEPTH TO CEMENTED PAN (IN)	60	40-60	40	CEMENTED PAN
5. [1]PERMEABILITY (IN/HR) (20-40")	---	---	2.0	SEEPAGE
6. DEPTH TO HIGH WATER TABLE (FT):	---	---	+	PONDING
APPARENT	5	3.5-5	3.5	WETNESS
PERCHED	3	1.5-3	1.5	WETNESS
7. SLOPE (PCT)	8	8-15	15	SLOPE
8. DOWNSLOPE MOVEMENT	---	---	2)	SLIPPAGE
9. FORMATION OF PITS	---	---	3)	PITTING
10. DIFFERENTIAL SETTLING	---	---	4)	UNSTABLE FILL

[1]Disregard (1) in all Aridisols except Salorthids and Aquic subgroups, (2) all Aridic subgroups, and (3) all Torri great groups of Entisols except Aquic subgroups.

[2]If the soil is susceptible to movement downslope when loaded, excavated, or wet, rate "SEVERE-SLIPPAGE".

[3]If the soil is susceptible to the formation of pits caused by the melting of ground ice when the ground cover is removed, rate "SEVERE-PITTING".

[4]If the soil is susceptible to differential settling, rate "SEVERE-UNSTABLE FILL".

TABLE 25

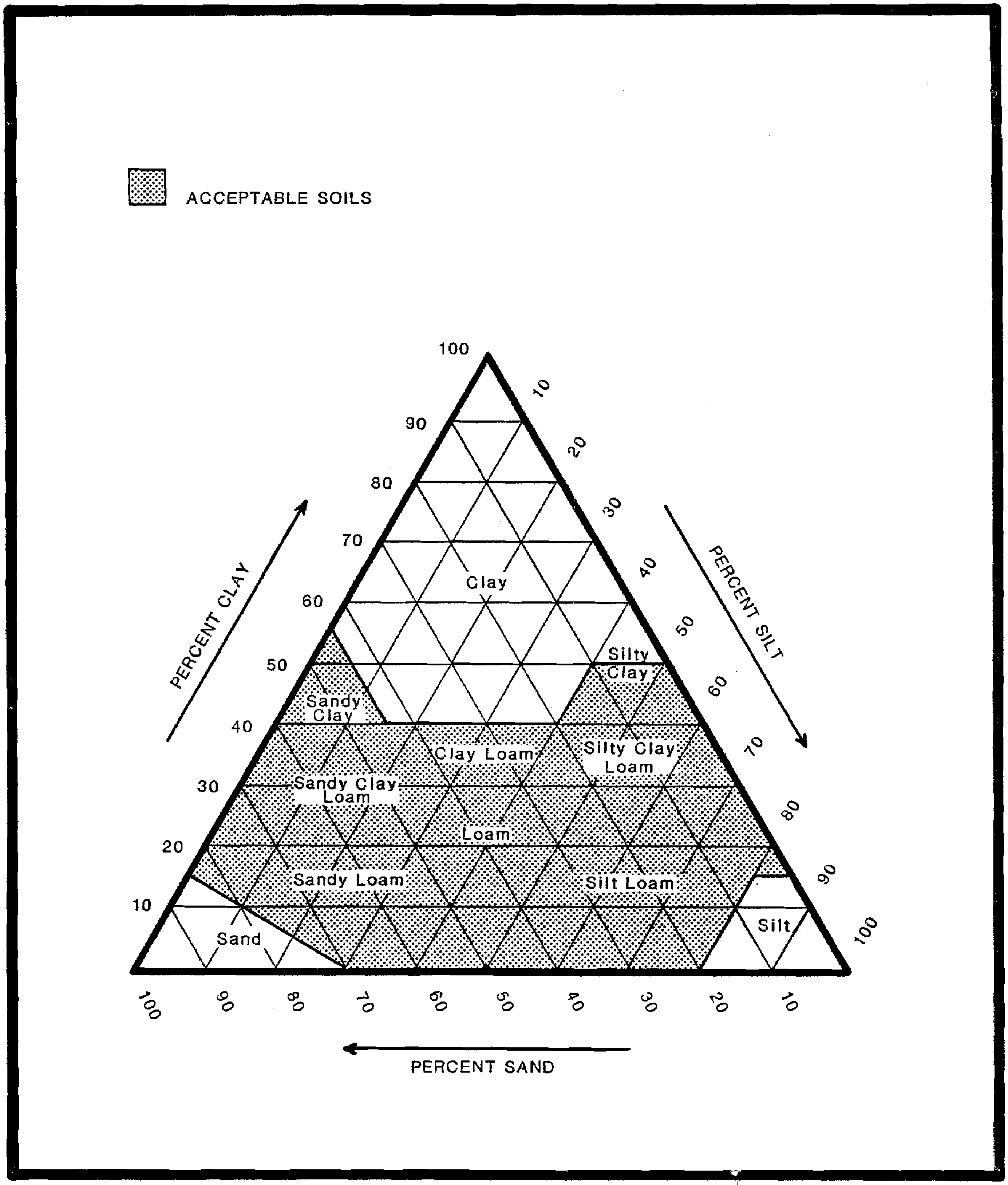
DAILY AND FINAL COVER MATERIAL REQUIREMENTS

Daily Cover Material Requirements
(Based on 6-inch daily cover)

Refuse Intake (long tons per day)	In Place Volume @ 1000 lbs per yds^3 ($yards^3$)	Total Area of Daily Cell ($yards^2$)			Total Daily Volume of Cover Material ($yards^3$)		
		Cell Depth in Feet			Cell Depth in Feet		
		6 ft	8 ft	10 ft	6 ft	8 ft	10 ft
25	56	28	21	17	5	4	3
50	112	56	42	34	9	7	6
100	224	112	84	67	19	14	11
200	448	224	168	134	37	28	22
500	1120	560	420	335	94	70	56
750	1680	840	629	502	140	105	84
1000	2240	1120	839	671	187	140	112

Final Cover Material Requirements

Acreage	Final Cover Material Required ($yards^3$)
25	80,700
50	161,400
100	322,800
150	484,200
200	645,600
250	807,000
300	968,500



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SOILS SUITABLE FOR COVER MATERIAL

FIGURE 15

In regions of above-average precipitation, as experienced in many areas of Alaska, special attention is required to divert drainage. Should interface soil conditions warrant, two indirect methods for control of site drainage can be assessed: impermeable barrier or drainage way. The peak rate of flow which needs to be diverted is a function of rainfall, land treatment, soil type, slope, and antecedent moisture conditions. Drainage channels most commonly used are earthen swales and split corrugated metal pipe. Recommendations for permissible velocities for bare earthen channels are found in Table 26. Final earthen swales can be grassed or a stone center ditch can be added to protect against erosion.

- Permafrost Soils--A sanitary landfill is generally not a practical method of disposal in permafrost areas. Excavation is extremely difficult and may create additional problems through destruction of the active layer. Cover material sources other than permafrost soils must be available, often necessitating expensive transportation charges.

- Environmental Constraints or Considerations--Project construction and operation in Alaska involve evaluation of existing environmental conditions prior to initiation to respond to the many environmental concerns unique to the state. Federal, state, and local regulatory and permitting requirements may dictate the type of solid waste management techniques selected by the Power Authority. Environmental issues are enhanced due to the lack of previous development activities at remote locations. Proximity

TABLE 26

PERMISSIBLE VELOCITIES FOR BARE EARTHEN CHANNELS

Soil Texture	Maximum Velocity (ft/sec)
Sandy and sandy loam (non-colloidal)	2.5
Silt loam (also high lime clay)	3.0
Sandy clay loam	3.5
Clay loam	4.0
Stiff clay, fine gravel, graded loam to gravel	5.0
Graded silt to cobbles (colloidal)	5.5
Shale, hardpan and coarse gravel	6.0

Source: Soil Conservation Service (1970) to eagles' nests, anadromous fish waterways, wildlife habitat and migration routes, parks, etc. may preclude solid waste activities.

In accordance with State of Alaska solid waste regulations (18 AAC 60), landfills should be surrounded with animal-resistant fencing. The design and construction techniques used should be developed in consultation with applicable regulatory agencies.

- Final Use of the Site after Completion--A determination, during the planning phase of a project, of the ultimate use of a completed solid waste site will result in a more effective design. In many instances, the landowner/manager may dictate how the site will be rehabilitated or how permanent slopes and drainage patterns will be constructed. Federal and state law may require installation of groundwater monitoring wells to be operated after site closure. Effective liaison with project planners will result in cost-effective site design to eliminate labor-intensive requirements to mold the area to fit designated needs after completion of the project.

- Access Roads--The chief goal in designing access to the site should be to minimize interference between solid waste vehicular traffic and other project activities. The roads, which should have a trouble-free surface (Table 27), should be designed to direct trucks to the working face and out as quickly as possible. Because haul roads at the landfill location (working face) are

TABLE 27

ROADWAY SOILS CHARACTERISTICS

Major Divisions		Name	Values at Foundation When Not Subject to Frost Action	Value as Base Directly Under Wearing Surface	Potential Frost Action	Compressibility and Expansion	Drainage Characteristics	Compaction Equipment	Unit Dry Weight Lb. Per Cu. Ft
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	Gravel or sandy gravel, well graded	Excellent	Good	None to very slight	Almost none	Excellent	Crawler type tractor, rubber tired equipment, steel wheeled roller	125-140
		Gravel or sanuy gravel, poorly graded	Good to excellent	Poor to fair	None to very slight	Almost none	Excellent	Crawler type tractor, rubber tired equipment, steel wheeled roller	120-130
		Gravel or sandy gravel uniformly graded	Good	Good	None to very slight	Almost none	Excellent	Crawler type tractor, rubber tired equipment	115-135
		Silty gravel or silty sandy gravel	Good to excellent	Fair to good	Slight to medium	Very slight	Fair to poor	Rubber tired equipment, sheepsfoot roller, close control of moisture	130-145
		Clayey gravel or clayey sandy gravel	Good	Poor	Slight to medium	Slight	Poor to practically impervious	Rubber tired equipment, sheepsfoot roller	120-140
	SAND AND SANDY SOILS	Sand or gravelly sand, well graded	Good	Poor	None to very slight	Almost none	Excellent	Crawler type tractor, rubber tired equipment	110-130
		Sand or gravelly sand, poorly graded	Fair to good	Poor to not suitable	None to very slight	Almost none	Excellent	Crawler type tractor, rubber tired equipment	105-120
		Sand or gravelly sand, uniformly graded	Fair to good	Not suitable	None to very slight	Almost none	Excellent	Crawler type tractor, rubber tire equipment	100-115
		Silty sand or silty gravelly sand	Good	Poor	Slight to high	Very slight	Fair to poor	Rubber tired equipment, sheepsfoot roller, close control of moisture	120-135
		Clayey sand or clayey gravelly sand	Fair to good	Not suitable	Slight to high	Slight to medium	Poor to practically impervious	Rubber tired equipment, sheepsfoot roller	105-130
FINE GRAINED SOILS	LOW COMPRESSIBILITY LL < 50	Silts, sandy silts, gravelly silts, or diatomaceous soils	Fair to poor	Not suitable	Medium to very high	Slight to medium	Fair to poor	Rubber tired equipment, sheepsfoot roller, close control of moisture	100-125
		Lean clays, sandy clays, or gravelly clays	Fair to poor	Not suitable	Medium to high	Medium	Practically impervious	Rubber tired equipment, sheepsfoot roller	100-125
		Organic silts or lean organic clays	Poor	Not suitable	Medium to high	Medium to high	Poor	Rubber tired equipment, sheepsfoot roller	90-105
	HIGH COMPRESSIBILITY LL > 50	Micaceous clays or diatomaceous soils	Poor	Not suitable	Medium to very high	High	Fair to poor	Rubber tired equipment, sheepsfoot roller	90-100
		Fat clays	Poor to very poor	Not suitable	Medium	High	Practically impervious	Rubber tired equipment, sheepsfoot roller	90-110
		Fat organic clays	Poor to very poor	Not suitable	Medium	High	Practically impervious	Rubber tired equipment, sheepsfoot roller	90-105
PEAT AND OTHER FIBROUS ORGANIC SOILS		Peat, humus and other	Not suitable	Not suitable	Slight	Very high	Fair to poor	Compaction not practical	-

constantly being built and buried, fill for dressing and repair must be available. Public access to the site must be controlled to minimize health and safety hazards. On projects adjacent to public thoroughfares, gates should be placed across the access road to regulate site use.

o Cell Design and Construction--To estimate the amount of land area required for preliminary planning purposes, the following example is provided:

Solid waste generation = 7.9 lbs/person/day[1)]
Compacted density @ landfill = 800 lb/yd^3
Average depth of compacted solid wastes = 8 ft

$$\text{Generation rate} = \frac{3300 \text{ people} \times 8 \text{ lb/person/day}}{2000 \text{ lb/ton}} = 13.2 \text{ tons/day}$$

$$\text{Volume required/day} = \frac{13.2 \text{ tons/day} \times 2000 \text{ lb/ton}}{800 \text{ lb/yd}^3} = 33 \text{ yd}^3\text{/day}$$

$$\text{Area required} = \frac{(33 \text{ yd}^3\text{/day})(365 \text{ days/yr})(27 \text{ ft}^3\text{/yd}^3)}{(10 \text{ ft})\ (43{,}560 \text{ ft}^2\text{/acre})} = .74 \text{ acres/yr}$$

The actual site requirements will be greater (varies 20 to 40 percent) than the value computed because additional land is required for site preparation, access roads, etc.

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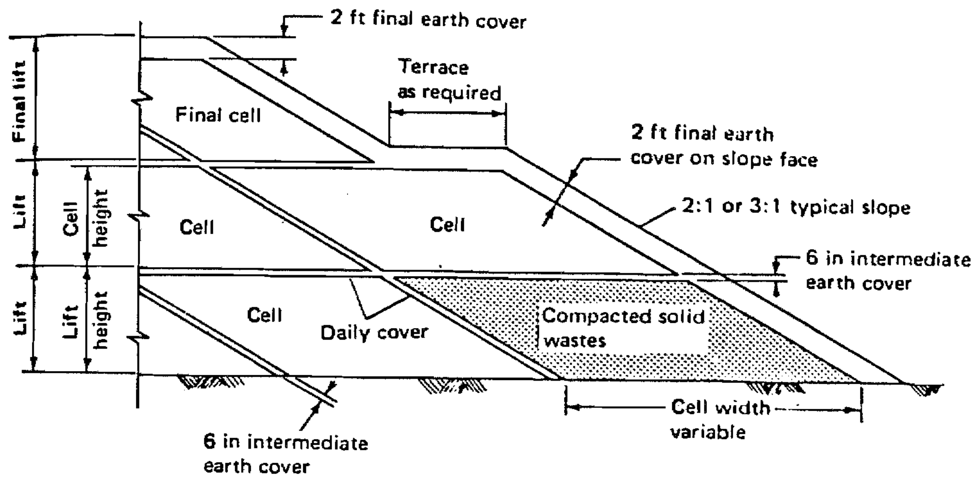
1) Not allowing for incineration/volume reductions.

Once volumes have been estimated and site capacities have been determined, the sequence for filling must be selected. Figure 16 shows a typical filling sequence using compacted solid wastes with an earth cover.

- o <u>Equipment Requirements</u>--The design of the landfill can only be realized using the right equipment and personnel. Equipment should be chosen to fit the plan. Equipment is required for spreading and compaction of solid wastes as well as for excavating and hauling cover materials. On a small site, the operation will probably use one piece of equipment (crawler or rubber-tired tractor with the following accessories: a dozer blade, 1 to 2 yard front-end loader, and trash blade) for the landfill operation with an occasional "assist" from an additional piece of equipment to procure and stockpile cover material. Table 28 provides a guide to the general capabilities of major items of landfill equipment.

- o <u>Fire Fighting Technique</u>--Proper cell construction will prevent underground fires from spreading. When fires occur, the technique most frequently consists of digging out the area and rolling out the smouldering contents. Appropriate fire extinguishers should be carried on equipment at all times.

- o <u>Litter Control</u>--The use of covered vehicles for transport of solid wastes such as paper, cardboard, ashes, etc. is a most effective control of litter. Movable litter fences are required



ALASKA POWER AUTHORITY

SECTIONAL VIEW OF A SANITARY LANDFILL

FIGURE 16

TABLE 28

EQUIPMENT SELECTION GUIDE FOR MULTIPLE UNIT SITES

Purpose		Loader	Dozer	Compactor	Track Scraper	Rubber Tired Tractor Drawn Scraper	Dragline	Backhoe	Truck	Motor Grader
Solid Waste Handling	Spreading	A	A	A	0	0	0	0	0	0
	Compaction	A	A	A	0	0	0	0	0	0
Cover Material Handling	Excavate Cover	A	A	0	A*	A*	A	A	0	0
	Spreading	A	A	A	B	B	0	0	0	B
	Compaction	A	A	A	0	0	0	0	0	0
	Shaping	B	B	B	B	B	0	0	0	A
	Hauling									
	300' or less	A	A	B	A	0	C	C	C	0
	300'-1000'	0	0	0	A	B	C	C	C	0
	More than 1000'	0	0	0	0	A	C	C	C	0

A = Excellent Choice
B = Secondary Choice
C = "In-Combination Only" Choice
0 = Not Applicable or Poor Choice
* = Scrapers may require loading assistance in tough soils and adverse weather conditions.

Source: Eldredge (1975).

at the site when landfills are subject to high winds. The fence, positioned downwind of the working face, will catch airborne trash resulting from the off-loading operation from the open working face prior to cover. Because winds are variable, three or four fences should be provided.

- Unloading Area--To control dumping, the width of the unloading area should be limited to twice the width of the compaction vehicle, or 16 feet. The fill area should be controlled to keep vehicles in safe areas and, where possible, working at the base of the loading face.

3.2.2.2 Advantages and Disadvantages

Advantages and disadvantages of landfill disposal are as follows:

Advantages:

- Most economical method of solid waste disposal if land is available
- Can receive a variety of solid wastes with the exception of toxic and hazardous wastes requiring special disposal procedures
- Flexible; increased quantities of solid wastes can be processed
- Operation is oriented toward typical and readily available construction equipment

Disadvantages:

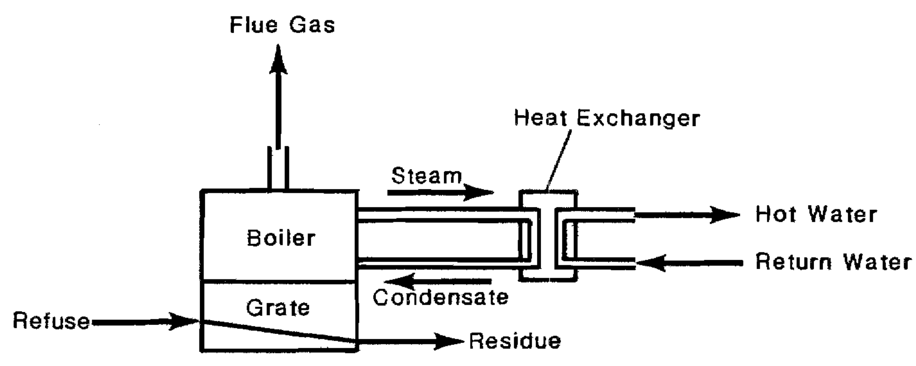
- Site selection limited due to pristine land areas, permafrost conditions, drainage patterns, cover materials, etc.

- Slow biodegradation of putrescibles and organics in Alaska
- Waste segregation control difficult--attracts birds and animals
- Impacts land and water resources
- Cover materials of effective quality may not be available
- Requires daily maintenance covering; may require groundwater or soil monitoring
- Landfill settling requires periodic maintenance
- Stringent permit requirements

3.2.3 Reclamation for Reuse

Many of the constituents of refuse, particularly metals and paper, can be recycled. However, because of the heterogeneous composition of wastes, sorting processes are complex. For many components, the cost of separation and return to market exceeds their value. Power Authority projects, with ancillary camp support, do not lend themselves to mechanical sorting due to the nature of the refuse. However, reuseable wastes could be segregated at the source of generation. Reuse, reclamation and salvage markets must be available for this alternative. Generally, storage and bulk transport of materials in large volumes may offset the high costs of long hauls and make the products more attractive to a buyer.

One option that should be assessed during the development of any incineration plan is energy recovery for heating buildings or water for camp use. Figure 17 depicts a typical schematic for an incinerator with a heat exchanger. In evaluating this alternative, consideration should include



ALASKA POWER AUTHORITY

INCINERATOR FOR ENERGY RECOVERY

FIGURE 17

the high initial costs along with any associated energy savings. The design engineer must also consider that the incinerator will have "down time" and that auxillary sources of energy for any heat recovery use systems must be provided.

3.2.4 Salvage

Salvage materials require additional space for storage either on the solid waste disposal site or at a specially designated site designed for adequate control and access. Salvageable materials known to accumulate at project sites in Alaska are off-road equipment parts, tires, batteries, oil drums, scrap metals and vehicles.

3.2.5 Special Treatment

Construction-related solid wastes are classified under state law as "rubbish". They may include spoil materials, lumber, plumbing and electrical parts, equipment parts, etc. State law requires special treatment for non-processed wastes since the wastes cannot be processed through an incinerator nor should they be mixed with the regular landfill wastes due to their bulk, physical characteristics, etc. which cause voids and improper compaction in a landfill.

State and federal regulations control the disposal of hazardous wastes and to date there are no authorized disposal sites in the State of Alaska. Incineration of these products requires special approval from EPA and ADEC. It is recommended that these solid wastes be stockpiled for recycling, returned to the manufacturer, or transported to an EPA-approved treatment and disposal site in accordance with state and federal regulations. The fuel and hazardous materials BMP manual should be consulted for particular application of hazardous waste requirements.

Special attention must be given to the design of the storage areas for hazardous wastes to comply with applicable federal and state regulations. (Information on design of these storage areas and special handling required by state and federal regulations is contained in the BMP manual on fuel and hazardous materials.) Such areas should be enclosed to control access and be posted for workers' safety. All solid waste personnel assigned to these areas must receive proper training in the handling and transporting of these wastes.

3.3 AT-SOURCE HANDLING

Provisions for handling solid wastes at the source before collection should be included in the design criteria. For large-scale projects, grinding, sorting and compaction will reduce the storage requirements. The types and capacities of the containers used depend on the characteristics of the solid wastes to be collected, and the space available for the placement of containers. Debris boxes, compaction containers, and garbage cans must be located in areas with direct collection truck access. Special considerations for storage areas should be made for sites where heavy snow loads preclude effective transfer of wastes without adequate cover over containers. Putrescible wastes, if stored for collection outside of buildings, must be stored in animal-proof containers. Pressurized cans must be separated from other refuse that will be treated by incineration.

3.4 TRANSPORT OF SOLID WASTES

Collection and transport of wastes can be by covered garbage trucks to prevent waste from escaping from the vehicle, satellite vehicles for easy mobility and access, open dump trucks for discarded equipment and timber, or hauled container systems. Table 29 provides typical data for vehicle selection for large collection systems. Design of the facility must include adequate space allowance for solid waste transport. Transporters should be licensed or authorized to accept and haul the waste material submitted for transport.

3.5 OCCUPATIONAL SAFETY AND HEALTH

A program of worker training must be initiated prior to waste facility operations to provide information and instruction on the waste management plans per design specifications. The training must include information on waste characteristics with particular emphasis on any toxic or hazardous wastes pertinent to the operation. Federal and state law require procedures to protect workers from dust or fumes inhalation; corrosive/dermatitis hazards; physical hazards such as noise, fires, etc.; and mechanical hazards (i.e. vehicular accidents).

The training program should include maintenance requirements, personal hygiene and protection, materials handling, waste monitoring, operational

TABLE 29

TYPICAL DATA ON VEHICLES USED FOR THE COLLECTION OF SOLID WASTES

COLLECTION VEHICLE			TYPICAL OVERALL COLLECTION VEHICLE DIMENSIONS				
Type	Available container or truck body capacities (yd^3)	Number of axles	With indicated container or truck body capacity (yd^3)	Width (in)	Height (in)	Length (in)	Unloading method
Hauled container systems							
Hoist truck	6-12	2	10	94	80-100	110-150	Gravity, bottom opening
Tilt-frame	12-60	3	30	96	80-90	220-300	Gravity, inclined tipping
Truck-tractor trash-trailer	12-50	3	40	96	90-150	220-450	Gravity, inclined tipping
Stationary container system							
Compactor (mechanically loaded)							
Front loading	20-45	3	30	96	140-150	240-290	Hydraulic ejector panel
Side loading	10-36	3	30	96	132-150	220-260	Hydraulic ejector panel
Rear loading	10-30	2	20	96	125-135	210-230	Hydraulic ejector panel
Compactor (manually loaded)							
Side loading	10-37	3	37	96	132-150	240-300	Hydraulic ejector panel
Rear loading	10-30	2	20	96	125-135	210-230	Hydraulic ejector panel

procedures, and record keeping.

The waste management organizational responsibilities, including each worker's role, must be well-defined for effective waste management.

CHAPTER 4 - REGULATORY ANALYSIS

Solid waste management has become increasingly more controlled as public health agencies, conservationists, and concerned citizens have pressed for more government control. The following agencies are delegated responsibility:

Federal

River and Harbor Act of 1899	Department of Defense (COE)
Solid Waste Disposal Act of 1965	Department of Health Education & Welfare
Clean Water Act, Section 404	Environmental Protection Agency
Resources Recovery Act of 1970	Department of Interior
Resource Conservation & Recovery Act of 1976	Environmental Protection Agency
("Cradle to the grave" regulatory requirements and documentation)	
o Toxic Substance Control Act	Environmental Protection Agency
o Hazardous Materials Transportation Act	Department of Transportation
o Occupational Safety & Health Act	OSHA, NIOSH

State

Liquid & Solid Waste Regulations: Dept. of Environmental Conservation

- 18 AAC 60 Solid Waste Management
- 18 AAC 15 Administrative Procedures
- 18 AAC 50 Air Quality Control
- 18 AAC 70 Water Quality Standards
- 18 AAC 72 Wastewater Disposal
- 18 AAC 74 Water and Wastewater Operator Certification and Training
- 18 AAC 75 Oil and Hazardous Substances Pollution Control
- AS 46.04.030 Oil Discharge Contingency Plans

Occupational Safety and Health: Department of Labor

- 8 ACC 61 Occupational Safety and Health

Land and Water Use: Department of Natural Resources

- 11 AAC 53 Easements and Rights-of-Way
- 11 AAC 58 Leasing of Lands
- 11 AAC 93 Water Management
- 11 AAC 96 Miscellaneous Land Use

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