Appendix L

Cost Analysis of Selected Flush Haul Water and Wastewater Systems in Rural Alaska

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prepared for

Alaska Native Health Board Operation & Maintenance Demonstration Project

prepared by

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Contents

1. Introduction....2
2. Cost Estimates for Buckland....3
3. Cost Estimates for Galena....5
4. Cost Estimates for Nunapitchuk....6
5. Cost Estimates for Mekoryuk....8
6. Cost Estimates for Quinhagak....10
7. Cost Estimates for Tuntutuliak....11
8. Comparisons and Discussion....12

1. Introduction

This research memorandum presents and compares estimates of the operating costs of selected flush haul sanitation systems in rural Alaska. The estimates are based on actual operating experience. An accurate picture of operating costs is important when evaluating flush haul systems because communities are generally responsible for paying these costs. People need to know these costs in advance when choosing among alternative systems.

In previous work (Colt 1994) I estimated life-cycle costs for prospective flush haul systems in Buckland and Mekoryuk. These systems have now been operating for several years. In addition, flush haul systems have recently been installed in Galena, Napakiak, Nunapitchuk, Quinhagak, Shishmaref, and Tuntutuliak.

As part of the Alaska Native Health Board Operation and Maintenance Demonstration Project, we collected operating data from the communities of Buckland, Galena, and Nunapitchuk.[1] Additional data for systems in Mekoryuk, Quinhagak, and Tuntutuliak has been collected by others (Yukon-Kuskokwim Health Corporation 1998). This paper therefore considers the six communities listed in Table 1.

Table 1
Summary of Communities Analyzed

Community	Units Served	Year and Data Source
Buckland	36	1997/98, ANHB demonstration project
Galena	97 water, 115 sewage	1997/98, ANHB demonstration project
Mekoryuk	65	1999, YKHC
Nunapitchuk	20	1997/98, ANHB demonstration project
Qunihagak	44	1999, YKHC
Tuntutuliak	37	1999, YKHC

This paper proceeds as follows. I first develop flush haul system cost estimates for each community. Next, I compare the data for the four Yukon-Kuskokwim communities using small haul vehicles (ATVs and snowmachines). Finally, I compare the estimates reported here to my earlier – prospective – cost estimates of operating costs (Colt 1994).

The definition of "cost" is the cost of operating the *delivery and removal* system. It does *not* include the cost of treating the water at the treatment plant. I focus on O&M costs,

[1] We also attempted to collect data from Mekoryuk, Napakiak, and Shishmaref as part of the ANHB Demonstration Project evaluation process. For Mekoryuk and Napakiak, much useful operating data is contained in the final project reports prepared by Cowater International, but these reports lack actual operating cost detail. From Shishmaref, we have detailed data on the allocation of the operator's time between flush haul and honeybucket haul activities, but no detailed financial data against which to compare this time allocation.

since capital costs are generally well determined and were not an objective of this data gathering process. However, I do consider expenses such as depreciation of haul vehicles where data is available.[2]

2. Cost Estimates for Buckland

Between 1993 and 1996, Buckland installed a flush haul system for 36 houses based on Hummer vehicles to haul larger quantities of water and sewage. This technology is feasible because the city sits on hard soils that can support the heavier vehicles. Monthly bills for the system can run to more than $200. In addition some customers have seen their electric bills increase substantially due to increased hot water heating. An additional 48 households were served by a honeybucket haul system as of 1998.

Table 2: Buckland Flush Haul System Summary (circa 1998)

FH System Size:	36	households (HH)	
Other System:	48	HH using HB Haul	
Initial Installation:	14	HH in 1993 (HUD/NIHA)	
Additions:	22	HH in 1996 (PHS)	
System Type:	PHS/HUD "Flush and Hold"		
Fees Charged:	25	$/full tank of water	
	30	$/sewage tank haul	
Late fees:	unknown		
Delinquency rate:	unknown		

The City of Buckland combines the positions of water plant operator, electric plant operator, and water and sewer haulers. The City Administrator uses a 60% allocation factor to assign these pooled utility labor costs to the water and sewer hauling functions, which include flush haul and honeybucket haul. The use of this 60% factor is built in to the monthly haul system cost data reported by the City.

Because of the honeybucket haul operations, it is necessary to break out the portion of total reported hauling costs that should be attributed to the flush haul system. To do this I use the proportion of total households that are served by flush haul and make three additional assumptions about the relative times and frequencies of flush haul (FH) and honeybucket haul (HB) operations. The key assumption is that the average time per honeybucket haul is 50% of the average time for a flush haul sewage haul, because several HB bins can be hauled one after another, while FH hauls are more likely to be "on-demand". With these assumptions I calculate that 60% of total reported water/sewer expenses should be allocated to flush haul services, as shown in Table 3.

[2] Since vehicles depreciate rapidly, they can be legitimately considered an operating cost or a capital cost, depending on one's perspective.

Table 3

Computation of FH share of the total water/sewer function time:	
Assumptions:	
ratio of FH sewer hauls to all sewer hauls:	0.27
ratio of HB haul time to FH sewer haul time	0.50
ratio of FH water hauls to FH sewer hauls	1.00
ratio of FH water haul time to FH sewer haul time	1.00
Results:	
Time breakout in units of FH sewer haul time:	
FH sewer hauls	1.00
Honeybucket sewer hauls	1.33
FH water hauls	1.00
FH time as % of total time	**60%**

Using this 60% allocation factor,[3] the resulting flush haul cost estimates for Buckland are shown in Table 4. The average cost of service is $1,007 per household per year.

Table 4: Buckland Estimated Flush Haul O&M Costs for 36 Houses

Item	total amount	FH share	FH amount	# of households	FH $ per household
Labor	54,608	60%	32,765	36	910
Fuel	1,294	60%	776	36	22
Electricity	-	60%	-	36	-
Equipment	-	60%	-	36	-
Parts	91	60%	55	36	2
Repairs (outside svcs)	4,291	60%	2,575	36	72
Supplies	114	60%	68	36	2
Travel	-	60%	-	36	-
Accounting & Legal	-	60%	-	36	-
Rent	-	60%	-	36	-
Telephone	-	60%	-	36	-
Other	-	60%	-	36	-
Total	**60,398**		**36,239**	**36**	**1,007**

It is important to note that these expenses reflect significant repairs to the Hummer vehicles, although they do not seem to reflect any kind of routine vehicle maintenance.

[3] It is a coincidence that both allocation factors mentioned in this section are equal to 60%.

3. Cost Estimates for Galena

The City of Galena has provided hauled water and sewer service since 1975. As of October 1997 they served about 100 customers with trucked water and about 115 customers with sewer haul.

Table 5

Galena System Summary -- as of October 1997			
Population and Households			
	1990 Census Occupied housing unit:	173	
	1997 occupied housing units	200	
Physical Size of system			
Water			
	HH receiving piped water	28	
	customers receiving hauled water	97	
Sewer			
	holding tanks pumped	115	
	septic tanks	36	
	honey buckets	38	
	outhouses	13	
	Haul system residential customers	160	
	Haul system commercial customers	20	
Rates			
	water delivery	0.075	$/gal
	sewer haul 200 gals	12.00	$/pickup
	sewer haul 1000 gals	45.00	$/pickup
	sewer haul 2000 gals	82.50	$/pickup
Output			
	gallons of water delivered by pipe	70,000	gal/mo
	water delivered by truck	70,000	gal/mo

The City of Galena maintains a well-developed bookkeeping system that allocates direct expenses to hauled water and hauled sewer functions. However, administrative costs for water, sewer, and solid waste are lumped together. I have allocated these admin costs based on the ratio of total haul system direct costs to total utilities (water/sewer/solid waste) direct costs. Table 6 shows the resulting estimates of haul system O&M costs. The average cost of service is $1,085 per household per year.

Table 6: Galena O&M Cost Summary for FY97 and FY98

	FY98 Budget	FY97 Actual	Average	# of cust.	$ per cust.	gallons/ cust/day
Water Delivery						
Labor (mostly operators)	32,961	44,243	38,602	97	398	
Fuel	1,800	2,179	1,990	97	21	
Vehicle repair	1,000	870	935	97	10	
Supplies	200	549	375	97	4	
Insurance	1,700	1,353	1,527	97	16	
Subtotal Water Delivery	37,661	49,194	43,428	97	448	24
Sewer Haul						
Labor (mostly operators)	29,973	32,907	31,440	115	273	
Fuel	1,800	1,626	1,713	115	15	
Vehicle repair	500	485	493	115	4	
Supplies	200	688	444	115	4	
Insurance	1,700	1,353	1,527	115	13	
Subtotal Sewer Haul	34,173	37,059	35,616	115	310	
Administration Cost (allocated)						
Total Direct Haul Operation	71,834	86,253	79,044		757	
Total Direct all non-electric utils	205,724	154,273				
Ratio for allocation of total admin to haul operations	35%	56%				
Allocated Admin Costs	30,126	41,768	35,947			
Total Cost of Haul Service	**101,960**	**128,021**	**114,990**	**106**	**1,085**	

Analysis of utility records revealed that a substantial number of households had reduced their usage to fewer than 10 trips per year. Also, there was a checkerboard pattern of FH use, which may cause average costs of service to be higher than they would be if more people used the service in contiguous blocks of houses.

4. Cost Estimates for Nunapitchuk

A combination of 5 Cowater plus 15 David Nairne FH units were in place in Nunapitchuk during the ANHB data collection period of October 1997 - September 1998. The expenditure data also reflect service to 87 HB haul household accounts.

The charges for service as of 4/98 are $20 for a full tank sewage haul or a full tank water delivery. This represents an increase from $15 per sewage haul as of 8/97.

Joe Sarcone's field notes from 8/97 indicate that the city spent about $3,000 the previous year maintaining boardwalks for FH system use. This expense would be categorized as a labor item according to the list of expense categories used.

Table 7 summarizes the basic system data for Nunapitchuk. The main point to note is that the water and sewer system is a combination of 20 flush haul units *and* 87 honeybucket haul units.

Table 7: Nunapitchuk Flush Haul System Summary

FH System Size:	20	households (HH)	
Other System:	87	HH using HB Haul	
Initial Installation:	5	HH in 1991 (Cowater)	
Additions:	15	HH in 1996 (Nairne)	
System Type:	Cowater (5) and Nairne (15)		
Fees Charged:	20	$/full tank of water	
	20	$/sewage tank haul	
Late fees:	5%	surcharge rate per month on late payments	
Delinquency rate:	10%	after interest rate imposed	

Because of the honeybucket haul operations, it is necessary to break out the portion of reported actual costs that should be attributed to the flush haul system. I use the same method as described above for Buckland. For the Nunapitchuk situation I calculate that about 50% of total reported water/sewer expenses should be allocated to flush haul services, as shown in Table 8.

Table 8:

Computation of FH share of the total water/sewer function time:	
Assumptions:	
ratio of FH sewer hauls to all sewer hauls:	0.19
ratio of HB haul time to FH sewer haul time	0.50
ratio of FH water hauls to FH sewer hauls	1.00
ratio of FH water haul time to FH sewer haul time	1.00
Results:	
Time breakout in units of FH sewer haul time:	
FH sewer hauls	1.00
Honeybucket sewer hauls	2.18
FH water hauls	1.00
FH time as % of total time	**48%**

With the allocation percentage estimated, I now compute the actual expenses for the flush haul system during the study period. The total actual O&M expenses are $768 per household served. This is almost surely an underestimate of the true cost since it does not include any vehicle depreciation, vehicle repairs, or replacement parts. However, some of the reported labor cost may be due to routine vehicle maintenance.

Table 9:
Nunapitchuk Estimated O&M Costs for Flush Haul Service to 20 Households (based on data from 10/97 to 9/98)

Item		total amount	FH share	FH amount	# of households	FH $ per household
Labor		28,225	50%	14,113	20	706
Fuel		1,503	50%	752	20	38
Electricity		323	50%	162	20	8
Equipment		-	50%	-	20	-
Parts		-	50%	-	20	-
Repairs (outside svcs)		60	50%	30	20	2
Supplies		4	50%	2	20	0
Travel		-	50%	-	20	-
Accounting & Legal		-	50%	-	20	-
Rent		-	50%	-	20	-
Telephone		217	50%	109	20	5
Other		391	50%	196	20	10
Total		**30,723**		**15,362**	**20**	**768**

5. Cost Estimates for Mekoryuk

The Mekoryuk flush haul system was one of the first to be installed in Alaska. When data were collected during the first half of 1999 the system comprised 65 Cowater Flush Tank and Haul (FTH) units (YKHC 1999). The Cowater system uses blowers to transfer sewage and greywater from the house to an external holding tank. Sewage and water are hauled in 100-gallon tanks pulled by an ATV or snowmachine.

Table 10 summarizes the Mekoryuk system characteristics. The low number of hauls per unit is perhaps noteworthy. The YKHC report suggests that some customers self-haul their water and others have disconnected their kitchen sink drains from the system so that greywater is manually emptied into outdoor drainage ditches.

Table 10: Mekoryuk Flush Haul System Summary

FH System Size	65	units			
(as of winter 1999)					
System type:	Cowater Flush Tank and Haul (FTH)				
Gallons per haul	100				
Estimated annual water hauls	538	hauls, or:	8	hauls per unit	
Estimated annual sewage hauls	757	hauls, or:	12	hauls per unit	
Fees Charged:	$ 22.50	per 100 gallon tank of water			
	$ 22.50	per sewage haul			

The cost data for the Mekoryuk FTH are not "co-mingled" with other functions due to the accuracy of the survey methods. No allocations of shared operator time are necessary. Table 11 shows the resulting cost estimates.

Table 11:
Mekoryuk Annual Operating Expenses for Flush Haul Service to 65 Units
(based on data from 1/99 to 6/99)

Item		total amount	FH share	FH amount	# of households	FH $ per household
Labor -- water		4,907	100%	4,907	65	75
Labor -- sewage		6,904	100%	6,904	65	106
Fuel		680	100%	680	65	10
Access (snow removal)		9,460	100%	9,460	65	146
Equipment depreciation		1,788	100%	1,788	65	28
Equipment routine O&M		1,278	100%	1,278	65	20
Major Repairs (outside svcs)		-	100%	-	65	-
Supplies		-	100%	-	65	-
Travel		-	100%	-	65	-
Admin, Accounting & Legal		7,625	100%	7,625	65	117
Rent		-	100%	-	65	-
Telephone		-	100%	-	65	-
Other			100%	-	65	-
Total		**32,641**		**32,641**	**65**	**502**
	Total number of hauls			1,295	(538 water + 757 sewer)	
	Average cost per haul			$ 25		

In contrast to Nunapitchuk, the Mekoryuk estimate does include an estimate for depreciation of the snow machine and ATV. The number may be low, however, due to the method used in the YKHC report.[4] A key issue in determining actual depreciation is whether the vehicles wear out over some fixed lifetime independent of the number of hauls they make per year, or whether they wear out in direct proportion to their running time. Only additional years of experience from several communities will be able to resolve this question. However, vehicle depreciation is a minor cost element, accounting for only 6-10% percent of total O&M in Mekoryuk and similar systems.

The other noteworthy cost item for Mekoryuk is snow removal, which costs almost as much in labor time as the actual hauling operations. According to the YKHC report, the Native Village of Mekoryuk requires that customers provide access to their external holding tanks, but since "access" has not been clearly defined, the City currently assumes the responsibility for clearing snow around tanks.

[4] The YKHC methodology starts with a vehicle "design lifetime" (5 years, for example) and assumes that this design lifetime would be achieved under "full-scale" village service (defined as service to all households). They then increase the vehicle lifetime if a system is only serving some portion of the "full scale" number of households. There is no way to judge in advance whether the assumed "design lifetime" or the adjustment for operation at less than "full scale" are valid. Only actual operating experience will provide the data on how fast these vehicles actually wear out.

6. Cost Estimates for Quinhagak

Quinhagak has a Pump and Haul (PH) system designed by David Nairne and Associates. As of June 1999, the system served 44 units. The PH system moves 200 gallons per haul. Table 12 summarizes the Quinhagak system.

Table 12: Quinhagak Flush Haul System Summary

FH System Size	44	units			
(as of winter 1999)					
System type:	Pump and Haul (David Nairne)				
Gallons per haul	200				
Estimated annual water hauls	471	hauls, or:	11	hauls per unit	
Estimated annual sewage hauls	456	hauls, or:	10	hauls per unit	
Fees Charged:	$ 15.00	per 200 gallon tank of water			
	$ 20.00	per 200 gallon sewage haul			

Quinhagak has roughly the same number of hauls per unit as other study villages even though the system provides twice as much volume per haul. Quinhagak also has slightly lower fees *per haul,* which translate to a user fee *per gallon* that is less than half the user fee per gallon in Mekoryuk. The lower fee per gallon is associated with about twice the usage in terms of gallons per unit.

Table 13 shows the estimated annual O&M costs for the Quinhagak PH system.

Table 13:
Quinhagak Annual Operating Expenses for Flush Haul Service to 44 Units
(based on data from 1/99 to 6/99)

Item		total amount	FH share	FH amount	# of households	FH $ per household
Labor -- water		4,634	100%	4,634	44	105
Labor -- sewage		4,130	100%	4,130	44	94
Fuel		555	100%	555	44	13
Access (snow removal)			100%	-	44	-
Equipment depreciation		867	100%	867	44	20
Equipment routine O&M		1,632	100%	1,632	44	37
Major Repairs (outside svcs)		-	100%	-	44	-
Supplies		-	100%	-	44	-
Travel		-	100%	-	44	-
Admin, Accounting & Legal		127	100%	127	44	3
Rent		-	100%	-	44	-
Telephone		-	100%	-	44	-
Other			100%	-	44	-
Total		**11,944**		**11,944**	**44**	**271**
	Total number of hauls			927	(471 water + 456 sewer)	
	Average cost per haul			$ 13		

The average cost in Quinhagak is only $271 per household -- significantly lower than the cost in Mekoryuk. There are two principal reasons for this. First, Quinhagak has no significant snow removal costs. Second, this system apparently uses little or no administrative time to operate the system. Although the YKHC analysis verified the very low amount of admin time devoted to system operation, it is possible that there are significant amounts of time being spent on flush haul work orders and billing by the clerical staff at the IRA Council office.

7. Cost Estimates for Tuntutuliak

In the Native Village of Tuntutuliak, the Tuntutuliak Community Services Association (TCSA) operates a Microflush (MF) system with 37 units as of June 1999. Each haul delivers 130 gallons of water or removes slightly more than 130 gallons of sewage. Table 14 shows the Tuntutuliak system summary.

Table 14: Tuntutuliak System Summary

FH System Size	37	units			
(as of winter 1999)					
System type:	Microflush (MF)				
Gallons per haul	130				
Estimated annual water hauls	642	hauls, or:	17	hauls per unit	
Estimated annual sewage hauls	606	hauls, or:	16	hauls per unit	
Fees Charged:	$17.50	per 130 gallon tank of water			
	$20.00	per 130+ gallon sewage haul			

Note that the Tuntutuliak system is used with almost twice the frequency of the Mekoryuk or Quinhagak systems. There is no obvious reason for this, since the fee per haul is about the same for all systems, and residents can self-haul water from the water plant at no cost in all three communities.

Table 15 shows the annual cost estimate for Tuntutuliak. The average cost per household is $961, almost twice the amount for Mekoryuk. The main reason for this higher number is that the MF system uses two operators per haul, according to the YKHC survey. Other reasons why the estimated cost is higher include the high number of service calls to repair plumbing on the customer's premises and the explicit recognition of routine vehicle maintenance at 8 hours per month of operator time.

Table 15:
Tuntutuliak Annual Operating Expenses for Flush Haul Service to 37 Units
(based on data from 1/99 to 6/99)

Item		total amount	FH share	FH amount	# of households	FH $ per household
Labor -- water		12,626	100%	12,626	37	341
Labor -- sewage		12,879	100%	12,879	37	348
Fuel		216	100%	216	37	6
Access (snow removal)		672	100%	672	37	18
Equipment depreciation		650	100%	650	37	18
Equipment routine O&M		3,544	100%	3,544	37	96
Repairs to Plumbing		1,618	100%	1,618	37	44
Supplies		-	100%	-	37	-
Travel		-	100%	-	37	-
Admin, Accounting & Legal		3,365	100%	3,365	37	91
Rent		-	100%	-	37	-
Telephone		-	100%	-	37	-
Other			100%	-	37	-
Total		**35,570**		**35,570**	**37**	**961**
	Total number of hauls			1,248	(642 water +	606 sewer)
	Average cost per haul			$ 29		

8. Comparisons and Discussion

Comparison of the Four Small Vehicle Systems

As a way of drawing together and summarizing the data, the following two tables present a comparison of the four small vehicle systems operating in southwest Alaska. The operating cost of flush haul service (over and above the cost of providing water at the treatment plant) varies from less than $300 per unit per year (Quinhagak) to almost $1,000 per unit per year (Tuntutuliak).

When cost is measured in terms of gallons of water delivered, it ranges from 13 cents per gallon in Quinhagak to 61 cents per gallon in Mekoryuk. Tuntutuliak residents pay about 43 cents per gallon. Thus, Tuntutuliak residents pay more total dollars per year partly because they have significantly more water delivered. There is not enough data to calculate a per gallon cost for Nunapitchuk.

Table 16:
Comparison of the Four Small Vehicle Flush Haul Systems

	Nunapitchuk	Mekoryuk	Quinhagak	Tuntutuliak
units served	20	65	44	37
Level of Service				
Water				
fees, $ per haul	20.00	22.50	15.00	17.50
hauls per unit per year	unknown	8	11	17
gallons per haul	100	100	200	130
gallons per unit per year	unknown	828	2,141	2,256
Sewage				
fees, $ per haul	20.00	22.50	20.00	20.00
hauls per unit per year	unknown	12	10	16
gallons per haul	100	100	200	130
gallons per unit per year	unknown	1,165	2,073	2,129
Reported Cost of Service				
Direct Labor -- water haul		4,907	4,634	12,626
Direct Labor -- sewer haul		6,904	4,130	12,879
Direct Labor -- snow removal		9,460	-	672
Direct Labor -- plumbing				1,618
****Direct Labor -- Total**	14,113	21,271	8,763	27,795
Fuel & Electricity	913	680	555	216
Equipment depreciation		1,788	867	650
Equipment O&M	30	1,278	1,632	3,544
Admin, Accounting & Legal		7,625	127	3,365
Office Expense & Other	306	-	-	-
Total Reported Cost of Service	**$ 15,362**	**$ 32,641**	**$ 11,944**	**$ 35,570**
Cost per Unit per Year	$ 768	$ 502	$ 271	$ 961

Table 17:
Cost of Service per Unit and per Gallon

	Nunapitchuk	Mekoryuk	Quinhagak	Tuntutuliak
Cost Per Unit Per Year Breakdown				
Direct Labor	706	327	199	751
Equipment (Fuel, O&M, Depr)	47	58	69	119
Admin & Office	15	117	3	91
Total Cost per Unit per Year	**$ 768**	**$ 502**	**$ 271**	**$ 961**
Total Flush Haul Cost per Gallon of Water Delivered				
Gallons water per Unit per Year	unknown	828	2,141	2,256
Total Cost per Gallon (of water deliver	unknown	$ 0.61	$ 0.13	$ 0.43

Figure 1:

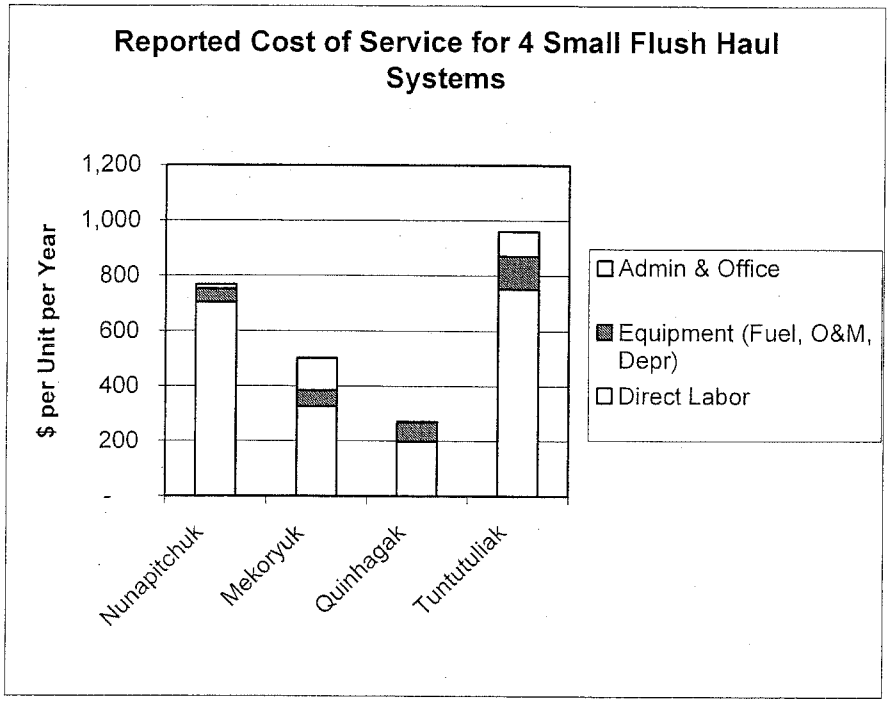
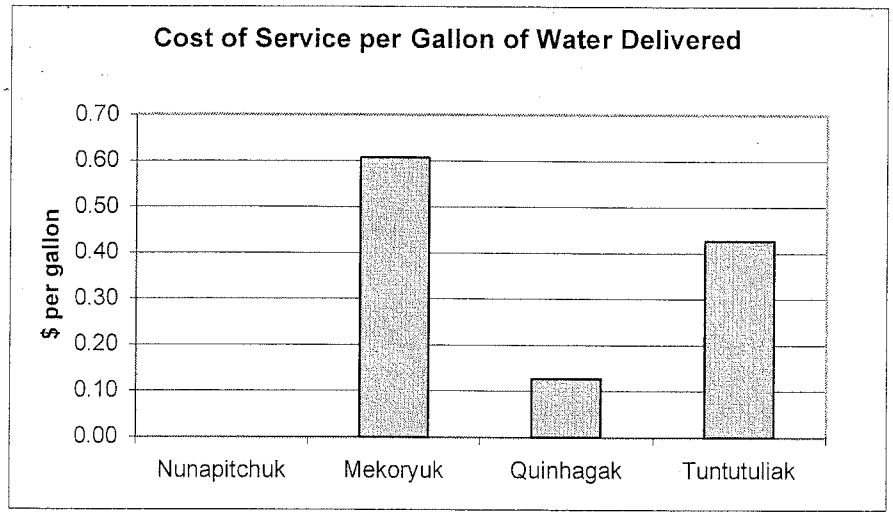


Figure 2:



Comparisons to Previous Estimates

Buckland. In a previous paper (Colt 1994) I estimated life cycle costs for three possible systems that were contemplated or just entering service in 1994. I concluded that the average annual O&M cost for a Buckland-type truck haul system would be about $1,435 per household. This compares with a figure of $1,007 estimated here from actual data. Since the actual data may be skimping on vehicle maintenance expense, I believe the two estimates are reasonably close. The 1994 estimate was for a system serving all 84 houses in the village, while the data used here reflect only 36 houses.

Other Communities -- Small Vehicle Systems. In 1994 I estimated the annual O&M for small vehicle flush haul system to be about $2,000 per household per year, of which about $1,600 was for direct labor.

The cost data presented here for the four small vehicle systems suggest that *due to reduced demand for the service*, annual labor costs range between $300 and $750, or less than half of the projected amounts. The Nunapitchuk data reported above include very little provision for vehicle maintenance or replacement. Applying the allowances for these items that were estimated in 1994 to the actual data on labor costs yields a revised estimate of about $1,200 per household per year for Nunapitchuk. The Quinhagak data shows almost zero cost for administration and billing. Adding in a reasonable estimate of $200 per unit per year would increase the Quinhagak cost up to about $500 per unit per year.

The main conclusion from the detailed studies of actual usage conducted by YKHC is that many people apparently prefer to self-haul their water and/or directly empty their greywater to keep their monthly bills down. Under this arrangement, the people still receive many of the health benefits of the flush haul system, such as isolation from raw sewage. The cost per unit served of the system may be higher than necessary due to diseconomies of small scale. But if the key cost element – labor – is paid for on an hourly basis based on actual deliveries, then this cost can be kept down if the demand for service is low. Unfortunately it is not possible to tell from the YKHC data whether the subject communities are in fact paying their operators for actual deliveries or for some flat amount of time. Flexibility in labor use appears to be the key to keeping costs down for the flush haul systems examined here.

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