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DEPT. OF HEALTH AND SOCIAL SERVICES

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INFECTIOUS DISEASES
AIDS/STD
TUBERCULOSIS
IMMUNIZATION 561-4406
CHRONIC DISEASES
DIABETES
INJURY CONTROL

SKAGWAY ALASKA GATEWAY TO THE KLONDIKE

Health Hazard and Risk Assessment

from

Exposure to Heavy Metals in Ore

in

Skagway, Alaska

Final Report

October 23, 1989

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Health Hazard and Risk Assessment
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Introduction

We evaluated the exposure of Skagway residents to heavy metals and especially to lead, beginning our investigation in September 1988. In November 1988 and September 1989, residents participated in voluntary blood test programs to measure levels of lead and erythrocytic protoporphyrin. Results of the 1988 investigation, conducted in conjunction with the national Centers for Disease Control, were reported in several interim reports, the last published on December 20, 1988. This report presents the results of the blood testing done in September 1989 and our final findings and recommendations.

Background

Skagway, Alaska (population 712) is an historic town dating from the Alaskan gold rush days of the 1890s. Situated at the mouth of the Skagway River in a small valley at the northernmost end of Alaska's inland passage, the town is only 5 blocks wide and one mile long. It is the only seaport serving the vast Canadian Yukon Territory, and lead and zinc ore shipments from the Yukon Territory are a major contributor to the town's economy.

Between 1967 and 1982, ore was transported to Skagway by railway freight cars; starting in 1985 it was transported by truck. Ore trucks from the Yukon Territory arrived in Skagway approximately every 30 minutes, 24 hours a day, 362 days a year. The ore is stored in a large warehouse on the dock at the edge of town and loaded onto ships for transportation to overseas ore smelters. Empty ships arrived approximately every 14 days, were filled with ore over a two to three day period, and then departed. Reportedly, it was common in the past for workers at the warehouse to sweep ore off the dock into the harbor. Also, many residents observed windblown ore spread around the warehouse site and into the adjacent southern part of town.

Prior to being transported to Skagway, ore undergoes a process called "concentrating." This process involves wet grinding to a small particle size, conditioning the slurry to establish the proper alkalinity, and then mixing with floatation chemicals to collect the lead and zinc bearing minerals in a concentrate. The concentrated ore transported through, and stored in, Skagway has approximately the consistency of gritty talcum powder. The lead ore concentrate contains up to 62% lead, primarily as lead sulfide (galena, PbS).

In 1987, the operator of the ore warehouse hired a private environmental engineering firm to evaluate the extent of environmental ore contamination both at the warehouse and in the town of Skagway. In 1988, this firm reported the results of surface soil sampling done throughout Skagway to state health and environmental agencies. These results indicated that lead was present in large amounts not only around the warehouse but also in many residential areas of town.

Environmental sampling results provided by the engineering firm found concentrations of up to 60,000 ppm (6% lead) in the immediate vicinity of the ore warehouse. Elevated lead levels were found along the railroad tracks and State Street, the principle routes used to transport ore through Skagway. Arsenic (160 ppm), mercury (122 ppm), and cadmium (300 ppm) were found in the ore in lesser amounts. Samples from street gutters along State Street measured as high as 28,000 ppm lead, however, 60% (12 of 20) of soil samples collected five feet from the road contained less than 1,000 ppm lead. Evidently, ore did not travel far from the road surface despite the constant physical disturbance. Most soil samples taken on residential property contained less than 500 ppm lead.

Skagway has no resident physician. A community clinic is staffed by two certified physician assistants who are assisted as necessary by nurses and local citizens certified as emergency medical technicians. These health care providers are supervised by a physician in the town of Haines, Alaska, about 20 miles across the inland passage. An itinerant public health nurse makes periodic visits to conduct well baby clinics, provide routine immunizations, and offer other services. Patients with more complex problems can be seen when the doctor visits from Haines or are transported to a hospital in Juneau, Alaska or Whitehorse, YT depending on the severity and urgency of the problem. No cases of childhood lead poisoning have ever been reported from Skagway.

Under the supervision of both the Alaska Department of Labor and the federal Occupational Safety and Health Administration, ore warehouse workers were routinely monitored for elevated blood lead concentrations. However, children and non-occupationally exposed adults of Skagway had not been systematically tested for abnormal blood lead levels prior to November 1988.

Methods

Laboratory analysis: Blood samples were analyzed for lead concentration and erythrocytic protoporphyrin concentration by ESA Laboratories, 43 Wiggins Avenue, Bedford, MA 01730. This laboratory was selected to analyze all 1989 samples because they analyzed the blood samples collected in November 1988.

We collected two blood samples from 60 persons and submitted the duplicate samples blindly to ESA Laboratories as a way to check on the validity of the results and to have a way to estimate variation in sample results.

We asked residents who had blood drawn in November 1988 to come in for retesting in September 1989. We phoned individuals who had higher blood lead (>15 ug/dl) and erythrocytic protoporphyrin (>35 ug/dl) levels and especially encouraged them to be retested. Of 29 persons we contacted and encouraged to be retested, 20 (69%) were retested. All participation in testing was voluntary, and we tested any person who requested to be tested.

Population studies of blood lead concentrations have shown that lead concentrations have a skewed distribution. Therefore, overall blood lead concentrations for a population studied are generally described using geometric means rather than arithmetic means. Both means were presented in the NHANES II published technical document ("Blood Lead Levels for Persons Ages 6 Months - 74 Years: United States, 1976-80." Data from the National Health and Nutrition Examination. Vital and Health Statistics, Survey Series II, No. 233. National Center for Health Statistics. J L Annest and K Mahaffey. August 1984). We have presented both arithmetic means and geometric means in this report.

Results

In September 1989 we drew blood from 167 residents of Skagway. We were not able to report results on three people because of low specimen volume or labelling problems. Of the 164 residents for whom we have results, 48 were 0-18 years old, and 116 persons were older than 18 years. Results of the blood lead tests are shown in Figures 1-3 and Tables 1 and 2.

- Of 48 children tested, none had blood lead levels exceeding 15 ug/dl.
- Of 116 adults, only one employee working at the ore terminal had a blood lead level higher than 21 ug/dl. The worker's level, 28 ug/dl, was well below the OSHA worker monitoring level of 40 ug/dl.
- The geometric mean blood lead level for all 164 residents was 6.75 ug/dl, and the arithmetic (7.85 ug/dl) and geometric means were similar.
- The distribution of blood lead levels showed that all children and 94% of adults had blood lead levels at or below 15 ug/dl.
- Only 9 (5%) of 164 residents had erythrocytic protoporphyrin (EP) levels exceeding 35 ug/dl.

Of the 164 residents tested in September 1989, 49 were tested in November 1988. The results of both tests for these 49 individuals are shown in Figures 4 and 5 and Table 3.

- The arithmetic means of the differences between the 1988 and 1989 blood lead levels for each of the 49 individuals who had tests results for both 1988 and 1989 ranged in absolute value from 0.125 to 2.173 ug/dl with large standard deviations. These means of the 1988 - 1989 differences in blood lead levels are not larger than what we expect by chance and are not statistically different from zero. The mean differences (0.125 to 2.173 ug/dl) are smaller than the expected variation in values reported by the laboratory (6 ug/dl).

- The actual blood lead levels for the 49 individuals tested in 1988 and 1989 are shown in Figures 4 and 5.

- At our request, ESA provided actual numbers for low blood lead levels even though the lower limit of accurate determination of blood lead is 5 ug/dl. As shown in Figures 4 and 5, there is no consistent pattern of increase or decrease in blood lead levels for the group as a whole or by age group.

- Blood lead levels above 20 ug/dl are from ore terminal employees.

- Mean blood lead levels of the 49 individuals tested in November 1988 and September 1989 show no significant difference.

We compared blood lead levels in individuals who were tested both in November 1988 and September 1989 according to location of residence (Figure 6). There were no significant differences in changes among the residents living close to high environmental lead levels compared to residents living far from areas with high lead levels.

Of six children whose parents were ore terminal workers in November 1988 and who were retested in September 1989, five children had lower levels and one no change. All had blood lead levels less than 15 ug/dl.

Of six children who had blood lead levels greater than 15 ug/dl in November 1988 and were retested in September 1989, all had lower blood lead levels in 1989, and none had a blood lead level in 1989 higher than 15 ug/dl.

We are providing for comparison the data from the tests we conducted in November 1988 (Figures 7-9). The description and discussion of the November 1988 data can be found in our previous report. (Interim Report No. 3: Skagway Heavy Metal Investigation, December 20, 1988).

We compared the distribution of blood lead levels among Skagway residents to those found in the national NHANES II survey. We tested 158 Skagway residents in November 1988 and 164 in September 1989. Of those tested in 1989, 49 were also tested in November 1988. Therefore, we have blood test results from 273 Skagway residents. We have combined these data in Figures 10 and 11 and as part of Table 4. The NHANES II study did not breakdown the national data into ranges of blood lead levels smaller than those shown in Table 4.

- Nationally, only 22.1% of the 9,933 persons tested had blood lead levels less than 10 ug/dl compared to 78.4% of Skagway residents.

- Nationally, 85% of those tested had blood lead levels less than 20 ug/dl compared to 97.4% of Skagway residents.

- Except for ore terminal workers, all Skagway residents had blood lead levels of 20 ug/dl or less.

- In 1989, all Skagway children tested had blood lead levels of 15 ug/dl or less.
- Lead levels by percentile of the population sampled show that Skagway residents have much lower lead levels than the U.S. population tested in the NHANES II survey.

We also determined levels of erythrocytic protoporphyrin (EP). Of the 164 residents tested in September 1989, only 9 had EP levels greater than 35 ug/dl. (Table 2).

We evaluated individually the results of every resident tested in September 1989 who had a blood lead level greater than 15 ug/dl or an EP level greater than 35 ug/dl.

- Only one person had both an elevated blood lead and EP, an ore terminal employee being monitored in accordance with OSHA approved medical surveillance and industrial hygiene standards.
- No children had blood lead levels above 15 ug/dl.
- Two children had elevated EP levels, but their blood lead levels both were 3 ug/dl. Arrangements have been made with their medical care provider for further evaluation to determine the cause of their elevated EP levels.
- Seven adults were found to have elevated EP levels. Two were ore terminal workers. The remaining five all have blood lead levels less than 10 ug/dl. Arrangements have been made with their medical care provider for further evaluation to determine the cause of their elevated EP levels.
- Of the 273 Skagway residents who have been tested, none who have not been occupationally exposed have been found to have any symptoms, illnesses, or abnormal tests after medical evaluation that can be shown to have been caused by lead.

Of the 712 Skagway residents, 273 (38%) now have been tested including 84% of children aged 0-5 years and 73% of children 6-18 years (Table 5).

As a check on the accuracy of the laboratory, we drew two tubes of blood from 60 of the 164 Skagway residents who we tested in September 1989. Each of these duplicate tubes was given a unique code number before being sent to the laboratory. The results of the analysis of these duplicate specimens showed a very high level of accuracy, overall (Figure 12). For all 60 specimens, the mean difference between the two specimens was 0.25 ug/dl. However, as shown in figure 9, in some cases there were reported differences as high as 6.0 ug/dl.

Discussion

We tested 158 Skagway residents in November 1988 and 164 persons in September 1989.

Of those tested, 49 were tested both times, and 273 different people have now been tested. Because many different people were tested in 1988 compared to 1989, we cannot directly compare 1988 and 1989 results. For example, when we returned to Skagway in September 1989, we brought a list with the names of all persons who had a blood lead level of 15 ug/dl or higher or an erythrocytic protoporphyrin level of 35 ug/dl or higher. We phoned these people and made every effort to retest them. Therefore, we selectively encouraged individuals to be tested who were more likely to have higher blood lead levels. In addition, we tested more children in November 1988 (115/158, 73%) than in September 1989 (48/164, 29%). Even with these limitations, 1988 and 1989 results show similar patterns. Overall, the results show no significant change in blood lead levels.

Because we were able to retest 49 individuals, we compared their test results in detail. When we compared 1988 and 1989 matched results, there was no significant change in blood lead levels overall for the group of 49 or broken down into three age groups.

Measuring blood lead and erythrocytic protoporphyrin at very low levels is difficult. The lower limit of accurate laboratory detection is 5 ug/dl, and results routinely are reported as less than 5 ug/dl. The laboratory can report actual values down to less than 1 ug/dl and did so at our request. However, there is quite a bit of variation in values reported at levels less than 5 ug/dl, and there may be no real difference between a value of 1, 3, and 5 ug/dl.

To evaluate laboratory performance, we submitted blind duplicate specimens. Overall, the agreement was very high, but in a few instances values reported varied by up to 6 ug/dl. This variation is to be expected. Differences in any one individual's test results may be up to 6-8 ug/dl as a reflection only of laboratory variation while the true blood lead level in the person has not changed.

Several issues have been discussed widely leading to controversy about the validity of our findings, conclusions, and recommendations. Some of this controversy has been generated by erroneous statements from outside "experts" who have not reviewed the data available and who have only had a superficial understanding of Skagway and the community's exposure to the ore.

Much debate has centered around the question of whether people, and especially children, can suffer adverse health effects from exposure to lead at blood lead levels below 10 ug/dl. This question cannot be answered by tests or studies in Skagway. Research studies conducted during the past 5-10 years have raised the possibility that various subtle effects on health may occur at these very low levels, but the significance of these studies is not settled within the scientific community because it is extremely difficult to measure subtle health effects and low blood lead levels. It may be many years before researchers are able to define health risks at very low blood lead levels (less than 25 ug/dl).

We believe an ideal blood lead level is zero. But lead is ubiquitous. There are many sources. Our main goal in the Division of Public Health is to determine if the ore operations contributed to high level of lead and a serious public health threat to Skagway residents. This we believe we have been successful in determining.

Although lead ore has been present for many years, the residents of Skagway have blood lead levels well below most residents of the United States. In fact, levels found are those expected from communities considered to be located in pristine environments. For example, the NHANES II study showed that only 22% of those tested in a national survey of 9,933 people had blood lead levels below 10 ug/dl, compared to 78% of those tested in Skagway.

Because of recent concerns that blood lead levels below 25 ug/dl, the level currently accepted for screening, may result in adverse health effects, the national Centers for Disease Control is now in the process of reconvening a committee of experts to examine all scientific knowledge and to make recommendations about the level of blood lead recommended for screening. There is no way to know what the committee will recommend. The committee is expected to be appointed in 1989, to meet early in 1990, and to develop recommendations for release in the summer of 1990. Some experts believe the committee will recommend lowering the screening level to 15 ug/dl while others believe the committee will not change the current standard.

Regardless of the level set by the national committee, the level set is one used to screen for exposure to lead. If a child is screened and the blood lead level is above the value established (now, 25 ug/dl), the result indicates a need to investigate further. A finding of blood lead above 25 ug/dl does not, necessarily, prove a need for medical intervention. A key step in medical evaluation is to measure erythrocytic protoporphyrin (EP) as a way to measure an effect of lead in the body. Taken together, blood lead levels and EP levels provide very important information about the status of an individual. But, these two results are not enough. In order to assess the significance of the levels, it also is important to have information about exposure to lead. When this information is obtained, as it has been in Skagway, then it is possible with a high level of confidence to draw conclusions about exposure, body burdens, and the potential for adverse health effects.

Several individuals expressed concerns that tests done in November 1988 did not accurately represent exposures and blood lead levels of residents. They insisted that repeat tests be done because one test would not reflect exposures. Results of the September 1989 tests confirm the findings of the November 1988 assessment. This was expected because chronic exposure to lead leads to accumulation and deposition of lead in the body (body burden). After chronic exposures have led to increased body burdens, then blood lead and EP elevations fall only slowly over time after continued exposure stops. For example, lead is deposited in skeletal bone. If all further exposure ceases, lead is mobilized from bone and excreted over a period of many years with a half-life in adults of 10-20 years and a half-life in children of 7-10 years. If lead is absorbed into the body and reaches levels high enough to result in impaired synthesis of hemoglobin, then levels of erythrocytic protoporphyrin begin to rise. Once EP levels have risen as a result of exposure to lead, it takes 3-4 months for EP levels to return to normal after lead exposure ceases.

Because we were assessing community-wide chronic exposure, the combination of blood lead and EP tests done in November 1988 accurately reflected the communities exposure to lead. The results from the retesting in September 1989 confirm our November 1988 findings.

Concern also focused on the bioavailability of lead. This controversy arose because of an erroneous statement made in a technical report ("Technical Considerations Involved in Setting Cleanup Levels for Skagway, Alaska," Ref: TDD: T10-8812-001, Ecology and Environment, Inc., Priscilla Anderson, April 18, 1989) prepared by a contractor for the EPA. The report erroneously states (p.11): "The specific identity of an inorganic lead compound has little influence on its bioavailability or toxicity."

Numerous studies have documented the widely different solubility and bioavailability of different forms of lead, and have also documented a strong relationship between particle size and bioavailability and solubility. Lead ore in Skagway is of very low solubility, low bioavailability, and likely is of large particle size.

The community of Skagway, the companies involved in transportation of heavy metal bearing ore, the Alaska Department of Environmental Conservation, and the EPA have apparently arrived at a mutually agreed upon strategy for cleaning up the industrial areas that were heavily contaminated by lead. Concentrations of lead in soil have been agreed upon to provide an objective standard to monitor and evaluate the effectiveness of clean up efforts.

Great energy has been invested in establishing appropriate clean-up measures, procedures, and target levels. Agreement has been reached between responsible parties regarding clean-up of the industrial areas. Recent discussions have turned to issues pertaining to residential areas including clean-up of outside soil and dust and ore inside houses and buildings.

We believe it important to define explicitly the goals of clean-up before further decisions are made regarding establishing additional clean-up levels, if any. Ultimately, the extent of clean-up will be determined by an individual decision of each Skagway resident and a legal decision reached by the city of Skagway, the companies involved, and state and federal agencies. We believe it essential at this point to separate public health issues from clean-up issues.

All evidence establishes the low risk to health from ore in Skagway. What little risk exists may be reduced a slight amount by clean-up activities currently being implemented. But the establishment of clean-up levels for residential areas, house dust, vegetables, etc., should not be based on simply extrapolating computer model calculations developed from investigations in other places where exposures were very different. We cannot rely on further environmental sample test results in Skagway to add valuable information to help with further decisions on clean-up.

Even the EPA contractor, Ecology and Environment, Inc., acknowledges that Skagway's situation is unusual. "Most sites involving lead contamination are associated with a mine and/or smelter, or a battery recycling operation. All of the sites identified by TAT fall into these categories. Sites involving only ore concentrate, such as the case in Skagway, are unusual." (p.9). Unfortunately, the report then goes on to review studies of sites that involved different types of lead exposures (i.e., smelters and battery recycling operations) and extrapolates from them recommendations for Skagway clean-up levels. This approach has led to much anxiety, confusion, frustration, and misunderstanding.

The definitive tests to evaluate health risks from lead involve determining actual exposure, absorption, and effects of lead in residents of Skagway. This has been done. The results should be very reassuring to everyone.

The absence of high blood lead levels and documentation of low health risks should not result in complacency. Removal of ore is feasible and may lower slightly the amount of lead absorbed by individuals. Each person needs to decide how much exposure to ore is acceptable to him, her, or their children. Each person needs to evaluate the results of all available information in order to be able to make the most informed decision possible so they have a high level of comfort with their decision.

But, reliance on further environmental sample test results will not provide meaningful data to assist in these decisions. Many sample results may not be able to be interpreted. For example, several samples of lettuce recently were tested, and several samples had high levels of lead. But, these data are of little value. The levels of lead in lettuce were established elsewhere as standards based on certain assumptions about the form and bioavailability of the lead as a result of investigations of communities exposed to smelters that had very high levels of blood lead. If a few samples of lettuce from Skagway show elevated lead levels, should people stop eating lettuce? People in Skagway have been eating home grown fruits and vegetables for many years, but their lead levels are very low.

How much effort should be expended to clean up ore and dust from inside homes? Again, this must be an individual decision. A few studies in communities with high blood lead levels caused by exposure to lead from smelters have documented that meticulous cleaning can reduce lead levels in house dust with the greatest reduction immediately after wet-mopping. However, lead levels rise soon after. Only over many months did house dust levels fall, and the levels did not fall to background. Important to know is that the lead in these studies consisted of highly bioavailable forms of lead primarily introduced into the homes and the community from airborne routes from smelters.

In Skagway, lead is of low bioavailabilty. This means that if ore is ingested, almost all of it will be excreted in the feces. Only a tiny amount of lead in the ore in Skagway, if any, gets absorbed through the intestine into the blood stream. We believe that lead ore also is of large particle size. This is important because studies have documented that both solubility of galena (PbS) and bioavailability are greatly affected by particle size. The larger the particle size, the lower the solubility and bioavailability of the lead. Especially important is that the larger particles cannot remain airborne so they are not widely dispersed; they fall rapidly to the ground so they are not inhaled into the airways. Absorption (and, therefore, bioavailability) of lead is greater from the respiratory tract through inhalation than from the gastrointestinal tract from ingestion.

For these reasons, we believe that further environmental sampling of residential soil and house dust is not necessary or useful. We recommend that residents of Skagway simply follow common sense measures in cleaning homes and vegetables. It is unlikely that any test results of vegetables, residential soil, or house dust will make any difference to clean-up measures recommended for individuals. In fact, the expectation that further test results can assure a higher level of health protection is misplaced.

Final decisions about further clean-up and further use of environmental tests must rest with Skagway residents, as individuals and as a community. But no further benefits to health can be anticipated from more testing of environmental samples.

Conclusion

Based on the results of all tests and findings, the community of Skagway does not have a serious health problem from lead. The contribution to the body burden of lead from the ore is minimal. Risk from exposure to lead ore cannot be said to be zero, but the contribution from ore to the body burden of lead among Skagway residents is so low as to constitute no basis for public health concern.

- For the community of Skagway as a whole, mean blood lead levels in 1988 and 1989 are similar. No change has occurred in overall blood lead levels of the community.

- All children tested in 1989 have levels of 15 ug/dl or below.

- The mean blood lead levels of children and adults are similar to those found in pristine, rural communities with low lead exposures.

- No Skagway resident who is not a worker at the ore terminal has evidence of any abnormal effect from blood lead as determined by results of blood lead levels and EP levels. We have made arrangements for further evaluation to determine the cause of the elevated EP levels in seven individuals who have high EP levels not caused by lead.

- There were 8 children tested in November 1988 who had blood lead levels greater than 15 ug/dl. All 6 who were retested in September 1989 had levels of 15 ug/dl or less.

- Even prior to institution of environmental clean up efforts, blood levels of Skagway residents from November 1988 documented that there was not a serious public health hazard.

No further environmental samples "on demand" are warranted. Without a systematic research plan and detailed research design, results from such samples cannot be meaningfully interpreted and serve no useful purpose. There is no useful purpose to be served by testing further samples of house dust, vacuum bag material, home grown produce, etc.. Results will not be useful in assessing effectiveness of clean up efforts and have little value to individuals. In view of the low blood levels in the community, it is very unlikely that all exposures to lead could be determined, and measures to reduce exposures to lead would not be different from those already recommended.

Decisions on how much to clean or what to eat or where to play are personal ones. What is critical is to know that risk of adverse health effects is very small and the amount of reduction of risk from extensive personal efforts to reduce lead will be so small as not be able to be measured.

The findings and recommendations of the Alaska Division of Public Health and national Centers for Disease Control as published in our report of December 20, 1988 are confirmed and strengthened by the results of the September 1989 blood tests.

Recommendations:

Common sense measures recommended in December 1988 will help reduce exposure to ore. These measures include:

- Clean up of ore terminal operations, frequent street cleaning, and washing of ore trucks as is being done;
- Attention to simple personal hygiene and housekeeping practices such as
    - increased emphasis on hand washing,
    - wet mopping and dusting with a dampened cloth inside homes, and
    - removing street shoes at the door; and
    - rinsing of locally grown vegetables to remove surface dirt; and
- Good nutrition through a well balanced diet with adequate amounts of iron, calcium, and vitamins.

Further environmental sampling should be done as needed to monitor compliance with the existing clean up program.

Acknowledgments

We are very grateful for the tremendous cooperation and assistance we have been given by the residents of Skagway. We appreciate their patience and understanding as we have worked together to learn and share information about the health impacts related to the ore.

Table 1. Skagway residents tested in September 1989
164 People tested
Blood Lead Levels (ug/dl)

Age Group	N	Arithmetic Mean	Geometric Mean	Range
0 - 5 yrs	13	8.769	8.311	6 to 15
6 - 18 yrs	35	8.057	7.226	2 to 15
> 18 yrs	116	7.681	6.464	1 to 28
Total	164	7.848	6.753	1 to 28

Table 2. Skagway residents tested in September 1989
N=164

Blood Lead
(N, Column %)

Blood Lead Levels (ug/dl)	Children (0 - 18 yrs)	Adults (> 18 yrs)	Total
0-10	37 (77.1)	95 (81.9)	132 (80.5)
11-15	11 (22.9)	14 (12.1)	25 (15.2)
> 15	0 (0.0)	7 (6.0)	7 (4.3)
Total	48	116	164

Erythrocytic Protoporphyrin (EP)
(N, Column %)

EP Levels (ug/dl)	Children (0 - 18 yrs)	Adults (> 18 yrs)	Total
0-35	46 (95.8)	109 (94.0)	155 (94.5)
> 35	2 (4.2)	7 (6.0)	9 (5.5)
Total	48	116	164

Table 3. Skagway residents tested both in November 1988 and September 1989
Arithmetic Mean Blood Lead Levels (ug/dl)

		1988	1989	(1989–1988)	
Age Group	N	Mean	Mean	Difference	Standard Error
0 - 5 yrs	10	7.180	8.900	1.720	7.604
6 - 18 yrs	24	8.292	8.167	-0.125	5.375
> 18 yrs	15	7.760	9.933	2.173	4.357
Total	49	7.902	8.857	0.955	5.603

Table 4. Distribution (%) of Blood Lead Levels

	Blood Lead (ug/dl)				
	< 10	10 - 19	20 - 29	30 - 39	40+
SKAGWAY:					
Combined (N=273)	78.4	19.0	1.8	0.4	0.4
1988 (N=158)	80.4	14.6	3.8	0.6	0.6
1989 (N=164)	68.9	29.3	1.8	0.0	0.0
NHANES II (N=9,963) 1976-1980	22.1	62.9	13.0	1,6	0.4

Distribution (%) of Blood Lead Levels

	Blood Lead (ug/dl)					
	0-10	11-15	16-20	21-25	26-40	>40
1988 (N=158)	81.7	6.3	7.6	2.5	1.3	0.6
1989 (N=164)	80.5	15.2	3.1	0.6	0.6	0.0

Table 5. Proportion of Population Tested

Age Group (years)	Number Tested	Population	Percent Tested
0 - 5	31	37	83.7
6 - 18	98	135	72.5
> 18	144	540	26.7
Total	273	712	38.3

Figure 1 Blood lead levels for Skagway residents
September 1989
(N = 164)

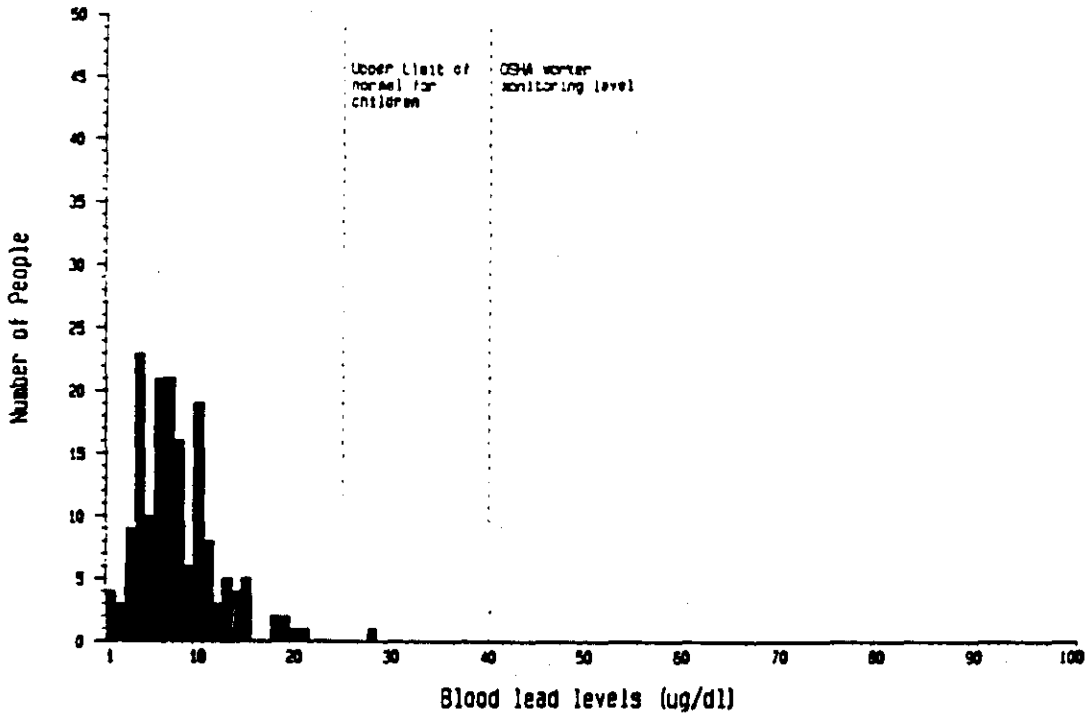

Figure 2 Blood lead levels for Skagway children (Ages 0-18 years)
September 1989
(N = 48)

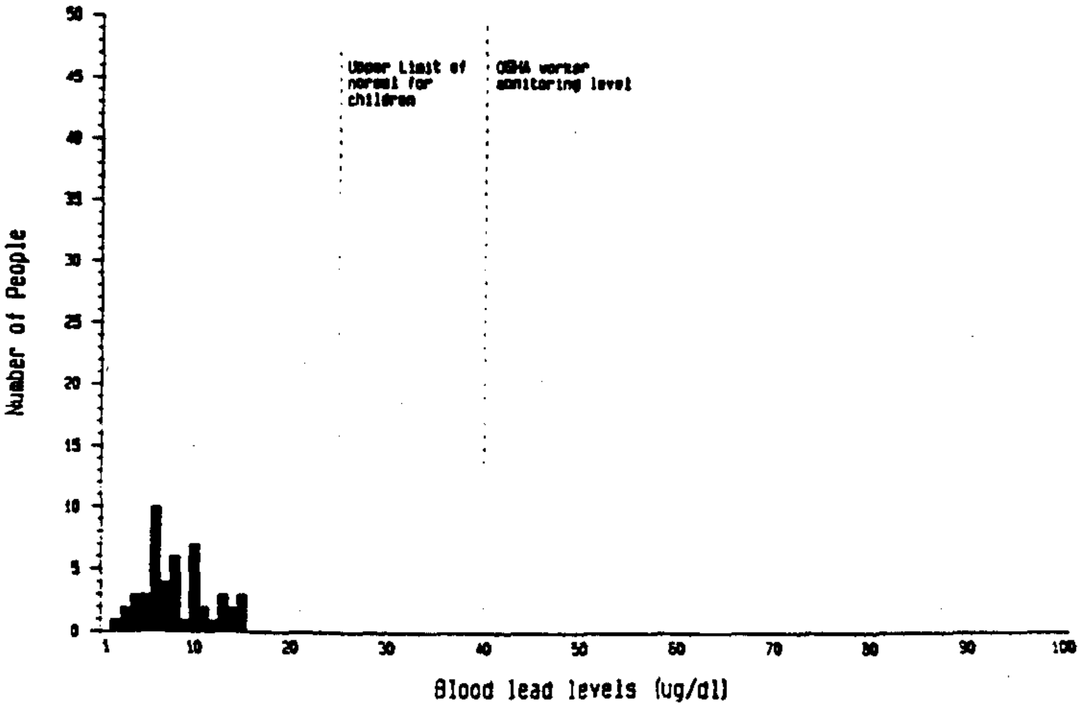

Figure 3 Blood lead levels for Skagway adults (Ages > 18 years)
September 1989
(N = 116)

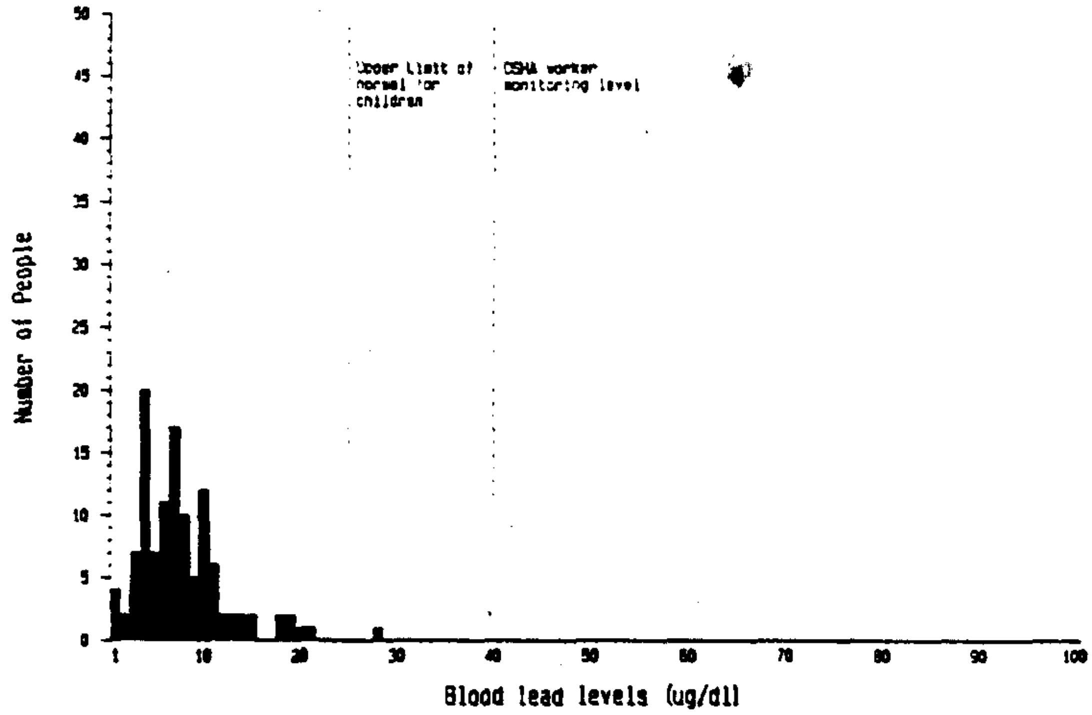

Figure 4 Blood lead levels for Skagway residents
tested both in November 1988 and September 1989
1988 blood lead → 1989 blood lead
(N = 49)

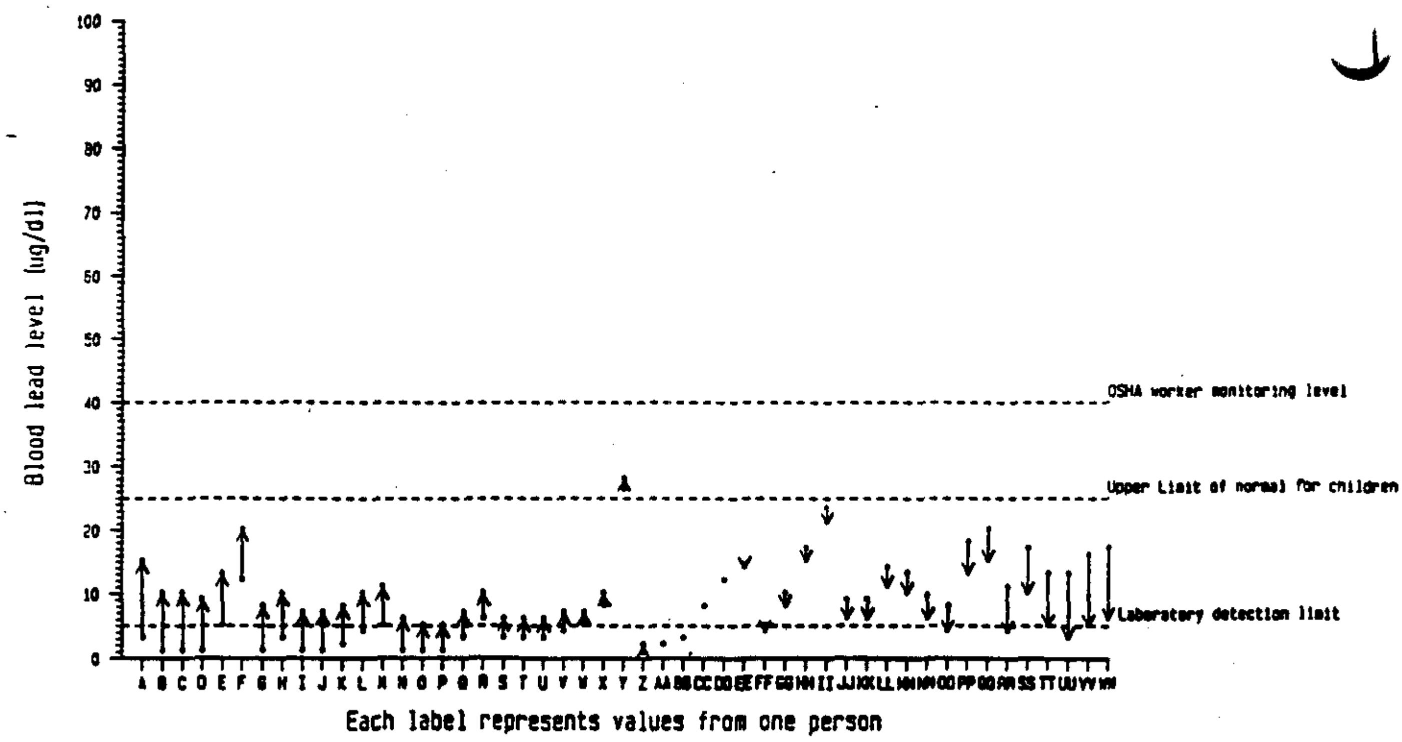

Figure 5 Blood lead levels for Skagway residents tested both in November 1988 and September 1989 By Age Group (N = 49) 1988 blood lead → 1989 blood lead

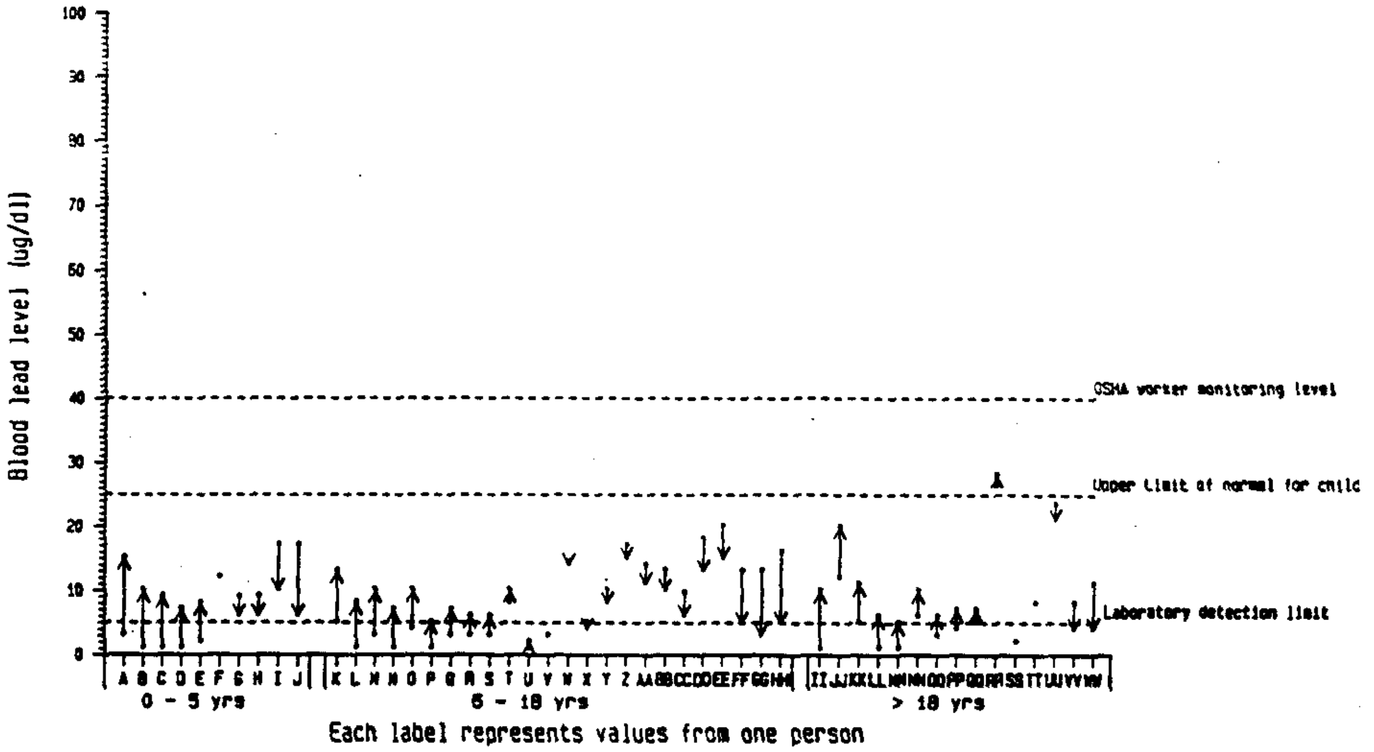

Figure 6 Blood lead levels for Skagway children (Age 0 - 18 yrs) tested both in November 1988 and September 1989 By Location of Residence (N=34) 1988 blood lead → 1989 blood lead

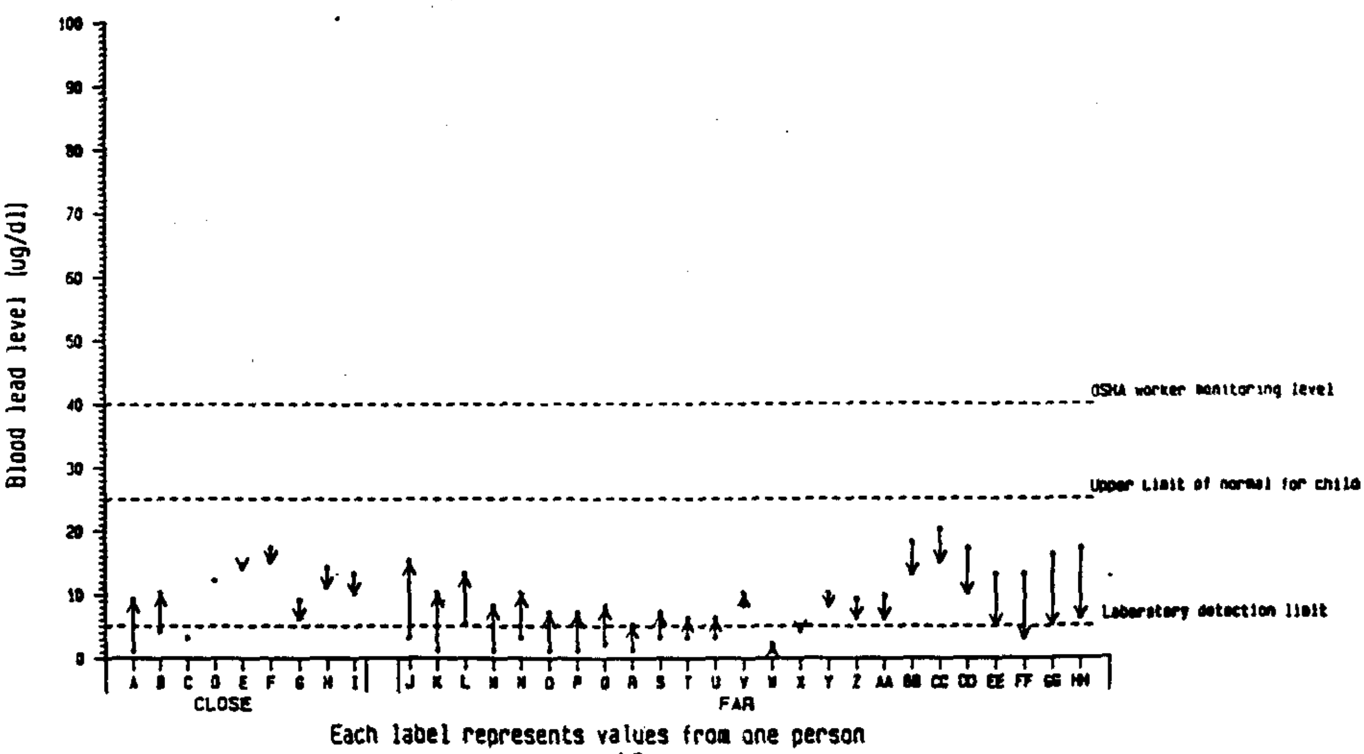

Figure 7 Blood lead levels for Skagway residents November 1988 (N = 158)

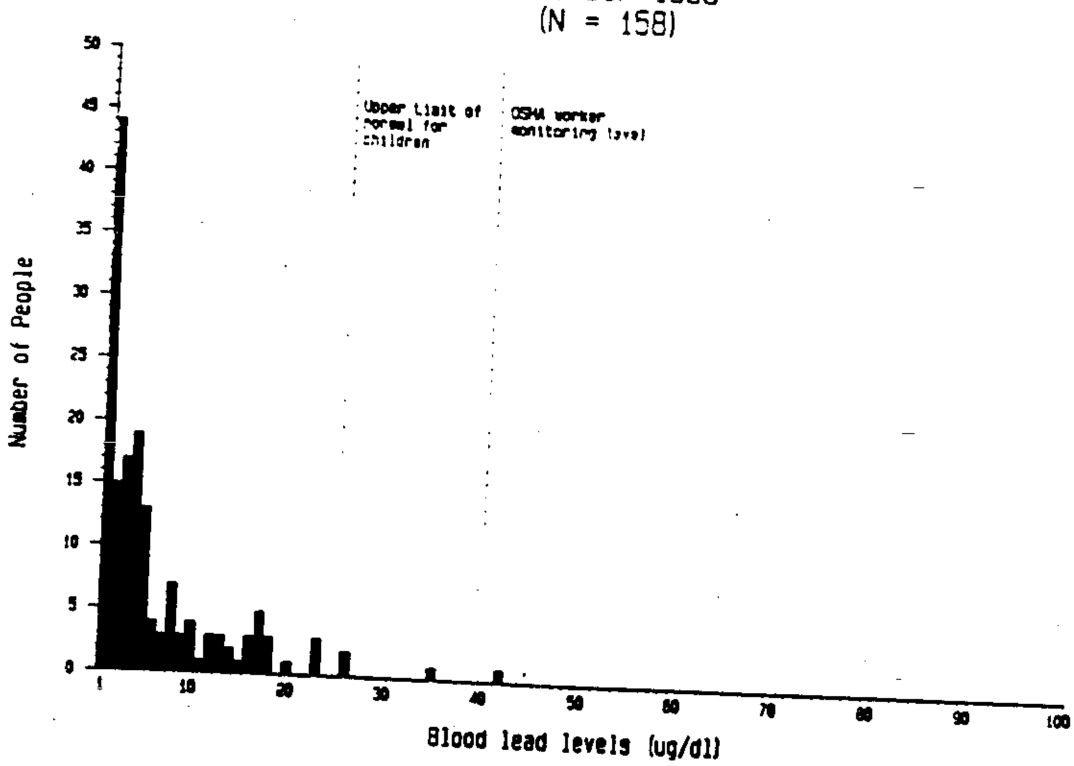

Figure 8 Blood lead levels for Skagway children (Ages 0-18 years) November 1988 (N = 115)

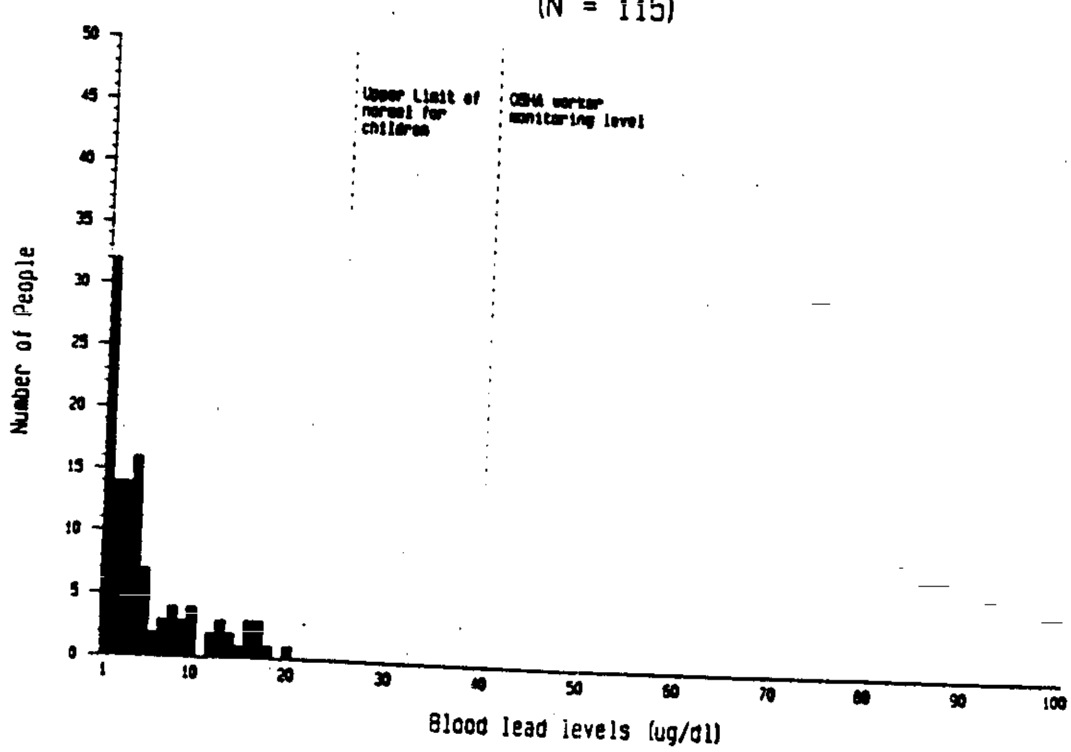

Figure 9 Blood lead levels for Skagway adults (Ages > 18 years)
November 1988
(N = 43)

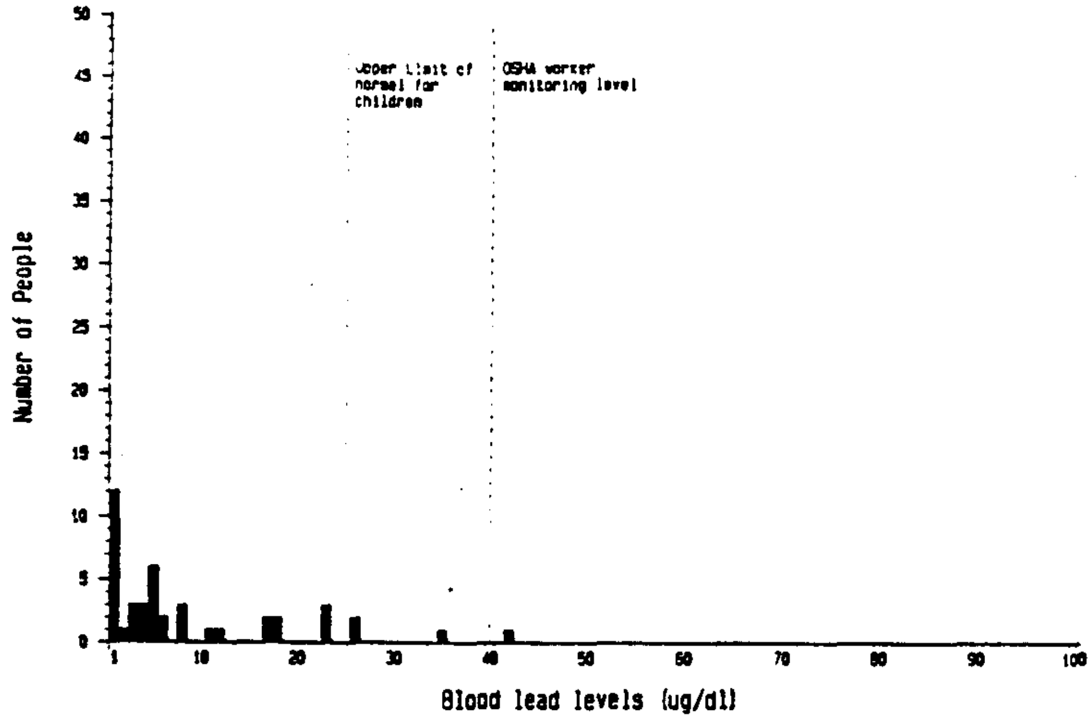

Figure 10 Blood lead levels for Skagway residents
From November 1988 to September 1989
(N = 273)

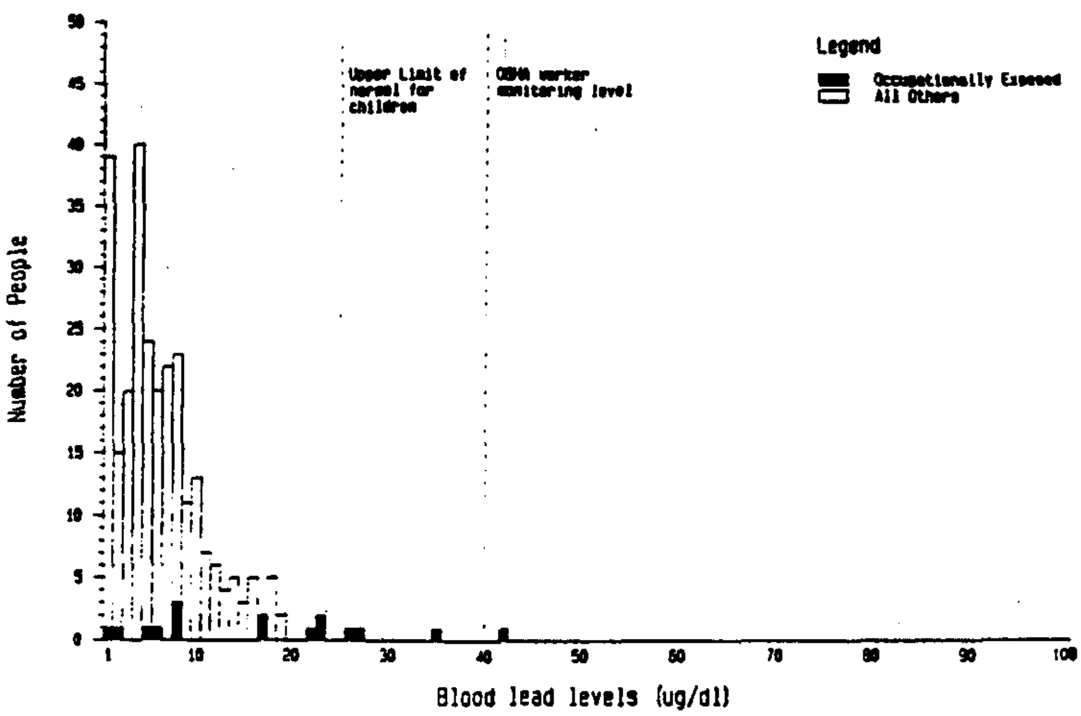

Figure 11 Blood Lead Levels
By Percentiles of Population
SKAGWAY (N=273) and NHANES II (N=9,933)

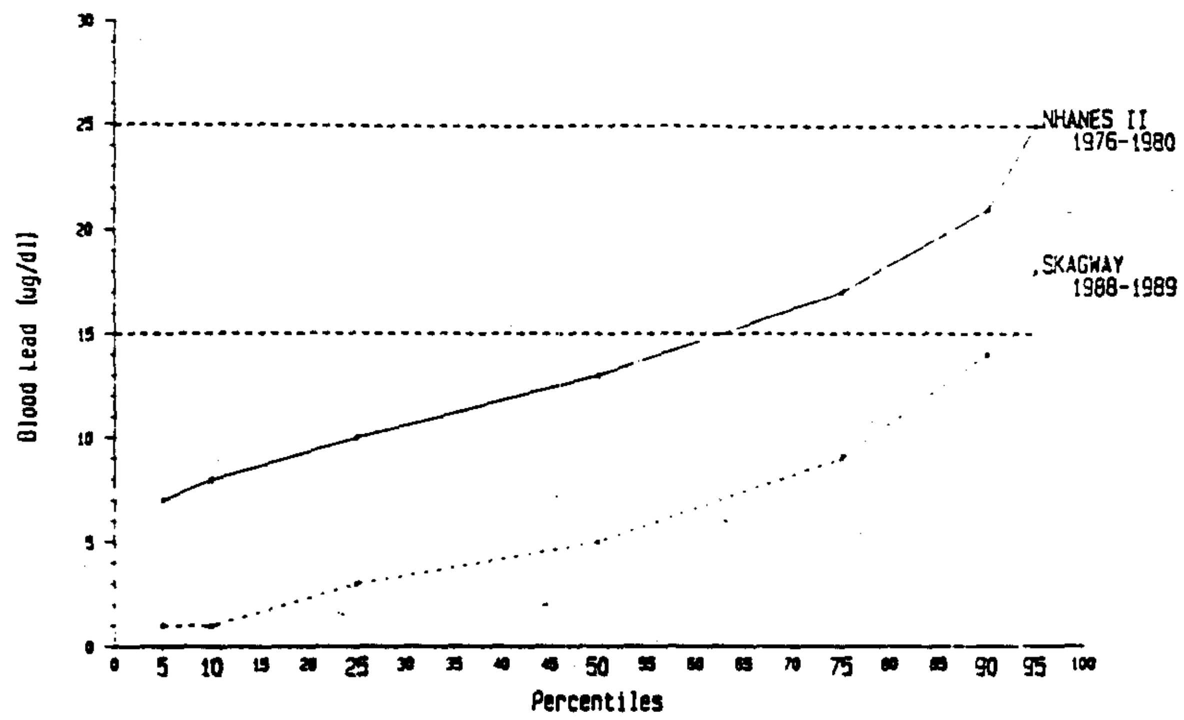

Figure 12 Blood lead levels for Skagway residents
with two tests done in September 1989
(N = 60)