Addressing Health Risks Related to Waste Disposal Sites in Rural and Isolated Alaska Native Villages: The role that source-resident distance plays[1]

1.0 Introduction

A growing body of work has identified significant health risks associated with rural and isolated Alaska Village Disposal Sites (referred to in this paper with the local nomenclature of "dumps"). While funding for improvement of landfills is scarce compared to the need, a significant funding source exists in separate road monies. The purpose of this review paper is to describe health issues related to the substandard status of remote Alaska Village landfills, and to identify the significant role that landfill access road projects can play in reducing these risks.

There are two broad categories of Village solid waste management situations where a fundamental justification for a new landfill road presents itself:

1. In roadless Villages, landfill roads are logistically necessary **to develop new solid waste disposal sites at an alternate location.** Here, the community is isolated, their current site must be closed for one of several reasons discussed below, but roads outside of their town do not exist.

2. Repaired or upgraded landfill roads are necessary **to improve access to existing disposal sites.** Here poor-condition (unsafe) ATV trails or dilapidated boardwalks are used. This type of access degenerates each year, precipitating additional risks from modified waste disposal patterns, including increased waste contact, physical injuries, and tundra destruction. Also, in an effort to avoid using the access, practices such as in-town waste burning, in-town waste storage, and alternative site creation or use, proliferate, presenting an ever-more untenable solid waste management scenario.

Considerations related to each situation are discussed in the next two sections. The primary interest of the authors is the role that landfill roads play in public health (i.e. not in environmental protection or in economic development, although these issues are obviously linked). Recently, there have been a small number of scientific studies and comprehensive projects carried out that address specifically Alaska Native Village solid waste disposal sites. Quantified health risks to residents associated with poor-condition open dump sites in Alaska Villages that have been identified through specific epidemiological studies include:

- Adverse birth outcomes in gestational age, birth weight, small for gestational age
- Birth defects
- Short-term health effects such as faintness, numbness, headache, nausea, congestion.

We believe these results have substantial import to State- and Federal policies on landfill road expenditures (and solid waste management in general), whether formulated regionally, Tribally, State-wide, or Federally. As they have not been compiled before, we highlight significant results and descriptive data for solid waste disposal health risks in Section 4, before presenting the final discussion in Section 5, and conclusions in Section 6. A last note on terminology: 95% of remote Alaska Native Village solid waste disposal sites are not

"landfills", but legally and practically "open dumps"[2], and are generally referred to as "dump sites". We use the term "landfill road" here to mean a well-designed road that provides access to a waste disposal site, regardless of site status.

Igiugig New Landfill and Road Project, Photo Source Iliamna Lake

2.0 Rationale for landfill roads based on need for new solid waste disposal sites

New solid waste disposal sites are needed in many Villages for a variety of reasons, highlighted briefly below. Detailed health risks related to these issues are presented in Section 4.

2.1 In Rural, Non-Hub Alaska, Almost Three-Fourths Of Dumps Are Within About One Mile Of Town — Considered Too Close To Town And Homes.

Axiomatically, given all things equal, a shorter separation distance is associated with an increase in health risks from dump smoke or fume inhalation, in-town dump odor nuisance problems, and disease transmission from vectors. Based on available studies, less than two miles is within an open dump separation distance that would be associated with significant health risks[3].

Thus, for the majority of off-Road System Villages that have no summer land-vehicle access outside their town due to "mucky" tundra, the construction of **a landfill road would allow relocation of the waste disposal site at a safer distance from homes *immediately***. This circumstance is of public health policy interest for Villages that lie particularly proximate to their dump site, because a large portion of the waste disposal-related risks they face now would be eliminated, regardless of whether their new site was functionally upgraded over that of the current one. We are able to make this observation because the majority of these Villages possess a disposal site that has no design, management, fencing, trenching, cover material (for vector and odor control), or structures, etc, anyway[4]. They are simply a plot of land (and/or occasionally pond water) with all, or nearly all, solid and hazardous wastes generated in the Village lying on top.

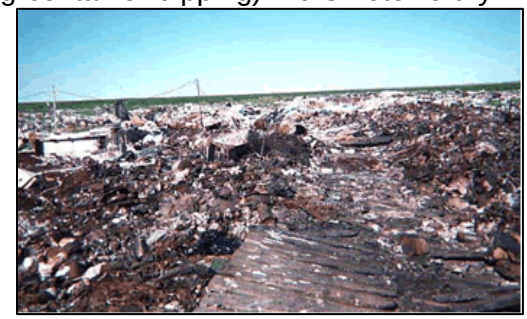
We detail some of the documented health risks in Section 4. However, the relation of separation distance to disease transmission is at least functionally straightforward. Opportunities for flies, mosquitoes, pet dogs, and birds to make the round trip between dump site and homes would likely decrease with the increased separation distance made possible by a new landfill road. For example, flies are a common complaint in many Villages, and their presence and breeding at nearby dumpsites, of which over approximately 90% are not covered[5], is undisputed. In studies of fly flight ranges from infestation sources (e.g. an open dump site), flies of the type commonly associated with dump sites and home are known to

normally restrict travel to no more than one or two miles[6]. **If a dumpsite were placed further out from homes, disease transmission to town by flies thus could be expected to decrease substantially.** But, particularly **in roadless Villages, a new waste disposal location is only possible with a constructed landfill road.** Note that unpaved ATV paths cannot be developed by wetland tundra Villages without quickly becoming muck and resulting in ever-increasingly deteriorating permafrost and tundra. Other Interior Villages might not have the resources to clear an appropriate path through forested land.

Similarly, open dumps are notorious mosquito breeding habitats because they provide shallow (warm), ponded water in tires, ruts, etc., and an abundant food source. But a large proportion of the identified mosquitoes in Alaska have flight ranges of less than two miles, and some much less[7]-- suggesting a substantial reduction in disease transmission risks by flies and mosquitoes would be possible with moderate-length landfill roads. While the West Nile Virus has not established in Alaska yet, its occurrence in the future is seen as likely, and being planned for by State Public Health and ADFG officials[8]. So it is noteworthy here that, *Culex pipiens*, an Alaska species known to be able to carry West Nile Virus, has a flight range of less than ½ to 1 ½ miles[9].

Likewise, the presence of the Norway Rat, another species whose imminent establishment is viewed as likely in roadless Villages[10], at an open dump would almost certainly engender significant additional solid waste disposal-related health risks[11]. But the rat's home range is just several hundred feet, and its *maximum* forage range is two to three miles[12].

When local birds feed at dumpsites, pathogens (from diapers, honeybuckets, household medical wastes, napkins, etc.) can adhere to their feet and beaks, and then become dislodged onto surfaces in town. Of particular concern here might be the significant number of YK Delta households that use rain catchment roof systems to collect their (untreated) drinking water. An additional exposure pathway to dump pathogens could thus be realized via bird feet-to-roofs, roof-to-rain water, and water-to-mouth (and to-hand during container dipping). It is noteworthy here that a primary consideration in setting the FAA minimum dump-to-airstrip separation distance at 1 to 2 miles[13] was to reduce the possibility of the airstrip being within the normal flight activity range of any dump bird population. While there are additional considerations, one would expect a similar logic to apply to the dump-to-town separation distance — move the dumpsite beyond the activity range of the bulk of the dump bird population, and less dump birds will frequent town. Again, the risk of disease transmission is cut because the risk of exposure is reduced.



Another purely functional observation is that, given that very young children generally do not have access to a vehicle, it seems reasonable that a short separation distance might contribute to the relatively high number of Villages (14% or higher) where children use the dump as a playground[14]. A longer separation distance would be expected to discourage this practice.

Additional problems that may be at least partly redressed by placing dumpsites further out include: Adverse financial and environmental outcomes from fire risks; Liability risks (e.g. from smoke inhalation, fires, injuries); and Tourism disincentive from the aesthetic and safety issues presented by an open dump adjacent to town.

2.2 Dump Site Drainage Too Close to Drinking Water Supply and/or Subsistence Areas.

In a survey of over 100 Villages, hunting or fishing was reported to take place in the vicinity of the dump at 45% of Villages, and 34% of Villages reported drinking water sources within one-quarter mile of their dumps[15]. This proximity to community water and food sources, together with the under-management and under- or lack of- protective features at open dumps, engenders a significant potential for contamination of drinking water and subsistence food. Further, in rural Alaska use of untreated traditional water sources for drinking and household use is common and in some Villages predominant, as concluded by a UAF study[16], as well as a wealth of ethnographic observation. Subsistence foods (i.e. foods hunted, gathered, and fished from the lands) comprise a substantial, and often dominant, portion of the diet of the nearly 200 rural Alaska Native Village communities off the road system. In a number of studies where intake has been assessed, subsistence foods contribute more than half the protein, iron, vitamin B-12, and omega-3 fatty acids[17].

The dependence of rural Alaska Natives on untreated water and local subsistence foods would strongly indicate that environmental contamination from dump site drainage is likely to result in a proportionately higher overall contaminant exposure for this population than would be expected from hypothetically similar dump site conditions faced by virtually any other U.S. population group. As an indication of the potential scale of the contamination issue,

Compounding the problem**,** in Villages where the local availability and range of nutritious commercial food is limited and comes at high retail cost, subsistence food intake is vital to maintaining rural Alaska Native health[18]. And maintaining subsistence-based traditions and values in Alaska Native cultures has been identified in a wide range of studies and projects to be integral to community socio-cultural health[19]. Socio-cultural health and cultural integrity have been in turn identified as key indicators for socio-economic and socio-ecologic "community resilience", the long-term ability to successfully adapt, manage, and even thrive over the long-term in the face of adverse economic and ecologic events, such as climate change and loss or lack of an economic base[20].

Thus, it is of significant public health and socio-economic interest that Village residents' concerns over potential contamination of subsistence resources from their dump sites have been found to be associated with impacts to subsistence activities[21]. In the CCTHITA epidemiological study, some 64% of residents from disparate Village situations had altered their subsistence activities due to their fears of subsistence contamination caused by their sites[22].

This finding indicates that **location of a new dump site away from significant subsistence areas may decrease negative impacts to subsistence** associated with solid waste disposal*, regardless of whether the new site is funded adequately* to upgrade its protective features.

2.3 Dump Site Is Running Out Of Space.

Due to hydrology and functional access reasons, undeveloped and accessible land in tundra and roadless Villages that is generally not subject to flooding is commonly scarce. Dumps that are not managed, where trenching is not possible due to permafrost or lack of heavy equipment,

will expand quite rapidly[23]. The issue of over-capacity is repeatedly a top concern expressed by rural Villages[24]. We list here two particular grounds that legitimize such concerns:

Association with increased burning Unsurprisingly, field observational data and Village self-reports suggest that open dump burning, burnbox burning, and home barrel burning are more likely to be used as a waste management method when an apparent (or perceived) land-scarcity situation exists[25]. A higher level of waste burning activity engenders increased exposure risks associated with smoke inhalation. Increased open burning naturally increases the risk of out-of-control fires that endanger homes and natural resources. Note that a lack of adequate fire fighting equipment (e.g. fire truck, water hookup) is common in Native Villages. Financial losses from dump fires that spread can be significant and over 100 reportable dump fires have been recorded since 1985, requiring outside assistance to control[26].

Disproportionate increase of risks The substantial under-management and under-design of the majority of Village open dump sites[27] would suggest that conditions and circumstances that precipitate disease transmission, environmental contamination, accidental fire, and accidental injury to be more prevalent at over- or near-capacity sites than for sites where space is not a primary issue.

2.4 Economic Development Concerns

Additional concerns that precipitate a need for a new solid waste disposal site (and hence a landfill road) include:

- Redeveloping solid waste disposal sites and surrounding buffer for preferred site (re)development opportunities[28], particularly for acute housing shortages
- Avoiding potential liability issues associated with harm or perceived harm from residents' (or tourist's) injury or health potential claims[29]
- Increasing capacity needs due to higher populations and tourism development
- Upgrading design or features for industrial or other business wastestreams (and thus attract development),
- Minimizing commercial fishery impacts
- Meeting ecotourism expectations for aesthetic rural experiences

2.5 Climate Change/Permafrost Melt/Subsidence/Erosion/Flooding Processes

For a number of Villages, a consequence of these earth science processes is an undesirable disposal site location, now or in the future, based on landfill function and structure considerations. Some 56% of Villages noted site seasonal flooding or standing water problems in the YR 2001-02 CCTHITA survey.

2.6 Dump Site Is Too Close To Airstrips.

Approximately 32% of Villages have dumpsites that are less than one mile from their airstrip[30], failing to meet the minimum separation distance required by FAA. Birds attracted to the dump and dump smoke create navigational hazards to aircraft, as well as to the residents below.

2.7 Dump Site Is In A Wetland Area

For a number of Villages, dump sites are in an environmentally sensitive wetland area, presenting significant environmental risks (and potential liability risks emanating from degradation that is in violation of a number of environmental regulations).

3. Some communities need landfill roads built to existing sites because existing access is unpaved trail, disrepaired boardwalk, or is subject to seasonal flooding, or no practicable or designated access exists.

Poor access increases the likelihood of:

- **Expansion of dump edge towards town** (to avoid walking or driving on wastes, residents will dump wastes at furthest edge, or along route closer to town, instead of driving/walking the full way to designated drop off)[31].

- Residents **dumping in other non-authorized areas**, such as river dumps or near-town vacant lots (to avoid dump visits), thus promulgating additional public health and/or environmental problems.

- Residents using **home barrel burning** (to reduce number of needed visits to dump). And thus, given resultant nearer proximity of the smoke source compared with dump site smoke, increasing the risk of toxin and particulate exposure through smoke inhalation, and the potential exposure risk to toxins through dermal contact and/or ingestion exposure of in-town smoking/hanging racks of fish and meats (due to smoke particulate deposition).

- **Residents storing garbage in and around homes** (to reduce visits to dump), resulting in public health and nuisance issues.

- And when the access is used, the risk of **disease vector/pathogen exposure** may increase due to increased likelihood of waste contact. Based on the CCTHITA survey, at 25% of the dumps, it is difficult to even unload garbage, and at up to 55% of dumps, it is generally necessary to walk on top of other garbage to find an unloading spot—a risky activity from an injury prevention and pathogen exposure perspective. Potholes, missing boards, lack of clearly marked, differentiated, and safe access translates to residents dumping/dropping wastes along the way, particularly near the dump edge, engendering the need for subsequent dump users to walk/drive on the wastes when they use the same path.

4. Summary Of Documented Health Risks Associated With Alaska Open Dump Sites

Outside of rural Alaska, open dumps that are the main disposal site for full communities exist primarily in developing countries. Epidemiological studies on such communities-- living as far as five miles away from these dumps, as well as on communities living within the "exposed zone" of closed dumps and hazardous waste sites in industrial nations, have consistently identified significant associations with decreased immunity, toxicological effects, and stress-

related physical health symptoms[32]. Inside Alaska, the handful of studies that have been carried out appear to align well with these findings, as discussed below.

4.1 Health Risks Identified Specific To Inadequate Separation Distance Between Dumps And Homes

In this Section we summarize quantified health risk study results that specifically indicate a greater dumpsite-town separation distance would improve public health. YR 2001-2002 CCTHITA study and survey results indicate Villages are experiencing significant adverse health effects associated specifically with the close location of their open dump to their homes. To be clear, these results support the concept that locating dumpsites further from homes (accomplished simply by building landfill roads, with or without a "better" dump site at the end) could substantially reduce solid waste disposal health risks.

- In the CCTHITA epidemiological health study of four roadless Villages, **people living closer than one mile** to their open dump were *19 times more likely to have eye irritation*, and *3 to 4 times more likely to have headaches or faintness*[33].

- **In the same study, people who were bothered by dump odors or smoke**, a proxy indicator for wind direction and proximity of daily activities to the dump, were over *6 times more likely to experience faintness,* and over *5 times more likely to have ear irritation.*

- Yet, the related CCTHITA comprehensive survey of 100 Villages found that a full **72% of dumps are within about one mile of homes**. Based on self-reports, At least 30% are within about *one-quarter mile* of homes[34].

4.2 Need For New Dump Sites – Health Risks Associated With Dumpsite Condition

We present in this sub-section quantified health risks related specifically to dumpsite condition. Note, the results listed here do not address whether a greater separation distance is needed. However, they do indicate that health risks could be reduced substantially by building improved landfills. And, as mentioned above, in the case of the majority of non-Hub, off-road system Villages, a new landfill site requires that a new landfill road be built first.

- In a recent retrospective cohort study[35], a number of significant associations between the condition of Village open dumps and birth outcomes and congenital anomalies were identified**. Effects on newborn babies** associated with Village open dumps that were ranked medium to high hazard condition included: **low and very low birth weight, preterm birth, and small for gestational age** (SGA). Infants born to mothers residing in Villages with high hazard dumpsite contents were significantly **more likely to have miscellaneous birth defect(s)** than other infants. The study adjusted for smoking, alcohol use, age, education, race, quality of prenatal care quality[36], and level of Village water hookup[37].

- In the CCTHITA epidemiological study, **residents who regularly visited their open dump** were *2 to 3.7 times more likely* to experience faintness, fever, vomiting, stomach pain, ear and eye irritation, headache and numbness.

- In the CCTHITA 110-Village survey, at least 20 percent of Villages reported significant dump site accidents in the prior 5 years.

4.3 Need For New Dump Sites, Roads, And/Or New Access – Health Risks Associated With Waste Burning Activities

We mentioned briefly how inadequate town-dump separation distance can engender increased smoke exposure from waste burning activities at the dump, how poor access can increase home-barrel burning, and how over-capacity dumps can increase waste burning activities at the dump and in-town. Each of these circumstances can be addressed by landfill road construction.

Here, we summarize the specific health risks that would be addressed. Smoke from open waste burning commonly contains such contaminants as dioxins, carbon monoxide, nitrous oxide, benzene, styrene, furans, and PCB's[38]. These agents have been variously associated with respiratory complaints, dizziness, and headaches in the short-term, and cancer, heart disease, liver damage, and neurological and reproductive effects in the long-term.

It is commonplace for villages to report dump smoke odor in at least a portion of town for some burn days. Out of 50 villages attending a solid waste training in the past year where the question was asked, well over 75% responded affirmatively that dump smoke was smelled at residences. In the 2001 CCTHITA field study, dump smoke from uncontained waste burning was smelled commonly by ** of residents ** away. Exposure to smoke toxins can occur variously through inhalation, absorption through skin, and ingestion. Ingestion of smoke toxin-contaminated foods may be of particular concern in Alaska Native Villages due to the common location of outdoor subsistence drying racks, and the phenomenon of particulate deposition. Supporting the supposition that ingestion represents a complete pathway, a number of anecdotal observations have been recorded of dried fish, and indeed local traditional water sources within the smoke plume, tasting differently immediately after (and during) a dump burn[39]. Additionally, it is well established that children are known to ingest dirt incidentally during play[40], and thus the risk of ingesting settled smoke toxins exists via this settlement pathway as well.

Smoke from an open dump fire hangs over a rural Native Village

In addition to acute and chronic toxicological effects of smoke contaminant exposure, a wide range of serious health risks are associated with inhaling ash and other flyables that are generated by the burn and associated with the smoke plume (particulate matter, referred to as "PM"). Smoke from open dump burning, "burnboxes", "burncages", and "burnbarrels" has a high concentration of particulate matter in comparison with emissions from the Clean Air Act -compliant "incinerators" that are cost-infeasible for typical Village population sizes. Health effects associated with increased inhalation of PM include: Increased mortality, Cancer, Hospitalization, Functional Limitation, and Physiological impairment[41]. Those with impaired immune systems, cardiovascular disease, COPD, elderly individuals, infants or very young children, pre-adolescent children have been found to be most susceptible to these effects. Particulate matter is also indicated as a precipitator of asthma in children and adults.

Yet, in the face of these risks:

- Burnboxes or dump fires are set often, in up to 73% of Alaska Villages.

- Over **61% of residents** in the CCTHITA epidemiological study were **regularly bothered by dump odors or smoke**, during the course of everyday activities.
- *To avoid visiting the dump*, **residents in at least 66% of Villages burn wastes** just outside of homes. Note, with no, or few, roads, homes generally are set close together in native Villages, so that breathing this smoke is unavoidable.
- In the CCTHITA epidemiological study, **people who burned their own trash were *5 to 17 times* more likely to feel faint, and almost *5 to 10 times* more likely to develop numbness**, with the risks increasing the more often people burned. Home burners were almost *30 times* more likely than other people to have developed rashes. Other symptoms that were found to be significantly higher include fever, sore throat, and cough.

4.4 Health Risks and Considerations Associated With Increased Disease Transmission

We mentioned briefly that the exposure risk of disease transmission functionally increases with shorter town-dump separation distance and likely increases disproportionately with over-capacity sites. Both of these situations may be addressed by landfill road construction. Here we summarize studies that support this notion.

- A UAF study confirmed for the first time that a pathogen indicator species (*E. coli* bacteria), can indeed track from open dump sites to towns, on at least ATV tires and boot footwear[42]. *E. coli* was also found to track from contaminated sites within the community, into the local school and to boardwalk locations directly adjacent to homes. While it is unclear whether dry boardwalks offer suitable conditions for *E. coli* transmission[43], moist organic material caught between tire ridges and boot grips do offer a suitable venue. From a health perspective, it should be noted that a small number of boardwalk samples adjacent to the dump also provided viable *Enterococci* (a more hardy, but less specific fecal indicator), even though *E. coli* were no longer present. Fecal source discrimination analysis appeared to eliminate pet dogs (chain-restricted) as a significant source of *E. coli* at ten of twelve sites selected for a broader geographic spread in and around the community during the experimental period.

- In a separate project component, it was demonstrated that a significant fraction of coliform bacteria survive for more than six months in soil at different temperatures and moisture contents. Survivability of coliform bacteria at subzero temperatures decreased with an increase in moisture content and with an increase in temperature. Total coliform bacteria in soil samples placed outdoors during winter had lower survivability in comparison to samples placed at controlled temperatures below 0^{o}C. High survivability of total coliform bacteria at controlled, subzero temperatures was assumed to be related to the reduced metabolic activities of the bacteria.[44]
- Honeybucket disposal is a central concern of solid waste disposal health risks in about half of isolated, roadless, non-hub Villages. Thirty-three percent of these Villages have **honeybucket disposal sites located adjacent to their open dump**, and at least 28 percent have a single access route to both solid wastes and honeybucket wastes.
- In at least 30 percent of the Villages, **honeybucket wastes are discarded at the dump site**, or trash is discarded at the honeybucket disposal site, thus increasing exposure of residents and risk of disease transmission between households.

5. Discussion

We address a number of reasonable arguments that we have heard against a priority construction of landfill roads over other transportation infrastructure:

Argument 1: Landfill roads do not promote development. It is true that income is not likely to generate from a new landfill. At this time, economies-of-scale (due primarily to population, lack of necessary infrastructure and transportation logistics) do not present significant potential for self-sustaining resource recovery/recycling in the bulk of off-road, rural Villages outside the Southeast, and that have only seasonal barge access[45].

However, **the lack of a safe landfill can preclude economic development**, particularly ecotourism[46]. Liability risks, whether perceived or actual (or both) are too high. Imagine a tourist's dismay (and health concern) at arriving at a Village where the dump was burning out of control.

Also, landfill road projects provide economic stimulus to the local community, and may be combined with local job training programs[47] that bring in additional revenue and assorted positive outcomes. Once built, **a new landfill provides an improved opportunity for the local government to charge user fees,** or for a private individual to take over a collection or management service. It has been observed that residents are not prone to support waste service fees in communities where their open dumps present visual blight, odors (from dump proximity to town), access and user safety concerns, and lack of environmental protective features[48].

Finally, violation of FAA minimum separation distance regulations may present a disincentive for upgrading airstrips.

Argument 2: Landfill Roads do not make sense unless landfill funding is secured. We hear two legitimate concerns related to this argument:

a. Money will be wasted if the landfill is never built: A distinct possibility exists that a landfill road could be built and the new site never constructed. However, we believe that situation could be managed against via reasonable evaluation of the Village's situation and priorities. In our experience, Villages with exigent solid waste disposal situations would be highly motivated to relocate their dump site, given the opportunity. Even without consideration of health risks, a new site for those Villages with extreme poor access or site conditions would present an opportunity that would actually decrease residents' time and efforts in discarding their wastes.

There is a Catch-22 aspect here. If a Village wants a new landfill, they search for facility funding before the road is built, both to secure DOT road funding under current policy, and to ensure that facility funds are in place in a timely manner. But this situation leaves sanitation facility/health agencies that might fund landfills (e.g. USDA, VSW) in the awkward situation of funding a project that cannot begin until a road is built, for which funds have not been truly secured yet, and that won't be built for some 2 - 6 years away (if ever). While an analysis has not been carried out of which we are aware, it is quite possible this situation places roadless Villages at a competitive disadvantage. Indeed, landfill roads provide

codified leverage for securing landfill funding through USDA and USEPA[49]. Thus, if the policy continues of awarding road funds only to those Villages who have found funding for their landfill, these potentially disadvantaged Villages could be caught in a cycle of no-funding that is difficult to address (no Road-- no Landfill, but no Landfill-- no Road). Funding is in short supply and should never be wasted if it can be helped. But we note that concerns of wasting road monies must be weighed against concerns of losing or stalling potential landfill monies that will generally mean a markedly improved quality of life for the Village.

Note too that funding opportunities when they surface are rarely in an ideal order, or on a predicted schedule. Funding landfill roads for those Villages that truly need them (regardless of their landfill funding status) could place Villages in the best possible situation to take advantage of all future landfill funding opportunities.

**Finally, we mention the idea that even if a site is not subsequently located at the end of the new road, monies perhaps do not need to be wasted. Landfill roads are a potentially ideal application for the technology of interlocking plastic road "mats" or "blocks" already used successfully in Alaska at several oil exploration and military installations, ATV Trail roads, a tundra wetland landfill road [50]. Several types exist offered by different manufacturers. Regardless, this type of road has virtually no O & M requirements, should create virtually no dust, and can be moved easily by local Village labor when desired, as in the case when the landfill is to be closed, re-designed, or re-adjusted. Indeed, it can be relocated immediately to serve as an emergency alternate route when needed due to storm washout or flooding of a vital road section. In the case of climate change forced relocations, the road may be placed into use to "leap frog" a planned move to a higher or more stable ground, and then placed back into use as the new landfill access or as town roads. Weather-related construction contingencies are substantially reduced, a wetlands permit is facilitated, and a one mile road is place-able within one week by local labor. Hence, we have the rather comforting concept that road funds need not be wasted because the "landfill road" can be used as an "anywhere road" down the line. Indeed, it could even be barged out to another Village. At this point, the primary drawbacks of road mats are that they do not provide the longer infusion of conventional road construction jobs, and the capital cost for particular product versions of the product[51], although depending on desired road width it could be on a par with conventional road projects in Bush Villages lacking a gravel source[52]. Rising fuel and construction costs also can be expected to increasingly favor road mat cost comparison in the future.

b. Another open dump will result without proper landfill funding: There is much evidence suggesting that this indeed would be the case for many Villages. Typically, zero to two Class III landfill projects are funded each year for rural Villages. But there are intermediate scenarios possible here. Funds do exist through USEPA Indian General Assistance Special Project Program, Federal Interagency Open Dump Grant, Denali Commission, BIA discretionary funds, Village Health Corporations, and perhaps private non-profits, to implement some upgrade features to new sites. For each Village situation, the upgrade features that would most reduce health risks can be different, but such upgrades might include one or more of the following: Fencing, Better-Design burnboxes, Collection program subsidies (to keep residents away from the dump), Heavy equipment, Cover, Hazardous waste storage, Backhaul subsidies, etc. The resulting site may in the end resemble a Class III

landfill, and may more importantly perform adequately to meet the intent of the new State guidelines that are in formulation. Certainly, carried out thoughtfully, the resulting site could be closer to meeting State regulations and recommended best management practices than the old site.

Of course, as mentioned several times in this paper, there are firm grounds for contending that in a significant portion of cases, relocation of the waste disposal site will result in substantial reduction of health risks, even without any installed features or safeguards. These cases generally would include at least those Villages whose sites have substantially inadequate protective features now, with a short separation distance, and that present certain health exposure risks through waste burning issues or other well-identified issues related specifically to the site location.

Ethically, can the State, federal, or Tribal group sanction a landfill road if they know that an open dump will result? On a case-by-case basis, we certainly believe so. A strong public health argument (not to mention economic development and fund-leveraging argument) can be made that it is in the Village's best interest to relocate their open dump further away from town and/or subsistence areas. Note, we include the topic of ethics here because a legislated role of individual agency programs that might not include public health explicitly does not eliminate the overall role of government (and thus the agency) in providing for the greater good. What might these cases look like? The health risk studies that have been carried out so far are too limited and scant in data to delineate an exact breakdown. But certainly, as a start, Villages that are downwind of dumps located within about one-third mile of town would present very compelling cases. Based on self-reports, CCTHITA database results suggest that perhaps as many as 30% of Villages could match this scenario, although many of these would be in a financial position to upgrade their dumps to some degree.

What are the legal implications of building roads where the resultant site might not meet guidelines? Identifying the legal implications to consider is beyond the scope of this paper. These would need to be worked out by each agency. We note here a few considerations. For most Villages, new landfills meeting solid waste guidelines (RCRA) are arguably an unfunded mandate. Some 95 percent of rural, non-hub Villages do not meet State guidelines as it is. And legal implications already exist for agencies that use Village waste disposal sites not meeting RCRA[53]. Thus, it seem reasonable that a number of resultant potential litigation risks would be reduced with a new site that addresses many of the community concerns, reduces many of the risks, and comes closer to meeting State guidelines.

Argument 3: Funds should be spent on improving the dump site, rather than build a new landfill road.

We note first that Federal Highway Administration monies, the source of the large bulk of State and federal agency road project funding, are earmarked solely for transportation projects, and thus can't be converted to site improvement funds.

We confine our remarks in the remainder of this Section to those other source funds that are re-allocable. We absolutely agree that improving the site is the preferred action in many cases, and know of several Villages where this precept holds. Even for those Villages that need a new landfill road, significant benefits

would accrue from *any* improvement in their waste disposal situation as soon as possible, while they awaited funding for a preferred site relocation. Certainly, in every case, if a Village can afford to operate a collection system, simply keeping residents away from the site will significantly reduce health and environmental risks. Switching from open burning to a well-designed burnbox is another common example that could substantially reduce smoke toxicity, disease vectors, and fire risks.

But a large portion of the roadless, non-hub Villages – based on the CCTHITA database we estimate broadly anywhere from as few as 15% to as many as 70% --are in a position where relocation truly is a warranted course of action. For example, a flooded dumpsite is a flooded dumpsite, and there is nothing about that situation that makes it a functionally-acceptable sanitation facility, particularly when it is proximate to the Village. There are Villages where dumpsites are currently, or in imminent danger of, eroding into the river. Another seemingly warranted relocation situation is in wetland tundra Villages where the remaining accessible land that is suitable for houses (i.e. non-flood prone) is next to, or at, the dumpsite[54].

Then there are Villages where the site location is acceptable, but unless they have a reasonable access, they will continue to face the variety of risks mentioned in Section 3. We apologize for the hyperbole, but from our experience, it is difficult to imagine the site improvement required to entice residents into using an access where they risk losing their ATVs' in mud and walking on broken honeybucket bags or diapers.

And of course, there is the situation highlighted in this paper of Villages with proximate dumpsites[55] where a number of health concerns can be addressed with a greater dump-town separation distance (i.e. new or extended landfill road). Relocation, would be preferably in combination with other site improvements, but indeed, as discussed further below, not necessary to precipitate a vast reduction in disease transmission and smoke exposure risks (as well as in adverse fire, subsistence activity, and quality-of-life impacts).

Addressing disease transmission through improving the dump site. Here, we discuss the idea that sites can be improved to address disease transmission. Covering wastes with cover material (primarily silt, gravel, sand, soil) is the primary means at a conventional disposal site to control vectors and disease transmission. But, simply due to their geology, "roadless" situation, or lack of proper equipment, a majority of Villages do not have access to cover material. As it is, less than 10% of Villages regularly apply "cover". Methods for rural Villages to substantially reduce disease vectors without cover include incinerating, baling (less so), sackfilling, or backhauling the organic vector-attractant wastes. But all of these methods, because they require supporting facilities and equipment, require capital costs in line with the cost of a one to two mile landfill road (in the ballpark of $1 to $2 million, depending on a host of variables) [56]. Remember, the Villages we speak of have virtually no infrastructure from which to build upon. Even fences for those approximately 60% of Villages that have them would likely not be in a condition suitable for responsible reuse.

But perhaps of greater consideration, all of these methods require operation and maintenance (O & M) costs that are outside the range of what has been the practical experience of non-tourist/non-hub Villages. Only about 32% of Villages are able to afford even a part-time dumpsite operator/manager now, and these full-solution waste management methods require significantly more staff time than a typical open dump, because they require the daily, trained operation of the additional involved equipment. One has only to look at the general failure

of O & M for water and sewer projects to imagine the unpalatable scenario of investing heavily in landfill projects throughout the State that become open dumps *right next* to the Village again[57].

What would O & M costs be to support these landfill alternatives? For a large isolated (non-hub) roadless Village of 800, monthly household costs outside the Southeast would cost about $350 per household monthly (minimum). Discarding that idea, based on Alaska community case studies, monthly fees for baling and incineration would be about $90 (including household waste collection which would be required for these methods to work well)[58]. Costs could be reduced by some $10 to $30 with transfer station collection versus house-to-house, and local business fees. However, we should note for smaller Villages that fixed costs for incinerator and baler options are quite high, and economies of scale are nearly proportionate with population, translating to significantly higher household fees.

"Supersacks", the remaining viable "mainstream" vector-reduction option for those Villages without cover (and only for the 50% of Villages without bear problems), would exact about $60 monthly (assuming the sacks were made part of capital costs), and as little as $30 monthly with transfer station self-haul and business support. Supersacks and Tundra-Teck bags[59] have another advantage in that their maintenance requirements are not dependent on daily operation or trained heavy equipment operators. The first ever sack-fill is being successfully constructed in the Native Village of Nightmute, whose site is located on an eroding riverbank and is thus losing wastes into a main subsistence river each year. In the absence of heavy equipment, residents have cleaning up their dumpsite by burning the majority of non-hazardous organic trash and storing other wastes in Supersacks. The sacks are placed to form a wind-berm and fence on this flat tundra area, with the future use of additional sacks planned as they become financially available[60]

Smoke exposure risk reduction via on-site improvements Of all the waste burning practices and techniques mentioned here, it is only Clean Air Act-compliant incinerators that, as the description implies, could theoretically be operated within or adjacent to the Village without presenting significant smoke exposure health risks because indeed, the smoke from other units is toxic, regardless of how well they are operated[61]. But, as mentioned above, while new technology is being researched[62], operation of such an incinerator at this point in time involves O & M (and capital costs) well over that of what would be considered feasible for the vast majority of Villages that lack strong economic bases. The sharp cost rise in fuel, required in operation, will likely make conventional incinerators cost-prohibitive for the foreseeable future.

A burnbox, loaded and emptied by heavy equipment, is left open while it burns.

Another consideration is that where a community is operating at the margin, a disruption in service is likely to result from any number of events – be it equipment failure, with a delay typically experienced by Villages in obtaining parts or mechanic to repair it, or a community event such as search and rescue, winter storm, or indeed gravesites falling into the ocean, with every able-bodied person called to duty. Waste, however, does not wait. It is not practicable to store wastes inside an incinerator or baler building for more than a couple of days unless the facility is designed for unbaled storage, which increases capital costs substantially. At that point, the community will possess once again a proximate waste pile. There are a number of issues that are precipitated along with such a scenario as well, concerning community fee payment, disposal behavior response, trained staff turnover possibilities, etc.

6. Conclusions

We present this as a review and discussion paper on developing a policy for prioritizing landfill roads that makes sense and best serves the rural Villages of Alaska, and hence by inference the wider needs of all Alaskans. We realize a number of unaddressed issues relate to points mentioned here including, for example, road maintenance needs and road dust exposure[63]. And while this paper is intended to address only the issue of landfill roads *per se*, it lends itself to discussion of what the best policy is to address waste disposal problems in Villages in general, Statewide.

With 95% of rural Alaska Native Village sites not meeting State standards, and 70% of those inspected receiving failing (not simply "substandard") marks[64], solid waste conditions in Villages are, by and large, deplorable, and no single entity or phenomenon need take that blame. With those conditions is a growing body of work specific to Alaska Villages indicating significant health and quality-of-life threats to Village populations, adding to a literature describing the established associations between health and proximate open dump sites that have been documented elsewhere.

What remains is to address the situation, via a wide range of avenues. At bottom, road funding is one of those avenues. For many Villages, road funding can be what is available to address their exigent public health risks *now*. There exist many roadless Villages that are located away from hubs, economic activity, and feasible transportation logistics, that are simply not able to sustain significant O & M efforts for their dumpsites. Without a new landfill road, their disposal site will remain where it is-- too close. *With* a new landfill road, they can take action on their own to relocate their site immediately, to reduce their health risks and subsistence impact concerns, and to improve their quality of life. The advantages of a site further from town will continue, regardless of this Village's ability to pay for O & M. In such a case, we believe it a worthwhile exercise to consider a new landfill road as a sustainable "waste disposal option". While not ideal, unless O & M subsidization program(s) are made available, sufficient to the need and judiciously carried out, for some Villages, a road might serve as their best interim alternative.

A final note is that, by and large, road funds come from a different pool of monies (i.e. FHWA and ADOT funds) than are available for landfill facilities. Once allocated, tradeoff arguments are moot. A one million dollar road does not "take away" from the small pool of funds available for Villages to improve their landfills. It takes away from another road or bridge project. Thus, in terms of public spending merit, it is against *these* projects that landfill roads must be weighed.

---

[1] Compiled by L. Zender, Ph.D., S. Gilbreath Ph.D. and S. Sebalo MS.C., Zender Environmental Science and Planning Services, Dec 2005. ©Copyright Zender Environmental Services 2005. Full reproduction of this discussion document is granted to non-profit entities, with appropriate citation. For other purposes, or for partial reproduction, contact Zender Environmental Services, 907 277-2111, or email lzender@zender-engr.net .

[2] See "Left Out in the Cold" for descriptive statistical and pictorial summary of Village sites at http://www.ccthita-swan.org/pdf/left_out_in_the_cold.pdf .

[3] See Section 4, and note 32. Exposed zones have been identified in studies to include a 2 to 5 mile radius.

[4] Based on Central Council of Tlingit and Haida Indian Tribes of Alaska (CCTHITA) YR 2001 – 03 comprehensive waste management survey. Results based on self reports from 110 Alaska Villages, with proportional representation characteristics including geography, water hookup, road vs. off-road system. Survey and relational database vehicle (Microsoft ACCESS platform) was designed for by Zender Envr Sci & Plng Svcs for, and is summarized in Zender, L., S. Sebalo, S. Gilbreath, Conditions, Risks, and Contributing Factors of Solid Waste Management in Alaska Native Villages, Proc. Of the 8th. AWWMA R & D Conf., Fairbanks, Apr. 2003, available at http://www.ccthita-swan.org/pdf/AWWMA.pdf . See full survey results available online at the CCTHITA Solid Waste Alaska Network website (http://www.ccthita-swan.org/dbase/start.cfm).

[5] Ibid.

[6] See for example, Salvato, Joseph *Environmental Engineering and Sanitation*, Wiley and Sons, New York 1982. Also, see a general reference on flies such as http://www.entomology.ucr.edu/ebeling/ebeling6.html. Note bacteria can live up to one month in a fly's digestive system and be transmitted through succeeding generations. A classic *in-situ*, open air radioactive study was carried out in 1959 to study house fly (*Musca domestica* L) population movement behavior from an open manure-farm dump, a technique that would not be possible (legally) today. Only a small portion of the population foraged further, up to 20 miles. Schoof, Herbert F. "How far do flies fly?" in *Pest Control*, 1959.

[7] For example, *Aedes aegpti* has a flight range of less than one mi, see *Ibid*. See also generally for example, Univ. of Rutgers Mosquito Biology and Control website at http://www-rci.rutgers.edu/~insects/njmos.htm,

[8] State of Alaska Health and Social Services Epidemiology Program and State of Alaska Fish and Game see http://www.epi.hss.state.ak.us/bulletins/catlist.jsp?cattype=West+Nile+Virus, www.wildlife.**alaska**.gov/aawildlife/disease/wnv.cfm, **westnilevirus**.nbii.gov/states/**alaska**.html. West Nile Virus (WNV) has not been established in the State yet. Locally-acquired WNV could occur if viremic migratory birds arrive in Alaska when appropriate mosquitoes were active and when temperatures were adequate to permit adequate amplification. At least two of Alaska's mosquito species can carry the west Nile virus. Forty percent of the 110 bird species arrive in Alaska each Spring. http://www.ipmofalaska.com/files/ADNbugsWNV.html, http://www.epi.hss.state.ak.us/bulletins/docs/b2004_26.pdf

[9] *Savage, H., and B. Miller. 1995. House Mosquitoes of the U.S.A., Culex pipiens* complex*. Wing Beats, Vol. 6(2):8-9.*

[10] See http://www.juneauempire.com/stories/050805/out_20050508038.shtml

[11] See Armitage, D. 2004. "Rattus norvegicus" (On-line), Animal Diversity Web. Accessed December 24, 2004 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Rattus_norvegicus.html. The species plays hosts to a plethora of diseases, including Trichia, Typhus, and the Plague. These rats also carry bacteria in their saliva that can infect those bitten and cause a sickness known as Rat Bite Fever. Dumps and other public sanitation facilities are of particular concern because they may host the full range of community pathogens in a single convenient location for vectors. Open dumps in Villages present a unique opportunity because only some 6% are covered as a management practice. Thus shelter from the cold and predators (in old furniture, etc) and a food source (garbage) are conveniently available.

[12] See for example, "Rat Patrol sniffs out pests before they can destroy Aleutian species, Anchorage Daily New, Nov. 15 2004.

[13] FAA regulations stipulate 1 mile for non-jet airstrips, two miles for jet aircraft, including turbo prop planes. The regulations apply to any open sanitation facility, including wastewater lagoons.

[14] Based on CCTHITA survey results from 110 Alaska Villages (see note 4). Note, observation data suggest that one reason children play at dumps is that the dump site is can be one of the few (or only) summer-accessible high-ground open areas, particularly for tundra boardwalk Villages. Full survey results available online at the Solid Waste Alaska Network website (http://www.ccthita-swan.org/dbase/start.cfm).

[15] Based on survey results from 110 Alaska Villages, with proportional representation characteristics including geography, water hookup, road vs. off-road system. Supra note 4.

[16] Chambers, Molly, Malcom Ford, Daniel White, Silke Schiewer and Dave Barnes, *Eek Alaska, Preliminary Research and Survey Findings, Summer 2004,* Water and Environmental Research Center, University of Fairbanks, 2004.

[17] A number of studies and literature documenting a primary role of subsistence foods in rural Village diets exist. Subsistence foods in rural Alaska accounted for about 354 pounds per capita, compared with 19 to 35 pounds in Anchorage, Fairbanks, and Juneau, www.state.ak.us/adfg/wildlife/geninfo/hunting/harvest02.pdf . For example, in a 13 (self-identified) Village cross-regional study, 79% or more of rural Village participants consumed all of the following in one year - moose or caribou, geese, at least two types of berries, and in Southeast at least two types of seaweed. Two-thirds of participants consumed several types of subsistence fish. Ballew, C. et al. Final Report On The Alaska Traditional Diet Survey, 2004, Alaska Native Epidemiology Center of the Alaska Native Health Bd, www.anhb.org/sub/epi/documents/final_aggregate_report.pdf . Also see the Alaska Traditional Knowledge and Native Foods Database, Institute of Social and Economic Research, Univ. of AK, at http://www.Nativeknowledge.org/db/files/ .

[18] For example, Schumacher, C., M. Davidson, G. Ehrsam *Cardiovascular Disease Among Alaska Natives,* International Journal of Circumpolar Health, 62:4, 2003. At http://ijch.oulu.fi/issues/624/624_Schumacher.pdf /

[19] For example, *Alaska Natives Commission, Final Report*. Anchorage: Alaska Natives Commission, 1994. See *Volume 1, under* Alaska Natives' loss of social and cultural integrity. Available Online At: http://Www.Alaskool.Org/Resources/Anc/Anc_Toc.Htm**,** Berkes, F., Indigenous knowledge and resource management systems in the Canadian sub-Arctic, in *Linking Social and Ecological Systems*, edited by F. Berkes, C. Folke, and J. Colding, Cambridge University Press, Cambridge, United Kingdom, pp. 98-128, 2000, BESIS, The impacts of global climate change in the Bering Sea region [PDF], an assessment conducted by the International Arctic Science Committee under its Bering Sea Impacts Group (BESIS), International Arctic Science Committee,

Oslo, Norway, 1997. Callaway, D., J. Eamer, E. Edwardwen, C. Jack, S. Marcy, A. Olrun, M. Patkotak, D. Rexford, and A. Whiting, Effects of climate change on subsistence communities in Alaska [PDF], in Proceedings of a workshop, Assessing the consequences of climate change for Alaska and the Bering Sea region, Fairbanks, 29-30 October 1998, edited by G. Weller and P. A. Anderson, Center for Global Change and Arctic System Research, University of Alaska Fairbanks, 1999.

[20] For example, the development and reinforcement of Inupiaq cultural values that favor generosity, reciprocity, and communitarianism, and discourage hoarding and individualism were identified as key to Inupiaq community success (based on range of measures) in the face of climate change Berkes, F. and D. Jolly. 2001. *Adapting to climate change: social-ecological resilience in a Canadian western Arctic community*. Conservation Ecology **5**(2): 18. [online] URL: http://www.consecol.org/vol5/iss2/art18 . Also for example, Lewis, M, and Lockhart R.A. Centre for Community Enterprise, April 2002*, Performance Measurement, Development Indicators and Aboriginal Economic Development* (Cultural strength is integral to social capital, which in turn is needed in economic development). A study at Alaska Pacific University of over 30 Alaskan communities – found that the social cohesiveness of a community contributes to community resilience and quality of life. See http://polar.alaskapacific.edu/gregb/report5.pdf#search='community%20resilience%20alaska%20pacific'.

[21] See Ch 3 and Appendix B in *A guide for closing solid waste disposal sites in Alaska Villages*, Central Council of Tlingit and Haida Indian Tribes (CCTHITA), 2001, and various queries in CCTHITA database at www.ccthita-swan.org

[22] Study was performed by Zender Environmental Science and Planning Services for Central Council o f Tlingit and Haida Indian Tribes of Alaska, summarized in Zender, L., S. Sebalo, S. Gilbreath, Conditions, Risks, and Contributing Factors of Solid Waste Management in Alaska Native Villages, Proc. Of the 8th. AWWMA R & D Conf., Fairbanks, Apr. 2003 and in Gilbreath, S. *Health effects associated with solid waste disposal in Alaska Native Villages*, Doctoral Dissertation, Graduate Program in Epidemiology, University of California, Davis 2004.

[23] For example, in the Native Village of Selawik, population 870, unchecked, the front dumpsite edge encroaches towards town at a measured rate of about 200 ft each summer. Since purchase of a used dozer 3 years ago, the town is able is able to significantly slow this expansion by consolidation of the site at Freezeup. As is the case with many tundra Villages, the dozer cannot be used during summer (when the need is greatest) due to soft ground. The rate of summer dump expansion is such that they are not able to make progress in reducing the size of the dump. During winter, due to snowmachine (i.e. snowmobile) access to all sides, dump expansion of the 24-acre un-designed site is difficult to measure. Anecdotally, dumpsites seem to grow to 2 to 6 acres for smaller Villages within 10 years, depending on practices, which again depend partly on resource availability. There is no typical dumpsite or typical Village. Still, based on our experience at well over 100 open dumps in the Pacific Northwest, including Alaska, we offer the following conservative ballpark estimate exercise for a town of 400 with a waste generation rate of 3 to 6 lbs per capita that does not practice heavy equipment compaction or burning: Assuming an initial *in situ* placement specific weight of 100 to 175 lb/yd^3, with 50% to 90% of the dump site ground covered, an average waste depth of 1 to 2.5 ft, and a combined decomposition and (primarily) degradation/natural compaction (i.e. gravity, rain, snow, wind, etc.) rate for organics of 25% to 75% of volume the first year (highly dependent on location and other variables), the site will expand at about 1/3 acre to 3 ½ acres per year (taking into account continued, albeit slow, decomposition processes). We note that overall site expansion (regardless of the distribution details) will tend to be on the high side with poor access (so that residents are unable to pile wastes in locations already taken), and on the low side with good access and control. See also note 31 for additional considerations.

[24] For example, in an open ended answer format Site Closure/New site/Relocated Site was listed most frequently as the top concern by 100 responding Villages in the CCTHITA database questionnaire (52 out of 100 listed this as a priority), followed by procuring a burnbox or used oil burner, followed by community education. See full database at http://www.ccthita-swan.org/dbase/start.cfm

[25] Documented for example in the YR 2000-01 CCTHITA solid waste demonstration study of four villages. Self-reports by Village participants concerning their burning practices are commonplace at solid waste sessions of the Alaska Forum on the Environment and Alaska Native Health Board annual conferences.

[26] White Paper, Alaska Bureau of Land Management Fire Service, 2005. $4.5 million dollars has been spent by BLM Alaska Fire Service and Alaska DNR on suppression. Fires spread anywhere from two acres to over 26,000 acres, averaging 253 acres.

[27] Approximately 95 percent of dump sites in rural, isolated (non-hub) Native Villages fit the technical definition of open dump (i.e. not meeting federal RCRA guidelines or the State of Alaska delegated waiver regulations for Alaska Class 3 landfills). But a significant (but still minority) portion may be managed or designed adequately to avoid increased risks caused from near or over capacity conditions. For example, in YR 2003, of the 70 Native Village sites that were inspected and scored by ADEC, 70 percent received failing marks, 15 percent were considered substandard, and 15 percent were considered adequate. With slightly different criteria (of most note, recordkeeping/permitted requirements are not included), of the 177 Village dump sites that have been scored by ANTHC (essentially a 638-compacted Indian Health Service), 70 percent have been scored as high hazard, 25

percent as moderate hazard, and 5 percent as low hazard. Rather than management and (original) design, year-round or seasonal landfill function (primarily drainage), recordkeeping, site distance, and other criteria might be inadequate which, while engendering risks, can not be said to precipitate overall higher risks as a result of over-capacity usage.

[28] For example, the open dump site at the Village of Emmonak occupies the last undeveloped parcel of high ground in-town. This growing community is searching for landfill road funds so that they may relocate the dumpsite, and develop critical new housing at the existing site.

[29] Citizen's suits are allowed under RCRA (the federal environmental statute governing solid and hazardous waste). See Mattie Blue Legs et al. v. United States Environmental Protection Agency, et al. Civ. No. 85-5097, Slip Opinion (D. South Dakota, Sept. 3, 1987) and subsequent cases in Eight Circuit Court of Appeals). In this case, a tribal member sought redress from negative impacts she experienced due to the several open dumps on the Pine Ridge Reservation. The Court made clear, that tribal member status was not an issue, and that any citizen has the same litigation right against the owners and operators, as well as those responsible. Here, BIA, IHS simply contributed waste to the sites.

[30] CCTHITA database results, see *supra* note 4.

[31] As with the example of Selawik discussed in note 23, it may not be the overall expansion that is of highest public health concern, as much as the encroachment of the town-side of the dump--- which is lopsided compared to site expansion at other points because residents can't access the site anywhere else during Summer months. If the distribution of new waste is concentrated along one side, and/or along the site access route (see picture), a conservative uncontrolled expansion of one-third acre per year can have a significantly greater visual impact (e.g. one-third of an acre equates to about 1,000 ft of wastes dumped on either side of the access. It can also present a significantly greater health impact, not only because wastes will tend to expand towards town more quickly, but precisely because expansion takes place that most residents must necessarily frequent. We note here again also that total site areal expansion (regardless of the distribution details) will tend to be on the high side with poor access (so that residents are unable to pile wastes in locations already taken), and on the low side with good access and control.

[32] See for example, Vrijheid, M. Health effects of residence near hazardous waste landfill sites: A review of epidemiologic literature*. Environmental Health Perspectives*, 2000. 108(Suppl. 1): p. 101-112. Fielder, H.M.P., et al. Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: Retrospective analysis*.* British Medical Journal, 2000. 320(7226): p. 19-23. Elliott, P., et al. Risk of adverse birth outcomes in populations living near landfill sites*. British Medical Journal*, 2001. 323 (7309): p. 363-368. Miller, M.S. and M.A. McGeehin. Reported health outcomes among residents living adjacent to a hazardous waste site, Harris County, Texas, 1992*. Toxicology & Industrial Health*, 1997. 13(2/3): p. 311-19. Pukkala, E. and A. Ponka. Increased incidence of cancer and asthma in houses built on a former dump area*. Environmental Health Perspectives*, 2001. 109(11): p. 1121-1125.

[33] Gilbreath S, Zender L, & Kass P. Self-reported health effects associated with solid waste disposal in four Alaska Native villages. *International Journal of Environmental Health Research*, 2006; Zender, L., S. Sebalo, S. Gilbreath, Conditions, Risks, and Contributing Factors of Solid Waste Management in Alaska Native Villages, Proc. Of the 8th. AWWMA R & D Conf., Fairbanks, Apr. 2003. See also Gilbreath, S. *Health effects associated with solid waste disposal in Alaska Native Villages*, Doctoral Dissertation, Graduate Program in Epidemiology, University of California, Davis 2004. Research performed by Zender Environmental Science and Planning Services, funded CCTHITA through BIA.

[34] Full survey results available online at the Solid Waste Alaska Network website (http://www.ccthita-swan.org/dbase/start.cfm). Methodology discussed in Zender et al, *supra* note 4.

[35] In Gilbreath S & Kass P. Low birth weight and preterm birth associated with open dumpsites in Alaska Native villages. *American Journal of Epidemiology* Vol 164(6),518-528 2006 and Gilbreath S & Kass P. Stillbirths, neonatal deaths, and congenital anomalies associated with open dumpsites in Alaska Native villages. *International Journal of Circumpolar Health,* 2006; 65 (2):133-147. Birth records from 1997-2001 were used to identify the 10,360 eligible infants born to mothers who resided in 197 Alaska Native Villages with dumpsite rankings. Infants born to mothers living in Villages with intermediate [(odds ratio) OR=1.64; 95% CI: 1.03, 2.63] and high hazard dumpsites (OR=1.99; 95% CI: 1.26, 3.13) had a higher proportion of low birth weight infants than infants in the referent category. Infants, on average, weighed 36 g less (95% CI: -71.2, -0.8) when born to mothers from the high exposure group than infants in the intermediate exposure group and 55.4g less (95% CI: -95.3, -15.6) than infants in the low exposure group. On average, pregnancies, lasted 1.2 days less (95% CI: -2.0, -0.3 g) in mothers from high hazard potential Villages than pregnancies in the intermediate hazard ranked Villages and 1.0 days less (95% CI: -2.0, -0.1 days) than pregnancies in the referent category. Infants born to mothers residing in Villages with high hazard dumpsite contents were more likely (RR=4.27; 95% CI: 1.76, 10.36) to have other defects than other infants. Additionally, positive odds ratios for all congenital anomalies, central nervous system anomalies, circulatory and respiratory anomalies, urogenital anomalies, musculoskeletal and integumental anomalies, multiple anomalies were found. Further, the estimates were similar to significant associations found in other birth defect studies on maternal

populations living near open dump sites in developing countries, indicating that associations in Alaska Villages with these birth defect categories could be significant with a higher population size or greater exposure detail.

[36] Month prenatal care began and number of prenatal visits relative to length of pregnancy.

[37] Villages were categorized as fully plumbed, partially plumbed, or honeybucket.

[38] See for example, Lemieux, P. Evaluation of Emissions from Open Burning of Household Wastes in Barrels, EPA Available at http://www.epa.gov/ttn/atw/burn/burnpg.html#docs1

[39] For example, in separate conversations at different times, residents from four different Villages that the authors have worked with have mentioned such an effect, unsolicited and unrelated specifically to the conversation purpose.

[40] For an interesting perspective, as well as a number of useful citations, see for example, Callahan, Gerald Eating Dirt, Emerging Infectious Diseases, Center for Disease Control, Vol. 9, No. 8, August 2003, online at http://www.cdc.gov/ncidod/EID/vol9no8/03-0033.htm .

[41] Vedal, Sverre M.D., M.Sc., Health Effects of inhalable particles: Implications for British Columbia Dept of Medicine Univ of British Columbia 1995.

[42] Chambers, Molly, Malcom Ford, Daniel White, Silke Schiewer and Dave Barnes, *Eek Alaska, Preliminary Research and Survey Findings, Summer 2004,* Water and Environmental Research Center, University of Fairbanks, 2004.

[43] August 2004 sampling (unusually dry conditions unfavorable to *E. coli*) confirmed poor *E. coli* survival on boardwalks probably as a result of desiccation.

[44] Adhikari, Hrishikesh, Master's Thesis, University of Alaska, Fairbanks, 2005.

[45] Cooperation of barge companies in providing free backhaul of hazardous wastes and recyclable wastes is developing well, particularly along the Yukon. However, these services rely on free service by the barge company, and do not include the problematic transfer of bulk refuse, such as food wastes, contaminated paper, broken appliances, non-recyclable plastics, etc. which comprise the majority of the wastestream. Liability issues, putrefaction concerns, and the need for a full-scale baler system in each Village are likely to hamper efforts to overcome adverse economics for the foreseeable future. For example, in YR 2005, barging material from a Northwest Village to Seattle cost approximately $900 per ton, *excluding* transfer, handling charges to materials recovery facilities. Aluminum, the highest priced recyclable by far, fetches $800 to $1,000/ton. Corrugated, baled cardboard fetches $20-$40/ton. Transporting either of these commodities to processing facilities requires a baler, baler facility, over-winter storage facility, and staff time. While the metals market has surged, barge transportation costs have increased substantially since then as well. In 2008, some Alaska barge companies have indicated a willingness to barge scrap metals for $400 per ton if they are provided the metals recovery fee to help offset their discounted rate.

[46] For example, substantial short-term health risks from visiting or being near the Selawik community's open dump site were formally documented in an epidemiological study. Due to the site's proximity to town (1,500 ft), tourists would automatically be exposed to these risks. The site is visible from town, and the smoke blows directly into town when the dump catches fire. Liability risks are considered too high to develop lodging facilities, and the adverse aesthetics add an additional disincentive.

[47] For example, for EPA Brownfield Job Training proposals are ranked partly on whether communities can offer program participants additional job opportunities in the future where they may use their acquired skills. The City of Selawik was awarded this grant partly because they had an ADOT landfill road project on-line.

[48] This is a comment made by numerous Villages that we have worked with. Incremental service additions might provide justification for incremental fee institution. For example, after several unsuccessful years of attempting to collect fees to pay for a waste collection service, one village obtained funds from a discretionary solid waste demonstration award, started their collection service, and were able to collect $15 per month from about half of the Village after one month of service, without additional education efforts.

[49] For example, landfill road funding fulfills the USDA community match requirement for landfill construction grants. The Federal Interagency Open Dump Grant award is based on ranking criteria that prioritizes leveraged funding and support. With water and wastewater sanitation facilities still higher priorities on the Alaska State capital improvement project list, USDA and Interagency Open Dump Grant programs are the primary means for Alaska Villages to secure landfill funding.

[50] Dura-Base was evaluated by ADOT in a recently completed research report commissioned by ADOT. Citation unavailable at publication time. To obtain a list of Alaska projects, and view photos and additional information, two distributors for Alaska projects can be contacted via http://www.composite-tech.com/ and http://north-pacific.com/root/dept/durabase/ This note does not constitute an endorsement of products or services by particular vendors and may not represent the full list of suppliers available for Alaska.

[51] Note, information regarding the emission toxicity in the advent of the road being engulfed in a fire, and potentially burning, was not researched at draft time. Of consideration is whether the risk of fire conditions necessary to "burn" the road is significant, and what level of significance the road emissions would represent of total emissions involved in a major fire, particularly if the dump were involved.

[52] For non-hub YK Delta Villages, approximately $1 million per mile, including shipping, installation, materials for a 7 ft wide road (appropriate in boardwalk communities), and $1.75 million per mile for a 13 ft wide road.

[53] See note 28. Agencies that contribute wastes to disposal sites that do not meet RCRA can be held liable. In the *Blue Legs* case, BIA and IHS were obligated to pay a proportionate share of cleanup costs.

[54] The context here is that in a number of low-lying Villages, the dumpsite was located on scarce higher ground to avoid flooding, but with Village expansion and greater flooding, dry land for housing is now not available.

[55] We decline in this paper to define precisely what would constitute "proximate", although certainly sites within about one-quarter mile would seem to qualify and, as discussed, past about two miles, a number of vector risks would be likely decreased. Distance is not the only factor in an analysis of disease transmission or smoke inhalation risks. For example, wind direction analysis is one criterion in determining exposure risk to dump smoke and/or vapors. Exposure would be expected to be considerably higher in Villages where the dominant wind direction is from the dump towards town.

[56] Backhauling wastes requires over-winter storage facilities and a baler facility; incinerators and balers require the equipment and facilities (and landfill site), and Supersack landfill require the sacks, handling equipment, and landfill site. As an example of cost comparison, based on Alaska case studies of active facilities in smaller communities, capital costs in a YR 2002 feasibility study for the Native Village of Selawik for construction of an incinerator, baler, and Supersack facility were $1.6, $1.9, and $1.8 million respectively. With no gravel source, YR 2002 road construction in Selawik was estimated at $1.5 million per mile, and has since increased to approximately $1.7 million.

[57] For a discussion of O & M for water and sewer projects, see for example UAA ISER Report *ID*# 991 S. Haley, et al.. *Evaluation of the Alaska Native Health Board Sanitation Facility Operation and Maintenance Program, Final Report on Phase III Projects and Extended Phase II Projects*, September 2000, pp. 144; pp. 98 (two volumes). See also http://www.iser.uaa.alaska.edu/Publications/sustainA.pdf

[58] See cost comparisons in Solid Waste Management Plan for the Native Village of Selawik

[59] Supersacks are pre-fabricated heavy-duty impermeable synthetic bags used for loose container shipments (e.g. sand). "Tundra-Teck" bags are a new woven fiberglass technology developed specifically for use in Village dumpsites, with the future idea of local production. They are porous and more significantly more expensive, but do not breakdown in ultraviolet light. Their use will be tested in the next two years as well.

[60]

[61] Several units produce emissions that vendors claim are safe for the community, and they may have their place in some Village waste disposal solutions. But these require a high degree of waste separation to operate (i.e. community disposal behavior control and high staff time), and in practice this is unlikely to occur in most communities with poor resources. They also, like a true incinerator, require a dump site for unburned wastes and ash.

[62] EPA National Center for Environmental Research Small Business Innovation Research Phase I Program Solicitation No. PR-NC-05-10246 http://es.epa.gov/ncer/rfa/2005/2005_sbir_phase1.html#B3 .

[63] Regarding landfill road dust, the sole certainty we have is that individual dust exposure on a long dusty road would be higher than on a short dusty road. However, for a given community, it is not at all clear that use of a new landfill road would increase or decrease overall net exposure of residents to road dust, and whether that change would be significant in relation to the total road dust exposure in the community. From a responsible public health standpoint, the question must be addressed within the larger context of the resultant change in total exposure to dust contaminants and particulate matter from all sources (including non-road and non-dust sources). A number of complex factors are of consideration here, involving both changes in community disposal practices that result from the landfill road and new site, as well as changes in (reduced) exposure to site and smoke contaminants, including toxics and particulates.

[64] See note 27. Yr 2003 statistics, new permitting regulations are under development.