This discussion paper is in regards to the use of Styrofoam food service products by LKSD schools in the Nelson Island Area Villages of Chefornak, Newtok, Nightmute, Toksook Bay, and Tununak. These Villages have formed the Nelson Island Consortium, which is dedicated to improving public health and environmental conditions in the communities and shared subsistence grounds.

Each day, Styrofoam trays, bowls, cups, and plates are used in serving lunch to LKSD students and staff. This consumption pattern results in an estimated 1.5 tons of Styrofoam discarded annually, equivalent to about 400 cubic yards of trash bags. The production of Styrofoam consumes non-renewable petroleum products and releases toxic compounds in the nation's waterways. After consumption, the impact of Styrofoam on the environment depends on the local waste disposal method employed. It is nearly an inert product when landfilled and covered, but is toxic when incinerated, or its scattered pieces inadvertently consumed by wildlife. As with the vast majority of communities, the Nelson Island Village waste disposal sites provide minimal protection for problematic wastes such as Styrofoam. Due to lack of cover, suitable land space, equipment, and/or operational funds, Styrofoam is ultimately burned via methods lacking emissions treatment, such as controlled open burning, burning via "burnbox", or accidental dump fires. While allowable under State of Alaska Class 3 regulations, these methods result in the release of toxic compounds to the atmosphere, including styrene, benzene, and dioxin. Available information on smoke emissions from municipal garbage burned via these methods indicates that concentrations of these chemicals can exceed the Maximum Contaminant Levels (MCL's) for health effect thresholds. Additionally, in the case of Villages where burning occurs only occasionally via dump fires, due to its flyable and breakable nature, Styrofoam litters the area surrounding the dumpsite, and can inadvertently be consumed by wildlife and fish.

Styrene vapor, a potential carcinogen, is formed from incineration of polystyrene (Styrofoam), at the low temperatures characteristic of open burning and burnboxes. Acute exposure to styrene in humans results in respiratory effects, such as mucous membrane irritation, eye irritation, and gastrointestinal effects. Based on studies of workers exposed to styrene, chronic exposure to styrene in humans results in effects on the central nervous system (CNS), with symptoms such as headache, fatigue, weakness, depression, CNS dysfunction (reaction time, memory, visuomotor speed and accuracy, intellectual function), and hearing loss, peripheral neuropathy, minor effects on some kidney enzyme functions and on the blood. No data on the health effects of breathing low-levels of styrene over long periods of time exists. And little information exists about the health effects of styrene ingestion on humans.

Used primarily as a raw material in the synthesis of styrene, benzene is a recognized carcinogen. At lower acute exposure levels to benzene above the MCL, mild CNS effects appear to be concentration dependent and rapidly reversible. But other effects include immune system depression and bone marrow toxicity leading to aplastic anemia. Acute exposure to high levels produces central nervous system (CNS) effects and death. Daily to weekly exposure to dumpsite smoke containing benzene constitutes chronic exposure to benzene. Chronic exposure to Benzene at levels above the MCL has the potential to cause chromosomal aberrations.

If benzene is released to the atmosphere, it will exist predominantly in the vapor phase. Gas-phase benzene reacts with hydroxyl radicals, resulting in the the production of phenol, nitrophenols, nitrobenzene, formic acid, and peroxyacetyl nitrate. Incineration of cholorinated benzene, as occurs when Styrofoam is burned, produces dioxin. Additionally, Benzene is fairly soluble in water and is removed from the atmosphere in rain. When benzene is released to soil, it will be subject to rapid volatilization near the surface, but that which does not evaporate will be highly, to very highly, mobile in the soil and may leach to groundwater. Although most public drinking water supplies are free of benzene, exposure has been found to be very high from consumption of water sources contaminated by landfill drainage. Because Nelson Island disposal sites are unlined and proximate to drinking water sources, exposure to benzene via this pathway in addition, to the smoke inhalation pathway, is of concern.

Dioxin is one of the most toxic and environmentally stable tricyclic aromatic compounds of its structural class, and is potentially carcinogenic. Additionally, acute exposure to dioxin at levels above the MCL has been found to potentially cause liver damage, weight loss, atrophy of thymus gland and immunosuppression. Chronic exposure to Dioxin at levels above the MCL has the potential to cause a variety of reproductive effects, including reduced fertility and birth defects.

Particulate-phase dioxin in smoke may be physically removed from air by wet and dry deposition. Due to its very low water solubility, most of the dioxin in water is expected to be associated with sediments or suspended material. Dioxin is resistant to biodegradation, and bioconcentration in aquatic organisms that consume this material has been demonstrated. Thus, contamination of subsistence resources by deposited dioxin is a potential pathway of exposure, in addition to the primary pathway of concern, smoke inhalation.

Beyond public health concerns, due to its low specific weight, the use of Styrofoam exacts a significant, disproportionate future financial cost to Villages. Suitable land for disposal sites is very scarce, and only one to three villages each year are able to obtain funding for landfill road and facility construction statewide. Priority is for Villages of higher populations that those of Nelson Island. Styrofoam takes up approximately three to five times more volume than an equivalent weight of paper, and is non-biodegradable. Based on a YR 2005 wastestream analysis in Tununak, we estimate the school Styrofoam wastestream alone to comprise approximately 15 percent of the total community wastestream volume, as discarded. Without burning the wastes, school Styrofoam would occupy approximately 8 to 10 percent of the waste volume *in situ* at Nelson Island waste disposal sites (due to natural waste compaction processes).

An issue of global responsibility for the use of Styrofoam exists as well. The manufacturing process of Styrofoam involves the use and disposal of additional chemicals, including carbon tetrachloride, polyvinyl alcohol, antimony oxide, tert-butyl hydroperoxide, and bensoquinone. When Styrofoam is produced in developing countries with relaxed environmental and worker safety regulations, workers and local communities can be exposed to these chemicals.

An increasing number of entities—government agencies, institutions, and private businesses, have ceased their use of Styrofoam to rely instead on either paper or alternative foam products produced with new technologies from non-toxic, renewable resource materials.

To evaluate the potential for such a conversion for their schools, the Nelson Island Consortium commissioned the below cost analysis on sample food service vendor retail prices:

Styrofoam, 1000 ct.

Item	Example Product cost	Shipping Cost ($0.37/lb)	Total Cost
Bowl, 12 oz	$40	$3.90	$44
Plate, 9 “	$50	$8.60	$59
Cup, 8 oz	$30	$3.00	$33
Tray, 9” by 12”	$60	$6.00	$66
Total Set	$180	$21	$201

Renewable Resource Material, 1000 ct.

Item	Example Product cost	Shipping Cost ($0.37/lb)	Total Cost
Bowl, 12 oz	$45	$8.80	$54
Plate, 9 “	$62	$15.00	$77
Cup, 8 oz	$48	$8.00	$56
Tray, 9” by 12”	$90	$13.70	$104
Total Set	$245	$45	$291

Paper, 1000 ct.

Item	Example Product cost	Shipping Cost ($0.37/lb)	Total Cost
Bowl, 12 oz, lightweight	$90	$6.40	$96
Plate, 9 “, heavyweight	$100	$27.20	$127
Cup, 8 oz, lightweight	$58	$5.60	$64
Pulp Tray, 10” by 7”	$155	$15.50	$171
Total Set	$403	$55	$462

Our research indicates that conversion to starch-based, vegetable-oil, or other new technology material products from Styrofoam will be the least expensive alternative. Based on 185 days of food service each school year, we have calculated the following range cost-to-convert to an alternative product, with an estimated 20% margin of error to account for price differences in actual negotiated contracts, shipping rates, and material availability and suitability:

Estimated Cost To Convert From Styrofoam Bowl, Cup, Plate, And Tray To Alternative Product

Community	Number of students plus staff	Approximate number of 1,000 ct. case sets	Estimated cost to convert from Styrofoam to alternative.	Maximum estimated cost, with 20% price uncertainty for both product sets[1]
Chefornak	159	29	$2,581	$5,435
Newtok	119	22	$1,958	$4,123
Nightmute	76	14	$1,246	$2,624
Toksook Bay	210	38	$3,382	$7,121
Tununak	122	22	$1,958	$4,123

[1] Assumes Styrofoam set can be obtained for 20% *less* than estimated, and Alternative Material set must be purchased for 20% *more* than estimated.

Minimum operation and maintenance costs for a disposal site meeting State operational requirements to protect public health in the Nelson Island area are as follows (YR 2005 dollars):

Chefornak	Tununak	Toksook Bay	Nightmute	Newtok
$97,685	$97,685	$107,203	$72,301	$97,685

Based on a YR 2001 feasibility study for solid waste management options in Chefornak, AK. Includes O & M of equipment, staff salary, site closure and post-care sinking fund, sinking fund for 25% match of capital costs. See Appendix A.

A YR 2001 wastestream characterization study in Chefornak determined the school contribution to the community wastestream *by weight* as 61% of non-residential wastes, and 7% of the total wastestream, averaged out over one calendar year[1]. Assuming the school contribution is similar for each community, we provide below estimates of the school proportionate-cost share of disposal site operation and maintenance, the *maximum* annual cost to switch from Styrofoam to biodegradable products, and the cost difference between the two values.

Comparison of estimated Styrofoam-to-Alternative product conversion cost with school share of true costs for operation and maintenance of the local waste disposal site, annually.

Chefornak		Tununak		Toksook Bay		Nightmute		Newtok	
Maximum cost to convert	School share of waste disposal O & M	Maximum cost to convert	School share of waste disposal O & M	Maximum cost to convert	School share of waste disposal O & M	Maximum cost to convert	School share of waste disposal O & M	Maximum cost to convert	School share of waste disposal O & M
$5,435	$6,849	$4,123	$6,849	$7,121	$7,517	$2,624	$5,069	$4,123	$6,849
Difference: **$1,415**		*Difference:* **$2,726**		*Difference:* **$395**		*Difference:* **$2,446**		*Difference*: **$2,726**	

Even using the estimated *maximum* cost to convert to environmentally-friendly products, our analysis indicates that a conversion is financially feasible for LKSD through mutual cooperation with the Nelson Island communities. The food service conversion is in the interest of the Nelson Island communities, and discounted disposal costs for use of the local waste site in the interest of the local schools. Our communities are willing to work with LKSD in achieving both aims.

[1] Zender Environmental Science and Planning Services, *Assessment of Solid Waste Management Situation for the Native Village of Chefornak,* funded by Central Council of Tlingit and Haida Indian Tribes of Alaska, 2001.

Appendix A
Landfill Operation and Maintenance Costs for Nelson Island Villages

Estimated Operation and Maintenance Costs for Chefornak, Newtok, and Tununak[0]

Item	Unit	Cost/Unit	Quantity	Cost ($/per year)	School contribution
Operator 0.6875 FTE [1]	hr	$25	1430	35,750	$2,507
Administration 0.10FTE[1]	hr	$20	208	4,160	$292
Equipment operation and maintenance	hr	$20	400	9,142	$641
Equipment replacement fund	$82,000 for Small Track Loader, inc. shipping	$82,000	1	3,148	$221
Safety gear	Lump sum	$500	1	571	$40
Replacement parts (burnbox)	Lump sum	$300	1	343	$24
Generator fuel	Lump sum	$100	1	114	$8
WQ testing[2]	priority pollutant scan	$1,350	1	1,543	$108
Final cover/closure[3]	$325,000/small site closure in bush	$325,000	1	12,479	$875
Post-closure care[4]	ac	$3,500	2	2,180	$153
Training	Lump sum	$1,500	1	1,714	$120
20 yr sinking fund for capital costs of new landfill	25% match	844,000 for new landfill	1	8,102[5]	$568
Subtotal				$84,944	$4,988
Contingencies @ 15%				$12,742	$748
TOTAL				**$97,685**	**$6,849**

0 To adjust for sizeable population differences, Toksook Bay labor and site closure & care costs should be adjusted 25% up, and equipment hours 15% up. Nightmute labor should be adjusted 25% down, and equipment and site closure & care costs 15% down.

1 Includes insurance, retirement and administrative overhead

2 Assumes testing and analysis of heavy metals and fecal coliform performed with water sampling kit (quarterly while landfill is active and once per year after closure). Priority pollutant analysis is performed once per year at an outside lab.

3 The $325,000 is an estimate based on actual closure costs for several villages from A Guide to Closing Waste Disposal Sites in Alaska Villages, Central Council Tlingit and Haida Indian Tribes of Alaska, 2001. Placed into sinking fund for planned life of landfill (20 yr) calculated at 4% interest rate, includes 40% mobilization/demobilization plus contingency rate. See note above.

4 Estimated according to actual cost average incurred for several sites. From A Guide to Closing Waste Disposal Sites in Alaska Villages, Central Council Tlingit and Haida Indian Tribes of Alaska, 2001. Placed into sinking fund for planned life of landfill (20 yr) calculated at 4% interest rate, includes 40% mobilization/demobilization plus contingency rate.

5 Placed into sinking fund of 4% interest rate.