Environmental Geochemistry and Health (1996), **18**, 17–24

A co-operative approach to risk management in an active lead/zinc smelter community

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Trail, Canada has been the site of a large lead/zinc smelting facility since 1916. In mid 1990, the Trail Community Lead Task Force was established and given responsibility for developing a strategy to reduce children's blood lead levels. With funding from the provincial government, the smelting company and the municipal government, the Task Force has carried out blood lead screening, case management, community education, exposure pathways modelling and remediation trials. The decline in children's blood lead levels appeared to accelerate following the implementation of these programmes. The average blood lead in Trail children aged 6–72 months fell 14% from the autumn of 1991 to autumn of 1992, whereas for the previous 16 years, the average annual decline had been about 4%. In subsequent years, blood lead levels have appeared to plateau. Throughout the 5-year history of the Task Force, its members have demonstrated a strong sense of common purpose and have worked co-operatively to reach consensus on most issues.

Keywords: Risk management, blood lead, remediation

Introduction

Trail, British Columbia, Canada, has been the site of a major lead and zinc smelting facility since 1916. In 1975, Neri *et al.* (1978) found that children's blood lead levels in Trail were significantly higher than those in the nearby comparison community of Nelson, BC. The primary correlates of elevated blood lead at that time were neighbourhood soil lead concentrations and proximity to the smelter site (Schmitt *et al.*, 1979). A 1989 study found that soil lead concentration and, secondarily, house dust lead concentration, were the principal environmental determinants of elevated blood lead levels in Trail children (Hertzman *et al.*, 1991). Although the average blood lead level had declined from 22.4 $\mu g\ dL^{-1}$ for 1–3-year-olds in 1975 to 13.8 $\mu g\ dl^{-1}$ for 2–5-year-olds in 1989, 39.4% of the children tested in 1989 were above the US Environmental Protection Agency's 'level of no concern' of 15 $\mu g\ dl^{-1}$ at the time (US EPA, 1986).

The 1989 study's recommendations prompted the formation of the Trail Community Lead Task Force. The study authors recommended that the Task Force should focus its environmental assessment efforts on tracking lead in soil to its origins, investigating bioavailability factors and intensively mapping the depth and consistency of soil leads. The Task Force was cautioned, however, that massive soil removal might not be rational until after smelter emissions had been controlled. The study also recommended that a comprehensive awareness and education campaign be implemented.

The Task Force is composed of representatives from the smelter company (Cominco, Limited), the government of British Columbia, local government and numerous community groups as shown in Figure 1. Cominco, the BC Ministry of Health and the BC Ministry of Environment each contribute 30% of the Task Force's annual budget, while 10% is provided by the City of Trail.

When the Task Force was formed in 1990, it was faced with developing a strategy for reducing Trail children's lead exposures. Communities with inactive smelters or mine sites have often implemented large clean-up programmes to permanently reduce lead exposures. By contrast, the strategy for Trail was expected to help the smelter and the community to continue to co-exist by focussing on actions that would be ongoing.

The Task Force estimated the cost of residential soil replacement in Trail proper alone at over $55,000,000 and expressed concern that excavation and soil transport might result in a transient increase in lead exposure. In addition to the financial deterrent and questions of efficacy, soil removal appeared to be socially unacceptable in Trail. The lead smelter currently relies on outdated process technology and, despite efforts to control emissions, the amount of lead discharged to the environment is about 300 kg d^{-1} (Cominco Ltd, 1993). Smelter emissions, and therefore soil contamination rates, were expected to continue at close to present levels for a number of years. For all of these reasons, the Task Force chose not to undertake any immediate soil replacement. Instead, the Task

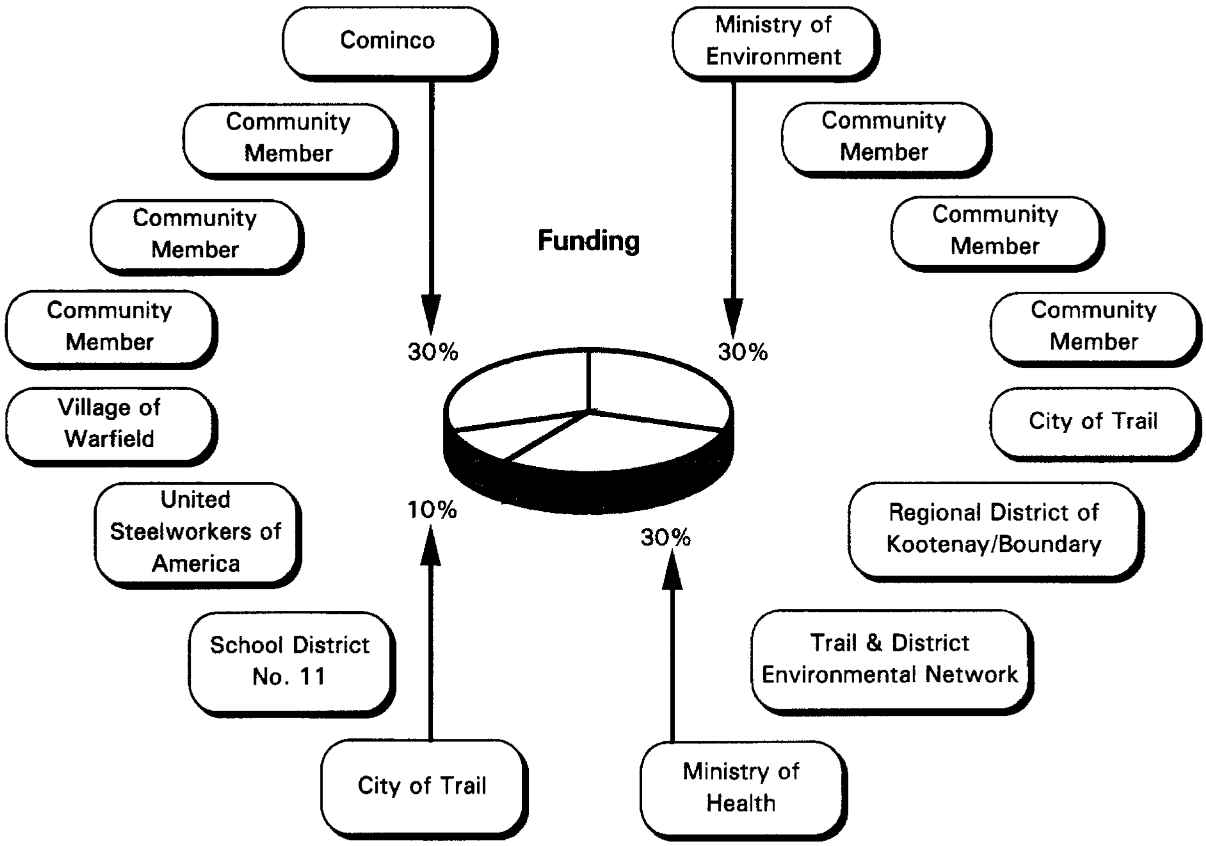

Figure 1 *Trail Community Lead Task Force structure*

Force embarked on ambitious programmes of community education and case management, as well as environmental assessment aimed at better understanding lead exposure pathways. The philosophy adopted by the Task Force was that environmental remediation should not be conducted without evidence that it would be effective in reducing blood leads. Remediation options would be considered in light of new information on exposure pathways and then tested for effectiveness.

A need for concrete action

In mid 1991, after work had begun on community education and case management, it became apparent that it would take several more years before the exposure pathways assessment and other environmental groundwork could be completed. At the same time, members of the Task Force and Lead Program staff began to receive feedback that the community wanted something done to improve conditions.

The Task Force felt that some actions which could be taken at relatively low cost should not be delayed. In particular, there was wide support for a programme to 'green' public areas by planting grass and shrubs. The premise was that covering areas of bare, high-lead soil with vegetation would reduce children's direct contact with the soil and decrease movement of dust by wind. A host of similar projects was considered, including dust control on unpaved alleys, street cleaning and provision of seed and fertiliser to householders. It was recognised, however, that it would be virtually impossible to measure an impact on blood lead due to any one of these projects. The Task Force accepted that such projects would help to educate and involve the community and that they would be evaluated in terms of practicability in Trail, rather than in terms of impact on blood lead.

Summary of projects to date

Exposure pathways modelling

In 1992, the Lead Program collected data on children's blood lead levels, their habits and their living environments (Trail Lead Program, 1995a). Using structural equations modelling, Pan (1993) constructed an exposure pathways model which depicts the most likely routes by which children are exposed to lead. The pathway model depicted in Figure 2 suggests that the main direct contributor to blood lead is house dust lead loading and that environmental lead passes from dust fall through street dust, soil and yard dust into the house dust. The relative importance of indoor *versus* outdoor exposure appears to vary with age. For children less than 18 months old, interior house dust is by

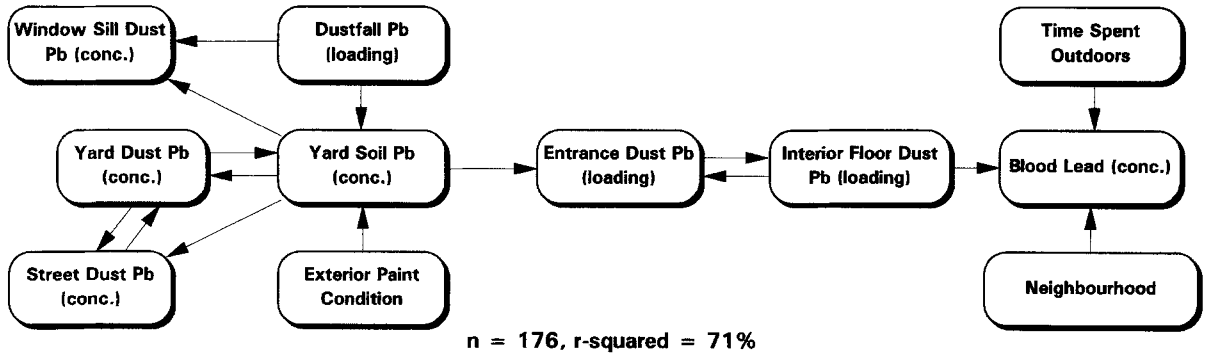

Figure 2 *Lead exposure pathways model for Trail (based on stuctural equations modelling by Pan, 1993)*

far the strongest correlate of blood lead ($r = 0.66$). For children 18 months of age or older, current blood lead level is determined mostly by prior blood lead ($r = 0.82$). However, time spent outdoors daily and yard soil lead concentrations are also significant predictors of blood lead in children over 18 months, which suggests that continued exposure at this older age occurs mainly outdoors.

Despite some concern that education and counselling might have weakened the relationships between blood and environmental lead in Trail, the exposure pathway model is extremely good at explaining the variance in blood leads. The model explains 71% of the variance in blood lead, whereas similar models for other sites have typically explained about 30-45% of the variance in blood lead (Bornschein *et al.*, 1986; 1988; University of Cincinnati, 1990; Butte-Silver Bow Department of Health and University of Cincinnati, 1992).

The main purpose of the exposure pathway model is to assist in targeting remediation/intervention efforts. The model suggests that the most effective actions would be to reduce the amount of lead settling out of the air and to reduce the amount of dust in homes. The former action is primarily a Cominco responsibility, which the company is addressing through site management and housekeeping, process control and implementation of new-lead smelting technology. The reduction of house dust is being addressed by the Task Force and by individual families.

The data analysis also confirmed the importance of the Task Force's education messages regarding family hygiene and habits. Children tended to have higher blood leads if they chewed their fingernails, put dirt in their mouths, had an indoor dog or cat, lived in a house where someone smoked or lived in a house that had recent renovations involving sanding painted surfaces.

Community greening and dust control

The Rotary Club of Trail, with funding from the Task Force and the federal Environmental Partners Fund, has completed a substantial amount of seeding and planting in public areas that were identified by the Lead Program as having high lead levels (Trail Lead Program, 1995c). Each summer since 1993, magnesium chloride dust suppressant has been sprayed on unpaved alleys and parking areas. This odourless, colourless salt brine is widely used to reduce dust on dirt roads. It physically binds the top layer of the road surface and attracts a film of moisture that keeps the surface wetted. The greening and dust control has so far been very successful and work is continuing on additional sites. Unfortunately, there is no way to evaluate the impact of these efforts on blood lead levels or environmental lead levels.

Ground cover subsidy programme

The exposure pathway analysis described above also showed that children tend to have higher blood lead levels if they live in homes with higher percentages of bare soil. This effect has also been observed by Cook *et al.* (1993) in the former mining and smelting community of Leadville, Colorado. This information suggests that ground cover such as grass, concrete, or ground shrubs can provide an effective barrier between contaminated soil and children. This principle has been accepted and adapted for use at other sites (Farrell and Calder, 1988; Lamb and Kiernan, 1988).

The lead programme in Port Pirie, Australia, has found that home-based lead abatement is more successful when householders participate actively than when all the work is done for them (C.V. Phipps, personal communication). To test whether householders in Trail would respond similarly, a residential ground cover pilot project was commenced in 1993 (Trail Lead Program, 1995d). The project provided a 50% rebate on material costs to householders who covered bare soil in their yards. Any type of ground cover was eligible, including turf, landscape fabric and mulch, shrubs, concrete or gravel. The aim of the project was to see whether a significant percentage of eligible families would participate and whether their ground cover projects would be well maintained.

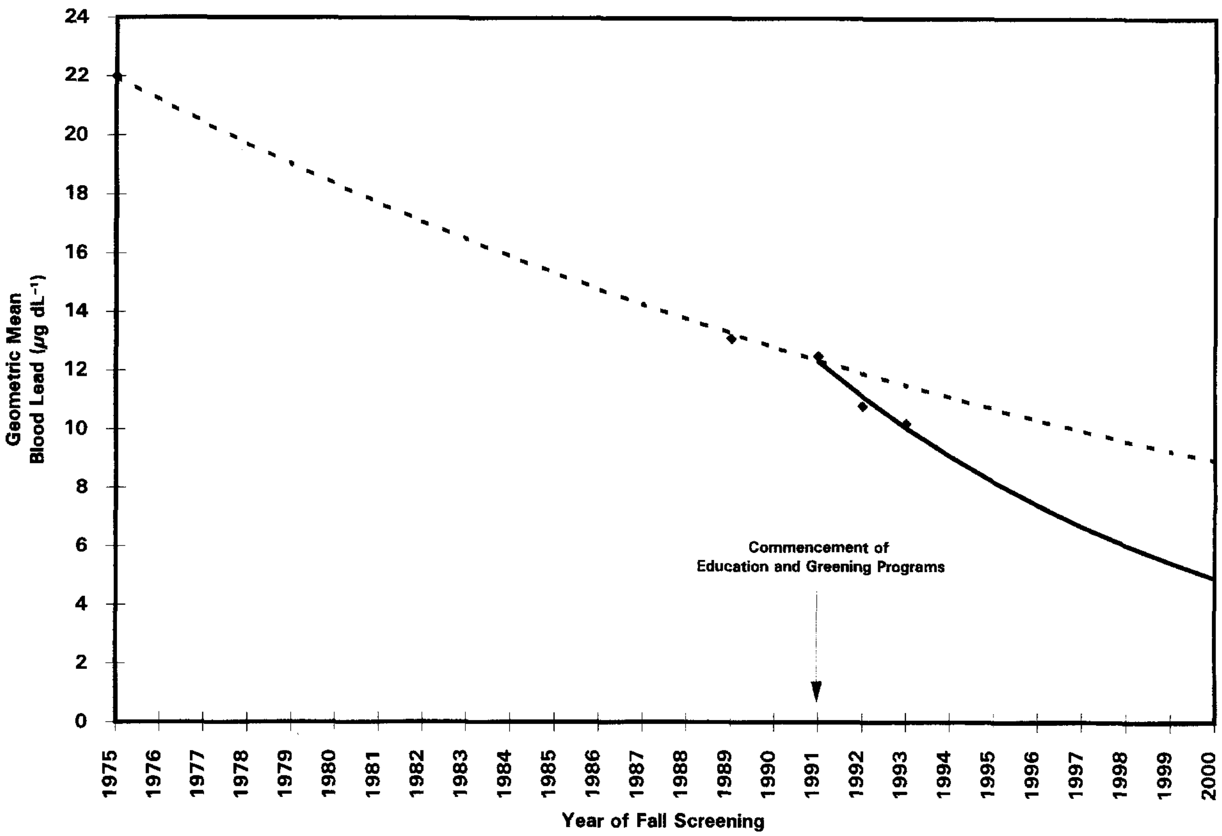

Figure 3 *Inferred impact of lead intervention programmes on geometric mean blood lead levels*

All families who had children 6–72 months tested in the 1992 fall blood clinic (292 families) were eligible to receive rebates, provided that they had bare areas of soil in their yards. The participation rate among eligible families was only about 23%, with 44 families completing projects. Unfortunately, the participation rate was lowest in the lower income areas nearer the smelter, where ground cover improvement would actually be of greatest benefit. A follow-up assessment during the late summer of 1994 confirmed that the ground cover projects were being adequately maintained. However, it was noted that 12 of the 44 properties would require further ground cover work to achieve 100% coverage of bare soil.

Education and case management

Trail's Lead Education Program is regarded as one of the most comprehensive and effective of such programmes. The variety of individuals reached and number of contacts made in 1991–92 are summarised in Table I. This effort has appeared to pay dividends in terms of reduced blood leads. The average blood lead in Trail children aged 6–72 months fell 14% from the autumn of 1991 to the autumn of 1992, whereas for the previous 16 years, the average annual decline had been about 4% (see Figure 3.) It is not possible to conclusively attribute all of this decline to the community education and case management programmes. However, environmental monitoring data indicate that community lead levels in soils, suspended particulate and dustfall did not change appreciably during the 1991–92 period (Trail Lead Program, 1995b). Nor can the weather take credit for the decline, as the spring and summer of 1992 were exceptionally dry.

The average blood lead declined by a further 6% from 1992 to 1993. It appears that the impact of education programmes was greatest in the first year of their operation, as has been observed at other sites, such as Port Pirie, South Australia (Maynard *et al.*, 1993). In 1994, the age range of children tested was narrowed to 6–60 months and the outlying areas were eliminated from annual blood lead screening, making comparison with previous years difficult. Comparison with results for the same age and area group from 1991 to 1994 does show that 1994 blood lead levels rebounded to approximately what they were in 1992. The rebound appears to be mostly attributable to protracted hot, dry weather from June through September in 1994.

Participation rates in the voluntary blood screening clinics have been high, with 75–80% of children participating in annual autumn testing and 85–90% of children participating in follow-up clinics for children with elevated blood leads. The Case Management Program includes increased blood lead monitoring and provision of in-home exposure reduction counselling for parents of children with blood

Table 1 *Summary of educational contacts by Trail Lead Program 1 September 1991 to 31 August 1992*

Type of Contact	Particulars of contact	No. of presentations of issues	No. of contacts with children	No. of contacts with adults	No. of minutes in contact per group or family
Contacts with educational groups	School bulletin boards	8	9600	480	
	Artwork/circle time ideas	10	4080	268	
	Meetings with or presentations to elementary school administrators, teachers and students	55	525	55	25
	Meetings with or presentations to day care directors, instructors and students	18	240	45	45
	Meetings with or presentations to Mom & Me leaders, mothers and children	9	290	137	35
	Subtotals	100	14 735	985	
Health promotion and case management contacts	Screening clinic anticipatory guidance	300	100	400	10
	Phone/letter family contacts	880	0	1075	4
	Home/office counselling visits	275	150	350	40
	PHN contacts with families	240	30	300	10
	Meetings with health professionals	10	0	48	30
	Prenatal classes	11	0	154	30
	Subtotals	1716	280	2327	
General community contacts	General community newsletter	1	0	7050	
	School newsletters to parents	10	0	16 800	
	Local newspaper educational ads	6	0	81 840	
	Public meetings	12	0	10	60
	Miscellaneous functions (info booth etc.)	5	50	360	3
	Subtotals	34	4100	106 060	
Grand totals		1850	19 115	109 372	

lead levels of 15 μg dl^{-1} or higher. As of 1994, assistance in the form of ground cover materials or cleaning supplies, equipment and services is also being offered to eligible families. Parents of children under 1 year old are included in the programme if their child's blood lead level is above 10 μg dl^{-1}. The programme is being well received and the Task Force has found that many parents are willing to take their own actions with some minimal assistance.

HEPA house cleaning pilot project

The benefit of providing repeated house vacuuming using HEPA vacuum cleaners was studied in Trail in 1993 (Hilts *et al.*, 1995). Fifty-five treatment homes received thorough vacuuming of finished accessible floor areas once every 6 weeks for 10 months, while 56 control homes did not. The study failed to show a clinically significant impact on either blood lead or floor lead. Therefore, regular HEPA vacuuming is not a primary component of the community-wide intervention strategy at this time. However, a survey of participants and an ancillary investigation of recontamination provided insight into factors that influence indoor lead exposure and indicate that more frequent vacuuming might be beneficial in some cases. In particular, the vacuuming service achieved greater reductions in floor lead loadings in homes where the parents did not vacuum frequently and where the children had higher blood leads at the start of the study.

A follow-up study was conducted in 17 homes located in high-risk neighbourhoods. Families in the follow-up study received HEPA vacuuming, wet-mopping and wet-wiping once every 2 weeks over the summer months. Participants also received advice on reducing exposure and financial assistance with ground-cover improvement. There was no random assignment to a control group in the follow-up study. The average blood lead level of children in the study group rose by 2.9 g dL^{-1} from April to September, whereas the blood leads of 10 children about the same age, living in the same neighbourhoods, but not enrolled in the study, rose by 4.2 μg dl^{-1} over the same period. The difference between groups was not statistically significant. The average amount of lead on carpet surfaces in the study group did not change from start to finish (0.47 to 0.42 mg m^{-2}; p value 0.60), whereas the lead on carpets in 14 homes in the same neighbourhoods nearly doubled over the same period (0.52 to 0.90 mg m^{-2}; p value 0.01). Therefore, the interventions appeared to prevent a seasonal rise in the amount of lead on the surfaces of carpets and may have lessened the rise in blood leads. The cleaning service is now being provided as part of the Case Management Program described above. The cleaning is offered every 2 weeks during summer months and monthly throughout the rest of the year in homes with children less than 2 years of age and blood lead 15 μg dL^{-1} or higher or with children less than 1 year old and blood lead greater than 10 μg dL^{-1}.

Bioavailability

The health risk posed by lead contaminated soil is not determined by lead concentration alone. Factors such as the chemical form of lead, soil pH, texture and organic content all influence the bioavailability of lead in soil (Chaney *et al.*, 1988). Investigating the geochemistry of Trail soils might provide additional options for remediation. For example, studies have suggested that inducing lead in soil to alter to low solubility lead phosphate may be effective in reducing bioavailability (Ma *et al.*, 1993; Ruby *et al.*, 1994). The Task Force has conducted a programme to characterise Trail area soils in preparation for conducting bench-scale amendment trials in 1995. The characterisation work showed that the six areas sampled had similar soil geochemistry. In particular, all had relatively low clay and organic matter content, low pH and low water-soluble phosphate. These low levels suggest that soil amendment using phosphate and lime may be quite beneficial.

The Community Task Force process

The Trail Community Lead Task Force meets monthly to receive reports from its staff, discuss issues and make decisions. All meetings are open to the public and the media. However, public attendance is minimal unless specific issues of public interest are on the agenda. Generally, reporters from the local newspaper and radio are in attendance and coverage of the meeting's highlights is provided the next day.

In addition to financial contributions, the provincial government and Cominco provide technical resource people with health, environment and public relations backgrounds to participate in programme planning. Cominco has made independent contributions to educating workers and the public and finds itself in the somewhat unusual position of having to convince sceptical factions of the citizenry that lead contamination is a health concern which should be dealt with.

The cost-sharing between government and industry has been accepted by the community and by all funding agencies. The original terms of reference for the Task Force specify that it has responsibility to recommend financing formulae for the implementation of the remedial plan, as well. However, recently enacted provincial legislation will require that parties responsible for contaminating sites pay the full costs of remediation. To this point, the Task Force members have worked co-operatively to reach consensus on most issues and Cominco has been a willing participant in all Task Force programmes. Some community members fear that the constructive relationship that has existed between the company and other Task Force members may be jeopardised if the company is required to pay for all remedial programmes.

Future directions

Clearly, if the Task Force had insisted on quantifying the effect each remedial action would have on blood lead before implementing it, several of the valuable programmes described above (e.g. community education, greening of public areas) would not be underway today. The fact that childhood lead intake is derived from many sources and occurs *via* numerous pathways makes it extremely difficult to prove an impact on blood lead due to individual remedial actions such as soil abatement or house cleaning.

The exposure-pathways modelling exercise has indicated which remedial measures are most likely to be effective in the current situation of high smelter emissions. That is, the remedial strategy for Trail should focus on education, case management and environmental remediation that will reduce children's exposure to mobile dusts. Education messages aimed at hygiene and habits can be effective if personal contact is made with families at risk (Terragraphics Environmental Engineering, 1993; Kimbrough *et al.*, 1994). Dust control measures such as house cleaning and ground-cover improvement have proved effective when used in combination with family education (Charney *et al.*, 1983; Mielke *et al.*, 1992). The entire package of education, case management and interventions could be evaluated in terms of annual declines in Trail blood leads, relative to global background declines and the historical rate of decline. The Task Force is producing a series of reports on its work in Trail.

These reports will provide the basis for development of a remedial plan, which in turn will be submitted to the Ministry of Environment for approval. Cominco recently began construction of a new lead smelter using state-of-the-art technology. Completion of the new smelter in late 1996 is expected to reduce lead emissions by about 80%. It is anticipated that the remedial strategy developed for Trail will include further actions to be taken during the interim (before completion of the new smelter) as well as additional measures that might be taken after smelter completion, depending on the new plant's impact on environmental and blood lead levels.

Although Task Force membership includes six community representatives, plus two city councillors, a broader community consultation process involving the use of focus groups, surveys and/or public meetings will be developed to ensure that the final remedial plan meets with public expectations and requirements.

Acknowledgements

The work described in this paper was conducted by the Trail Community Lead Task Force with funding received from the BC Ministry of Environment, Lands and Parks, BC Ministry of Health, Cominco Limited and the City of Trail. The author is grateful to the following for their contributions Dr N. Ames, S. Bock., T. Oke and C. Yates.

References

Bornschein, R.L., Succop, P.A., Krafft, K.M., Clark, C., Peace, B. and Hammond, P.B. 1986. Exterior surface dust lead, interior house dust lead and childhood lead exposure in an urban environment. In: D.D. Hemphill (ed.), *Trace Substances in Environmental Heath XX, Proceedings of the University of Missouri's 20th Annual Conference on Trace Substance in Environmental Health*, 1986, pp. 322–332. Columbia, Missouri.

Bornschein, R.L., Clark, C.S., Grote, J., Peace, B., Roda, S. and Succop, P. 1988. Soil lead–blood lead relationship in a former lead mining town. In: B.E. Davies and B.G. Wixson (eds), *Lead in Soil: Issues and Guidelines*. pp. 149–160. Environmental Geochemistry and Health, Monograph Series 4, Supplement to Vol. 9. Science Reviews Ltd., Northwood, UK.

Butte-Silver Bow Department of Health and University of Cincinnati. 1992. *The Butte-Silver Bow County Environmental Health Lead Study Final Report*. February, 1992.

Chaney, R.L., Mielke, H.W. and Sterrett, S.B. 1988. Speciation, mobility and bioavailability of soil lead. In: B.E. Davies and B.G. Wixson (eds), *Lead in Soil: Issues and Guidelines*. pp. 105–129. Environmental Geochemistry and Health, Monograph Series 4, Supplement to Vol. 9. Science Reviews Ltd., Northwood, UK.

Charney, E., Kessler, B., Farfel M. and Jackson, D. 1983. A controlled trial of the effect of dustcontrol measures on blood lead levels. *New England Journal of Medicine*, **309**, 1089–1093.

Cominco Ltd. 1993. *Emissions Management Report. Trail Operations*, 25 pp. Cominco Ltd, Trail.

Cook, M., Chappell, W.R., Hoffman, R.E. and Mangione, E.J. 1993. Assessment of blood lead levels in children living in a historic mining and smelting community. *American Journal of Epidemiology*, **134**, 447–455.

Farrell, T.P. and Calder, I.C. 1988. Management of soil lead contamination in Port Pirie, South Australia. In: B.E. Davies and B.G. Wixson (eds), *Lead in Soil: Issues and Guidelines*, pp. 213–233. Environmental Geochemistry and Health, Monograph Series 4, Supplement to Vol. 9. Science Reviews Ltd., Northwood, UK.

Hertzman, C., Ward, H., Ames, N., Kelly, S. and Yates, C. 1991. Childhood lead exposure in Trail revisited. *Canadian Journal of Public Health*, **82**, 385–391.

Hilts, S.R., Hertzman, C. and Marion, S.A. 1995. A controlled trial of the effect of HEPA vacuuming on childhood lead exposure. *Canadian Journal of Public Health*, **86**, 345–350.

Kimbrough, R.D., LeVois, M. and Webb, D.R. 1994. Management of children with slightly elevated blood lead levels. *Pediatrics* **93**, 188–191.

Lamb, G.L. and Kiernan, B. 1988. Bunker Hill Study - Kellogg, Idaho. In: B.E. Davies and B.G. Wixson (eds), *Lead in Soil: Issues and Guidelines*, pp. 121–128. Environmental Geochemistry and Health, Monograph Series 4, Supplement to Vol. 9. Science Reviews Ltd, Northwood, UK.

Ma, Q.Y., Traina, S.J., Logan, T.J. and Ryan, J.A. 1993. *In situ* lead immobilization by apatite. *Environmental Science and Technology*, **27**, 1803–1810.

Maynard, E.J., Calder, I.C. and Phipps, C.V. 1993. *The Port Pirie Lead Implementation Program: Review of Progress and Consideration of Future Directions (1984–1993)*. Public and Environmental Health Service, South Australian Health Commission, Adelaide, SA.

Mielke, H.W., Adams, J.E., Huff, B., Pepersack, J., Reagan, P.L., Stoppel, D. and Mielke, P.W. 1992. Dust control as a means of reducing inner-city childhood Pb exposure. In: B.D. Beck (ed.), *Trace Substances in Environmental Health XXV; Proceedings of the University of Missouri's 25th Annual Conference on Trace Substances in Environmental Health*, 20-23 May 1991, pp. 121–128. Columbia, Missouri.

Neri, L.C., Johansen, H.L., Schmitt, N., Pagan, R.T. and Hewitt, D. 1978. Blood lead levels in children in two British Columbia communities. In: D.D. Hemphill (ed.) *Trace Substances in Environmental Health XII; Proceedings of the University of Missouri's 12th Annual Conference on Trace Substances in Environmnental Health*, 6-8 June 1978, pp. 403–410. Columbia, Missouri.

Pan, U.W. 1993. *Identification of Major Contributors to Childhood Blood Lead Concentrations and Exposure Pathway Modelling Based on 1992 Data from Trail, British Columbia*. University Environmental Health Foundation, Cincinnati, OH.

Phipps, C.V. 1992. Personal communication. Environmental Health Centre, Port Pirie, SA.

Ruby, M.V., Davis, A., and Nicholson, A. 1994. *In situ* immobilization of lead in soils. *Environmental Science and Technology,* **28**, 646–654.

Schmitt, N., Phillion, J.J., Larsen, A.A., Harnadek, M. and Lynch, A.J. 1979. Surface soil as a potential source of lead exposure for young children. *Canadian Medical Association Journal,* 121, pp. 1474-1478.

Terragraphics Environmental Engineering 1993. *Bunker Hill NPL Site: Assessment of Lead Health Intervention Efforts 1985-1993.* Report prepared for Idaho Department of Health and Welfare. December 23, 1993.

Trail Lead Program 1995a. *Exposure Pathways Investigations – Final Report.* Trail Community Lead Task Force, Trail, BC.

Trail Lead Program 1995b. *Effect of Education Programs on Childhood Blood Lead Levels.* Trail Community Lead Task Force, Trail, BC.

Trail Lead Program 1995c. *Community Dust Abatement Programs – Status Report.* Trail Community Lead Task Force, Trail, BC.

Trail Lead Program 1995d. *Ground Cover Subsidy Program – Final Report.* Trail Community Lead Task Force, Trail, BC.

University of Cincinnati 1990. *Midvale Community Lead Study Final Report.* Department of Environmental Health. July, 1990.

US Environmental Protection Agency 1986. *Air Quality Criteria for Lead.* EnvironmentalAssessment and Criteria Office, Research Triangle Park, NC.

[Manuscript 414: reviews co-ordinated by Dr Nord L. Gale and accepted August 16, 1995.]