UTILIZATION OF LAND USE DATA TO IDENTIFY ISSUES OF CONCERN RELATED TO CONTAMINATION AT SITE 050 OF THE MID-CANADA RADAR LINE

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Abstract / Résumé

Abandoned Mid-Canada Radar Line (MCRL) stations in northern Canada are remnants of the "Cold War." Since these stations were not properly decommissioned, contaminants (e.g., PCBs and lead) have entered the environment surrounding these sites. The first MCRL site to be remediated was Site 050 on Anderson Island. Remediation of this site was given priority because of its proximity to Fort Albany First Nation (FN) and the high levels of PCBs in soil (up to 21, 000 ppm; >50 ppm is considered hazardous waste) found on site. Data collected in the present study supported the hypothesis that Fort Albany FN residents have been exposed to contaminants originating from MCRL Site 050.

Les stations de la ligne de radar centre canada (LRCC) abandonnées dans le Nord du Canada sont des vestiges de la « guerre froide ». Étant donné qu'elles n'ont pas été adéquatement déclassées, des contaminants (BPC et plomb) ont été absorbés dans l'environnement autour des sites. Le premier site de la LRCC à faire l'objet de mesures correctives a été le site 050 sur l'île Anderson. Le rétablissement du site a reçu la priorité en raison de sa proximité à la Première nation de Fort Albany et des niveaux élevés de BPC dans le sol (jusqu'à 21 000 ppm, alors que plus de 50 ppm indique la présence de déchets dangereux). Les données collectées pour la présente étude soutient l'hypothèse selon laquelle les Autochtones de Fort Albany ont été exposés à des contaminants provenant du site 050 de la LRCC.

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Introduction

After the test of the first Russian-made atomic bomb in 1949, the Pinetree Radar Line was constructed at approximately the 49th parallel as a joint Canadian-American effort to provide warning of a Soviet nuclear attack (Myers and Munton, 2000). The successful test of a Soviet hydrogen bomb in 1954 heightened the need for the early detection of a Soviet attack across the shortest route (the Arctic region of North America) to populated, industrial centres of the USA (Huebert, 2000). Although there was no overt physical confrontation between the two superpowers, relationships were strained between the USA and Russia; this political climate was referred to as the "Cold War." In this political environment of increasing concern with respect to a nuclear strike, two radar lines (using manned and unmanned stations) north of the Pinetree line were conceived and built during the 1950s. The Distant Early Warning (DEW) Radar Line and the Mid-Canada Radar Line (MCRL) would give earlier warning of a Soviet nuclear strike than that of the Pinetree Line, allowing time for the deployment of American aircraft to intercept any Soviet bombers (Myers and Munton, 2000).

The DEW Radar Line consisted of 63 stations stretching from Alaska to Greenland at approximately the 70th parallel. The DEW Line was primarily an American effort with 42 stations being built in the Canadian territories (Northwest, Yukon, Nunavut) (Myers and Munton, 2000). The DEW Line was replaced by the automated North Warning System during the mid-1980s (Myers and Munton, 2000).

The MCRL or "McGill Fence" consisted of 98 radar stations (eight manned and 90 unmanned) that stretched from Dawson Creek, B.C., to Hopedale, Labrador, at approximately the 55th parallel (Environmental Sciences Group [ESG], 1999a; Thorne, 2003; Wilson, 2003). The MCRL was an entirely Canadian undertaking because it was believed that one authority would result in fewer delays and lower cost (and also avoid Canadian funding of the more costly DEW Line; Canadian Cabinet Defence Committee, 1954). The MCRL would allow detection of Soviet bombers between the altitudes of 300 feet to 60,000 feet using the doppler principle, basically a "trip-wire" system (Canadian Cabinet Defence Committee, 1954; Thorne, 2003). The MCRL was fully operational in 1958 and closed in 1965 (Thorne, 2003; Wilson, 2003). Fifteen MCRL stations were located in Ontario, Canada: three manned sites at Winisk (Site 500), Cape Henrietta Maria (Site 415), and Fort Albany (Site 050); and 12 small, unmanned stations (ESG, 1999a). These MCRL stations were not properly decommissioned (Gibson, 1993).

Beginning in the 1980s, First Nations (FNs) Chiefs of the Mushkegowuk Territory (collectively called the Mushkegowuk Tribal

Council, the regional FN political organization of the western James Bay region of northern Ontario, Canada) began to express concerns over contamination originating from the MCRL sites (Edmund Metatawabin, former Chief Fort Albany FN, 1988, pers. comm.; Hunter, 1998). The main contaminant that has been of interest with respect to the abandoned MCRL sites are polychlorinated biphenyls (PCBs), although lead (a toxic metal) has also been identified as a concern (Langstaff, 1998; ESG, 1999a). PCBs are persistent organic pollutants, synthetic in origin, and mixtures of a possible 209 congeners (ATSDR, 2000). In Canada, PCBs were voluntarily removed from use in open systems (in contact with the environment) during 1971; in 1976, federal legislation restricted all uses of PCBs and its disposal (Frank et al. 1993). It should be mentioned that the Canadian Department of National Defence ([DND], 2001:unumbered) has maintained that northern radar line sites "were operated using practices and materials accepted by the environmental standards of the time. The environmental standards of today are not those of yesterday – they are much more rigorous in accordance with current environmental knowledge." Nevertheless, PCBs do exist at MCRL sites and are of environmental and human health concern.

The first documented case concerning PCBs contamination originating from a MCRL site in Ontario (Site 415) occurred in 1983-84, where the DND, Ontario Ministry of Environment and Energy (OMOEE) and Ontario Ministry of Natural Resources (OMNR) participated in a clean-up of spilled oil containing PCBs (ESG, 1998). FN concern over PCBs was elevated in the western James Bay region when a control (non-exposed) group comprised of individuals from Attawapiskat FN were found to have concentrations of PCBs in the blood higher than exposed (contact with an abandoned weather station transformer) members of the community. These unexpected results led to an Ontario-wide survey of contaminants in FN communities between 1984-86 (Health Canada, 1999). In 1991, Fort Albany FN reported the existence of waste PCBs at Site 050 (Gibson, 1993). During the summer of 1993, the OMOEE, OMNR and the Ontario Management Board Secretariat inspected the 15 abandoned MCRL sites in Ontario (Gibson, 1993). In 1997, a partnership was formed between representatives of the federal government (DND represented by the ESG), the provincial government (OMNR and OMOEE), and FN organization (Nishnawbe Aski Nation [supra-regional FN organization], Mushkegowuk Tribal Council) with respect to remediation of MCRL sites in Ontario (ESG, 1999a). A Technical Working Group was formed containing members from all the partners "to perform the investigations [environmental assessment, including delineation of the MCRL sites in Ontario], interpret the results, and make recommendations by consensus" (ESG, 1999b:1). Fort Albany FN or more specifically MCRL Site 050 on Anderson Island was selected as the first site to be remediated because of the high levels of PCBs in soil (up to 21, 000 ppm) and the proximity of Site 050 to the community of Fort Albany FN (ESG, 1999a).

A human health risk assessment (Becking and Bickis, 1999) based on existing data was commissioned by Medical Services Branch of Health Canada specifically to deal with potential health issues related to Site 050 (Population Health – MSB, 1999). The report by Becking and Bickis (1999) generated a lot of response from representatives of both the federal and provincial government (Cameron, 1999; Downs, 1999; Gibson, 1999; Kaczmarek, 1999; Population Health – MSB, 1999; Smith, 1999; Zeeb and Reimer, 1999). One point was clear from the Becking and Bickis (1999) report and responses to the report, a land use study was essential in assessing potential human exposure to PCBs. Documented data was limited with respect to land use activities on Anderson Island although anecdotal information did exist; for example, Langstaff (1998) stated that human visitors to Site 050 had been reported as frequent. Information such as who had lived on Anderson Island, who had swam in ponds and creeks on or around the island (Becking and Bickis, 1999), who ate wild food harvested from the island (Kaczmarek, 1999; Population Health – MSB, 1999) and who used vascular plants harvested for food or medicine near Site 050 (Zeeb and Reimer, 1999) would be invaluable in assessing the potential for human exposure to contaminants originating from Site 050. Thus, a FN land use study was warranted with respect to Site 050.

Since the 1970s, land use studies have become more popular in Canada (Fast and Berkes, 1994). In the Hudson-James Bay bioregion alone, 15 land use studies have been performed (see Fast and Berkes, 1994, for a summary). Land use studies in the Hudson-James Bay bioregion have concentrated on five main objectives:

> To document Native land claims.
> To facilitate regional planning and resource co-management.
> To assess environmental impacts.
> To document land use activities over time.
> To fulfill environmental impact assessment requirements (Fast and Berkes, 1994:20).

To our knowledge, we are the first group to use a land use study in the Hudson-James Bay bioregion to examine potential human exposure to contaminants (lead and PCBs). The only comparable study we are aware of is by Kinney et al. (1997). In the Kinney et al. (1997) study, existing residency and PCBs data (and some newly generated environmental receptor data) collected in the vicinity of the Akwesasne Reserve, NY, USA, were geocoded utilizing a Geographic Information System (GIS). Environmental contaminant data were overlaid on residential locations to determine potential routes of exposure and gaps in information (Kinney et al. 1997). In the present study, we will collect, collate and overlay Anderson Island land use data on existing contaminant, spatial data, to identify potential routes of contaminant exposure for members of Fort Albany FN. Results will be used to identify gaps in our knowledge with respect to potential human exposure that will help direct us to environmental receptors that need to be sampled and analyzed. Data collected in the present study will provide information to support or dismiss the hypothesis that Fort Albany FN residents have been exposed to contaminants originating from MCRL Site 050 as suggested by Smith (1999).

The Study Area

Fort Albany First Nation

Fort Albany, Ontario, Canada, is a FN of approximately 850 people where the Cree language is still predominantly spoken (Tsuji et al. 2001). It is located in the western James Bay region of northern Ontario, Canada, on the southern shore of the Albany River (52°15', 81°35'; Hill, 1999; Tsuji et al. 2001). The community is approximately 18 km upstream of James Bay and has been designated special access, that is, Fort Albany FN is accessible year-round only via air transport, by barge in the summer and fall prior to freeze-up, and by tractor train on the winter ice/snow road (Hill, 1999). Services include: a gravel road system connecting dwellings (170 housing units) and buildings (e.g., combined elementary and secondary school, teacherages, FN administration offices, Northern Store, Nishnawbe Aski Police office, post office, Peetabeck Health Centre, James Bay General Hospital, day care centre, Koostachin's Motel, Roman Catholic Mission, Hydro building, three stores, abandoned Mid-Canada Radar Line Site 050, and Camp Weechehin); piped water and sewage; hydroelectric power; telephone and television services (Hill, 1999). The community is divided into three areas: the village proper on Sinclair Island, the mainland, and Anderson Island (Tsuji et al. 2001). Anderson Island is the site of the abandoned Mid-Canada Radar Line station, Site 050.

Site 050

Although the western James Bay region is generally characterized by muskeg (i.e., blocks of closely spaced stunted spruce [*Picea* spp.] or tamarack [*Larix laricina*], areas of brush on hummocky moss and lichen-covered ground, and water-logged areas of grasses and sedges in the vicinity of numerous ponds and lakes; Hanson, 1953), areas of boreal forest also exist, such as, on Anderson Island. Site 050 has been described to consist of four feet of top soil mixed with gravel overburden, an underlying layer of 45 feet of impervious clay, followed by limestone (Langstaff, 1998). Fifteen to 45 cm below the ground surface is the water table (Langstaff, 1998).

After the closure of the Mid-Canada Radar Line Sites in 1965, a Canadian company was hired to salvage equipment from the abandoned radar bases and demolish all structures; the contract was never completed and bases were left in various stages of demolition (Gibson, 1993). An exception was Site 050, as detailed in Tsuji et al. (2001), the radar base and other equipment and supplies were acquired by the Episcopal Corporation; subsequently, Mid-Canada Radar Line site buildings, equipment and material were moved off site to the mainland or Sinclair Island. By 1986, all buildings except the diesel generating building (powerhouse) had been moved or demolished (Langstaff, 1998). Paint sampled from the walls of the powerhouse contained levels up to 42,000 ppm of lead; paint flaking from the powerhouse and other buildings originating from Site 050 would be of concern from a human health perspective because lead in paint may be inhaled and/or ingested (Langstaff, 1998). Further, the sump pit in the powerhouse was examined and it was found that the surface liquid contained 978 µg/L of PCBs, while lower in the pit, a level of 4,120 µg/L of PCBs was reported (Langstaff, 1998). Langstaff (1998) reported concern over the potential for off site migrations of PCBs because the sump pit likely drained to a septic tank that drained to Yellow Creek (through an eight inch plastic drainpipe). Historical flooding of the Fort Albany area is also a real concern for off site migration of contaminants. Moreover, in 1993 personnel of the OMOEE transported equipment leaking PCBs in a storage trailer from Site 050 to Moosonee, Ontario, located at the southern tip of James Bay (Gibson, 1993; ESG, 1999).

Delineation of Site 050

Initial delineation of Site 050 by the ESG revealed greatly elevated levels of PCBs in soil (up to 21,000 ppm), vascular plants (up to 550 ppm) and paint (up to 1,400 ppm; ESG, 1999a). Leaching from paint containing PCBs has been documented in other studies (Kimbrough, 1995). PCBs >50 ppm in environmental media are considered hazardous waste under the Canadian Environmental Protection Act and must be removed from site; material containing 5 - 50 ppm can be remediated in situ or removed from contact with the environment, while, material < 5 ppm does not require remediation. Paint chips sampled from Site 050 were found to contain lead in the range of 2,600 to 39,700 ppm (ESG, 1999a).

Final delineation of Site 050 allowed for the demarcating of the area to be remediated and the estimation of the amount of soil to be remediated in the different categories, that is, 2,800 m^3 > 50 ppm of PCBs and 4,300 m^3 in the 5 - 50 ppm range (ESG, 1999b). Woody vegetation (n = 26), rose hip berries (n = 2) and groundwater (n = 5) contained little PCBs (< 0.5 ppm) (ESG, 1999b). Further, potential sites of concern identified by community members and in Tsuji et al. (2001) were found not to be potential sources of PCBs (lead determination was not done; ESG, 1999b). Remediation of MCRL Site 050 was completed in the summer 2001.

Methodology

Questionnaire

Data was gathered through a detailed questionnaire that had been developed in partnership with Fort Albany FN. Potential participants had to be 18 years of age. Candidates were chosen at random and interviewed by FN representatives; however, at the Band's request, an effort was made to include all people who had lived on Anderson Island. Questionnaires were completed in a compressed time period (June, 1999; incomplete questionnaires or questionnaires that needed clarification were completed outside this time period), so that data collected could be initially analysed prior to the scheduled remediation of Mid-Canada Radar Line Site 050 located on Anderson Island. Of 146 people (females, n=71; males, n=75) approached to participate in this study, only two people (males) refused to be interviewed; these males were not demographically different from those participating in the study. Community participation rate was acceptable; 41% of eligible community members (females, 43%; males, 39%) participated in the study.

Respondents were asked about personal activity on Anderson Island, habitation (location, time period), work (location, type of work, length of work term), recreational activities (type, location, season of activity, days/year, time period of activity), educational activity (location, length of time in educational activity, time period), harvesting activity of small game (species, location, time period, season or months, days/year, amount of harvest/year), harvesting of fish (species, location, time period, season or months, days/year, amount of harvest/year), harvesting of berries (type, location, time period, season or months, days/year, amount of harvest/year), harvesting of plants (species, location, time period, season or months, days/year, amount of harvest/year), trapping (species, location, time period, season or months, days/year, amount of harvest/year), harvesting of trees (species, location, time period, season or months, days/year, amount of harvest/year), and consumption of water (sources, location, time period, season or months, days/year). Two open-ended questions at the end of the questionnaire allowed participants to add anything that they deemed was important and/or not covered by the questionnaire.

A data dictionary was devised based on responses to the questionnaire; categories were mutually exclusive and formulated dependent on the answers most commonly given by respondents. Data were entered into a spreadsheet to derive summary/descriptive statistics. Male and female data were treated separately to investigate sex differences in activities. Male and female data was not treated separately when producing maps.

Land-use Maps

In order to produce a series of land use maps identifying activity on Anderson Island and surrounding surface water, a base map was created by tracing features of interest from an air photo of the area. The resulting base map delineated Anderson Island, Sinclair Island, a portion of the mainland, the surrounding surface hydrology, and anthropogenic features of interest including transportation networks, and the "decomissioned" radar base. The base map was then segmented into one-inch square (2,500 m^2) quadrats/cells. Each interviewee was then asked to identify the regions on the map where they participated in a number of daily activities (as outlined in the *Questionnaire* section) including: living, working, recreation, education, fishing, trapping of hare, harvesting of grouse, berry picking and water collection. A series of eight base maps were then prepared for each activity based on interviewer response that identified the number of individuals in each quadrat/cell who indicated participating in each activity of interest.

In order to facilitate further analysis, the base map was scanned and digitized using the GIS software ArcGIS 8.3. The base map was imported into the software as a scanned bitmap image and a series of spatial layers was created that were synonymous with features of interest including land, surface hydrology, roadways and the contaminated site. A spatial database was then created by digitizing the one-inch quadrat lattice. This created a spatially exhaustive but discrete series of polygon objects on a separate spatial layer. Each quadrat then formed a single record in a corresponding spatial database containing a unique field for each land use activity. The database was then populated by entering the number of individuals participating in each activity within each quadrat.

Because the study was primarily concerned with activity that occurred on Anderson Island and the surrounding surface hydrology, data were isolated to the region of interest through a series of geoprocessing procedures. First the grid was combined with the land-data layer through an *Intersection* procedure. This involves the overlay of polygons in one spatial layer with polygons in another spatial layer such that a unique layer is produced where regions common to both polygons form a unique shape which then contains the attributes associated with each of the original polygons. The outcome of this produces a unique map for both land and water bodies such that the information associated with each quadrate is now spatially restricted to the boundaries of each land form and surface hydrology feature. A separate spatial layer was then created for Anderson Island and the surrounding hydrology from the resulting overlay. These layers were then used in combination with other land features and quantitative shading symbology to produce a series of chroropleth maps (Figure 1-9) illustrating the frequency, spatial variation and pattern for each activity of interest in conjunction with the road network and the quadrat/cell containing the contaminated site/radar base. It should be noted that the cell containing the contaminated site/radar base is larger than the actual delineated area because of the level of spatial partitioning used (i.e., the use of one-inch quadrats).

Results

Of the 71 females interviewed, 68 women (96% of participants) responded that they had been active on Anderson Island. Similarly, 71 of 73 males (97%) responded that they had been active on the island. The average age of female participants was 42 years (range, 19 - 85 years) while for males it was 43 years (range, 18 - 85 years). It should be noted that non-responses to questions and responses that could not be quantified (e.g., a person who would eat berries as soon as they were picked, often could not recall the amount harvested; terms such as some, lots, etc. could not be categorized) were not included in the calculations; thus, number of respondents for sub-categories of questions do not always add up to the number of people who stated that they participated in a particular activity. For example, 15 females (21% of participants) and 17 males (23%) responded that they had lived on Anderson Island. One female had lived on the island pre-1955 while 11 had lived on the island post-1955. For males, six had lived on the island prior to 1955 and six post-1955. Not all respondents indicating that they had lived on Anderson Island were accounted for as explained above.

Non-Harvesting Activities

Eighteen females (25% of participants) and 47 males (64%) replied that they had worked on Anderson Island. For females, employment at Camp Weechehin (Anderson's Point) was the workplace most commonly reported (n=7) and counsellor (n=4) was the most common job description given. Other places of employment included the Hudson Bay Company, old age home, and health centre. Length of employment varied: 1-6 months (n=8), 7 months - 1 year (n=4), >1 - 2 years (n=3), >2 -3 years (n=1), and 4 years (n=2). The most common response for males was "many places" (n=10); other identified workplaces were the Hudson Bay Company, old age home, air strip, powerhouse, MCRL base, barge loading area by Anderson's Point, and Camp Weechehin. Length of employment data were as follows: 1-6 months (n=20), 7 months - 1 year (n=5), >1 - 2 years (n=7), >2 -3 years (n=6), >3-4 years (n=2), and 4 years (n=6). The most frequently reported type of work was "many things" (n=7) with labourer (n=6) being the next most commonly reported job type.

Educational activity data are presented in Table 1. Most of the respondents for both females (35% of people who had been active on Anderson Island) and males (17%) spent 1 - 6 months in educational activities on the island. For women, most of the activity was concentrated during the 1975-1999 time period (20% of people who had been active on Anderson Island); meanwhile, men (14%) were most active in the 1956 - 1975 period (Table 1).

The most common activity on Anderson Island was related to recreation (Table 1). Ninety-three percent of all women and men interviewed were involved in recreational activities on Anderson Island. Recreational activities included the following: walking (females, n=53, 78% of women active on Anderson Island; males, n=47, 66%), playing/other (females, n=26; males, n=36), biking/riding (females, n=23; males, n=16), swimming (females, n=16; males, n=7), camping (females, n=5; males, n=3), driving (females, n=6; males, n=7), hiking (females, n=8; males, n=10), picnicking (females, n=15; males, n=6), snow machining (females, n=9; males, n=5), jogging (females, n=8; males, n=8), hockey (females, n=4; males, n=3), four-wheeling (females, n=5; males, n=7), sledding (females, n=4), and baseball (males, n=2). Most women (34% of females responding as active on the island) participated in activities during the years 1976 - 1999; most men (28%) were active in the 1956 - 1999 time frame. The most popular season for activity by women was the summer (34%) while for the men, most men (31%) utilized the island all year. Men (37%) and women (35%) were typically active 1 - 50 days/year on Anderson Island; however, 23% of females and 20% of males were active 51 - 250 days/year, while 12% of females and 17% of males were involved in activities 251 - 365 days/year.

Table 1
Recreational and educational activity data for people responding as having been active on Anderson Island.

Variable	Activity			
	Recreational		Educational	
	Females n	Males n	Females n	Males n
Participants (%)[a]	66 (97%)	68 (96%)	25 (37%)	23 (32%)
Time Period				
< 1955	1	-	1	-
1956 - 1975	5	10	3	10
1976 - 1999	23	16	14	5
< 1955 - 1999	7	5	-	-
1956 - 1999	11	20	3	4
Seasons of Activity				
Winter	-	-	na	na
Spring	2	-	na	na
Summer	23	19	na	na
Fall	-	2	na	na
Two-seasons	19	18	na	na
Three-seasons	2	4	na	na
Year-round	16	22	na	na
Days of Activity (per year)				
1 - 50	24	26	na	na
51 - 250	16	14	na	na
251 - 365	8	12	na	na
Months of Activity				
1 - 6	na	na	24	12
7 - 12	na	na	-	5
13 - 24	na	na	1	3
25 - 36	na	na	-	1
> 36	na	na	-	2

[a] Percentage of people responding as having been active on Anderson Island.

Harvesting Activities

Species of small game harvested on Anderson Island were the sharp-tailed grouse (*Tympanuchus phasianellus*), spruce grouse (*Falcipennis canadensis*), ruffed grouse (*Bonasa umbellus*), and the snowshoe hare (*Lepus americanus*). A sex difference was noted where more males (n=37) and a larger percentage of males (52% of the men responding that they were active on Anderson Island) harvested grouse compared to females (n=13, 19%; Table 2). For both females and males, 1976 - 1999 (women, 38%; men, 54%) and 1956 - 1999 (women, 46%; men, 35%) were the two time periods most people were actively harvesting grouse. Activity for a single season was greatest during the fall for both males (46%) and females (31 %) although women were equally active in the summer. Most people were active 1 - 50 days/year (females, 54%; males, 70%) while 38% of women and 14% of men were active 51 - 250 days/year. There was a large range in number of birds harvested per year; most men (49%) reported 1 - 10 birds taken per year in contrast to most women (31 %) who indicated 50 birds/year. Hare harvesting was shared between the sexes with 18 females and 25 males reporting partaking in this activity (Table 2). People were most active during the 1976 -1999 (females, 28%; males, 44%) and 1956 - 1999 (females, 44%; males, 40%) time periods. Winter was the most commonly reported single season for harvesting hares (females, 61 %; males, 28%). Most men (52%) and women (39%) reported being active 1 - 50 days/year; however, 33% of the women also reported being active 51 - 250 days/year. Although most people harvest 1 - 10 hares/year (females, 50%; males, 40%), some people (females, 6%; males, 12%) harvest 50 hares/year.

Species of fish harvested around Anderson Island include: whitefish (*Coregonus spp*.), pike (*Esox lucius*), suckers (*Catostomus spp*.), and walleye (*Stizostedion vitreum*). Fishing is a popular activity for both women (32% of the women responding as having been active on Anderson Island) and men (51%; Table 3). The time period 1956 - 1999 was the interval most women reported as having been active in fishing (32%), followed by 1956 - 1975 (27%). By contrast, males were most active in fishing (47%) during the 1976 - 1999 time period. Summer was the single season of greatest activity for females (54%) and males (44%). The majority of men (47%) were active 1 - 50 days/year while women were equally active (41%) in the 1 - 50 and 51 - 250 days/year categories. The majority of women (68%) harvested 50 fish/year; most men (36%) harvested 21 - 30 fish/year but 25% harvested 50 fish/year.

Types of animals trapped on Anderson Island: marten (*Martes americana*), mink (*Mustela vison*), weasel (*Mustela erminea*), muskrat (*Ondatra zibethica*), skunk (*Mephitis mephitis*), fox (*Vulpes spp.*), beaver

Table 2
Small game harvesting data for people responding as having been active on Anderson Island.

Variable	Activity			
	Grouse Harvesting		Hare Harvesting	
	Females n	Males n	Females n	Males n
Participants (%)[a]	13 (19%)	37 (52%)	18 (26%)	25 (35%)
Time Period				
< 1955	-	1	1	-
1956 - 1975	2	1	3	2
1976 - 1999	5	20	5	11
< 1955 - 1999	-	1	-	-
1956 - 1999	6	13	8	10
Seasons of Activity				
Winter	1	3	11	7
Spring	-	-	-	-
Summer	4	-	1	4
Fall	4	17	1	4
Two-seasons	-	10	3	6
Three-seasons	3	3	-	-
Year-round	1	2	-	-
Days of Activity (per year)				
1 - 50	7	26	7	13
51 - 250	5	5	6	4
251 - 365	-	1	-	3
Number Harvested (per year)				
1 - 10	3	18	9	10
11 - 20	2	7	3	4
21 - 30	3	4	3	3
31 - 40	-	4	-	3
41 - 50	-	1	-	-
> 50	4	2	1	3

[a] Percentage of people responding as having been active on Anderson Island.

Table 3

Fishing and trapping activity data for people responding as having been active on Anderson Island.

Variable	Activity			
	Fishing		Trapping	
	Females n	Males n	Females n	Males n
Participants (%)[a]	22 (32%)	36 (51%)	1 (1%)	15 (21%)
Time Period				
< 1955	-	2	1	-
1956 - 1975	6	5	-	-
1976 - 1999	4	17	-	8
< 1955 - 1999	1	-	-	-
1956 - 1999	7	9	-	6
Seasons of Activity				
Winter	-	2	-	2
Spring	-	-	-	-
Summer	12	16	1	-
Fall	3	4	-	8
Two-seasons	6	10	-	4
Three-seasons	-	2	-	-
Days of Activity (per year)				
1 - 50	9	17	1	8
51 - 250	9	11	-	6
251 - 365	3	7	-	-
Number Harvested (per year)				
1 - 10	4	5	1	3
11 - 20	-	2	-	4
21 - 30	2	13	-	4
31 - 40	-	2	-	-
41 - 50	-	3	-	-
> 50	15	9	-	2

[a] Percentage of people responding as having been active on Anderson Island.

(Castor canadensis) and squirrel *(Tamiasciurus hudsonicus)*. Trapping was a predominantly male activity (21% of men responding as having been active on Anderson Island) with only 1% of females participating (Table 3). Moreover, the lone female only trapped prior to 1955. Males reported trapping during only two intervals 1976 - 1999 (53%) and 1956 - 1999 (40%). Fall was the single season most men (53%) were active. Days of activity per year for men were nearly evenly split between the two categories 1 -50 (53%) and 51 - 250 (40%). Number of animals trapped were generally 30 (73% of males) but some men (13%) reported 50 animals/year.

Types of berries reported as being harvested included: cranberries, raspberries (*Rubus ideaus*), gooseberries (*Ribes grossularia*), mooseberries (*Viburnum edule*), blueberries (*Vaccinium uliginosum*) and ground berries (*Gaultheria procumbens*). A large proportion of people (females, 66% of people active on Anderson Island; males, 41%; Table 4) reported having participated in berry picking. Cranberries were harvested by most people (females, n=31, males, n=18), followed by raspberries (females, n=13; males, n=7). The most common time period for berry harvesting was 1976 - 1999 (females, 38%; males, 52%) followed closely by the interval 1956 - 1999 (females, 36%; males, 38%). The majority of women (60%) reported summer as the single season when berry harvesting occurred. In contrast, 48% of men were active in the fall. Days of activity per year clustered in the 1 - 50 category for both sexes (females, 80%; males, 90%). Women most often collected 1 - 5 pails/year (27%); responses from men were more varied (i.e., 7% of respondents each fell into one of these categories, a ° pail, 1 bucket and >1 gallon).

Types of plants reported as being collected included: Labrador tea (*Ledum groenlandicum*), moss (*Bryophyta*), herbs, grasses *(Poaceae)*, and rose hips (*Rosa* spp.). A greater proportion of females (25%) harvested plants compared to males (14%; Table 4). Harvesting activity was concentrated in the 1956 - 1999 time period for females (35% of people responding as having been active on Anderson Island); no clear pattern was discernable for males. The majority of activity for a single season was found to be during summer (women, 29%; men, 70%). Most people (females, 65%; males, 70%) were active 1 - 50 days/year collecting plants in bunches (females, 41%; males, 40%).

Trees species harvested were tamarack, spruce and pine. Males (52% of people responding as having been active on Anderson Island) dominated this activity compared to females (24%; Table 5). The most active period for females was 1956 - 1999 (38%), and for males, 1976 - 1999 (49%). Winter was the season of greatest activity for both groups

Table 4

Berry and plant harvesting activity data for people responding as having been active on Anderson Island.

Variable	Activity			
	Harvesting of Berries		Harvesting of Plants	
	Females n	Males n	Females n	Males n
Participants (%)[a]	45 (66%)	29 (41%)	17 (25%)	10 (14%)
Time Period				
< 1955	2	-	3	-
1956 - 1975	7	1	3	2
1976 - 1999	17	15	3	3
1956 - 1999	16	11	6	2
Seasons of Activity				
Winter	-	-	-	1
Spring	-	1	1	-
Summer	27	5	5	7
Fall	15	14	-	-
Two-seasons	2	8	3	1
Three-seasons	-	-	1	-
Days of Activity (per year)				
1 - 50	36	26	11	7
51 - 250	4	3	3	1
251 - 365	-	-	2	1
Amount Harvested (per year)				
° pail (° pint)	7	2	na	na
1 - 5 pails	12	1	na	na
1 bucket (1 gallon)	3	2	na	na
> 1 gallon	5	2	na	na
Bundle	na	na	4	2
Bunches	na	na	7	4

[a] Percentage of people responding as having been active on Anderson Island.

Table 5
Tree harvesting and water collection data for people responding as having been active on Anderson Island.

Variable	Activity			
	Tree Harvesting		Water Collection	
	Females n	Males n	Females n	Males n
Participants (%)[a]	16 (24%)	37 (52%)	31 (46%)	36 (51%)
Time Period				
< 1955	2	-	1	-
1956 - 1975	2	5	5	10
1976 - 1999	5	18	9	7
< 1955 - 1999	-	-	1	1
1956 - 1999	6	5	14	11
Seasons of Activity				
Winter	11	21	na	na
Spring	1	5	na	na
Summer	3	9	na	na
Fall	-	8	na	na
Days of Activity (per year)				
1 - 50	7	26	10	9
51 - 250	5	6	14	15
251 - 365	-	1	1	11
Number Harvested (per year)				
1 - 20	6	11	na	na
21 - 40	-	10	na	na
41 - 60	5	4	na	na
61 - 80	-	3	na	na
81 - 100	-	1	na	na
> 100	-	1	na	na

[a] Percentage of people responding as having been active on Anderson Island.

(females, 69%; males, 57%). The largest percentage of females (44%) and males (70%) indicated they were active 1 - 50 days/year and harvested 1 - 20 trees (females, 38%; males, 30%).

Sources of water utilized on Anderson Island were reported as river, spring and tap. The sexes participated equally in this task (females, 46%; males; 51%; Table 5). Activity was greatest during the 1956 - 1999 time period (females, 45%; males, 30%). The greatest percentage of people were active 51 - 250 days/year (females, 45%; males, 42%).

Spatial Relationships of Activities on Anderson Island to Mid-Canada Radar Line Site 050

Not all areas on Anderson Island have been utilized equally by people of Fort Albany First Nation. Figure 1 and 2 clearly illustrate that the majority of people who have lived and/or worked on Anderson Island have done so in the area that includes Site 050. Moreover, 88% of people interviewed in the present study reported to having been involved in recreational activity in or around Site 050 (Figure 3). Recreational activity was greatest in the areas where there was ease of access, that is, along roads, old throughways and the abandoned runway (Figure 3). Educational activity was centred in two areas, Site 050 and Anderson's Point (Figure 4).

Two types of small game, grouse and hare, were mapped. Figure 5 shows that harvesting of grouse was concentrated along the road on Anderson Island. Further, fourteen people indicated that they harvested grouse directly in the area of Site 050. By contrast, hares were harvested primarily in the grid square of Site 050 or the contiguous areas (Figure 6).

Fishing occurred around the whole perimeter of Anderson Island but was concentrated in the channel separating Anderson Island and the mainland (Yellow Creek), and around Anderson's Point at the tip of the island (Figure 7). The pattern of trapping showed no clear preference for men to utilize a specific grid square; thus, this figure is not presented.

Berry harvesting showed a pattern similar to recreational activity where activity was concentrated along roadways on Anderson Island. Important to note is that 14% of the people interviewed harvested berries in the area of Site 050 (Figure 8). The pattern of plant harvesting was diffuse with no real area where harvesting was relatively intense was reported, but four people do report harvesting plants in the area of Site 050. Similarly, no distinctive pattern was seen for areas of tree harvesting; however, it should be noted that seven people did harvest trees in the area of Site 050 (no figures are presented for plant and tree harvesting).

Water was obtained from the river around Anderson Island including Yellow Creek, from taps at the homes on Anderson, and from a spring located in the grid square where Site 050 was located (Figure 9). Moreover, 26% of the people interviewed drank water that originated from the area of the old radar line site.

Discussion

It is clear from the present study that members of Fort Albany FN have been extremely active on Anderson Island with the majority of activity being centred around the contaminated quadrant (Figure 1-9). This is not surprising because of the road and trails throughout Site 050; ease of access has been identified as a factor increasing risk of exposure for humans as well as wildlife to contaminants (Myers and Munton, 2000). When one also takes into account the halo effect, where contaminates from old radar line stations have been shown to undergo short range transport (PCBs, 5 km from a point source, Bright et al. 1995a; PCBs and lead, 10 km, Dushenko et al. 1996), then the area of potential contaminant exposure increases to include not only the contaminated area but also contiguous areas.

Specifically, it is clear that non-harvesting activities on Anderson Island are spatially clustered in the grid square containing the contaminated site (Figure 1-4). Approximately 23% of people participating in the present study lived on Anderson Island. The vast majority lived in close vicinity to Site 050 (Figure 1). Although the majority of people surveyed worked in the grid square containing the contaminated site (Figure 2), exposure to contaminants would depend on exactly where one worked in the grid and also what type of work one performed. Only men reported having worked in Site 050 and often as manual labour; thus, the potential for exposure through employment would be greater for men because of the probability of direct physical contact with the contaminants. Time of employment would be another factor impacting risk; some men reported working in the contaminated grid for 4 years. Educational activities were clustered in the contaminated area and in the vicinity of Anderson Point. Although there is potential for contaminant exposure from educational activity, it would be minimal. The non-harvesting activity with the greatest potential for contamination exposure other than having worked on the MCRL site is recreation.

Recreational activity on Anderson Island was spatially most concentrated in the contaminated area; activity was also high in grid squares where there was a road, path, or some clearing to allow for ease of access (Figure 3). Taking into consideration that it is relatively easy to move in and around Site 050, the potential for contaminant exposure is tremendous, especially when the type of activity people were involved in is accounted for. For example, the activities of walking, playing, biking/riding, swimming, hiking, and jogging in the vicinity of Site 050 would obviously increase the risk of exposure. Time spent in and around the contaminated site would also be of importance. Although most people were active on Anderson Island 1 - 50 days/year, 24% of females and 20% of males were active 51 - 250 days/year and 12% of females and 17% of males participated in recreational activities 251 -365 days/year (Table 1). Clearly, the time community members spent on Anderson Island participating in recreational activities is of concern as related to potential contaminant exposure.

Harvesting activities in the present study refers to hunting, fishing, trapping and the collection of berries, vascular plants, trees, and water. These type of data are important in the characterization of dietary input of contaminants. In addition to the actual ingestion of contaminated environmental media, there is potential for contaminant exposure through the harvesting activity itself through inhalation and dermal contact, especially for PCBs. Harvesting data will also provide justification for which receptors to sample and analyze. Although Berkes et al. (1994) report relatively low rates of harvesting for potential hunters (males 18 years, female heads of household) during the 1990 calendar year for Fort Albany (Berkes et al. 1994), results of the present study do not support this contention. Differences in the studies may be related to the fact that the present study examined yearly averages (rather than calendar year harvest data) and female respondents were well represented in the present study. The spatial scales were also different in that we only examined activity on Anderson Island while Berkes et al. (1994) examined the whole Mushkegowuk Territory; thus, if anything, data from the present study would underestimate harvesting activity because of the small circumscribed area (Anderson Island) studied.

For small game, hare harvesting (26% of respondents) was more popular with females relative to grouse harvesting (19%), by contrast more males harvested grouse (52%) than hare (35%; Table 2). This sex difference may be related to the method of harvest; hare are generally snared while grouse are harvested either with lead shotshell or 22 calibre bullets (note: grouse were traditionally snared in the past). Perhaps, females are less likely to own a firearm. When harvest data (Table 2) are combined for the two activities (grouse and hare harvesting) and the sexes are not separated, the number of estimated participants (33% of respondents) is in general agreement with Berkes et al. (1994), who reported 30% of respondents in Fort Albany FN participated in small game harvesting; however, grouse harvesting data for males indicates that approximately half the males interviewed were involved in this activity. To calculate the number of small game animals harvested/year/person, the lower end of a range (an underestimation) was used and multiplied by the number of people in a category to get the number of animals per range, these values were summed and then divided by the total number of people in all harvest categories to get an average of the number of animals harvested per person. The mean harvest per person for small game (14.3) in the present study is in general agreement to that reported by Berkes et al. (1994) for Fort Albany of 15.9. Similar to Berkes et al. (1994), we found that the majority of small game harvesting activity is concentrated in winter and fall. It appears that our data support Berkes et al. (1995) assertion that females are active in small game harvesting and that this activity is concentrated around the community.

Spatial distribution of small game harvesting shows a distinctive pattern for grouse harvesting along roadways and paths where grouse are known to frequent including the contaminated zone (Figure 5), with hare (a herbivore) harvesting being concentrated in the contaminated area and the contiguous zone around Site 050 (Figure 6). The pattern of small game harvesting is of concern because the activity of harvesting itself (i.e., walking, setting snares, etc.) in the contaminated zone, could expose a person to contaminants. Further, vascular plants from Site 050 are known to be highly contaminated (up to 550 ppm; ESG, 1999a) and it has been shown that a 6.5 fold increase in PCBs concentration occurs from vascular plants to herbivore in northern Canada (Braune et al. 1999). Further, grouse species typically ingest grit (small stones and sand) and store this material in their gizzard to assist in the mastication of vegetative matter; thus, grouse could be exposed to contaminated soil (PCBs or lead) through this mechanism resulting in tissue uptake. There is real potential for small game to become contaminated in or nearby Site 050 and pose a threat to humans who ingest them.

Fishing was a popular harvesting activity; it was found that 42% of all participants in the present study (females, 32%; males 51%) fished (Table 3). This participation rate contrasts sharply the reported 12% of respondents reported that they fished in the Berkes et al. (1994) study. Likewise, 3,548 person days/year (calculated in the same manner as reported for small game) were devoted to fishing while Berkes et al. (1994) reports only 199 person days spent on fishing for Fort Albany. This difference is probably a reflection of the close spatial proximity of Anderson Island, a person may spend a short period of time fishing (e.g., one hour), but it would still be calculated as a day in the present coding system. However, it is in the opinion of the authors through personal experience that the number of person days attributed to Fort Albany is underestimated in the Berkes et al. (1994) study. Mean number of fish also differed between studies with 29.2 fish/year/person for our study and 63.3 being reported by Berkes et al. (1994). However, we are in agreement that most fishing occurs during the summer season (Table 3). Spatially, most people fish in Yellow Creek or around Anderson Point. Thus, there is potential that fish may be a source of contaminants for the community if it can be shown that there is migration of PCBs off site from the old MCRL station. The potential for off site migration is real because concern has been reported about an 8" plastic drainpipe leading from the potentially contaminated septic tank in the powerhouse to the bank of Yellow Creek (Langstaff, 1998). Further, off site radar line contamination has been noted in aquatic receptors in several studies (Bright et al. 1995b, Bright et al. 1995c). Nevertheless, the potential for contaminant exposure through this route cannot be properly assessed because no PCB contaminant data for sport fish in the Albany River exists (Kaczmarek, 1999), except for a limited study by McCrea and Fischer (1986). This potential route of exposure is currently being explored (McCreanor et al. unpublished data).

Trapping was found to be a primarily male activity, the only women who reported trapping did so prior to 1955 (before the MCRL was built; Table 3); thus, discussion of trapping data will be limited to males. Approximately 21% of male respondents had participated in trapping activities on Anderson Island, averaged 18 animals (all species) per year when trapping, and trapped primarily in fall and winter (Table 3). Berkes et al. (1994) report only 4% of Fort Albany respondents trap with a mean catch of 12.2 animals per year; Berkes et al. (1995) adds that trapping occurred primarily during winter and late fall. The difference in reported data for the two studies is probably a reflection of historical information (present study) versus recent information for a calendar year (Berkes et al. 1994). The potential for contaminant exposure appears minimal because trapping occurs uniformly on Anderson Island and most activity is concentrated in late fall and winter where physical exposure would be decreased due to a layer of clothing.

Although 53% of all respondents participated in berry harvesting, only 419 person days (6 days/year/person) were spent on this activity. Similarly, Cummins (1992) found that 39% of households in the western James Bay community of Attawapiskat FN participated in berry harvesting. If one takes into account that rose hip berries (n = 2) sampled from Site 050 have been shown not to be contaminated with PCBs (<0.5 ppm), it appears that the ingestion of berries is not of great concern, but more data are needed (ESG, 1999b).

It has been demonstrated that concentration of PCBs in plants are significantly correlated with PCBs in soil (r^2=0.98) (Braune et al. 1999); thus, it is not surprising that the levels of PCBs in vascular plants have been reported up to 550 ppm at Site 050 (ESG, 1999a). PCBs levels in vascular plants may be the result of either absorption through root uptake or adsorption of airborne contamination (Dushenko et al. 1996). Airborne contamination may be the result of either long range transport or short range redistribution from a point source (AMAP, 1998). PCBs in soil undergo volatilization (Ayris and Harrad, 1999) and are aerially redistributed to the surface of leaves. In this scenario, PCBs would undergo adsorption to the waxy cuticle, a lipophilic surface (Dushenko et al. 1996). It matters little for human or wildlife exposure if the PCBs are absorbed or adsorbed to tissue (Zeeb and Reimer, 1999). Zeeb and Reimer (1999) were quite correct when they suggested that PCBs were entering the food chain through vascular plants at Site 050. Results of the land use study indicate that people could be exposed directly to PCBs in vascular plants through the ingestion of Labrador tea or indirectly through ingestion of herbivores (e.g., hares) that consume vascular plants. We do not concur with the assertions of Kaczmarek (1999) that the ESG (1999a) vascular plant data were of limited use because plants tested were not of types used for human consumption and Smith (1999) that grass is not necessarily part of the food chain. Thus, the potential exists for exposure through direct ingestion of contaminated vascular plants or indirectly through the consumption of herbivores. It should be noted that the ingestion of contaminated vascular plants would be relatively less important than herbivore consumption, since plant harvesting was not centred around Site 050. Also, harvesting of plants was not reported as being popular for males (Table 3).

Accounting for the fact that tree harvesting on Anderson island was an important activity for the community, especially for males (Table 5), this finding has to be put in perspective of recent studies. In a composite samples of woody plants (n = 26) collected from Site 050, it was found that all samples had PCBs concentrations < 0.5 ppm (ESG, 1999b). It was concluded that the wood is safe to be burned (ESG, 1999b). The concern was that if the wood was contaminated with PCBs, improper incineration of the wood would produce PCDFs, a highly toxic substance with proven human health effects. Harvesting and burning of wood taken from Site 050 cannot be considered a potential route of human exposure.

Water collection on Anderson Island by members of Fort Albany FN has been extensive with approximately half of the people interviewed (Table 5) indicating that they have collected water from this area. Moreover, the majority of people that have collected water on Anderson Island did so in the contaminated grid square (Figure 9) and some people used Yellow Creek for water. The potential for water contamination in Yellow Creek has been discussed earlier. Thus, concern is warranted; however, the ESG (1999b) found that water samples collected from ground monitoring wells on Anderson Island (four of these wells were within the PCB-contaminated area) contained low levels of PCBs (<0.2 ppb of PCBs measured as Aroclor 1254; <0.6 ppb of PCBs measured as Aroclor 1260; ESG, 1999b). Since, PCBs are lipophilic, it is not surprising that levels of PCBs in water were negligible; PCBs would be bound to particulate matter in the water not dissolved in the water. Until water samples from Yellow Creek and the spring in the contaminated area are sampled, water as a route of PCBs exposure cannot be discounted. Other issues include concern over surface run-off during the spring thaw and the effect of flooding.

The present land use study has provided definitive data showing that Anderson Island, and more specifically the contaminated site, have been utilized extensively by members of Fort Albany FN during the time period when the MCRL Site 050 was in existence. There is no doubt that people of Fort Albany FN have been exposed to contaminants either directly or indirectly, but the question remains of human uptake (this is presently being investigated; Tsuji et al. unpublished data); exposure does not equal uptake. Lastly, if levels of contaminants are found to be elevated, human health endpoints should be examined. This type of land use approach would be useful to identify potential routes of exposure and data gaps (e.g., what type of receptors need to be sampled) for other MCRL sites in need of remediation, DEW line sites, other military installations and any other potentially contaminated sites.

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Figure 1
A land-use map of the areas where people have lived (note: each quadrat/cell = 2,500 m²).

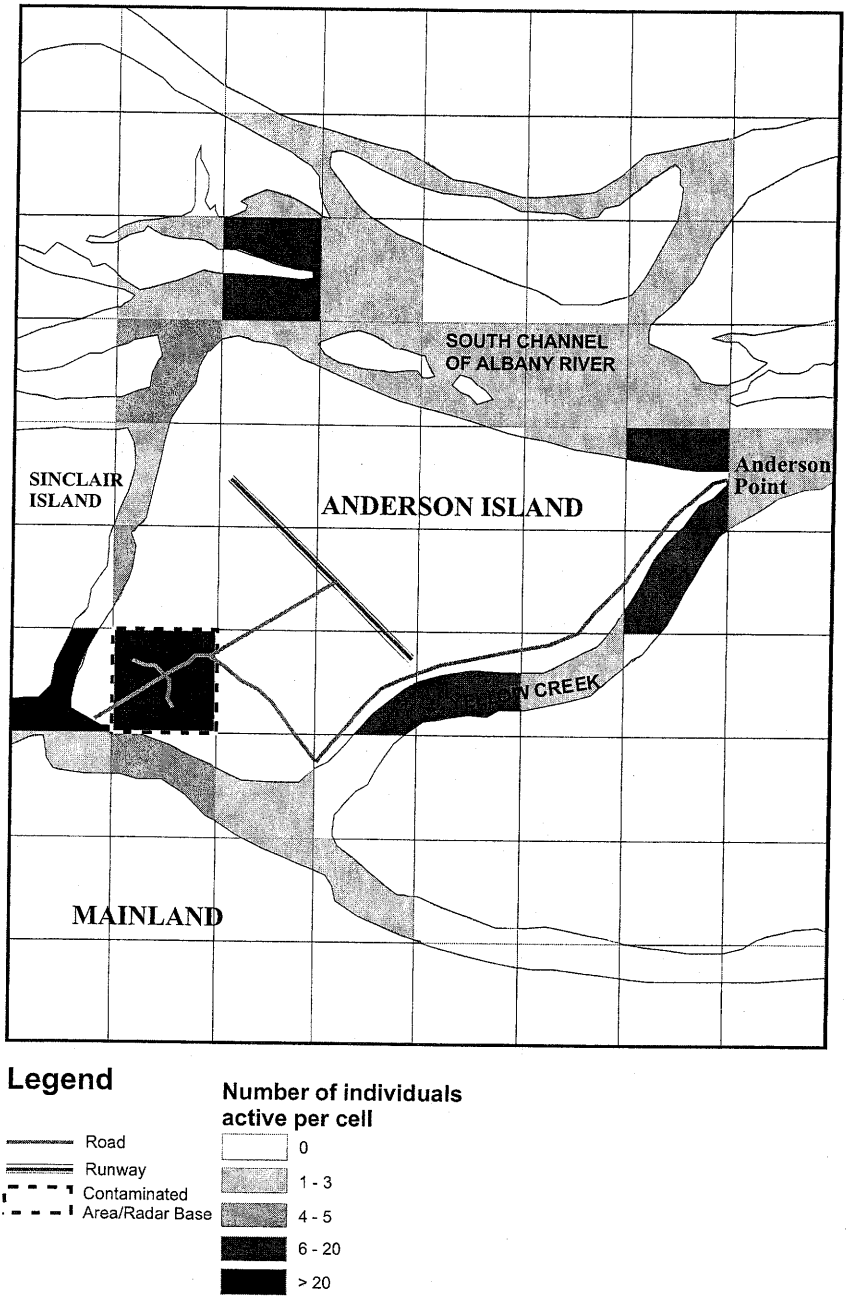

Figure 2
A land-use map of the areas where people have worked (note: each quadrat/cell = 2,500 m²).

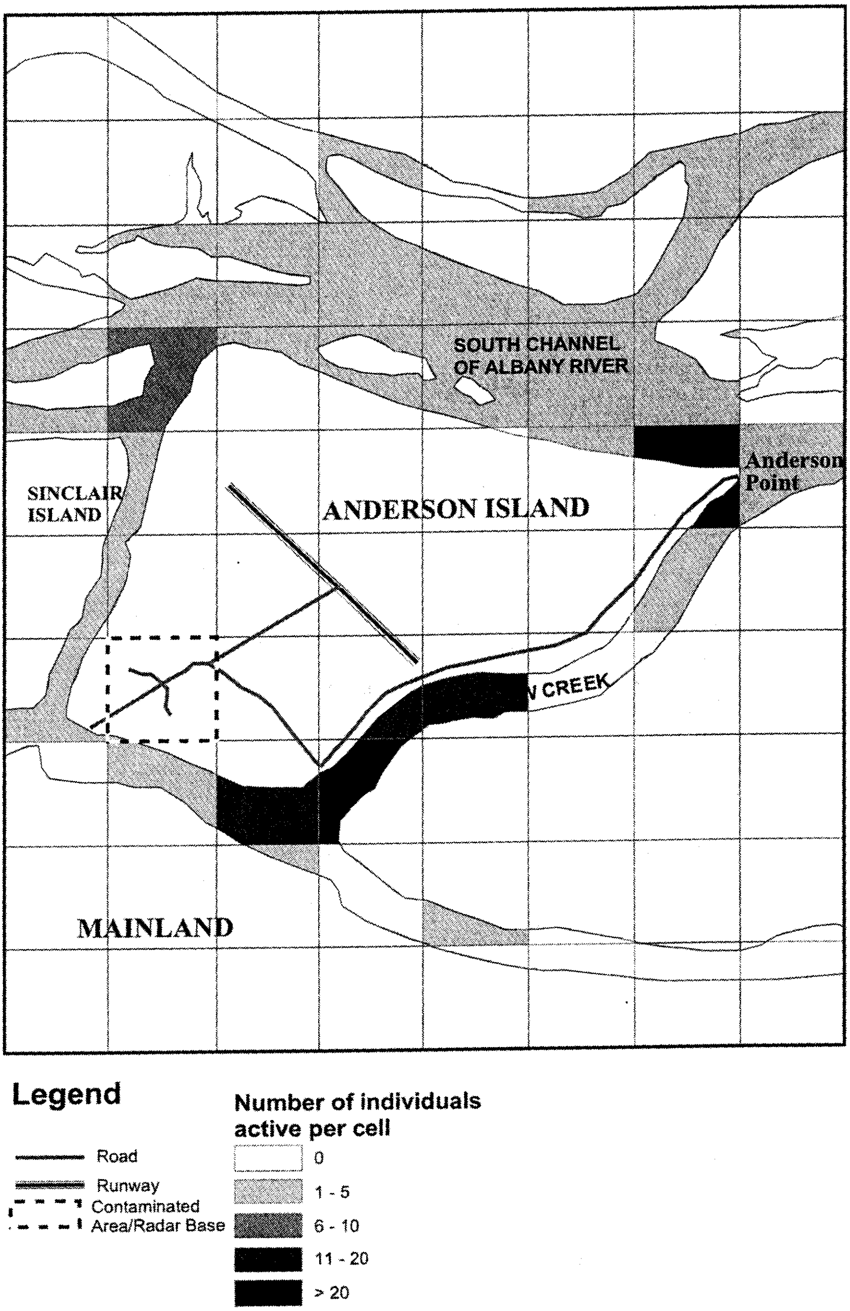

Figure 3
A land-use map of the areas where people have participated in recreational activities (note: each quadrat/cell = 2,500 m²).

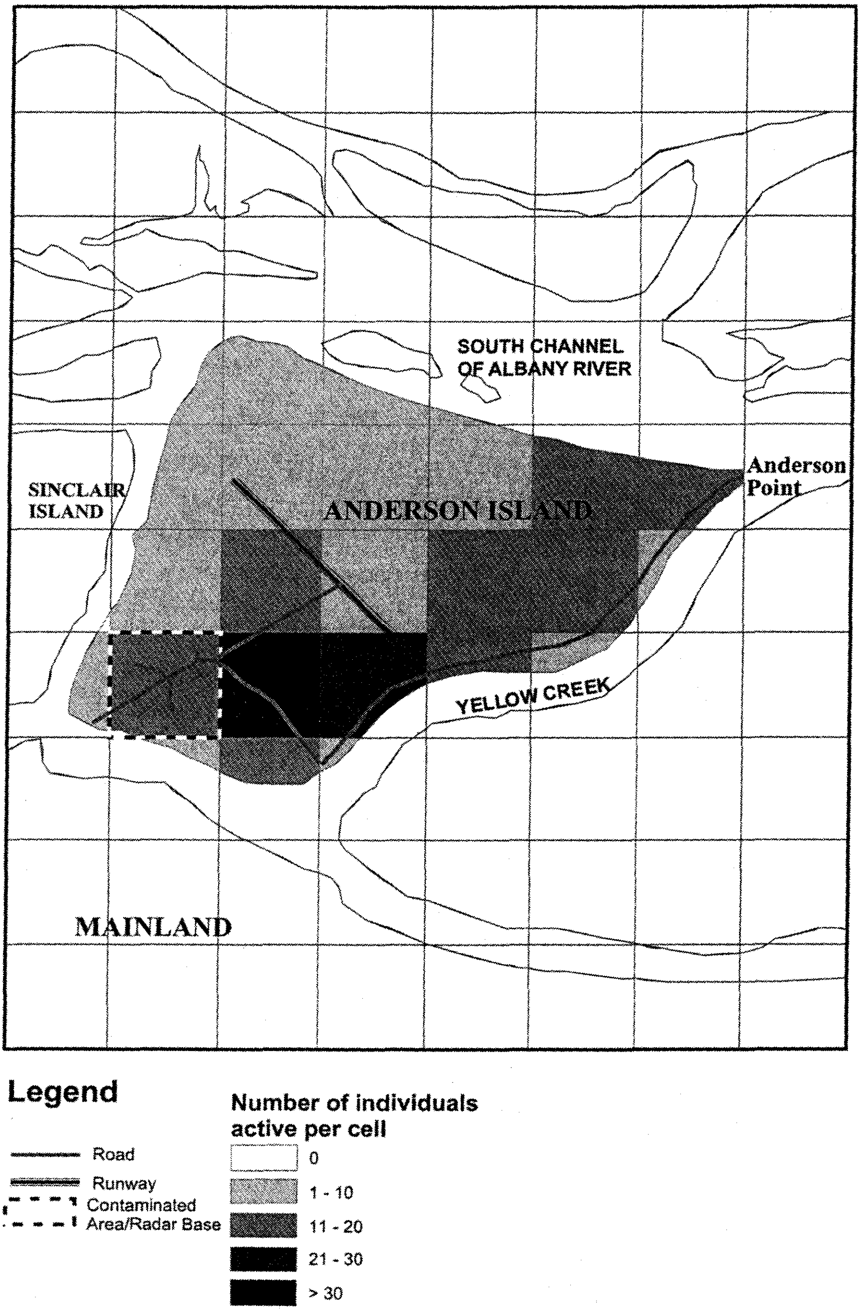

Figure 4

A land-use map of the areas where people have been involved in educational activities (note: each quadrat/cell = 2,500 m²).

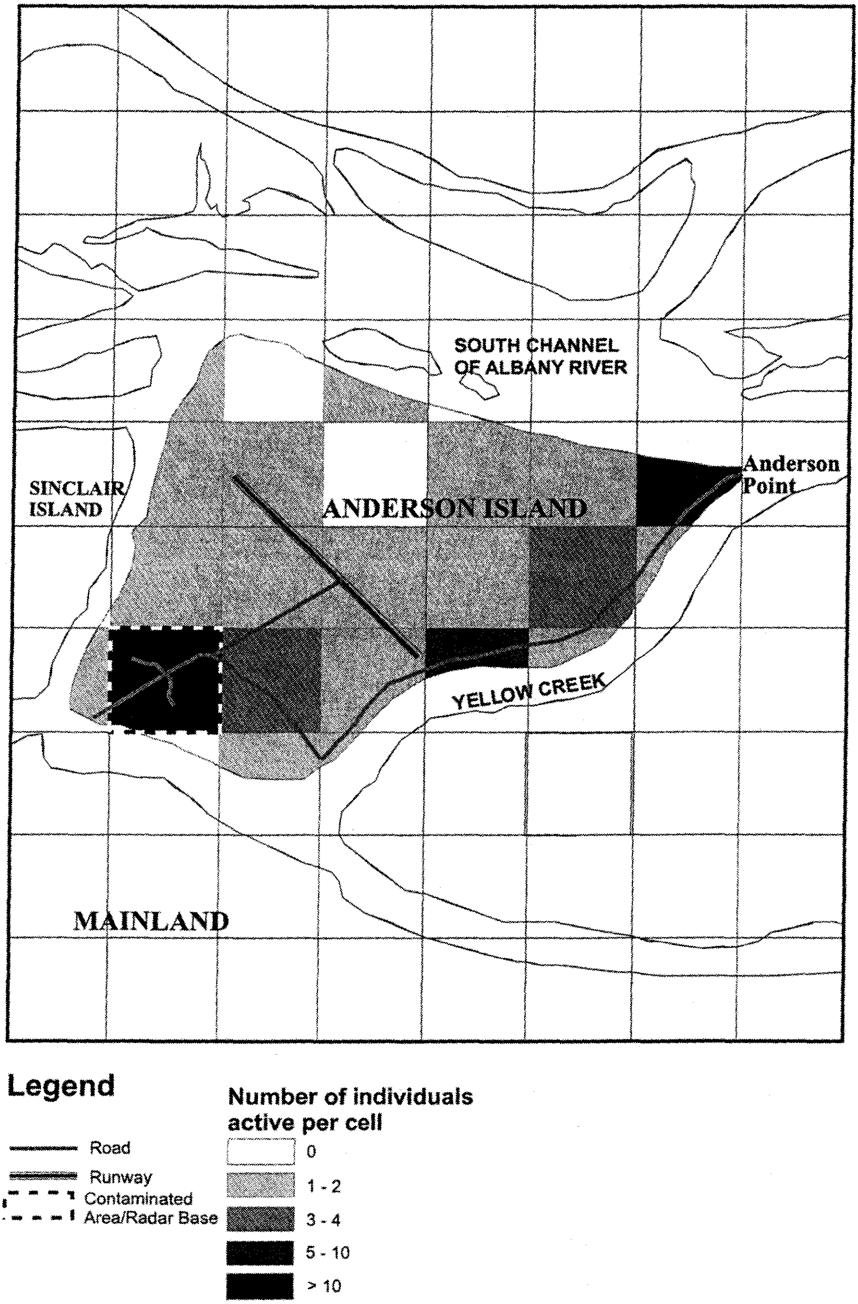

Figure 5
A land-use map of the areas where people have harvested grouse (note: each quadrat/cell = 2,500 m²).

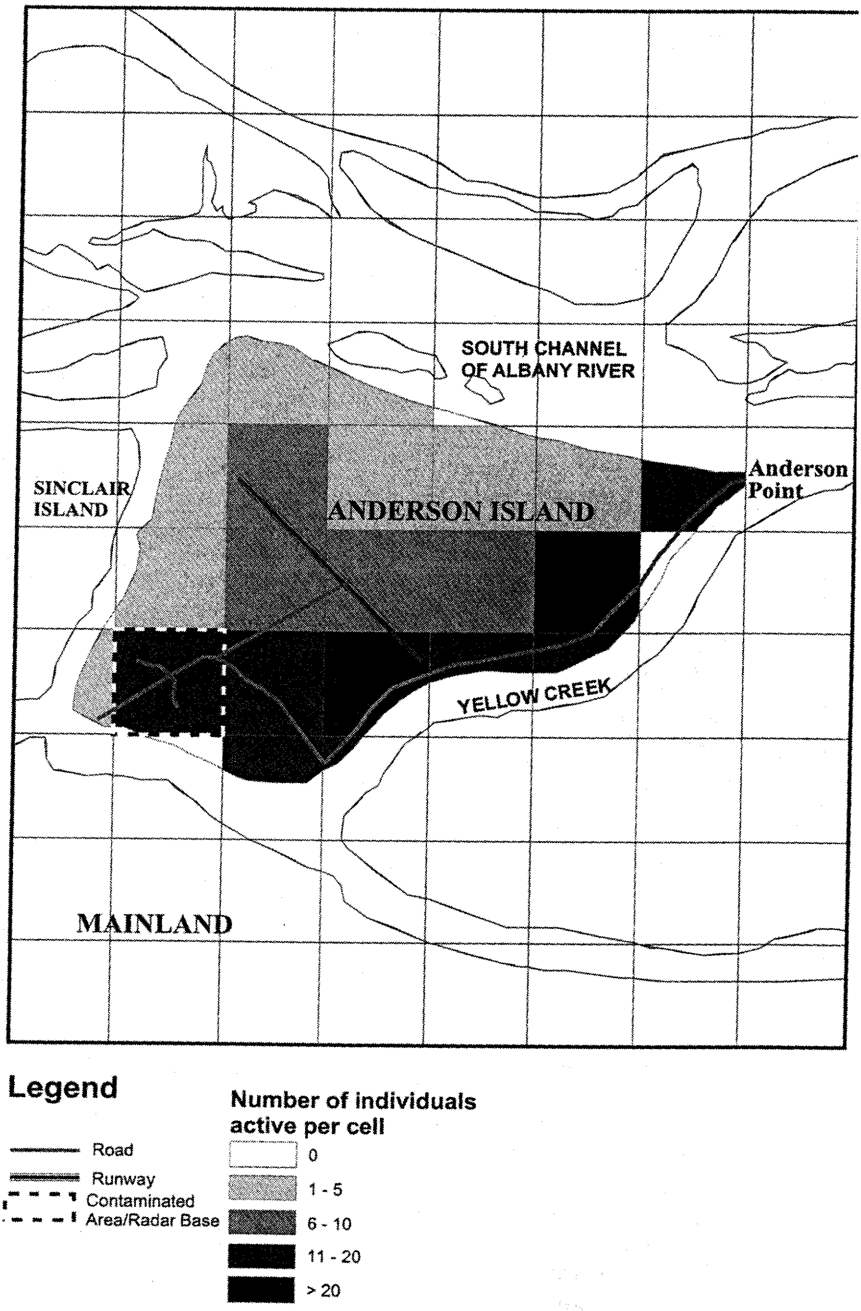

Figure 6
A land-use map of the areas where people have harvested hare (note: each quadrat/cell = 2,500 m²).

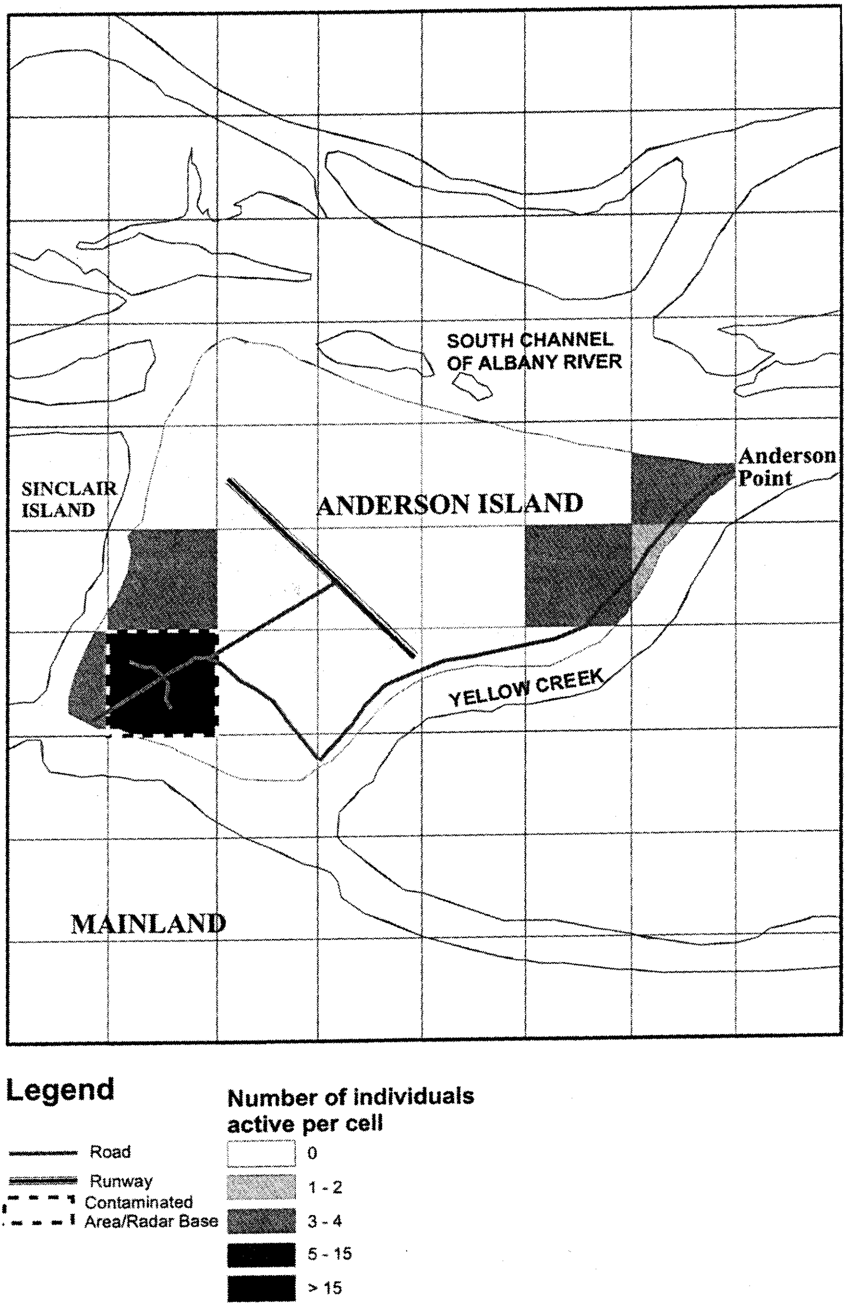

Figure 7
A land-use map of the areas where people have harvested fish (note: each quadrat/cell = 2,500 m²).

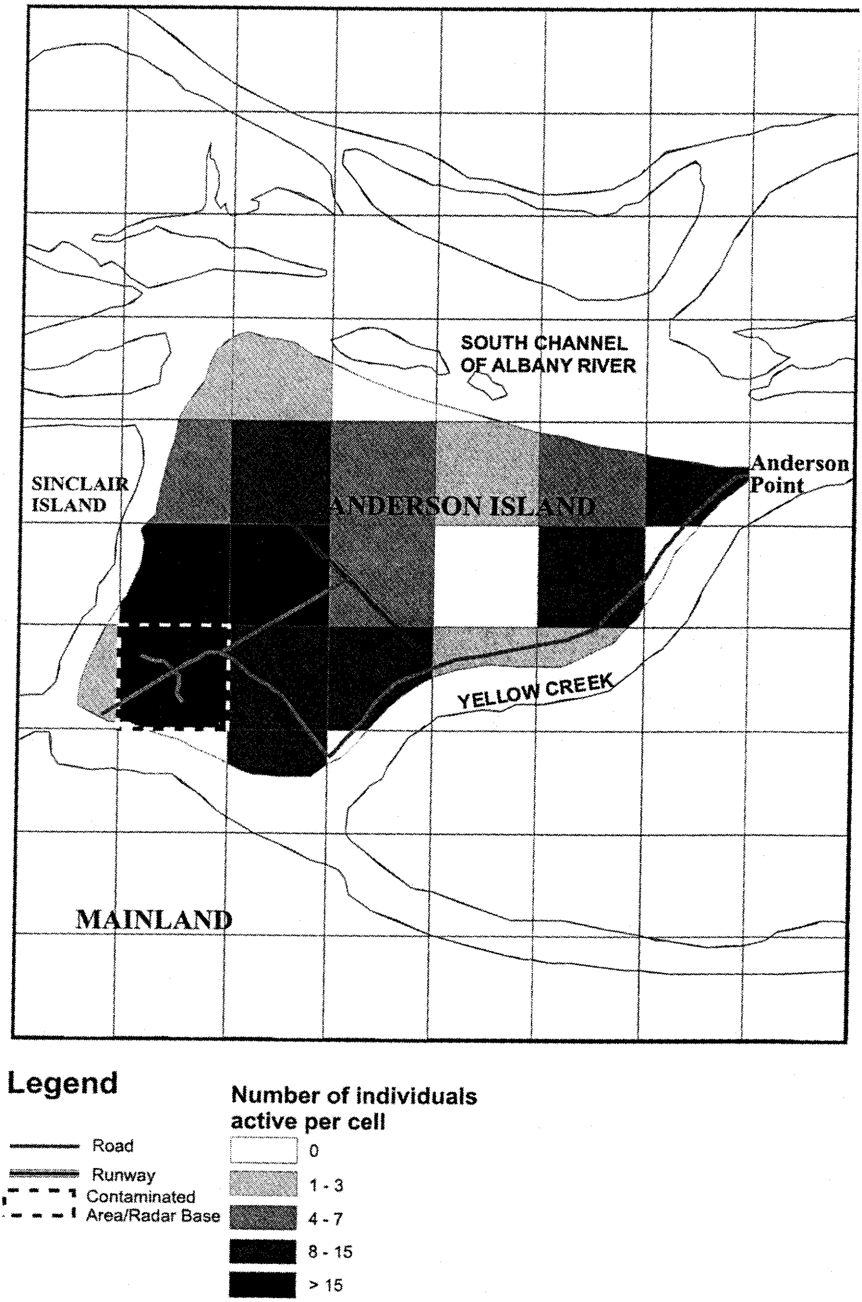

Figure 8

A land-use map of the areas where people have harvested berries (note: each quadrat/cell = 2,500 m²).

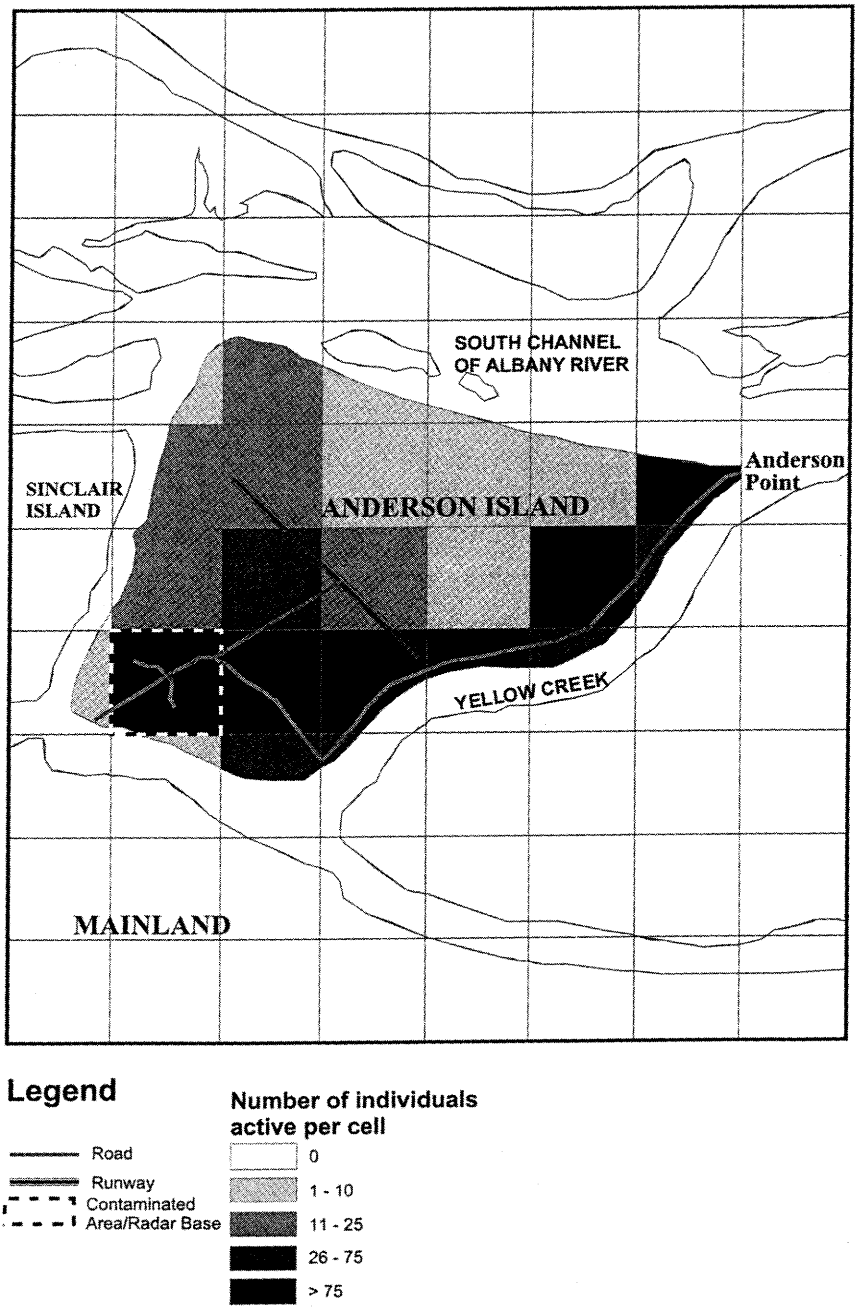

Figure 9
A land-use map of the areas where people have collected water (note: each quadrat/cell = 2,500 m²).