The Uranium Mining Industry of the Bancroft Area: an Environmental History and Heritage Assessment

A Thesis Submitted to the Committee on Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Master of Arts in the Faculty of Arts and Science

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ABSTRACT

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Michèle Proulx

Environmental history is the study of the past with reference to the interplay of relations between human culture and the biophysical environment. Environmental history allows one to reflect upon the present day context of a place as the composite of layers of human cultural impact over time. As such, environmental history leads to heritage: the memory of place is acknowledged in the remains of human activities on the landscape and in the story that these traces tell.

The environmental history of the Bancroft area is presented with emphasis on the rise and decline of the uranium mining industry, from the early 1950s until the present day. This story stands as a metaphor for globalization, whereby the economy of a small, remote community was greatly influenced by the commodification of a strategic mineral and Canada - U.S. trade relations in the Cold War nuclear arms race. The Bancroft area uranium industry offers lessons about global trade and the changing economies of one place that reflect patterns of economic boom and bust experienced on a regional, national and global scale. In the wake of the demise of this industry, the case study of the decommissioning of the Madawaska Mine and the community activism associated with this process, as well as with the abandoned Bicroft and Dyno mines, illustrate the dynamic between the community, government agencies and private companies. It offers lessons about the waste legacies of such industries and the resolution of conflicts concerning the delegation of longterm responsibility for these wastes. As industrial heritage, the story of this industry is given testimony by the tailings impoundments and mill remains. It extends lessons about mining and milling technologies, the influence of global politics and environmental stewardship. It provides insight into the ways that Bancroft is set apart from its neighbours, and it offers the wisdom of acknowledging all facets of the story of place, in order both to celebrate the unique and to apply lessons learned from past experiences to future land use decisions.

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Introduction

Environmental history provides opportunity for holistic research that, in a cumulative way, offers insights regarding the story(ies) of a place and the composite of relationships and interrelationships between people and their environment. A sense of environmental history allows one to begin to consider place as a whole, to begin to understand natural origins and the layers of human cultural influences that, over time, have produced their present day context and that, in time, will determine future setting and situation. To achieve a holistic understanding of one's home environment and one's place within it, it is necessary to consider the environment and its responses to the continual impacts of human culture as a complex of interrelationships. In this light, it is imperative to compile and analyze the stories of a place's economies. Stephen Dovers defines environmental history as:

> ...the investigation and description of previous states of the biophysical environment, and the study of human impacts on and our relationships with the non-human setting. Environmental history seeks to explain the landscapes and issues of today and their evolving and dynamic nature and from this to elucidate the problems and opportunities of tomorrow (22).

Donald Worster provides a practical context for the study of environmental history: "Environmental history has a great potential for changing the way we conceive of the past. It can help us explain more satisfactorily how we got to be where we are today. ... Above all it speaks to our present and future situations" (viii).

In the case of the Bancroft area, the story of the uranium industry stands as an overlooked affair that needs to be compiled, analyzed, and recorded. The story of the uranium industry contributes to one's understanding of the region's industrial and economic history. The origins, development and decline of this industry offer the researcher a metaphor for the process of globalization, which as represented in the case of this industry, allows one to perceive the influences of the global economy on a specific place. As Dan Flores notes: "...a small place can encapsulate and exemplify many broad historical themes" (13). As one reflects upon the metaphor of globalization, one must acknowledge the relationships between international and national defense policy, trade relationships and the geological makeup of a small rural area that determined its relationship to federal and foreign powers. This industry was created by the policies of the Canadian federal government, in concert with the United States Atomic Energy

Commission in the post World War Two nuclear arms race. In recent years it has been sustained by the development of Ontario Hydro's domestic nuclear energy program and the federal export of Candu nuclear technology.

The story of the uranium industry in the Bancroft area also represents a significant facet of the area's industrial heritage. As heritage it is part of the present-day fabric of place. The legacy of the low level radioactive wastes from the mines demands that not only must this heritage be acknowledged as a relic of the past but also as a responsibility for present and future generations. As such, the story of this industry can contribute to our understanding of the environmental impacts of mining on the environment. It can provide guidance for solutions to the long-term management of the mine sites and insight towards future resource management decisions, within a context of sustainable development. Finally, as the story of a recently developed, 'new' industry / technology, it is important to consider the challenges presented by the more or less permanent environmental degradation of the mine sites and tailings disposal areas. As Stephen Dovers cautions:

> In examining the factors / process that have led particularly to deleterious environmental change, environmental history will expose many past decisions and actions that are regrettable, even lamentable... the leveling of accusations and the laying of blame are to be avoided... Past actions were more often than not fully consistent with the understanding and beliefs of the time (29).

Perhaps then, the most valuable contribution of environmental history is by way of recording and analyzing the story(ies) of a place, so that we may learn by way of acknowledging the journey to our present, how to be wiser with our choices for future decisions and actions.

Chapter One *The Development of the Canadian Uranium Industry*

This chapter presents the historic context for the development of the uranium industry in the Bancroft area. An overview of the discovery of uranium and radium, as well as early atomic research are included. The development of nuclear weapons and the subsequent growth of the Canadian uranium industry, based upon special price contracts to supply the expansion of nuclear arsenals in the United States and the United Kingdom, are described. A brief account of the decline of the Canadian uranium industry, in the wake of the U.S. decision not to exercise their option to purchase Canadian uranium, is followed by a description of the development of Canada's civilian nuclear energy sector. The chapter closes with an account of the attempt to control the world supply and price of uranium by Canada, France, South Africa and Australia in the early 1970s and the present state of the Canadian uranium industry.

1.0 *Origins: Radium and Radioactivity*

Uranium was discovered in 1727 in a silver mine near St. Joachimsthal, what is now Jáchymov, Czech Republic. The black crystalline material was named *pech blende*, or pitchblende. In 1789, a chemist, Martin Klaproth, heated pitchblende with charcoal and discovered a new yellow oxide which he considered to be a new metal. He named this new metal *uranium* after the recently discovered planet Uranus, with the symbol U and in time, it received the atomic number 92 (Bothwell, Eldorado 3). Klaproth's contemporaries found that uranium salts made excellent dyes for glass, cloth and pottery and the mining of the raw ore, pitchblende, began. By the nineteenth century, uranium salts were used medicinally to treat diabetes, stomach ulcers and tuberculosis (Caufield 25).

In 1895, Wilhelm Roentengen discovered radiation which he named *X rays*, for mystery. These rays would pass through many substances but not human bones, glass or some metals (Caufield 3). With the news of this discovery, Henri Becquerel, a professor of physics, began to experiment with luminescent materials to determine whether they emitted X-rays. By chance, Becquerel noted that uranium exposed photographic plates and concluded that it was spontaneously emitting some kind of energy that could penetrate paper and thin sheets of metal (22).

Marie Curie expanded upon this investigation in the course of her research for her doctorate in physics which she defended in May 1903 (Quinn 183). She published her first paper on the subject in 1898, observing that the pitchblende emitted more radiation than was expected by its content of uranium. Curie dubbed these spontaneous radiations *radioactivity*. In 1898, she and her husband, Pierre, discovered polonium and radium which are other highly radioactive components of pitchblende. Marie Curie spent the next few years manually processing tailings from the St. Joachimsthal pitchblende mine in order to isolate enough measurable radium to gain its official status as a new element. By 1902, she had isolated one tenth of a gram of radium from seven tons of pitchblende tailings. The method that Marie Curie developed to extract the radium was later adopted by industry (154). For these discoveries, the Curies and Becquerel shared the 1903 Nobel Prize in physics (189). In 1911, Marie Curie was awarded the Nobel Prize in chemistry for measuring the atomic weight of radium as well as for producing it in a metallic state (308).

Within a decade, radium was being used to treat cancers and other ailments. Containers with very small quantities of radium or radon gas were laid upon the surface of the area to be treated or inserted into diseased parts of the body. Radium was very scarce and difficult to extract from pitchblende ore, thus at this time it was valued at $120,000.00 per gram (Caufield 22). At the same time, patent medicines containing radium were sold to cure any and all ailments. Radium water was an especially popular tonic as were spas boasting radioactive waters (28). Radium-based luminescent paint was used for wristwatches and instrument dials for the military during World War I and after the war this paint became a popular consumer item (30). World production of radium was initially dominated by the American Standard Chemical Company using carnotite ore from the southwest United States. After World War I, Union Minière developed its pitchblende mine in the Belgian Congo with ore grades far richer than the American reserves. The world price for radium dropped below $100,000 per gram and American Standard was unable to remain in business (Bothwell, Eldorado 8).

The earliest discovery of radioactive minerals in Canada occurred in 1847, on the eastern shore of Lake Superior, although the exact location of this discovery was lost for a century. This discovery was described by a New York physician, Dr. John L. LeConte, who was given a sample of the mineral by a

Captain Benjamin Standard who had picked it up in the course of his travels as a supplier to the Montreal Mining Company. The captain informed LeConte that the sample was obtained "about seventy miles from Sault Ste. Marie, at the junction of trap and syenite: the vein in which it is found is about two inches in width: but on account of its position (on the face of an almost perpendicular cliff) only a few specimens were obtained, and those with great difficulty"(LeConte qtd. in LeBourdais 84). Other early discoveries were made in the province of Quebec in association with mica mining in pegmatite dikes in 1897 and in 1901 (Spence and Carnochan 1).

In order to encourage the discovery and the development of radium, the Ontario government passed The Radium Act in 1914. The act offered a $25,000.00 reward for "the first person proving to the satisfaction of the Lieutenant - Governor - in - Council that he has discovered radium in the province of Ontario": radium included "all deposits of carnotite, pitchblende, or other substances containing radium in sufficient quantity for commercial extraction." (LeBourdais 84). At this time, the Ontario Department of Mines distributed samples of uranium ore to prospectors who were told to watch for uranium stainings while prospecting for gold and silver (85). In 1948, pitchblende was discovered by Robert Campbell, a prospector working for the Camray Syndicate at Theano Point on Lake Superior, fifty miles north of Sault Sainte Marie. Using a geiger counter, he located an occurrence in a vein of green rock which was later identified as pitchblende. This occurrence was named the Camray discovery and it was briefly considered to be the location of the original find. Camray Mines Limited was organized to undertake development work but the low market value of uranium precluded mining (87). In 1949, the original location of the 1847 discovery was located a few miles along the shore from the Camray site. Though neither of these occurrences proved to be commercially viable, they led prospectors back to the area in the early 1950s and that wave of prospecting led to the discovery of the Elliot Lake uranium field, for a time Canada's leading producer of uranium (Griffith 7).

The discovery that led to the eventual development of Canada's uranium industry was made by Gilbert Labine and E.C. St. Paul in 1930 at Great Bear Lake, Northwest Territories. The two men flew in to investigate an occurrence of cobalt reported by the Canadian Geological Survey in 1900. Labine was

able to recognize pitchblende which the two discovered along with silver and cobalt. They staked claims for the Eldorado Gold Mining Company. Underground development began in 1932 and production of radium and silver commenced in 1933 (Griffith 7). A radium refinery was constructed by the company at Port Hope Ontario in 1933 (Alexander, Eldorado 35). At this time, radium was still a rare commodity worth $75,000.00 per gram, but by the end of the 1930s the value had decreased to $20,000.00 per gram (Downey 5). At this time, uranium was an unused by-product of the radium extraction process and there was no significant market for it prior to World War II. By 1940, Eldorado had closed its mine in Port Radium at Great Bear Lake; the company had large inventories of radium but no market due to the war in Europe.

1.1 *Uranium Becomes a Strategic Mineral*

The transformation of uranium, from a nearly useless by-product of radium extraction to the world's leading strategic mineral, began with the same scientific community that had studied radioactivity at the turn of the century. In 1930, a Jewish Hungarian physicist, Leo Szilard, was the first to conceive of the conditions required for nuclear fission: critical mass and a chain reaction. He perceived the strategic importance of these ideas and filed for British patents on them while maintaining secrecy in order to prevent the Germans from acquiring them. These patents were overlooked by the British army and filed away by the British Admiralty (Caufield 43).

As early as 1934, Enrico Fermi was splitting uranium atoms by bombarding them with neutrons but he and his contemporaries could not accept that fission was occurring until 1938 when two German scientists, Otto Hahn and Fritz Strassman, duplicated the experiment. Proof that a nuclear chain reaction was feasible was achieved by both Fermi and Szilard at Columbia University and by Irene and Frederick Juliot-Curie in Paris. Uranium was chosen for the study of atoms' nuclei because its isotope, U^{235}, is readily fissionable or splittable (Bothwell, Eldorado 133). In August 1939, United States' President Roosevelt received a letter from members of the American scientific community, including Albert Einstein, which emphasized the potential destructiveness of nuclear fission. Roosevelt subsequently appointed an Advisory Committee on Uranium to investigate the development of an atomic bomb. The

British scientific community was also investigating the development of atomic weapons. In July 1941, the MAUD committee reported that a uranium bomb could be constructed by the end of 1943. This report spurred on the American efforts to develop this technology. In October 1941, Roosevelt directed the Office of Scientific Research and Development to produce an atomic bomb; by early 1942 what became known as the Manhattan Project was under way.

In 1942, Eldorado Mining and Refining Limited owned the only significant uranium mine and the only radium refinery outside of occupied Europe. Both the Americans and the British required a secure supply of uranium for their nuclear weapons research. That year, Eldorado's Port Radium mine was reopened due to the first of several contracts to supply 54 tonnes of uranium concentrates to the United States' atomic project. Uranium replaced radium as the object of the company's mining and refining. Eldorado eventually supplied the Americans with a total of 771 tonnes of uranium concentrates in addition to the original sixty ton order (Bothwell, Eldorado 97). In 1943, the Government of Canada passed Orders in Council that prohibited private mining and staking as well as the publication of the whereabouts of radioactive mineral occurrences: all such discoveries were reserved for the crown. These bans remained in place until 1947. In 1944, the Canadian government, after two years of attempts to acquire a majority of shares of Eldorado to gain a controlling interest, expropriated the company and turned it into a Crown Corporation (Alexander, Eldorado 8; Bothwell, Eldorado 149).

Until the summer of 1942, British and American atomic research took place within a co-operative relationship which influenced the British decision to move its research team to Canada, where it would be both more secure and closer to the Americans (Bothwell, Eldorado 119). In September of that year, a joint Canadian-British atomic energy research program was established to develop methods of plutonium production from uranium in a heavy water nuclear reactor (LeBourdais 38). A site was chosen at the Université de Montreal and the project was under way by February 1943. At this time, the Americans changed their attitude toward co-operative research with the British and this led to their eventual exclusion from the Eldorado uranium supplies (Bothwell, Eldorado 131). However, a year later in January 1944, a joint program between the Montreal Lab and the Chicago Metallurgical Group was established to develop a heavy water pilot reactor. The site chosen for this project was Chalk River,

Ontario (LeBourdais 40). In August 1945, the Montreal Lab accomplished operation of the first nuclear reactor outside of the United States. The Zero Energy Experimental Pile (ZEEP) served as a test reactor for the design of subsequent research reactors such as the NRX (LeBourdais 151; Bothwell, Eldorado 61).

2.0 *The Birth of the Canadian Uranium Industry*

In 1946, the federal government passed the Atomic Energy Control Act which established the Atomic Energy Control Board and invested it "to make provision for the control and supervision of the development, application and use of atomic energy and to enable Canada to participate effectively in measures of international control of atomic energy"(AECB, Control 4). As a strategic mineral, uranium was placed within the jurisdiction of the federal government instead of within the provincial domain as are all other natural resources.

After the use of atomic weapons by the United States' government on Hiroshima and Nagasaki, the United Nations attempted to reach an international agreement to control both the proliferation of nuclear weapons and that of uranium as a strategic mineral. When this attempt failed in 1947, the Cold War began in earnest. At this time, the AECB recommended that restrictions on private prospecting, staking and mining of uranium be rescinded in order to stimulate the development of the uranium industry. The Canadian government's willingness to facilitate the development of this industry was based upon its close historical military and economic relationship with the United States, which at this time did not have plentiful domestic reserves of uranium because no significant American occurrences had been discovered (Downey, 7; Alexander 18). Canada, with the British and the Americans, was a member of the Combined Development Agency (CDA), whose role was to procure and allocate all uranium. Thus, Canada was aware of the favourable position it occupied as a supplier of a highly sought after strategic mineral (Downey 118; Hunter 330). When the Americans indicated that they would purchase any uranium that Canada could produce, the federal government responded. As Alexander states: "From that point on the Canadian government suckled the private uranium industry into existence"(22).

As well as lifting restrictions on private activity in the development of a uranium industry, the AECB designated Eldorado Mining and Refining Limited as the sole purchasing and exporting agent of

uranium in Canada. In 1947, a minimum price per pound for uranium concentrates was established and guaranteed with mining and milling allowances until 1952. This early price formula was based upon the ore grade of the Port Radium mine (Downey 140). This purchasing formula was set at $2.75 per pound. was increased to $6.00 per pound in 1950 and again in 1951 to $7.25 per pound. The guarantee period was likewise extended from 1952 to 1955 and then to 1962. This purchasing formula established guarantees for prospective uranium developers and stimulated Canada's largest prospecting boom. resulting in the identification of over ten thousand radioactive mineral occurrences by 1956 (Griffith 9). This formula was developed by Eldorado in consultation with the United States Atomic Energy Commission (USAEC) and was similar to the prices paid by that agency to its domestic suppliers of uranium.

In 1951, Eldorado announced the development of its Ace mine in the Beaverlodge area of northern Saskatchewan; the same year, Gunnar Gold Mines Limited was the first private interest to report development of a mine nearby. Neither of these deposits contained ore as rich as that of the Port Radium mine. thus both properties required greater capital and operating expenditures to process their ore (Griffith 11; Downey 40). It was evident that the existent price formula was not adequate for the lower grade ore properties.

2.1 *The Special Price Contracts*

On December 10, 1953, the USAEC agreed to purchase all the uranium that Canada could produce on the basis of special price contracts to be negotiated by Eldorado Mining and Refining Limited with individual producers and guaranteed until March 31, 1962. These special price contracts were designed to allow a uranium producer to "amortize all expenses and realize a generous profit"(Downey 140). The special or premium price formula specified a quantity of uranium oxide concentrates to be produced over a five-year period. The price per pound for concentrates was calculated to produce a generous profit after amortization of capital investment and operating costs. A ceiling price of $10.50 per pound was established for most of the contract negotiations to limit producers to those who could operate within the ceiling. To obtain a special price contract, a prospective producer submitted documentation to

Eldorado that indicated the orebodies, the plans for development, estimates for capital and operating costs and the state of finances. Eldorado assessed this information and offered the company a price per pound calculated on the basis of the information submitted and designed to reimburse the company for all of its investment within a five-year operating period (Downey 141; Hunter 334).

In addition to the special price contracts, the Income Tax Act gave new mines an income tax exemption period for their first three years of operation, a depletion allowance for the ore being removed from the ground and deductions for the expenses incurred for prospecting and developing ore bodies (Downey, 146). Downey contends that, because of these provisions, none of the private companies paid income taxes prior to 1962, regardless of their healthy profits. Other subsidies to the private producers were provided by the mapping of radioactive mineral occurrences by the Canadian Geological Survey. The research and development on ore treatment methods undertaken by Eldorado Mining and Refining Limited and the federal Department of Mines were made available to the private companies at no charge. In addition to its role as sales agent, Eldorado provided transportation and custom milling to private companies in northern areas (Downey 149; Alexander 23; Hunter 336).

The announcement of the special price contracts made it possible for prospective producers to consider developing lower grade ore bodies, especially those in places more accessible to the industrial heartland of Canada. This consideration precipitated a staking blitz across the country. Shortly after the USAEC announcement, Gunnar negotiated the first special price contract worth $77 million, later increased to $118 million (Downey 154; Griffith 11). Earlier that year, a two-phase staking blitz in the Blind River area led to the establishment of a dozen uranium mines. The first blitz, which encompassed 1400 claims over 22,662 ha, was undertaken in secrecy by American financier John Hirshorn, who, with his associates Joubin and Preston, ended up controlling seven uranium mines. News of the first blitz initiated a second of 8,000 claims over 129,502 ha and leading to the development of the other four mines in the area (Downey 154). In the end, the Elliot Lake region producers received special price contracts worth $1 billion from a total of $1.7 billion for all of Canada's uranium producers (Downey 155). Of this total, $1.5 billion was for the USAEC contracts and $220 million was for the United Kingdom Atomic Energy Authority (Hunter 338). Concurrently, prospecting and staking in pegmatite deposits of the

Bancroft area led to the establishment of four mines: Bicroft Mines Limited. Canadian Dyno Mines Limited. Faraday Mines Limited and Greyhawk Mines Limited.

In April 1955, Eldorado Mining and Refining Limited announced that it would no longer consider applications for special price contracts after March 31. 1956. At the same time. Eldorado announced that companies holding special price contracts had to be in production by April 1, 1957. By this time. there were four private mines poised to begin production: Gunnar in the Beaverlodge area of Saskatchewan. Nordic and Quirke in Elliot Lake and the Bicroft mine near Bancroft. By 1958. there were nineteen mines in five districts with seven additional mines shipping ore on a custom basis (Table 1).

Under the terms of the contract with the Canadian government. the USAEC was not obligated to indicate its intention to purchase additional uranium until after March 31. 1962. In the mid 1950s the USAEC extended its purchase guarantees to its domestic suppliers which led to significant discoveries of uranium in New Mexico and Wyoming. In 1958. the Americans announced the end of domestic supply contract awards signifying that they had secured domestic supplies for their needs. The Canadian uranium industry did not heed these early warnings of the impending decline of their export market. At this time. Eldorado Mining and Refining Limited extended the deadline for production start-up from April 1. 1957 to September 30. 1957 to allow lagging contracts to begin production. This decision was made without any assurance from the Americans that the market would exist after March 31. 1962 (Downey 179). The Canadian uranium industry remained optimistic about its prospects after 1962. with hopes based upon the swift and smooth development of the civilian nuclear energy sector. In 1958, Eldorado changed its status as the sole sales agent for Canadian uranium; private companies were given permission to sell up to 2000 pounds of uranium concentrates surplus to their USAEC contracts.

Table 1: Canadian Uranium Producers circa 1958

Original Corporate Name and Mine Location	Mill Capacity Tons per Day	Period of Operation	Value of Contract $ Millions	Capital Expenditure $ Millions
Elliot Lake, Ontario				
Nordic Mine (Algom)	3,700	Jan. 1957 -	207 (incl. Quirk)	48 (incl. Quirk)
Quirk Mine (Algom)	3,000	Oct. 1956 - Jan . 1961	-	-
Can-Met Explorations Limited	3,000	Nov. 1957 - Apr. 1960	80	20
Cons. Denison Mines Ltd.	6,000	June 1957 -	202	40
Milliken Lake U mines Ltd.	3,000	Apr. 1958 - June 1964	95	26
Buckles (Northspan)	no mill	early 1957 - Oct. 1958	custom	75 (incl. Lacnor. Panel and Spanish)
Lacnor (Northspan)	4,400	Nov. 1957 - July 1960	275 (incl. Panel and Spanish)	-
Panel (Northspan)	3,000	Mar. 1958 - June 1961	-	-
Spanish American (Northspan)	2,000	May 1958 - Feb. 1959	-	-
Pronto U Mines Ltd.	1,500	Oct. 1955 - Apr. 1960	67	6
Stanleigh U Mining Corp. Ltd.	3,300	Apr. 1958 - Jan 1961	91	33
Stanrock U Mines Ltd.	3,300	Apr. 1958 -	95	29
Bancroft, Ontario				
Bicroft U Mines Ltd.	1,400	Nov. 1956 - June 1963	36	12
Canadian Dyno Mines Ltd.	1,200	May 1958 - June 1960	35	8
Faraday U Mines Ltd.	1,200	Apr. 1957 - June 1964	45	9
Greyhawk U Mines Ltd.	no mill	Sept. 1957 - Apr. 1959	custom	n/a
Beaverlodge, Saskatchewan				
Black Bay U Ltd.	no mill	Feb. 1958 -early 1960	custom	n/a
Cayzor Athabaska Mines Ltd.	no mill	Feb. 1957 - Mar. 1960	custom	n/a
Cons. Nicholson Mines Ltd.	no mill	Feb. 1955 - Apr. 1956	custom	n/a
Eldorado Mining and Refining	2,000	Apr. 1953	211 (incl. Port Radium)	35
Gunnar Mines Ltd.	2,000	Sept. 1955 - Feb. 1964	119	20
Lake Cinch Mines Ltd.	no mill	May 1957 - Mar. 1960	custom	n/a
Lorado U Mines Ltd.	750	May 1957 - Apr. 1960	64	9
National Explorations Ltd.	no mill	Apr. 1955 - Oct. 1958	custom	n/a
Nesbitt Labine U Mines Ltd.	no mill	Sept. 1954 - June 1955	custom	n/a
Rix-Athabaska U Mines Ltd.	no mill	Apr. 1954 - June 1960	custom	n/a
Northwest Territories				
Port Radium (Eldorado)	300	Aug. 1943 - Sept. 1960	see above	n/a
Rayrock Mines Ltd.	150	June 1957 - July 1959	16	3

Source: Griffith 12

3.0 *The Decline of the Canadian Uranium Industry*

On November 6, 1959 the USAEC and Eldorado Mining and Refining Limited announced that the Americans would not exercise their option to purchase additional uranium from Canada after March 31, 1962 (Downey 195; Griffith 13). The American decision to end its purchase of Canadian uranium was due to the discovery of significant uranium occurrences in New Mexico and Wyoming which guaranteed a secure domestic supply for the United States (Downey 168). At this time, the stretch out program for the delivery of existing contracts was outlined. This program allowed for the transfer of contracts between companies, whereby less efficient, smaller operations could sell the undelivered balance of their USAEC contract to larger, lower cost operators. This arrangement allowed these smaller operations to leave the industry free of debt and potentially with a profit, while the more efficient operators were able to continue mining and milling for a period beyond the March 1962 deadline. The stretch out program also allowed the extension of deliveries for existing contracts for several years after March 1962. The purpose of the stretch out program was twofold: it was intended to avoid a complete collapse of the Canadian uranium industry after the expiry of the USAEC contracts in March 1962, while maintaining a small part of the industry. It also allowed the less efficient producers to leave the industry without losing money (Downey 211).

Within a year of this announcement, the number of mines in production had been reduced by half, with seven of the original twenty-two companies remaining. Employment figures illustrate this dramatic downsizing; at its height in August 1959, the uranium industry employed 13,600 workers; by December 1959, 11,800 were employed and a year later 6000 were employed (Downey 213). In the Bancroft field, approximately 1,400 workers were employed in 1959; by 1964 there were none. During the same period, the Beaverlodge field saw employment decrease from 1600 to 500 while in Elliot Lake the workforce declined from 8000 to 1300 (Downey 213).

In 1957, the government of Canada and the UKAEA verbally agreed on a contract for 12,000 tons (24 million lb.) of uranium concentrates valued originally at $192 million, to be delivered between 1963 and 1966. At that time, the American government still held options on all Canadian uranium

production after 1962 and this limited Canada's ability to commit formally to a contract with another buyer. In 1961, Canada initiated negotiations with the British and in August 1962 the contract was announced. By that time the British had less need for Canadian uranium and the final contract favoured the UKAEA; the price was reduced from $8.00 per pound to $5.03 per pound for a total value of $120 million and the delivery period was extended from 1963 for up to nine years (Downey 214; Griffith 13; Hunter 351). This contract did allow two of the remaining Bancroft area mines, the Faraday and the Bicroft mines, to extend their operating periods.

In addition to the stretch out program, the government of Canada attempted to bolster the surviving uranium companies through a series of stockpiling programs (Alexander 24). The Government of Canada General Stockpile program ran from 1963 to 1964 for $24 million worth of uranium concentrates and from 1965 to 1970 for $77 million worth (Gray 78). In 1974, the federal government administered a third stockpiling program through a new crown corporation, Uranium Canada Limited (UCAN). This program was initiated by threats from the owner of Denison Mines to shut down in protest against the restrictions placed on foreign ownership in the uranium industry by the Foreign Investment Review Agency (FIRA) policy (Alexander 24). These stockpiles were intended to provide uranium for export as well as for domestic energy uses.

3.1 *The Development of the Nuclear Energy Sector*

Research in Canada's nuclear energy sector began with the work undertaken by the Montreal Lab during World War II. In February 1947, the AECB asked the National Research Council (NRC) to take over the Chalk River research labs. The National Research Experimental (NRX) reactor became operational in July 1947 as a research prototype and producer of isotopes (LeBourdais 152; Bothwell, Nucleus 105). In April 1952, Atomic Energy of Canada Limited (AECL) was established to administer Chalk River both as a research centre and as an industrial supplier of plutonium and radio-isotopes from the planned NRU reactor (Bothwell, Nucleus 146). This next research reactor, the National Research Universal, was planned and developed during the early 1950's and became operational in late 1957 (143). This reactor served as a research prototype, a producer of plutonium for the USAEC and a producer of

isotopes (154). The fourth Chalk River reactor was the Pool Test Reactor or PTR. which was used to test nuclear reactor fuel samples (156).

In 1954. the Nuclear Power Group at Chalk River began to investigate natural uranium. heavy water reactors for nuclear power generation of electricity; a joint feasibility study was undertaken by AECL and Ontario Hydro in December 1953 (Bothwell 198). In 1955. AECL called for proposals to design and construct a Nuclear Power Demonstration Station (NDP). Canadian General Electric won the contract and Ontario Hydro was the utility selected to join the project (LeBourdais 157). The Nuclear Demonstration Project was located at Rolphton on the Ottawa River. Construction began in 1956 and the NDP-2 reactor began production in April 1962 (Bothwell. Nucleus 244). That same year. construction began on the WR-1 research reactor at Whiteshell Manitoba (EMR 1962. 602). The first Candu project followed at Douglas Point on Lake Huron during the early 1960's: it began production in November 1966. In 1964 the construction of the Pickering reactor east of Toronto was announced: it began operation in February 1971 (Bothwell. Nucleus 414). In 1966. the government of Quebec approved the construction of the Gentilly-1 reactor which commenced operation in 1971 (339). In June 1973. Ontario Hydro announced plans to develop Darlington near Bowmanville on Lake Ontario. Pickering B and Bruce B at Douglas Point (433). Construction of a reactor at Point Lepreau in the province of New Brunswick was undertaken in 1975 (440): it began operation in 1983 (EMR. 1989 65.3).

In 1955, the Canadian government agreed to undertake construction of a Canada-India Reactor (CIR), which was based upon the NRX design and used for nuclear research (Bothwell, Nucleus 156). In 1962, the Indian government announced construction of a Candu reactor, RAPP I, in Rajasthan . A second reactor. RAPP II was under way several years later. RAPP I began operation in 1973 and RAPP II in 1981 (368). India, which had not signed the Nuclear Non Proliferation Treaty of 1970, detonated a "peaceful" nuclear device using plutonium from the CIR reactor in 1974 (368).

The development of Ontario Hydro's nuclear energy program was due in part to its own inflated forecasts of significant continued growth in electrical consumption. With the development of its first reactor projects and long term plans for extensive reactor construction throughout the province, the Progressive Conservative government of the mid-1970s attempted to secure a long-term supply of uranium

through contracts with the Elliot Lake, Denison and Rio Algom. mines. In the absence of consensus. after review of these contracts by a Select Committee, the contracts were signed by the Premier. Bill Davis. who exercised his power to overrule the committee in February 1978 (Mckay 79). The contracts were cost-plus contracts to supply 198 million lb. of uranium concentrates for a base price of $5 per pound with allowances for depreciation. exploration. taxes and operating costs (75). The contracts were to last twenty years for an estimated value of six to seven billion dollars and deliveries were deferred until the completion of deliveries for contracts with Spain and Japan (77). Within four years of the signing of these contracts. the world uranium supply was once again in surplus and the price per pound for uranium had declined to half of its 1977 level (79). In April 1991. Ontario Hydro announced that it was terminating its contract with Denison effective January 1. 1993. In June 1991. Ontario Hydro advised Rio Algom that its contract would be terminated in 1996 instead of in 2020 (EMR 1991. 50.2).

Although the development of nuclear power proceeded apace throughout the 1960s and the 1970s. the sector did not develop as swiftly nor to the scale hoped for by the producers of Canadian uranium. In the wake of its decision to cease buying uranium from Canada. the United States proceeded to establish an embargo on the import of uranium for its own private nuclear utility companies in order to guarantee a market for its domestic uranium producers. This embargo was initially slated to last from 1964 until 1974. when it was announced that it would be gradually lifted over a ten-year period (Gray 157).

3.2 *The Uranium Cartel*

In early 1972, government officials and uranium companies from Canada, France, South Africa and Australia met in Paris to discuss the free world uranium market and its depressed price situation (Gray 109). In short, their purpose was to control the supply and to increase the price of uranium on the world market (7). In subsequent meetings, the cartel decided to divide the world market into allocations for each country: Canada 33.5%, South Africa 23.75%, France 21.75%, Australia 17% and the remaining 4% to affiliates in Namibia and Australia (138). The initial price schedule was set at $5.30 per pound to rise to $7.10 per pound by 1978 and it was agreed to extend these arrangements until 1980 (138).

There was no significant growth in the market for uranium until after the 1973 Arab oil embargo when oil prices rose almost 400 percent between late 1973 and early 1974 (Gray 167). One of the major impacts of the increase in oil prices was the heightened awareness of western nation dependence on Arab oil supplies. This awareness led to increased interest in long-term contracts by American nuclear utility companies and decisions by some governments to expand their nuclear power sector (169). By the middle of 1974, Canada was the only western country still willing to export uranium and the market had shifted from long favouring the buyer to favouring the seller. This turn of events prompted a ten-year federal - provincial initiative worth $50 million called the Uranium Reconnaissance program which was intended to stimulate the discovery of new ore bodies (Alexander 26).

In 1975, the American firm Westinghouse defaulted on its contracts to supply a total of 80 million pounds of uranium to twenty-seven utility companies (Gray 176). In the course of the court proceedings that followed, the antitrust division of the U.S. Department of Justice learned of the existence of the uranium cartel. The Justice Department subsequently subpoenaed Gulf Minerals Canada, Rio Algom, Denison Mines, Uranez Canada and Eldorado Nuclear, to which the companies did not respond (198). The Canadian federal government presented the U.S. Department of Justice with a background paper that outlined the development of the Canadian uranium industry for the benefit of the USAEC and its decline in the face of American decisions not to purchase Canadian uranium after 1962, the subsequent import embargo on uranium and other restrictive policies (199). When Australian documents about the cartel's activities became public, the Canadian government passed the Uranium Securities Information Regulation, a gag law that provided a five-year prison sentence for any person who discussed the cartel documents (200). The uranium market upsurge lasted until 1980, when supplies once again exceeded demand (204).

4.0 *The Present Status of the Canadian Uranium Industry*

Review of the *Canadian Minerals Yearbook* for the decade of the 1980s demonstrates a consistent uncertainty in the Canadian uranium industry with regard to the long-term prospects for the export market. By the middle of the decade, uranium suppliers were anticipating lucrative benefits from

the Canada - United States Free Trade Agreement. This agreement exempted Canada from uranium import restrictions with the United States (EMR 1988, 66.5). After the breakup of the Soviet Union, the western world uranium market was depressed by new sources of uranium from eastern Europe. The world price of uranium remained low due to large inventories that were not reduced as swiftly as anticipated (EMR 1991, 50.8). By 1990, employment in the Canadian uranium industry had declined to 2500 workers from 4700 the previous year (EMR 1990, 67.17) and to 1320 workers by the end of 1993 (EMR, 53.9).

Canada remains the primary producer and exporter of uranium, supplying approximately 40% of the world 's uranium (EMR, 1993 53.9). Within the past decade, Canadian production of uranium has come to be dominated by the province of Saskatchewan. As of December 1994, six of seven uranium mining developments were located in Saskatchewan while the seventh was located in the Northwest Territories (EMR 1994, 54.14). Canada's present policy on domestic security of uranium supply requires that a thirty-year supply is reserved at all times to meet the fuel requirements of all Canadian nuclear reactors, existing, committed and planned (EMR 54.13). Canada's primary domestic customers, consuming only fifteen percent of the nation's uranium production, are Ontario Hydro, Hydro Quebec and the province of New Brunswick (EMR 54.14). The major portion of Canada's uranium stocks are surplus to domestic requirements for nuclear fuel and research and therefore are available for export for peaceful purposes (EMR 54.2). Canada's production of uranium is, in terms of thermal energy, equal to two-thirds of the nation's combined production of petroleum, natural gas and coal (54.2). During the late 1950s and early 1960s, uranium ranked from a position of fourth to tenth among Canada's leading ten export commodities (Griffith 20) and during the 1980s it consistently ranked as the sixth export production metal commodity (EMR, 1991 50.1).

Since 1984, as the U.S. uranium embargo ended, Canada's primary export customer has been the United States. Table 2 demonstrates recent Canadian export contracts; the quantities include all uranium in contracts accepted between September 5, 1974 and December 31, 1994.

Table 2 : Canadian Uranium Under Export Contracts 1974-1984

Country of Buyer	Tonnes of U
United States	79,227
Japan	23,851
France	17,739
Germany	15,170
Sweden	9,628
South Korea	8,042
United Kingdom	7,667
Spain	4,068
Belgium	2,898
Finland	2,864
Italy	1,115
Switzerland	154
Argentina	69
Total	172,492

Source: EMR Canadian Minerals Yearbook, 1994 54.16

At present, Canada has twenty four nuclear power plants: twenty-two are in Ontario, one is in Quebec and the other is in New Brunswick. These plants supply approximately 15% of Canadian electricity, 50% of Ontario's and 30% of New Brunswick's requirements (EMR 1990, 67.8). Globally, there are 424 nuclear power plants with 54 under construction (EMR 1994, 54.11). These plants supply approximately 17% of the world's electricity (EMR 1990, 67.8). The future of Canada's export market for uranium, and thus the health of its uranium industry in general, will continue to be determined by the growth or the decline of the nuclear energy sector, both at home and abroad.

Chapter Two The Origins, Development and Decline of the Uranium Industry in the Bancroft Area

This chapter presents a brief review of the resource extraction history of the Bancroft area. Included is a description of the geological setting of the area's uranium deposits, followed by an account of early radium occurrence exploration and development. The uranium boom, the development and the closure of the four Bancroft area uranium mines are described. The development of settlements associated with the mines closes the chapter.

1.0 The Historical Setting of the Bancroft Area

In the years before the arrival of the lumbermen and settlers, the North Hastings area was subject to beaver trade wars between the Iroquois and the Ojibwa (Schmalz 26-28). The Algonquin-speaking Ojibwa prevailed in these conflicts, and North Hastings was inhabited by these people, who were eventually displaced from their land with the establishment of the Algonquin reserve at Golden Lake in 1873 (Wilson 18, Burns 10). Hastings County was established by a proclamation of Lieutenant-Governor Simcoe in 1792.

The village of Bancroft, which is located in the northern part of Hastings County, owes its existence to the York River, or the York Branch of the Madawaska River, which flows through it. This river was called the *Shawashkong*, which translates as "marshy", by the Ojibway people. In 1853, when the Geological Survey of Canada commissioned Alexander Murray to undertake a topographical survey of the land between Lake Huron and the Ottawa River, he used the *Shawashkong* for his return voyage. Murray described this river: "The Shawashkong, as its name implies, flows in many parts through immense marshes, especially at the lower and towards the upper extremities...Tracts of good hardwood land, mixed with pine occur in the valley of the Shawashkong" (Reynolds 9,10).

By the time of Alexander Murray's survey, the extraction of white pine and hemlock, for mast cuts for the British Navy, was already under way around present-day Baptiste Lake with planned extension of logging north of Papineau Lake (Reynolds 10, 18). The first spring log run through the site of Bancroft occurred in 1854 and the final run took place in 1926: "For seventy two springs the York

Branch moved whole townships of floatable timber - masts, squared and sawlogs to Bancroft and in early years beyond it to Quebec City" (Reynolds 12). The York River provided transportation for logs and for people as well as water power for sawmills, planing mills, shingle mills, grist mills, woollen mills and hydroelectric power generation. One of Bancroft's first white settlers, James Cleak, who arrived in 1855 to claim one of the 100-acre land grants along the Hastings Colonization Road, established the first grist and saw mills on the York River (Burns 12; Reynolds 20). Thus Bancroft was initially known as York Mills, York Branch, The Branch and York River; when the first post office was established in 1861, the name of the settlement was York River (Burns 9).

James Cleak sold his grist mill, saw mill and mill reserve to an entrepreneur based in Belleville, Senator Billa Flint, in 1877 (Reynolds 90). Flint's investments in York River's mills attracted new mills and businesses, especially lumber interests with headquarters in and around the settlement; this gave York River an advantage in growth over its nearest competitor, L'Amable (Reynolds 76).

In 1879, Senator Flint applied to the Postmaster General to change the name of York River to Bancroft in honor of his wife's mother, Elizabeth Ann Bancroft Clement (Reynolds 90). Although this name change was protested by the residents of York River, the settlement's new name was approved and came into effect on October 15, 1879 (Burns 9).

Billa Flint converted the grist mill he had purchased from James Cleak into a woollen mill in 1883 and sold it to the millwright, Donald Fuller. Each year, the Bancroft Custom Woollen Mill processed 25-30,000 lb. of wool, from local sheep (Reynolds 94). Wool was the material used for most clothing at that time and although Fuller's mill supplied only a local market in its early years, it eventually shipped wool across Canada (Reynolds 96). When the mill closed in the early 1970s, it was one of three Ontario companies still licenced to buy wool (Reynolds 97). Other mill-based businesses included a chopping mill to produce feed for local dairy and beef farms and a roller mill to produce "Pride of the North" flour (Reynolds 97, 98). Of note is the establishment of one of the earliest hydroelectric lighting systems, the Bancroft Light and Power Co., by local entrepreneurs in 1901 (Reynolds 101).

Two railways influenced the development of Bancroft after the turn of the century. The Central Ontario Railway (C.O.R.) completed its line from Trenton to Coe Hill in 1884 and extended this line to Bancroft in 1900 (Reynolds 175, 177). The development of this railway was affected by the gold rush that followed the discovery of gold near Madoc in 1866 and the development of the iron mine at Coe Hill in the 1880's. The C.O.R. timetable stated that it provided "...the only direct route to the gold fields of North Hastings" (Reynolds 175). Although mining was an incentive, lumber became the primary material shipped by the C.O.R.. The Central Ontario Railway amalgamated with the Canadian National Railway in 1956 and the Bancroft Station was closed in 1975 (Reynolds 177).

The Irondale Bancroft and Ottawa (I.B.O.) Railway resulted from the purchase by the Toronto Iron Co. of a mine, a smelter and railway line in Snowden Township (Reynolds 178). By 1887, the company had extended the line from Howland through Gooderham to Baptiste Lake; the I.B.O. and the C.O.R. met at Bancroft in 1910. The I.B.O. was purchased by the C.N.R. in 1943 and it ceased operation in 1960. The Diamond Lake road was constructed on the I.B.O. rail bed and radium water was bottled and sold from a spring in a rock cut on the line east of Diamond Lake (Reynolds 182).

In 1933, the Department of Northern Development established work camps throughout North Hastings to provide relief work for men. The work camps were located at intervals along the original colonization roads; the Hastings Road, the Monck Road, the Paudash and the Burleigh roads. The workers were paid $0.88 to $1.20 per day to widen and to grade these roads (Burns 93; Reynolds 150). From Madoc to Bancroft there were five camps of 200 men each (Reynolds 150). In 1937, the Department of Highways took over the Colonization Roads Branch of the Department of Northern Development. The final gap on the road from Burleigh Falls to Bancroft (Highway 28), between Apsley and Paudash Lake, was completed in 1937/38 (Reynolds 150). The completion and the upgrading of these roads, in concert with the increase in the private ownership of automobiles, influenced the development of the cottage / tourist resort industry in the area.

Mining activity in North Hastings County was precipitated by the discovery of gold near Madoc in 1866, which led to the establishment of Eldorado (Reynolds 184). This discovery motivated residents

of the county's northern townships to search for gold and other valuable minerals. The settlement of Coe Hill developed around the Coe Hill iron mine, which operated from 1882 to 1887, to which the C.O.R. constructed its rail line. During the 1890s several Bancroft area farmers attempted to develop iron occurrences on their properties (184). The most successful iron mining venture was undertaken by the Mineral Range Iron Mining Co. which established the Bessemer Mine and the Childs Mine twenty-nine kilometres south-east of Bancroft. These mines began operation in 1900 and in 1906 the Mineral Range Iron Mining Co. signed a $500,000.00 contract with the Pittsburgh Schwab Co. to deliver ten rail cars of iron ore per day (184). The C.O.R. constructed spur lines to the mines within sixty days. The contract increased the mines' work force to 300 men; by 1909 the local work force was insufficient and the company recruited workers from outside of the area. Approximately fifty houses were constructed near the mines, which closed without warning in September 1912 (184).

Corundum, an abrasive used in manufacturing, was extracted by several mining companies from the late 1890s until the 1920s, when synthetic abrasives displaced corundum (Reynolds 184). For a time, the production of corundum from the Bancroft area dominated the world market; mining companies in the area included the Combermere Corundum Co., Canada Corundum, Ontario Corundum and the Burgess Corundum Mine (188).

Four quarries in Faraday and Dungannon Townships were active from the early 1900s until the 1930s. Marble was extracted and shipped by rail in slabs and blocks for use as building material for Casa Loma, the Royal Ontario Museum, Queen's Park and the Parliament Buildings in Ottawa (Reynolds 189). The operations at the Mill, Cliff, Winfield and Barker quarries were dictated by contracts and therefore sporadic; when public building activity declined during the Great Depression, activity in the marble industry ceased.

Sodalite, a distinctive blue rock used in the same manner as marble in buildings, has been quarried since the early 1900s. The Princess Sodalite Mine was named after the Princess of Wales who, on a Royal Tour of Canada as the Duchess of Cornwall, was gifted with a sample of sodalite and

subsequently ordered it to decorate Marlborough House in England (Reynolds 191). The Princess Sodalite Mine has operated sporadically since then and produces mainly mineral specimens for collectors.

Other mineral deposits that have been mined in the past include apatite, for fertilizer (1869 - 1890), molybdenum, as a World War I steel additive and lubricant (1914-1920), fluorite, a World War II steel additive (1940 -1950), phlogopite (1890 -1960), muscovite and feldspar (1890-1970) (Easton 828). Many of the old mine and development sites are now used for mineral specimen collection. The Bancroft Mineral Society was established in 1960 (Burns 33), and since 1964, the village has hosted an annual Rockhound Gemboree (Reynolds 193). The geology of the area is lovingly described by Reynolds:

> Ancient glaciers, once a mile high, gouged away soil and rock repeatedly until the very heart of volcanic mountains were exposed. From earth's seething core a fantastic variety of molten minerals and non-metallics once bubbled forth under pressure to penetrate crevasses and crannies in the Precambrian granite. These provide the precious sauce on Bancroft's very special nature sundae, the jewels in a treasure chest of more than 1,600 identified and collectible minerals and non-metallics to be found within a fifty mile radius of the village (184).

It is evident that the Bancroft area has witnessed several phases of resource extraction since the proclamation of Lord Simcoe established Hastings County in 1792. Lumbering companies preceded the settlers and harvested the area's old growth white pine and hemlock; logging of the second growth forest of mixed hardwoods and conifers has continued since those days. The first settlers cleared land for farming, worked in the lumber camps and used the water from the York River to power grist mills, saw mills and woollen mills. For ninety years, sheep raised on these farms provided wool for the Bancroft woollen mill.

Interest in the rocks of the Bancroft area was precipitated by the Eldorado gold strike in the south of Hastings County in the 1860s. The development of iron and corundum mines and marble quarries was facilitated by the arrival of rail transport to the area. Indeed, the attainment of special price contracts by the Bancroft area uranium mines was in part due to their proximity to the industrial heartland of Canada and the provision of good roads and rail transport.

The development of the area's highways was aided by relief work projects during the Great Depression. Once these highways were improved and the gaps closed, the area's lakes became available

for the development of cottages. By the time of the uranium boom, the area was well stocked with cottages and tourist resorts, which helped to provide accommodation for newcomers who came to work in the mines.

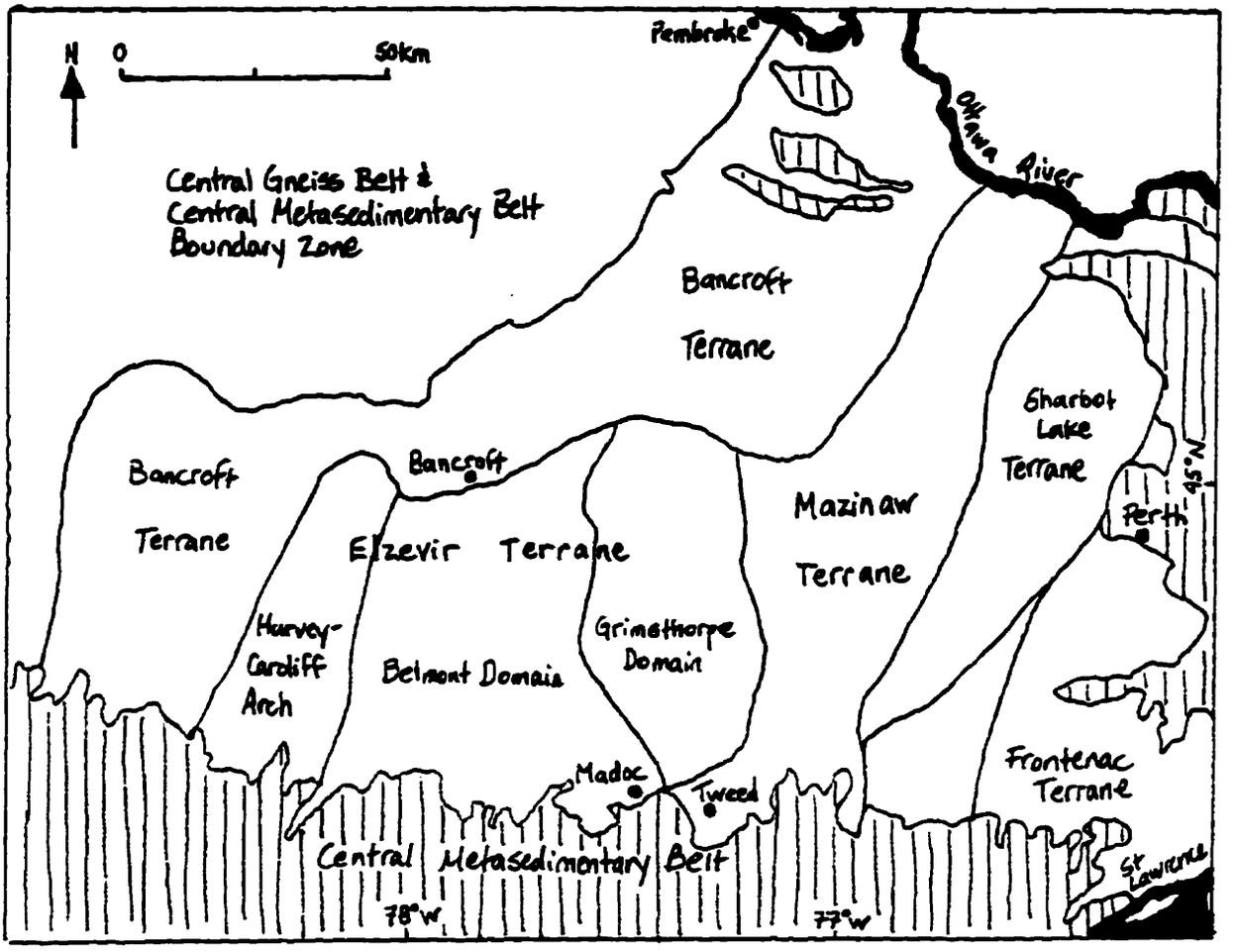
In the wake of uranium extraction and milling, the village of Bancroft has capitalized on the wealth and diversity of mineral specimens to be found in the rocks of the area. As the "Mineral Capital of Canada", Bancroft attracts rockhounds, students of geology and interested visitors to its many mineral collecting sites and to its annual Gemboree. So it is that the rocks and minerals of the area have fueled economic development in past years as well as the tourist industry of recent years. The following description of the uranium mines begins with the geology and early attempts to develop radium occurrences into mines.

2.0 *The Geological Setting of the Bancroft Area Uranium Deposits*

The uranium occurrences of Southern Ontario are found in the Grenville Geological Province of the Canadian Shield. Geological provinces are subdivided into terranes. Terranes are defined as regional bodies of rock bounded by faults which are characterized by a geological history that is distinct from neighbouring terranes (Bates and Jackson 697). Terranes are subdivided into domains, which are defined as bodies of rock, each with a distinct geological history which may or may not be bounded by faults (Meyn, Personal Communication Oct. 1,1996). The most recent, comprehensive account of the geology of the Grenville Province is found in Easton.

The uranium occurrences which became the mines of the Bancroft area are located in the Bancroft and the Elsevir Terranes of the Central Metasedimentary Belt of the Grenville Province (Figure 1), (Easton 785). The Bancroft Terrane begins near Coboconk and extends northeast to the Ottawa River to include the settlements of Minden, Haliburton, Bancroft and Pembroke. The Bancroft Terrane is bordered on the northwest by the Central Metasedimentary Belt Boundary Zone and on the south east by the Elsevir Terrane.

Figure 1: The Lithotectonic Terranes and Domains of the Central Metasedimentary Belt



Source: Easton 782.

The Bancroft Terrane consists mostly of deformed carbonate metasedimentary rocks. (highly metamorphosed sediments laid down as limestones and sandstones in early Precambrian seas). such as marble, which were plutonically intruded by nepheline syenite and syenite *circa* 1270 to 1220 Ma (Mega years or 10^6 years) (Easton 727). During the Grenville orogeny, which occurred *circa* 1250 to 1050 Ma. these rocks were involved in mountain building which resulted in their being buried several kilometres below the surface and subjected to intense heat and pressure of approximately 600°C to 700°C and 6 to 8 MPa (million Pascals). (Easton 811). The Greyhawk and the Faraday / Madawaska mines were located in the Bancroft Terrane; the ore from these mines is associated with uranium-bearing pegmatite veins or dikes in, or near the plutonic intrusions of gabbro (Meyn).

The Elsevir Terrane is located adjacent to the Bancroft Terrane in the southeast: it encompasses the area between Bancroft and Madoc, from Stony Lake in the west, to Highway 41 in the east. The Elsevir Terrane is subdivided into three domains, the Harvey-Cardiff Arch, and the Belmont, and Grimthorpe domains (Easton 818). This terrane consists of metasedimentary and metavolcanic rocks which were formed between 1300 and 1250 Ma, then subjected to plutonic activity and metamorphism between 1250 and 1230 Ma (Easton 833). During the Elseviran and the Ottawan orogenies, between 1130 and 1070 Ma, these rocks were metamorphosed by temperatures and pressures ranging from 600°C and 6 MPa at their contact with the Bancroft Terrane, to 400°C and 4 MPa in the vicinity of Madoc (Easton 833).

The Harvey-Cardiff Arch is characterized by domal plutonic masses large enough to be considered as batholiths, surrounded by metavolcanic and metasedimentary rocks (Meyn). The Bicroft Mine, the Canadian Dyno Mine and the Wilberforce Radium Occurrence are located in the Cardiff dome, or batholith, and the Canada Radium Occurrence is located in the Cheddar dome of the Harvey-Cardiff Arch. The uranium occurrences of the Bancroft area are uranium-thorium occurrences within late pegmatite veins located in, or near metavolcanic rocks. Lentz suggests that the uranium-bearing pegmatites of the Grenville Province were formed between 1060 and 1020 Ma from fluids of mid-crustal origin that followed structural channels, such as faults and the margins between the plutonic domes and the metavolcanic and metasedimentary rocks (qtd. in Easton 828).

The location of the Bancroft area uranium mines is described by the foremost geologist of the uranium boom period, D.F. Hewitt:

> The Canadian Dyno mine lies on the east flank of the Cheddar Batholith one half mile east of the contact...The Canada Radium Mine is on the north east margin of the Cheddar Batholith... the Croft workings of the Bicroft mine are on the south east flank of the Cardiff Plutonic complex a few hundred feet from the...contact of the Centre lake granite sheet. The Centre lake workings of the Bicroft mine are also located... less than one quarter mile from its contact. The Faraday Uranium Mine lies on the hanging wall side of the Faraday granite, one mile from the contact. The Greyhawk mine similarly lies in the same zone...1.25 miles from the granite contact (51) ...Although uranium occurrences have been found within the batholithic complexes and also at some distance from them, the most favorable structural position seems to be marginal to the major intrusive sheets or batholiths in the mixed hybrid zone within a mile or two of the contacts (Geology 52).

3.0 *The Wilberforce Radium Occurrence*

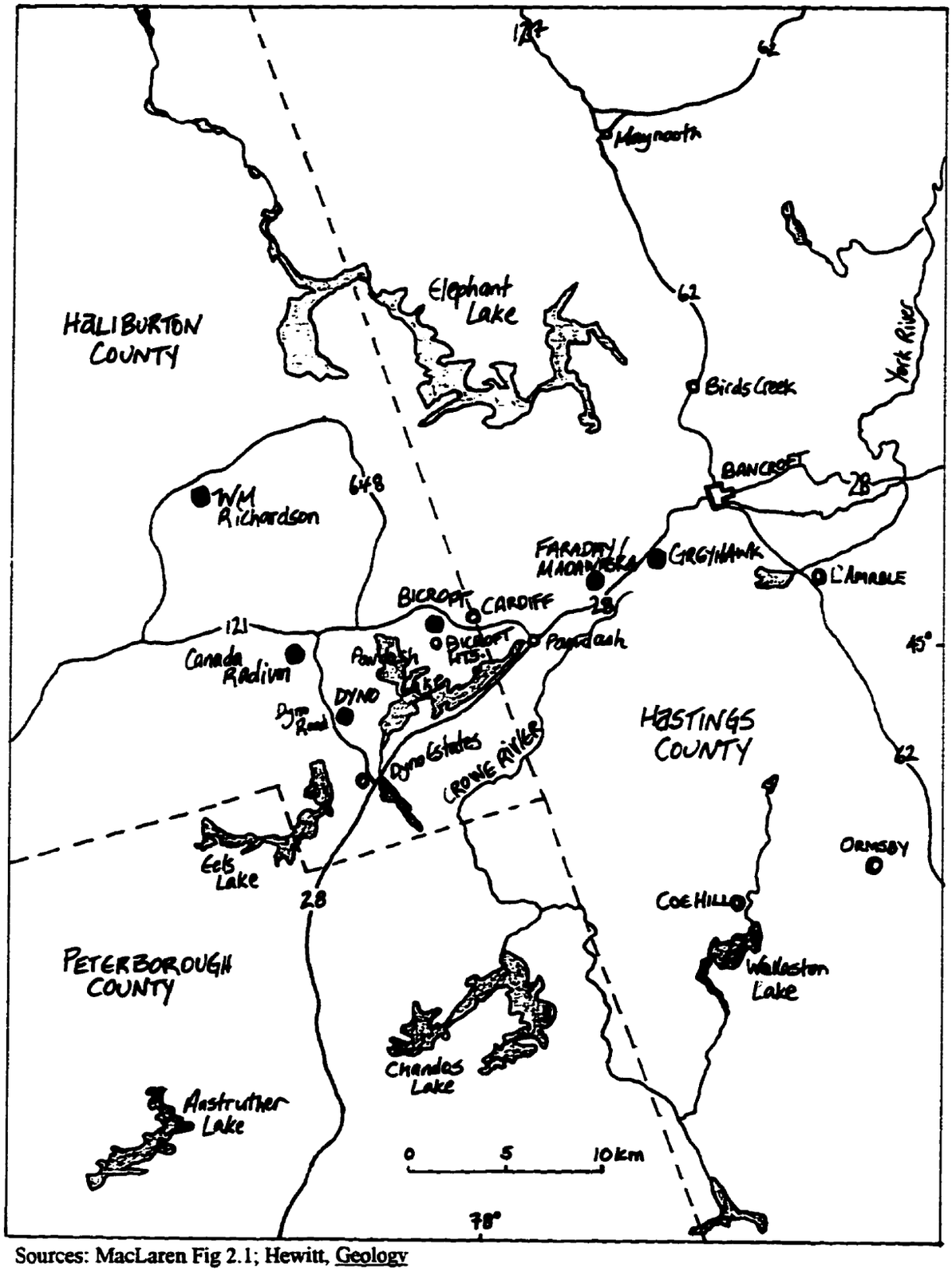
The first phase of uranium-related exploration and mining activity in Haliburton County began with W. M. Richardson's discovery of radium (Figure 2). The authors Spence and Carnochan describe this initial discovery of radioactive minerals:

> The first discovery of radium ore in the Wilberforce district was made in 1922 by Mr. W. M. Richardson, a prospector and miner with Alaska and Yukon experience, who had come to Wilberforce in connection with the finds of molybdenite that had been made near that place, and had taken up residence about one-half mile north-west of the site ... In the course of prospecting the district, Mr. Richardson found a heavy, black mineral in surface outcrops of pegmatite at different points on the property, and having obtained a sample of Joachimsthal pitchblende, identified this mineral as uraninite. He, therefore, took up the mining rights on lots 4 and 5 in concession XXI, and on lot 4 in concession XXII, and proceeded to open up a number of small prospect pits and trenches (6).

Richardson sent samples of the ore to New York for testing and initial analysis indicated that the ore contained 58.35% uranium oxide which would yield 147 milligrams of radium per ton of ore (Spence and Carnochan 6). Further tests were undertaken on behalf of a Toronto syndicate, at the University of Toronto in 1923 (7). Analysis of the water of the small lake and the springs on the property indicated "distinct radioactivity" (7). There was no other development work done until 1927, when the property was acquired by the Ontario Radium Corporation (7).

The Ontario Radium Corporation undertook further testing of ore in 1929 by sending samples of ore to the Mines Branch as well as to the Imperial Institute in London, England. Development work consisted of three pits (Spence and Carnochan 10, 22) and a tunnel. In one of the pits it was possible to hand pick the crude ore (37). One of the tests produced $22.73 worth of radium from one ton of ore (28). The authors compared this cost of production at $20/mg to the $5/mg cost of extracting radium by the world's primary supplier in the Belgian Congo (29). The viability of the Wilberforce site, regardless of its favorable location close to rail, roads and hydro, was determined by the extent and the quality of the occurrence, the costs of extraction and radium production and ultimately by the price of radium on the world market (28, 29).

Figure 2: Locations of Bancroft Area Uranium Mines, Radium Occurrences and Settlements



Sources: MacLaren Fig 2.1; Hewitt, Geology

The Ontario Radium Corporation was purchased by International Radium and Resources Limited in 1931. This company undertook some underground exploration as well as the construction of a 150-ton mill on the site, which never operated successfully (Hewitt, Geology 2). International Radium and Resources Limited ceased its activity on the property in 1933 (Hewitt, Uranium 20). A claim for the reward of $25,000.00 under The Radium Act was made but was not successful because proof of commercial extraction required by the act was not met. This act was repealed in 1937 (LeBourdais 85). From 1947 through 1949 and from 1954 to 1955 the property was reopened for exploration by Fission Mines Limited who undertook a program of extensive diamond drilling (Hewitt Geology 2). No further development work has occurred since that time.

3.1 *The Canada Radium Mine*

The property of the Canada Radium Mine was located on the north-east corner of the Cheddar Batholith, in Cardiff Township, on Concession XII lots 7 to 11, and Concession XIII lot 8 and the southern half of lot 7 (Figure 2). (Satterly 41). The Canada Radium Mines Limited was incorporated in 1926 and it began its activities on the property in 1932. This work included the development of a 400' (122m) deep vertical shaft as well as lateral work. In the late fall of 1939 and early 1940, a 100-ton mill was constructed. Although no mining had occurred, the mill was enlarged with a 50-ton magnetic separator in late 1940. During June and July of 1942, test runs of 200 tons of pegmatite ore occurred without the desired results. Operation of the mill ceased and on July 16, 1942 the property was shut down (42).

In 1954, the Canada Radium Corporation dewatered the underground workings, which were examined and allowed to fill with water again. In 1955, a diamond drilling program was undertaken on the basis of scintillometer and magnetometer readings of the property (Satterly 42). Since that time there has been no further development of the property.

4.0 *The Uranium Boom in the Haliburton - Bancroft Area*

Satterly (3) reviews three periods of activity with regard to radioactive mineral deposits in the Bancroft area. The first period was initiated by the reward offered by The Radium Act of 1914 and resulted in an increase in prospecting in the area; it is marked by the discovery of uraninite on the Richardson property in 1922 and the subsequent development of the property by the Ontario Radium Corporation and International Radium and Resources Limited until the mid-1930s. As well, this first phase saw development work at the Canada Radium Mine property at Cheddar which lasted until the early 1940s. The second phase of activity occurred between 1947 and 1951 when the Richardson property was reopened by Fission Mines Limited and underground development was undertaken by Cardiff Uranium Mines Limited and the Rare Earth Mining Corporation of Canada (3). The third phase was ushered in with the underground development of the Centre Lake Uranium Mine which, combined with the results of a large-scale aerial scintillometer survey that showed many radioactive anomalies in the area, touched off a staking rush that lasted for two years, 1953 and 1954 (3). By 1956, there was exploration for uranium being carried out on one hundred and twenty-five properties in the region; sixty of these properties were located in Haliburton County, thirty-six in Peterborough County and twenty-two in Hastings County. Exploration work on these properties involved surface exploration with trenches, scintillometer and Geiger counter surveys, magnometer surveys and in many cases, diamond drilling (1).

A small number of these properties showed sufficient quantities of mineralization of a grade of at least 0.1% uranium oxide to warrant mining. Satterly describes the activities at the 125 properties, four of which became productive uranium mines. Two of these mines, Bicroft and Canadian Dyno, were located in Cardiff Township in Haliburton County and two, Faraday and Greyhawk, were located in Faraday Township in Hastings County. The Faraday and Bicroft mines became major producers while the Dyno and Greyhawk mines produced lesser quantities of uranium oxide concentrate (Satterly 4). The Canadian Dyno Mine was originally contracted to produce quantities of concentrates similar to the two major Bancroft area producers, but the balance of its contract was sold to Gunnar Mines of Saskatchewan in 1960. During the operating period from 1956 until 1964, the total production of uranium oxide

concentrates by these mines was approximately 500,000 kg, worth $105,000,000, which required the extraction and milling of 5,380,000 tonnes of ore (James F. MacLaren Ltd.2-3). The Faraday Mine reopened as the Madawaska Mine in 1976 and operated until 1982. During this time, the Madawaska Mine produced an additional 1,247,802 kg of uranium concentrates (Alexander, Madawaska 391).

The mines that became operational received special, or premium, price contracts from the Crown Company, Eldorado Mining and Refining Limited, to supply the uranium oxide for Canadian government contracts with the United States Atomic Energy Commission (Table 3).

Table 3: Contracts and Letters of Intent with Eldorado Mining and Refining Limited

Letter of Intent or Contract	Name of Company	Date of Letter of Intent or Contract	Value of Uranium Precipitates
Contract	Bicroft Uranium Mines Limited	August 1955	$35,805,000
Contract	Faraday Uranium Mines Limited	January 1956	$29,754,000
Letter of Intent	Cavendish Uranium and Mining Company Limited	July 1956	$24,192,000
Letter of Intent	Canadian Dyno Mines Limited	August and November 1956	$34,881,000
Letter of Intent	Greyhawk Uranium Mines Limited	August and November 1956	$20,350,000
Total			$144,982,850

Source: Satterly 1

Comparison of the total value of the contracts in the above table ($144,982,850.00) with the amount cited by Maclaren ($105,000,000.00) shows a difference of $39,982,850.00. This figure may be accounted for by the amount of the letter of intent offered to the Cavendish Uranium and Mining Company Limited ($24,192,000.00) and the balance of the Canadian Dyno contract ($24,363,000.00) that was transferred to Gunnar Mines Limited. In 1956, the Cavendish Uranium and Mining Company merged with Halo Uranium Mines and the Rare Earth Mining Company Limited to form two new companies, Amalgamated Rare Earth Mines Limited and Consolidated Halo Uranium Mines Limited

(Satterly 4). The companies were unable to raise sufficient capital financing to begin production before the deadline of September 30, 1957, and thus did not secure a special price contract (Griffith 26).

5.0 *The Development of the Four Uranium Mines*

Table (4), provides a summary of the mines' number of employees, the mill capacities, the years of operation and the value of their special price contracts with the USAEC, and in the case of Madawaska Mines Limited, with AGIP, an agent of the Italian government. Discrepancies between the values of the special price contracts / letters of intent in Table 3 and the value of the contracts listed in Table 4 may be accounted for by the closure of the Greyhawk Mine and Faraday Uranium Mines Limited acquisition of the balance of its contract. As well, in addition to the contracts with the USAEC, there were small contracts with the United Kingdom Atomic Energy Authority. When the United States decided not to renew its purchase contracts with Canada after 1962, there were small contracts for stockpiling programs and additional contracts with the UKAEA to prolong the operation of Canada's uranium industry. These measures would have generated revenues in addition to the original special price contracts.

Table 4: Uranium Mines in Haliburton and Hastings Counties

Mines	Maximum Number of Employees	Value of US Contract	Mill Capacity Tons (Tonnes)	Years of Operation
Bicroft	500	$37,885,000	1,100 (998)	1956 - 1963
Canadian Dyno	450	$34,875,000	1,000 (907)	1958 - 1960
Faraday	565	$46,410,000	1,000 (907)	1957 - 1964
Madawaska	n/a	6,000,000 lb. U_3O_8 with AGIP of Italy	1,500 (1,360)	1976 - 1982
Greyhawk	75	$20,350,000	no mill	1957 - 1959
Totals	1,590	$139,520,000	4,600 (4,172)	

Sources: Carson-Brown 14; Hewitt 38; Alexander; SMDR 247; ODM 1957-1959

5.1 Bicroft Uranium Mines Limited

The Bicroft property is located in Cardiff Township on Concessions XI lots 27 and 28 and XIV, XV, XVI lots 30, 31, 26 to 32 and 30 to 32 respectively (Figure 2). This property encompassed 11.852 ha with an ore strike length of about 9.1 km (Griffith 196). The Bicroft property is the result of amalgamation of two adjacent properties, the Centre Lake property in the south and the Croft property in the north, which occurred in April, 1955.

The Centre Lake Uranium Mines Limited property was first staked on July 1, 1952 by garageman Garnet Burns of Downers Corners and his friend Bob Steele of Peterborough (*Bancroft Times* Dec. 17, 1953). In correspondence with the Geological Survey of Canada, dated December 18 1955, Garnet Burns describes the original discovery (Township of Bicroft Files):

> In an old report in the library here [Peterborough]... I read of a showing in Cardiff Township...and went to Mr. Howard Sarginson to see if he could tell me where this old pit was as he lived on the adjoining lot, but he had never saw nor heard of it, but was willing to go with me to show me Centre Lake which I had never been to.
>
> As we were walking along an old wagon road, I saw where a wheel of a steel-rimmed wagon had slipped across the face of a rock exposure and it was covered with a purplish, coloured dust and upon chipping it with my hammer found it to be a very deep purple fluorspar, and by the book (Prospecting for Uranium and Thorium) the colour was due to a radioactive mineral in the same vicinity, and at the next exposure about 75 yards north I found a crystal about .25 inch in diameter completely surrounded by radial fractures of 1 to 2 inches in length which the same book said was caused by the radioactivity of the crystal inside the fractures.
>
> I dug the crystal out and brought it home and the next day went back with my son and looked around some more and found several nice surface samples which due to the colour of oxide on them I thought must be associated with uranium, but I did not own a geiger counter and only knew where there was one in Peterborough, which was owned by Mr. Robert Steele.
>
> So I took my samples to him to have checked on his counter and he said they read very high and could we get together and get some ground staked in partnership before the news got out, which we started to do the very next day, but as neither of us had ever staked a claim before we did not get as much ground covered as we should have, due to being too painstaking in sighting lines, measuring claims, etc. and then the word got out and we were surrounded by staked claims.

The Croft property, controlled by Macassa Gold Mines Limited, began development at about the same time. Macassa was a well established gold mining company with successful gold mines in Northern Ontario (LeBourdais 135).

Figure 3: The Bicroft No. 1 Shaft

Source: Archives of Ontario RG 13-130-1-223.1

Figure 4: Bicroft U Mines Limited, 1956

Source: Archives of Ontario RG 13-130-1-223.2

Surface exploration began in 1952, with trenching and diamond drilling. The first shaft was excavated in 1954 on the Centre Lake property (Figure 3). After amalgamation of the two companies in 1955, a contract for uranium oxide shipments of $35,805,000.00 was negotiated in August, with Eldorado Mining and Refining Limited, for the purchase of uranium oxide (Satterly 1). The contract for the uranium oxide was a special price contract which limited delivery of the concentrates up to March 31, 1962 (Griffith 196). The contract provided the financial impetus for the development of a 1000-ton per day mill. The mill was designed by Killborn Engineering and built by Norcanda Construction Services Limited (LeBourdais 135); construction began in September 1955 and production commenced on October 29, 1956 (Griffith 198). The first shipment of $100,000.00 worth of uranium oxide concentrate occurred on December 11, 1956 (Satterly 1). During the period of construction of the mill, the second production shaft for the mine was begun. The cost of putting the mine into initial production in October 1956 was $10,832,481.00; by the same time the following year, additional capital investment had increased this amount to a total of $11,489,062.00 (Figure 4) (Griffith 215).

The Ontario Department of Mines Annual Reports for 1957, 1958, 1959 and 1960 provide statistical summaries of the Bicroft Mine operations that include quantitative descriptions of development work such as drilling and stoping, on the Number 1 and Number 2 Shafts, as well as accounts of milling and ore reserves and statements of production costs, operating costs and profits.

The contract with Eldorado Mining and Refining Limited allowed a maximum production and shipment of uranium oxide concentrates prior to July 1, 1958. After this date, the Bicroft monthly shipments were reduced by twenty percent and production was subsequently curtailed, although excess concentrates were stored at the mine site for future sales to Eldorado and to other agents. As of December 1958, $15,740,310.00 of the contract had been delivered (*Fourth Annual Report of Bicroft Uranium Mines Limited*). By December 1960, Bicroft had accumulated a stockpile of 133,693 lb. (49,904 kg) of uranium oxide (Griffith 198).

Bicroft fulfilled its contract for Eldorado Mining and Refining Limited in 1961. The mine's operations were temporarily halted at this time. Bicroft entered into another agreement with Eldorado to

produce an additional 342,000 lb. (127,659 kg) of concentrates, at cost, for delivery by January 30, 1962 (Griffith 198). Bicroft then merged with Macassa Gold Mines Limited and fulfilled a portion of Macassa's contract to supply uranium oxide concentrates to the United Kingdom Atomic Energy Authority (UKAEA): this allowed the Bicroft operations to continue until June 1963.

This fortuitous contract with the UKAEA was a result of the lobbying undertaken by the parish priest who served the mining community of the Bancroft area. Father Henry J. Maloney was assigned as pastor to the Bancroft parish in 1957. With the onset of the development of the area's uranium mines, Father Maloney struck a building committee to expand the church and rectory as well as to establish a Catholic school and a convent residence. Many of the miners who came to the area were French Canadian Catholics and the Bancroft parish grew from about fifty families to more than two hundred and fifty families. Construction of the school was well under way when, in January 1960, the first major mine closure (Dyno) was announced. That the balance of the Dyno mine's contract was assumed by Gunnar Mines Limited of Saskatchewan was perceived as unfair by the residents of the Bancroft area. As well, there was a growing concern with regard to the long-term viability of the remaining Bicroft and Faraday mines when the USAEC contract deliveries ended in 1963. Father Maloney became the organizer and representative for a group of concerned citizens seeking assurance from the federal government that the mines would continue to operate.

Maloney was an appropriate choice as spokesperson for the community. His father, Martin Maloney, was the Conservative Member of Parliament for South Renfrew from 1925 until 1935. His brother, Arthur, was a Member of Parliament for a Toronto riding and his brother, James, was the Ontario Minister of Mines from 1958 until 1961. Father Maloney, with business and community leaders, founded the Bancroft and District Chamber of Commerce and formed a delegation to travel to Ottawa to lobby for the extension of the mines' contracts. Beginning in March 1960, the delegation made several trips but it was when the Bicroft mine announced impending layoffs of two hundred workers, to take effect after the fulfillment of its USAEC contract in 1961, that Father Maloney obtained a meeting with John Diefenbaker, then Prime Minister of Canada. The two met in the Prime Minister's office, and over lunch, discussed the future of the Bicroft and Faraday mines. The meeting resulted in the mines' participation in the fulfillment of the contract with the UKAEA as well as participation in the stretch out program which was intended to extend deliveries of existing contracts to prolong the operation of Canada's uranium

industry. The contract with the UKAEA was announced in August, 1960 by the Federal Minister of Trade and Commerce (*Bancroft Times*, 07/15/87). The stretch out program allowed Bicroft shipment of 475 tons (430 kg) of concentrates between January 1962 and June 1963 in addition to its original contract with Eldorado. The Bicroft Mine ceased operation in June, 1963 (Griffith, 198). Tables 5 and 6 illustrate the mine's production and employment.

Table 5: Bicroft Mine Production Including Waste Rock (discard)

Year	Gross Production	Tons Milled per Day (Tonnes)	Tons Milled per Year (Tonnes)	Tons Mill Discard per Year (Tonnes)
1956	$465,667	n/a	n/a	n/a
1957	$7,156,693	1,134 (1,028)	414,024 (375,520)	n/a
1958	$8,850,454	1,273 (1,155)	464,680 (421,465)	8,029 (7,282)
1959	$8,288,700	1,162 (1,053)	424,373 (384,906)	46,948 (42,582)
1960	$8,117,007	1,110 (998)	404,682 (367,047)	52,355 (47,486)
1961	$6,724,823	923 (837)	336,618 (305,312)	52,142 (47,293)
1962	$4,682,178	975 (884)	355,914 (322,814)	48,686 (44,158)
1963	$2,437,831	n/a	117,852 (106,892)	n/a

Source: Hewitt, Uranium 16; Griffith 197; SMDR 000154

Table 6: Bicroft Mine Employment

Year	Average Number of Employees	Number on Surface	Number Underground
1956	284	154	130
1957	616	270	346
1958	619	283	336
1959	552	226	326
1960	556	195	361
1961	488	187	301
1962	490	190	300
1963	183	91	92

Source: Ontario Department of Mines Annual Reports 1956 to 1963

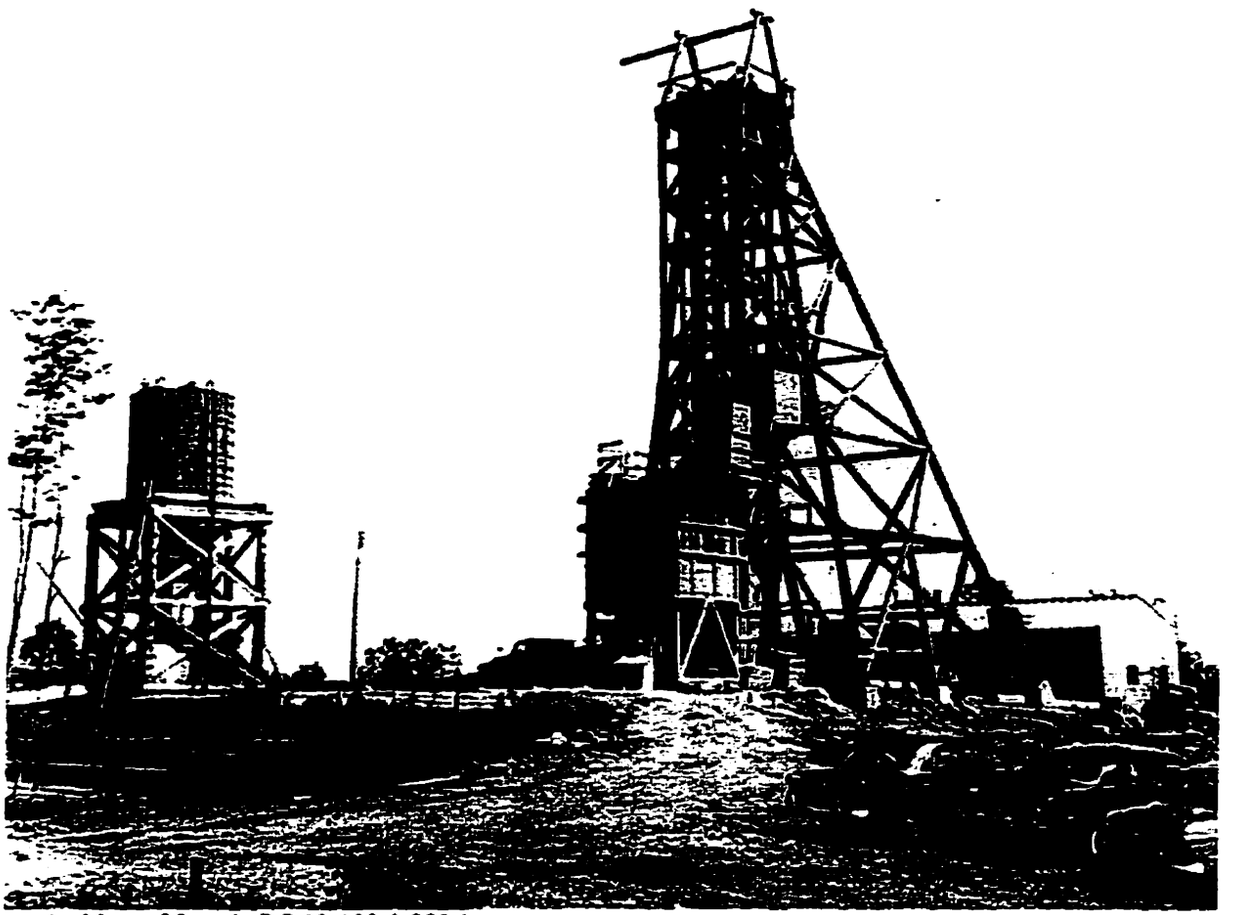
5.2 *Canadian Dyno Mines Limited*

The properties of the Canadian Dyno Mines Limited are located in Haliburton County, Cardiff Township, Concessions VII, VIII and IX, lot 12 (Hewitt, Uranium 11). Radioactive mineral occurrences on the property were discovered by Paul Mulliette of Toronto in November, 1953. Diamond drilling occurred from that time until 1955 and the resulting geological maps located five ore zones. By the middle of 1955, there was sufficient ore indicated to justify the sinking of a 1000' (305 m) shaft to begin underground exploration (Griffith 217). In order to provide Eldorado Mining and Refining Limited with the necessary development data and cost estimates before the deadline of March 31, 1956, Canadian Dyno Mines Limited sank this 1000' production shaft and opened up a level to locate ore zones (Figure 5). This measure indicated sufficient ore to qualify the company for a special price contract, although in time, the ore reserves did not meet with the projections (LeBourdais 137).

McLelland Gold Mines Limited was incorporated in 1951. In June 1953, the name was changed to Dyno Mines Limited. In December 1956, the name was again changed to Canadian Dyno Mines Limited (ODM 1957 143). With incorporation, Canadian Dyno Mines Limited acquired the assets of Dyno Mines Limited. The special price contract, to supply 3,321,500 lb. (1,239,828 kg) of uranium oxide concentrates, worth $31,710,000.00, to the Crown agent Eldorado Mining and Refining Limited, was awarded in August 1956 (Satterly 1). In November, the value of this contract was increased to a total of $34,880,000.00 (Satterly, 43). The contract scheduled delivery of the concentrates to begin on April 1, 1958 and to end by March 31, 1963 (ODM 1959 11) (Griffith 217). LeBourdais provides a description of the Dyno Mine site:

> The terrain in the Bancroft region is rugged, the elevation being formed by low rocky knobs, ridges and hills, interspersed by lakes, some quite large, and many areas of swamp or muskeg. So much of Canadian Dyno's property consists of low-lying land that the location of a site suitable for the shaft and for the mining and milling plant constituted a problem. The shaft was collared at the top of a high ridge flanked on either side by steep valleys. The major structures, requiring bedrock for their foundations, are gathered close around. Structures not requiring such firm foundations are built upon fill from shaft sinking and from excavations for the foundations of the mill and other main buildings (137).

Figure 5: The Canadian Dyno Headframe



Source: Archives of Ontario RG 13-130-1-223.1

The Ontario Department of Mines Annual Reports for 1956 through 1960 describe development work such as diamond drilling, construction of the mine and mill holdings, equipment acquisition, and amounts of ore hoisted, processed and shipped. Shipments were planned at a rate of 58,435 lb. of U_3O_8 per month (Cross 5). Of note is the mention of shipments of uranium oxide concentrates to the United Kingdom Atomic Energy Authority (UKAEA). The first shipment, in 1959, was of three 20,000 lb. lots; the balance of the year's production was shipped to the USAEC (ODM 1960 110). In 1960, fifteen lots of 20,000 lb. each were shipped to the UKAEA; the balance of production was sent to the USAEC (ODM 1962 123). The 1000- ton capacity mill was designed by Kilborn Engineering and constructed by E. G. M. Cape and Company of Montreal. The estimated capital cost of bringing the mine into production was

$10,467,000.00; the actual cost of bringing the mine into production was $9,693,275.73, which was $774,724.22 below the estimate (Cross 6). As well, the operation boasted the lowest operating expenses in the Canadian uranium industry (Cross 1). The mill began to process ore on May 1, 1958 and operated until April 27, 1960 (Hewitt, Uranium 11). Initial ore reserves for the mine were reported at 2.25 million tons with an average grade of 0.093 percent uranium oxide, but by 1959, the company began to experience problems with supplying the mill to capacity, due to lower than expected grades of ore (Griffith 219). This lower than expected grade of ore was due to the structure of the ore bodies: "a result of irregular walls and unpredictable content in ore dikes" (ODM 1960 110). Refer to Tables 7 and 8 for production and employment figures.

In early 1960, Canadian Dyno Mines Limited negotiated an agreement with Gunnar Mines Limited of Saskatchewan to take over the balance of Canadian Dyno's contract to supply uranium oxide concentrate to Eldorado Mining and Refining Limited. The assumption of Dyno's contract was part of the stretch-out plan for uranium producers that came into effect in 1963, after the USAEC decided not to continue to purchase uranium from Canadian producers (Griffith, 219). The last days of the Dyno mine are described in the Ontario Department of Mines Annual Report for 1960:

> Following the completion of the Dyno - Gunnar agreement, steps were taken immediately to close down the operation. All available broken ore was hoisted and treated. The mill circuit was cleaned out. The underground was completely salvaged. All major equipment was cleaned, and corrosive resistant measures were taken to ensure protection during prolonged storage. Equipment lists were prepared and distributed. The sale of equipment, supplies and buildings has been proceeding satisfactorily (124).

Table 7: Canadian Dyno Mine Production

Year	Gross Tons Hoisted (Tonnes)	Gross Tons Milled (Tonnes)	Average Tons Milled / Day	Production / Earnings
1958	261,591 (237,263)	228,284 (207,053)	932 (845)	n/a
1959	363,300 (329,513)	381,750 (346,247)	1,046 (949)	452,636.5 lb./ 174,091 kg worth $4,799,155.00
1960	n/a	209,291 (189,827)	865 (784)	n/a

Sources: Ontario Department of Mines Annual Reports for 1959, 1960 and 1961

Table 8: Canadian Dyno Mine Employment

Year	Average Number of Employees	Number on Surface	Number Underground
1956	29	24	5
1957	148	79	69
1958	423	153	270
1959	377	149	228
1960	64	38	26

Sources: Ontario Department of Mines Annual Reports for 1959, 1960 and 1961

5.3 *Greyhawk Uranium Mines Limited*

The Greyhawk Uranium Mines Limited property is located in Faraday Township in Hastings County. Early descriptions of the holdings from Ontario Department of Mines annual reports include Concessions A, B, XI, XII, XIV and XV, while recent references in the Ministry of Northern Development and Mines assessment files refer to only lot 10 in Concession XII where the production shaft was excavated (Figure 2).

In 1955, uranium was discovered at the site by K. D. Thomson and M. Card, employees of Goldhawk Porcupines Mines Limited, while undertaking a survey with geiger counters (MNDM Assessment Files). In November 1955, Goldhawk Porcupine Mines Limited changed its name to Greyhawk Uranium Mines Limited. At this time, a 60' by 300' (18m by 91m) radioactive rock exposure was diamond drilled to a depth of 450' (137m) to test an area 2000' (610m) in length. In 1956, a vertical shaft was sunk to 361' (110m) and three levels were established. Approximately 2000 tons of ore were hoisted (ODM 1956 148).

In August 1956, Greyhawk received a letter of intent from Eldorado Mining and Refining Limited for the purchase of $17,850,000.00 worth of uranium precipitates. This amount was increased to $20,350,000.00 in November of that year (Satterly 1). 1956 also saw the construction of a hoist room, a compressor house, a dry-house, a machine shop, a carpentry shop, an office and two dwellings (ODM 1956, 148). No mill was constructed and arrangements were made to ship the ore to the nearby Faraday mill for processing on a custom basis. With this arrangement, Faraday Uranium Mines took over the Greyhawk contract with Eldorado (Griffith 240; Hunter 346; LeBourdais 134). Shipments of ore began in September 1957 and continued until March 1959. Ore shipments ranged from 136 to 181 tonnes per day, while mine production averaged approximately 113 tonnes per day. The shipments were comprised of ore hoisted from the mine and ore from the aforementioned 2000-ton stockpile The year 1957 witnessed the construction of a 200-ton ore bin, a bunkhouse, a warehouse, a 10,000-gallon wood stave water tank and a building to house a blacksmith, a machinist and an electrician (ODM 1957, 155).

Greyhawk ceased production on March 1, 1959 due to poor ore grade and insufficient funds to develop ore of an acceptable grade (MNDM Assessment Files). Greyhawk Uranium Mines Limited went into voluntary bankruptcy and the mine and the surface buildings were stripped of all useful materials which were sold later that same year (Hunter, 346; ODM 1959, 116). The Greyhawk property was acquired by Faraday Uranium Mines Limited in 1962. Refer to Tables 9 and 10 for Greyhawk Mine production and employment figures.

Table 9: Greyhawk Uranium Mines Limited Employment

Year	Average Number	Number on Surface	Number Underground
1956	7	n/a	n/a
1957	71	28	43
1958	75	25	50
1959	21	7	14

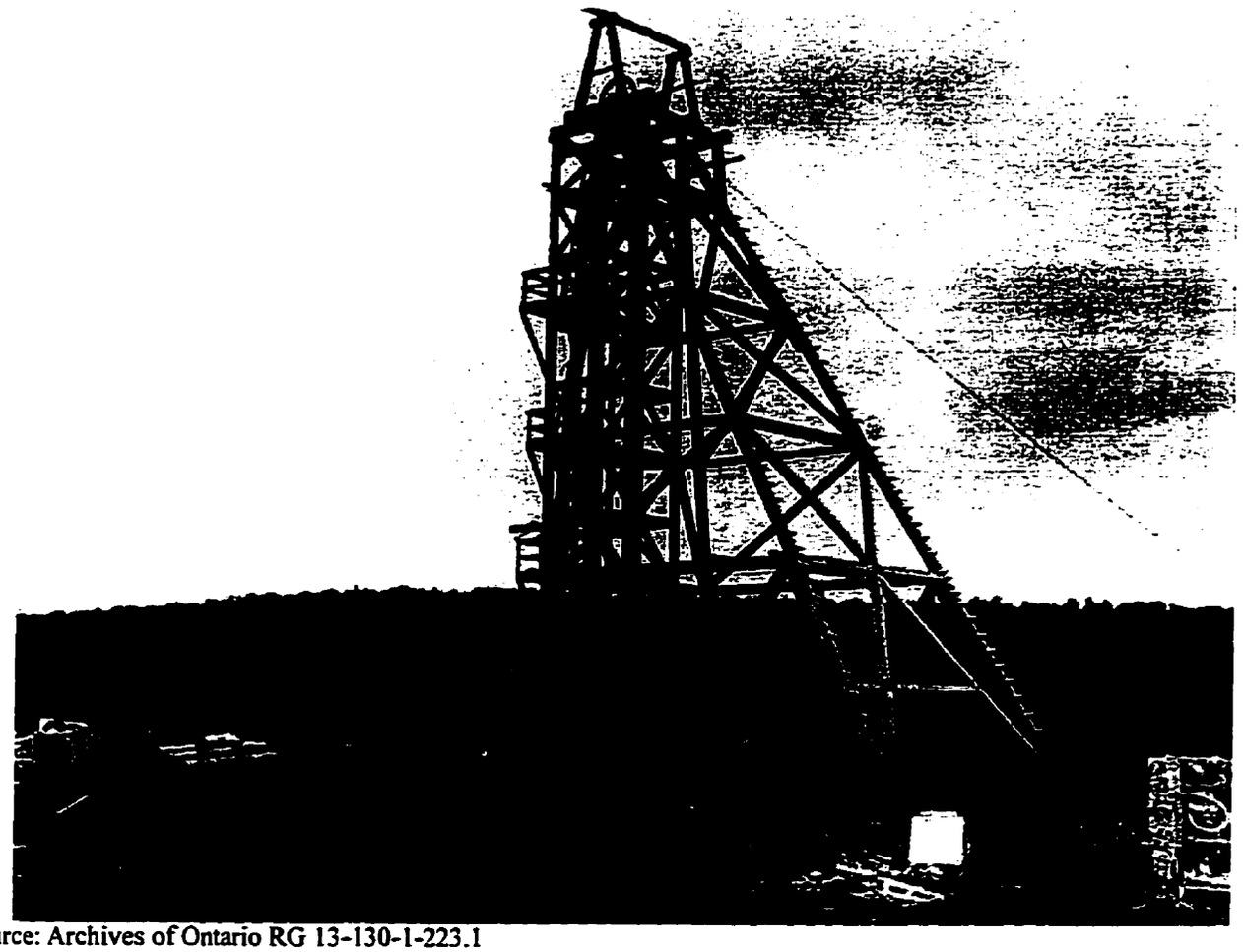
Sources: Ontario Department of Mines Annual Reports for 1956, 1957, 1958 and 1959

Table 10: Greyhawk Uranium Mines Limited Production

Year	Gross Production in Pounds (kg)	Tons (Tonnes)Milled	Average Recovery Per Ton lb./ton
1956	40,000 (15,384)	none	none
1957	21,382 (8,224)	19,535 (17,718)	1.09
1958	78,812 (30,312)	52,517 (47,633)	1.50 (worth $819,014)
1959	10,934 (4,205)	8,195 (7,432)	1.33 (worth $114,041)
Totals	151,128 (58,125)	80,247 (72,783)	1.38

Sources: Ontario Department of Mines Annual Reports for 1956, 1957, 1958 and 1959

Figure 6: The Greyhawk Headframe



Source: Archives of Ontario RG 13-130-1-223.1

5.4 *Faraday Uranium Mines Limited*

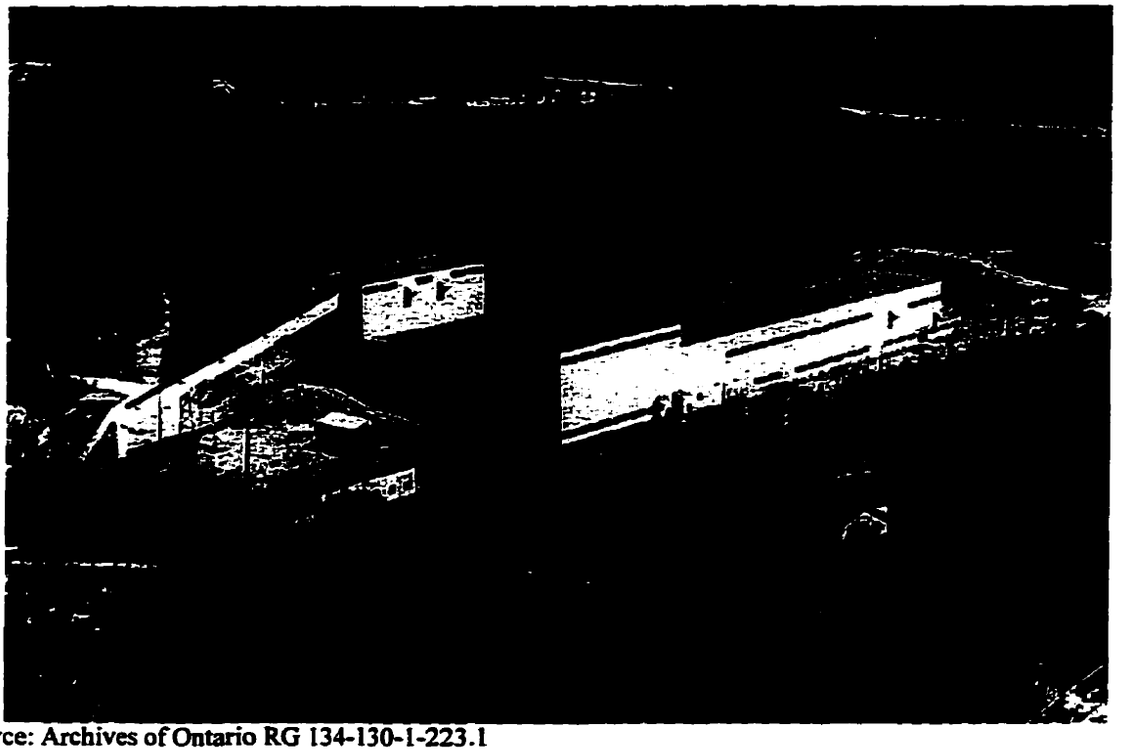
The Faraday property is located approximately eight kilometres south-west of Bancroft and was comprised of twenty-two lots in concessions A, B, IX, X and XI in Faraday Township, Hastings County (Figure 2). The radioactive showing which led to the development of the Faraday Uranium Mine was discovered by Bancroft resident Arthur H. Shore on lot XV, concession A, in 1949. That same year, Shore began surface stripping and trenching on the showing and incorporated Faraday Uranium Mines Limited. His initial attempts to raise funding for further exploration did not succeed (Griffith 225). This was due to the association of the Bancroft ore with pegmatite dikes which was not, at that time, considered to be commercially viable host rock (LeBourdais 132).

In 1952, Newkirk Mining Corporation of Toronto provided financing for expanded surface exploration, including an aerial scintillometer survey and ground scintillometer surveys. That same year, Pole Star Mining undertook a diamond drilling program on the property (MNDM Assessment Files). Seven radioactive anomalies were identified and the main ore body was discovered by drilling into the anomalies in late 1953 (Griffith 225: MNDM Assessment Files). Underground development began in 1954 with the opening of three adits into a prominent hill on the north shore of Bow lake (MNDM Assessment Files). By September 1955, underground drilling had confirmed the presence of a sufficient quantity and grade of ore to be considered for a special price contract. In January 1956, Faraday Uranium Mines Limited was awarded a special price contract by Eldorado Mining and Refining Limited to supply 2,920,000 lb.(1,089,958 kg) of uranium concentrates worth $29,754,880.00 by March 31, 1962 (MNDM Assessment Files) . The value of the Faraday Uranium Mines Limited contract with Eldorado increased substantially to approximately $46,410,000.00 with its assumption of custom milling of the ore from the Greyhawk Mine. Financing for the Faraday Mine mill complex was accomplished by the issue and sale of $8.5 million worth of First Mortgage Sinking Fund Debentures (LeBourdais 133).

During 1956, the development of surface infrastructure was initiated with the construction of the following buildings: a hoistroom, the mill building to house the ore treatment plant, a crusher house, a

transfer house, a boiler house, a chlorate storage house, a pumphouse, workshops, a dry house, two bunkhouses and a cafeteria (ODM 1956, 155).The mill was designed by Kilborn Engineering and constructed by Norcanda Construction Services Limited (LeBourdais 133). In early 1957, the treatment plant received its crushing and milling equipment and the milling of ore began in April at an initial rate of 400 tons per day (ODM 1957, 149). Additional buildings completed in 1957 included a powder magazine, a compressor house and a garage. A custom ore bin and a custom ore sampling building were constructed to handle the ore shipped from the Greyhawk mine on a custom basis which began in August of that year. In 1958, Faraday Uranium Mines Limited operated at full production levels with the mill processing in excess of 1400 tons per day by year's end (Figure 7). Several of the surface buildings were enlarged and a ventilation building and a backfill disposal building were completed.

Figure 7: Faraday Uranium Mines Limited



Source: Archives of Ontario RG 134-130-1-223.1

Ontario Department of Mines Annual Reports from 1956 through 1962 summarize the company's annual reports with mine and mill production figures as well as the development work required to bring existing and new ore bodies into production.

In April 1959, when Greyhawk ceased shipping ore, the Faraday Mine had to increase production in order to fulfill the Greyhawk contract in addition to its own. In November, the United States Atomic Energy Commission announced its decision not to renew its uranium contracts with Canadian suppliers and Eldorado Mining and Refining Limited announced the implementation of the contract stretch out program. With this news, Faraday Uranium Mines Limited decided to curtail its development work and to maintain the maximum mill rate of 1650 tons per day until the end of April 1960, when the three-year tax-free period granted to uranium producers ended (ODM AR 1959, 119).

After 1960, the mill rate was reduced to approximately 900 tons per day and development work was maintained at the curtailed level. In 1962, the Faraday mine received a portion of the UKAEA contract: the allotment for Faraday amounted to 1,083,191 lb. of uranium concentrates to be delivered between October 1962 and March 1964 (Griffith 225; Downey 215). In 1963, the Faraday Mine was included in the Canadian government's short-term stockpile program. The mine was eligible for this program because it was still in operation when the program was announced in July 1963 (Downey 206). Faraday Uranium Mines Limited completed its deliveries to the federal stockpile in June 1964 and the mine closed at that time. For the period 1957 until 1964, the company produced 6,155,505 lb. of uranium concentrates, while for the period 1976 until 1982, the company recovered 3,342,863 lb. of concentrates for a total production of 9,498,368 lb. (3,545,490 kg) of U_3O_8 (Alexander, Madawaska 388, 391). At shut down in 1964, the mining machinery, shop and crusher house equipment were sold but the mill itself was kept intact (MNDM Assessment Files). The property was retained on a "care and maintenance period" and the mine workings were allowed to flood (Madawaska Mines Limited 1987, 2-8).

In its initial period of development, financial control of Faraday Uranium Mines Limited was held by Continental Mining Exploration Limited. Later, this position was assumed by the Canadian Faraday Corporation Limited. In December 1963, the property became the Bancroft Division of Metal

Mines Limited. In 1967, the Canadian Faraday Corporation Limited amalgamated with Augustus Exploration to form Consolidated Canadian Faraday Limited. This company purchased the assets of Metal Mines Limited which included the Bancroft property. The same year, a subsidiary, Can-Fed Resources was established to undertake exploration of the Faraday property. The mine workings were dewatered and a program of exploration and development was initiated to establish an estimate of the mine's ore reserves. By 1969, the ore reserves had been assessed and the development work ceased while the mine workings were maintained in preparation for production (MNDM Assessment Files). At this time, Federal Resources Incorporated, of Salt Lake City, Utah, acquired a 51 percent interest in the property while Consolidated Canadian Faraday retained a 49 percent interest and the size of the property increased from approximately 6,419 ha to 11,851 ha (MNDM Assessment Files). These two companies formed Madawaska Uranium Mines Limited in 1974. In May 1975, this company received approval from the Atomic Energy Control Board (AECB) to enter into a contract for six million pounds (2.7 million kg) of uranium concentrates with Azienda Generale Italiani Petroli (AGIP), an agency of the government of Italy (Alexander, Madawaska 404; MNDM Assessment Files). The contract was signed in early 1976 and the mine was reopened in June. The mill resumed production in August. The mill rate for this time was planned at 1500 tons per day, five days a week.

In 1979, Rare Earth Resources Ltd., and Esso Minerals Canada negotiated with Madawaska Mines Limited for a custom milling contract for three uranium occurrences in the area; however, these were not developed (EMR 1979, 505). In 1980, Madawaska reorganized, whereby it became 100% owned by Federal Resources Corporation. Madawaska Mines Limited retained a 51% interest in assets and liabilities and Consolidated Canadian Faraday retained direct owner interest and 49% of operating profit (EMR 1980, 519).

In March 1982, when Madawaska announced its plans to close the mine, Father Maloney took on the role of community representative with the Bancroft Community Committee. Maloney met with Bill Davis, then Premier of Ontario, in the hopes of securing some portion of the Ontario Hydro contracts for Madawaska Mines Limited. In June, Ontario Hydro decided to contract uranium from Saskatchewan and

Elliot Lake. The Bancroft miners responded by picketing the Ontario Legislature. Maloney met with Premier Davis again and presented him with a brief outlining the economic multiplier effects of the jobs lost with Madawaska's closure. In July, the Employment Bridging Program was announced: a voluntary labour intensive program for the mine workers which was jointly funded by the federal and the provincial governments (*Bancroft Times* 07/15/81).

The mill ceased operation in July 1982, when AGIP canceled the balance of its contract after only 3.3 million lb. of concentrates had been delivered (Alexander, Madawaska 391). The company was not able to find another customer for its uranium due to the oversupply of uranium on the world market (Alexander, Madawaska 404; MNDM Assessment Files). Refer to Tables 11 and 12 for Faraday / Madawaska production and employment figures.

Table 11: Faraday Mine Employment

Year	Average Number	Number on Surface	Number Underground
1956	127	71	56
1957	399	200	199
1958	501	215	286
1959	507	203	304
1960	n/a	n/a	n/a
1961	316	148	168
1962	232	128	104
1963	260	110	150
1964	145	66	79

Source Ontario Department of Mine Annual Reports 1956 -1964

Table 12: Faraday / Madawaska Mine Production 1957 - 1982

Year	Gross Production	Ore milled in tons (Tonnes)	Tons Treated / day(Tonnes)	Uranium Concentrates in pounds (kg)
1957	$4,071,993	280,668 (254,566)	1,160 (1,052)	399,428 (153,626)
1958	$7,699,964	491,826 (446,086)	1,347 (1,221)	836,770 (321,834)
1959	$9,362,472	537,594 (487,598)	1473 (1,336)	917,285 (352,802)
1960	$8,579,134	468,939 (441,654)	1,282 (1,163)	841,917 (323,814)
1961	$7,980,867	339,659 (308,070)	931 (844)	784,565 (301,756)
1962	$7,336,320	306,339 (277,849)	839 (761)	779,789 (299,919)
1963	$4,460,486	355,039 (322,020)	973 (882)	780,382 (300,146)
1964	$2,234,890	none		390,814 (150,313)
1966	$3,746			624 (240)
1977		295,068 (267,627)		440,753 (169,520)
1978		375,533 (340,608)		546,998 (210,384)
1979		390,366 (354,062)		605,533 (232,512)
1980		397,065 (360,138)		610,792 (234,920)
1981		353,172 (320,327)	1,360 (1,233)	668,080 (256,954)
1982				396,270 (152,411)
Totals				9,000,000 (3,461,538)

Sources: Griffith 226: SMDR 000247: EMR Canadian Minerals Yearbook 1977-82

6.0 *Settlement Patterns: The Improvement District of Bicroft*

Special Improvement Districts were established by the provincial government in areas where there was only one major property taxpayer (McColl 1995). Improvement Districts were first authorized in 1943, as a form of local government to meet the requirements of "...rapidly developing areas such as mining or pulp based communities which have not had any existing community around which to establish municipal institutions" (Ontario Municipal Management Institute, 16). In the case of the Haliburton County uranium mines, the major taxpayers in Cardiff Township were the Canadian Dyno Mine Limited

and the Bicroft Uranium Mine Limited. The Cardiff townsite was established in 1953 and a portion of the Township of Cardiff became the Improvement District of Bicroft in 1956 (McColl). This Improvement District encompassed the townsite of Cardiff. the Bicroft Heights. the Dyno Estates as well as the mine sites and the properties of the Bicroft and the Dyno mines. In contrast to the elected membership of a township council, the Special Improvement District was comprised a board of three trustees: a Chair, a Vice Chair and one member. who were appointed by the province. These appointments were for an indefinite period. ending only with resignation. death or dismissal by the province. The manager of the Canadian Dyno Mine. P. S. Cross. sat on the first board of the Improvement District (Cross 17). The only mention of the Improvement District encountered in the Bicroft Mine documentation follows: "Operation of the new compact Improvement District proved much more satisfactory to all concerned than the previous arrangement whereby the identification embraced a whole settled township"(*Fourth Annual Report of the Bicroft Mines Limited*).

When the mines closed. the Improvement District of Bicroft was replaced by the Bicroft Special Improvement District in 1962 (Figure 2). Outstanding debts for the Cardiff school. water and sewer held by the mining companies were paid off by the province (McColl). On December 1. 1982. the Bicroft Special Improvement District was replaced by the Township of Bicroft and the usual practice of representation by election resumed.

6.1 *Cardiff and the Bicroft Heights*

During the construction phase of the Bicroft mine, the workers were housed mainly on the site. In his overview of the uranium industry in Canada, Griffith describes the housing situation during this phase of operation:

> Most Canadian Mining men who have established new operations since World War Two have found that to maintain reasonable efficiency they must provide housing for staff and a large percentage of skilled hourly personnel. The Bancroft area, despite its many advantages over a "bush" location, was no exception. The initial problem at Bancroft was housing for the temporary construction workers and the mine crew. At their peak these numbered 1,000, about 600 of whom were accommodated at the property. Besides a cookery, two permanent bunkhouses were provided, each holding 69 men. The rest of the men were lodged in tents and improvised quarters, the latter consisting mainly of a shell that later became a permanent recreation building

> and curling rink. This building accommodated 180 men. The management felt it desirable to consider these facilities in the early stages in preference to spending the money on temporary bunkhouses that would later be of no use or value. The need for bunkhouse accommodation declined rapidly after the construction period, and in 1958 all bunkhouses were closed (217).

The *Annual Report* for the Ontario Department of Mines for 1956 (142) indicates that a public townsite for the workers of the Bicroft Mine and the Dyno Mine was laid out by departments of the Provincial government, while LeBourdais refers to an arrangement reached by the mining companies and the Ontario Department of Planning and Development (136). Griffith (217) states that the original plan for the townsite called for 100 houses, while the O.D.M. annual report cites 150 houses. This report states that the company made the arrangements for the construction of 150 units for rental to employees. As well, five additional houses were constructed for a total of seventeen at the staff townsite, Bicroft Heights. The construction of a five-room school was undertaken and a new branch highway of three miles in length was built to connect the mine site to Highway 28. The O.D.M. *Annual Report* for the following year states that the 150 bungalows at the Cardiff townsite were completed but that the company had to assume responsibility for sewer and water services at the townsite. The *eight*-room school was completed and filled to capacity (148). The *Fourth Annual Report for Bicroft Mines Limited* states that the public school was enlarged to eleven rooms and the townsite expanded to two hundred houses: fifty for the Dyno Mine and one hundred and fifty for the Bicroft Mine. At this time, the houses were rented to the miners by the companies for $75.00 per month and they were filled beyond capacity (Stevenson 22); if a worker changed employers he was required to move to a house owned by the new employer (Lyons 65). As well, the *Fourth Annual Report for Bicroft Mines Limited* states that the commercial development of the townsite was restricted by "unrealistic controls and lack of zoning in adjacent areas"(7), resulting in the establishment of businesses in the unserviced fringe areas of the townsite. Finally, the conversion of one of the bunkhouses to apartments was mentioned. A swimming pool was constructed in 1958 with materials donated by the mines and volunteer labour from the miners. Two churches were built: the Catholic church in 1958 and the United church in 1960. A branch of the Royal Canadian Legion was also established because many of the Bicroft miners had fought in the Royal Canadian Engineers during World War Two with the mine manager, Captain John Thompson (Rabb 1995).

Griffith summarizes the accommodation for the workers at the Bicroft and Dyno mines by stating that the 150 worker houses at Cardiff and seventeen staff houses at the Bicroft Heights provided room for approximately 275 employees. Griffith concludes:

> About 160 employees looked after their own accommodation, largely by buying or renting existing houses or winterizing summer cottages or, to a lesser extent, by building their own homes. Cottages absorbed the majority, some tourist camps renting on a year-round basis. Trailers played a negligible part as far as the company was concerned. Had the mine not been in an old, established summer-tourist area, additional housing, trailer parks or bunkhouse accommodation would have been necessary (217).

Current residents of Cardiff and the Bicroft Heights, whose spouses were employed directly or indirectly by the Bicroft Mine, remember their early days in the area. Eleanor Rabb, whose husband was a diamond driller, recalled that the townsite initially had no plumbing and water was brought in a pump truck from the mine on a daily basis. Her husband's first task was to drill the well for the townsite. Dorothy Amm, whose husband was the purchasing agent for the Bicroft mine, observed that there was never a dull moment in those days; the community was close knit and the mine provided a recreation centre and curling rink where there was "something going on all the time for us". Muriel Penton, whose husband was a sign maker, concurred that the community felt well cared for by the mining company and when the mine shut-down occurred they did not hold Bicroft Uranium Mines Limited responsible. It was the Prime Minister of the era whom these women hold responsible for the closure of the mines: "We thought the mines would be there twenty-five years and it was Diefenbaker that closed us all down" (Penton 1995).

Although rumors circulated in the wake of the Bicroft closure that the townsite was to be bulldozed or the houses sold off for $1000 each for scrap, the residents of Cardiff knew that fifty of the houses had already been sold off by the Dyno Mine. Only a few of the miners actually bought their house when given the opportunity. Most moved out of the area to find employment opportunities in other mining camps.

Carson-Brown (15) states that there was no difficulty disposing of this housing in the wake of the mining activity: "This pleasant area was deemed so suitable for the quiet life that the provincial

government and the mining companies concerned had little trouble in selling every house in the community as a home for people of retirement age." According to the Clerk of the Township of Bicroft, Sandra McColl, the Cardiff townsite bungalows were advertised in the Toronto Star as a retirement community; potential buyers were enticed by the offer of a maple rocking chair or an airplane ride over Paudash Lake with the purchase of one of the three styles of bungalows priced at $4500.00.

The Greatest Real Estate Sale of the Century was the idea of two young real estate agents from Peterborough, John Bowes and William Cocks, who gained permission from the Canadian Mortgage and Housing Corporation to sell off the houses on long-term mortgages, in order to recoup a portion of its $3 million investment. The sale was held on May 9, 1964, with a sales pitch that touted Cardiff as Canada's first retirement community set in a pristine woodland. Two- and three-bedroom bungalows with full basements that had cost $11,000 to construct in 1956 were offered for $4,250 and $4,500 respectively. The terms were ten percent down and $50 per month mortgage payments for twenty years. The payments included complete sewer and water and electrical services. Although the uninhabited houses were suffering from lack of maintenance they were structurally sound; thirty-nine houses were sold the first day and the balance were purchased within two months (Stevenson 22).

6.2 *Dyno and the Dyno Estates*

There is no explicit mention of the development of the Dyno Estates in the Ontario Department of Mines Annual Reports for the time period of the mines' development and operation. However, the fifteen bungalows that comprise the Dyno Estates were constructed for the Dyno mine staff, much like the Bicroft Heights were for the staff of the Bicroft mine (McColl 1995). The *Final Report of the Canadian Dyno Mines Limited* summarizes the development of the Dyno Estates:

> Early in the summer of 1956 a small fifteen acre tract of land was purchased on the Cheddar road near Highway 28, approximately 2½ miles south of the mine, for a Staff Townsite location. At that time 12 houses were constructed for senior operating personnel who were on 24 hour call. In 1957 three additional houses were added to the townsite. The townsite was completely serviced with a central water supply system, sewage disposal system and rural hydro (17).

The Dyno complement of fifty houses at Cardiff were sold off when the mine closed in 1960. They were sold by a Peterborough realtor for $4,250 and $4,500 for the two- and three-bedroom models (Hambleton, 1960).

The Ontario Department of Mines Annual Reports summarize the development of residential and recreational facilities for the Dyno miners on the actual mine site. The *Annual Report* for 1956 mentions the construction of several permanent buildings including a ten-man staff house, a change house (or dry), a 150-man bunkhouse and a cookery / cafeteria (Figure 8) (ODM, 1956 143; Cross 3). These facilities were described in more detail in a feature article in the *Western Miner & Oil Review*:

> The cookery is a two-storey building, divided into dining room, commissary, kitchen, bakery, food storage, cloakroom, refrigeration, and potato peeling rooms; the upper storey into nine, two-man bed-rooms, a washroom, and a sitting room. This upper storey houses the cookery staff. The dining room is designed to feed 124 persons at one sitting. Cooking is done by propane ranges except the bake ovens which are electric.
> The bunkhouse, a two-storey building, is in the form of an H. It consists of 74 two-man bedrooms, the necessary washroom, toilet, and shower facilities, and three lounges.
> The staff house is a single-storey building and is divided into four two-man bedrooms, a two-man guest bedroom, lounge room, kitchen and bathroom. (Pancer 94).

Figure 8: The Canadian Dyno Mine Camp Buildings

Source: Pancer*et al.* 87.

The *Annual Report* for 1957 mentions the construction of buildings relating only to mine operations (148). The *Annual Report* for 1958 makes note of the construction of a recreation hall on the property (112) while the company's final report mentions the construction of a baseball field (Cross 3). With the closure of the Dyno mine in 1960, the buildings were sold and presumably moved from the property (ODM A.R., 1962 122).

At the Faraday Mine, eleven residences were constructed for the mine staff and their families adjacent to Bow Lake. According to LeBourdais, a settlement of fifty-five houses was constructed on a parcel of land near Bancroft. The land was purchased by the company and was subsequently annexed to the village. The village provided services, for which it was compensated through taxes paid by the company (134).

7.0 *Conclusion*

It is evident that the patterns of economic development and settlement of the Bancroft area have been shaped by the phases of resource extraction and their impacts on infrastructure development such as mills, roads, railways and housing. Initial resource extraction focused on timber, and the York River provided early transportation and hydro power. The discovery of gold in Eldorado and iron mine development in Coe Hill and Bessemer led to the extension of rail transport to the area. Subsequent mining of corundum and marble made use of the railways. Depression-era relief work to improve the colonization roads established the highway system which enhanced the area's development as a summer tourist resort and cottage destination.

The uranium boom in the Bancroft area, which was preceded by radium-related exploration and development in the 1920s, 1930s, and 1940s, was influenced by the existing transportation and settlement infrastructure. Arthur Shore's early work on the Faraday mine property, in the late 1940s and early 1950s, was not sufficient to merit financing for mine development, since the pegmatite uranium mineralizations were not considered to be commercially viable at that time. The staking rush that was precipitated by the development work on the Bicroft Mine property and the results of an airborne scintillometer survey, resulted in the establishment of the four mines, because Eldorado Mining and

Refining Limited decided to award special price contracts to the marginal pegmatite occurrences, due in part to the Bancroft area's proximity to Canada's industrial heartland and the availability of good road and rail transport. In the end, the Bancroft uranium camp gave way to the richer ore bodies of Elliot Lake and Northern Saskatchewan.

Present-day Bancroft, in the wake of the uranium mining era, has been left with "new" highways, settlements, churches and schools, as well as four low level-radioactive waste sites. The vegetation, rocks and scenery of the region now provide the foundation for a tourism-based economy that capitalizes on the scenery as well as Bancroft's image as the " Mineral Capital of Canada".

It is important to consider the Bancroft area and the uranium boom as an early example of, or a metaphor for, globalization. Marcia Nozick defines economic globalization as "the replacement of local markets with global markets" (No Place 3), which results in a community becoming marginalized and "dependent upon imports and powers outside of their control"(6). The rise and decline of the uranium industry in the Bancroft area fits this phenomenon, with a uranium market created by federal government policies and three decades of coexistence adjacent to the mine wastes of the abandoned Bicroft and Canadian Dyno mines.

The uranium mining and milling industry of the Bancroft area was not brought into existence as a local initiative to develop a product in response to the local market. Rather, the motivation for uranium prospecting and for the development of the mines was provided by the price guarantees and special price contracts developed by the federal government's Crown company, Eldorado Mining and Refining Limited, in response to the U.S. government's demand for uranium with which to make nuclear weapons. The market forces that provided the impetus for the development of this industry were choreographed by the politics of the cold war and the close relationship between the Canadian and U.S. governments. American military policy and the subsequent contracts with Eldorado created a market that was very secure for a very short time, a market that otherwise would not have existed.

The utter dependence of this industry on these external forces is evident in the creation of the four mines, Bicroft, Dyno, Faraday and Greyhawk, based upon the receipt of a special price contract or a

letter of intent from Eldorado Mining and Refining Limited, which allowed them to secure financing from the private banking sector. Secondly, the demise of the local industry at the onset of the 1960s was dictated by the end of the U.S. demand for foreign uranium. There was no local control over this situation; in spite of the lobbying efforts of the Bancroft and District Chamber of Commerce, led by the well connected Father Maloney, there were no long term market guarantees to ensure the continued operation of the mines. The federal government's stretch-out program extended the delivery period for contracted uranium for a few years, but there was no customer available to fill the market vacated by the American military. Two of the three remaining mines closed permanently at this time. The Faraday mine reopened as the Madawaska mine for several years in the late 1970s and early 1980s.

By the end of the 1960s, the market for uranium was, in part, driven by the production of electricity using uranium fueled-nuclear reactors. The Bancroft area mines were not party to this new market although, from 1979 until 1982, Madawaska Mining and Refining Limited did supply AGIP of Italy with fuel for its nuclear reactor program. This is another example of an industry created and controlled by federal and provincial governments. The health of Canada's uranium industry continues to be determined by the strength of sales to countries with domestic reactor programs.

Nozick also outlines the negative consequences of the process of globalization (No Place 7). The first of these, *economic deindustrialization*, is illustrated in this case by the shut-down of the mines and the loss of this employment, however fleeting the jobs may have been, as well as the loss of the economic multiplier effects to the local economy. The second consequence, *environmental degradation of crisis proportion*, is demonstrated by the abandoned mines and their legacy of low-level radioactive wastes. The local economy benefited from a decade of uranium mining but it is the local community that is left with the toxic inheritance of the mines' wastes. The third consequence, *loss of control over our communities*, is evident in the ten years of activism on the part of local groups such as the Bancroft and District Action Committee and the Paudash Lake Conservation Association. Such groups have persisted in resolving the issue of the decommissioning of the abandoned Bicroft and Canadian Dyno mines within a vacuum of government jurisdictional responsibility.

The uranium industry was created specifically by and for national governments. The Bancroft area mines were products of external demands for uranium to supply the American military, and to a lesser extent the United Kingdom Atomic Energy Authority. The local community exerted no influence in the face of the U.S. market decline which resulted in the closure of the mines. The Bicroft and the Dyno mining companies were able to abandon the mine sites without any measures for the safe disposal and maintenance of the mine wastes. The local community has had no control over the maintenance of these wastes and it has taken a decade of effort by concerned citizens to begin to accomplish the remedial decommissioning of these sites.

Chapter Three *Uranium Mine Decommissioning and Remedial Work in the Bancroft Area*

This chapter describes uranium mine and mill waste disposal and presents the regulatory framework for the management of uranium mining and mill wastes in Canada. The decommissioning of the Madawaska Mine is presented as a case study of the decommissioning of a uranium mine in Central Ontario. As well, the remedial work undertaken in recent years on the abandoned Bicroft and Dyno mines is described and compared to a case study of the decommissioning process of the Madawaska Mine. The scientific study of the abandoned tailings and the widespread disposal of mine waste rock are noted. Community activism associated both with the disposal of radium-contaminated soil and the two abandoned mines is included to illustrate the influence of these events on the evolution of the low-level radioactive waste disposal situation in the Bancroft area, which has evolved to include public consultation and the inclusion of the public's expressed concerns in actions undertaken by the AECB and the owners of the mine sites.

1.0 *Uranium Mine and Mill Waste Disposal*

In general, there are six stages of activity in mining: exploration, development, extraction, beneficiation (milling), refining, and decommissioning. In the exploration phase, after the initial identification of a mineral through surface and airborne geophysical exploration, orebodies are defined through stripping, trenching and diamond drilling. Mine development includes feasibility studies, mine and mill design and construction, waste management design and, in recent years, environmental impact analysis. Extraction techniques are divided primarily between surface mining (open pit, strip mining) and underground mining. Underground mining techniques are divided between open stoping and filled stoping. Filled stoping refers to backfilling mined out areas with waste rock or mill tailings. The extraction phase produces large volumes of waste rock which have implications for both atmospheric and hydrospheric emissions of toxic elements and radionuclides. These emissions require abatement procedures through the containment and treatment of mine water in settling ponds and wind erosion

control and dust collectors to minimize airborne contaminants from waste rock and tailings (Ripley *et al.* 22).

Beneficiation, or milling, is the treatment of ore to remove the unwanted components and to increase the concentration of the desired mineral. There are three basic steps in the milling process (Ripley *et a.l* 25). Crushing and grinding break up the ore into particles. Concentration separates the desired mineral from the other components of the ore. Uranium mills in Bancroft used a weak acid leaching process to concentrate the ore into magnesium diurinate, called yellowcake. The residues from the concentration, known as gangue, are discarded. The final stage of milling is the dewatering of the concentrate. The concentrate is purified using ion exchange, chemical precipitation, drying and packaging (Griffith 239). The waste products from the milling process are known as tailings and their initial treatment involves the addition of lime and the use of settling ponds.

The next stage of mining activity is refining. In Canada, yellowcake is refined at Blind River Ontario into uranium trioxide. Conversion of this compound into uranium dioxide or uranium hexafluoride occurs at Port Hope, Ontario. Uranium dioxide is used in Candu reactors and uranium hexafluoride is used in foreign light water reactors (Ripley *et al.* 205).

The final stage of mining, decommissioning, occurs when the mine ceases to operate due to depletion of orebodies or changes in the market. Historically, when a mine was closed down it was abandoned and there was no waste management beyond the initial application of lime to the tailings. In short, after salvaging transportable equipment and machinery, the entire operation was demolished or even left standing. These practices are no longer accepted. Decommissioning now requires that the mine workings are returned to an acceptable state, including the mitigation of impacts on adjacent surface water and groundwater, humans, and wildlife. According to Ripley *et al.*: "This stage of mining is still in its infancy" (47). Indeed, for uranium mines, decommissioning has been a requirement only since 1977: mines closing prior to this date are classed as abandoned mines and thus are not subject to the present decommission procedures regulated by the AECB.

1.1 *Environmental Considerations for Decommissioning*

The average Canadian metal mine disposes of 42% of the total material mined as waste rock: 52% of the total material mined becomes mill tailings. 4% becomes slag and the remaining 2% represents the value for which the deposit is mined (Ripley *et al.* 9). Uranium mining involves the extraction and processing of radioactive materials that can be harmful in the short term and in the long term to humans and to other organisms. According to Kalin (Radionuclide 1), only 15% of the total radioactivity of the ore is extracted through the production of yellowcake: the balance of 85% remains in the tailings and waste rock. This residual radioactivity can be further subdivided into 15% short-lived and 85% long-lived radionuclides. The aim of the decommissioning of mine waste management systems is to prevent the radioactive and toxic components of the tailings and the mine water from making contact with adjacent land, water, air, and organisms.

The main radionuclides in the uranium decay chain include Radium 226, and Thorium and their decay products, or progeny. The most dangerous of these progeny are Lead 210, Polonium 210 and Thorium 230 as well as Radon gas which is an early decay product of Radium 226. The Radon progeny contained in Radon gas represent hazards through inhalation (Ripley *et al.* 207). In addition to radionuclides, the mine wastes can contain non-radioactive elements such as iron, lead, arsenic, copper, manganese, magnesium, rare earths, nickel, iron, vanadium and molybdenum (Ripley *et al.* 211). These substances can be transported by air or by water. Therefore the objective of decommissioning is containment to prevent such movement through leaching, exhalation or wind erosion. Containment is achieved through the use of a permanent cover of water or of soil on the tailings. A soil cover of 30 cm will reduce radon emissions to background levels (209). As well, soil cover on the tailings can reduce surface gamma radiation to background levels (212). In addition to the use of a cover, ground water and surface water access to the tailings is minimized through the use of diversion channels and more recently, natural and synthetic liners for tailings basins and dams (211). The surface of the tailings cover is additionally stabilized through revegetation, both natural and planted. Radon can be released through plant leaves. Therefore the most appropriate choice of plants for revegetation are those with shallow roots

and small leaves. such as the conifer. red pine (*pinus resinosa*). that are not attractive browse for herbivores. in order to minimize food chain transfer of radionuclides (216).

In addition to containment. it is necessary to monitor the tailings management areas in order to assess their long-term stability due to the relatively long half-life of elements such as Radium 226 (1600 years). Containment failure over a minimum period of centuries will result in the release of these materials into the surrounding area. Ripley *et al.* cite the National Uranium Tailings Program which was established in the mid-1980s to assess the long-term risks of uranium tailings:

> A monitoring program directed specifically at existing uranium mine wastes... identified the principal environmental concerns as surface water runoff from tailings impoundments: seepage from tailings into surface watercourses: exfiltration of porewater from tailings into ground water. wind erosion from tailings material: and radon exhalation from tailings (218).

A monitoring program has four main components. rehabilitation monitoring. aquatic monitoring. atmospheric monitoring. and biotic monitoring. Rehabilitation monitoring is focused on the physical integrity of the tailings impoundment structures. erosion control. and revegetation. The physical. chemical. and radiological characteristics of the tailings are monitored and the impoundment structures are visually inspected through the use of ground surveys or aerial photographs (Beak. Cost 5.1). Aquatic monitoring is concerned with leachate transfer to ground and surface waters and thus requires regular lab analysis of samples from test wells and surface waters. Atmospheric monitoring for radon and wind-borne particulates involves the use of monitoring stations with instrumentation to measure quantities of wind-blown particles and concentrations of atmospheric radon. Biotic monitoring assesses the bioaccumulation of radionuclides and other elements from aquatic. terrestrial. and atmospheric pathways through the use of lab analysis of floral and faunal samples (5.1). An example of biotic monitoring is the use of mosses and lichens. which are used as indicators of air contamination because they absorb atmospheric fallout rather than substances from soil (Ripley *et al.* 218).

Decommissioning programs are intended to restore a mine site. including the quality of downstream water. to a state that resembles. as closely as possible. its original state (Ripley *et al.* 219). In Canada. after the completion of a successful monitoring period. in which the site has demonstrated the

integrity and the stability of its impoundment measures. the site and responsibility for long-term monitoring reverts to the Crown (Beak Cost i).

2.0 The Atomic Energy Control Board and Regulation of the Uranium Industry

The Atomic Energy Control Board (AECB) was established in 1946 with the passage of the Atomic Energy Control Act. "To make provision for the control and supervision of the development. application and use of atomic energy and to enable Canada to participate effectively in measures of international control of atomic energy" (AECB. Control 4). The broad powers of the AECB were modified in 1954. with amendments to the AEC Act that established Atomic Energy of Canada Limited and empowered it and the Crown agent. Eldorado Mining and Refining Limited. with control of commercial exploitation and atomic research. while the AECB remained as the regulator of the uranium industry.

Uranium mining is regulated by the AECB as part of the nuclear fuel cycle. The AECB administers the mining. milling. and refining of uranium within a joint regulatory framework that includes consultation with Environment Canada. Transport Canada. National Health and Welfare and provincial ministries such as Natural Resources. Health. Environment and Labour.

In contrast to the rigid procedural practices of other uranium-producing countries. such as the United States. the AECB uses a licencing system that requires applicants who wish to mine. refine. process. export or use prescribed substances such as uranium. thorium. or deuterium to submit a detailed proposal to prove that they can meet Canadian health and safety standards. This approach has developed over time. as the industry itself has evolved. and it allows for site- and situation-specific flexibility. In addition to this review process. the AECB inspects and monitors all licencees to ensure that the conditions of their licence are met.

The AECB regulates the uranium mining industry through the issue of Mining Facility Operating Licences and Mining Facility Decommissioning Licences. The Directorate of Fuel Cycle and

Materials Regulation oversees this system of licencing while the Uranium Mines Division addresses all aspects of uranium mining, including tailings management, and the Compliance Division serves as the inspection agency. It has only been since 1977 that the AECB has assumed jurisdictional authority for the decommissioning of uranium mines, at the time of the establishment of the Compliance Division.

The decommissioning of uranium mines is presently determined by three main AECB policies: the *Uranium and Thorium Mining Regulations Document C-36*, the *Policy on the Decommissioning of Nuclear Facilities, Regulatory Document R-90*, and the *Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes - Long Term Aspects, Regulatory Document R-104*.

The *Uranium and Thorium Mining Regulations Document C-36* states the licencing requirements for all aspects of uranium mining operations, including decommissioning. With regard to decommissioning, *Consultative Document C-36* presents the requirements for the licencee's submission of an application to decommission. These requirements include the estimated start date of decommissioning, the strategy for decommissioning, with a pathway analysis for releases of contaminants, and a description of the proposed environmental monitoring program (Section 2.6). As well, the requirements of the licensee's annual report are outlined to include the submission, on March 31 of each year, of a summary of decommissioning activities for the preceding calendar year, including:

a) a list of the sales and distribution of salvaged equipment
b) a description of activities undertaken and an assessment of their effectiveness; and
c) a summary and analysis of monitoring information (2.6).

With regard to abandonment, *Consultative Document C-36* states that the AECB's written approval to abandon occurs only when the Board is "satisfied that the licensee has successfully decommissioned the mining facility in accordance with the terms and conditions of the licence to decommission" (2.7). The AECB's decision to grant such an approval is based on its assessment of the decommissioning measures and the performance of the site relative to the environmental monitoring program.

The *Policy on the Decommissioning of Nuclear Facilities, Regulatory Document R-90* describes the AECB policy for uranium mine and mill decommissioning. The term, *nuclear facilities*, includes uranium mines, mills and refineries as well as research reactors, nuclear generating stations and heavy water production facilities. In short, these regulations prohibit a licencee from abandoning its operation, "except in accordance with the written instructions of the AECB" (Section 2). This policy is summarized as follows:

> The AECB requires that all nuclear facilities be decommissioned satisfactorily in the interests of health, safety, security and protection of the environment, according to plans approved by the AECB. Such plans shall be developed during the early stage of design of the nuclear facility and refined during the operating life of the facility and the associated decommissioning actions assured by adequate financial planning (Section 3).

The policy outlines the regulatory requirements for a detailed decommissioning proposal to be submitted within six months of the permanent cessation of mine and mill operations (Section 4). These requirements include timelines, estimated inventories of radioactive substances and radiation levels associated with the facility. As well, they include descriptions of disposal and or storage procedures and measures to address concerns related to health and safety and environmental protection; and predictions of environmental impacts of proposed decommissioning activities and controls to mitigate these impacts (Section 4.2).

This regulatory document emphasizes the use of decommissioning controls that do not require long-term human intervention:

> In general, reliance on institutional control mechanisms which involve active ongoing human intervention... to control the impacts from decommissioned facilities is not acceptable. However, more static institutional control mechanisms, such as land use controls subsequent to completion of decommissioning activities, may be acceptable (Section 4.4.1.).

With the approval of an operation's decommissioning proposal, the AECB issues a specific licence to decommission. The completion of the decommissioning program may be followed by a period of monitoring known as the transition phase: "During a transition phase, the licencee would be required to conduct a monitoring program to evaluate the impacts of the decommissioned site relative to the predicted performance" (Section 4.4.2.). The length of this phase is determined by the performance of the site

relative to expectations: five or more years may be required to assure the site's stability. With the successful completion of this phase, the AECB grants an approval to abandon the site. The approval to abandon removes any further responsibility from the operator for the site under AEC Regulations, but not from compliance with other federal, provincial or municipal laws or regulations.

Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes - Long Term Aspects, Regulatory Document R-104, which came into effect in 1987, describes the regulatory basis for the evaluation of radioactive waste disposal options within the existing regulatory framework. The basis of the regulation is radiation protection using the waste management strategies of containment and isolation from people and from the environment. The AECB derives its radiological dose limits from the limits recommended by the International Commission on Radiological Protection (ICRP) which is 1 millisievert (1 mSv) per year (Section 4.3.1.). The objectives of this regulatory document are to: "minimize any burden placed on future generations, protect the environment, [and] protect human health, taking into account social and economic factors" (Section 3). In order to achieve these objectives, a combination of "processes, barriers and institutional controls" (Section 3) is used to achieve isolation and containment. *Processes* refers to radioactive decay, adsorption, chemical precipitation, dilution, and dispersion where emphasis is on the transport of radionuclides. *Barriers* refers to the passive use of a site's natural geology with or without human-made barriers. *Institutional controls* refer to human activities intended to ensure that containment and isolation are ongoing. These activities include "monitoring and treatment of contaminated releases, the keeping of records and the imposition of land-use restrictions registered in property deeds and by-laws" (Section 3).

Regulatory Document R-104 states that the burden on future generations shall be minimized through the following considerations:

> a) selecting disposal options for radioactive wastes which to the extent reasonably achievable do not rely on long-term institutional controls as necessary safety features;
> b) implementing these disposal options at an appropriate time, technical, social and economic factors being taken into account; and
> c) ensuring that there are no predicted future risks to human health and the environment that would not currently be accepted (Section 4.1).

Consideration for the environment is acknowledged by the following: "Radioactive waste disposal options shall be implemented in a manner such that there are no predicted future impacts on the environment that would not be currently accepted and such that the future use of natural resources is not prevented by either radioactive or non-radioactive contaminants" (Section 4.2).

Included in *Regulatory Document R-104* are discussions of the predicted radiological risk which is defined as "the probability that a fatal cancer or serious genetic defect will occur to an individual or to his or her descendants" (Section 4.3.1.). and is limited to a maximum of one in a million in a year. which is associated with a dose of 0.05 mSv/yr. The use of the concept of a critical group in assessing dose limits is also presented. The critical group is a theoretical group of people that is expected to receive the greatest radiological exposure due to its location. age. habits. and diet. The critical group is used in pathway analysis to determine potential exposures in the long term (Section 5.1). The conceptual framework of the long term is presented within the context of a time scale of 10.000 years which is the generally recognized time frame for the next glaciation. With glaciation. the "near-surface wastes in Canada will be dispersed and diluted in the environment by the movement of ice sheets" (Section 5.3). *Document* R-104 concludes with discussion of the use of predictive modeling to calculate individual risks and the use of optimization studies to determine higher risk situations.

2.1 *Memorandum of Agreement*

On January 23. 1996. the most recent policy decision regarding the decommissioning and perpetual care of uranium mines in Ontario was finalized with the signing of a *Memorandum of Agreement* by the federal Minister of Natural Resources and the provincial Minister of Northern Development and Mines. The agreement applies to all uranium mines in the province of Ontario. including sites licensed by the AECB whose owners are bankrupt or insolvent. With regard to the decommissioning of uranium mines whose owner is bankrupt or insolvent and thus defaults on its obligation to decommission. Canada and Ontario each agree to pay 50% of the costs incurred undertaking decommissioning activities (Section 3.1). The same division of funding obligation applies to sites owned

by the Crown where the uranium producer is bankrupt or insolvent (3.2). With regard to the Rio Algom Stanleigh mine for which Ontario Hydro is obligated to provide funds for decommissioning, Canada agrees to pay 70% and the province 30% of the costs of all AECB approved decommissioning activities (3.3). The costs of perpetual care activities in the case of a bankrupt or insolvent owner shall also be divided evenly between Canada and Ontario. The province, however, will pay the labour costs for all monitoring activities (4.1).

The management and administration of the agreement will be accomplished by a Management Committee comprised of equal numbers of federal and provincial representatives reporting to the Deputy Ministers of Natural Resources and Northern Development and Mines (6). Finally, the agreement is intended to last for fifty years and may be renewed for another fifty years; it is to be reviewed every seven years (8.1, 8.2).

3.0 *The Decommissioning and Close-Out of the Madawaska Mine*

The decommissioning and close-out of the Madawaska Mine is presented as an example of the AECB regulated decommissioning process and its evolution from the onset of the decommissioning program to the present. The original items in the company's proposal were modified in response to site-specific conditions and influenced by community activism.

Madawaska Mines Limited (MML) ceased operation in June, 1982, several months after the buyer of its concentrates cancelled its contract. The AECB approved close-down in April, 1982 as part of Madawaska's Mining Facility Operating Licence, AECB MFOL 107-3. Close-down was to include suspension of operations and maintenance of the mine and mill facilities until a new contract was obtained or until the company decided to close permanently. MML assessed its market position and made the decision to decommission its property due to the development of high grade ore deposits in Saskatchewan. The company submitted a *Proposal for Decommissioning and Close-out of the Bancroft Property* to the AECB. The proposal and subsequent annual reports to the AECB were prepared by F. Clyde Lendrum Consulting Limited. The proposal presented the company's plan of action for close-out of

the property and reviewed the existing waste treatment and environmental monitoring programs. In its statement of intent, the company indicated that its decommissioning and close-out would not preclude reapplication for a Mining Facility Operating Licence should markets improve. A summary of the proposed decommissioning and close-out activities follows:

- Maintain adequate security to protect the company's physical assets.
- Monitor the sprinkler system in the mill from the mine residences.
- Complete the contouring of the No. 2 Tailings Area during 1983.
- Complete the grassing of the new berm on the north-east corner of the No. 1 Tailings Area.
- Cover the No. 1 Tailings Area with rock and / or gravel to allay dust and encourage encroachment of indigenous vegetation.
- Contour the north edge of the No. 1 Tailings Area to allow runoff from the area north of the tailings area to drain across the tailings area into the shallow pond. The contoured ditch will be rip-rapped to minimize erosion.
- Seepage from the west sump will be allowed to flow into the old septic tile bed.
- The decant tower from the No. 1 Tailings Area will drain into the gravel filter bed, by-passing the concrete settling basin.
- Monitor surface and ground water for Radium 226.
- ...Sell expendable stores and equipment which may deteriorate or become obsolete. All sales or donated material will meet the requirements of the AECB as to safe levels of radioactivity (MML, 1984 4).

The proposal included historical overviews of the company's mining, milling, waste management and environmental monitoring operations. Included is the overview of the older No. 2 Tailings area which was used by Faraday Uranium Mines Limited to contain neutralized tailings and mine water from 1957 until June, 1962. The tailings were placed in a rock depression adjacent to Highway 28 and the Bentley Creek channel was diverted from the tailings area to flow alongside the highway (MML, 1983 12). The impoundment occupies twenty acres (8 ha) with five- to eight-metre high dams and the tailings are a maximum of twelve metres in depth (MML 32). Due to the fact that Madawaska Mines Limited had not used the site for tailings disposal, the company planned no remedial work for the site but intended to monitor it (35). The No. 1 Tailings Area is located in another bedrock depression to the north of Tailings

Area No. 2 and it was used initially from 1962 until the first mine shut down in 1964. When the mine and mill were reactivated in 1976, the No. 1 Tailings Area became the location for tailings disposal. Additional containment measures undertaken in 1976 included the construction of a grout curtain alongside the No. 1 Tailings Area to prevent seepage into Bentley Lake, the recycling of overflow water from the active tailings area to the mill through a settling pond and containment of seepage on the west side of the active tailings area with a concrete wall (18).

The proposal also made note of the disposal of the Barium-Radium sulphate settling tank which collected the $Ba/RaSO_4$ produced during milling. The concrete tank was drilled with holes and filled with gravel and buried at a depth of four to six metres in the north-west corner of Tailings Area No. 1. Finally, the proposal noted the monitoring program for Ra 226 which made use of test wells and piezometer holes for ground water samples, while the Ministry of the Environment monitored the surface waters of Bentley Lake, Bentley Creek, and Bow Lake (MML, 1984 36).

The AECB issued Decommissioning Approval DA-139-0 on November 24, 1983 based upon this proposal document, which authorized the company to decommission its mine, mill, and waste management system and to prepare its property for abandonment. In correspondence accompanying the Decommissioning Approval, the AECB Directorate of Fuel Cycle and Materials Regulation emphasized that the approval authorized only those activities necessary for preparation for abandonment and that the company was obligated to comply with any applicable federal, provincial or municipal regulations or legislation. A five-year monitoring phase, extending to November 30, 1988 was indicated to follow the completion of decommissioning activities. Final approval to abandon was to be contingent upon the completion of this phase and the submission of documentation to summarize the "Performance of the facilities during this monitoring phase and any effects of this performance on predictions of future performance" (Smythe). Included as well, was a listing of the agencies to be consulted during the decommissioning and monitoring operations. This list was composed of employees of Environment Canada, Labour Canada, Ontario Ministry of the Environment, Ontario Ministry of Labour and Ontario Ministry of Natural Resources.

The approval document was divided into three sections. The General section referred to maximum permissible doses of ionizing radiation, the submission of annual reports on the progress of decommissioning activities and the monitoring program, staffing levels, contractors, compliance inspections and protocols for hazards or breaches of security. The Waste Management section outlined the requirements for containment of mine wastes and other materials, the environmental monitoring program and the submission of a detailed summary report in the fourth year of the monitoring phase. The Mine and Mill section related the requirements for the closure of the shafts, raises, adits and other surface openings. This section also contained requirements for the submission to the Ministry of Labour of a detailed surface plan, plans on both the horizontal and the vertical planes showing the mine workings, and a plan detailing the electrical apparatus and wiring. Finally, this section stated requirements for monitoring for radioactivity of any articles removed from the mine site, as well as the contents of the mill, until the mill was either decontaminated or demolished (AECB, 1983).

3.1 *Madawaska Mines Limited Annual Reports to the AECB 1984 to 1995*

Madawaska Mines Limited contracted F. Clyde Lendrum to submit annual reports to the AECB as required by the terms of the Decommissioning Approval. The original period required to complete the decommissioning process, including the original five-year monitoring period, was from November, 1983 until November, 1988. Each year, an annual report was presented with summaries of actions taken for decommissioning and close-out, including records of compliance inspections and meetings and relevant correspondence. In 1988, the Annual Report included a summary of all the activities undertaken to that time, in anticipation of an approval from the AECB to abandon the property. The request for approval to abandon was denied at that time, and to date (1996) has not been approved. Review of each of the main decommissioning activities from the Annual Reports 1984 through 1995 follows to illustrate the process and to provide some rationale regarding the items that prevented the scheduled abandonment of the property.

3.1.1 *Aquatic Monitoring*

The original parameters for aquatic monitoring were set out in Schedule B of the Decommissioning Approval AECB-DA-139-0. In 1984 and 1985, Madawaska Mines Limited tested the surface waters of Bentley Lake and Bow Lake, and the ground water of the property through a series of test wells and piezometers, all on a quarterly basis. The flow from the filter bed was tested monthly and the flow from the grout curtain was tested once. These tests included levels of Ammonia (NH_3), Radium 226 (Ra 226), Uranium, Iron, Total Dissolved Solids (TDS), pH and conductivity. The Ministry of the Environment also tested ground and surface waters for heavy metals. Since the Bancroft uranium ores are pegmatites with very small amounts of pyrite, ferric iron effluent was not significant and the AECB agreed to discontinue monitoring for Iron. Ammonia was not used in the mill process and thus, it as well, was eliminated from the aquatic monitoring program.

In 1986, water quality tests included Ra 226, uranium, pH, TDS and conductivity. Frequency of testing ranged from weekly, to monthly, to quarterly for surface waters and for ground water. At this time, the first diamond drill hole with an outflow was discovered on the north side of Bow Lake; this indicated that the mine was flooded. The water flowing from the drill hole had significantly higher levels of both Ra 226 and uranium and it was grouted, that is, plugged with cement.

In 1987, Schedule B was again amended to discontinue aquatic monitoring for pH and conductivity. Test sites and frequency of monitoring remained constant. Two more drill holes with outflow were discovered at Bow Lake. Water from both showed high Ra 226 and uranium levels and both were grouted immediately. In 1987, when the request to abandon made by Madawaska Mine Limited was denied, the AECB identified the need for a longer monitoring period to ensure that uranium levels in Bow Lake had stabilized.

3.1.2 *Pathway Analysis*

In 1987, Beak Consultants Limited was contracted by Madawaska Mines Limited to undertake a radionuclide pathway analysis on a hypothetical critical group to determine whether the decommissioning objectives of isolation and containment had been met. The critical group was defined, to:

> Live at the eastern end of Bow Lake; consume only water from Bow Lake; eat 1.7 lb. per person per week of fish from Bow Lake; live in poorly ventilated homes and remain in the house 80% of the time; the other 20% of the time would be spent on site except for two hours per week engaged in skiing or hiking on the tailing areas (MML, 1987 2-51).

Beak Consultants Limited concluded that the worst case scenario annual dose to a member of the critical group would be 1.9 mSv/yr. and that the actual dose to a non-critical group person would be 0.5 mSv/yr. (MML 2-58). The AECB was not satisfied with these conclusions and requested that the pathway analysis be reassessed to include persons living at Birchwood Drive, east of the No. 2 Tailings area, ingesting garden produce grown on the site and allowing children to play on the tailings area for more than two hours per week (Jack).

In 1988, water was tested only for Radium 226 and uranium, and the surface waters of Bentley Creek, above and below the tailings, were added to the test sites which included Bow Lake and Bentley Lake, the grout curtain, six test wells, two piezometers and the West Dike Seepage. Three more drill holes with outflow were found in Bow Lake, tested for uranium and grouted. From 1989 through to 1995, aquatic monitoring for Ra 226 and uranium remained consistent at the above sites, which were tested at monthly intervals. The Ministry of the Environment tested the sites for heavy metals in 1990 and again in 1993. Finally, the spring runoff across the No. 1 Tailings area was monitored for Ra 226, U, pH, TDS and conductivity from 1984 through 1995.

3.1.3 *Buildings and Equipment*

In 1984, there was an extensive sale of mining, milling and office equipment which was all tested for β activity below 100 kBq/m^2 prior to disposal. Several of the smaller surface structures were demolished and the underground entranceways were secured with concrete bulkheads. In 1985, half of

the mill complex was demolished and the timber frame was placed within the foundations and covered with fill. Four of the fifteen mine residences adjacent to Bow Lake were sold. In 1986, the remaining mill complex was demolished. The main adit was sealed with a bat hole left at the request of MNR. Eight more residences were sold and a ditch was placed across the access road to the property in order to provide a barrier to casual access. In 1987, the mill site and yards were graded and planted with red pine seedlings. More buildings were demolished and all remaining equipment was sold. In 1988, several sinkholes on the mill site were filled in and the remaining mine buildings were demolished. In 1994, the PCB storage building was demolished and the site covered with gravel. The PCBs were shipped to the Swan Hills, Alberta waste treatment facility.

In September, 1995, the firm Golder Associates was contracted to inspect the existing mine openings in order to "address final closure issues" (MML, 1995 3),and to "...assess the long term stability of existing mine openings for mine closure purposes" (Golder, Review 1). The inspection resulted in the identification of twenty-nine openings: two shafts, four adits, twenty-one raises and two stopes (3). Concrete caps or bulkheads were observed on twenty-four of the openings; two openings (the #6 stope raise and the #17 raise) lacked adequate caps; two openings (the #38 raise and A4W6 raise) were not located. Stope #5 was fenced and the #5 stope raise, the #45, #17 and #29 raises were located, excavated and capped. The bat hole in the #1 adit was reduced in size to prevent human access (4).

Golder Associates recommended fencing of the entire area containing near surface mine openings in order to restrict access in the event of future subsidence (cave-in) (8). It was also recommended that a geotechnical engineer inspect the site every three years to assess the integrity of surface opening caps, subsidence and fencing. Thinning of brush from fences was recommended to occur every six years and total fencing replacement every fifty years (9).

3.1.4 *The No. 1 Tailings Area*

In 1984, a rock and gravel cover, ranging in depth from thirty cm to forty-six cm, was laid down, contoured and planted with red pine seedlings. A spillway across the tailings was completed to channel

spring runoff. In 1985, more seedlings were planted and the spillway was rip-rapped to prevent erosion. In 1986, several sinkholes near the east tailings dam were filled in and more seedlings planted. In 1987, additional sinkholes were filled in and the AECB undertook a gamma survey along three transects. Most of the readings were below the target of 100 to 200 μR/hr except in some places, where sheet erosion of the gravel cover had occurred. In 1988, Madawaska Mines Limited considered the decommissioning of the No. 1 Tailings Area to be complete. In its denial of the company's request to abandon the site, the AECB referred to some locations on the tailings with high gamma activity and the incidence of sinkholes indicating ongoing stabilization (MML 1989 Appendix 2). In 1989, additional seedlings were planted on the site and the AECB and Ministry of Labour conducted a gamma survey which showed consistent readings below 100 μR/hr except in eroded locations. In 1990, Madawaska Mines Limited once again declared the decommissioning of the No. 1 Tailings Area to be complete and since that time there have been no documented anomalies.

3.1.5 *The No. 2 Tailings Area*

The No. 2 Tailings Area was used by Faraday Uranium Mines Limited for tailings disposal from 1957 until 1962; from 1962, until 1964, Faraday used the No. 1 Tailings Area. Due to the fact that Madawaska Mines Limited never used the No. 2 Tailings Area for disposal of its mill tailings, the company did not consider that area as part of its decommissioning responsibility. In 1984, the *Annual Report* referred to the thriving indigenous vegetation on the site and stated that no remedial work was planned for the site. However, correspondence from the AECB dated July 16, 1984, expressed concern for gamma radiation levels on some portions of the site. In 1985, MML did not undertake any remedial measures on the site. In 1986, the company had 3000 seedlings planted, filled in a dam slump, demolished the decant tower and filled in the resulting hole. The AECB undertook a gamma survey and concluded that no remedial measures were required. In 1987, Madawaska concluded in its *Annual Report*: "No. 2 Tailings Area has been stable for thirty years and is considered to have returned to the typical background levels of radiation for the area" (MML 1988 2-40). At that time, the AECB undertook a gamma survey along two transects and the readings of 800 to 900 μR/hr demonstrated minimal cover on

some parts of the tailings area. In 1988, with its refusal to grant approval to abandon the property, the AECB referred to locations on the tailings with high gamma readings and sinkholes indicating ongoing stabilization (MML 1989 Appendix 2). In 1989, MML resisted assuming responsibility for remedial work on Tailings Area No. 2, citing thirty years of growth of indigenous vegetation and placement of cover only on parts of the tailings area as requested by the AECB. In 1990, Madawaska agreed to undertake remedial work on the No 2 Tailings Area. This was contracted to Beak Consultants who removed existing vegetation and placed the cover in 1991. In 1993, red pine seedlings were planted on the site and no further work was planned.

3.1.6 *Compliance Inspections and Meetings*

During the initial years of the decommissioning process, regular compliance inspections were held on site at the Madawaska property during the spring, the summer and the autumn. In latter years, the regular compliance inspection has occurred annually in the spring. In 1995, no compliance inspections or meetings were held. Compliance inspections were attended by representatives from MML, AECB, and the various federal and provincial agencies listed in the Decommissioning Approval document, such as Environment Canada, Labour Canada and the Ontario Ministries of Labour, Environment, Natural Resources and Northern Development and Mines. The compliance inspections consisted of a walking tour of the property with visual inspection of the tailings impoundments. The compliance inspections were followed by a meeting, during which the annual report or a summary of decommissioning activities was reviewed and discussed, as were any items noted during the inspection. Included in the *Annual Reports* with the compliance inspection records, are the notes from the meetings recorded by MML representatives and AECB representatives. As well, included are copies of correspondence pertaining to items of concern raised during the inspections or the meetings. Examples of these concerns include the amendment of Schedule B of the Decommissioning Approval to eliminate iron and ammonia from aquatic testing and discussion of Madawaska's desire to have its decommissioning progress approved in progressive stages and the AECB response, that judgment would be reserved until the end of the five year monitoring phase (MML, 1984 Appendix A). Of note is correspondence from the

AECB. dated Nov. 15. 1988. confirming its decision to reject Madawaska's request to abandon (MML 1989 Appendix Two). The rationale for this decision included the need for a longer period of monitoring uranium levels in Bow Lake: high gamma readings on some portions of the tailings; the presence of sinkholes on the site indicating ongoing stabilization and deficiencies in the initial pathway analysis.

Compliance meeting notes and attached correspondence from 1994 illustrate the most recent context of the decommissioning of the MML property. Reference to an inspection occurring on June 2. 1994 indicated that "...all of the decommissioning activities on the site had been completed" (AECB Dec. 23. 1994) and that radiation measurements were consistently within the established criteria: the surface water samples tested below Ontario's drinking water standards: the structural integrity of the dams and containment berms of both tailings areas were sound. good vegetation growth had occurred throughout the site: no observed changes regarding the mine or mill workings had occurred. Compliance meeting items included discussion of the production of a summary report by MML. the establishment of long-term institutional controls. relicencing of part or of all of the site and a public meeting to review the long-term care options for the site.

A teleconference was held in November. 1994, with representatives from the AECB. MML and provincial agencies. to address the desire of Madawaska Mine Limited to de-licence or to reduce the licenced area of the property. As a result of this conference. the Ontario Ministry of Northern Development and Mines established a Provincial Technical Committee to review the decommissioning of the Bancroft area mines. including Dyno and Bicroft. The committee was composed of representatives from the ministries of Labour . Environment and Energy, Northern Development and Mines. and Natural Resources. After reviewing Madawaska's request to de-licence portions of its property in January. 1995. the committee recommended the following:

- The province would concur with the de-licencing of areas within the current project site that can be shown to have no radioactive hazards or mine workings.
- Areas containing tailings, ore. the mill. settling tank. sand filter or waste materials or that are underlain by hazardous mine workings should not be delicenced.

- The Province may support de-licencing of areas underlain by mine workings if those workings pose no danger of subsidence, movement or collapse.
- The Province would expect a summary decommission report to be provided which would state that all public safety and environmental hazards, land use conflicts have been properly addressed (March 1, 1995).

In 1996, the owner of the Madawaska Mine and the Dyno Mine, Conwest Explorations Limited, was purchased by the Alberta Energy Corporation. This new owner is divesting itself of its mining properties and thus is attempting to finalize negotiations with the province in order to de-license those portions of the property that do not contain tailings or underground mine workings. The newly de-licenced areas, such as Bow Lake, will subsequently become available for development. The final agreement between the province and the company will concern the long term institutional care of the remaining licenced areas. Monitoring of the ground and surface waters will occur annually; the tailings impoundments and spillways will be monitored and any remedial work will be contracted out locally (Cowan 1995).

The decommissioning of the Madawaska Mine can be observed and analyzed as a case study of the application of the AECB-regulated process as it responds to site-specific events and related activities in the community in which the facility is located. The decommissioning of the Madawaska Mine stands as an example of the AECB approach to decommissioning that is site-specific and situation-specific, in contrast to other uranium-producing countries, such as the United States, which use rigid procedures and rules to govern decommissioning. The approach of the AECB is illustrated by the following statement: "The Atomic Energy Control Board is responsible not for developing solutions to waste management, but for judging proposed solutions, and issuing licenses if and only if strict criteria are met" (AECB, 1986 31). With reference to the *Policy on the Decommissioning of Nuclear Facilities (R-90)*, this approach is provided with more detail:

> The decommissioning programs appropriate to specific nuclear facilities may vary greatly with facility type and, to a lesser extent, amongst facilities of a similar type. Decommissioning of individual facilities may be accomplished in continuous programs or over discrete, progressive or intermittent phases. It may thus include, with valid justification, periods of 'storage with surveillance'. Consequently, the time periods required to complete individual decommissioning programs will be facility specific, and may range from shortly after cessation of operations to several decades... (Sec. 2).

It is important to note that the decommissioning of the Madawaska Mine began in 1983, several years before the adoption of the *Uranium and Thorium Mining Regulations*, the *Policy on the Decommissioning of Nuclear Facilities*, and the *Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes - Long Term Aspects*, which presently regulate the decommissioning process. Madawaska Mines Limited began to operate in 1976, and to decommission in 1983. Thus there was no requirement for the company to plan its decommissioning activities in advance of close-down or to make financial provision for the decommissioning process. Perhaps if there had been some advance planning, many of the items that have delayed closure of the process, such as Tailings Area No. 2, the Bow Lake drill holes, and uncapped surface openings, could have been identified and considered at the outset of the process.

It may also be considered that Madawaska Mines Limited Decommissioning Approval was issued in 1983, only six years after the assumption of regulatory authority for decommissioning was assumed by the AECB. The AECB was, as a regulating body, learning on its feet, and not able to benefit from the experience of previously completed decommissioning processes to lend it a proactive approach to the Madawaska facility. As an example of the facility-specific nature of the AECB approach to regulation of decommissioning, one may observe the length of time expended for the decommissioning of the Madawaska Mine. At the outset of the process, a five-year monitoring phase was considered to be adequate. Due to unforeseen items such as sinkholes in the tailings areas, the Bow Lake drill holes, unacceptably high gamma readings on the tailings, and surface openings without adequate caps, the period for monitoring was extended from five years to at least thirteen years.

In the course of the decommissioning program, there were changes made to the environmental monitoring program that reflected the site- and situation-specific nature of the process. The amendments to aquatic monitoring, as dictated in Schedule B of AECB DA-139-0, included the deletion of tests for Ammonia and for Iron (1985), for pH and conductivity (1987), and the addition of Bentley Creek to the testing schedule in 1988. The conflict over the treatment of Tailings Area No. 2 stands as another

example of this situation-specific process and the evolution of decommissioning criteria. At the outset of decommissioning, Madawaska Mines Limited very explicitly indicated that it did not consider Tailings Area No. 2 to be part of the decommissioning program. The AECB did not immediately counter this position, but shortly before the end of the five-year monitoring phase, undertook a gamma survey of the tailings area that confirmed minimal cover of the tailings. These readings were used by the AECB in its requirement that MML decommission Tailings Area No. 2, prior to receiving permission to abandon. Although Madawaska Mines Limited initially resisted fulfilling this requirement, the company undertook remedial work on the tailings area in 1991. This conflict over the treatment of Tailings Area No. 2 was possibly the single most significant barrier to the scheduled abandonment in 1988.

Although Madawaska Mines Limited secured most surface openings in 1984, the inspection, inventory and remedial work on the surface openings (adits, raises and stopes) undertaken in the autumn of 1995 provides a final example of items required by MML late in the decommissioning process. The first oblique mention of this item in the Decommissioning documentation occurs in the recommendation of the Provincial Technical Committee in March of 1995, with regard to not de-licencing areas of the Madawaska property that are underlain by hazardous mine workings.

The ongoing decommissioning process of the Madawaska Mine has also been influenced directly and indirectly by events relating to the controlled and the casual disposal of mine waste rock in the Bancroft area from the late 1970s through to the present day. These events include the remedial measures for reduction of radioactivity undertaken by the firm James F. MacLaren Ltd. in 1979, as well as the community activism undertaken in response to the planned transport of radium-contaminated topsoil to the Madawaska Mine and the activism of the Paudash Lake Conservation Association with regard to the abandoned Bicroft and Dyno mines and the decommissioning of the Madawaska Mine. Included as well are vegetation studies and pathway analysis for the abandoned mines. Summaries of these items follow to illustrate their influence on public attitudes towards the uranium mining industry and *vice versa*, the profile of AECB within the community and the phases of community activism regarding mine wastes.

4.0 *The MacLaren Report*

The *Report on Investigation and Implementation of Remedial Measures for the Reduction of Radioactivity found in Bancroft Ontario and its Environs*, otherwise known as the MacLaren Report, was submitted by James F. MacLaren Limited to the Atomic Energy Control Board in 1979. This area was chosen for investigation due to its geology and because of its history of uranium mining (2-1). The study objective was the decontamination and control of radioactivity in the Bancroft area, and *environs* included the settlements that were established by the Bicroft and Dyno mining companies: Cardiff, Bicroft Heights, and the Dyno Estates. The study involved investigation of natural radioactivity from uranium-bearing minerals present in the bedrock and in glacial drift as well as cultural radioactivity resulting from uranium mining activities, specifically from the "uncontrolled spread of waste rock"(James F. MacLaren iii). Both of these factors caused elevated radiation levels in residential buildings in the study area. Study methods included the measurement of gaseous and particulate airborne radioactivity and ambient gamma radiation in order to determine the sources and the entryways for radon gas (1-2). Survey methods included the use of interior and exterior grid surveys for gamma readings, subsurface inspection with boreholes to test soil fill and bedrock, potable water tests and interior and exterior air sampling for radon and radon daughters (4-3,7,9).

From the 412 sites that required investigation, a sample of 129 was chosen for detailed radiological examination. Of this sample, twenty-six sites were in Cardiff, ten sites were in Bicroft Heights and seven sites were at the Dyno Estates. The detailed examination identified the source and the nature of contamination, determined the number of sites requiring remediation and the appropriate remedial techniques, prioritized the sites and estimated the associated costs (james F. MacLaren 4-1). Of the sample of 129 sites, fifty-five or 43% required remedial work (6-2). Based upon this result, it was projected that 109 sites in the entire identified group of 412 would require remediation. The budget for the study and the remedial work was $1.2 million with $673,000.00 set aside for the remedial work (iii). Based upon these figures, the cost of remedial work on 109 sites would have been an average of $6,174.00 per site.

In the description of the area's mining history, the mining settlements were emphasized: "These mining companies provided housing for their personnel and new communities such as Cardiff, Bicroft Heights, Dyno Estates ... were developed in this area. These developments naturally, but unfortunately, were located close to the mining activity in areas prone to uranium mineralization" (James F. MacLaren 2-3). The Bicroft Heights was described as underlain by marble with the nearest potentially radioactive rock, a pegmatite dike, located 200 m from the houses. The village of Cardiff is underlain by marble with no known radioactive deposits within 2.5 km of the site. The Dyno Estates are located within 1.5 km of the Cheddar Batholith and therefore within an area that favours the existence of uranium deposits (2-9). In addition to the geology and proximity to uranium deposits, the impact of cultural activities was emphasized:

> The most common source of this material has been rock produced in the development of shafts, drifts, etc., to gain access to ore bodies. Often included in this waste rock is ore of too low a grade to process. The segregation of ore from waste mine rock was usually lax until an electronic separation technique was developed around 1959-60. In the early stages, the Bicroft Mine waste rock was produced in a coarse size (8 cm). However, later all waste rock, from this source and the Faraday Mine, was crushed to a 2 cm maximum size.
>
> Disposal of development waste rock was not controlled and no records were kept of production or subsequent distribution. However, the many thousands of tons of waste rock produced at several sites has virtually disappeared. The large size (8 cm) has been observed as backfill around structures, while finely crushed material has been used in road and driveway construction, trench backfill, subgrade material beneath basement slabs and filter material for basement window wells and domestic weeping tile systems (2-12).

The use of mine waste rock in Bancroft, Cardiff, Bicroft Heights, and Dyno Estates was noted, and this rock was mostly distributed within a fifteen- to thirty-kilometre area of the mine sites (2-12). The presence of mine tailings was not observed at any of the sites in the study (2-13). Another source of potential contamination was the uncontrolled distribution to the general public, of contaminated building materials from the mines and mills, after they were closed in the early 1960s (2-13).

In the summary of radiological aspects by locality, each of the settlements was discussed in turn and the problem sources were traced to specific causes. For Cardiff, the observations included the following:

> ...extensive use of mine waste rock on roads, driveways (up to 100 μR/h gamma on contact), and as backfill material. ... throughout the townsite. Low level radon concentrations (below 7 pCi/L) prevalent in most problem sites appear to be related to the entry of soil gas through weeping tile systems and cracks in structural foundations (4-21).

The summary for the Bicroft Heights follows:

> Extensive use of radioactive waste rock has been observed on all roads and driveways (up to 200 μR/h gamma on contact) and as backfill around and under structures, on lawns, in window wells (up to 300 μR/h gamma on contact) and as retaining walls. It would appear that waste mine rock is the significant source of radioactivity at problem sites in this community (4-21).

The summary for the Dyno Estates follows: "Waste mine rock of low activity (up to 30 μR/h gamma on contact) has been used to a limited extent. Although investigations to date have not been sufficient to specifically identify all sources of radioactivity at problem sites it is probable that mine waste rock is the predominant contributor" (4-21).

In relation to the entire study sample, the above settlements accounted for twenty-one of thirty-eight driveway anomalies and thirteen of thirteen anomalies in the 'other' category. It was also noted that the Bicroft Mine waste rock disposal and tailings areas were a significant source of radon gas (8.3 pCi m s) and gamma radiation (100-500 μR/h at one metre) and that: "Access is not restricted and there are indications that materials are being removed from the sites" (4-23).

Remedial measures for the project included the removal of the source of radioactivity and the improvement of seals and ventilation in buildings. Source removal included the excavation of waste rock from under basement floors, foundations and fireplaces as well as from driveways and lawns (5-6). This material was transported to the Madawaska Tailings Area No. 2 for safe disposal and the total quantity was not expected to exceed 15,000 tonnes (5-11). Estimates for the cost of the source removal measures ranged from $2,500.00 to $3,500.00 (6-2). Seal out measures ranged from sealing crawl spaces, cracks and joints in floors and walls, as well as exposed bedrock, to applying an epoxy sealant to the entire surface of basement floors and walls (5-6). Costs for individual seal out measures ranged from a low of $2,000.00 to a maximum of $9,200.00 (6-2). The modification of sumps and floor drains was included in the seal out program. Estimates ranged from $500.00 to $1,500.00 (6-2). Mechanical ventilation,

electrostatic precipitation and the aeration of potable water were included as measures to improve building ventilation (5-6). According to the Bicroft Township Clerk, Sandra McColl, the owners of the residences requiring remedial work were given the choice of having the work done or having the radon gas / gamma radiation problem recorded on the title for the property. All of the Cardiff townsite owners chose the option of the remedial work (McColl 1995).

The remedial work on homes in the Bancroft area, that occurred in the wake of this study, undoubtedly influenced the awareness and the attitudes of area residents towards the issue of low-level radiation from the mine waste rock. The following events had an even greater impact on the attitudes of area residents towards the long-term disposal of low-level radioactive mine wastes.

5.0 *McLure Crescent and Radium-Contaminated Soil*

During World War Two, a farmer on the outskirts of Toronto accepted rags that were used in the manufacture of radium-painted dials. The farmer burned the rags and spread the ash over his fields in the hope that the radium would enhance the growth of his crops. This farm eventually became part of the city of Scarborough and the Malvern subdivision was constructed on the site (*Bancroft Times* 05/27/81). In the fall of 1980, the AECB discovered that the soil of McLure Crescent, in the Malvern subdivision, was contaminated with radium and it was announced that this soil would be removed from the site (Discovery 11/20/80). The following spring, on May 6, 1981, the residents of the Bancroft area learned, from a Global Television newscast, that the AECB intended to dispose of 3628 tonnes of radium-contaminated soil on the inactive No. 2 Tailings Area at the Madawaska Mine.

On May 21, the AECB hosted a public meeting at the Cardiff Community Centre to present its soil disposal plan to the community. The meeting was held under the auspices of the Federal-Provincial Task Force on Radioactivity, which was established in 1976 to examine low-level radiation contamination in Canada (*Bancroft Times* 05/20/81). The following quotation from Jon Jennikens, then president of the AECB, illustrates the purpose of the meeting: "This kind of situation can very easily be blown out of

proportion through lack of information and the conjecture which results...In the public interest it is obviously the Task Force's responsibility to cut off conjecture with facts" (Ibid.).

The meeting was chaired by Father Maloney, the pastor who had lobbied John Diefenbaker on behalf of the community in the face of the mine closures in the 1960's. It was well attended by people from Haliburton and Hastings Counties and they faced a phalanx of officials from the federal and provincial governments sitting on a raised platform at one end of the hall. In addition to Jon Jennikens, there were four other AECB representatives as well as officials from Health and Welfare Canada and the Ontario Ministry of the Environment.

The tone of the meeting quickly became characterized by alienation and mistrust. The government officials presented their plan as a *fait accompli* and responded to the questions from the audience with "arrogance and sarcasm" (*Bancroft Times* 05/27/81). The radium-contaminated soil was presented, quite accurately, as less hazardous than the tailings at the Madawaska Mine and officials announced that the transport of soil was scheduled to begin within four to six weeks. Although Madawaska Mines Limited was not in agreement with the AECB decision, the transfer of soil was applicable within the terms of its operating licence and the AECB had the power to overrule the company's position.

Sonja Holiday-Rhodes, a seasoned anti-pollution activist and President of the Haliburton County Anti-Pollution Committee, recalled that her comments helped to focus both the concerns of the audience regarding the safety of the soil, and the impatience of the audience with the attitudes of the government officials. Mrs. Holiday-Rhodes initiated her comments with a request to address the audience from the same position of authority as the government officials, from the podium. When this request was granted, she gave a brief speech in which she emphasized public health concerns regarding the transfer of radionuclides in groundwater, through radon inhalation and the development of latent cancers through long-term exposure to low level radioactive wastes (Holiday-Rhodes 1981). The audience responded to this articulate summary of their concerns with a standing ovation. The tone of the meeting deteriorated

further when some members of the audience became openly threatening to Jon Jennikens. He was escorted from the hall (Holiday-Rhodes 1996).

The May 27, 1981, edition of the *Bancroft Times* contains comments from meeting attendees and government officials that provide an elegant contrast of perspectives. A resident of Bancroft commented in regard to the AECB's determination to pursue their disposal plans in spite of the community's attitude: "It makes us feel that we are only second class to the people in Scarborough... why should we want to import the pollution from the city, while this is what we come [here] to avoid", while Jon Jennikens responded: "Next time... I'm sure that there will be a consultation with the municipality.... I doubt that there will be any further opposition, because you will see that we are correct."

The following week, a public meeting was held to organize the community in protest against the AECB soil disposal plan. More than one thousand people attended the meeting at the North Hastings High School in which the fourteen-member Bancroft and District Action Committee (BDAC) was established. The first motion to be passed called for a meeting, with the provincial Minister of the Environment and other provincial and federal representatives, for disclosure and discussion. The primary concerns of the citizenry were identified as public health and the potential effects of the soil disposal on the tourism industry.

The BDAC held its first public meeting on June 4. The committee resolved "to take any action necessary to prevent such disposal" (*Bancroft Times* 05/10/81) and called for a safe, permanent disposal solution in consultation with the communities involved. The committee acquired a technical advisor, Haliburton resident Michael Collins, who acted as expert on the chemical and medical effects of low-level radiation (Collins 1996). A public information meeting was scheduled for June 11 at the North Hastings Senior Elementary School. In addition to inviting the AECB, Environment Canada, Members of Parliament and Provincial Parliament, the Ontario Ministries of Natural Resources, Labour and Environment, the BDAC invited Energy Probe, Pollution Probe, and the National Coalition for Nuclear Responsibility.

The BDAC actions were widely supported by the community: many local businesses included a "Stop The Dump" logo in their *Bancroft Times* advertisements. while groups and individuals planned their own protests. Some misguided citizens sent anonymous threatening letters to the AECB. A group of older adults from the Riverside Chateau booked a bus to transport them to the mine site to block the trucks when soil shipments began. Bancroft resident Larry Tadman walked from Bancroft to Queen's Park to deliver a token quantity of radioactive soil to Premier Bill Davis. When he reached the legislature and was greeted by police. Tadman placed the container of soil in a toy truck and put it down on the steps. He was escorted to a police car and the bomb squad was called in to dispose of the truck. Tadman's final comment to the press suggests a novel solution to the disposal problem: "Dump it in Prime Minister Trudeau's vault where he keeps his uranium (cartel) secrets. Then the soil would not again see the light of day." (*Bancroft Times* 05/17/81).

The June 11 meeting of the BDAC was attended by more than six hundred people although the AECB declined to attend. The meeting focused on putting pressure on the members of provincial parliament to use the province's legislative powers to block transport of the soil. As well. it was resolved to use peaceful civil disobedience in the event of the soil transport. By the first of July. the BDAC had retained legal counsel in order to prepare some form of legal action against the AECB. As well. the committee wrote the Teamsters Union to request that its members refrain from participating in the transport of the soil (*Bancroft Times* 07/01/81). Tenders for the soil transport were scheduled to open on July 8 and the committee planned a second public meeting for July 15. On that date. the AECB informed the BDAC that the soil would not be transported to the Madawaska mine.

The concerted actions of the BDAC. their intention to pursue legal counsel and the widespread public support for their intention to stop the shipment of radium-contaminated soil. influenced the AECB's decision not to transport the soil to the Madawaska Mine site. Although the decision to dispose of the soil at the mine site may have been technically sound. the absence of public consultation. combined with the patronizing attitudes demonstrated by the officials of the AECB. resulted in alienating the federal organization from the community. It is evident that the AECB chose to avoid further conflict. negative

publicity and the potential for an extended legal struggle to dispose of the soil. by deciding not to use the Madawaska Mine site as its disposal location.

6.0 *Studies of Abandoned Uranium Mill Tailings*

The 1980s witnessed the study of the mill tailings of the abandoned uranium mines in Haliburton County. Margarete Kalin of the University of Toronto Institute for Environmental Studies published three related studies of these sites for the federal government. It was determined that in order to make informed decisions about the long-term treatment of these waste sites. there was a need to understand the nature and the extent of the ecological processes occurring on the tailings (Synoptic ii). The first of the studies was a synoptic survey and inventory of the plant life on the tailings. The second study focused on the growth patterns of the tailings' vegetation and the third study examined the radionuclide concentrations of the vegetation associated with the tailings. Table 13 provides a summary of the tailings sites.

Table 13: Dimensions and Historic Data of Abandoned Uranium Mill Tailings Sites

Location	Years of Operation	Dry Surface Area	Amount of Tailings (tonnes)	Vegetation Cover	Habitat	Previous Landform
Auger Lake	1957 - 63	2 ha	2.000.000 t	70%	wet	lake
Bicroft proper	1956-57	4 ha	350.000 t	50%	wet & terrestrial	swamp
Bicroft Swamp	n/a	2.2 ha	?	n/a	wet & terrestrial	swamp
Dyno	1957-60	2.7 ha	570.000 t	90%	wet & terrestrial	lake
Totals		10.9 ha	2.920.000 t			

Sources: Kalin. Synoptic 7 and Radionuclide 7.

The synoptic survey observed the presence of wetland vegetation dominated by species of cattails (*Typhaceae*). rushes (*Juncaceae*) and sedges (*Cyperaceae*). aquatic bryophytes and acid-tolerant algae. Uptake of radionuclides and heavy metals was demonstrated by the roots of the cattails. The study observed the presence of sporadic indigenous vascular plants. mostly trees. such as trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*). The trees demonstrated uptake of

radionuclides and heavy metals throughout their organs. Radionuclides included Radium 226 and Lead 210: heavy metals included aluminum. copper. cobalt. manganese. magnesium. nickel.and lead as well as sodium and chlorine (1). The study concluded that primary colonization was occurring. though whether the species diversity would increase with the age of the site would be influenced by the type of impacts that the site had experienced as a disposal site for tailings. The author concluded with the following statements: "The rehabilitation in the long-term is dependent upon the success of primary colonists to survive the stresses of the environment on the tailings" and "The uptake of radionuclides and heavy metals ... may facilitate the transfer of these elements to the environment ... could result in undesirable effects and ultimately the contamination of the environment" (Kalin 102).

The synoptic survey was followed by a study to examine the growth patterns of the aquatic and terrestrial vegetation on the tailings. The study focused on the cattail stands and the trembling aspen and birch trees. It was concluded that the cattails were influenced more by the site hydrological conditions than by the chemistry of the tailings (Kalin. Radionuclide i). The trees (xiii) were observed to be growing at their limits of ecological tolerance which reflects the generally poor site conditions: "Although colonization and the growth of trees occurred on the sites. the patterns and processes of stand development differ greatly from those observed in normal forests" (93). The stunted growth of the trees resulted from the absence of nutrients in the tailings.

The third study examined the concentrations of radionuclides and heavy metals in the tailings. the water and the vegetation on the sites. It was observed that radionuclide concentrations varied greatly throughout the sites. although the concentrations tended to be higher in the wetland areas. The concentrations ranged from detection limits (<1 pCi/g or 37 mBq/g) to 400 pCi/g or 14800 mBq/g (86). The study concluded that the uptake of Radium 226 and Lead 210 is species-specific and not related to the tailings' characteristics (Radionuclide 85). Due to this. larger trees growing in uraniferous (uranium-mineralized) soils will produce more biomass and thus more radionuclides than will trees growing on the tailings. due to their stunted growth. Ultimately. the trees on uraniferous soils will make more radionuclides available for transfer to the food chain (86).

These studies demonstrate that the abandoned tailings sites are slowly returning to a forested state, however stunted. The concentrations of heavy metals in the tailings and the biomass of the vegetation do not present an immediate threat to the food chain. In the absence of appropriate decommissioning measures, however, the sites could be subject to incremental deterioration of the tailings dams which could release tailings material and water into the Paudash Lake and Eels Lake watersheds. Also, over time, as the sites become more heavily vegetated, there is greater potential for people to unintentionally come into contact with the sites. The following studies demonstrate that these issues have been addressed to some degree, by both public agencies and private interests, within recent years.

7.0 The Paudash Lake Conservation Association and the Canadian Institute for Radiation Safety

The Paudash Lake Conservation Association (PLCA), a group of residents and cottagers in the Bancroft area, was formed in the early 1970s when the Ministry of Natural Resources announced an autumn water level drawdown of three metres for Paudash Lake, to alleviate the risk of spring flooding. The focus of the group was the conservation of Paudash Lake and the group's initial activism concerned maintaining the lake's water levels. The inclusion of uranium mines on the association's agenda began in the mid-1980s when PLCA president, Bill Davis, discovered a broken tailings dam on the Bicroft mine site. He reported this to the Ministries of Natural Resources and Labour and to the mining company (LAC Minerals); the dam was repaired. The PLCA then investigated the conditions at the Bicroft and the Dyno mine sites and found them to be in poor condition (Davis 1996).

In 1985, the Paudash Lake Conservation Association approached the Canadian Institute for Radiation Safety (CAIRS) for assistance in acquiring the information needed to address their concerns regarding the potential radiological contamination of ground and surface waters, soils, and vegetation in the areas around the Madawaska, Bicroft, and Dyno mines (CAIRS, Information 2). CAIRS initiated the collection of information from the relevant federal and provincial bodies and compiled a summary of their responses which was released in 1986 as *Bancroft Uranium Tailings: Information Obtained by CAIRS from the Federal and Ontario Governments*. The report concluded that the primary responsible agencies

were the Ontario Ministry of the Environment and the Atomic Energy Control Board (CAIRS. Report Stage II 1). Also. it was noted that Energy. Mines and Resources Canada had undertaken studies of uranium mine tailings sites and had developed theoretical models but that no data for the Bancroft sites had been collected. Finally. the report acknowledged that the primary jurisdictional authority for the disposal and management of the wastes at the Bicroft and Dyno mine sites was not clear. The mines were both closed in the 1960s. prior to the assumption by the AECB of active jurisdictional control for uranium mining and waste disposal. Thus the companies abandoned the sites without any measures made to minimize the radiation hazards of the mill and mine wastes (CAIRS. Information 2).

The second CAIRS report for the Paudash Lake Conservation Association was released in 1987. This report presented a discussion of the problems identified in the first report and compared the uranium mine decommissioning practices of the Canadian and the United States' governments. The report also examined the human health effect of exposure to low-level radiation. The problem discussion included exposure to gamma radiation. radon gas. and the bioaccumulation of radionuclides through the ingestion of contaminated groundwater and fish from the affected lakes (CAIRS. Report Stage II 13). As well. the issue was identified of the unwitting use of materials from the sites or even the inhabitation of the sites in the future when the succession of vegetation disguises their nature as waste sites (13). The comparison of Canadian and American decommissioning practices illustrated that the AECB licenses decommissioning through the use of site-specific conditions with no detailed governing regulations. in contrast to the more explicit American practices (24-31). The concerns of the inhabitants of the area were summarized in the statement of requirement made with regard to the mine sites. The report called for remedial treatment of the sites to minimize both the unwitting disturbance of the tailings by people and their natural erosion. by wind and water.

The third CAIRS report was released in 1988 and it presented a proposal for a process to develop a remediation and management plan for the Bicroft and Dyno mine sites. The report contained endorsements for the proposal from the municipal councils of Bicroft. Cardiff. and Faraday Townships. the Federation of Ontario Cottagers. the Eels Lake Cottagers Association. and the Crowe Valley

Conservation Authority. The position of the community represented in this report is clearly stated: "The abandoned uranium tailings at the old Bicroft and Dyno mines must be put into a position that is acceptable to the people who are affected by their existence ..." (CAIRS. Proposal 6). CAIRS lauded the project in the following passage: "... this may be the first time that local residents have proposed to governments a practical approach to dealing with a major problem of radioactive waste in their own backyard" (12). The proposal for the development of a range of options for the decommissioning of the mine waste at Bicroft and Dyno included four stages. The first stage was a preliminary study to determine the parameters. the resources required and the costs of the detailed study. The second stage was the detailed study to establish a range of cleanup options for the two mines including the costs and the benefits of each option. The third stage involved the choice of a decommissioning option by the residents and the relevant government agencies. The final stage was the implementation of the decommissioning option with an evaluation of the site conditions after treatment.

According to a spokesperson for the Canadian Institute for Radiation Safety (CAIRS). Tina Degues. the reports published by CAIRS for the Paudash Lake Conservation Association served both to educate the community about radiation and to create an atmosphere of cooperation between the community. their scientific advocate (CAIRS) and the levels of government involved with the abandoned mine sites. Through the publication of these reports and the ongoing interest in the decommissioning of the Madawaska Mine. the PLCA has influenced the evolution of public attitudes towards the uranium mines. Prior to the study initiatives of this organization. the attitude of residents of the area towards the mines was one of denial. With the publication of these studies. this general attitude has changed to reflect a spirit of working towards a long-term solution. that is. the decommissioning of the abandoned mines (Degues 1995).

In the spring of 1988. the PLCA sent a letter to the federal Minister of State for Forestry and Mines that expressed the association's concerns regarding the decommissioning and the potential abandonment of the Madawaska Mine. scheduled for November. 1988. Specific issues of concern included the lack of clear responsibility for the long-term care of this mine and the two abandoned mines

as well as the lack of remedial work on the No. 2 Tailings Area at the Madawaska Mine (Masse 1988). The letter included a request for the minister to intervene to prevent the AECB's approval for MML to abandon the site (PLCA 1988). When the members of the PLCA received the minister's reply in early November, they felt that their concerns were being dismissed. The PLCA responded to the minister's letter by preparing a press release that outlined their actions and expressed their dismay at the federal government's inadequate response to their concerns. The group also prepared a strongly worded brief to the AECB, on the subject of abandonment, which was perceived by that body as a direct attack (Hunnias 1996). The PLCA then approached Global Television and the *Toronto Star* with its story. On November 24, the Star printed an article entitled *Who's in charge if things get 'hot'? - No one has yet assumed responsibility for nuclear waste in the Bancroft area.* The article emphasized the lack of regulation for the abandoned mines and the impending abandonment of the Madawaska Mine.

These actions alienated some members of the Bancroft community, who considered that tourism would be adversely affected by the widespread publication of the situation. The AECB responded, however, by inviting the PLCA and local government officials to meet to discuss the situation on the condition that the press was not invited (Hunnias 1996). At this meeting, the AECB announced that they would henceforth monitor the abandoned mines and that the owners of the abandoned mines would be encouraged to undertake remedial work on the sites at their own expense (Ibid.). Concurrently, the AECB declined Madawaska's request to abandon, citing a longer monitoring period, high gamma readings on some parts of the tailings, the presence of sinkholes, and pathway analysis deficiencies (MML, 1989 Appendix 2).

8.0 *Report on the Surface Conditions of the Bicroft and Dyno Mine Sites*

In May of 1989, the Ontario Interministry Abandoned Mines Committee presented the *Report on the Surface Conditions of the Bicroft and Dyno Minesites* in response to concerns for public safety that had been raised by the PLCA. The expressed concerns related to the issues of uncontrolled trespass on the minesites and unauthorized removal of radioactive materials. The committee made use of the personnel

from the Ministry of Natural Resources. the Ministry of Labour. the Ministry of the Environment. and the Ministry of Northern Development and Mines to undertake an inspection of the surface features of the mine sites and a review of all available mine maps (Ontario Interministry Abandoned Mines Committee. 1989 2). The committee compiled a report on both of the mine sites consisting of mine data. a critique of surface conditions and recommendations to improve surface safety. followed by a radiological hazard assessment.

The recommendations for the Bicroft Mine site included regular inspections of the tailings dam to ensure that it continued to be sound. as well as inspections of the buildings on the site to prevent hazards to the general public (Ontario Interministry Abandoned Mines Committee. 1989 4). The Dyno Mine site recommendations included replacing the missing barricade at the road entrance to the site. monitoring the tailings dam to prevent a catastrophic failure. fencing the area of the crown pillar to prevent a falling hazard to the public and clearing debris from the mill building foundations (8). The radiological inspection concluded that neither site represented a hazard for recreational uses such as hiking or skiing, but that continuous occupancy could present a hazard (9).

9.0 *Remedial Work on the Bicroft Mine Site*

LAC Minerals Limited. which is now American Barrick Resources Corporation. began its involvement with the Bicroft Mine in 1961 with Macassa Gold Mines Limited. Bicroft Division which was taken over by Wilroy Mines Limited in 1970 which became LAC Minerals (Senes 1990 1-1). During its operations. the Bicroft Mine discharged tailings into the north basin at Auger Lake and the smaller south basin. Located below these basins. the polishing pond retained the runoff from both. Water from this pond flows into Deer Creek and from there into the north end of Paudash Lake at Inlet Bay. The tailings are mostly covered in water and terrestrial tailings sustain vegetation (1-1).

Prior to 1981. LAC Minerals monitored the site on an annual basis; since that time inspections occur in the spring and the fall. These inspections focus on the integrity of the tailings dams. spillways and decants and include monitoring the water quality of the tailings runoff. The Ontario Ministry of the

Environment also tests the water quality and performs occasional gamma radiation surveys of the site (1-1). As well, LAC has capped the shafts and raises and undertaken construction of emergency spillways, ditches and access roads (1-2).

In 1990, LAC Minerals contracted Senes Consultants Limited to undertake a pathways analysis for the Bicroft mine site. The pathways analysis was used to estimate the annual radiation doses received by three different critical groups: a person living adjacent to Paudash Lake, a resident of the Bicroft Heights and an occasional recreational user of the tailings site (Senes Consultants Limited, 1990 1-2). The resident of Paudash Lake was assumed to live within two km of the mine site year-round, to obtain his potable water from the lake, to ingest both fish from the lake and venison from the tailings area. The total annual dose for the resident was calculated to be 0.47 mSv/yr (Senes Consultants Limited 5-1). The resident of Bicroft Heights was assumed to live there year-round, to obtain his drinking water from a well, to consume fish and venison from the tailings. The estimated dose for this person was calculated to be 0.41 mSv/yr (5-2). The exposure received by the recreational user of the tailings area was assumed to be in addition to the dose received by either of the above residents. Potential recreational activities included occasional hiking, hunting, or snowmobiling. The estimated dose for this person was 0.43 mSv/yr (5-2). Thus, a combined exposure would be either 0.9 mSv/yr or 0.84 mSv/yr relative to the location of the residence.

The pathways analysis sets the background radiation exposures for the area at 2 to 3 mSv/yr and observed that the pathway exposure estimates were small in comparison to background radiation levels (Senes Consultants Limited 5-2). As well, it was observed that the predicted exposures for residents were approximately 10% of the AECB public exposure limit and 40% to 50% of the ICRP recommendations (5-3). Predicted exposures for recreational users were close to 18% of the AECB limit and 90% of the ICRP limit (5-3).

In 1990, Lac Minerals retained the firm, Golder Associates Limited to provide the engineering services for design and engineering supervision during the construction of the decommissioning works of the Bicroft Mine (Golder Associates Limited, 1991 1). This work included the construction of roads to

provide access to all of the tailings area dams. dam regrading and stabilization. construction of spillways and seeding of exposed tailings. The 1990 Decommissioning Project was intended to ensure the long-term stability of the tailings dams and to replace the old decants with overflow spillways (2). The Bicroft mine site has been inspected annually in recent years by the AECB and provincial representatives after the annual compliance inspection of the Madawaska Mine.

According to Bernie Gzola of the AECB. the owner of the greatest portion of the Bicroft Mine site property. American Barrick. is interested in delicensing those portions of the property without tailings or mine workings. The ownership situation is complex. however. since the Township of Bicroft owns the mill area and American Barrick does not own all of the land overlain by tailings. American Barrick desires to consolidate its ownership of all of the mine-related lands in order to licence them (Gzola 1996).

9.1 *Remedial Work on the Canadian Dyno Mine Site*

In 1960. when Canadian Dyno Mines Limited ceased operations. the company closed out the property in compliance with the standards in effect at that time: the equipment was removed. the buildings were demolished and all of the surface openings were sealed. Conwest Exploration Company Limited (Conwest) acquired the property in 1976. In 1990. Conwest contracted Beak Consultants Limited to undertake an environmental audit and monitoring program and a pathway analysis for the site. The intent of these actions was to determine whether the 1960 close-out of the property was adequate and would "not result in any future unacceptable routine exposure to radionuclides or trace elements" (Beak Consultants Limited. 1991 1.1).

In 1989 and 1990. Beak Consultants Limited undertook a gamma radiation survey of the mine and mill areas. the roads and the tailings impoundment area. Gamma readings from the waste rock fill around the mine and mill area ranged from 70 to 100 μR/hr with spot readings of up to 200 μR/hr (Beak Consultants Limited 3.3). Three transects of the tailings area indicated readings between 100 and 200 μR/hr with the highest measurement at 370 μR/hr (3.4). Gamma readings from the tailings dam were in the same order as readings from the tailings surface (3.4). These surveys resulted in the identification of

two sources of potential radiological exposure: the waste rock that is spread throughout the site and the tailings in the impoundment area and below the dam (4.1). The primary hazard was identified as direct gamma radiation received by walking over the waste rock or by sitting on it (4.1). As well, downstream leaching of radionuclides, radon exhalation and airborne particulate matter from the tailings were identified as sources of exposure.

The pathway analysis assumed a critical group living in a seasonal dwelling for 80 days a year and visiting the site for a total of 100 hours per year. The assessment of external gamma radiation exposure assumed a hypothetical recreational user of the site to spend a total of 100 hours on site, which was divided into 20 hours on the tailings and 80 hours on the rest of the site (Beak Consultants Limited 4.2). A background dose rate of 25 μR/hr was used and an exposure rate of 125 μR/hr was assumed for casual hunters and hikers on the site (4.2). An exposure rate of 250 μR/hr was assumed for the hypothetical walker on the tailings. Eighty hours of walking on the mine/mill area resulted in an exposure of 800 μR/yr or 8 mR/yr, while twenty hours of walking on the tailings resulted in a dose of 3.5 mR/hr for a total dose of 11.5 mR/yr. This dose was converted to an air-borne dose from radon to result in an absorbed dose of 0.086 mSv/yr (4.3).

The aquatic pathway analysis assumed a critical group defined as seasonally inhabiting a cabin on the south-east shore of Farrel Lake downstream from the tailings. The critical group was assumed to inhabit the cabin for a total of eighty days a year. It was assumed that the critical group acquired their potable water from Farrel Lake and consumed 2 kg/wk of fish from the lake (Beak Consultants Limited 4.4). The total dose from water consumption was calculated to be 0.151 mSv/yr and from fish consumption to be 0.03 mSv/yr for a total internal dose of 0.181 mSv/yr. The combined dose for the critical group was thus calculated as 0.267 mSv/yr (4.5). Using the same Bancroft area background radiation exposure levels described previously, that is 2 to 3 mSv/yr, the combined airborne and aquatic pathway exposure of 0.267 mSv/yr is small in comparison. As well, the pathway exposure comprises approximately 25% of the IRCP dose limit of 1 mSv/yr.

The pathway analysis concluded that the tailings berm is stable and in no need of remedial work. It recommended that casual access to the site be discouraged through the placement of a rock berm on the entrance road and removal of the parking area. Finally, the report recommended that the radiological and chemical hazards of the site be registered on title to prevent residential or recreational development of the property (5.3).

In 1992, a spillway was constructed at the north-east end of the tailings dam in order to drain standing water from the tailings (AECB 1994, 2), and seedlings were planted on the tailings in 1992. A 1994 status report by the AECB on the Dyno Mine site indicates that the AECB now reviews all proposals for remedial activity. As well, water quality of the tailings basin drainage and the growth of the vegetation on the tailings are monitored through a Dyno Mine site inspection by provincial and federal officials after their yearly compliance inspection of the Madawaska Mine site.

9.2 *The Present Status of the Bicroft and Dyno Mine Sites*

The activism of the Paudash Lake Conservation Association has achieved its objectives with regard to the Bicroft and Dyno mines. Remedial work has been undertaken at both of the abandoned mines and the decommissioning of the Madawaska Mine was prolonged to include work on the No. 2 Tailings Area. The issue of perpetual care and monitoring of the sites has yet to be fully resolved. According to Bernie Gzola, a policy decision has been made recently to licence the sites which will then be regulated by the AECB. Decommissioning work will proceed according to the procedures of the AECB. When the decommissioning has been accomplished, the sites will be delicenced and will revert to the jurisdiction of the province under the Mining Act. The challenge in this regard is that the provincial jurisdiction relates only to crown land; private land can not be delicenced and therefore the task is to reduce the private surface holdings to allow the largest possible area to be delicenced, in order to minimize the hazards to the public and maximize opportunities to develop (Gzola 1995). The recently signed *Memorandum of Agreement* (January 1996) does not relate directly to any of the Bancroft area uranium mines because it concerns properties whose owners are bankrupt or insolvent and thereby unable

to fulfill their obligations for decommissioning and perpetual care. The Bancroft area mines are, at present, owned by companies who are able to finance any decommissioning and perpetual care activities.

Finally, the remedial work that has been accomplished at the Bicroft and Dyno mine sites will be included on the agenda of a public meeting that is planned to finalize the decommissioning of the Madawaska Mine (MML 1994, 3). This meeting has been postponed until the Alberta Energy Corporation has resolved with the Ministry of Northern Development and Mines and the AECB, the final areas of the Madawaska Mine property and the Dyno Mine property which will remained licenced. As well, American Barrick must consolidate the Bicroft properties in order to be able to present a complete solution for the property's long-term care to the community (Gzola 1996).

10.0 *Conclusion*

The remedial work that has been accomplished in recent years at the Bicroft and the Dyno mines can be compared to the decommissioning of the Madawaska Mine. The decommissioning of the Madawaska Mine has included fourteen years of aquatic monitoring of ground and surface waters on and adjacent to the site. A pathway analysis was undertaken and modified as per the requirements of the AECB, to assess the containment of the mine site's radiation hazards to people living in proximity to the site. Surface structures were demolished and the foundations were covered, contoured and planted with red pine seedlings. The No. 1 Tailings Area was covered, contoured, and planted; a spillway for spring runoff was constructed and sinkholes were filled in. The No. 2 Tailings Area was a subject of disagreement between Madawaska Mines Limited and the AECB, but eventually the indigenous vegetation was removed, the tailings covered and red pine seedlings planted. Regular compliance inspections of the site were held with MML representatives and employees of the federal and the provincial governments from 1984 until 1994.

To contrast, the Bicroft and the Dyno mines were closed down in 1964 and in 1960 respectively, long before the AECB assumed jurisdictional authority for uranium mine decommissioning in 1977. Thus, both mines are classed as abandoned mines and the sites are not subject to the decommissioning

process undertaken at the Madawaska site. Both sites are monitored by their owners: Conwest monitors the Dyno site and LAC Minerals monitors the Bicroft site. As well, aquatic monitoring is an annual task accomplished by the Ontario Ministry of the Environment and Energy at both sites. In 1990, in the wake of activism by the PLCA, LAC Minerals undertook remedial work on the Bicroft tailings areas. This work included capping surface openings, road, ditch and spillway construction, as well as dam reconstruction and seeding of exposed tailings. The same year, a pathway analysis was completed to assess the radiation dose to people living in proximity to the Bicroft site.

The Canadian Dyno Mine site was not subjected to any remedial work from 1960 until 1990. In 1990, an environmental audit and pathway analysis were undertaken. The environmental audit included gamma surveys of the mill site and the tailings area. The pathway analysis assessed the radiological hazards of the site to nearby seasonal inhabitants. A spillway was constructed on the tailings dam and seedlings were planted on the tailings in 1992/3.

The Madawaska Mine site has been subjected to an extensive and rigorous decommissioning process that has been modified as required by the AECB. The site is completely devoid of structures, covered with gravel, contoured and revegetated. Both the Bicroft and the Dyno sites retain structures: in the case of the Dyno site the mill foundations stand in mute testimony and at the Bicroft site the mill building and the ore bin foundations remain.

To conclude, it is evident that the disposal of low-level radioactive mine and mill wastes has been influenced by a series of interrelated events. These events include the decommissioning of the Madawaska Mine, the remedial work undertaken by the firm James F. MacLaren, Kalin's studies of the vegetation on the abandoned mine tailings, and the BDAC organized protest that stopped the AECB plan to dispose of radium-contaminated soil at the Madawaska site. A major influence on the disposal of these wastes has been the PLCA and its scientific advocate CAIRS who successfully lobbied for remedial work at the abandoned mines, the extension of Madawaska's decommissioning process, and brought about the deal struck by the AECB and the mine site owners to undertake remedial work and monitor the sites.

From the late 1970s to the present day, there has been an evolution in the AECB attitude towards this community from patronizing disregard to wary respect. The most significant indicator of this evolution is the planned public meeting scheduled to be part of the closure process for the decommissioning of the Madawaska Mine. Public participation has not been part of the decommissioning process to date, but the AECB has learned from its previous conflicts with Bancroft area residents in 1981 with the BDAC, and in 1988 with the PLCA, that the interested parties in the community will continue to express their desire to participate in the decision-making process as it relates to the mine wastes. As well, the status of the abandoned mines is included on the agenda of this meeting which in itself provides evidence of the evolution in attitude that has translated itself into remedial action and monitoring of these sites that the AECB had officially disregarded for three decades.

Chapter Four *The Bancroft Area Uranium Industry as Industrial Heritage with Opportunity for Cultural Tourism*

This chapter presents a brief discussion of concepts of heritage. Included is consideration of heritage values and their significance, in light of the potential for industrial heritage to both enhance a community's sense of identity and pride, as well as to provide opportunity for cultural tourism. Cultural tourism is discussed with reference to the tourism sector in general and in regard to the cultural tourist. Included are recent local initiatives that refer to the Bancroft area's attractiveness to the cultural tourist, that acknowledge opportunity to develop attractions based upon minerals and mining heritage, and that refer to the concept of mining heritage tour development. A case study of the Gold Rock mines in Northwestern Ontario follows, with descriptions of recent heritage mural projects in Chemainus, British Columbia and Atikokan, Ontario. The chapter is completed by a uranium mining mural development proposal for Bancroft village, a mining heritage tour concept and a case study of the industrial processes of the Canadian Dyno Mine.

1.0 *Heritage*

Fram and Weiler (5) refer to heritage as a general term that is "used to identify an object or activity for which people have a particular affection as something that belongs to them in some way". The authors' working definition of heritage is based upon the legal concept of property that changes hands through the process of inheritance (5). This framework includes the concept of cultural property which includes moveable objects as well as immobile sites and structures. Property is defined as: "[hu]man-made heritage...the consultable record of past human activities, endeavors or events... part of the environmental inheritance of the people of the whole or any part of Ontario" (5). The concept of human-made heritage is differentiated between cultural landscapes and cultural features wherein a cultural landscape reflects the cumulative impacts of human activities on the use and the appearance of the land (7), and where a cultural feature is a specific human-constructed component of that landscape "in, on or under the land"(8).

In a 1995 draft version of the Ontario provincial policy for cultural heritage resources, the Ministry of Culture, Tourism and Recreation provides an inclusive definition of heritage as:

> ...everything that our society values and survives as a representation of our past, including archeological sites, built resources, traditional use areas, cultural landscapes and shipwreck sites...it expresses our collective experiences and values, from which we can derive a sense of identity and meaning, and find confidence about what we can achieve (2).

Heritage is linked to a communal sense of identity and thereby includes not only the concrete and tangible remains of the past but also the memories and the stories of members of a community. This conceptual framework connects heritage to a community's positive attitude towards its future endeavors.

Our Creative Diversity, the report of the World Commission on Culture and Development, calls for a more inclusive definition of heritage that moves beyond the traditional understanding of the concept that is "...biased towards the élite and the masculine: the monumental rather than the homely, the literate rather than the oral, the ceremonial rather than the workaday, the sacred rather than the profane..."(176). Heritage must thus be perceived as inclusive of the ordinary and the everyday, of the tangible structural remains and the less tangible stories of place. Stories and artefacts will have emerged from a community's patterns of settlement based upon its socio-economic history, which developed in response to its specific natural and social setting. As such, heritage includes both the stories of work and the landscape legacies of industrial activity. In the draft version of the MCTR Policy for Cultural Resources, three broad categories of cultural heritage landscapes are presented. *Historically designated landscapes* include places such as Queen's Park. The Agawa pictograph site is an example of a *designated sacred landscape*, whereas the Cobalt mining area is presented as an example of an *evolving landscape*, a category which includes rural, urban and industrial landscapes (5).

In the broadest sense, industrial heritage encompasses all of the evidence of activities that people undertake in the process of procuring a living in an industrial sector including manufacture, transport, distribution and disposal of goods. Industrial heritage is characterized by transformation and evolution because industrial activities and patterns of land use evolve over time and their impacts on a landscape change its appearance on a continual basis. The uranium mining industry is a much overlooked aspect of

the recent history and heritage of the Bancroft area. The story of the prospecting, staking, development, mining, abandonment and decommissioning of the mines fits within the concept of industrial heritage as discussed. The story and the remains of the uranium mining activities in the Bancroft area can be classified generally as cultural heritage and specifically as industrial heritage.

The significance of an industrial heritage resource is determined by the degree to which it is valued by a community and by how it can contribute to the story of the community. Fram and Weiler (8) link the significance of a heritage resource to whether it is unique, outstanding or "an example of a remaining few," that is, representative or exemplary. These authors identify the value of heritage resources as based upon their architectural, engineering or archeological merit as well as an historic association with an event, a person, group or activity (8). The draft version of the MCTR Policy for Cultural Resources states: "The importance of these resources to a local community, in reflecting the past and by providing a sense of place and identity to that community, is a critical means by which to measure the significance of a particular cultural heritage landscape" (5). Thus the value of an industrial heritage resource is determined by the degree to which it is valued by a community. It is critical to consider, however, that with the passage of time, the story and the traces of a heritage resource can be lost or overlooked. Thus a community's relationship to an industrial heritage resource must be assessed with regard to its awareness of the industry in question.

Recognition of heritage values includes consideration of opportunity for their commemoration and conservation, wherein conservation includes some degree of commemoration and *vice versa.* Commemoration implies some degree of celebration or honouring of the heritage resource or of the story that it represents. Conservation is a comprehensive process of identification, preservation, interpretation and use of the heritage resource, the scope of which is determined by the nature and the status of the heritage resource.

In a keynote address to the 1994 Heritage Canada / Heritage Montreal Conference, Marcia Nozick described the role that heritage can play in the development of sustainable communities. Within the broad context of globalization, the current global economic restructuring based upon the market-

driven economy with the political and economic dominance of transnational corporations, rampant growth and the development of mass culture. Nozick emphasizes the economic and social decline of communities. Among the negative impacts of globalization, she includes the "erosion of local identity and cultural diversity, as we conform to the values of a mass consumer society" (Heritage 2). To counter these effects of globalization, Nozick calls for a revitalization of local cultural identity. This revitalization is based upon the social and the natural histories of communities. This requires a perception of heritage "that is integrative, evolving and part of the living dynamic of everyday life," as a process that can link "past, present and future"(3). As Nozick states: "Heritage... has the potential to restore and reconnect people to the land, to each other, to past and future, and to rediscover themselves in their collective roots" (3). The authors of *The Industrial Heritage* (52) also link the value of heritage to community identity: "Everyday heritage gives us our sense of place - continuity - stability." As well, the preservation and interpretation of industrial heritage are identified as means:

- to explore, to investigate
- to learn how to care for resources practically
- to share and to show
- to place one's self, one's surroundings
- to learn from, wonder at, be inspired by
- to remember, memorialize
- to possess
- to value (56).

It is evident that, conceptually, heritage embraces all aspects of the story of place and that its significance to a community is based upon the degree to which it is valued by the community. It is of interest to contrast the consideration of heritage significance as linked to a heritage resource's status as unique or exemplary (Fram and Weiler), with the integrated framework for heritage as espoused by Nozick, who identifies heritage as an integral component of any strategy to nurture a sense of local identity. In short, Fram and Weiler associate heritage significance with the uniqueness of a heritage feature or landscape, while Nozick links significance to the particular story of a specific place in order to

honor the diversity of each place and not simply single representative examples that tell the general story of anyplace/everyplace.

Within Nozick's inclusive frame of reference, the story of the uranium industry, though not exemplary on a provincial or national scale, provides opportunity to celebrate and to nurture the identity of the Bancroft area community. With this opportunity to celebrate, comes the means as indicated above, to learn about this industry, Bancroft's role as provider of a strategic mineral in the Cold War nuclear arms race, and as a community faced with the long-term responsibility for the industry's waste legacy. Thus in caring for the story of this local and global industry, there are opportunities to learn from it, for both residents of and visitors to the Bancroft area. As such, there is opportunity for the inclusion of the industrial heritage of the uranium mining industry as a resource to develop opportunities for cultural tourism.

2.0 *Cultural Tourism*

In the *Cultural Tourism Handbook*, cultural tourism is defined as: "Visits by persons from outside the host community motivated wholly or in part by interest in the historical, artistic, scientific or lifestyle / heritage offerings of a community, region, group or institution" (1). By the end of the 1990's, tourism is expected to be both the world's largest industry as well as its greatest employer (Lord, Cultural 1). Cultural tourism is a promising growth area within this sector, as "understanding culture" and "enrichment" have become significant travel motivators (2). Cultural tourism encompasses institutions such as museums, galleries and historic sites, as well as streetscapes, monuments, customs and food, festivals, fairs and special events.

The tourism industry stands to profit from the growth of cultural tourism, as is demonstrated by the following profile of the cultural tourist. Cultural tourists enjoy greater than average earnings and spend more money while on vacation than the average tourist. They spend more time visiting an area and they are more likely to stay in hotels and motels. Cultural tourists shop more and tend to travel in larger groups. Finally, cultural tourists are more often female than male (Lord, Cultural 8,9).

Demographic and social trends support the continued growth of this sector. The aging of the North American population brings with it growth in the Mature Market, defined as persons fifty years of age and older, who presently account for approximately one-third of all households and close to two-thirds of all wealth. This market segment ranks culture among its top three considerations, after cost and new places to visit, for travel destinations. Mature Market tourists are more inclined to travel during the off season, to stay longer, to participate in tours and to shop (Lord, Cultural 10).

Increased levels of education attainment by the general population raise the likelihood of participation in both cultural and tourism activities (11). Finally, with increased paid workforce participation and greater overall cultural participation, women represent a significant market for cultural tourism (11).

Among the competitive tourism market advantages that benefit the province of Ontario, two apply directly to the Bancroft area. The Bancroft area is located midway between the international gateway cities of Ottawa and Toronto. Gateway cities serve as destinations in their own right as well as launching points for travel in the surrounding area (14). Also, international tourists perceive Canada as a place of pristine wilderness. The Bancroft area, which is well endowed with regard to natural, outdoor and wilderness resources, is well positioned to link such resources with cultural attractions.

To capitalize on opportunities for cultural tourism, Lord Consultants recommend partnering and packaging as key strategies for market development. Partnering is the development of "an association between two or more parties for mutual benefit," while packaging is the "presentation of a number of products and services that are offered as a single product at a single price" including accommodation, dining, transportation, recreation and entertainment (21). Opportunities for partnering and packaging exist among cultural products of the same type or theme, for example museums or historic sites. Similar opportunities for partnering and packaging exist for cultural products of different themes or types, such as special events or festivals, that include the use of heritage resources. Partnering and packaging between cultural and non-cultural products include linking culture and heritage resources with shopping, sports, recreation and wilderness activities (21-22).

Opportunity for the conservation and interpretation of the industrial heritage of the uranium mining industry exists within the context of several recent tourism-related studies for the Bancroft and Haliburton areas. *The Haliburton County Trails and Tours Network Strategy* (1994) aims to identify opportunities to promote the economic benefits of tourism within Haliburton County with emphasis on the development, management and marketing of trails and tours (1-1). The term *tours* refers to the viewing and experiencing of a range of places and activities (1-1). The consultants identify Haliburton County as positioned to receive a 20% share of the Central Ontario Tourism Market with projections of 2.2 million day visitors and 1.48 million overnight visitors per year by the year 2000 (2-19). An identified market trend, that relates to the theme of industrial heritage, is the general growth of the cultural tourism sector and the identification of cultural opportunities as "important trip planning criteria" (2-18).

The resource inventory component of the strategy identifies a range of destination activities and points of interest with sites of natural, cultural and historic interest (3-1). Among the strengths identified is the "...untapped potential of many old ghost towns, mining sites, pioneer settlements and logging history that would be of interest to travellers" (3-13). Resource maps include a tour map with routes and the locations of some of the above points of interest; identified touring activities include bus, car, bicycle, snowmachine and ski (3-10). The summary section emphasizes the importance of a wide variety of features and activity destinations as integral to the viability of a successful tour (3-13). The report concludes that there is significant untapped potential for tours within the county. In order to fully exploit its unique natural and cultural features and to capitalize on its "rich pioneer and settlement history" (4-5), there is a need to promote tour routes and destinations as well as to develop infrastructure in the form of an interpretive centre to service group tours (6-6). The Tours Map refers to four uranium sites including the Bicroft and Canadian Dyno mines, two uranium development sites, and the Canada Radium Mine (A-18). Finally, included with the tour framework, is the opportunity for partnership with Hastings County Mineral Tours (3-12).

The Bancroft Chamber of Commerce commissioned the *Mineral Development Report* (1994) to devise strategies to optimize "the economic impacts of resident and tourist use of the Bancroft area's

mineral resources"(1). Among the recommendations, several relate directly to the enhancement of cultural tourism opportunities in general, and to mineral collecting specifically. Cultural tourism initiatives include the development of package accommodation and field trips for school groups; partnering with accommodation, recreation, shopping and entertainment to target the international vacation market and the development of weekend getaway field trip and accommodation packages for the Ontario market (i). Mineral-specific initiatives include the development of retail opportunities for mineral specimen collection equipment and guidebooks to collecting sites. Of note, is the development of media information packages on the history and the current status of the collecting sites; this recommendation does not include direct reference to any past uranium producers (I). This omission may reflect upon the ambivalence of local residents, which is based upon a concern that the area's identification as a uranium producer may deter tourists from choosing Bancroft as a destination.

Included in the report are the results of two mineral recreation questionnaires, the first for field trip participants and guidebook purchasers, the second for mineral clubs. The surveys were used to estimate the economic impacts of mineral collecting for the Bancroft area. For the first group, the 1994 average per day party expenditure was $80.67 (18). This group made expenditures mostly for fuel, food and accommodation. The second group spent an average of $77.00 per party per day on food, fuel, accommodations and mineral specimens and equipment (23). Using a percentage of the vehicle traffic count for the summer season, the overall economic impact of mineral collecting tourism was estimated to be $5.6 million per season (28).

The 1992 *Earth Sciences Centre Pre-feasibility / Concept Development Study*, examined the viability of the development of an institution to interpret the social and economic history of the Bancroft area and to serve as an environmental research and education resource for both the public and the private sectors (1-1,2-14). Emphasized in the report are the unique strengths of the area which include its rich natural resource base, its heritage resources and its strategic location between Toronto, Montreal and Ottawa (2-9). Among the market trends noted is the saturation of the Muskoka tourist area, which positions the Bancroft area to receive the potential market overflow (2-19). As well, in light of the

increased interest of travellers in heritage attractions. touring and sightseeing. many Bancroft area attractions already reflect the economic heritage of the area including the mining and mineral displays at the museum and the annual Rockhound Gemboree (2-21).

During consultation with post-secondary education institutions regarding the Earth Sciences Centre concept, interest was expressed in several aspects of mining heritage. These included the history of mining, mining technologies. the environmental impacts of mining, groundwater contamination and land and tailings rehabilitation (4-11). Similar consultation with private industry resulted in the identification of environmental reclamation and the development of related commercial technologies as integral to establishing the Earth Science Centre concept as distinct from Science North. the Royal Ontario Museum or the National Museum of Nature (4-20).

The story of uranium mining represents a significant opportunity to commemorate an as yet untapped aspect of the industrial heritage of the Bancroft area. In addition to the aforementioned items identified in the Earth Sciences Centre concept, there exists a significant opportunity to explore the global and the national contexts of this industry. Additional items for interpretation include the role that Canada played in providing uranium for the United States' atomic arsenal and the development of our domestic nuclear power industry. as well as the evolution of early mining and milling technologies and the development of policies. procedures and technologies for the decommissioning of mine and mill facilities . Above all. the interpretation of the uranium mining industry offers an exciting opportunity to describe and to analyze the relationships between the economy of a small community. the impact of Canadian trade relations with the United States. and changes in the global market for strategic minerals. Thus. interpretation of the uranium mining story is well positioned to gain from the growth of the cultural tourism sector: as a heritage attraction it emphasizes a cultural feature that is. within Central Ontario. unique.

3.0 *Strategies for Interpretation*

The evaluation of an industrial heritage resource begins with an inventory that includes both on-site field research and a review of related literature. This inventory process provides a framework for the assessment of heritage significance as well as the information required to undertake any measures for conservation and interpretation. On-site field research is preceded by preliminary evaluation of the site using both current and period maps, aerial photographs and site plans. A foot survey of the site follows in which detailed drawings, photographs and sketches are used to provide an illustrative inventory and written descriptions of individual features provide a descriptive text (Fram and Weiler 26. Alfrey and Putnam 135). Any buildings are assessed through a structural survey that includes descriptive text, sketch plans and photographs.

Documentary research is used to identify past and present ownership of the site as well as to produce a detailed account of the history of the site. This includes all related literature, photographs, maps, site plans, audio and visual records; interviews or oral history from older local residents are also invaluable (Fram and Weiler 11.12). As the documentary and field research progress, geographic, chronological and thematic boundaries can be determined (Alfrey and Putnam 135).

As individual components of the site are identified and described, relationships emerge to tell the story of the site. It is recommended that the analysis of a site move beyond the traditional framework of structural appearance, integrity and historical context to include the underlying functions and industrial processes (Andreae 35). In *Appreciating the Architecture of Industry*, Andreae suggests that industrial processes be used as a starting point: that in tracing the movement and the transformation of material, the industrial processes can be understood and the relationship of any structural remains to their functional and historical contexts can be achieved (36). The use of both period site plans and industrial process flow charts can illustrate the specific arrangement of equipment and buildings to provide both description and analysis of functions to tell the story and complement any on-site remains. In short, this process-based framework for evaluation and analysis can provide a sound basis for interpretation of the resource, that is

constructing an understanding of the remains and communicating its value as a part of the story of a place and a community.

Storytelling is the foundation of any strategy for interpretation. In communicating the story of a landscape or cultural feature, a community's understanding of, and their ability to identify with, their landscape is nurtured. The enhanced understanding and sense of place can contribute to an ethic of stewardship for the landscape and for the story. Interpretive plans are based upon the physical remains and traces and the story that can be told about them: incomplete structures and traces require the use of period photos, maps, plans and oral history to contextualize and present the story as a whole. Alfrey and Putnam summarize the process-based approach to interpretation of a mine / mill complex: "As the visitor follows the route taken by the ore, the operation of the machinery can be explained in technical terms, but the site can also be animated by an account of the work required in the operation: how many people worked in the plant, where were their stations, what it was like to work there"(224).

3.1 *Gold Rock*

The Gold Rock case study is an example of an assessment of the heritage values of an abandoned and remote gold mining centre. In 1977, the Ontario Ministry of Natural Resources' northwest region geological staff undertook a survey of historic gold mining sites, in order to address the relative neglect of the story of primary resource industries by provincial historians (Campbell and Cuming 190). The Gold Rock site, *circa* 1890 to 1910, consisting of four mine sites, forty kilometres south of Dryden at the north end of Manitou Lake, was determined to be the best example. The following year, a joint project to assess the heritage value of the Gold Rock site was undertaken by the Ministry of Natural Resources, the Ministry of Industry and Tourism and the Ministry of Culture and Recreation. The project aimed to establish the site's historical context, to evaluate its physical, technical, economic and social impacts on the surrounding area, to evaluate ruins and remains and to determine an appropriate strategy for conservation (Campbell and Cuming 181).

The historical context was established by a review of annual reports from the former Ontario Department of Mines, which provided specific details of the Gold Rock mines' exploration, development, production and inspections. The annual reports also provided a general overview of the development of gold mining in the province (Campbell and Cuming 190). To determine the relationship of the gold mining industry to the region's settlement patterns and economic development, newspapers and journals, claim files, company files, Department of Labour mine inspections and colonization road plans were reviewed (191). Through this review, it was determined that mining was dependent upon logging; access to remote areas was provided by the logging industry and timber interests financed early mine development (196). The site's technological status was determined through the use of period textbooks and American publications; technical diagrams of equipment and standard plant layouts were obtained for on-site field surveys. A chronology of mining activity was developed, as was a description of each stage in the mining and milling of the ore (199).Through this review it was determined that the Gold Rock site represented:"... the first application in Canada of American gold mining technology and as such resulted in the training of a number of prospectors, miners and engineers who later went on to build the Porcupine" (196).

A field survey of the site was undertaken to obtain a detailed assessment of the condition of the remains, artifacts and the general landscape (205). The survey was applied in two phases, a preliminary field survey, followed by a more detailed examination of each mine site: Elora, Detola, Laurentian and Bigmaster. Sketch maps, photographs and site plans were generated to make a record of each feature's design, construction and condition; features included structures, tailings and development work such as trenches, test pits and shafts (206). A description and assessment of each of the four sites was developed in order to compare them to similar sites elsewhere in Ontario (213).

The study concluded that the Gold Rock site was representative of early gold mining activity in Ontario and that the most appropriate strategy for conservation was designation of the site as an historical class of Provincial Park, in the Northwestern Ontario Boundary Waters Gold theme segment, within the Mining and Mining Communities theme (188). However, the Gold Rock site was not in public ownership

and acquisition of the land was not within the scope of the study (189). The final recommendations included immediate measures to protect the site from weathering and vandalism and further study to determine an appropriate conservation strategy and designation as an historic provincial park or as an historic zone within a provincial park (218).

The Gold Rock case study demonstrates that, even as the industrial heritage values of mine sites have been acknowledged as sufficiently valuable to study, the same heritage values have not justified the allocation of the resources required to conserve and to interpret these sites. Although the Gold Rock sites were not developed as heritage resources, the preliminary study and assessment provide a foundation of information to tell the Gold Rock story and a model for the assessment of mine sites that can be applied to evaluate other sites for heritage significance. Two heritage mural case studies follow to illustrate an alternative approach to commemorating and interpreting local heritage in general and mining heritage in particular.

3.2 *Chemainus*

Chemainus, population 3900, is located on the east coast of Vancouver Island between Victoria and Nanaimo. Since the arrival of European settlers in the late 1850's, the economy of Chemainus has depended upon timber extraction and milling. In the early 1980's, the town's economic viability was threatened by a temporary closure of the MacMillan Bloedel mill. At this time, the provincial government chose Chemainus for a downtown revitalization project (Meisler 55). The town chose to revive its downtown with an historical mural project for the walls of downtown businesses. The project has resulted in a significant revitalization, attracting new businesses, new residents and an estimated 400,000 tourist visits per year (54).

Credit for the mural concept is owed to Chemainus resident, Karl Schultz, who emigrated from Germany in the early 1950s. He worked for a time at the MacMillan Bloedel mill and then established a custom woodworking business. While vacationing in Europe, he was impressed by 15th and 16th century frescos depicting biblical scenes and the lives of saints, that adorned the walls of Romanian monasteries.

The frescos inspired Schultz to suggest murals for Chemainus to attract tourists: he presented the concept unsuccessfully to the Chamber of Commerce in 1971 (55-56).

Ten years later, when Chemainus received funding to revitalize its downtown, the mayor directed Schultz to develop a strategy. Schultz successfully proposed the mural concept as the anchor for the revitalization project. The first five murals were commissioned for $10,000.00 in 1982; the following year, seven murals were commissioned. At present, there are thirty-two murals on buildings and on standing walls depicting many aspects of the history of the town. Subjects include logging and milling, shipping, local businesses, the telephone exchange, Japanese Canadian heritage and Coast Salish heritage. The murals are based upon historic photographs compiled in a 1963 history of Chemainus. Artists have included local residents as well as artists from across British Columbia and outside of the province.

3.3 *Atikokan*

In 1986, the Atikokan Economic Development / Futures commissioned two studies to examine strategies to increase the tourist draw to the town. Among the recommendations, was a linkage of the tourist bureau, the town core and the Steep Rock Mine heritage with banners, artifacts and murals.

The art and English teacher at the Atikokan High School, Heather Schmutzer, was inspired by the use of historic photographs at the Iron Mine restaurant. In 1990 she began her first mural, *The Ore Movers*, depicting a huge Lectra Haul truck being loaded with iron ore from the pit of the Steep Rock Mine. Her second mural, *The Lake Movers*, shows the removal by dredges of material from the bottom of Steep Rock Lake, to develop the pits for the two iron mining companies, Steep Rock Iron Mines and Caland Ore Company (Figures 9 and 10). Two additional murals have been undertaken as projects by the senior art classes at the high school. Teaching staff develop a preliminary selection of historic photographs; students choose and research a photograph and paint that section of the mural. One of the student murals provides an overview of the development of the Steep Rock Mine; the other depicts various items of interest in the history of the Atikokan area (Figure 11).

Figure 9: The Earth Movers, Atikokan Ontario

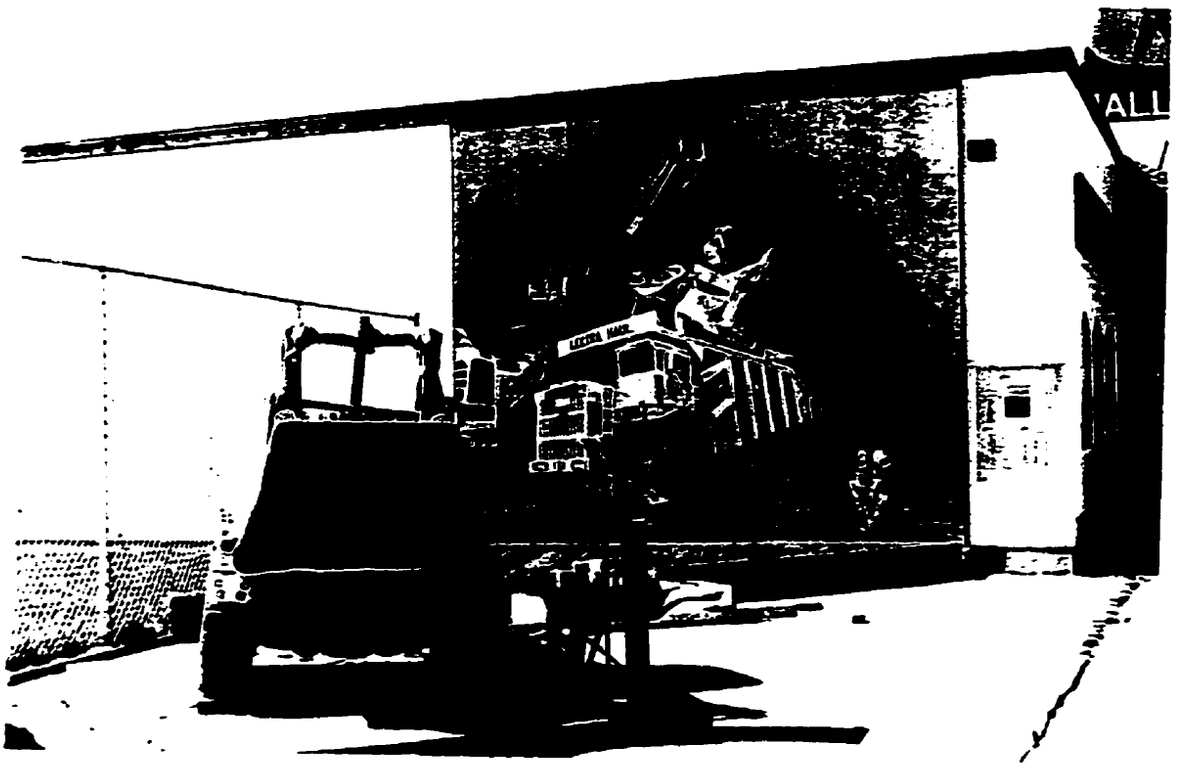
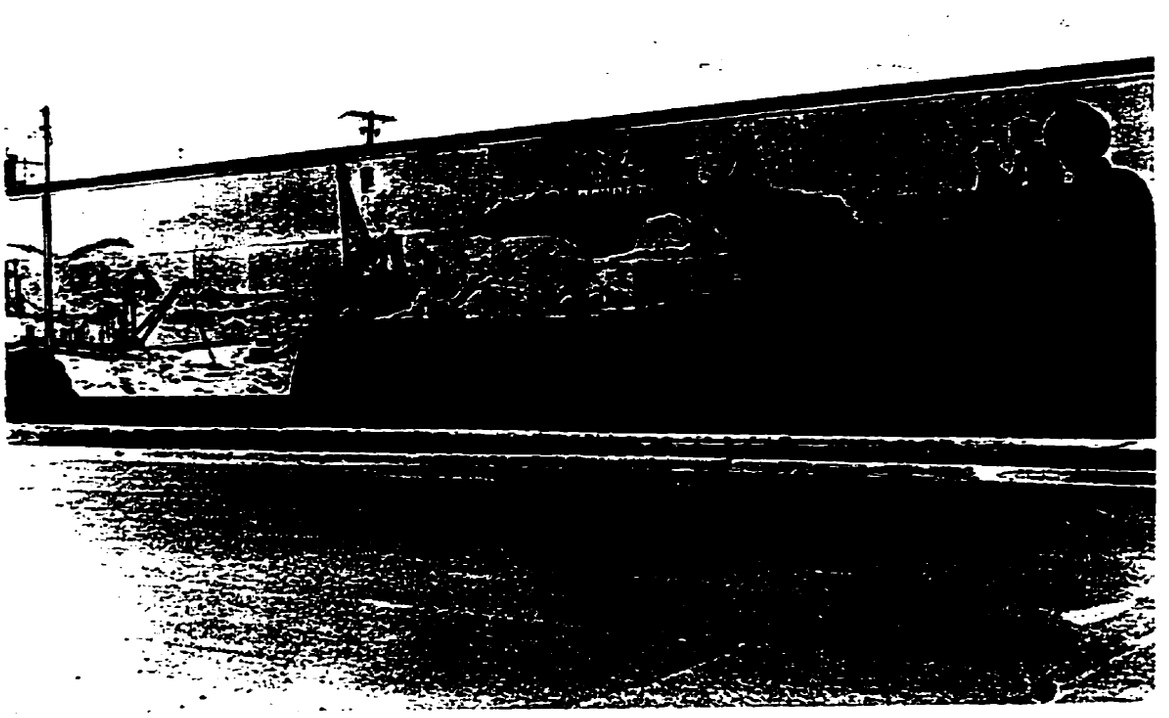
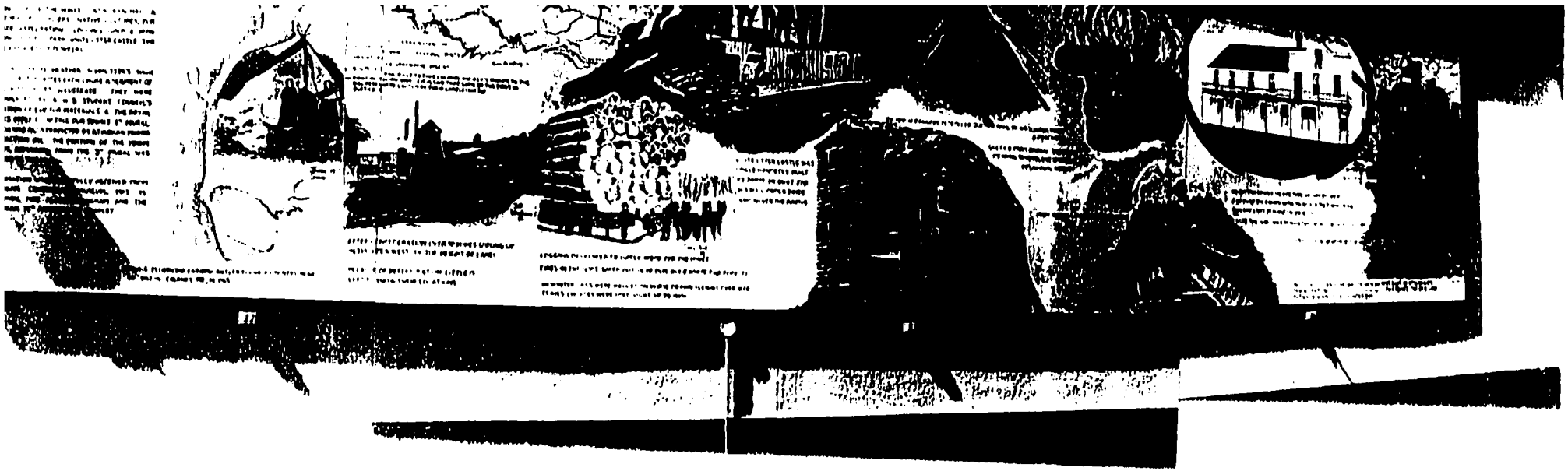


Figure 10: The Lake Movers, Atikokan Ontario





Funding for the murals has been provided through the sale of mural squares, grants from the Ministry of Northern Development and Mines, donations from the Atikokan High School Student Council and from local businesses. Labour has been donated to bring the cost of the murals to approximately $2500.00 each. Enthusiasm for the mural project has developed considerably; two local banks and one service club have provided the financing for displays of mining artifacts and interpretive plaques set in boulevard parks adjacent to the murals. Heather Schmutzer emphasizes the benefits for education, the nurturing of local pride and identity and community economic development. She is presently working on the fifth and final mural in the mining heritage series, a mural that will focus on the closure of the mines. Themes for future mural development include First Nations, the forest industry and the railway (Schmuzter 1996).

3.4 *Bancroft*

The concept of heritage mural development can be applied to the interpretation of the industrial heritage of the uranium mining industry in the Bancroft area. The development of murals on the sides of buildings or on standing walls can facilitate the telling of a story of which few readily accessible traces remain. Mural development is also a means to effectively address the issue of exposure to low-level radiation that may preclude the development of on site interpretive displays at any of the former mine sites, or it may complement the development of a trail or tour approach to interpret the uranium mining story.

Mural development is optimally based upon the use of historical photos. The collection of historical photographs and oral history represents a valuable opportunity for nurturing community identity and a sense of ownership for the story of the industry. A call for old photographs or participation in an oral history project would alert older residents to the value of their memories and artefacts. The development of a heritage mural could be modeled on that of the Atikokan High School art classes: students could undertake the research and execute the mural. There are also numerous visual artists in the Bancroft area who could execute the actual painting of a mural or who could work with students to

accomplish this. There exists a significant opportunity to unite art and industrial heritage, to nurture local artists, to celebrate a neglected story and to inform visitors and newcomers about the economic history of the area.

The potential for economic revitalization from mural development is evidenced by both Chemainus and Atikokan: once murals are completed, business owners develop an appreciation for their value for local pride and as points of interest for tourists, and become involved in financing additional murals and other interpretive presentations.

In any discussion of creating opportunities for cultural tourism, the unique aspects of a place are identified as elements to be celebrated (Nozick, Heritage 8). In the case of the Bancroft area, it is the legacy of the uranium industry that sets it apart from the Muskoka area, the Ottawa Valley and the Peterborough area. Sadly, the story of this industry is more often perceived as a liability by residents and business owners of the Bancroft area. There is a widely held belief that circulation of the uranium mining story would deter new permanent and seasonal residents and business investors. The curator of the Elliot Lake Nuclear and Mining Museum, which was established in the early 1960s to tell the story of uranium mining in Elliot Lake, advises honesty and openness in any approach to this story. In the Elliot Lake museum, visitors make rather infrequent inquiries regarding the radiation safety of the industry and its remains; more often, they indicate an interest in visiting underground (Hemingway-Conway, 1996).

The story of this industry is not to be feared or ignored. Rather it stands as an example of how global politics and federal defense policy can affect the economic life of a small community on the periphery of major population centres. The story of the uranium mining industry illustrates the typical boom and bust cycle of the mining industry in general and how changes in technology and the discovery of richer bodies of ore in other places will determine the long-term viability of the industry. The story also stands as an example of the evolution of uranium mine decommissioning and environmental reclamation technologies. Finally, this industry deserves acknowledgment as a significant player in local economic history, which left behind a legacy of infrastructure in the form of settlements, highways, churches and schools as well as a legacy of low-level radioactive waste that requires long-term monitoring and care.

3.41 *Mining Heritage Tour*

With reference to the Trails and Tours study reviewed previously, the story of the uranium industry in Haliburton and Hastings Counties can be told with an automobile-based tour that traces this industrial activity from early radium-related exploration and development in the 1920s, to the final stages of mine site decommissioning in the 1990s. Some sites may be accessed from a car window while others may require reconnaissance on foot. Development of a tour is realized through a self guided-tour map that would include a summary of industrial activity for each of the following points of interest as well as information to provide a general context for the uranium industry. The Fission Mines Limited property (Cardiff Township, Concession XXI, lots 4,5,6) at the north end of the Highway 648 loop near Wilberforce, hosts the site where W. M. Richardson discovered radium in 1922, before the founder of Eldorado Mining and Refining Limited, Gilbert Labine, staked his claim at Great Bear Lake in 1930 (Figure 2). The W. M. Richardson site represents an ideal starting point for the story of the uranium industry, with its origins in association with radium as a treatment for cancer. The Cheddar site, also known as the Canadian Radium Corporation Limited property (Cardiff Township, Concession XII lot 9), is located on Highway 121 close to the junction with Highway 648 / Dyno Road (Figure 2). This property may represent the next phase of the story, as one of many mining properties which witnessed significant development activity but no actual operation as a mine. The next chapter of the story is represented by the village of Cardiff and the two nearby uranium mines for which it provided housing; the Bicroft Uranium Mines Limited (Cardiff Township, Concession XI lots 27, 28) and the Canadian Dyno Mines Limited (Cardiff Township, Concession VII, VIII, IX lot 12). Cardiff is still home to people who remember the mining era and the townsite itself possesses a story as a settlement accompanying the establishment of a remote industrial development. The Dyno Mine site contains the foundations of the mill and other surface structures, which can be viewed at a distance from the Dyno Road or which can be toured on foot. The Bicroft Mine tailings impoundment area is readily visible from Highway 121 across from Center Lake. Both the Bicroft and the Dyno sites represent mines that were abandoned in the 1960s and subjected to remedial decommissioning work in the 1990s. The Bicroft mill buildings were seized by the township for

the nonpayment of property taxes in 1995. These buildings present an opportunity to develop an interpretive infrastructure to enhance development of a tour initiative. The Madawaska Mines Limited property (Hastings County. Faraday Township. Concessions A. B. IX. X. XI) and the Greyhawk property (Faraday Township. Concession XII. lot 10). represent the most recent context of the uranium industry. that of decommissioning and long-term monitoring (Figure 2). The Madawaska property. which is covered with gravel. contoured and revegetated. is readily visible from Highway 28 as one approaches the village of Bancroft. The Greyhawk property has been similarity treated but it is not visible from the highway. Clearly. the story of uranium mining in Haliburton and Hastings Counties could be told in a tour that begins with the Fission property. proceeds to the Cheddar property. continues at the Cardiff townsite with the Bicroft and the Dyno mine sites and which concludes at the decommissioned Madawaska property.

4.0 *The Canadian Dyno Mine*

When evaluating the industrial heritage value of the Bancroft area uranium mining industry with regard to opportunity for site-specific conservation and interpretation. the Canadian Dyno Mine represents the only site which still contains significant remains. The mine / mill complexes at the Greyhawk and Madawaska mines have been completely demolished. while the Bicroft mill building and ore bins still stand. The remainder of its mine / mill complex no longer exists. The Canadian Dyno site. however. contains foundations and walls for most of the mine / mill complex. in a visually striking setting. located a short distance from the tailings impoundment area (Figures 12 through 14). In addition to the physical remains. descriptions of the mining and milling processes are available and the mine's operating life is chronicled in the 1960 *Final Report* of the Mine Manager. P.S. Cross.

For the past two decades. the property of the Canadian Dyno Mine was owned by Conwest Exploration Company Limited. which was recently purchased by the Alberta Energy Corporation. This company also owns the property of the former Madawaska Mines Limited. which is the only Bancroft area uranium mine to be decommissioned according to the procedures of the Atomic Energy Control Board.

Figure 12: The Fine Ore Bins and the Mill Foundations of the Canadian Dyno Mine

Figure 13: Fine Ore Bin #2 at the Canadian Dyno Mine

Figure 14: The View from the Top of the Canadian Dyno Mill Foundations

The ownership of these two properties by the same company provides an opportunity both to interpret the most intact former mine site, the Canadian Dyno Mine, as well as to interpret as a case study, the process of decommissioning of the Madawaska Mine. The Madawaska Mines Limited *Annual Reports* to the Atomic Energy Control Board (1983-1995) provide an extensive chronology of a site specific-decommissioning program.

The *Final Report* for the Canadian Dyno Mine provides the foundation for an interpretive strategy for this site. A summary of this report follows to illustrate the interpretive value of such documents. This summary is accompanied by a description of the Canadian Dyno Mines Limited mining and milling operations as industrial processes.

The *Final Report* indicates that the mine was brought into production approximately $775,000.00 under capital estimates and that transferring the balance of Canadian Dyno's contract with Eldorado Mining and Refining Limited, to Gunnar Mines Limited of Saskatchewan, allowed the company to pay off its debts and to provide a respectable profit to its shareholders (Cross 1). This report provides descriptions of the mine's location, its water and electrical supplies, as well as accommodation and fire protection for its senior personnel, married and single employees (2-3).

The story of the mine's initial exploration and development is chronicled with a description of the company's receipt of a letter of intent for a premium price contract that positioned it to arrange financing in order to secure the contract (5). Plant construction for the mine and the mill are reviewed, including estimated and actual capital costs, with four tables that list the specific values of buildings, surface plant equipment and underground equipment (6).

The review of underground development includes descriptions of the excavation of the main production shaft and the various working levels, including a table that summarizes all of the development work such as shaft sinking, crosscutting, drifting, stope raising and surface and underground diamond drilling (7). Descriptions of the mining operation include stoping methods and the extensive use of timber supports and rock bolting for the stope walls that occurred when the ore shoots were discovered to be more

narrow and irregular than had been indicated by the initial development drilling (8-9). Stoping costs of $4.14 per ton of ore are summarized in a table that presents a breakdown of the cost into each component of ore retrieval such as drilling, mucking and tramming, timbering, hoisting, sampling, ventilation, power and direct and indirect labour. Another table provides a summary of the quantities of ore and waste generated during the operation of the mine.

The Canadian Dyno Mine operation was divided into nine departments, each with a department head reporting directly to the Mine Manager. The departments included the Milling Department, the Mining Department, the Engineering Department, the Geological Department, the Electrical Department, and the Mechanical and Surface Department. The Accounting Department contained Purchasing and Warehousing as well as the Safety and the Security Departments (15-16). A table provides the distribution of employees in each department.

The Geological Department was responsible for discovering, developing and controlling the uranium ore through the use of diamond drilling, test holes and geiger counters to indicate ore shoots and to test muck samples. This department directed the activity of the Mining Department through development layouts which were based upon information about ore shoots obtained through drilling and geiger probing. Geologists visited the stopes daily to mark the working faces for the drill operators and they monitored the muck grade by using geiger counters (10-11).

The Engineering Department undertook surface and underground surveying, mechanical design and drawing, and mining layout work. The Chief Engineer supervised the surveyors and prepared the monthly production reports. The Planning Engineer supervised the surveyors and recorded development footage and the quantities of ore broken. The Bonus Engineer calculated the monthly contract bonus which was based upon a price per unit of work, minus wages and powder, from the mine's gross earnings. The Ventilation Engineer made routine dust and radiation surveys on the surface and underground and reported these to the Ontario Department of Mines (11-12). The Safety Engineer was responsible for all aspects of safety for the operation. The safety record of the mine and the mill was not favourable, and the *Final Report* cites the condition of the wall rock and a working climate of continual pressure to increase

production as factors that influenced the high accident rate, which included six fatal accidents in three years. A summary of these fatalities includes their names, ages, ethnic origins, marital status, number of dependents and cause of death (12-13).

The mill operation of the Canadian Dyno Mine boasted the lowest operating costs in the Canadian uranium industry, due to ongoing ore treatment innovations that increased the recovery of uranium and automation in the mill circuit that reduced the number of workers (14). A table summary of production and a copy of the company's *Summary of Lot Shipments* are included (15). Operating costs are summarized in a table in which these expenses are related to milling, mining, development, marketing, general and contingency. The higher than anticipated costs of development were attributed to a greater amount of that work required for each ton of ore due to its unpredictable distribution and the resultant changes in stoping (15).

Labour relations were summarized with an account of the formation of a union, the Canadian Dyno Employees' Association, in August 1957, which successfully negotiated a two-year contract in September of the same year. Unsuccessful bids, to become bargaining representatives for the workers, by the International Union of Operating Engineers and the United Steelworkers of America are included (17).

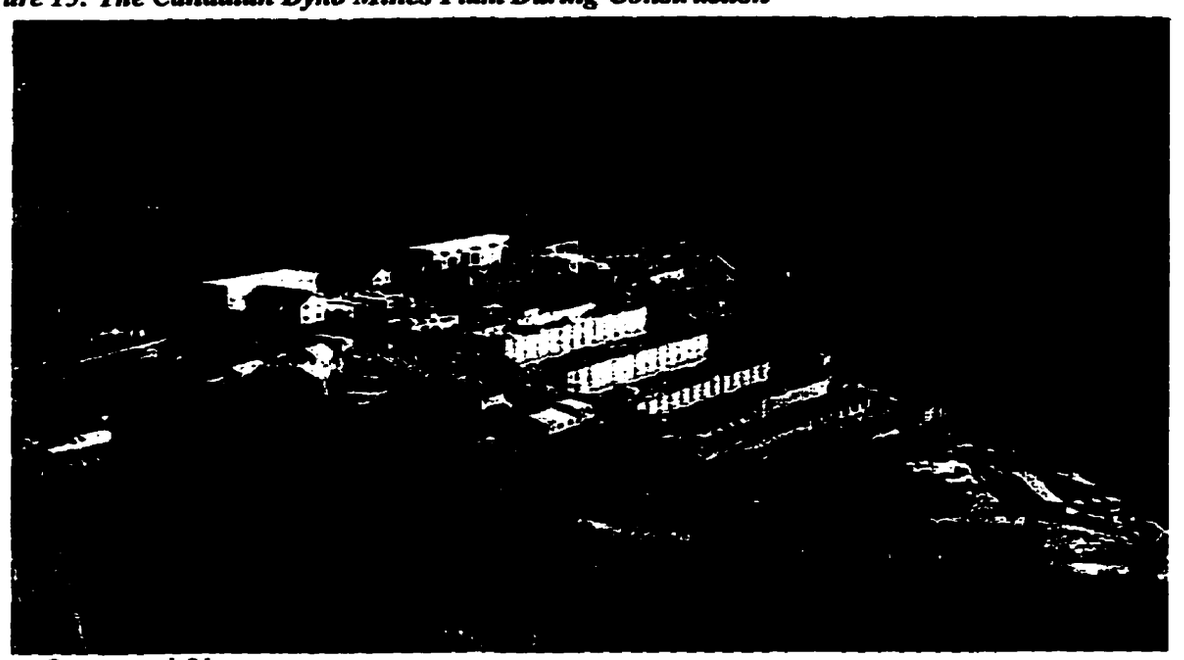
The final section of the report chronicles the close down of the Canadian Dyno operation. This includes the removal of all "Steel, pipe, rail, electrical equipment, and other items of value"(18), from underground, as well as the sealing with concrete of all underground openings. Salvage work in the mill included the dismantling and removal of conveyor belts, pumps, motors, piping, lab equipment, electrical fittings and heating and plumbing equipment. Inventories of equipment and supplies were prepared for their sale and several buildings were sold and removed from the property.

4.1 *Interpretation as Industrial Process*

There exists a significant opportunity to interpret the story of the Canadian Dyno Mine as an example of an industrial process. Within its historical context of Canadian federal policy to supply the USAEC and the UKAEA with uranium oxide, there exists the story of the exploration and development of the mine, the extraction of ore through mining, its transformation through the mill circuit, to emerge as uranium oxide, to be refined by Eldorado Mining and Refining Limited and shipped to either the United States or England for use in nuclear weapons.

The Canadian Dyno Mine site contains the foundations of the mill, the crusher house, the warehouse, the machine shop and other surface plant buildings. The *Canadian Dyno Mines Limited Plant Layout* (Figure 16) presents the distribution of buildings at the Canadian Dyno Mine in 1957. This diagram can be enhanced by a period photograph (Figure 15) and with a recent aerial photograph of the site, to allow for interpretation of the remains without requiring a visit to the site. The mill circuit, (Figure 20), allows one to trace the movement of ore and its transformation into yellowcake.

Figure 15: The Canadian Dyno Mines Plant During Construction



Source: Pancer *et al.* 91.

4.2 *Surface Plant*

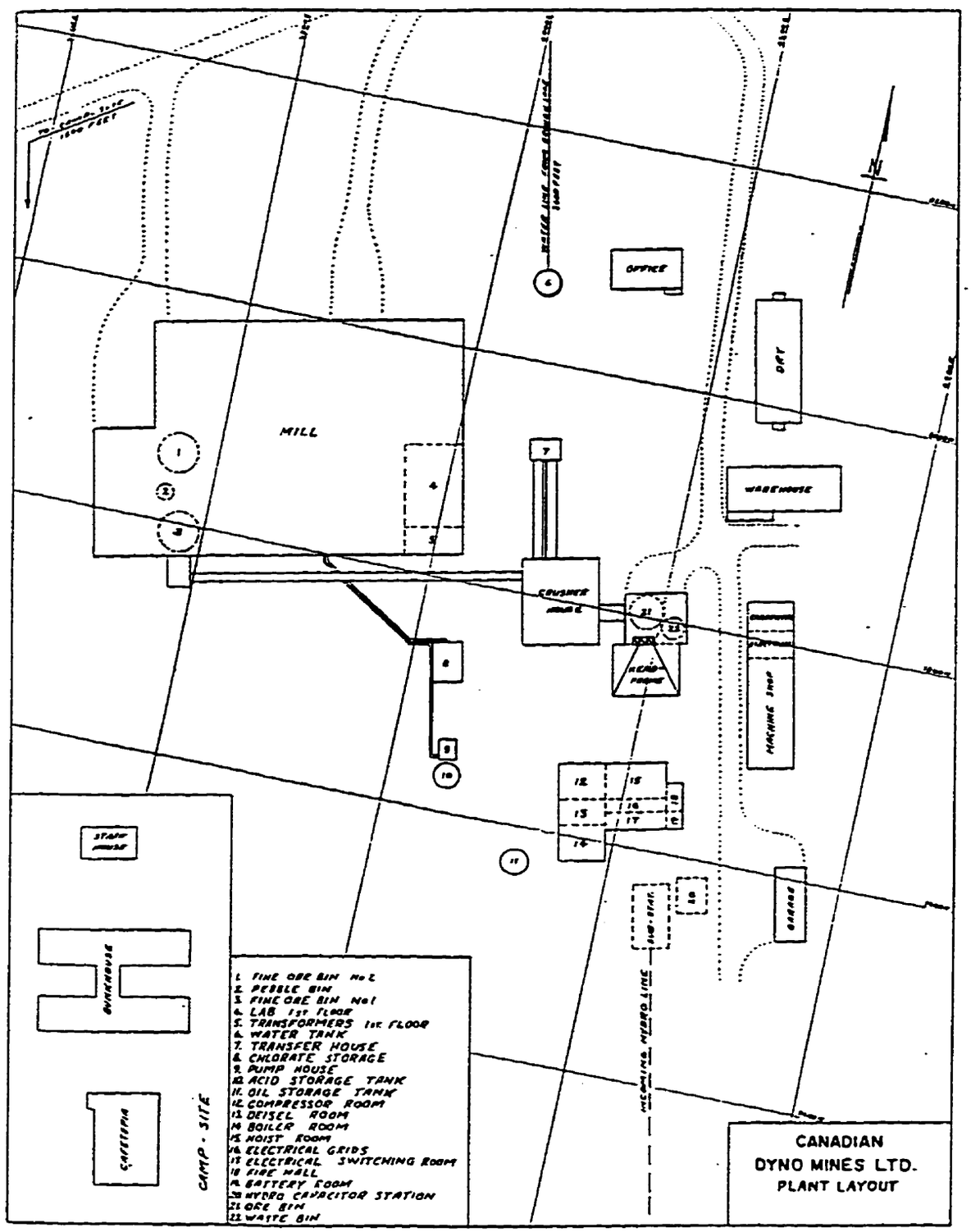
The compact arrangement of the buildings that comprised the surface plant of the Canadian Dyno Mine is related to the topography of the site. The Number One shaft (production shaft) was drilled at the summit of a ridge bounded on all sides by valleys. The headframe, hoist house, crusher house, bin house, water tank and mill were constructed on the bedrock of this ridge, while the bunkhouse, staff house, cafeteria and other service buildings were built upon rock fill produced by the sinking of the production shaft (Pancer *et al* 90). The *Canadian Dyno Mines Limited Plant Layout* (Figure 16) shows the location of the following buildings.

The headframe was built over the production shaft to a height of 110' (33.5m). It was constructed of fir from British Columbia and the timber was covered with shiplap, asphalt felt and white mine siding. The hoisting equipment consisted of 100" (2.54m) bicycle-type head sheaves supported on roller bearings that were set on steel beams. The headframe was designed to operate to a depth of 2500' (762.2m). The shaft house contained the machine doctor's shop, bit grinding and the core shack (Pancer *et al.* 90).

The bin house (#21, #22 on the *Plant Layout*) was located adjacent to the headframe and shaft house. It contained the ore bin and the waste bin. The 1000 ton capacity ore bin was constructed of steel to measure 30' (9m) in diameter; it was supported by six tubular columns for a total height of 58' (17.7m). The 250-ton capacity waste bin was 18' (5.5m) in diameter and was supported on four tubular columns (Pancer *et al.* 90).

The compressor room, hoist room, diesel room, boiler room, electrical switching room, fire hall and battery room, (#12 through #19), were all located in a building constructed of timber framework sheathed in a manner similar to the headframe and shaft house. The hoistroom (#15) contained a 300-hp motor designed to pull up to 28,000 lb. (10,448 kg). The compressor room (#12) contained two air compressors, each with a capacity of 3200 cf./m @110 lb., driven by two 600 hp motors, that delivered compressed air to a 14-inch line that ran down the production shaft. The heating plant (#14) consisted of

Figure 16: The Canadian Dyno Mine Plant Layout



Source: Pancer *et al* 92

two boilers supplied by a 25,000-gallon oil tank (#11). The boilers supplied heat for all surface buildings as well as heat for the drying of the uranium precipitate in the mill (Pancer *et al.* 90).

The machine shop, the electrical shop and the carpenter shop were located in a building across from the headframe and shaft house. Rail track from the shaft house ran the length of the machine shop to the electrical shop. A garage housed the surface vehicles which consisted of dump trucks, pickup trucks, a cranemobile and a bulldozer. The warehouse provided 2400 square feet of storage: four hundred square feet were heated for the purchasing agent's office and the records room (Pancer *et al.* 91).

The change house, or dry, had two floors and dimensions of 40' by 107' (12m by 32m). The ground floor housed the miners' change room, with adjoining toilet and shower facilities, and a capacity for 272 miners. This floor also contained the first aid station, storage for miners' equipment and offices for the mine captain, shift bosses and the timekeeper. The second floor contained the staff locker room, a lecture room and the mine superintendent's office. The ground floor housed the offices of the mine manager and the accounting staff, while the second storey contained the engineering and geology offices. The building also contained a two-storey cement block vault (Pancer *et al.* 91).

A powder magazine provided storage for up to 30,000 lb. (11,194 kg) of explosives; it was constructed of wood, with sand-filled walls, a steel door and ventilation louvers. A ventilation fan for the underground workings was constructed approximately 800' (244m) south of the production shaft. Water was pumped from a 100,000-gallon capacity, 90' (27m) high steel water tank (Pancer *et al.* 91).

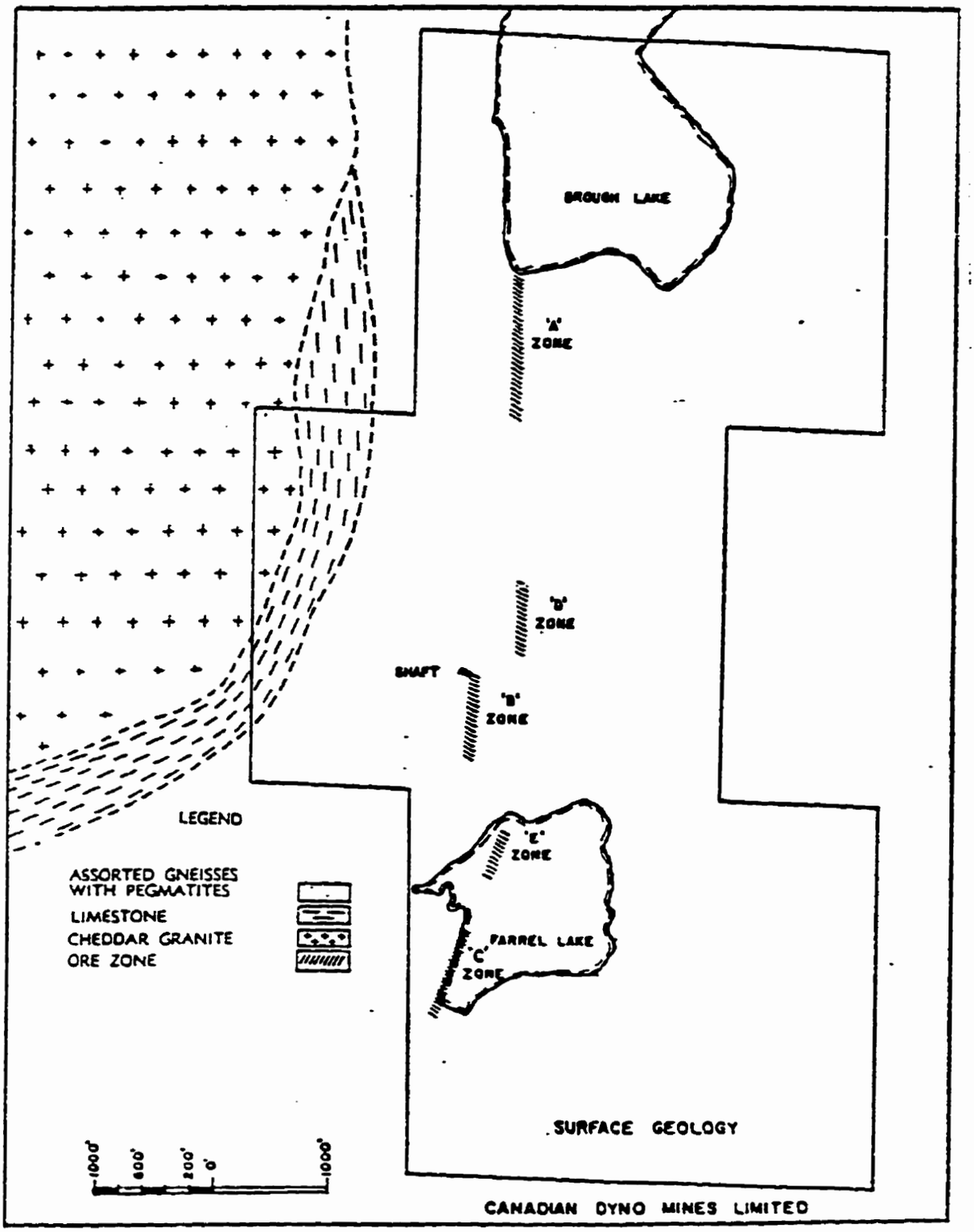
4.3 *Mining*

The Number One shaft (production shaft) was excavated from the top of the ridge to a depth of 1000' (305m); it measured 17' 8" by 6' 10" (5.5m by 2.1m) and was divided into three equal compartments each measuring 5' by 5'6" (1.5m by 1.5m). The two hoisting compartments were served by aluminum skip cages, while the manway contained the air line, the water line, the pump discharge line, the ventilation pipe and the electrical cable. Five working levels were established at 150' (46m) intervals from a depth of

180' (55m) to include 330', 480', 630' and 780' (100m, 146m, 192m and 238m). Pumping equipment to discharge ground water from the mine was located at the 930' (283m) level (Pancer *et al.* 88).

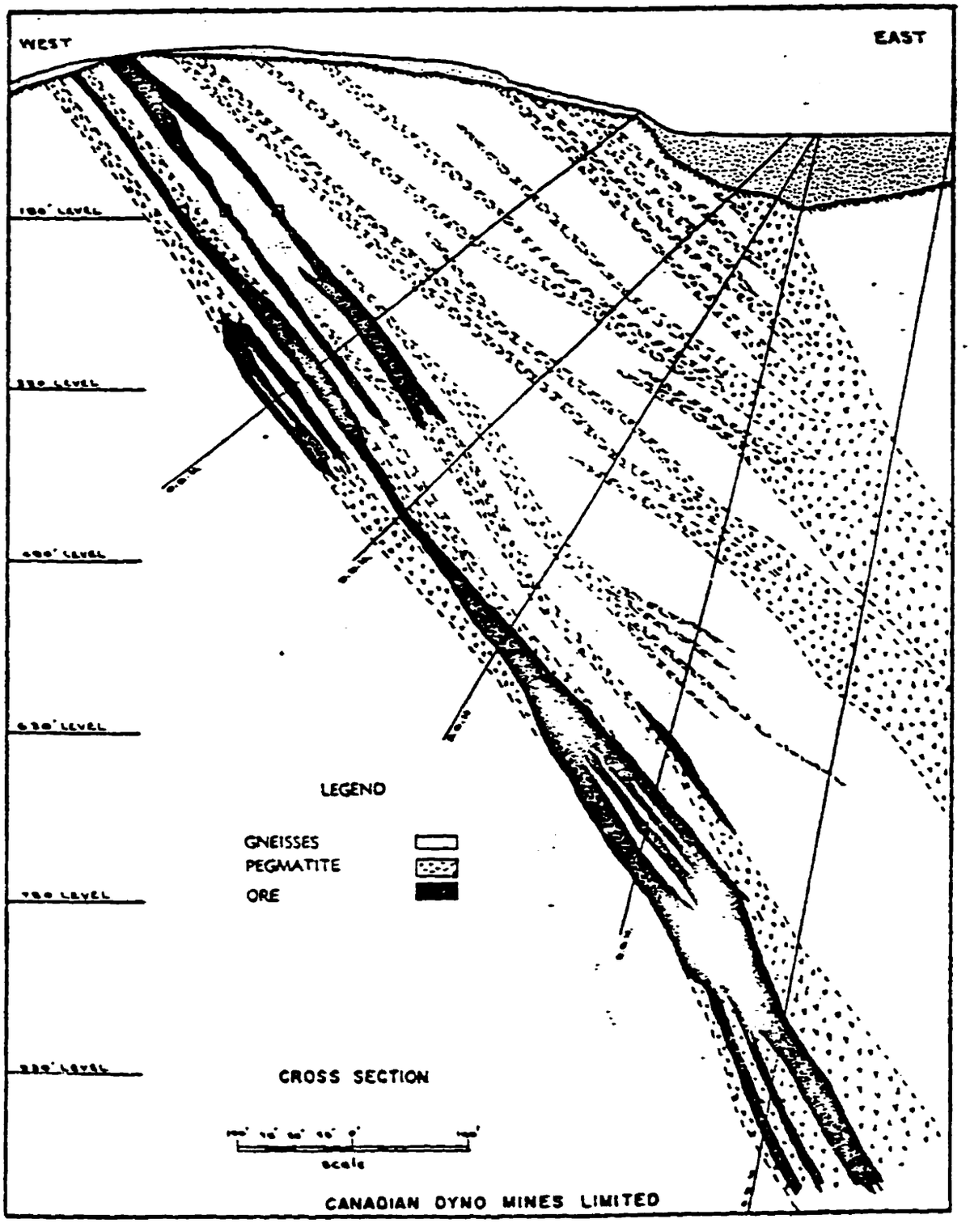
At each working level, a haulageway was excavated parallel to the ore zone (Figures 17- 19). From the haulageway, perpendicular loader drifts, spaced 45' (14m) apart and measuring 8' by 8' (2.4m by 2.4m), were excavated with boxhole drifts measuring 6' by 7' by 8' (1.8m by 2.1m by 2.4m) for stope preparation (Pancer *et al.* 88). The loader drifts were cut with jackleg drills equipped with tungsten carbide drill bits. Loaders were used for mucking (removing the ore) while battery-powered locomotives on 24" gauge rail, with 50 cubic foot capacity side dump cars, hauled the ore to the ore and waste passes. Stopes were broken with jackleg drills and explosives from 18' (5.5m) raises driven from the boxhole drifts. The ore and waste passes were isolated from the level workings with dust doors. The waste passes were equipped with 12' by 10' Grizzly openings and four-ton measuring bins. A 7' by 15' (2.1m by 4.6m) raise was cut to the surface 800' (244m) south of the production shaft to provide ventilation and an emergency exit from the mine (Pancer *et al.* 89).

Figure 17: Surface Geology of the Canadian Dyno Mine Site



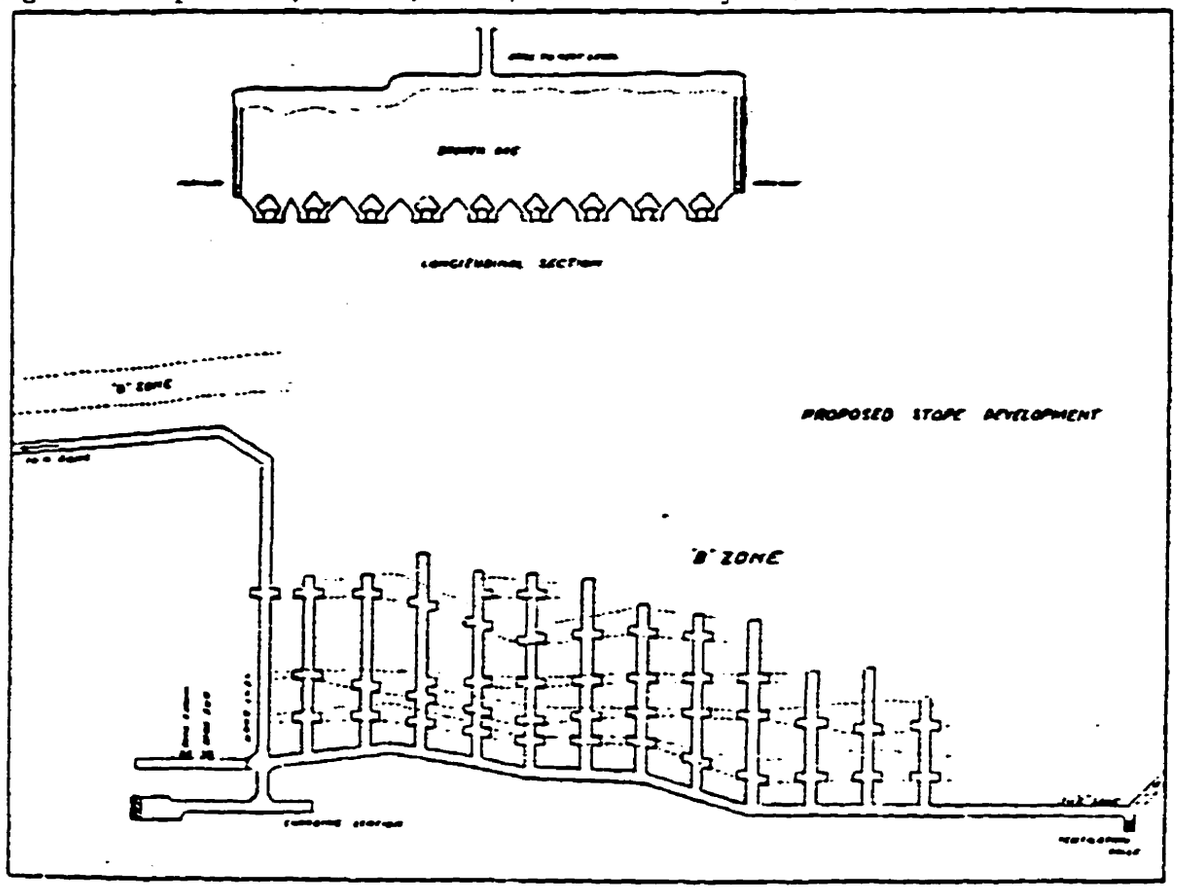
Source: Pancer *et al* 86

Figure 18: Sub-surface Ore Distribution of the Canadian Dyno Mine



Source: Pancer *et al* 86

Figure 19: Proposed Stope Development of the Canadian Dyno Mine



Source: Pancer *et al* 87

4.4 *Milling*

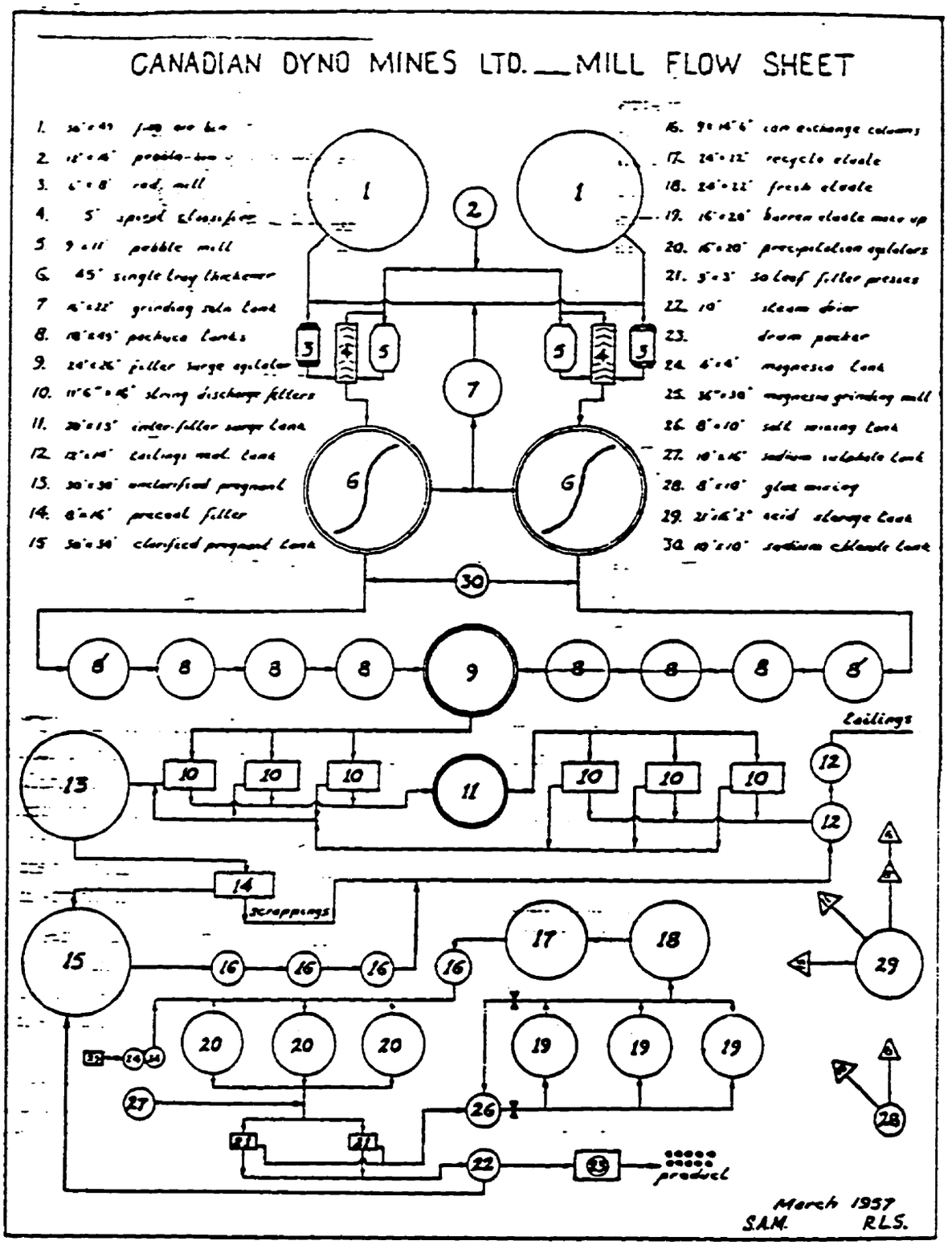
The process that transformed uranium ore into magnesium diurinate, or yellowcake, began underground where the ore was removed by drilling and blasting. Ore and waste rock were mucked out of the stopes and transported to the surface on skips for storage in the 1000 ton capacity ore bin at the head frame. The ore was discharged through the bottom of the bin to a conveyor belt, which delivered it to a 36" by 48" (91 cm by 122 cm) crusher (Pancer *et al*, 95). When the ore was crushed and screened to a pebble size of less than 4" (10 cm), it was transferred to a 5.5' (1.7 m) cone crusher, which reduced the ore to a pebble size smaller than ½ inch (1.3 cm). The *Plant Layout* (Figure 16), shows the location of the ore bin and the crusher house and the *Mill Flow*(Figure 20), illustrates each step in the mill circuit. Pebbles for the grinding mill were obtained by diverting oversized ore to a 2¼" by 2¼" (5 cm by 5 cm) screen and

collecting the sized pebbles in the 100-ton storage bin (#2 on the *Mill Flow*). The finely crushed and filtered ore, referred to as mill feed, was delivered to two, 1500-ton capacity, wooden fine ore bins (#1). The grinding of the mill feed was accomplished with two 6' by 8' (1.8m by 2.4m) rod mills (#3) in conjunction with two 5' (1.5) spiral type classifiers (#4). The sands from the classifiers were used in the pebble mill (#5) for additional grinding. The grinding units were designed to each grind 500 tons of mill feed per day, for a total daily capacity of 1000 tons (Pancer *et al.* 96).

The pulp from the classifiers contained approximately 20% solids. It was pumped to a series of 45' (14m) single tray thickeners (#6), where the solids content was increased to 60% for the acid leaching treatment. One pound of sulfuric acid was added to each ton of pulp to attain a pH of 6.8, and 0.1 lb./ton of organic flocculant was added to facilitate the settling of particles. The overflow from the thickening process was recycled to the grinding circuit (#7). The thickened pulp was then treated in two lines of four 18' (5.5m) diameter, 45' (14m) high pachuca leacher tanks (#8). Thirty to forty pounds of sulfuric acid were added to each ton of pulp in the first pachuca tank to reduce the pH to 2.0. The pachuca tanks were agitated with low-pressure air at 45 pounds per square inch (#9). As the pulp moved through the line of pachuca tanks, sulfuric acid was added, as required to maintain the pH, as well as sodium chlorate, to prepare the pulp for the extraction of uranium (Pancer *et al.* 96).

The acid leaching phase was followed by several stages of filtration. The acid pulp from the pachuca tanks was distributed to three 11' by 16' (3.4m by 4.8m) filters with string discharge (#10). Organic flocculant was added and a water wash transformed the acid pulp into first stage filter cake (#11). The first stage filter cake was repulped with sulfuric acid to a 60% solid solution and fed to the second stage filtration, with more organic flocculant and another water wash (#10) (Pancer *et al.* 96). The discharge from the second stage filter cake was pumped to the tailings neutralization tanks (#12) before discharge to the tailings impoundment. The first and second stage filtrates were combined to produce unclarified pregnant liquor (#13) and were passed through a drum precoat filter of diatomaceous earth (#14), to collect solution impurities and suspended solids. This produced clarified pregnant liquor with a pH of 1.8 (#15) (Pancer *et al.* 97).

Figure 20: Canadian Dyno Mines Limited Mill Flow Sheet



Source Pancer *et al* 96

The clarified pregnant liquor was treated in a four-column ion exchange unit (#16) which was used to upgrade the uranium content of the pregnant liquor by a ten to one ratio. Each of the four 9' by 14'6" (92.7m by 4.4m) columns contained 322 cubic feet of IRA 400. an ion exchange resin which selectively removed 99.5% of the uranyl sulphate molecules from the liquor. The columns operated in sequence: three of the columns operated on the adsorption phase and the fourth operated on the elution cycle. The solutions from the third column in the adsorption sequence no longer contained uranium. and were sent to the tailings neutralization. The elution cycle occurred when the resin from the first column in the adsorption sequence became saturated. The uranyl sulphate ($2UO_2$ SO_4)was removed from the resin by adding the elution solution of sulfuric acid and sodium chloride. This solution also regenerated the chloride ion content of the resin (#17. #18. #19) (Pancer *et al.* 97).

Uranium from the pregnant liquor was precipitated in wooden precipitation agitators (#20) which were equipped with stirring mechanisms. "Milk of Magnesia" (MgO) was added to obtain a pH of 7.0: this formed magnesium diurinate (MgU_2 O-). In order to facilitate the magnesium diurinate crystal growth. the pH had to be raised slowly over a period of three to four hours. When precipitation was completed the slurry was passed through a filter (#21), to remove the precipitate. The filter cake was washed with a dilute solution of sodium sulphate (#27) to remove the chlorides. which were then returned to the ion exchange columns as fresh eluate (#26. #19) (Pancer *et al.* 97).

The washed precipitate. or magnesium diurinate floc. was pressed to 50% moisture content and placed in a high-pressure steam dryer (#22). where its moisture content was reduced to 2%. The dried product. known as yellowcake. was packed in 55 U.S. gallon metal drums. each weighing 1000 lb.. and shipped to the refinery (Table 13). (Pancer *et al.* 98). Tailings treatment consisted of the neutralization of free acids and acid salts with the addition of hydrated lime to a series of agitators (#12). The product discharged from the treatment would have had a pH that would "closely approximate that of the supply of waters... from surrounding lakes and streams" (Pancer *et al.* 97).

Table 14: A Summary of Canadian Dyno Uranium Milling Processes and Products

Process	Additives	Product
Mining Crushing Grinding	 Water	Ore / muck Mill Feed Pulp
Acid Leaching	Sulfuric acid, organic flocculant Sodium chlorate	Acid Pulp
Filtration	Organic flocculant, water, sulfuric acid Diatomaceous earth	Primary & Secondary Filter Cake Unclarified pregnant liquor Clarified pregnant liquor
Ion exchange Elution	IRA 400 resin Sodium chloride, Sulfuric acid	Upgraded pregnant liquor Uranyl Sulphate ($2UO_2$ SO_4)
Precipitation	Milk of Magnesia	Magnesium diurinate slurry (MgU_2 O_7)
Filtration and pressing	Sodium sulphate	Magnesium diurinate floc
Drying Packaging		Yellowcake Yellowcake in drums

5.0 *Conclusion*

To conclude, the story of the uranium mining industry represents significant opportunities for the Bancroft area to celebrate its past, to set itself apart from neighbouring communities and to build upon its reputation as the Mineral Capital of Canada. The remains of the surface plant of the Canadian Dyno Mine with documents, as reviewed, that provide detailed accounts of capital investments, operations and industrial processes, offer a significant foundation for the interpretation of this industry. Collection of period photographs and the memories of area residents who were involved in the industry would breathe life into the story. In addition, photographs and oral history would provide historical resources to use for the development of heritage murals, a uranium industry tour or other interpretive strategies, in association with the existing small-scale interpretation at the Bancroft Chamber of Commerce Mineral Museum.

The case study of the decommissioning of the Madawaska Mine represents an opportunity to interpret the industrial waste legacy of this industry within the context of environmental reclamation and long-term institutional care. It allows, in complementary interpretation with the general history of the industry, an opportunity to provide information to allay people's fear of nuclear waste and to provide a sense of closure to the story. Complementary interpretation of the industrial heritage of the Bancroft area

uranium industry with the decommissioning process for the Madawaska Mine also provides an opportunity for residents and visitors to evaluate the impacts of this industry on the community. This evaluation includes consideration of the infrastructure legacies of the industry: the highways, settlements, schools, churches and businesses, as well as consideration of the industrial waste legacy and its requirements for perpetual monitoring and maintenance.

Finally, the industrial heritage of the uranium mining industry of the Bancroft area serves as a metaphor for the process of globalization. The story of the exploration, development, decline and decommissioning of the mines stands as an early example of globalization, whereby the economy of a small community in Canada's hinterland was transformed, for a time, by the forces of international trade in a strategic commodity and influenced to this day, however indirectly, by the long-term waste management needs of the mine sites and the attitudes of residents, visitors and potential investors towards these low-level radioactive waste sites. As Marcia Nozick identifies heritage as a means to link "past, present and future," the story of the uranium industry provides us with an opportunity to combat the socially homogenizing threat of globalization. In celebrating this part of the story of the area's economic history, that sets it apart from its geographic neighbours, there exists an occasion to critically examine the forces of globalization while providing opportunity for economic renewal through cultural tourism. The final irony in this story of a small, quiet place caught up for a time in the thrall of arming the American nuclear arsenal is that the commodity uranium extracted from the rocks of the Bancroft area had the potential to destroy all life on earth. This industrial heritage offers visitors and residents with the opportunity to ponder this irony in the present face of our changing global economy, where local voices are not heeded in the boardrooms of multi- and transnational corporations, and where the lessons to be learned from the perpetual responsibility for the waste sites of these mines can be well applied in consideration of future opportunities for the extraction or development of renewable and nonrenewable resources.

Conclusion

Environmental history aims to tell the story of place in a holistic way, in a manner in which it becomes a reflection upon the relationships between people and their biophysical environment, the environment and its inhabitants, and the dynamic of these relations that, over time, produces present-day context and influences future opportunities. Environmental history offers people the opportunity to remember and to acknowledge the legacies of their past activities and the imprints that they have left upon the landscape; it attempts to bring to the story of place a richness and a depth that includes all of the memories of a community, as well as the influences of the world outside. As such, the environmental history of a small place can serve as an allegory for the world at large, where the grand themes of history play themselves out on a much smaller stage. Environmental history leads to heritage; they overlap and share the gifts of learning, celebration and reflection.

The story of the uranium industry in the Bancroft area stands as an example of environmental history. As an exercise in environmental history, the compilation of the story of the industry, the analysis of its impacts on the environment by way of settlements and mine wastes, and its influences on the inhabitants of the region by way of community activism have been presented.

In order to understand the story of a specific place, its relationship to the larger, global context must be examined. This thesis presented a description of the evolution of the Canadian uranium industry from early radium-related activity to the development of atomic weapons in World War II, and from the Cold War nuclear arms race to the development of Canada's domestic nuclear power program and its export of nuclear technology. This general story demonstrated the relationships between academic research and the development of new technologies, in which European and North American researchers discovered medicinal uses for radium and unleashed the vast powers of the readily fissionable U^{235} isotope. As well, this served to illustrate the relationships between global politics and Canada's hinterland. As the Cold War heated up, politicians in Ottawa and Washington negotiated trade agreements to provide uranium for the U.S. nuclear arsenal. The special price contracts guaranteed by Ottawa through Eldorado Mining and Refining Limited served as a catalyst for the development of an

entire industry within five years. The resource extraction sector of this industry was distributed across the more remote parts of Canada. Mines and mills were located in the Northwest Territories. Northern Saskatchewan. Northern Ontario and in the Bancroft area. Of all of the mining camps. only Bancroft was located in proximity to the nation's industrial heartland. The swift demise of this industry in the early 1960s emphasized the close link between the remote mining camps and international trade relations. Once the U.S. had secured its nuclear arsenal and its domestic supply of uranium. the export-dependent market for Canadian uranium dissolved. It was only through Ottawa's stretch-out contracts and stockpiling programs that a portion of this industry survived to supply Ontario Hydro's nuclear program and Canada's Candu projects. The viability of the uranium industry continues to depend upon the export of Candu reactors and the use of nuclear generating stations. both at home and abroad. Thus the industry stands as an example of globalization: there is no 'local' market for uranium.

The commodification of resources in the Bancroft area began with timber and water. Its early economy was in a sense 'renewable' and 'sustainable' with the harvesting of first- and second-growth forests. hydro power. agriculture and wool providing an economy that endured for close to a century. The mining activity that began with gold. iron and corundum and culminated with uranium. has evolved to consist of the collection of mineral specimens in a more 'sustainable' scenery-based tourist-oriented economy. The influences of global trade may or may not repeat the cycle of mining boom and bust at some future time.

The story of the four uranium mines in the Bancroft area brings emphasis to the themes presented earlier. The relationship of Canada-U.S. trade and its impact on the economy of the Bancroft area is illustrated by the prospecting boom of the early 1950s and the swift development of the Bicroft. Dyno, Faraday. and Greyhawk mines. The 1973 Arab oil embargo and its influence on the global market for uranium is evidenced by the reopening of the Faraday Mine as Madawaska Mines Limited in 1976. The relative powerlessness of the Bancroft area in the face of a market determined by Canada's international trade relations is emphasized by the nearly fruitless lobbying undertaken by Father Maloney and the Bancroft and District Chamber of Commerce in the early 1960s with Prime Minister John Diefenbaker and again in the early 1980s with Ontario Premier Bill Davis. The environmental impacts of

the industry are given some detail in the description of the mining settlements of the Bicroft Heights, the Dyno Estates and Cardiff. The continued inhabitation and vitality of these settlements is perhaps the most positive legacy of this industry.

The case study of the decommissioning of the Madawaska Mine is framed within the context of the site- and situation-specific regulatory framework of the AECB. It is the contention of this thesis that the decommissioning process of the Madawaska Mine was extended from five years to at least thirteen years, due in part to the influence of the activities undertaken by the firm of James F. MacLaren in 1979, by the misguided attempt of the AECB to dispose of radium-contaminated soil at the Madawaska Mine in 1981, without prior consultation with the community, and by the well informed activism of the PLCA from 1985 to 1988. It is no coincidence that Madawaska Mines Limited was refused permission to abandon in 1988, and that the company has been required to attend to several tasks such as the decommissioning of the Number Two tailings Area in 1991 and the capping of all surface openings in 1995. It is no coincidence that the owners of the abandoned Bicroft and Dyno mine sites have voluntarily undertaken radiological assessments and remedial work between 1990 and 1992. It is no coincidence that these two abandoned mines are now being monitored by the AECB after thirty years of neglect. It is also no coincidence that, with the conclusion of the decommissioning of the Madawaska Mine, the AECB intends to host a public meeting that will include an overview of the remedial work at the two abandoned mine sites. These actions serve to illustrate the dynamic between the community, its environment and outside agencies and businesses such as the AECB, Conwest and American Barrick. As an example of environmental history, the chronicle of these events serves to demonstrate that, even in the face of a local economy being determined by outside forces, concerted efforts by members of a community can at times influence the actions of the big players in both the public and the private realms.

Finally, the industrial heritage potential of the uranium industry in the Bancroft area was assessed. As an example of industrial heritage, the story of this industry offers opportunity for learning. As Nozick identifies heritage as a means to link "past, present and future" (Heritage 3), the story of the uranium industry and the decommissioning of the Madawaska Mine represent tools to learn about the development and the demise of an industry, relationships between the local economy and the global

economy, the evolution of decommissioning and environmental reclamation and the influence of grass-roots activism. As environmental history and industrial heritage, this story offers opportunity for the nurturing of Bancroft's unique character in the face of socially homogenizing influences of globalization. As heritage, it offers the area an opportunity for economic development and renewal by way of cultural tourism that builds upon the foundation of the Chamber of Commerce mineral and mining displays and the annual Gemboree. As heritage it also offers the potential to link several sites in Haliburton and Hastings Counties in a mining industry tour that offers economic development to a somewhat larger geographic area.

As an example of environmental history, the uranium industry of the Bancroft area demonstrates the importance of telling specific stories of place: in the case of Bancroft, this industry is regarded by some as a 'dirty secret' that threatens future economic development, and as such its existence is at best downplayed and at worst ignored. In the face of the social homogenization that occurs with present-day globalization, environmental history and the interpretation of industrial heritage offer respite from the erasure of the story of specific places. By celebrating this unique story, a community is offered the opportunity to learn from it; to reflect upon its infrastructure and waste legacies. Increased public awareness has the potential for the development of an ethic of stewardship for both the story and the place, an ethic of stewardship that can bring the wisdom gained from reflecting upon past experience to future land use decisions.

Finally, as an exercise in environmental history, the story of this industry provides opportunities for further research, both applied and academic, including, but not limited to, the following:

- The exploration of the impacts of low-level radiation on the health of the miners and the mill workers in the uranium mining industry, in Canada and abroad, through an epidemiological study of the incidence of cancers and birth defects in this population.
- The exploration of the impacts of low-level radiation on human health, through an epidemiological study of the incidence of cancers and birth defects in areas with uranium mineralization and uranium

mines. Such a study could focus specifically on the Bancroft area or it could compare the epidemiology of the Bancroft area to other uranium mining areas in Canada, the U.S. and abroad.

- The comparison of the Bancroft story of boom and bust, waste legacy and grass-roots activism to other uranium mining communities in Canada, the U.S., Australia, Zaire and South Africa.
- The examination of the uranium mining industry within the context of its impacts upon aboriginal communities in Northern Saskatchewan, the Northwest Territories, the American Midwest and Southwest, Australia's Northern Territories, and South and Central Africa.
- The comparison of the AECB policies and procedures that govern the decommissioning of uranium mines in Canada, to the policies and strategies used by other nations to decommission their uranium mines.
- The development of a complete interpretive strategy for the heritage of the uranium industry in the Bancroft area that builds upon the existing foundation of the mineral tours, and the Gemboree, to optimize opportunities for increasing the cultural tourist draw to the area.
- The development of curriculum and teaching strategies for environmental history, for elementary, secondary and post-secondary schools, using the Bancroft area uranium industry as a case study.

Environmental history can thus be considered as a way to fully acknowledge the memory of place and its relationship to the world at large. As is evidenced by this thesis, conflict is present in the dynamic between members of a community, government agencies and private businesses. There are always those members of a community or an agency who would prefer to downplay or erase aspects of the story of a place, and surely the story of the uranium industry stands as an example of this. Environmental history, then, offers us a way to fully acknowledge the journey to our present-day context as it suggests lessons to be applied to our future decisions.

Appendix A Working Definitions

Abandonment "The relinquishing of further responsibility by a licensee, under the Atomic Energy Control Act and Regulations, for a mining facility or part thereof" (AECB Control A1).

Adit The horizontal entranceway to a mine

Air Lift Agitator "A device employed in metallurgical processes, using compressed air to stir or shake" (Ripley *et a.l* 299).

ALARA Acronym for "As Low as Reasonably Possible" which, combined with consideration of social and economic factors, provides the basis for radiological protection, for both radiation exposures and for releases of radioactive materials, in Canada and internationally. This principle is applicable to the long-term disposal of mill tailings to protect the well-being of future generations in an acceptably healthy environment (Kalin Radionuclide 2). (Siting Task Force 127).

Alpha Particle "A heavy particle produced by a radioactive decay process, it consists of two protons and two neutrons and is identical to the nucleus of a helium atom" (Siting Task Force 127).

Alpha Radiation A form of ionizing radiation emitted from natural elements such as uranium and radium, as well as from human-produced substances. Alpha radiation is "Scarcely able to penetrate the surface of the skin, it can be stopped completely by a sheet of paper" (AECB, Control 5).

Atom "The building block of nature, an atom is composed of a nucleus containing protons and neutrons surrounded by orbiting electrons" (Siting Task Force 127).

Background Radiation "The natural ionizing radiation from such sources as cosmic rays from outer space (neutrons, protons gamma radiation which emanate from the sun and outer space), naturally occurring radioactive elements in the ground and naturally occurring radioactive elements in a person's body" (Siting Task Force 127).

Barren solution "In a metallurgical process, the solution left after the value has been removed" (Ripley *et a.l* 299).

Batholith A batholith is a large, irregularly shaped plutonic injection of magma into the earth's crust that fails to reach the surface before cooling. It is referred to by Butzer as "a mass of magma with the dimensions of a mountain range" (24).

Becquerel (Bq) A unit of measure of radioactivity corresponding to one nuclear disintegration per second (dps). 1 Curie (Ci) = 3.7 x 10 dps or Bq 1pCi = 37mBq (Kalin, Radionuclide xvi).

Beneficiation "The preparation of an ore for metallurgical processing; usually by means of communition and concentration" (Ripley *et al.* 300).

Beta Particle "A light particle produced in radioactive decay processes. It may carry a positive or negative charge and is identical to an electron in mass" (Siting Task Force 127).

Beta Radiation A form of ionizing radiation that is more penetrating than Alpha radiation. It can penetrate human flesh but can be blocked by a few millimetres of metal such as aluminum (AECB, Control 5).

Chain Reaction "The process in which neutrons, released during the splitting of one atom, go on to split other atoms, creating a self sustaining reaction" (Bothwell, Eldorado 11).

Comminution "The reduction of ore size through the use of crushing and grinding" (Ripley *et al.* 301).

Concentrate "Ore that has passed through the beneficiation stage and is ready for further processing" (Ripley *et al* 301).

Concentration "The process of physical separation of a mineral from its gangue in preparation for chemical separation or extractive metallurgy" (Ripley *et al.* 301).

Decay Radioactive disintegration: the spontaneous transformation of certain elements called nuclides, into one or more different nuclides which results in the emission of alpha and other types of radiation. For example, the parent Uranium 238 decays into the daughter Radium 226 which decays into Radon 222 which decays into Radon Daughters (James F. McLaren, 3-3).

Diamond Drilling Drilling in rock that is accomplished with a diamond head on a hollow drill to extract a tubular core from the rock (Bothwell, Eldorado 43).

Dike An intrusive plutonic which is classified according to its size and location. Dikes are larger masses of magma that spread upward and along a vertical joint or fracture and fail to reach the surface before cooling (Butzer, 23-24).

Drift "A horizontal passageway starting from the outcrop and following the deposit" (Bothwell 43).

Flocculant "A reagent added to water to aggregate minute suspended particles so that they may precipitate out of suspension" (Ripley *et al.* 303).

Gabbro "A group of dark-colored, intrusive rocks comprised of ferromagnesian minerals (mafic)...the approximate intrusive equivalent of basalt" (Ripley *et al.* 303).

Gamma Radiation Ionizing radiation in the form of electromagnetic waves that can penetrate the human body.

Gamma Ray Short wavelength (high frequency) electromagnetic radiation of nuclear origin. Gamma rays are emitted from the nuclei of a radionuclide in the process of radioactive decay from natural elements in the earth's crust and from the sun in association with cosmic rays. Gamma Rays are measured in *Roentgens* (McLaren 3-2). (Siting Task Force 128). Gamma waves are capable of penetrating very thick materials, only very heavy lead shielding will stop them (Bothwell 82).

Gangue "The valueless rock or mineral aggregates in an ore: that part of an ore that is not economically desirable but that cannot be avoided in mining. It is separated from the ore minerals during concentration" (Ripley *et al.* 303).

Gneiss "A foliated rock formed by regional metamorphism, in which banding or lenticles of granular minerals alternate with bands or lenticles of minerals with flaky or elongate prismatic habit" (Ripley *et al.* 303).

Gray " When ionizing radiation is absorbed in a substance, it imparts energy. The amount of energy divided by the mass of the material in which it is absorbed, is called the *absorbed dose*, and is measured in grays (Gy); 1 Gy = 1 Joule per kilogram...the milligray (mGy) is the most common unit of measurement" (AECB , Control 6).

Half Life "The time in which one half of the original number of nuclei of a particular radionuclide will have undergone radioactive decay" (Siting Task Force 128).

Igneous Rocks Igneous rocks are formed from magmas, the molten mix of minerals and gases from deep within the earth. Intrusive (plutonic) igneous rocks are magmas that were injected into the earth's crust without reaching the surface to cool: thus they have cooled and solidified gradually, resulting in a crystalline appearance where the crystal structures are visible to the eye (Butzer, 20).

Institutional Control "Control over an abandoned site by an authority or public institution for the purpose of ensuring the continued effectiveness of measures taken by a licensee in decommissioning the site: the control may be active (monitoring, maintenance, remedial action) or passive (land-use controls, records, land marking, fencing)"(AECB Control A1).

Ion Exchange "One of the methods used to recover the solution from the pregnant solution in an electrometallurgical operation. Replacement of an ion of one element by that of another element on an adsorptive surface" (Ripley *et al.* 303).

Ionizing Radiation "...a very specific form of energy... produced in a nuclear reactor and by radioactivity - the decay of an unstable atom, or a radio isotope. This form of radiation transfers energy by causing the molecules of any substance it touches to become electrically charged, or ionized. It can thus change the chemical structure of cells, including those of living tissue, and if enough radiation is absorbed, cells may be damaged or killed" (AECB, Control 4).

Low Level Radioactive Waste "All those radioactive wastes, other than spent fuel, arising from the mining, milling, refining or use of materials containing radionuclides" (Siting Task Force, 128).

Metamorphic Rocks "Metamorphic rocks that have undergone change, bringing about a new crystal structure and formation of new minerals. Such metamorphism can affect all kinds of rocks - igneous, sedimentary and other metamorphics. The changes may result from heat and pressure, which increase with depth... Metamorphosis can also result from permeation of a rock by gases or fluids from adjacent magmas or by mineral bearing groundwater" (Butzer, 20). "Most metamorphic rocks show a pronounced foliation or alignment of mineral constituents owing to recrystallization under the effects of heat and pressure"(Hewitt, Rocks 68).

Mine Waste Rock The material removed from mine shafts in the process of extracting the ore to be milled. Waste rock may contain unprofitable/ extractable quantities of ore and thus will in itself present a radiological hazard although to a lesser degree than tailings.

Orogeny Mountain building, or the deformation of the earth's crust that involves "folding and faulting or block faulting" (Butzer, 29).

Pachuca "A cylindrical tank with a conical bottom, widely used to circulate the pulp charge in slime leaching" (Ripley *et al.* 303).

Pathway analysis "An analysis of the pathways by which a substance is released, dispersed and transported through the environment, and of the resultant exposure of humans" (AECB, Control A2).

Pegmatite "An exceptionally coarse-grained igneous rock, with interlocking crystals, usually found in irregular dikes, lenses or veins....Pegmatites represent the last and most hydrous portion of a magma to crystallize and hence contain high concentrations of minerals present only in trace elements in granitic rocks" (Ripley *et al.* 305).

Plutonium Element named after Pluto (Pu). Produced in 1940 by Glenn Seaborg from irradiated uranium (Bothwell, Eldorado 32).

Pregnant Solution "A value-bearing solution in a hydrometallurgical operation" (Ripley *et al* 305).

Rad The former unit of measure of absorbed dose of ionizing radiation: 1 rad = 0.01 Gy. (AECB, Control 1986 6).

Radiation "The emission of energy through space or through a material medium" (James F. McLaren, 3-1). "...a form of energy that travels through space and gives up some or all of its energy upon contact with matter" (AECB, Control 4).

Radioactivity "The process in which nuclei spontaneously undergo decay and emit radiation" (Siting Task Force 129).

Radio isotope Any isotope that is radioactive; usually produced in a nuclear reactor (Bothwell, Eldorado 130).

Radon 222 Gas A decay product of Radium 226 which as a noble gas does not combine chemically with other materials and thus can migrate through air, soil and structural materials. Radon 222 gas decays into Radon Daughters which attach themselves to smoke and dust particles. As such they can be inhaled and through the emission of alpha radiation damage or destroy cells. Radon Daughters are measured in *Working Levels* (McLaren, 3-3).

Raise "An opening upwards from a level carved to connect one level with another" (Bothwell 44).

Rem The former unit of dose equivalence for ionizing radiation: 1 rem = 0.01 Sv; 100 mrem = 1mSv; 100 rems = 1 Sv (AECB, Control 6).

Roentgen The amount of gamma radiation that will produce the charge: 1R = 2.58 x 10 coulomb, in a kilogram of air. The criteria for biological damage refers to *milli-roentgens (mR/h)*, or 1/1000 of an R exposure in an hour. Instrumental measure of gamma radiation is expressed in units of *micro-roentgens (uR/h)*, or 1/1,000,000 of an R exposure per hour (James F. McLaren, 3-2).

Sedimentary Rocks Sedimentary rocks are formed from the erosion products of older rocks which are deposited mechanically or chemically. *Clastic* sedimentary rocks are formed by the mechanical aggregation of minerals, for example shale or sandstone (Butzer, 20).

Seivert "Equal absorbed doses of different types of radiation have different likelihoods of producing biological injury. To account for this, the absorbed dose is multiplied by a quality factor for the particular type of radiation, resulting in a *dose equivalent* with the unit seivert (Sv). The milliseivert (mSv) is more appropriate for radiation protection work. The average Canadian receives between 1 and 2 mSv a year from environmental radiation....The AEC Regulations specify the dose limit for atomic radiation workers at 50 mSv a year, and for the general public at 5 mSv a year" (AECB, Control 6, 8).

Stope "A step-like area where successive layers of rock are cut away" in the process of extracting the ore (Bothwell 44).

Subsidence "Sinking or downward settling of the earth's surface" (Ripley *et al.* 308).

Tailings "The material rejected after the ore is processed" (Siting Task Force 129). "Those portions of washed or milled ore that are regarded as too poor to be treated further, as distinguished from the concentrates, or material of value" " (Ripley *et al.* 308).

Thorium "A fertile radioactive metal that can be converted by neutron irradiation into a fissile isotope of uranium"(Bothwell 127).

Vein "A mineral deposit set in a fissure of rock" (Bothwell 42).

Working Level Unit of measure for Radon Daughters, it relates only to alpha radiation and reflects the potential for biological damage from airborne exposure to radiation. One Working Level *(WL)* is equal to any combination of the short-lived daughters of Radon 222 in 1 litre of air to produce 1.3 x 10 million electric volts of alpha energy (MeV). A *Working Level Month* is the exposure accumulated based upon a 173-hour month (James F. McLaren, 3-4).

Yellowcake Ammonium diuranate or magnesium diuranate, the concentrate produced by a uranium mill.

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