2.0 MINE OPENINGS CLOSURE DESIGNS

To permit the evaluation and assessment of various shaft and raise closure alternatives, four different capping methods were designed:

- Cast-in-place concrete cap
- Steel grating
- Pre-cast concrete panels
- Monolithic concrete slab

The four designs selected were suitable for the Stirling Mine site conditions, yet adaptable to other similar abandoned mine openings located throughout the province. The following sections detail the closure methods selected for the four openings found on the Stirling Mine site.

2.1 No. 1 Shaft

No. 1 Shaft is located on the west side of the former mine site, approximately 9 m west of a concrete channel through which Strachans Brook flows, as shown on Drawing No. 10903-1A, Appendix A. Access to the shaft is via a former site road which extends along the northwestern side of the mine site and crosses Strachans Brook.

2.1.1 Description

No. 1 Shaft was developed in 1925 to provide access to the underground mineralized zones during the initial operating period of the mine (1935-1938). The shaft is 3.76 m by 2.75 m in size (outside dimensions) with a concrete collar, which prior to capping activities extended between 0.3 and 1.1 m above surface grade. The concrete collar is 254 mm thick. Six notches, formed into the top exposed portion of the collar, were formerly utilized to retain timber support beams associated with the headframe and cage/skip arrangement. At the time of shaft capping, the shaft was partially blocked off with timber and debris approximately 6 m below the top of the shaft; however, there were no obstructions across the top of the shaft collar.

Photograph No. D1, Appendix D, shows the No. 1 Shaft collar prior to capping activities. Drawing No. 10903-1B, Appendix B, provides a dimensioned plan and sectional view of the shaft collar prior to capping.

2.1.2 Closure Design

The closure design selected for No. 1 Shaft was a reinforced, cast-in-place concrete cap. The concrete cap would be cast onto the top of the existing concrete collar and keyed 50 mm into the shaft opening to provide stability and lock the cap into the concrete collar. Rebar dowels, positioned around and grouted into the top of the collar, would also assist in locking the concrete cap onto the collar. Wooden stay-in-place forms were designed to support the concrete cap.

<u>Design Specifications</u>

Concrete Thickness:	250 mm overall, 200 mm over the existing concrete collar to provide 50 mm inclusion into the shaft opening.
Rebar Reinforcing:	25 M (#8) rebar @ 100 mm spacing parallel to short (2.75 m) axis of collar 15 M (#4) rebar @ 305 mm spacing parallel to long (3.76 m) axis of collar 15 M (#4) rebar dowels, 300 mm long, grouted 150 mm into concrete collar
Concrete Mix:	35 MPa (5,000 psi), 55 to 95 mm slump, 6 to 8 % air, portland cement
Wooden Forms:	150 mm x 200 mm x 2.4 m long railway ties set into the concrete notches, parallel to the short (2.75 m) axis of collar 50 mm x 100 mm x 3.2 m long timber ("2 by 4's") set on edge at right angles to the railway ties @ 300 mm spacing parallel to long (3.76 m) axis of collar 20 mm thick plywood cover placed on top of 50 mm x 100 mm timber

Drawing No. 10903-2B, Appendix B, provides design detail on the cast-in-place concrete cap for No. 1 Shaft.

2.1.3 Closure Design Specifications

The cast-in-place concrete cap was designed to provide long term (plus 50 years) closure of No. 1 Shaft and provide support for a 8,160 kg axle loading. Because the concrete cap would not be buried, there was no provision in the design for overburden loading.

A ventilation opening was not provided within the concrete cap because of the presence of a 50 mm diameter hole through the east side of the concrete collar. This hole was cored through the collar prior to site construction, to obtain information on the structural strength and condition of the concrete collar.

2.2 No. 2 Shaft

No. 2 Shaft is located in the central portion of the mine site, approximately 7.5 m northwest of the main site access road as shown on Drawing No. 10903-1A, Appendix A. Access to the shaft is available from the main site access road, which extends in a southwesterly direction from the provincial road which runs between the communities of Loch Lomond and Framboise.

2.2.1 Description

No. 2 Shaft was developed in the early 1950s, to provide access to the former underground mine workings and permit the development of additional mineralized zones. Ore hoisted from this shaft was conveyed to the new mill complex during the second operating period of the mine (1952 through 1956). The former three compartment shaft is 6.5 m by 1.85 m in size. A concrete collar located around the shaft opening, extends from 100 mm to 150 mm above surface grade and is believed to continue to bedrock.

At surface, the exposed portion of the concrete collar was 8.05 m long by 4.02 m wide. Three, 610 mm^2 concrete support columns, 200 mm in height, were located along the west side of the concrete collar. At the time of shaft capping, the shaft was partially blocked off with steel rails positioned approximately 1.5 m below the top of the shaft collar on which timber and debris had accumulated. A steel beam also extended across the short axis of the shaft opening and portions of the timber shaft guides extended through to the top of the collar. Rock and asbestos sheeting debris was also scattered over and around the concrete collar.

Two concrete lined access tunnels connected into the southeast corner of the shaft, approximately 600 mm below the top of the shaft collar. These tunnels connected to the former mine dry and hoist/electrical rooms. Small quantities of refuse and garbage had been disposed of within the shaft opening and tunnels.

Photograph No. E-1, Appendix E, shows No. 2 Shaft collar prior to capping activities. Drawing No. 10903-3B, Appendix B, provides a dimensioned plan and sectional view of the shaft collar before closure.

2.2.2 Closure Design

The closure design selected for No. 2 Shaft was a steel grate which would overlay the shaft opening. The steel grating would be anchored over the shaft opening on three sides using a cast-in-place concrete ring, positioned on the existing shaft collar into which the sides of the grating will be encased. The forth side of the steel grating would be attached to the existing shaft collar using metal brackets.

The steel grating was to be fabricated from 25 mm diameter steel rebar or 25 mm^2 steel stock, overlain to form 150 mm by 150 mm centre-to-centre openings. To ensure structural stability and discourage vandalism and removal of the steel stock, the steel was to be welded together at each location where they cross. Prior to installation, the grating would also be painted with a corrosion resistant coating.

Design Specifications

Steel Stock:	25 mm diameter steel rebar or 25 mm square steel bar
Coating:	Zinc rich or epoxy coating, applied prior to installation
Concrete Ring:	457 mm wide by 200 mm high, extending around three sides of the existing shaft collar, keyed into the collar using 15 M (#4) rebar dowels.
Rebar Reinforcing:	15 M (#5) rebar, two rows @ 300 mm spacing, positioned parallel to two sides and one end of concrete collar 15 M (#4) rebar dowels, 300 mm long, grouted 150 mm into concrete collar
Concrete Mix:	35 MPa (5,000 psi), 55 to 95 mm slump, 6 to 8 % entrained air, portland cement

Drawing No. 10903-4B, Appendix B, provides design detail on the steel grating, concrete anchor ring and steel brackets for No. 2 Shaft.

2.2.3 Closure Design Specifications

The steel grating was designed to provide medium to long term (30 to 50 year) closure of No. 2 Shaft, to prevent personal injury as a result of accidentally falling into the shaft opening. The grating was also designed to provide support should a small vehicle (car, light truck) or snowmobile accidently drive or travel onto the shaft opening.

The combination concrete anchor ring and steel brackets to attach the grating, were to be used to permit an evaluation of the long term suitability and cost effectiveness of the two attachment methods.

2.3 No. 1 Raise

No. 1 Raise is located west of the 1950s era mine site portion of the property, approximately 52 m southwest of No. 2 Shaft and 14 m southwest of the former conveyor alignment between the mine site and the 1950s mill, as shown on Drawing No. 10903-1A, Appendix A. Access to the raise is from the main site access road.

2.3.1 Description

No. 1 Raise was connected to the former mine workings and was utilized as an emergency escapeway and/or for ventilation. Prior to capping, it was visible on surface as a subsidence feature, extending approximately 2.5 m in depth. The top of the subsidence opening was between 4 and 5 m in diameter. A small quantity of timber and wood stave pipe was visible within the opening.

It is assumed that following closure of the mine, the raise was capped with a timber mat and subsequently covered over with fill and waste rock. Based on the size of No. 2 Raise (See Section 2.4), it is believed that No. 1 Raise measured 1.2 m wide by 2.1 m long, and would also have been timber lined from bedrock through the overlying fill to surface. In the absence of any mine plans, it was assumed that the raise was dipping at about 70 degrees to the west or southwest in the direction of the mine workings.

Photographs No. F1 and F2, Appendix F, show the subsidence feature associated with No. 1 Raise prior to capping activities. Drawing No. 10903-5B, Appendix B, provides a dimensioned sectional view of the subsidence feature and assumed location of the raise opening prior to closure.

2.3.2 Closure Design

The closure design selected for No. 1 Raise was a monolithic concrete slab, cast-in-place on the fill over the suspected raise opening. This closure method can be used over mine openings that have collapsed at the collar and have no apparent opening. The concrete slab supports the fill over the subsidence feature and is free to shift and subside as subsidence continues over time.

To ensure effective operation, the concrete slab was designed to support a 3.7 m thick overburden load plus the dead weight of the slab. The slab was designed to cover an area of 3.0 m wide by 4.6 m long to ensure the raise opening was covered. A rebar reinforcing mat was designed for placement in the bottom one third of the 350 mm thick slab.

Prior to pouring the concrete slab, the slopes of the subsidence feature would be scraped and groomed to remove debris, timber and vegetation. The size of the opening would also be enlarged as required to cast the concrete slab. Prior to placement of the rebar mat and concrete, the excavator would load the bottom of the opening to test for stability. If it is assessed that the base of the opening is able to support the concrete, the rebar mat would be positioned and the concrete cast directly into the excavation. Depending upon the nature of the fill at the bottom of the opening, a 200 mm layer of rip rap may be placed in the bottom of the opening, covered with a thin layer of gravel or rock fill. The concrete would then be cast on this prepared area.

Design Specifications

Concrete Thickness:	350 mm overall minimum thickness.
Rebar Reinforcing:	20 M (#7) rebar @ 100 mm spacing parallel to short (3 m) side of opening 15 M (#4) rebar @ 305 mm spacing parallel to long (4.6 m) axis of collar 20 M (#7) rebar @ 100 mm spacing parallel to short (3 m) side of opening
Concrete Mix:	35 MPa (5,000 psi), 55 to 95 mm slump, 6 to 8 % air, portland cement

Drawing No. 10903-5B, Appendix B, provides detail on the design and reinforcement of the monolithic concrete slab.

2.3.3 Closure Design Specifications

The monolithic concrete slab was designed to provide long term (plus 50 year) closure of No. 2 Raise and reduce the potential risk of personal injury by preventing the subsidence feature from increasing in size, and reducing the possibility that the raise opening will be exposed.

2.4 No. 2 Raise

No. 2 Raise is located about 11 m south of No. 1 Raise and approximately 61 m southwest of No. 2 Shaft, as shown on Drawing No. 10903-A1, Appendix A. Access to the raise is available from the main site access road.

2.4.1 Description

No. 2 Raise was also connected to the underground mine workings and was utilized as an emergency escapeway and/or for ventilation purposes. Prior to capping, the raise was timber lined from bedrock through approximately 2 m of waste rock and was partially open on surface. Deteriorating, 150 mm diameter logs covered approximately two thirds of the 1.2 m by 2.1 m raise opening. The raise was also flooded with water to within 0.5 m of the top of bedrock or base of the timber lining. Although the orientation of the raise was also unknown, it was assumed to dip in a south or southwest direction and extend parallel with the general orientation of the underground workings.

Photographs No. G-1 through G-3, Appendix G, show the raise opening at surface prior to capping activities:

- Security fencing around raise opening (Photo No. G-1)
- Deteriorating timber cover (Photo No. G-2)
- Timber lining extending through rock fill to bedrock (Photo No. G-3)

Drawing No. 10903-6B, Appendix B, provides a dimensioned plan and sectional view of No. 2 Raise prior to closure.

2.4.2 Closure Design

The closure method selected for No. 2 Raise was a pre-cast concrete cap positioned on bedrock. Five separate pre-cast panels would be positioned over the raise opening. This closure method is suitable where a raise or shaft opening can be excavated to stable bedrock. The pre-cast panels can subsequently be backfilled and the area over the former raise opening revegetated as necessary.

The five, pre-cast panels were each designed to be 3.0 m in length, 610 mm wide and 254 mm thick, with 25 M (#8) rebar reinforcement. To permit placement, all loose rock around the raise opening should be removed for a minimum distance of 1 m back along the long axis and 600 mm back along the short axis of the raise opening. Irregular bedrock surfaces would be chipped or removed to form a level surface on which the concrete pre-cast panels can be placed. Irregularities in the bedrock surface which cannot be leveled would be filled with concrete or fine, well-graded rock fill, to create a level surface onto which the pre-cast panels would be positioned.

Prior to positioning the pre-cast panels, a 25 to 50 mm thick, fine rock fill leveling course, would also be spread on the bedrock surface around the raise opening, to compensate for small irregularities and to ensure the concrete panels sit flat and are evenly supported with no rocking or point loading.

The concrete pre-cast panels will be positioned at right angles to the long axis of the raise opening, leaving a 25 mm spacing between each panel.

<u>Design Specifications</u>

Pre-cast Panels:	3,000 mm long by 610 mm wide by 254 mm thick
Rebar Reinforcing:	Six, 25 M (#8) rebar, equally spaced across 610 mm width, running parallel to long axis of panel, positioned 50 mm from bottom

Concrete Mix: 35 MPa (5,000 psi), 6 to 8 % entrained air (slump not specified), portland cement

Lifting Rings: Two galvanized cable lifting rings to be set in each panel

Drawing No. 10903-7B, Appendix B, provides details on the design and reinforcement of the pre-cast concrete panels.

2.4.3 Closure Design Specifications

The pre-cast concrete panels were designed to support a 2.0 m overburden load, the dead load of the panels plus an 8,160 kg axle loading over the raise opening. To provide control over the casting and curing conditions, the pre-cast panels were also to be cast off-site and transported to the mine property.

The closure method was also designed to provide medium to long term (30 to 50 year) closure of No. 2 Raise and prevent personal injury.