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PLACER GOLD DREDGING USING AN EXCAVATOR AND FLOATING PROCESSING PLANT

By

Fortymile Placers

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SUMMARY

This report provides information on a method of placer gold dredging. This dredging method differs from conventional bucket line gold dredging in that it uses a combination of land-based and floating dredging equipment. An excavator is used for digging the gravel, and a floating processing plant is used to process the gravel and stack tailings.

Using this combination of equipment offers many advantages. The cost of mining placer gravel is extremely economical; we have calculated mining costs at 96 cents per loose yard of gravel processed. This mining method also has environmental advantages. Total reclamation of the mined area is achievable and inexpensive. All water used in processing the gravel is recycled, so that there is no discharge of effluent to the watercourse.

The method has limitations. Only certain types of placer reserves can be mined. For example the ground must be thawed to bedrock depth, and have a high water table or the ability to hold a pond.

Design details and specifications for the equipment used in the mining system are discussed. General design information is given for each of the components used in the dredging system. We have provided detailed specifications for our own equipment as an example. Operating procedures are outlined; topics covered include equipment assembly and start-up, mining through a deposit, shut down procedures, and reclamation of the mined area.

Because of the current low gold price and rising operating costs, placer mine operators must explore new mining methods to remain profitable. As well, mining methods which minimize environmental impact must be adopted. This dredging method has the advantage of both lower production costs and minimal environmental disturbance. As well, reclamation is easily achieved and cost-effective.

Acknowledgements

We are indebted to the many New Zealand placer miners who spent time showing and explaining their floater operations to us. We used many of their ideas and suggestions in our own operation.

We appreciate the funding provided by the Canada/Yukon Economic Development Agreement, Mineral Resource Development Program, and the support of our project by the committees administering the Mineral Resource Development Program.

We are grateful to the Klondike Placer Miners Association for sponsoring this report for the dissemination of information on floater mining.

We acknowledge the help and support of the many Yukon suppliers of placer mining equipment with whom we consulted in determining capital and operating costs.

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1. INTRODUCTION

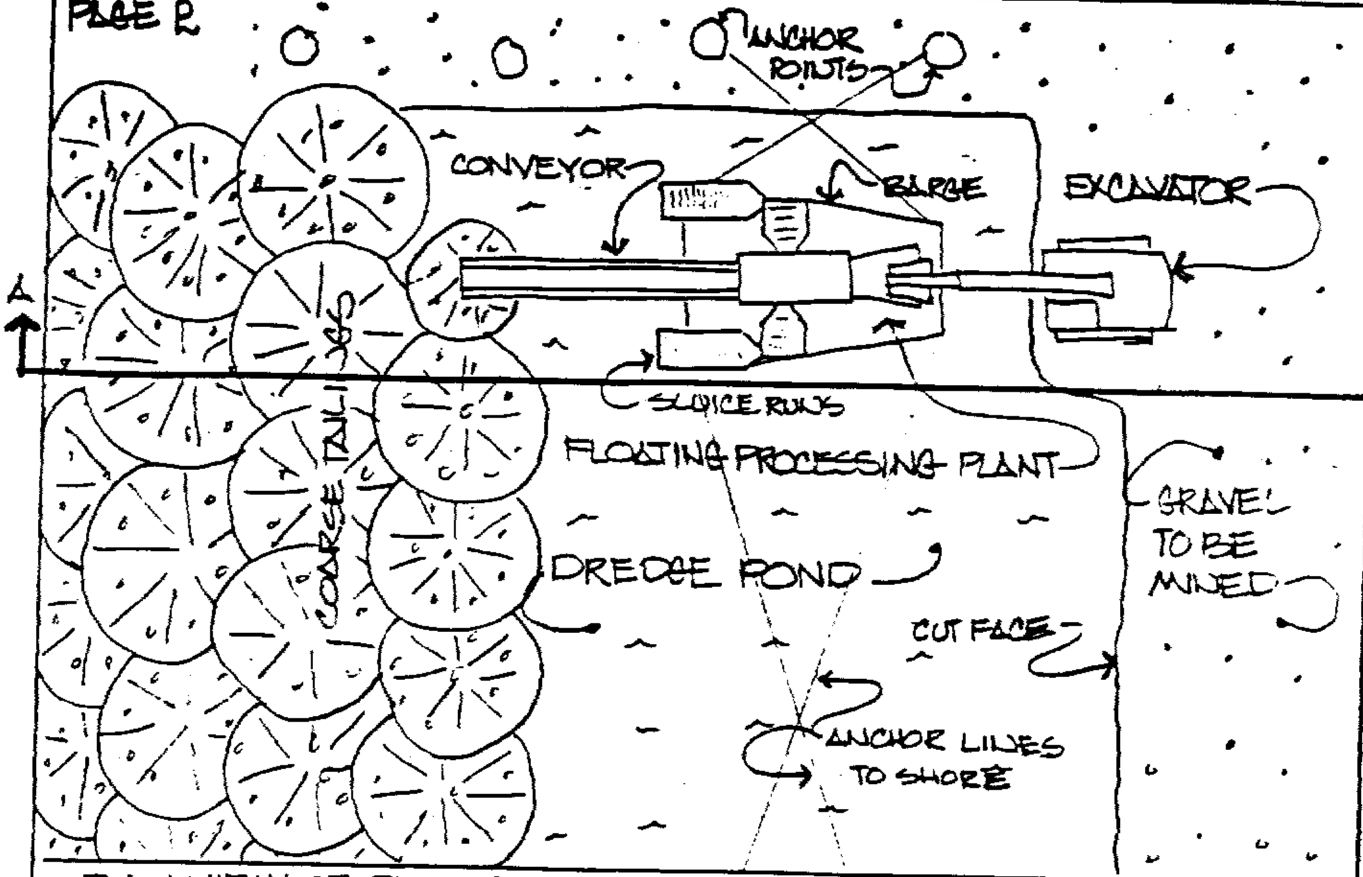
We became interested in dredging when we obtained placer gold dredging rights to the Fortymile River. There is a history of dredging on the Fortymile; several large bucket-line dredges operated on the river in the early 1900's. It was considered ideal dredging ground because the gravel in the river channel is thawed and the depth to bedrock is quite shallow.

Placer gold dredging is defined as the mining of gravel which is submerged below the water-table. It is generally considered the most efficient method of mining placer gravel where conditions warrant. It is the only method of mining which can be employed when the gravel cannot be drained of ground-water.

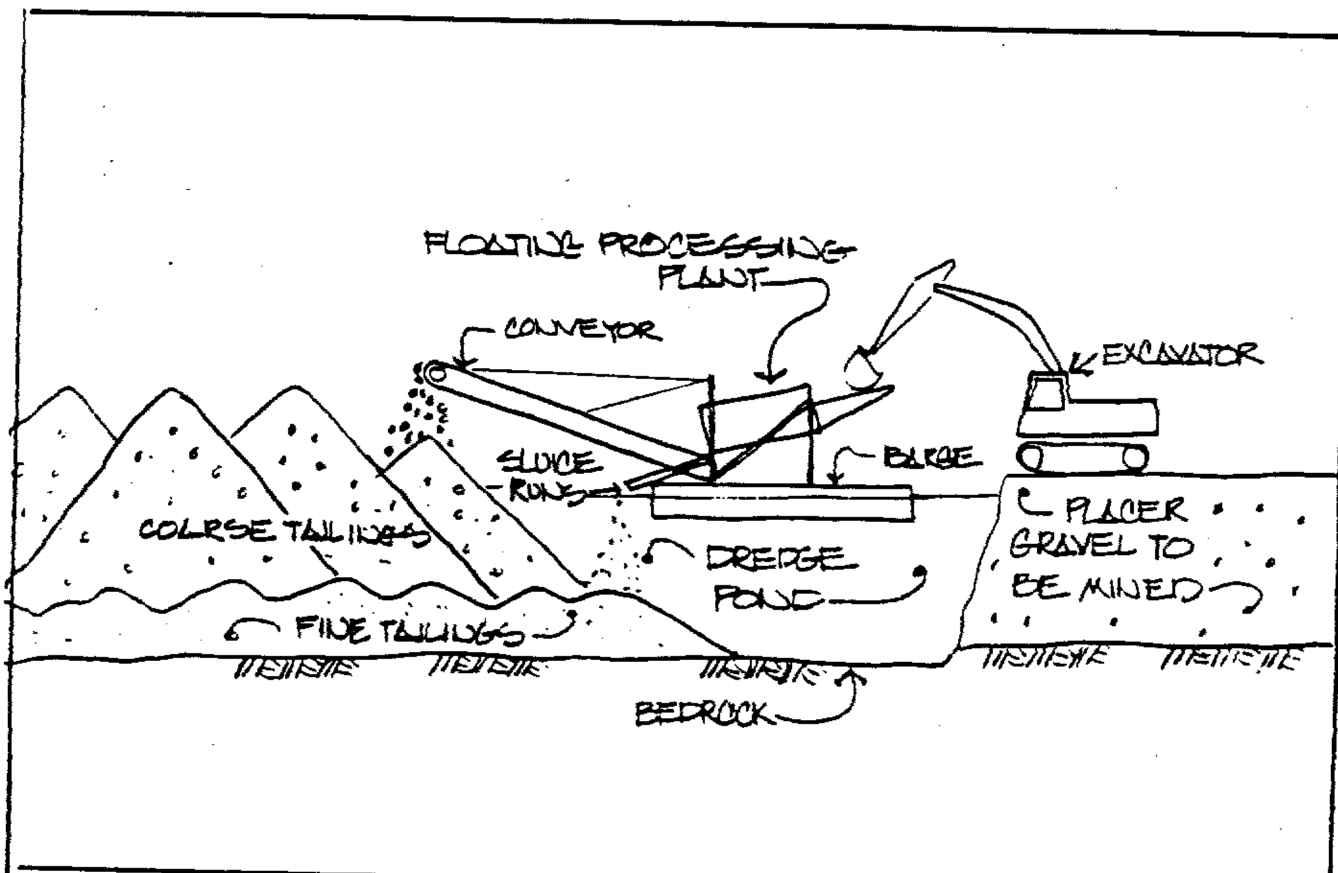
The advantage of dredging is that, because the digging and processing equipment are self-contained and float in a pond, the dredge can be moved to the gravel, eliminating long transportation distances for both head feed and tailings. Because of the low operating costs, lower grade deposits can be mined profitably.

There are some drawbacks to conventional dredging. The equipment used is specialized and built on a large scale. Because of the high capital costs, dredging projects are generally undertaken by large mining companies and substantial gravel reserves are required to make a venture feasible. Because dredging for gold is usually practised in valley bottoms, it can affect the watercourse of the valley, creating environmental concerns.

We began working on river gravel bars which are exposed after spring breakup, experimenting with a different type of dredging. This type of dredging uses a combination of floating and land-based equipment. A number of miners use this method of placer mining in New Zealand, where it is known as "floater mining". Floater mining has the benefits of conventional dredging, with none of the drawbacks.



PLAN VIEW OF FLOATER MINING OPERATION SCALE 1"=15' DRAWING 1



SECTION A-A FLOATER OPERATION SCALE 1"=15' DRAWING 2

The purpose of this report is to provide information on this system of placer mining, which we have been using on the Forytmile River. Numerous miners have come to see our operation; we prepared this report to answer the questions most asked about it. We discuss the operational method, it's advantages and limitations, equipment used, capital and operating costs involved, and layouts of typical operations in suitable ground. This report details general design principles, some of which we learned in New Zealand and some of which we developed to suit Yukon conditions. A floater mining operation can take many different configurations, depending on volume processed and components used. We give specifications, operating procedures, and costs involved, using our own floater mining operation as an example.

2. DREDGING WITH A FLOATER OPERATION

Floater mining is a simple mining method. The process is detailed in Diagrams 1 and 2 and described below.

The gravel processing plant floats in a pond created by ground-water in a pit excavated to bedrock. The excavator is stationed on dry ground in front of the pond. Gravel, excavated from the face at the front of the pond, is fed into the floating processing plant where it is washed and screened. The fine gravel is processed to recover the gold. The oversize coarse gravel tailings are stacked by a conveyor in the back end of the pond. A moving dredging/settling pond is created as the excavator digs away the pond face and the tailings stacker fills in the back end of the pond. The processing plant is anchored by winch lines to the shore, and is manoeuvred in the pond to keep it in front of the excavator. Land reclamation is performed as mining progresses, as the tailings from the conveyor are levelled with a dozer.

2.1 Advantages of Floater Mining

While we implemented a floater operation as a means of mining submerged gravel, we came to realize that this method of placer mining has many other advantages. These advantages are outlined as follows:

Photograph 1 - *The excavator is stationed on dry ground in front of the floating plant. The pond is separated from the watercourse. The river can be seen in the background of the photograph. The distinct difference in colours between the river water and the process water confirms that there is no effluent discharge.*

Photograph 2 - *The conveyor stacks tailings in the back end of the pond. The processing plant is winched sideways in the pond when the tailings pile reaches the height of the conveyor. Fine tailings slurry can be seen emptying into the pond from sluice boxes located on either side of the trommel.*

- Only one piece of earth moving equipment, the excavator, is required. Tailings are removed automatically by the conveyor, eliminating the need for tailings handling using heavy equipment.

- The floating processing plant is shifted as required so that it is always close to the pay gravel. Moving the plant also allows the operation to move out of the way of the tailings build up. The distance that the pay gravel and tailings must be transported is short, resulting in cost-efficient operation.

- Water pumping costs are minimal because the process water is obtained from the dredge pond using a pump mounted on the processing plant. The need for a pipeline is eliminated and the height to which the water must be pumped is relatively low.

- The cost of achieving water effluent standards is eliminated because the dredge pond also acts as the settling pond. Because the pond is continually moving, there is no need to clean it out or maintain it. This system has no discharge to the watercourse, so that visual and environmental impact is minimal.

- Reclamation is easily achieved because the conveyor stacker leaves a trail of continuous tailings piles as shown in Photographs 1 and 2. These tailings piles can be levelled quickly. Reclamation can be carried out simultaneously with mining. On-going reclamation has the advantage of reducing overall visual impact of the operation. It is also cost-efficient.

- Because we are mining on the gravel bars of the river, there is no overburden to strip, so that pre-production costs are reduced. There is also an environmental advantage in that no vegetation need be disturbed to obtain access to the gravel.

Photograph 3 - *This photo shows a typical river bar on the Fortymile River. River bars make good dredging ground. No stripping is required, the water table is high, and the ground is thawed. The test pit shown in the middle of the bar has filled with ground-water seepage.*

Photograph 4 - *This operation is terracing down to achieve greater digging depth. The excavator is stationed just above the water table and digs away the cut face below the water table as well as the gravel bank above the water level. Large boulders which are encountered are discarded in the back of the cut, for later removal. An old tunnel dug by hand miners can be seen behind the excavator.*

2.2 Limitations of Floater Mining in the Yukon

There are limitations to the applicability of this system of placer mining. Some of these limitations, and ways of minimizing or mitigating them, are discussed as follows:

- Only certain types of reserves can be mined using floater mining. The ground must have either a high water-table or the ability to hold a pond. In dry ground where water loss due to seepage isn't severe, make-up water can be added to the pond to keep the water level constant.

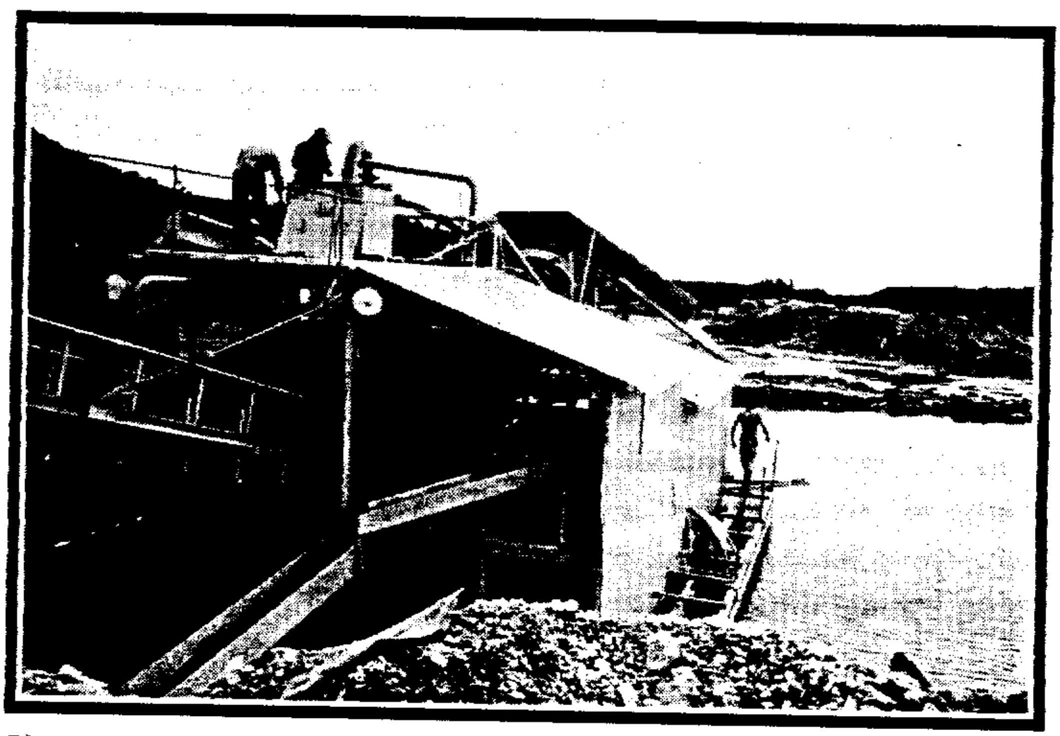
- The ground to be mined must be thawed to bedrock depth. This requirement eliminates much of the placer ground in the Yukon. It may be possible that, once a pit is excavated to bedrock in frozen ground and subsequently filled with water, a cut face could be started. Mining could progress due to the thawing action of the pond water on the cut face.

- Only ground which has some gravel exposed above the water-table, for the excavator to be positioned on, can be mined. Conventional dredging can operate in totally submerged deposits. However, due to environmental constraints, few submerged deposits located within a watercourse can be mined.

- The depth of gravel that can be mined is limited to the depth that the excavator can dig. The excavator can be modified in order to increase the depth obtainable. Another option used for mining deep ground is to "terrace down", positioning the excavator down in the cut just above the pond level so that it can reach deeper gravels, as shown in Photographs 4 and 5.

- The depth of barren gravel which can be stripped is limited to the gravel located above the water-table. The entire gravel section below the water-table must be mined. However, because the cost of moving gravel using this method is so low, it is often as cost-effective to

Photograph 5 - *Terracing down to achieve greater depth. This ground will be levelled and reseeded to create pasture land, after it has been mined. Topsoil overburden has been stacked to the side of the ground being sluiced.*



Photograph 6 - *A large pond helps to dilute the recycle/dredge pond water. The width of the pond will depend on total length of plant, from the hopper to the discharge end of conveyor. The length of the cut face can be as wide as required to obtain a pond of adequate size. This is a view of the stern of a large floater plant which has been covered in.*

mine the very low grade upper gravel layers as it is to strip them. Whatever gold is present in these upper gravels will be recovered, offsetting processing costs.

- Because the excavator operator can't see what he is digging, there could be gold lost due to improper cleaning of bedrock. Training the operator in digging techniques helps to minimize this drawback.

- Because the water in the pond is recycled, it may become heavily loaded with suspended solids. As the specific gravity of the process water becomes greater, gold recovery efficiency declines. Setting up the operation with a wide cut face increases the pond size, helping to dilute the effect of suspended solids on gold recovery. As well, clean water can be added to the pond from the stream with a separate pump if seepage into the pond isn't great enough to dilute the process water. Photograph 6 shows a dredge/settling pond of ample size.

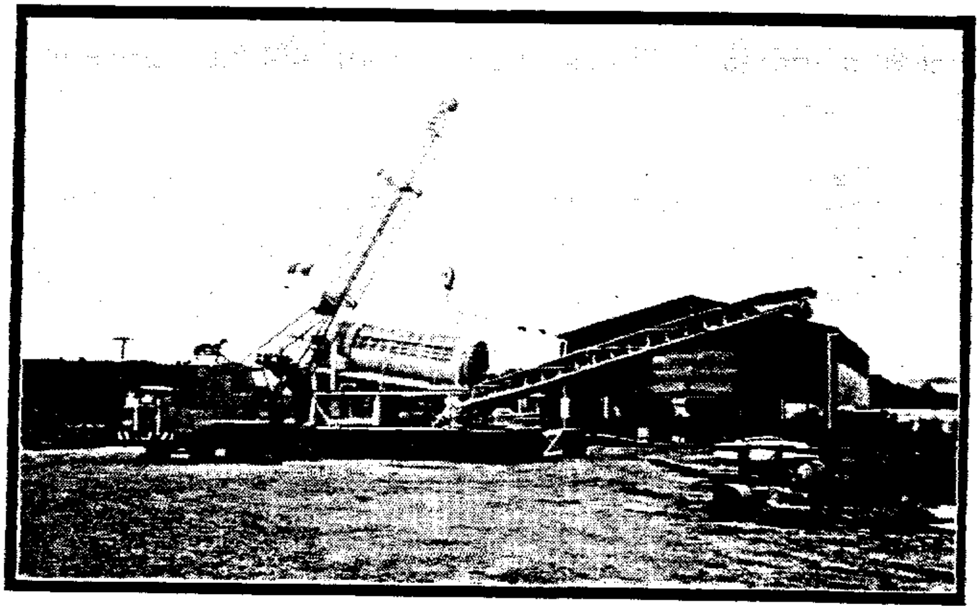
- The dredging season is very short in the Yukon. If river bars are being worked, the operator must wait for the bars to become exposed when the water level in the river drops after the spring run-off period. In addition, occasional flooding due to seasonal rainfall can be high enough to cover the river bars, forcing an operation to shut down until the water level in the river drops.

- Because the method is different from conventional placer mining, specialized training of the crew is required.

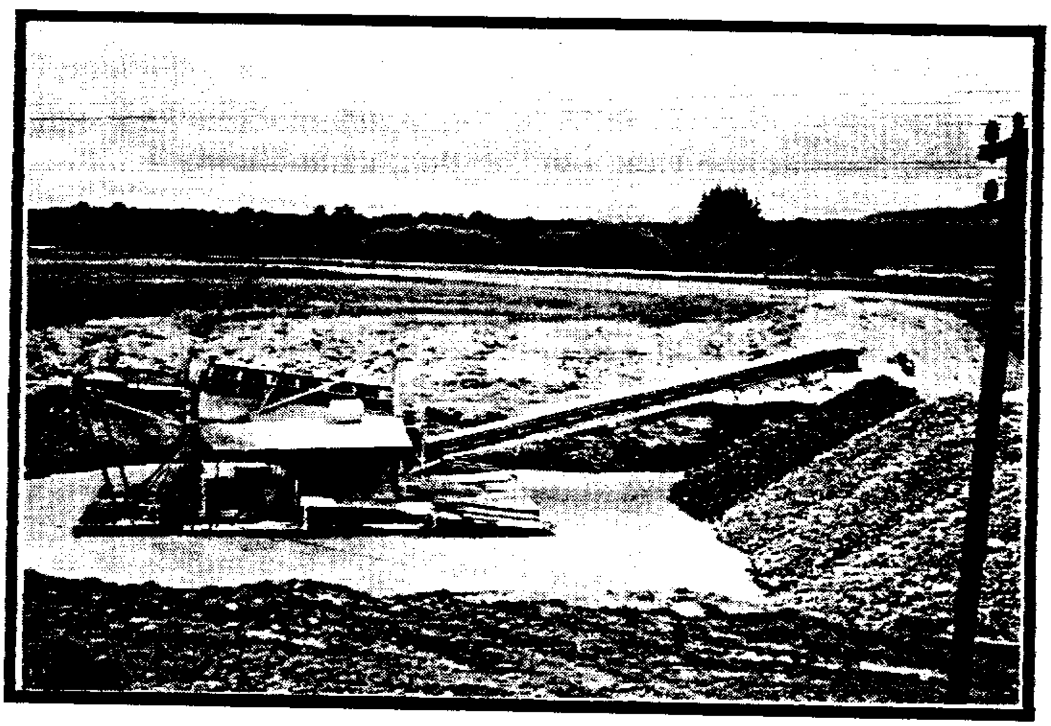
3. FLOATER EQUIPMENT DESIGN CONSIDERATIONS

The dredging system consists of two main components, the floating gravel processing plant and the excavator.

The floating processing plant consists of seven main sub-assemblies: the barge, the gravel processing equipment, the tailings stacker, the gold recovery equipment, the water supply system, the winch system, and the



Photograph 7 - *This is a large floater plant under construction in New Zealand. The barge has a large bottom surface area with relatively shallow depth. This floater plant will handle approximately 300 yph.*



Photograph 8 - *The conveyor overhangs the barge considerably. The barge is wider at the stern than at the bow, promoting stability and adding the necessary floatation for the load of gravel and the dead weight of the conveyor overhanging the barge. The dredge pond for this operation is very small, because it is just getting started. It will be widened as mining progresses.*

power system. While design specifications of each of these assemblies can vary, all seven must be present to have a workable dredging plant. Design of the floating plant is determined by the volume of gravel to be processed, depth of gravel to be mined, type of gravel being handled, type of gold to be recovered, and other factors.

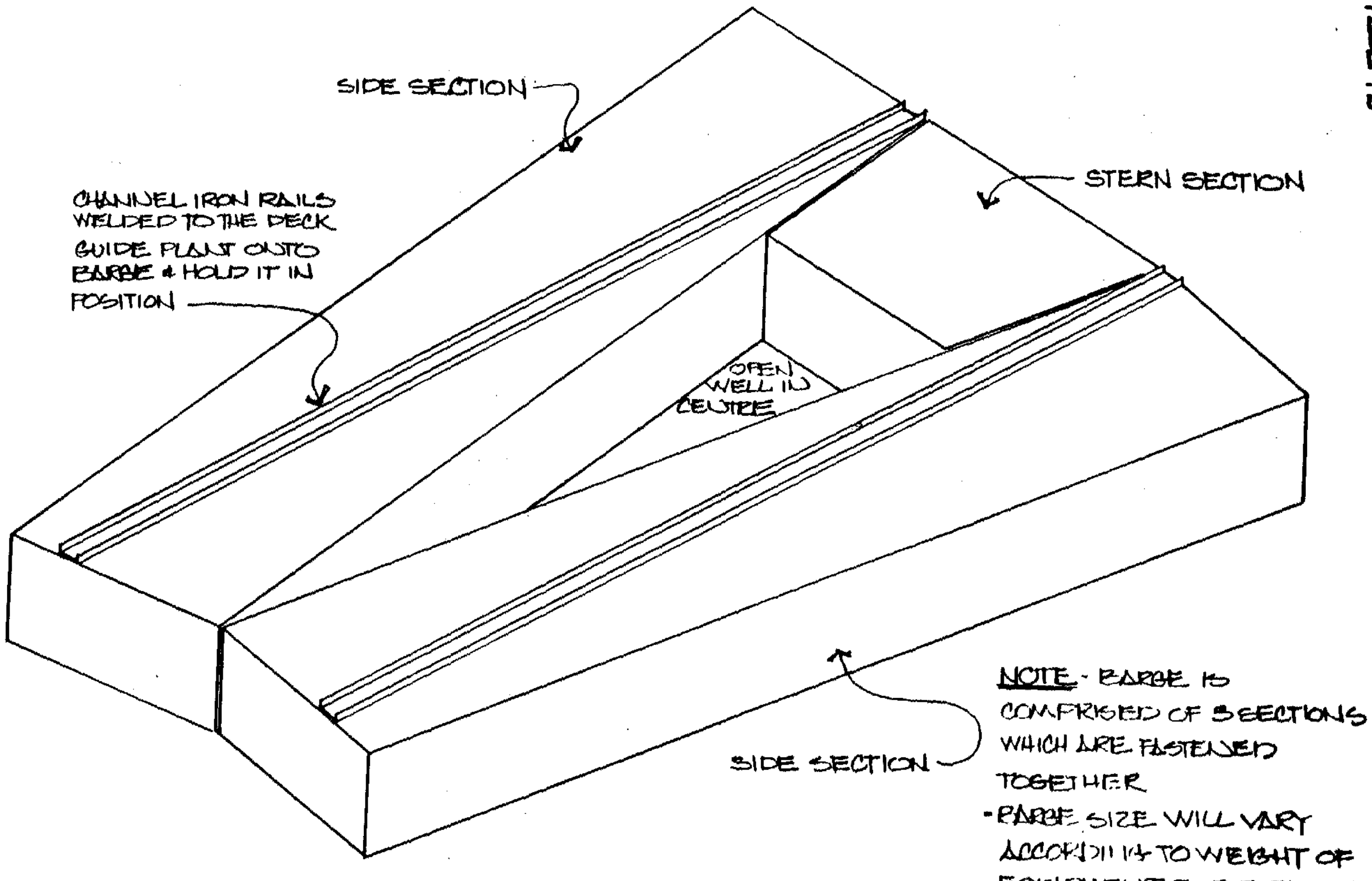
All of the components used in the floating plant are readily available through various suppliers, with the exception of the barge. Fabrication can be limited to incorporating the manufactured components into a workable end-product, or these components themselves can be built. Photograph 7 shows a large floater plant under construction.

We have outlined the design considerations for each of the components incorporated into the floating processing plant. We have followed this discussion with a description of, and specifications for, each of the components which we used in the construction of our own processing plant. We have also included a description of what we would do differently if we were building another dredge plant. A person contemplating building a floater can benefit from the ideas which worked for us, avoid ones that didn't, and arrive at a design reflecting his own ideas and requirements.

The operation which we built has a processing rate of 90 loose yards per hour. The gravel we are mining is sandy, rounded and easily washed. Approximately 40% of the gravel is -1/4 inch in diameter. Approximately 5% of the feed gravel consists of boulders over 1 foot in diameter. The depth of gravel above bedrock on the bars varies between 4 and 20 feet; the average depth is 15 feet. The gold which we are recovering is flat and flaky, with approximately 95% of the total passing through a 14 mesh screen and 30% of the total passing through a 100 mesh screen.

3.1 Barge Design Considerations

The barge should be large enough to float the processing equipment with enough freeboard to allow for load variations. A large flat surface area in contact with the water is desirable in order to promote stability.



DRAWING SHOWING GENERAL SHAPE OF BARGE   NO SCALE   DIAGRAM #3

The barge should be of an adequate length to minimize the rocking motion which is induced when gravel is loaded into the hopper. However it mustn't be so long that it impedes stacking tailings in the back end of the pond, or hampers the excavator when it is digging or loading the hopper at the front end of the pond. We observed in New Zealand that the barges have a wedge shape, with the stern wider than the bow. This shape makes a very stable barge. Because the conveyor overhangs the barge and carries a significant load of gravel, the wider stern provides the flotation required, as shown in Photograph 8. The narrow bow allows the excavator more room to dig at the cut face. This configuration provides a triangular-shaped well in the centre of the barge; this well is a good location for the pump intake.

It is helpful to build the barge in modular sections to facilitate moving it, since it is of considerable size and weight. Each section can be equipped with steel tabs with bolt holes to facilitate easy assembly. Lifting hooks on the barge sections aid in handling them.

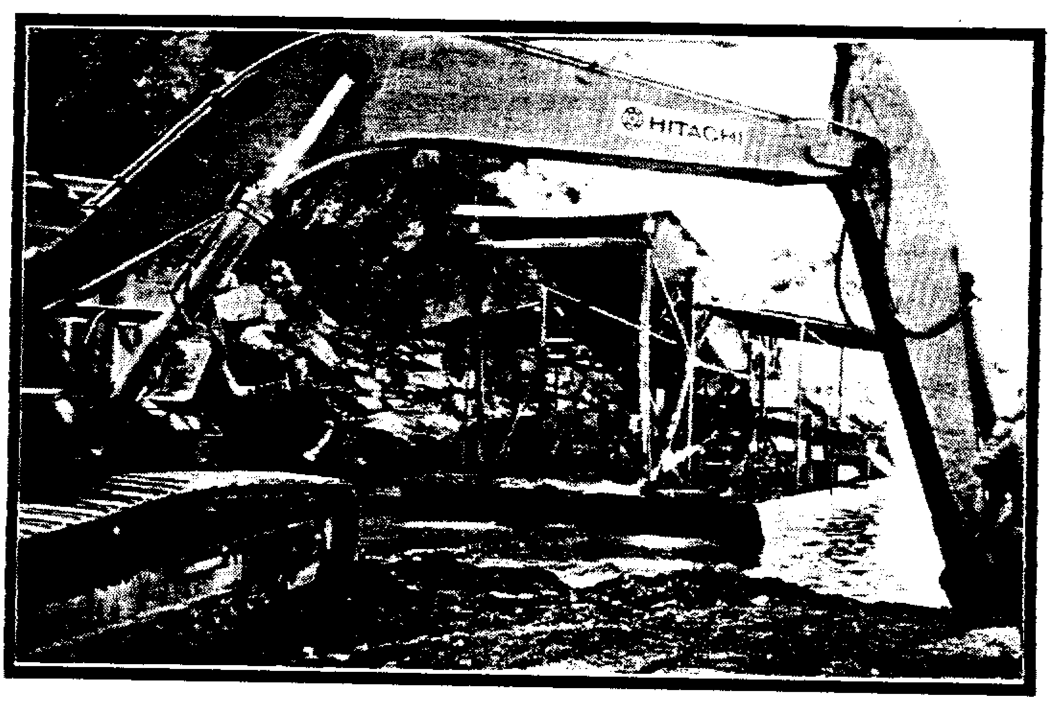
Internal baffles in each section of the barge add strength to support the equipment on the deck. If these baffles are made watertight, the barge will be unsinkable. Each compartment should be equipped with an inspection hole, large enough to accommodate a suction hose for pumping out water, should it become necessary.

The steel used to build the barge should be thick enough to ensure adequate strength and to facilitate ease of welding; however using steel which is thicker than required adds unnecessary weight to the structure. 3/16 inch is a good thickness of steel for the barge. Using checker-plate steel for the deck is advisable because the deck is usually wet and slippery.

Specifications for Our Barge

The barge which we built is comprised of three pieces. Two long rectangular float sections form the sides of the barge. These two pieces are 6 feet wide, 3 feet deep, and 28 feet long. See Diagram 3. Each side section is divided into six watertight compartments by baffles spaced at

Photograph 9 - *This photo shows the inside of a trommel screener from the back end. This trommel is screening to 1/2 inch minus material. Gravel which is being dumped into the hopper can be seen through the front end of the trommel. Because it is wet, the gravel slips easily down the floor of the hopper. The water flow from the small manifold can be seen at the lip of the hopper, aiding in gravel flow. The gravel has been well washed as can be seen from the tailings leaving the trommel barrel.*



Photograph 10 - *The hopper is mounted on springs to absorb the shock when a load of gravel is dumped into it. This hopper is large, making loading it with the excavator faster, and reducing gravel spillage onto the deck. The deck hand can be seen washing gravel off of the deck with a high pressure hose.*

4 foot intervals along the length. The third section of the barge is the centre stern float. This stern section has a trapezoidal shape. The dimensions of the two parallel sides are 8 feet and 6 foot 3 inches respectively. It is 6 feet wide and 3 feet deep. This size provides ample flotation for the equipment on the barge which we estimate to weigh approximately 20,000 pounds empty. Our barge is built of 3/16 inch steel plate.

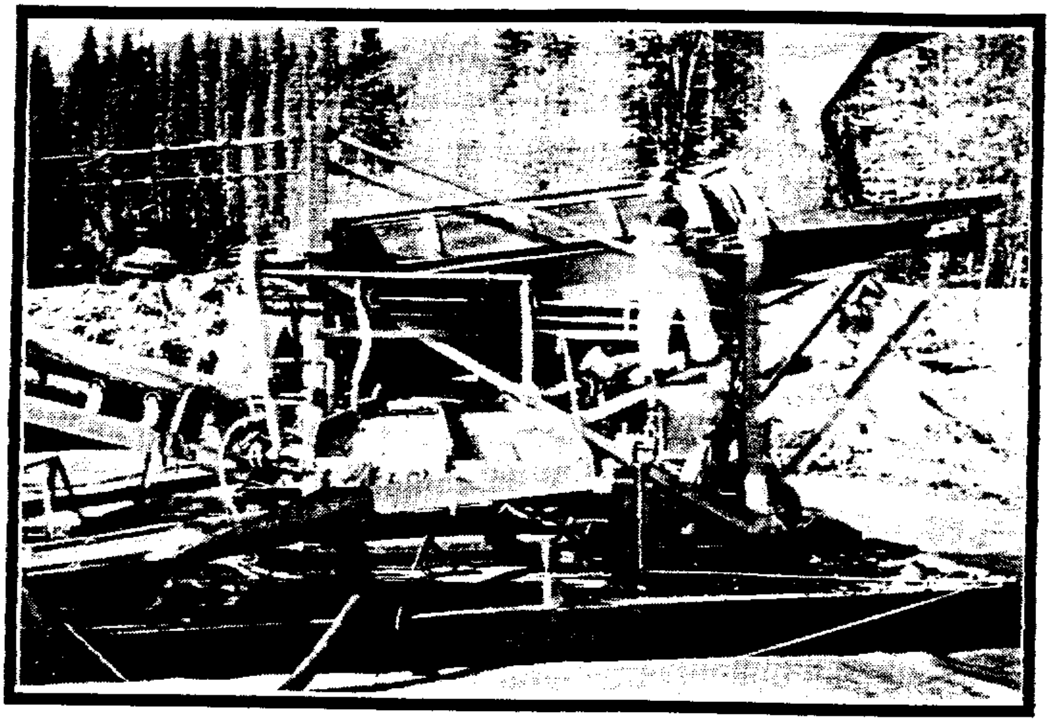
We think that our barge should be longer, to provide more stability along the lengthwise axis. It has a rocking motion which is induced when gravel is dumped in the hopper. More length would dampen this rocking; 32 feet would be a good length for our barge.

3.2 Gravel Processing Plant Design Considerations

The gravel processing plant serves the purpose of washing and splitting the gravel into coarse waste gravel to be tailed by the conveyor, and into gold bearing fines to be processed for gold recovery. We are using a trommel for this application. Alternately, a vibrating screening deck can be used.

The excavator loads gravel into a hopper. If there are a significant number of large boulders, the hopper can be equipped with a grizzly. Boulders entering the processing equipment cause added wear and can cause jam-ups in the hopper and conveyor. Boulders sliding off the grizzly should be directed back away from the cut face by chutes so that they don't fall back close to the cut face to be dug up again. If boulders are not a problem, a grizzly is not necessary. Operating without a grizzly has the advantages of reducing dump height for the excavator, and of eliminating the need to dislodge boulders which periodically become stuck between the grizzly bars.

The hopper provides a controlled flow of gravel to the screening unit. Because the gravel dumped into the hopper is wet, it slides readily down the hopper incline onto the screen deck or into the trommel. The hopper angle should be adjustable so that the rate of feed can be regulated.



Photograph 11 - *This is the trommel plant which we are using. It has a capacity of 90 yph. The trommel barrel is 4 feet in diameter and 12 feet long. The trommel is mounted on a skid built from 8 inch pipe. This skid sits in rails built of 8 inch channel iron welded to the barge, flange side up.*

Photograph 12 - *This is our trommel plant after we equipped it with a grizzly and boulder chutes. We added this grizzly to eliminate boulders entering the system. Boulders fall into the pond from the chute, well back from the cut face, so that boulders will not be dug up again. The crossed winch lines can be seen here. This triangulation makes moving the barge easy and keeps the barge in position securely.*

The gravel should flow smoothly down the hopper without surging. An angle of approximately 25 degrees to the horizontal, adjustable approximately 5 degrees either shallower or steeper, works well. A small manifold located at the front end of the hopper providing a small steady flow of water assists the flow of gravel into the trommel barrel or onto the screen deck.

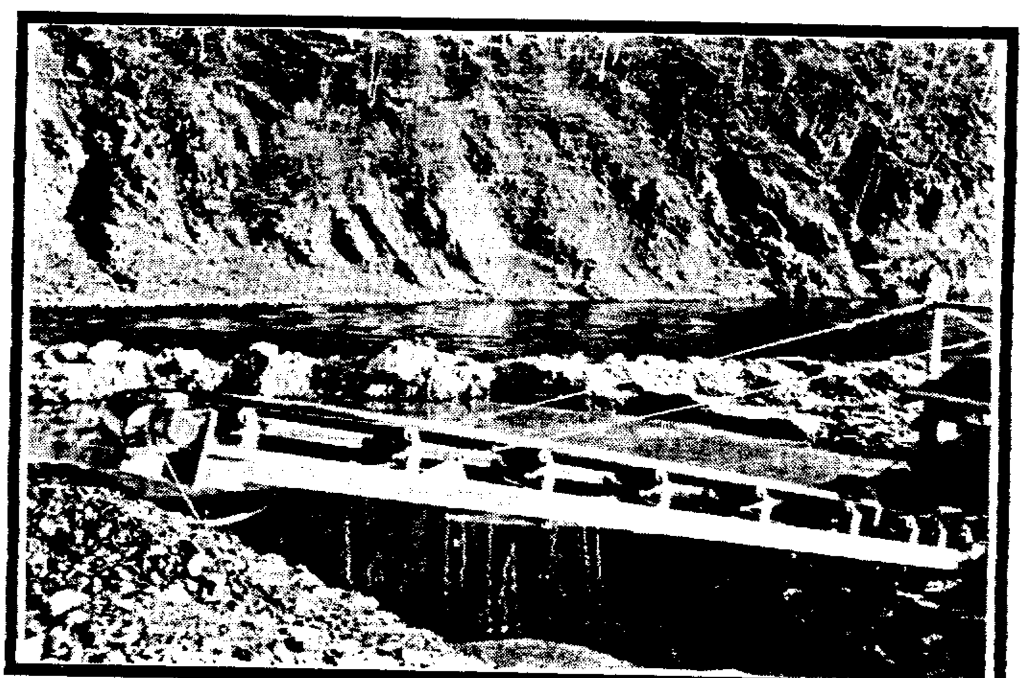
Specifications for Our Gravel Processing Plant

Our feed hopper is 8 feet wide by 8 feet long. It is set at an incline of approximately 25 degrees. It is equipped with a grizzly built of parallel railroad track bars spaced to give a 7 inch clear opening. The grizzly has an inverted "V" shape with the bars set at 35 degrees to the horizontal. Boulders slide readily down the bars, although occasionally one will become stuck, necessitating clearing it by hand.

Our trommel is 4 feet in diameter and 12 feet long, with a 10 foot effective screening length. It rotates at approximately 14 RPM with a chain drive. We use 1/4 inch screen in our trommel, because the gold we are mining is fine with very few nuggets. Eliminating coarse material passing through the sluice runs improves gold recovery. The drawbacks to fine screening are that the screen wears out faster than coarse screen and that through-put is reduced. Photographs 11 and 12 show the trommel which we are using.

A processing rate of 90 yards per hour is high volume for a trommel of this size, but because the character of the gravel we are mining is round and sandy, this volume of through-put is possible. We believe that, because we are screening to a fine size, a double deck screen deck would be the best choice for our particular application. A heavy rock deck for the top deck would handle the abuse imposed by the coarse rock, saving wear on the lower deck equipped with fine screen. We would get more operating hours between screen changes with this arrangement than we do with our trommel. Screen changes could be done faster and the screens would be less expensive.

Photograph 13 - Boards running up the sides of this conveyor belt help to train large rock, and keep large rocks from dropping off the side of the belt. It is equipped with a walkway up the side, to provide access to the drive unit for servicing. Two oil drums used for ballast can be seen on the back of the barge. The light, mounted on the cross bar from which the conveyor is suspended, illuminates the conveyor for night operation.



Photograph 14 - *This is the stacking conveyor which we are using. It has a 24 inch wide belt and is powered by a 3 hp, 3 phase electric motor with integral gear reducer. It is suspended with cables and has turnbuckles for adjusting the incline.*

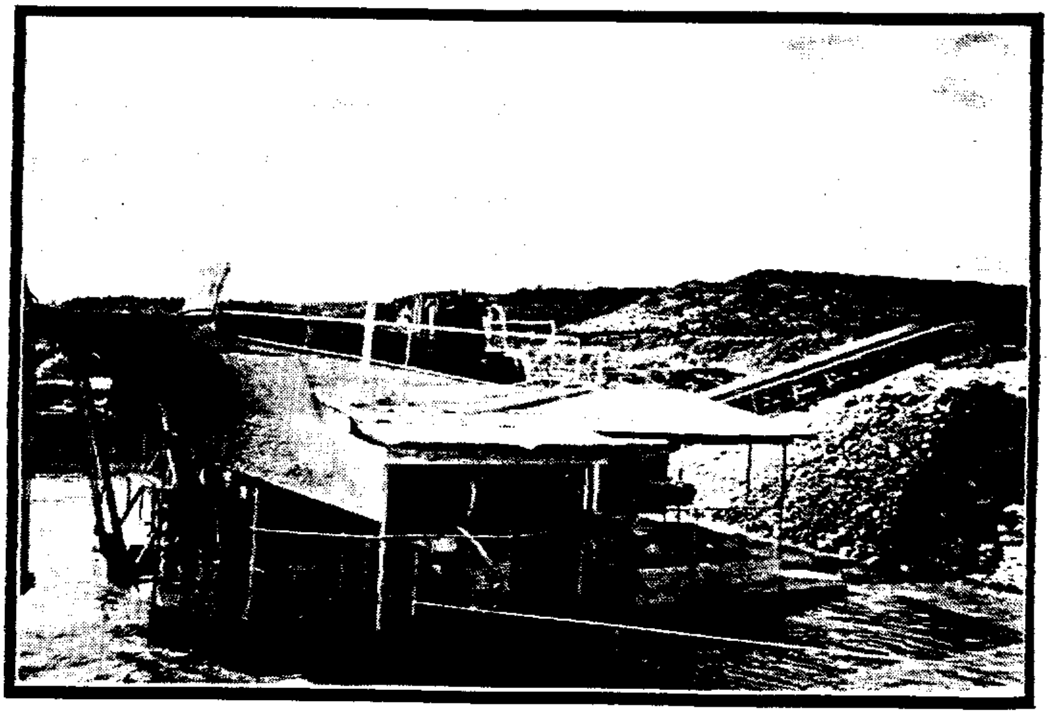
3.3 Tailings Stacker Design Considerations

The length of stacking conveyor to be used is dependent on the depth of gravel being worked, and also on the height of the gravel face which is located above the pond level. The deeper the total face of gravel, the longer the conveyor stacker must be in order to gain height for tailings piles. As well, a longer conveyor is required if there is a significant portion of the gravel face above water, because the barge will be floating lower in relation to the gravel deposit being mined. The conveyor should not be less than 30 feet long unless the gravel deposit is very shallow. An excessively long conveyor, however, increases flotation requirements significantly and affects stability of the barge.

The angle to which the conveyor is inclined should not be so great that rocks can roll back on it, but it should be set at a sufficient angle to allow for the maximum height and volume of tailings to be stacked. A good angle for the conveyor is approximately 20 degrees to the horizontal, although a steeper angle is possible if the gravel is not too rounded. A conveyor on which the incline can be adjusted is useful so that the angle can be set by trial and error to gain optimum performance in a given situation.

A wide conveyor is advantageous when the ground being mined has a large amount of coarse rock, especially if the rock is slabby. A 36 inch wide conveyor is a good width. Boards placed up the sides of the conveyor, as shown in Photograph 13, keep boulders trained when they are travelling up the belt.

Because the tailings are wet, the underside of the conveyor belt will be wet, and belt slippage can be a problem. We expect that if sticky material was being handled, some method of cleaning the underside of the belt would be required to eliminate a build up of wet clay on the inside of the belt.



Photograph 15 - *This photo shows a jig recovery system mounted on a floater in New Zealand. Gold bearing slurry is pumped to the cyclone on the roof of the plant. The slurry is then fed to a set of jigs mounted on either side of the plant. Cleanup of jig concentrates is performed by centrifugal bowls which can be seen under the roof. Extra float sections have been added to the sides of the barge to accommodate the extra weight and size of the recovery system.*

Photograph 16 - *This photo shows the recovery system, which utilizes two identical sluicing systems, one on each side of the floater, in order to maintain balance. Slurry empties into the pond well behind the barge, to prevent fine tails build-up under the barge.*

Specifications for Our Tailings Stacker

The tailings stacker which we are using is a common rubber belt conveyor. It uses a 24 inch wide belt and is 32 feet long. It is driven by a 3 horsepower, 3 phase electric motor. It is equipped with rubber impact rollers for the first 4 feet where the gravel from the trommel discharges onto the belt. These impact rollers help to cushion the impact of the gravel as it falls out of the trommel onto the belt, increasing the life of the belt. The head pulley of the conveyor is lagged with a rubber covering to decrease belt slippage. The back end of the conveyor is anchored to the plant and the discharge end is suspended from cables. Our tailings stacker is inclined at an angle of approximately 20 degrees. The incline is adjustable with turnbuckles located on the cables. This conveyor has worked well for the ground on the Fortymile, where the depth is usually 12 to 15 feet and the height of gravel above the water seldom exceeds 2 to 3 feet. The conveyor which we are using is stacking 60% of the 90 yards per hour feed rate, the +1/4 inch oversize material. Photograph 14 shows our conveyor.

We think that the conveyor which we are using should be wider, to allow us the option of operating without a grizzly in gravel which does not have a significant number of boulders.

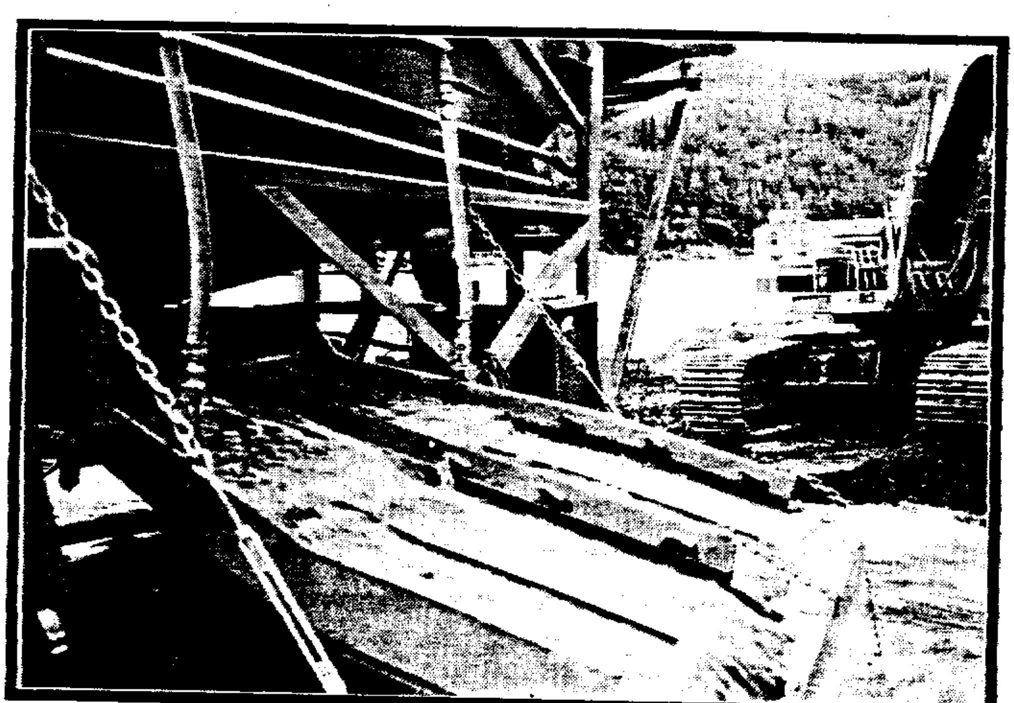
3.4 Gold Recovery System Design Considerations

A gold recovery system should be selected to suit the type of ground being mined and the character of the gold recovered. There are many options for gold recovery, including sluice runs, jigs, and centrifugal concentrating drums. Any type of gold recovery system can be incorporated into the floater plant. There are, however, some factors peculiar to the floating plant which must considered.

When installing the recovery equipment, the balance of the barge must be maintained. The recovery equipment must be located either on the centre line, directly under the trommel or screen deck, or a pair of identical recovery devices must be employed, one located on each side of the barge, as shown in Photograph 16.

Photograph 17 - *This photo shows the hydraulic riffle beds at the head of the side tables which we are using in our operation. Water is injected into the sluice bed from the hose on the left. The hose is connected with a cam lock coupling to facilitate removing the hose for cleaning up the riffles.*

Photograph 18 - *This photo shows flared side sluice tables with hydraulic riffles in the top end. Valves on the hoses to the hydraulic riffles allow adjustment of water volume and pressure to the hydraulic riffles. Turn-buckles allow for easy adjustment of the side tables. Slurry discharging from the side tables is collected in troughs and fed into the end sluice runs.*



Troughs which direct the fine tails well past the stern of the barge are required. If the fine tails discharge too close to the stern, they will build up under and behind the barge so that it becomes grounded, or pushed out of position, or both.

If jigs or centrifugal concentrators are used for gold recovery, sufficient flotation must be allowed for in the barge design, because this equipment becomes extremely heavy with concentrates. Photograph 15 shows a jig system employed on a floater plant.

Specifications for our Gold Recovery Equipment

We are using sluice runs to recover the gold. We estimate that 40% of the 90 yards per hour processing rate, or 36 yards per hour of -1/4 inch material is being sluiced. Two sets of sluice runs are set up identically, one on each side of the plant, so that balance on the barge is maintained. The sluice system consists of sluice tables located on either side of the trommel. These sluice tables have a flared shape, approximately 2 feet wide at the point where the slurry enters, and increasing to 6 feet wide at the discharge end. This generous width has the effect of spreading the feed slurry out and slowing it down, aiding in saving fine gold. The sluice tables have a relatively short run, approximately 6 feet in length.

The throats of the two side tables are equipped with hydraulic riffles. These hydraulic riffles are used in New Zealand and have worked very well for us. Hydraulic riffles work by injecting a small amount of water at low pressure into the sluice bed, creating a loose bed of heavy concentrates. The gold, the heaviest of the concentrates, penetrates into the bottom of the sluice bed. Once the gold penetrates through the sluice bed it is permanently trapped, allowing for longer intervals between cleanups. Gold cannot be lost due to scouring if the sluice tables run clean or under a reduced load. These riffles work particularly well for us because we have a large amount of black sand in the gravel; this black sand tends to clog up sluice riffles. Hydraulic riffles will reject black sand, yet save fine gold. We have approximately 2 feet of hydraulic riffles in the top ends of

Photograph 19 *This photo shows the consistency of the gravel being excavated. The gravel is very loose and has a significant amount of water in it, aiding in both the washing and the feeding of the gravel from the hopper into the trommel barrel. The water mark on the stick shows which pins and bushings are subject to excess wear induced by digging under water. When excavating wet gravel, it is not possible to heap the gravel in the bucket. Because buckets are usually rated in heaped capacity, this difference should be allowed for in choosing the excavator bucket. A struck bucket holds approximately 25% less than a heaped bucket. For example, a bucket rated at 1 1/2 yards heaped capacity would have a capacity of slightly over a yard of wet gravel. The bucket can be equipped with either teeth of a flat lip, depending on the type of bedrock.*

Photograph 20 - *The gravel which we are mining washes extremely easily in the trommel barrel, reducing water volume and pressure requirements. Because there is little clay content in the gravel, the pond stays relatively clean. The pump is located in the well directly underneath the hopper. The generator is located under the hopper so that it is protected from falling rock and water. The hose coiled in front of the generator is used to wash gravel off the deck of the barge.*

our side sluice tables. These hydraulic riffles catch nearly all of the gold. The remaining 4 foot length of the side tables are equipped with Nomad matting and expanded metal riffles. Photographs 17 and 18 show the side sluice tables.

The slurry from the side tables is collected in troughs and feeds into two sets of sluice runs which discharge off the stern of the barge. Each set of end sluice runs consists of two parallel sluice sections 2 feet wide and 12 feet long. These sluice runs are equipped with nomad matting overlain with expanded metal. The back ends of the sluice runs are suspended on turnbuckles to allow for angle adjustment and side-to-side levelling. The end runs overhang the back of the barge by approximately 3 feet. We have found that these end runs do not account for very much gold recovery. However, because the sluice slurry must be directed behind the plant we incorporated another set of sluice runs for this purpose. We clean the end sluice runs less frequently than the side tables, because we have found that they recover only approximately 3% of the gold.

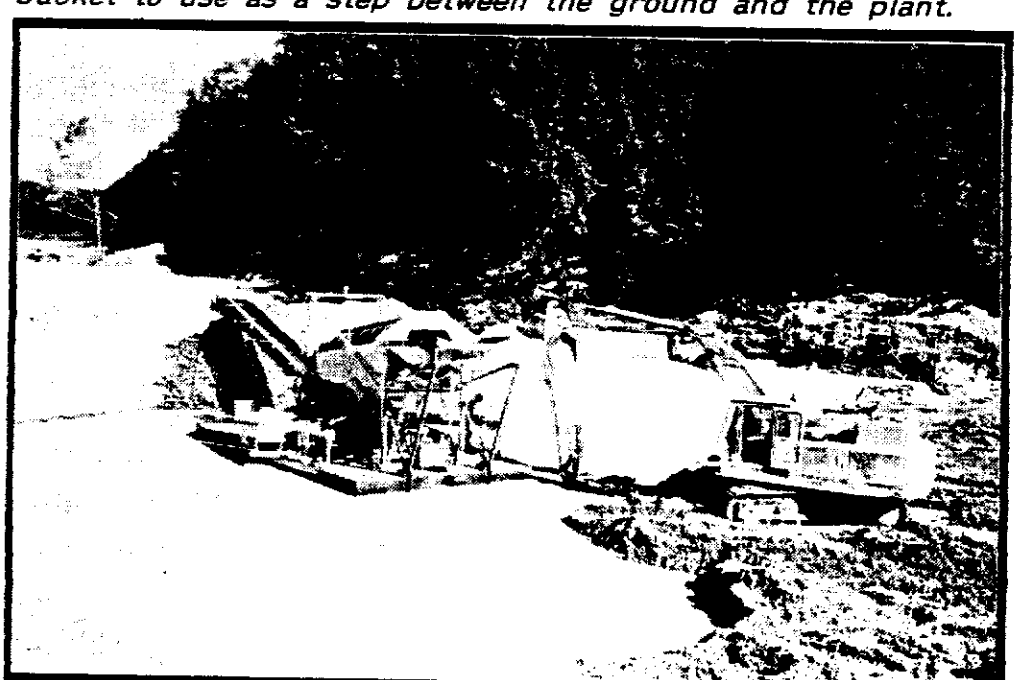
We are pleased with the performance of our recovery system. Periodic checks of tailings have confirmed that we are losing very little gold.

3.5 Water Supply System Design Considerations

The water pump which provides water for washing and sluicing the gravel is located on-board the barge. A pump capable of withstanding the abrasiveness of dirty water should be used because it is pumping pond water which is continually being recycled. Because debris, such as leaves and small sticks, collects in the dredge pond, the pump intake must be screened. The water volume and pressure required are determined by the amount of gravel being washed, the ease of washing the gravel, the type of gold being recovered, the type of recovery system used and other factors which are common to all placer operations. However, because the material is excavated from under water, it is wet when it enters the system so that it washes much more easily than dry material. Consequently, less volume of water is required for washing this gravel than for washing a

Photograph 21 - *The winches for moving the plant are located in a row under the hopper so that they can be operated together when moving the barge. The top end of the submersible electric pump can be seen hanging from a chain block under the hopper. The chain block makes it easy to lift the pump for periodic cleaning of the suction screen. The barge attendant is transported onto and off of the barge by standing on the excavator bucket. The gravel build up which can be seen on the deck should be cleaned off regularly to avoid affecting balance.*

Photograph 22 - *This plant is being moved. The operation is being run by one person. To get onto the barge, the operator positions the excavator arm as shown with a full bucket to use as a step between the ground and the plant.*



comparable volume of dry gravel.

Specifications for Our Water Supply System

We are using a 13 horsepower submersible electric pump with a 4 inch discharge. We estimate that it is delivering approximately 700 gallons per minute at a 25 foot head. We have located it in the well in the centre of the barge. The intake is screened with 10 mesh stainless steel screen. We like the submersible pump because it eliminates the need for suction lines, priming, and foot valves. We have found that because of the sandy nature of the gravel in the Fortymile, we don't have a problem with suspended sediments affecting pumping efficiency. Photographs 19 and 20 show the type of the gravel which we are sluicing.

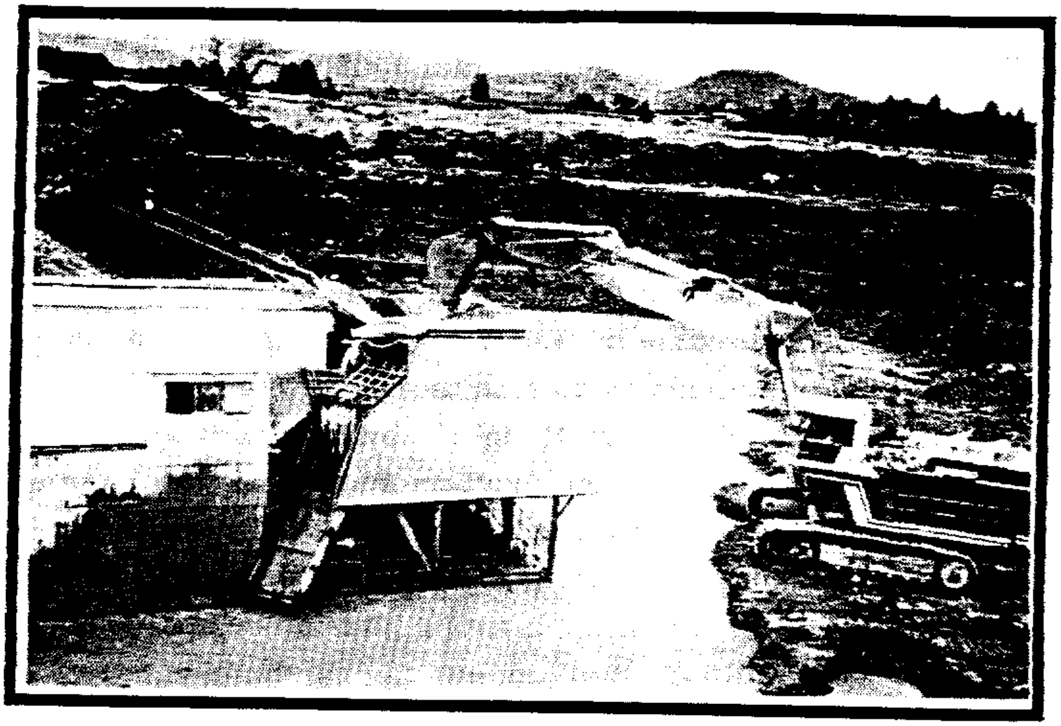
We believe that the pump we are using is well suited to our operation. It has performed reliably, and has stood up well to the abrasive recycled water. Volume and pressure are adequate for the volume of gravel that we are processing.

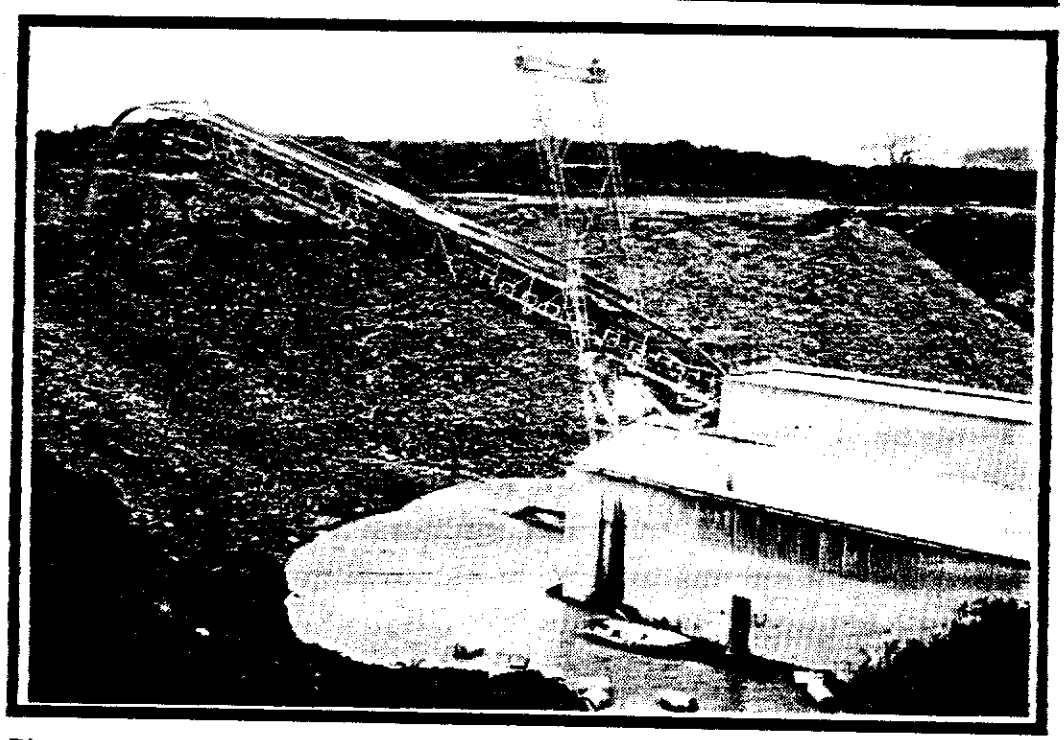
3.6 Winch System Design Considerations

The barge requires winch lines located at each corner in order to move it in the pond. The four winches which control the lines should be located together at a central point so that they can be operated simultaneously. The lines are guided to the barge corners by pulley blocks wherever the lines make a change in direction. Considering the weight of the plant, it can be moved very easily. Hand winches are all that are required to move a floater plant, except for very large scale machines. The winches should have a large enough rope storage capacity to accommodate the width of cut face that is being worked.

Specifications for Our Winch System

The winches that we are using are located at the bow of the barge under the hopper. They are arranged in a row so that they are all readily accessible. We are using common braided 1/2 inch diameter polypropylene rope for the winch lines. This rope has proved adequate for the purpose. We are using inexpensive hand winches which have a 5-to-1 reduction.





Photographs 23 & 24 - *The excavator must match the floater which it is feeding. This operation is processing approximately 450 yph. It has a grizzly system with side discharge to handle boulders and regulate feed. The man on top of the floater indicates the scale. The back end of the plant shows a long conveyor stacker. This long conveyor allows adequate discharge height for the operation to terrace down through dry gravel to achieve greater depth. The roof/shield surrounding the hopper keeps gravel spillage from landing on the deck.*

They can move the barge easily. Photograph 21 shows the location of the winches on our plant.

These winches do not have adequate rope capacity. We are planning to replace them with winches capable of spooling 150 feet of 1/2 inch rope since the cut faces which we work are approximately 100 to 120 feet wide. We originally used 3/16 inch cable for the winch lines; the cable gave us adequate storage capacity but it was continually kinking and fouling up. We found that rope was much easier to use.

3.7 Power System Design Considerations

Power is required to operate the screening machinery, to turn the conveyor, and to run the water pump. Power may also be needed for auxiliary equipment such as night running lights. Power can be obtained through hydraulics driven by a diesel engine on-board the barge. Another alternative is to power the equipment electrically with a diesel driven generator.

Specifications for Our Power System

Power for our operation is provided by a 3 phase, 230 volt, 35 kilowatt electrical generator mounted on-board the barge. Our plant was originally equipped with hydraulic power, but we switched to electricity because we felt that the electric power provides greater flexibility to power auxiliary equipment such as lights, welding equipment, and the water pump.

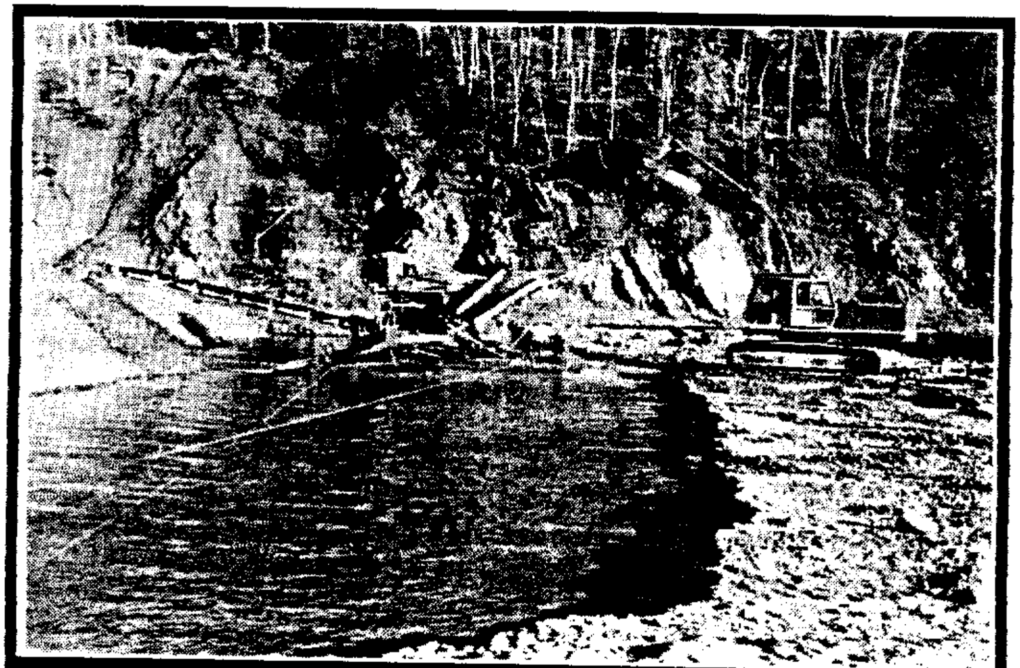
3.8 Considerations for the Choice of Excavator

The excavator must be chosen to handle conditions which are present in the ground to be mined, as well as the capacity of the gravel processing plant. Some of the factors to be considered are outlined as follows:

- The volume to be processed per hour.
- The depth from which the gravel must be excavated.
- The breakout force required, i.e. the tightness of the ground, and the quantity and size of boulders present.

Photograph 25 - *The web welded into the centre of the bucket keeps large boulders from entering the back of the bucket. Large boulders will stay on top of the web, making it easy for the operator to see them so that they can be rejected, rather than inadvertently dumped on the plant where they could cause damage.*

Photograph 26 - *This photograph illustrates the reach required when dumping into the hopper. Usually, the excavator should be equipped with a long stick. The crossed winch lines can be seen here. The excavator works a cut face across the pond. The plant is winched to stay directly in front of the excavator. When the operation reaches the end of the cut face, it reverses direction, working its way back across the pond.*



- The height to which the material must be lifted for discharge into the hopper.
- The reach required to dump into the hopper.

The bucket can be equipped with either a flat lip or teeth for digging. A flat lipped bucket cleans bedrock better; however a toothed bucket digs into bedrock better than a flat lip. Teeth wear out quickly when digging abrasive gravel in the water, adding to operating costs. We have found that a set of bucket teeth wear out in approximately 250 hours of digging. The choice as to whether to equip the bucket with teeth depends on the type of gravel being excavated and the type of bedrock being cleaned.

Digging under water with the excavator causes excessive wear on the bucket pins and bushings which are exposed to water. This wear can be mitigated to a certain extent by greasing frequently; we grease all pins and bushings which are submerged in the pond at 1 1/2 hour intervals. A power greasing system would be useful for this purpose. The excavator can be equipped with a sealed pin and bushing system, eliminating the need for greasing.

In ground with a large proportion of boulders, the excavator bucket can be equipped with a vertical web in the middle of the bucket, as shown in Photograph 25. The function of this web is to prevent large boulders from entering the bucket. When a boulder is excavated, the operator can see it because it does not enter into the bucket but stays on top of the load. The boulder can be discarded and the remainder of the load can then be fed to the plant.

Some excavators used for floater mining are modified by extending the boom so that deeper deposits can be mined. If the boom is extended, the bucket capacity must be reduced proportionally. Very deep ground can be handled with this arrangement.

Specifications for Our Excavator

We are currently using a Hitachi UH10 excavator. This machine weighs 57,000 pounds and has 165 horsepower. It has a long stick, 12 feet 5 inches, giving it a 25 foot 9 inch maximum digging depth, a 37 foot 2 inch reach, and a 21 foot 8 inch dumping height. It is equipped with a 44 inch bucket with a heaped capacity of 1.375 cubic yards. The bucket has 4 teeth. This machine is somewhat larger than necessary for the volume we are processing. We chose it because in many places the Fortymile has a layer of tightly packed boulders laying on bedrock; these boulders would be difficult for a smaller machine to break-out and lift.

4. CAPITAL COSTS

The costs of building or purchasing a floater mining outfit can vary considerably depending on a number of factors including the gravel volume to be processed, and whether the equipment is purchased new or used. All of the components, with the exception of the barge, are readily available from a number of suppliers.

We have provided capital cost data on the equipment used in our operation as a working example to illustrate the costs involved. Our approach was to buy good quality components new, and to assemble them into a working operation. Because of the short operating season, we wanted to achieve reliability. Anyone interested in determining the costs of assembling a floater operation can use our costs as a rough guide.

We have listed the costs of all components used, as well as the cost of labour to assemble the outfit. The cost of financing has not been included. If equipment is financed, interest costs can be significant and should be budgeted for. The cost of freight has not been included either since freight costs vary greatly depending on the transportation distances involved. We assembled our plant in 1989 so these costs are determined as of that date; GST would have to be included now. Notes on each of the capital cost items follow the costs summary below.

4.1 Total Capital Costs

Barge	$ 18,000
Trommel plant	$ 35,000
Conveyor	$ 8,500
Gold recovery equipment	$ 1,000
Winch System	$ 500
Pump and related equipment	$ 7,000
Power System	$ 14,000
Excavator	$187,000
Labour for construction	$ 6,000
Total	**$277,000**

Capital Cost Notes

Barge - We had the barge sections built by a fabrication shop. We found that the barge could be built as cheaply in a professional shop with bending facilities and high speed welding equipment, as we could build it in the field. However, quotes we received from various shops varied considerably.

Trommel plant - We bought our 4 foot diameter trommel plant in New Zealand. It was built in a shop specializing in placer mining equipment. It had a diesel motor and hydraulic components to power it; we switched the plant over to electric drive. We built the grizzly and the boulder chutes. The side sluice tables with hydraulic riffles came with the plant.

Conveyor - Our conveyor is 32 feet long and has a 24 inch wide belt. We found conveyor costs varied widely. We purchased it complete with electric motor, reducer, and switch gear.

Gold Recovery Equipment - Because the cost of the trommel includes the cost of the side sluice tables, we have calculated costs for only the end sluice runs. Costs are calculated for the two 12 foot long by 4 foot wide sluice runs, complete with nomad matting and expanded metal.

Winch System - Cost includes 4 winches, and 10 pulley blocks to direct the 1/2 inch braided polypropylene rope, and 600 feet of rope.

Pump - We are using a Flygt model 2125-B single stage submersible 3 phase electric pump with a 4 inch discharge. The pump is connected to the water supply line on the plant with a short length of rigid rubber hose.

Power System - We are driving all of the components on the floating plant with a 230 volt 3 phase 35 kilowatt generator powered by a Perkins diesel engine, purchased new in 1985; the cost would be higher now.

Excavator - We have quoted the cost of a new model EL-240 Caterpillar excavator, although we are using a Hitachi machine. There are many makes and models of excavators available, both new and used. The price of a new one provides a baseline for comparison. This value has also been used in the computation of operating costs.

Labour - Approximately 200 man-hours were expended in assembling the various components into a working dredge plant. We have charged this work out at $30 per man-hour. This figure takes into account welding equipment and supplies.

5. OPERATING COSTS

We have observed in placer mining that there are many different ways of determining operating costs because there are many different ways of operating a placer mine. For example, some large operations have to take into account overhead costs such as operating an office, and management costs as well as the direct operating costs. A family operation may not necessarily be paying wages to outside help, accounting for camp costs, considering equipment depreciation costs, or allowing for the cost of labour expended to keep equipment running.

In order to illustrate the operating costs of floater mining, we have detailed our operation as an example. We don't consider management fees,expediting costs, or other peripheral costs not associated with direct production. Costs which we do consider include equipment ownership (depreciation), parts and supplies, fuel, maintenance, wages and related costs of hiring people, and reclamation costs. We have grouped these costs into the three following categories: equipment ownership and operation costs, labour costs, and reclamation costs. We have outlined hourly operating costs and from these we have determined our cost-per-yard sluiced.

The operating costs do not take into account set-up costs preparatory to mining, or demobilization costs associated with shutting down the operation, since these costs are not on-going and will differ according to the site being mined. Some other costs which must be considered in setting up a floater operation are as follows:

- Transportation costs incurred in mobilizing and demobilizing the project.
- Stripping costs incurred if there is overburden to be removed.
- Dredge pond excavation; we estimate that it costs approximately $1.10 per yard to excavate the pond and to remove the gravel.
- Setting up the dredge; our dredge can be set up in approximately four hours.

When mining in a remote area, an allowance should be made for increased costs of supporting the operation.

5.1 Equipment Ownership and Operating Costs

Equipment operating costs include all costs associated with owning and operating the machinery used in the dredging operation. We have determined the operating costs separately for the floater plant and the excavator. We have broken down the operating costs into ownership cost and costs of consumable parts and supplies. A maintenance schedule can be determined from the information given in the costs of consumable parts and supplies.

Ownership cost

In determining ownership cost of the equipment we have assumed a 10,000 hour useful life. This figure is commonly used as the useful life which can be obtained out of a piece of heavy equipment before maintenance and down-time costs become excessive. We have determined a resale value after 10,000 hours of 25% of the new cost, a general rule of thumb for determining residual value of a run-out piece of machinery. We have determined the hourly ownership cost using the following formula:

[new cost - residual value]/10,000 hrs = ownership cost/hr

Consumable parts and supplies

These costs include fuel, grease, oil, and other materials used up on a daily basis. Costs for some consumable items such as bucket teeth, trommel screens, and filters, are incurred at regular but longer term intervals. Other items are replaced infrequently over the 10,000 hour life, for example the conveyor belt, excavator linkage pins and bushings, and winch ropes.

5.1.1 Operating Costs for All Barge Mounted Equipment

The operating cost of the floater plant is determined by adding the ownership cost and the costs of comsumables as follows:

Hourly ownership costs

The total new cost of the floater plant as determined in the capital cost section of this report is $90,000. Ownership costs are determined as follows:

[new cost - residual value] / 10,000 hours

[$90,000 - $22,500] / 10,000 . . . . $ 6.75

Cost of consumables for all barge mounted equipment

fuel to power generator- 1 gph @ $1.58/gallon	$ 1.58
trommel screens- 500 hr life @ $1,200	$ 2.40
oil changes, generator- every 250 hrs @ $20	$ .08
trommel drive chain- 1,000 hr life @ $200	$ .20
conveyor belt- 3,000 hr life @ $1,000	$ .33
winch ropes- 1,000 hr life @ $ .20/ft for 500 ft . . .	$ .10
Total	$ 4.69

Hourly operating cost for plant

hourly ownership cost + hourly consumable cost

$6.75 + $4.69 . . . . $11.44

5.1.2 Operating Costs for Excavator

Hourly operating cost for the excavator is determined by adding the ownership cost and the costs of consumables as follows:

Hourly excavator ownership costs

[new cost - residual value] / 10,000 hrs

[$187,000 - $46,750] / 10,000 hr **$14.03**

Cost of consumables for excavator

fuel- 5 gph @ $1.58 gal	$ 7.90
grease- 1 tube every 6.5 hrs @ $1.50/tube	$ .23
oil change & filter- every 250 hrs @ $80	$ .32
bucket teeth- every 250 hrs @ $250	$ 1.00
filters- every 500 hrs @ $100	$ .20
Hydraulic oil change- every 1,500 hrs, 80 gal @$10 . . .	$ .53
Bucket linkage pins & bushings *- 1,500 hrs @ $500 . .	$ .33
half life rebuild **- 10,000 hr @ $30,000	$ 3.00
Total	**$13.51**

* Replace only bucket linkage pins and bushings immersed in water.

** Allowance for rebuilding hydraulic components and undercarriage after 5,000 hours of use.

Hourly operating costs for excavator

hourly ownership costs + hourly consumable costs

$14.03 + $13.51 . . . . **$27.54**

The Caterpillar dealer informed us that the owning/operating costs for a Caterpillar model EL-240 excavator are considered to be US$23 per hour, which is **CAN $27.40**, very close to the $27.54 calculated above.

5.2 Labour Costs

We have determined labour costs at an all inclusive rate of $20 per hour. Two people are required, one operating the excavator and one tending the floater plant. We have found that, in general, for every 12 hour shift there are 10.5 hours of sluicing. Therefore, in determining labour costs per hour of sluicing, labour costs are increased by a factor of 12/10.5. With a two man crew, this schedule allows 3 man-hours per shift for daily routine maintenance, such as servicing the equipment, as well as periodic routine maintenance such as oil changes. It also allows a margin for accomplishing unscheduled repairs and other duties. Labour costs per sluicing hour are determined as follows:

$20/hr x 2 men x 12/10.5 . . . . $45.71

Ten and one-half hours of sluicing time out of a twelve hour shift gives an availability factor of 87.5%. This availability factor is useful in production planning.

5.3 Reclamation Costs

Reclamation costs associated with our operation consist of levelling the tailings to the original contour of the bar. To accomplish reclamation work we use a D6-C Caterpillar dozer. This machine works well for reclamation, since the work required is minimal. We estimate that, for every 100 hours of sluicing at a 90 yard per hour rate, approximately 3 hours are required with the dozer to level the tailings piles left by the conveyor.

We have determined an all-inclusive rate for owning and operating the dozer for reclamation work at $50 per hour. For every 100 hours of sluicing, 3 hours of cat work are required for restoration. The calculation to determine reclamation costs per sluicing hour is performed as follows:

dozer costs per hr x 3/100 sluicing hrs
$50 x 3/100 . . . . $ 1.50

5.4 TOTAL HOURLY OPERATING COST AND COST PER YARD SLUICED

We determined total hourly operating cost for our floater mining operation and cost per yard sluiced as follows:

Total hourly operating costs

Floater plant operating costs	$11.44
Excavator operating cost	$27.54
Labour costs	$45.71
Reclamation costs	$ 1.50
Total	**$86.19**

Cost per yard sluiced

The cost per yard sluiced can be determined using the following formula:

cost per hr / number of yards sluice per hr

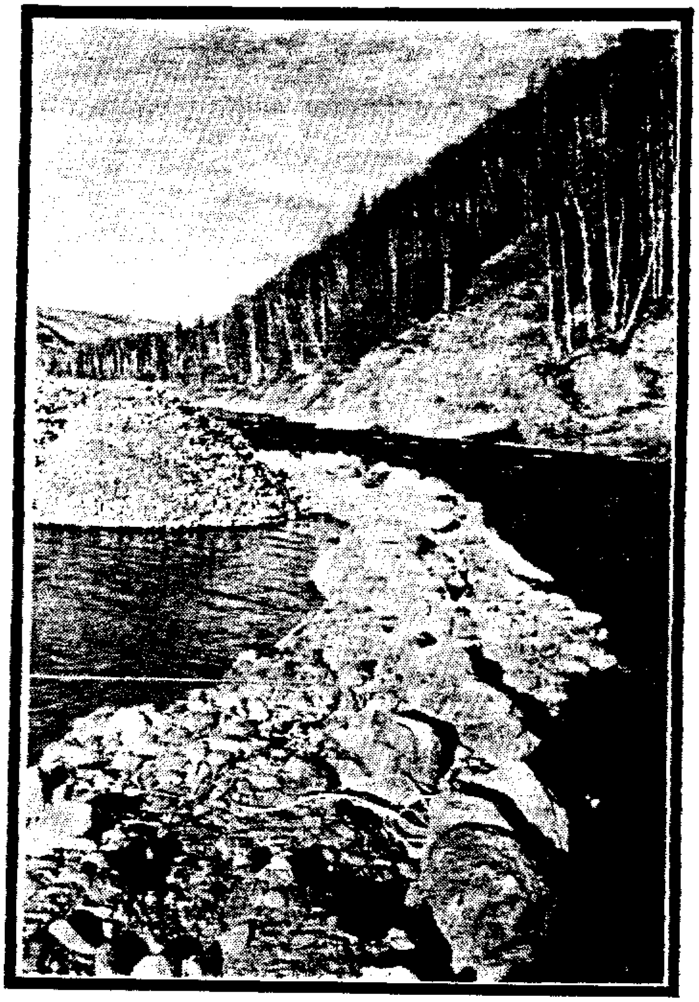
$86.19 / 90 yph . . . . **$ 0.96**

6. OPERATIONAL METHOD

To illustrate this dredging method we outline the procedure which we have adopted in setting up our dredging cut on the bars of the Fortymile River, operating it through a gravel deposit, shutting the operation down, and the subsequent reclamation work performed. It can be done other ways, however this method works well for us and will serve as an example.

6.1 Setting up the Operation

The float system is modular so that the pieces can be easily transported and assembled. The sluice plant is built on skids to facilitate moving it between sites and mounting it on the barge. We set up the operation in the following sequence:



Photograph 27 - *A berm is built at the edge of the bar being mined. This berm is designed to a 1 in 2 year flood standard. It is approximately 5 feet high and 10 to 12 feet wide at the base. We use boulders which we dig up and reject before they enter the plant to reinforce the berm. These boulders also provide good anchor points for the winch lines as can be seen here. There is no discharge of water from the pond to discolour the river water. Because there is a steady small loss of water in the pond from stacking wet tailings, a slight seepage into the pond from groundwater results. This seepage of water into the pond helps to keep the pond water from becoming excessively silty. Upon abandonment, the tailings are levelled and the berm is integrated into the restored bar.*

Photograph 28 - *This photo shows an island-bar being mined on the Fortymile River. The operation can be seen near the head end on the far side of the island. Four rows of tailings still to be levelled can be seen immediately behind the pond. The rest of the tailings have been flattened and integrated into the bar. The only difference between the levelled tailings and the original bar is the lighter colour of the reclaimed area.*

1) The plant is skidded into position directly behind the intended location of the pond.

2) A berm is built at the edge of the bar where the pond is to be excavated. The berm defines the limit of the outside edge of the cut, and acts as a barrier against fish entering the pond should the water level rise. We build the berm by pushing up a windrow with the dozer. The berm is shown in Photograph 27.

3) A pit is excavated into ground water. The pit size is just large enough to hold the barge. The depth of water in the pit is just deep enough to float the barge with the processing plant on it.

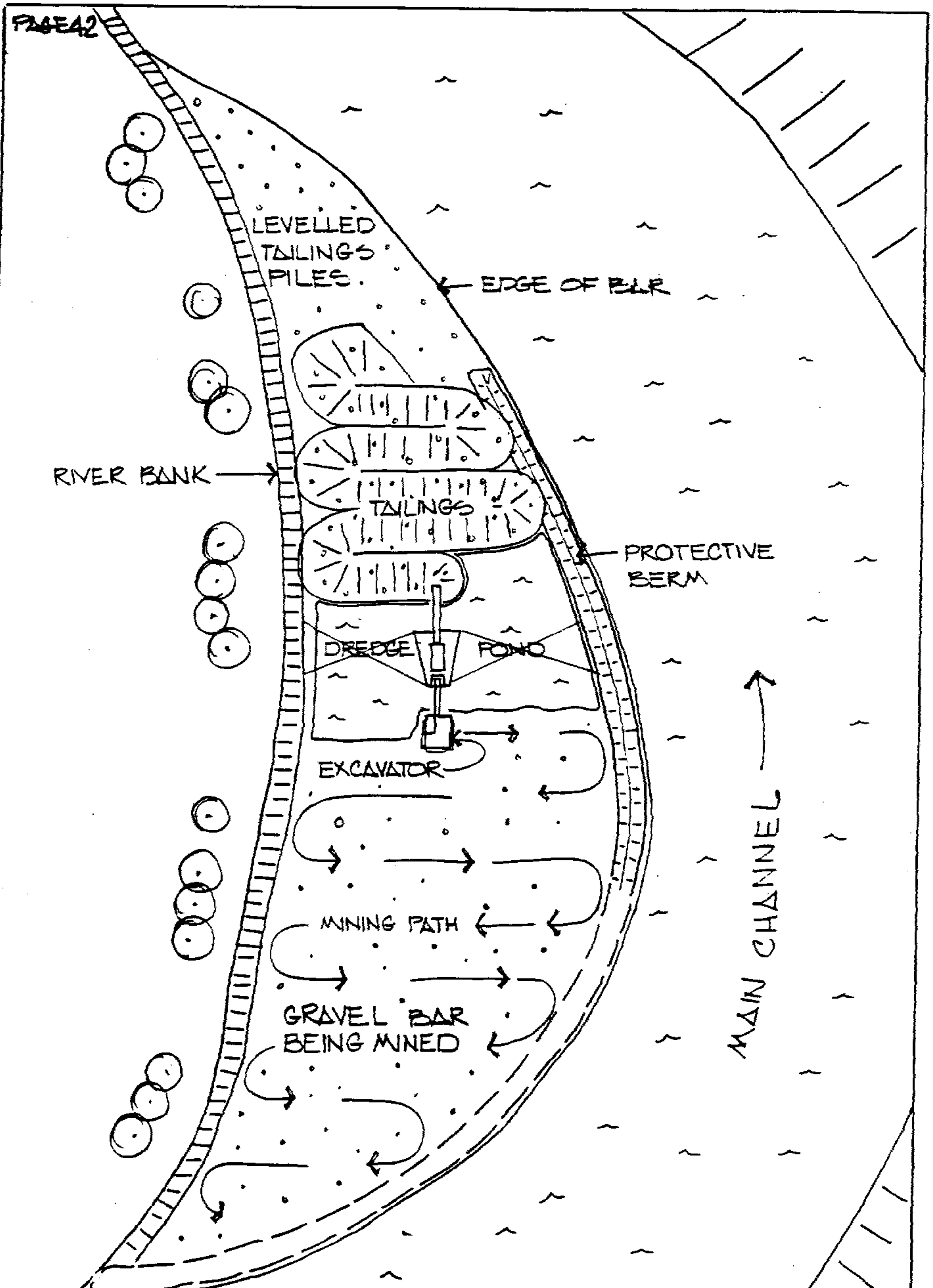
4) The pieces of the float system are placed in the pond using the excavator for lifting. Because they are floating in the pond they are easily moved into position for bolting together.

5) The barge is assembled and moved into position in front of the plant. The front of the pond is back-filled up to the bow of the barge so that the barge is held securely in place.

6) The excavator is positioned directly in front of the barge. A cable is run across the barge to the plant so that the excavator can use it to pull the plant onto the barge. The plant is then skidded onto the barge. There are rails on the barge deck to guide the skid onto the plant, and to hold it in place.

7) The working dredge pond is then excavated to bedrock beside the shallow holding pond in which the floating plant was assembled. The excavator digs the pond and a dozer pushes the material away, either using it for building a protective berm at the river's edge or spreading it over the bar to be mined.

8) The barge, with the plant on it, is pushed into the main pond where it floats freely. If the barge is not floating level, it is moved back into the holding pond and the plant is moved either forward or



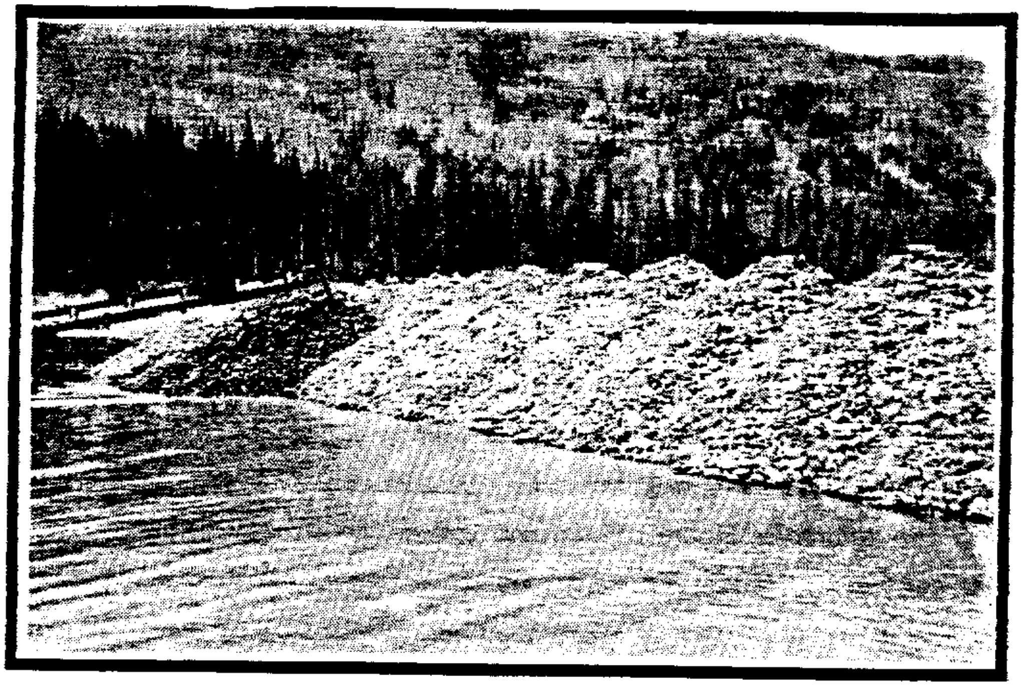
MINING PATH LAYOUT FOR TYPICAL GRAVEL BAR 1"=60' DRWG 4 backward on the barge to adjust the balance. When the barge floats level in the dredge pond, it is ready to begin processing gravel.

6.2 Mining

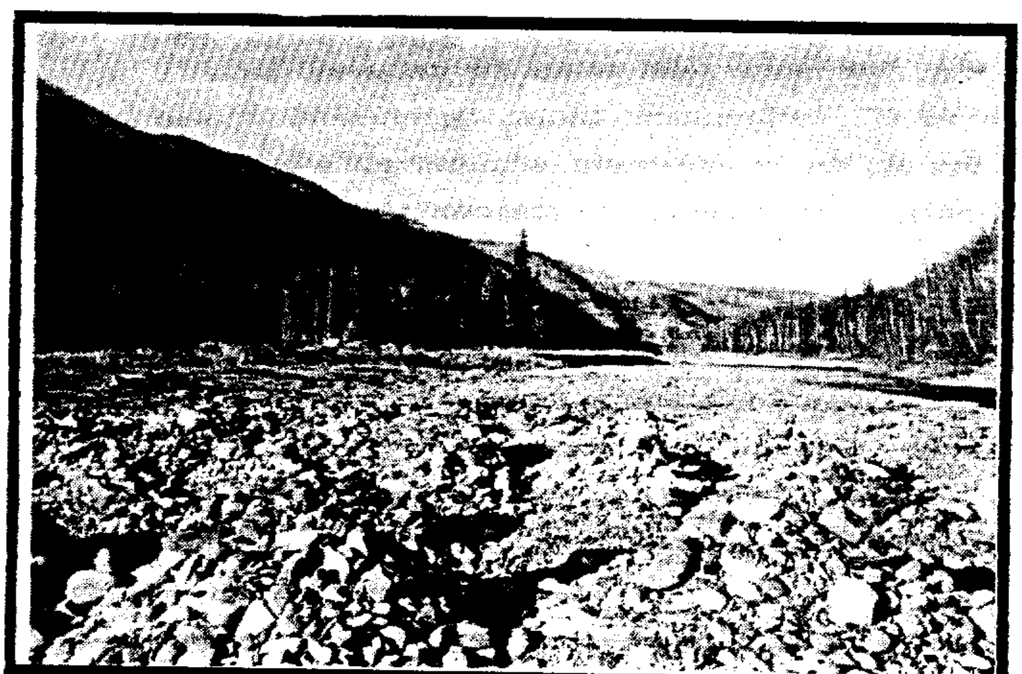
With the processing equipment assembled on the barge and the dredge pond excavated, mining can commence. Mining begins and progresses in the following manner:

1) The winch lines are set out and anchored to shore. We use boulders for anchors because they are plentiful and it is convenient to place them where they are needed; anything that forms a solid anchor can be used, for example clean oil drums filled with rocks. The winch lines are crossed so that the lines on the corners of the bow of the barge are anchored to rocks behind them. The back corners of the barge are anchored to boulders in front of them. This triangulation of the winch lines holds the barge steady and makes positioning it easier.

2) The excavator is positioned directly in front of the barge. It digs gravel away from the cut face beside the barge and loads the gravel into the hopper. The excavator always digs at bedrock level; gravel from higher on the cut face sluffs onto bedrock where it is dug up and deposited in the hopper. The conveyor is continuously stacking coarse tailings behind the plant while the fine tails are deposited behind the barge as they leave the sluice runs. When the coarse tailings pile approaches the top of the conveyor, the plant is winched sideways in the pond to start a new pile, a distance of approximately 15 or 20 feet. The objective is to move the barge far enough so that there is adequate room to begin a new tailings pile without wasting available space. It is important that the space available for tailings be used to maximum advantage, especially in deep ground. The plant progresses across the cut face in this manner, shifting sideways each time the tailings piles approach the maximum conveyor discharge height. We move the plant approximately every 30 to 40 minutes.



Photograph 29 - *These tailings can be easily flattened with a little dozer work. The distance between the peaks of the piles shows the distance that the barge is moved each time. An even line of tailings being deposited in the pond gives maximum room for tailings storage.*



Photograph 30 - *This photo show tailings piles in the foreground. Behind these piles, the tailings have been levelled to the original contour of the bar.*

3) When the operation reaches the end of the cut face, the winch lines are moved forward to different anchor points. The winch lines controlling the stern of the barge are anchored to new anchor points. The winch lines on the bow of the barge are secured to the anchors which were formerly used for the stern lines. The barge is winched forward in the pond, creating the starting point for a new line of tailings. The equipment is now in position to start a new cut.

4) The operation progresses across the cut face in the opposite direction.

5) This procedure is repeated with the operation working its way back and forth across the face, the winch lines being repositioned as required.

6.3 Shutdown

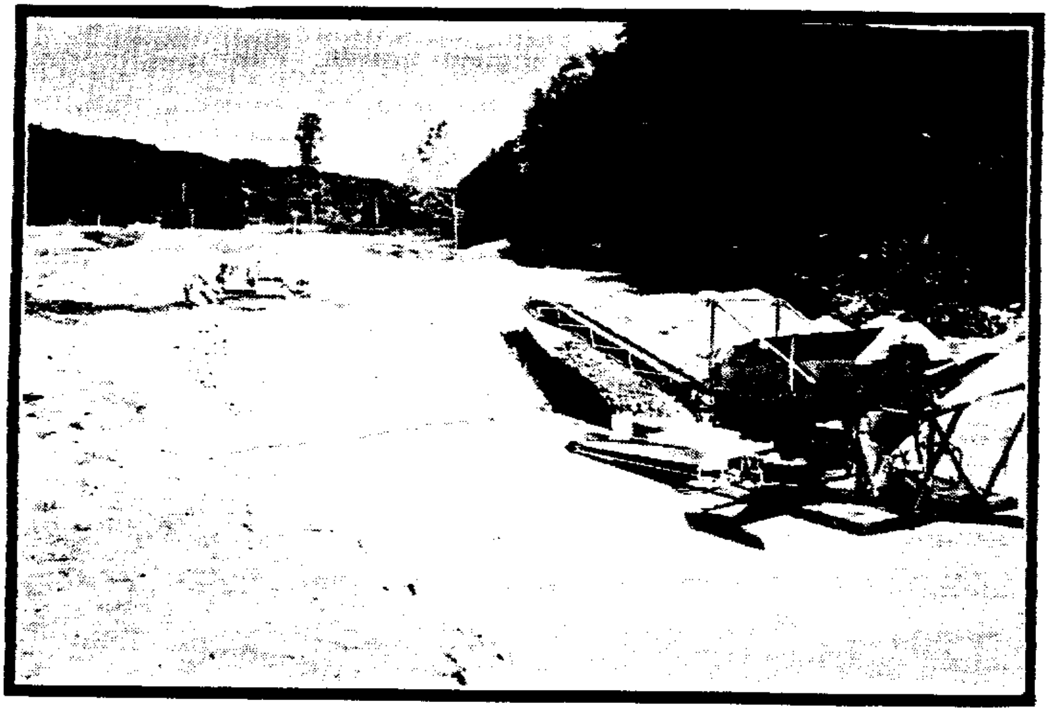
When the deposit has been mined out, or when freeze-up necessitates shutting down, we use the following procedure for disassembling the operation:

1) A shallow pond is dug beside the dredge pond. This pond is just large enough to hold the barge and just deep enough to float it. It is important that the barge be nearly grounding on the bottom of this holding pond when the plant is being pulled off of it.

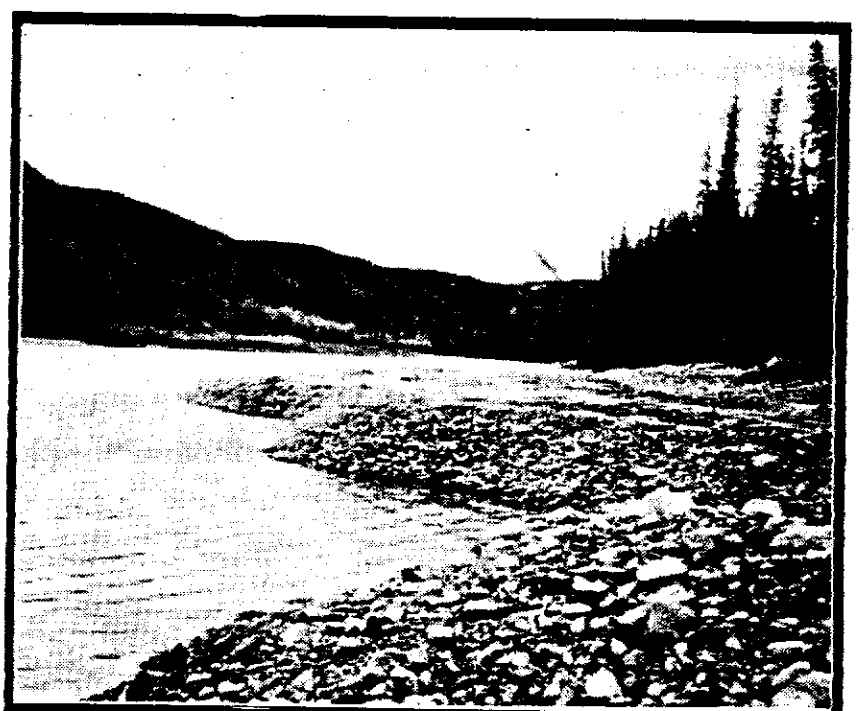
2) The barge is pulled into the shallow pond with the excavator.

3) The plant is pulled off the bow of the barge and onto dry ground. If the holding pond is too deep, as the plant is pulled forward the bow of the barge will sink, the stern will rise, the barge will be propelled backward in the pond, and the back end of the processing plant will fall back into the pond.

4) The barge is disassembled and the individual float sections are lifted out of the pond with the excavator. The components are now ready to be moved to a new location, or stored for the winter.



Photograph 31 - *In this photo, a dozer is spreading overburden, which has been saved, over tailings which have been levelled. This operation is not on a river bar. The excavator bucket which can be seen at the right of the photo has been heavily armoured to withstand the abrasive digging conditions.*



Photograph 32 - *This photo shows a restored river bar which we mined. The tailings have been graded up into the river bank to add stability to the bank. The edge of the bar will be sloped more naturally into the water by ice coming down the river in the spring breakup. After breakup, this bar will be indistinguishable from an unmined bar.*

6.4 Reclamation

Because we work in the wetted perimeter of the river, we are required to fill in the dredge pond either at the end of the season or when we finish mining a deposit, in order to avoid fish entrapment. It is filled with tailings from the piles at the back end of the pond. Costs of filling in the pond vary with the depth and size of the pond. Because the tailings piles provide ample material with a down hill push, filling the pond is easy work for the dozer. We have not included the cost of filling in the pond in the operating costs because it is a one time only job at shut down, not an on-going cost. On average, it takes approximately 10 hours with the D6-C to fill in a dredge pond with a working cut face of 100 feet wide and a depth of 15 feet. At an all inclusive rate of $50 per hour for the dozer, it costs $500 to fill in the pond upon cessation of mining.

Any remaining tailings piles are flattened to the original contour of the bar. We have found it advantageous to level the tailings as mining progresses so that there is not a backlog reclamation work at shutdown. We do our reclamation when the opportunity presents itself with one man having some spare time so that labour is used efficiently. Progressive reclamation is desirable from an environmental standpoint.

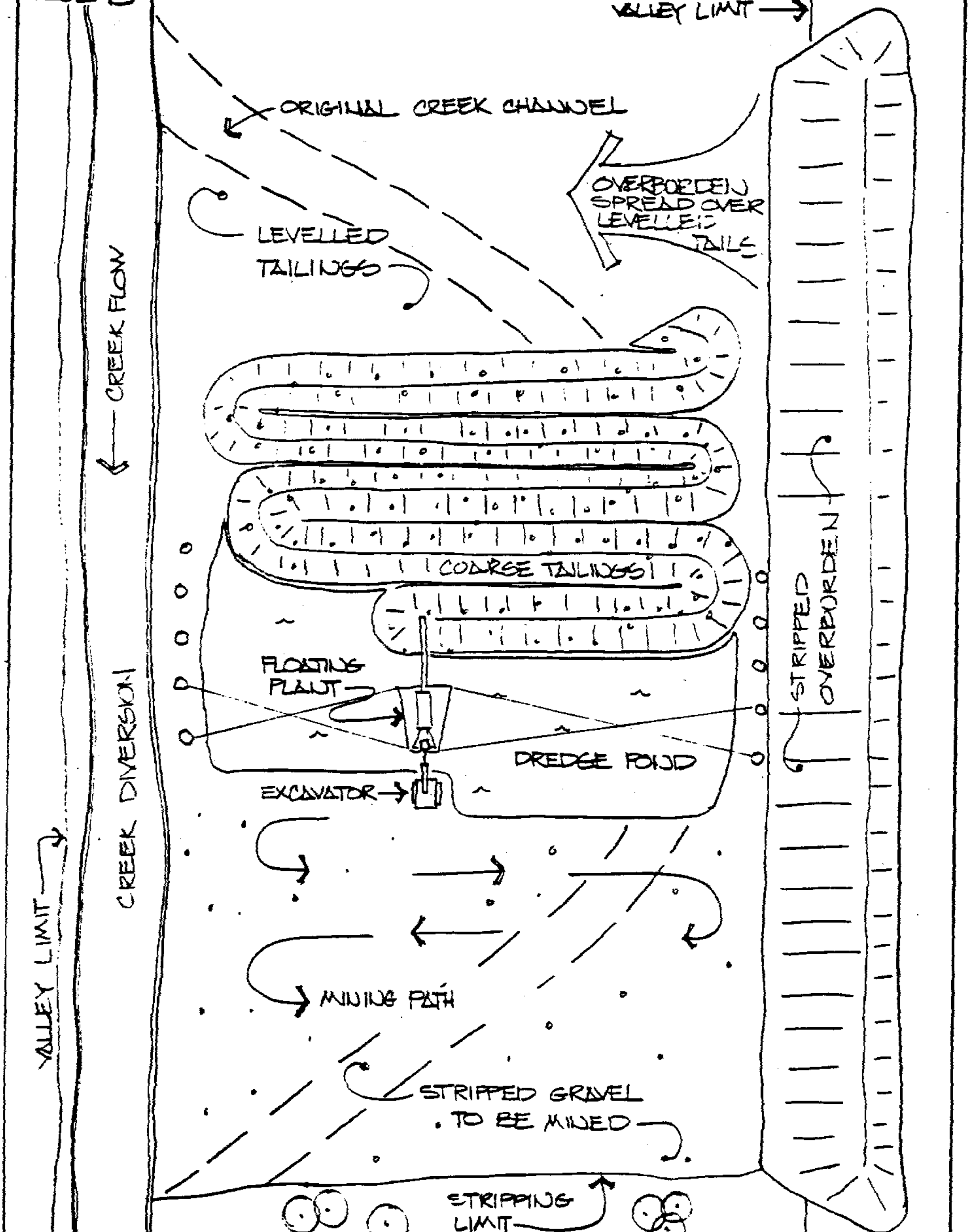
7. OTHER APPLICATIONS OF FLOATER MINING METHOD

There are many other rivers in the Yukon with similar characteristics to the Fortymile, in that they have a history of dredging, and that they have thawed bars which are exposed after the breakup period. Floater mining should also be applicable to these other rivers.

As well as river bars, there are other types of placer deposits in the Yukon where this method can be used.

7.1 Application to River Valley Ground Other Than on Gravel Bars

Ground adjacent to the larger rivers can be mined in this manner. The main criterion for floater mining in river bank ground is that the gravel



PLAN FOR TYPICAL CREEK SETUP SCALE 1"=60' DRWG.# 5 be thawed. One indicator of thawed ground is the growth of poplar trees. In this situation the ground must be stripped of vegetation and overburden. The excavated pit will usually fill with water from seepage. If seepage isn't present, the pit can be filled by pumping water out of the river. If seepage isn't sufficient or is nonexistent, it will be necessary to pump make-up water into the pond at a rate which maintains a constant water level in the pond. Restoration work required depends on the classification of the stream. When mining is finished, the pond can be left, creating habitat for moose, ducks and other wildlife. It is not necessary to fill in the pond since fish entrapment is not a concern.

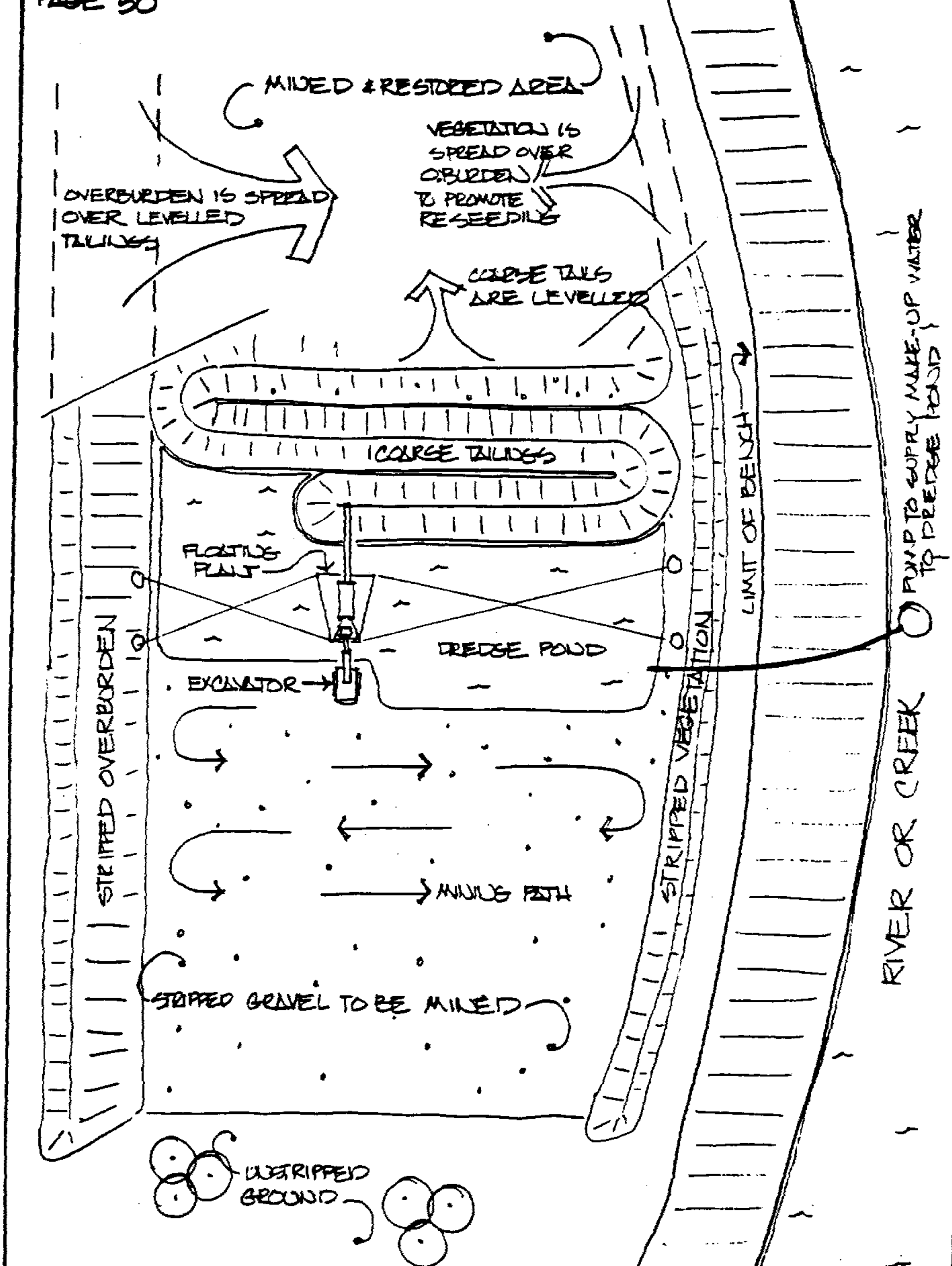
7.2 Application in Creek Mining

Floater mining can be employed in mining creek deposits. It has the same operational advantages and disadvantages as for river bar mining. The area to be mined must be stripped of vegetation before mining commences. A bedrock drain is not required for dredging in a creek valley. The method is particularly advantageous in narrow valleys where space is restricted. Because the settling pond is an integral part of the operation and the tailings are constantly filling in the mined area, very narrow gulches can be mined. However, in the Yukon most narrow valleys are in permafrost. Because this dredging method requires that the gravel section be thawed to bedrock in order to operate, the application is limited. Diagram 5 shows a typical floater mining set-up in a creek valley.

7.3 Bench Deposits

Bench deposits can be mined using this method, with the same advantages and limitations as outlined previously. As well, there is the advantage that the dredge pond acts as a water reservoir on the bench, lowering pumping costs since only make-up water is required in the pond. In a bench mining operation, barren top gravels can be stripped down to pay.

The gravel deposit must be tight enough to hold the pond. In very loose gravel, it is difficult or impossible to pump water into the pond fast enough to keep it filled.



PLAN FOR TYPICAL BENCH SET-UP SCALE 1"=60' DRWG 6

In setting up a bench operation, the area to be mined is stripped of vegetation. If the top gravel in the deposit doesn't warrant sluicing, it can be stripped as well. A pit is excavated to bedrock to start the dredging cut. This pit is then filled with water, and the plant is set up in the same manner as outlined for operating on a bar. A make-up pump is used to pump water into the pond at the volume required to keep the water level in the pond constant. The cut proceeds as outlined previously.

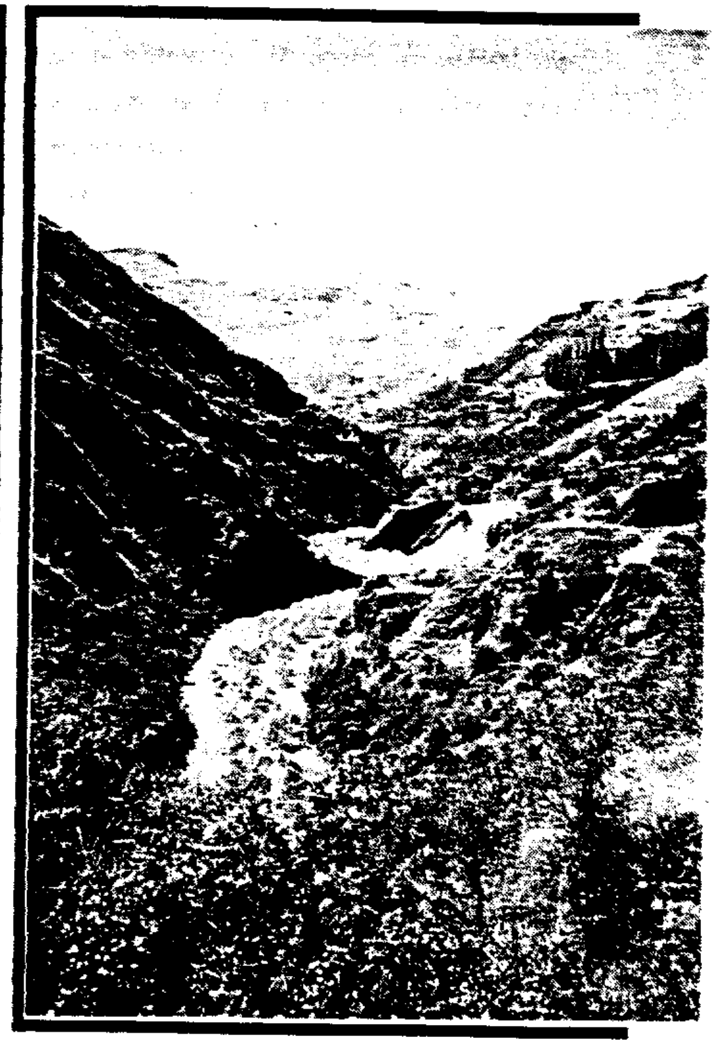
8. LICENSING AND REGULATORY APPROVALS

In order to establish a floater mining operation, as with any other type of placer mining, the miner must have the placer mineral rights to the property and a water licence. Floater mining does not presently fall under the Fisheries Authorization which prescribes effluent standards and mining practices required in a placer water licence, so there is no prescribed regulatory regime for this type of mining.

Our operation was licensed as a special case with specific conditions delineated. We are allowed a water discharge of .2 ml/l of settleable solids, as long as it does not exceed 200 mg/l of suspended solids, the same discharge standard the allowed for on any Type II, salmon rearing, stream. Because we have no discharge, this standard is not relevant. Our water licence specifies that we build a berm between the dredge-pond and the river channel to prevent fish from entering the pond and subsequently becoming trapped if the river water level rises over the bar and then drops. We are not allowed to operate in the actual river channel. A floater mine located on a different classification of river would probably be regulated somewhat differently.

9. CONCLUSION

Because of the current low gold price and rising operating costs placer mine operators face a challenge in order to remain profitable.



Photographs 33, 34, & 35 - *These photos show the systematic mining and subsequent restoration of a placer stream. The photo at the top left shows the operation at work. The photo at the top right shows tailings left by the operation. The bottom photo shows the stream at low water with the tailings levelled to original contour.*

As with all operators of natural resource industries, placer miners must take into account the impact of their operations on the environment. Watercourses must not be affected by effluent, and adequate reclamation of mined areas is required. Mitigating environmental impact has become a significant component of mining; the cost of treating process water and of performing restoration work add to the cost of mining. The placer industry must gear up for the challenge of mining with minimal environmental impact while remaining profitable. Floater mining is one such method of achieving this goal; there is no impact on the watercourse, no stripping of vegetation is required when gravel bars are mined, and total reclamation is easily and inexpensively achieved.

Today, many of the higher grade placer deposits have been mined out. There are still vast placer reserves in the Yukon but most of them are of significantly lower grade than those which have been mined in the past. As well, the price of gold is relatively low, when compared with the price in recent years. In order to operate profitably in low grade ground when the price of gold is low, placer miners must operate more efficiently. Floater mining, with mining costs at approximately $1.00 per yard of gravel processed, can be practised profitably in ground which would be considered too lean to be minable using other mining techniques.

This dredging method is a practical example of the philosophy of sustainable development, which seeks to preserve environment quality without sacrificing economic activity. Floater mining cannot be practised everywhere; it's limitations have been discussed. It is, however, one example of how the placer industry can meet the challenge of the future.