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MINE CLOSURE PLANNING AT EQUITY SILVER MINES LTD.

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Equity Silver Mines Ltd. has scheduled pit closure by the third quarter of 1992. In preparation for this event, detailed plans have been developed to insure there is a smooth transition for release of the workforce and that environmental concerns are addressed.

Socio-economic and mine closure plans have been completed to serve as guides for termination of operations. A socio-economic study, funded by Equity Silver and the Township of Houston, B.C., was developed to assess impact of mine closure and looked at means to mitigate this impact.

The mine closure plan, which will be the focus of this paper, was developed to serve as a guide for both Equity Silver Mines Ltd. and government agencies. It has under gone several reviews and revisions prior to being accepted as a final document. Of particular importance is the ongoing care and maintenance of facilities required to collect and treat acid rock drainage (A.R.D.) formed by oxidation of sulphides present in the mined waste rock.

A.R.D. treatment facilities, which will operate for an indefinite period, will require ongoing funding to sustain their operation. Bonding has been put in place to develop sufficient interest to cover the annual cost of these facilities.

The initial estimate for the bond was based on escalating historical environmental costs which resulted in a fund larger than originally anticipated. On the basis of this higher cost, the company decided to reslope the waste dump and install a compacted clay cover to mitigate the quantity of A.R.D. produced. Studies indicated that the clay cover would significantly reduce water infiltration into the waste dump and would also eliminate much of the oxygen transfer required to fuel the acid generation process.

INTRODUCTION

Equity Silver Mines Limited owns and operates a surface mining and 9000 tonne per day milling complex located in the central interior of British Columbia. The property lies 35 km southeast of the community of Houston and approximately 575 km north-northwest of Vancouver.

Ore reserves are confined to three known mineralized areas, the Southern Tail, Main Zone and Waterline Zone. The economic minerals (copper, silver and gold) are extracted from ore by conventional crushing, grinding, and flotation circuits. Additional gold and silver is recovered from concentrator tailing using carbon-in-leach technology. Mining of pit reserves are projected to be completed by the third quarter of 1992 at which time the work force will be significantly reduced.

Much concern existed over the impact that mine closure would have on the community of Houston. On this note Equity Silver and the Township of Houston commissioned a study to evaluate the socio-economic impact of mine closure. A number of mitigative strategies were identified in the report to assist in lessening the negative impact of mine closure on the employees and community in general. The formation of an Economic Development Committee and the Equity Silver Adjustment Committee were positive steps taken to address impact on employees and community.

Besides looking after the best interest of the employees, Equity Silver must also deal with the issue of mine closure in light of a difficult environmental problem. In 1981, acid rock drainage (A.R.D.) was found to be occurring as a result of oxidation of sulfides contained in the mined waste rock. A.R.D. from the minesite is collected and processed in a lime treatment plant to neutralize acid and remove metals prior to discharging water back to the environment. A bond has been established to generate interest which will provide ongoing funds to operate the treatment system after closure.

Reclamation measures were altered on the premise that A.R.D. volumes would be reduced which would also be reflected in the annual treatment cost and the bond sum required to sustain operations. This paper will outline past and present waste dump reclamation steps and the process leading up to the decision to proceed with installation of an engineered clay cover on the waste dump.

SOCIO-ECONOMIC IMPACT

The closure of Equity Silver will have a negative socio-economic impact on Houston which is to be expected given the mine directly employs 180 people and annually generates about $11.5 million in direct spending in the community. Under the base case for developing the socio-economic study, the number of people projected to leave the community is about 360 including workers and

family. This represents roughly 8% of the population.

A number of mitigative strategies were identified in the Socio-Economic report to offset the negative impacts of mine closure on the employees and community. The formation of a Economic Development Committee and the Equity Silver Adjustment Committee were positive steps in lessening the impact on employees and community. It was also stressed, mine closure aside, that Houston continue to pursue general economic initiatives that will help to diversify and strengthen the community's economic base.

Specific strategies recommended to the company and community are summarized below:

Company strategies:

- hiring employees for other Placer Dome Operations
- job placement assistance
- retirement counselling
- employee training to upgrade marketable skills
- employment and family assistance counselling
- a strong employment community relations program to keep all parties aware of plans and progress (Adjustment Committee)

Community strategies:

- a campaign to promote Houston businesses to "hire local"
- promoting availability of skilled workforce to attract industry to Houston
- lobbying government support for new industry
- continue to pursue economic development initiatives
- promote Houston as a bedroom community for commuter mines

Joint strategies:

- attract mining and other conferences to the area to promote Houston as a bedroom community
- explore opportunities of using Equity Silver as a training or research centre
- promote the mine site as an industrial location

Most all these initiatives are being pursued by Equity Silver and the Township of Houston. Equity Silver reviews progress of closure plans monthly by way of an Adjustment Committee comprised of representatives from management and the work force. The Houston Economic Development Committee" continues to investigate ways and means of promoting industrial growth in the area.

CLOSURE PLANNING

A conceptual closure plan was presented to government by April 1988. This plan laid out closure concepts with costs and schedules for decommissioning the site in year 1992. The plan received critical review from several government agencies by way of independent consultant contracts. Based on these reviews, Equity Silver issued a second and final closure plan in April of 1991. The revised plan presents a full description of work required to

decommission the current mine facilities, to reclaim the site and to complete the facilities required for the post closure collection and treatment of A.R.D.

The most significant issue to develop out of this review process was the question of long term lime demand to treat A.R.D. and environmental operating cost. At the time of the studies both were escalating at a significant rate. Discussions in regards to a long term reclamation bond were also proceeding at this time and became more critical as mine closure approached. After numerous reviews and discussions it was evident no progress was being made in establishing long term trends and cost liability to the company. It was imperative to both Equity Silver and the government to arrive at a realistic operating cost to establish a suitable but adequate bond sum.

In January of 1991, a Technical Committee was formed to identify and resolve outstanding differences between the groups. The mandate of the group was to arrive at an unbiased probability distribution of expected long term post closure costs. The Committee was comprised of representatives from Equity Silver, the Ministry of Environment, the Ministry of Mines and an independent consultant who acted as a mediator to the Committee. The Committee met six times over a period of three months. It was Equity Silver's wish that two specific cover scenarios be investigated; one with the existing uncompacted cover and the other employing dump resloping and placement of a 0.5 metre layer of highly compacted clay. The latter option had been tested over a 16 hectare site on the S.T. dump during the summer and fall of 1990. Cost estimates showed this to be a desirable option to reduce treatment costs.

Where the past cover allowed 40% infiltration of precipitation, the new compacted clay cover could be as low as 5%, although 10% infiltration was used for cost estimates. On the basis of these values and estimates of lime usage, cost estimates were developed for a range of cases. Present value costs were developed by extending lime usage and cost out for a 100 year period. The forecast bond size varied from a low of $22.8 million for compacted clay covers to a maximum of $56.6 million should no additional work be carried out at the minesite. Long term bond estimates are illustrated in Table 1.

	Dollars in Millions		
	Minimum	Most Likely	Maximum
Existing Covers (40% infiltration)			
Fixed	13.2	13.2	13.2
Variable	4.1	4.1	4.1
Lime	16.9	25.2	39.3
Total Cost	34.2	42.5	56.6
Compacted Clay Cover (10% infiltration)			
Fixed	13.2	13.2	13.2
Variable	1.2	1.2	1.2
Lime	8.4	11.5	17.7
Total Cost	22.8	25.9	32.1

Table 1: Bond Estimates - Present Value Estimates ($ Million)

Because many of the long term trends were at best educated estimates, Equity Silver decided to contract out a program to model the impact of a compacted clay cover on acid generation and the long term influence of this cover on lime consumption. Findings of the study confirmed estimates of the Technical Group and appeared to correlate well with existing lime consumption trends. This correlation is illustrated in the Figure 1 where actual lime consumption is compared to projections using compacted clay covers versus previous reclamation methods.

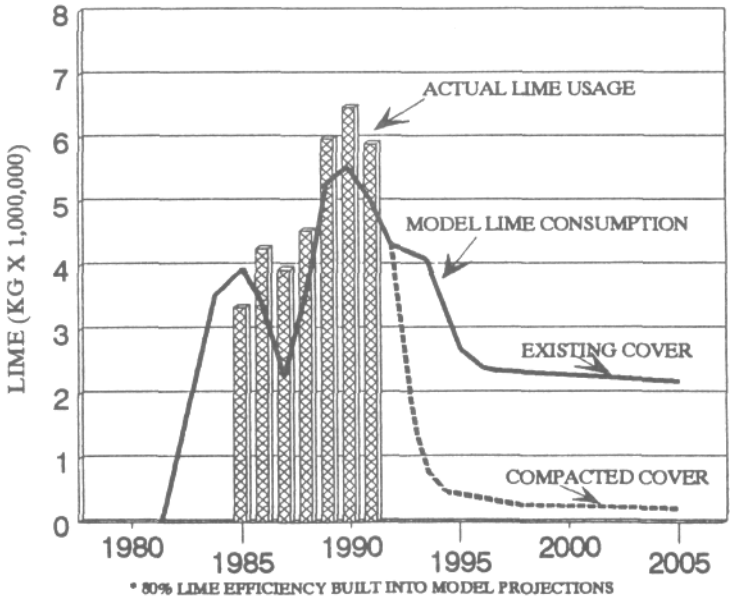

Figure 1: Projected (Modelled) Lime Consumption versus Actual

On the basis of these estimates, it was concluded that a compacted clay cover would significantly reduce annual volumes of

A.R.D. and ultimately treatment costs which would reduce the final bond requirement.

On the merit of this work, a total bond of 37.5 million dollars has been requested by the government. Of the total security, 32 million dollars is identified as the maximum amount estimated to finance the long-term treatment costs after the waste dump has been covered with a compacted till layer. The remaining security, 5.5 million dollars, has been established to insure placement of the compacted till cover and plantsite reclamation is completed.

Past Reclamation

Shortly after identifying the presence of A.R.D. on the property, steps were taken to first collect and treat the contaminated runoff followed by the investigation of methods to mitigate the oxidation process. A decision to proceed with a soil cover on the dump was made early in the program and scheduled into the mining cycle. Clay material stripped from the pits was hauled to finished sections of the waste dump and laid down at a 0.5 to 1.0 metre thickness. Side slopes were covered by pushing material off individual berms. No compaction was carried out on berms nor on the side slopes. Covered areas were revegetated by hand or hydroseeding methods and aerially fertilized.

Vegetation established quite well on both the flats and steep slopes of the dump. However, after considerable monitoring it was found that the revegetated cover did not prevent as much water from flowing through the dump as originally thought. As a result, costs to treat A.R.D. continued to increase annually.

Compacted Clay Cover

In preparing for the clay cover installation, dump faces were contoured to an average slope of 20-22 degrees. This was easily accomplished as waste piles were constructed at roughly the same angle for geotechnical reasons. Clay was then administered at a 0.5 meter thickness and compacted to a minimum of 95% of proctor using vibratory compactors. A second layer (30 cm) of clay was then placed on this surface to .act as a protective cover to hold moisture in the underlying barrier and also to serve as a base for vegetation. When completed, the surface was hand seeded with a grass legume mixture. Ditches were constructed into the side slopes of the dump to channel surface runoff out to the surrounding environment .

The cost of the program is expensive, however, as previously illustrated, it has the distinct advantage of reducing cost and ultimately the final reclamation bond size. Resloping and clay placement unit cost for a 2 kilometre haul distance plus seeding have been summarized in Table 2.

o Resloping	$0.80/m^3
o Clay Layer	$3.50/m^3
o Overall Cost	$34,000/hectare

Table 2: Reclamation Cost: Summary

This project will have the single most impact on environmental security and long range cost. It is difficult to assess the full impact of this cover at this time as a portion of the Main dump is still uncovered and no doubt is contributing to increased loading of contaminants. Many of the monitoring programs are still in the infancy stage and will likely take a couple of years of data collection after the covers are completed prior to drawing any conclusions.

However, on a smaller scale, encouraging results were obtained from an isolated test within the Southern Tail (S.T) Pit waste disposal area. A portion of the dump was reclaimed with a compacted clay cover in 1990. A detailed hydrology study was carried out on this area and was found to shed better than 95% of the snow melt and had a net effect of reducing contaminant loading out of the isolated S.T. Pit outflow. The attached graph (Figure 2) illustrates copper loading in the discharge from the S.T. dump.

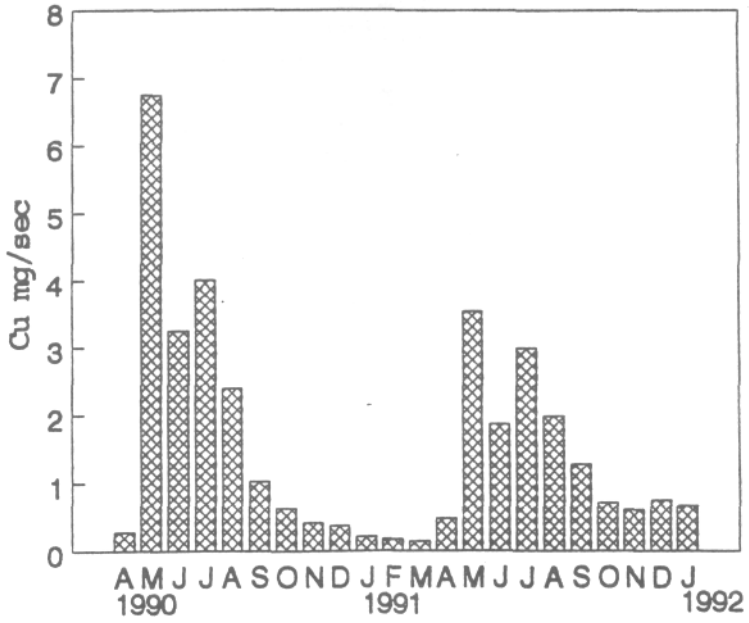

Figure 2: Copper Loading Out of S.T. Pit

Cumulative loading from this site for a portion of the year.

April to January, shows copper discharge to be reduced by 28% from 1990 to 1991. Although not illustrated, zinc shows a similar pattern but at a lesser reduction of 11%. This is in part a result of solubility coefficients for zinc at the higher ph values; that is to say zinc remains in solution far longer than copper.

It is this type of monitoring that will be essential in evaluating environmental programs such as that of the compacted clay cover. If metal loading and ultimately lime consumption can be reduced within the next 5 years, Equity Silver will have achieved a very significant goal in regard to mine closure and environmental security.

Cover Integrity

The compacted clay till cover that has been used on the waste dumps is a relatively new practice with only limited historical record. As a result, there has been some concern raised as to the impact of heavy frosts on the integrity of the cover. To investigate these concerns, a study was initiated to evaluate if cover deterioration was evident at several of the older compacted clay till dams on the minesite.

Two dams on the minesite were used in the study: the Surge Dam (6 years old) and the #1 Seepage Dam (12 years old). Material from both sites was tested using one-point proctor tests. A nuclear density/moisture probe was used to determine the density of the clay at depths ranging from 2" through 8" at 2" increments.

The compaction values 2" from the surface were found to be 91% of their respective proctor densities. As the depth of the density tests increased, the compaction values also increased. At a depth of 8" the compaction rate was found to be 100% of proctor for both dams. When averaged over the entire 8" test depth the compaction rate at the Surge Dam was 95.8% and #1 Seepage Dam 98.0%. Results have been graphed showing density versus depth (Figure 3).

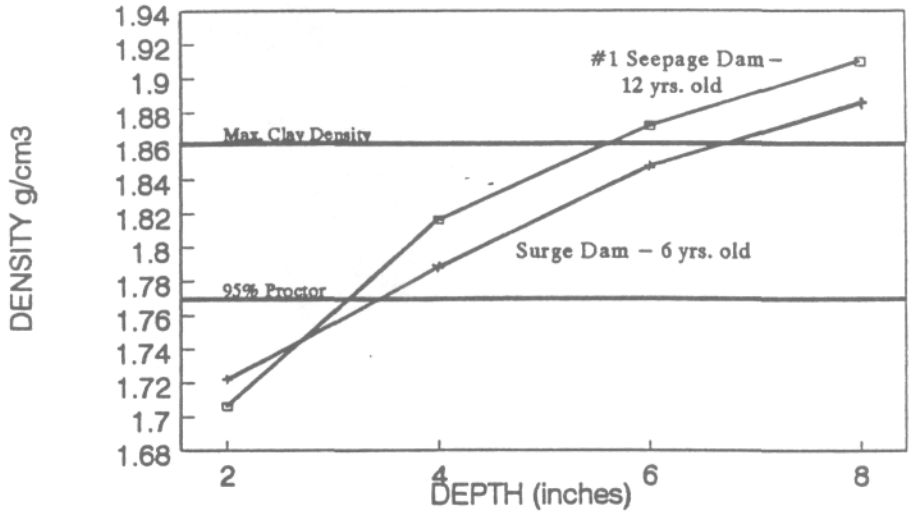

Figure 3: Density Comparison of Soils with Depth on Older Dams

The results from the study clearly show that the past frost events have had little effect on the integrity of compacted clay till dams. Even within the top 8" of the dams, the clay is still compacted to over 95% of the proctor densities. A comparison can be made between the dams and the dump cover since both are constructed of the same material and both have been compacted using similar methods. The integrity of the compacted dump cover will be further protected by the layer of uncompacted clay till that overlies it. From these results it is fair to assume that future frost events should have little detrimental affect on the dump cover.

Research Programs

Besides investigating the long term durability of compacted clay covers, there are several other research programs designed and in place to assess the effectiveness of this program. These will be briefly described in the remainder of this paper.

Quantitative analyses of effluent (A.R.D.) leaving the waste dump is compiled routinely to serve as a guide for establishing trends in acid generation rates from the waste dump. This program is termed "Contaminant Loading" and entails flow and water quality analysis of 12 sites around the property. The long term goal of the program is to serve as a check on lime consumption rates required to treat A.R.D. as well as to characterize the state of oxidation in specific sectors of the dump. Ultimately data will exhibit trends as shown in the following lime consumption graph (Figure 4). Also note the direct relationship of flow (A.R.D. treated) to tonnes of lime required for treatment. This relationship reinforces the effect of compacted clay covers on lime consumption through reduction in infiltration.

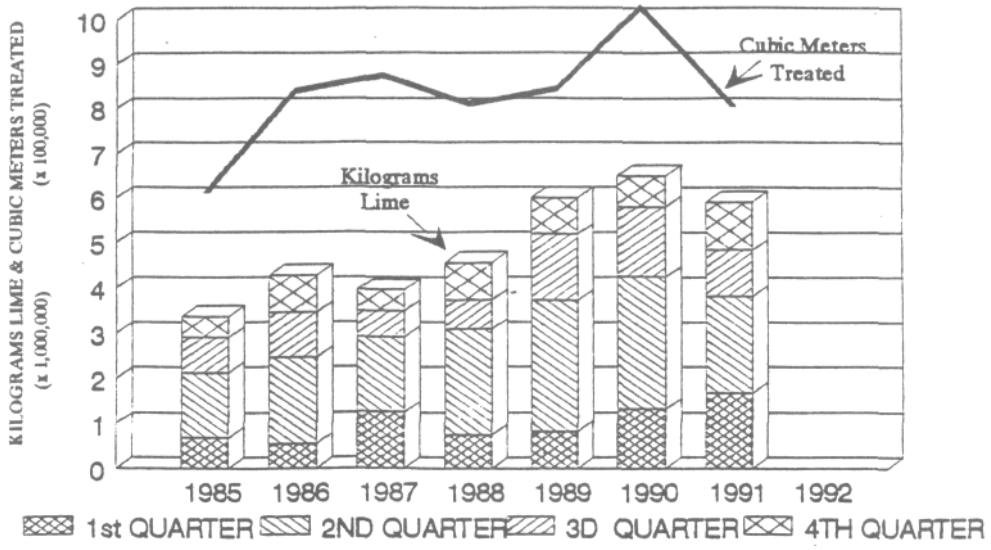

Figure 4: Flow versus lone Consumption Relationship

Hydrology assessments of waste dumps and clay covers also forms a critical component of the overall program. Data that is gathered with the contaminant loading program can be used to estimate precipitation infiltration rates on the various land forms around the property. These infiltration estimates have been used to model acidity loading from sectors of the dump and plantsite. Infiltration is expressed in percent of annual precipitation (Table 3).

o High Waste Fill	50 - 55%
o High Waste Fill - 1 m Loose Cover	37 - 40%
o High Waste fill - 0.5 m Compacted Clay	<5%
o Low Waste Fill - No Cover	60 - 65%
o Original Ground (Runoff)	65%

Table 3: Estimate of Precipitation Infiltration Rates In Percent

Compacted clay covers have been lab tested and found to have a hydraulic conductivity as low as 0.2 x 10"' m/sec. This of course has been established under ideal conditions. In order to verify the long term permeability of the cover, lysimeters have been installed below the clay cover to monitor water infiltration. These units have been constructed from plastic 45 gallon drums cut in half longitudinally. The lysimeters are installed flush with the waste rock horizon, slightly tilted to accumulate water at the sample tube end, and are filled with 3/4" crushed and washed gravel. Geotextile covers the lysimeter to prevent clay fines from entering the sample vessel. Samples are extracted using a hand held suction pump (Figure 5).

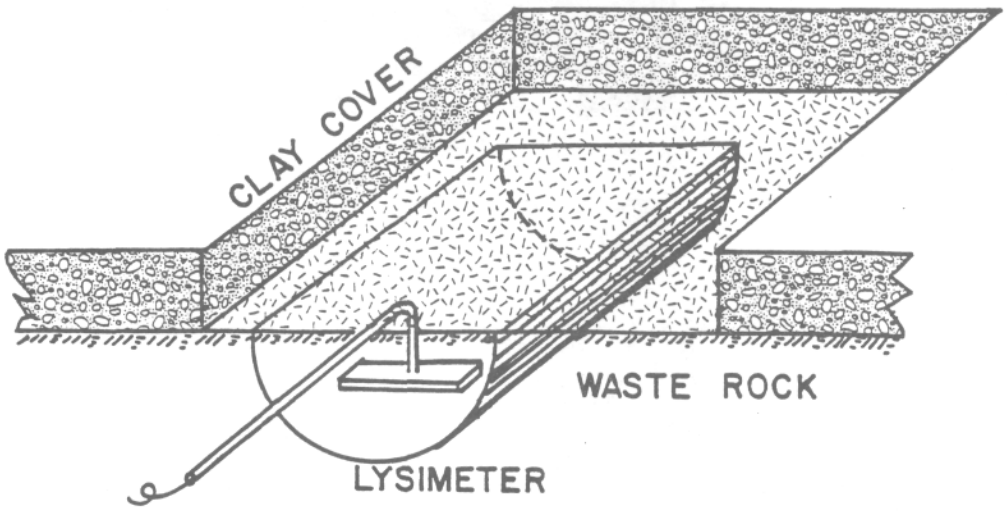

Figure 5: Typical Lysimeter Installation

Once a full season has passed, water will be pumped out: of the lysimeters and infiltration rates calculated. Monitoring of these test vessels will likely occur twice annually.

Oxygen plays an important role in the generation of A.R.D. While the clay cover is designed primarily for reducing water flow it will also act as a barrier to oxygen transfer. In order to monitor this transfer seven oxygen/temperature wells have been installed in the dump with each well containing up to 10 gas sampling tubes to a maximum depth of 18 metres. Temperature probes (thermocouples) will also be installed in each well to record temperature profile with depth. Installation of these units is not complete consequently no data has been collected to date.

SUMMARY

By maintaining close communication with mine personnel, much of the stress or uncertainty associated with the pending closure appears to be alleviated. Employees are taking full advantage of the skills upgrading courses and counselling offered by the company. This training may open new avenues of employment for those wishing to remain in the area. Severance packages are being offered to all employees being laid off plus advice in the proper use of these funds. A minimum of two months notice is given in advance of lay off to provide time for counselling and job search.

The Township of Houston have used the socio-economic study as a base for establishing studies to assess the potential for new economic development in the area. The Township will also promote its facilities for the commuter traffic for mining ventures in remote areas of the north. The socio-economic study is reported to be an asset for guiding future studies and dispelling myth of economic doom with closure of the mine.

The closure report serves as a guide for scheduling work projects in preparation for mine closure. All projects are being completed as planned and in some instances are ahead of schedule. One of the most important projects is the placement of a compacted clay layer on the waste dumps. Evidence of work completed thus far indicates reductions in volume and proportionately acidity and metal loading. If this metal loading and ultimately lime consumption can be reduced within the next 5 years. Equity Silver will have achieved a very significant goal in regard to mine closure and environmental security.

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