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ITEM 48

Report on Pollution of Leviathan Creek, Bryant Creek and the East Fork Carson River caused by the Leviathan Sulphur Mines.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

Report on Pollution of LEVIATHAN CREEK BRYANT CREEK and the EAST FORK CARSON RIVER caused by the LEVIATHAN SULPHUR MINE

January 1975

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I INTRODUCTION

Leviathan and Bryant Creek below the Anaconda Leviathan Sulphur Mine have been and continue to be polluted by the drainage emanating from that abandoned mine. The pollution is largely the result of the strip mining techniques practiced by the Anaconda Company during the 1950's. In 1962 the Anaconda Company sold the mine for $3,000 and thereby spared themselves any legal obligation for correcting any ensuing pollution. The mine has not been in operation since the Anaconda Company was the owner.

The California Regional Water Quality Control Board, Lahontan Region, has been working to correct the problem for many years. Attempts for correction by working with the present mine owners have failed and in 1969 the matter was referred to the Attorney General for legal action against the present mine owner. The bulk of this report was initially prepared as the first step toward prosecution of the present owner.

DESCRIPTION OF WATERSHED

Bryant Creek is located on the east slopes of the Sierra Nevada in Alpine County as shown on Figure 1A. The approximate 35 square mile watershed contains lands ranging in elevation from 5100 feet to 9000 feet. The terrain is typical of the east slope of the Sierra Nevada.

As shown on Figure IB, Leviathan Creek flows for a distance of approximately five (5) miles until it combines with Mountaineer Creek. At this point the streams form Bryant Creek, which has a length of about four (4) miles in California. After crossing the state line, it flows for approximately three (3) additional miles before reaching its mouth at the East Fork Carson River. Other tributaries to Bryant Creek, except for Doud Springs Creek, are intermittent.

Frequently during the growing season the entire flow of Bryant Creek is diverted to pasture lands of the River Ranch, located in California and Nevada, which is owned by Mr. Brooks Park. Mr. Park has exclusive rights to divert all water from Bryant Creek.

DESCRIPTION OF LEVIATHAN MINE

The Leviathan Mine is located on Leviathan Creek and is presently owned by Alpine Mining Enterprises. The mine has never been operated by the present owners. The Anaconda Copper Company sold the property for a small sum to an employee.

The mine consists of an open pit and one adit which enters the hillside near the entrance to the pit. Overburden material removed from the pit for access to sulphur ore was dumped directly into Leviathan Creek Canyon, damming the creek waters and causing them to percolate through and flow around the tailing dump area. The main features of the mine are shown on Figure IC.

FIGURE I-A
LEVIATHAN MINE VICINITY

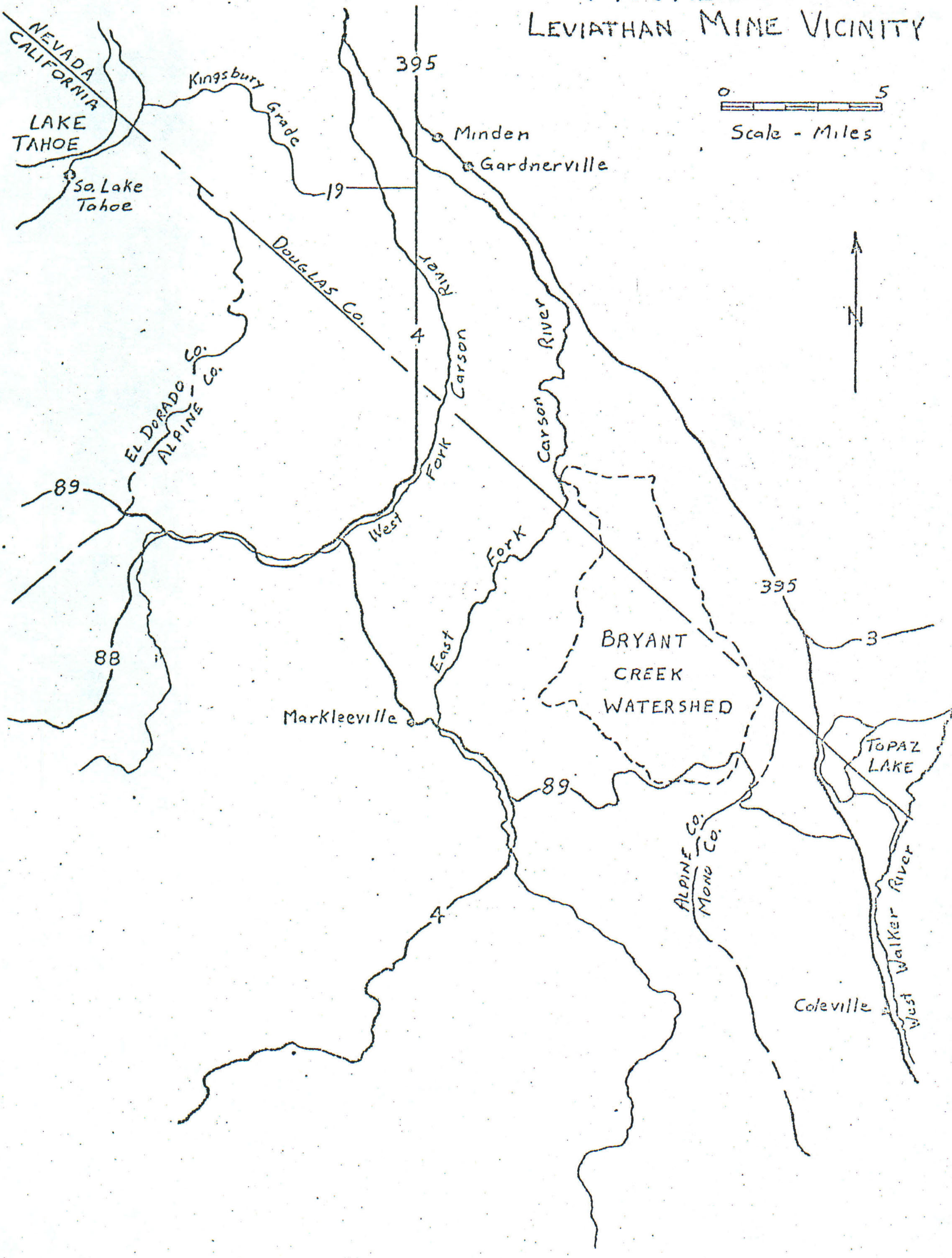


FIGURE I-B

BRYANT CREEK WATERSHE

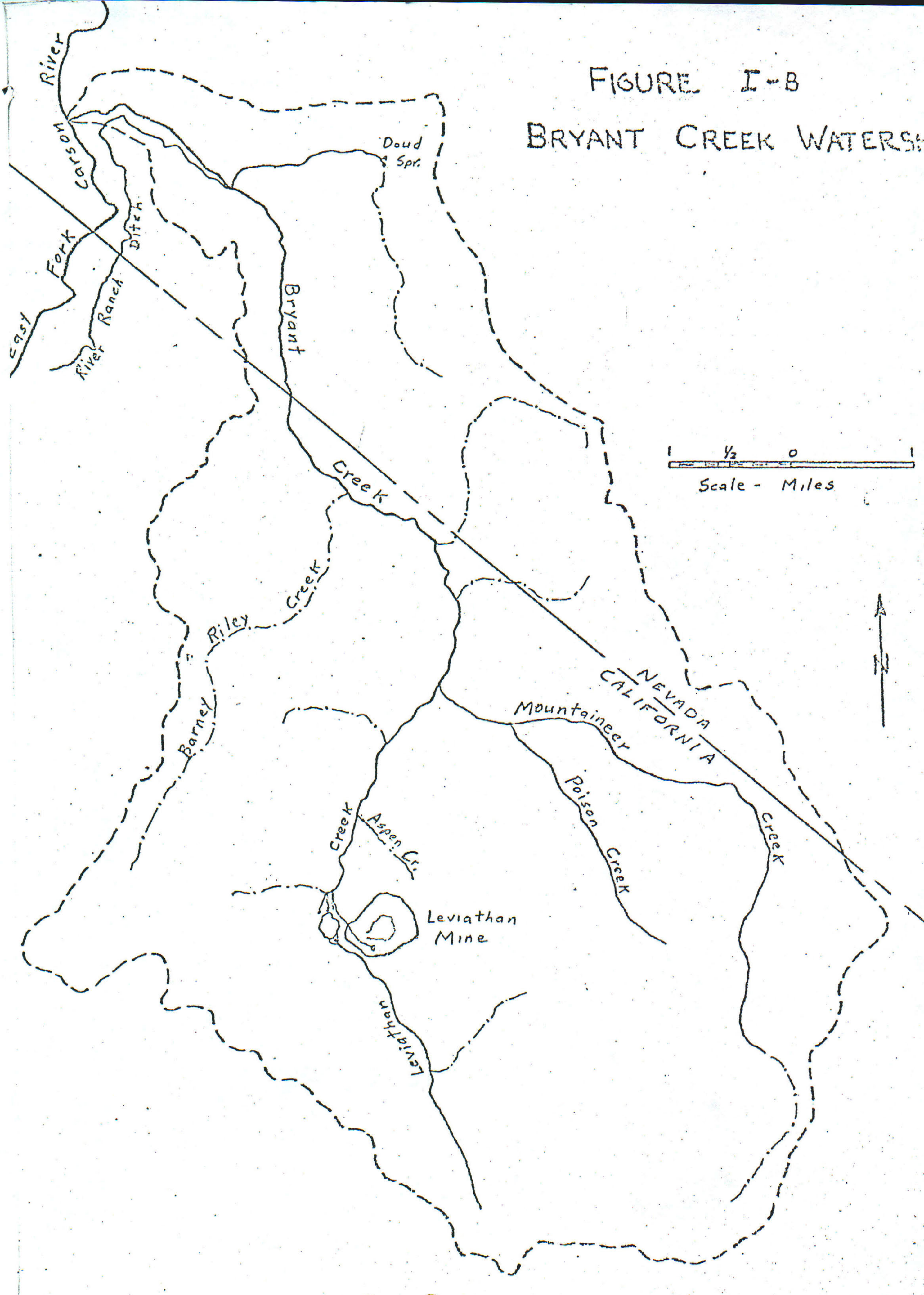
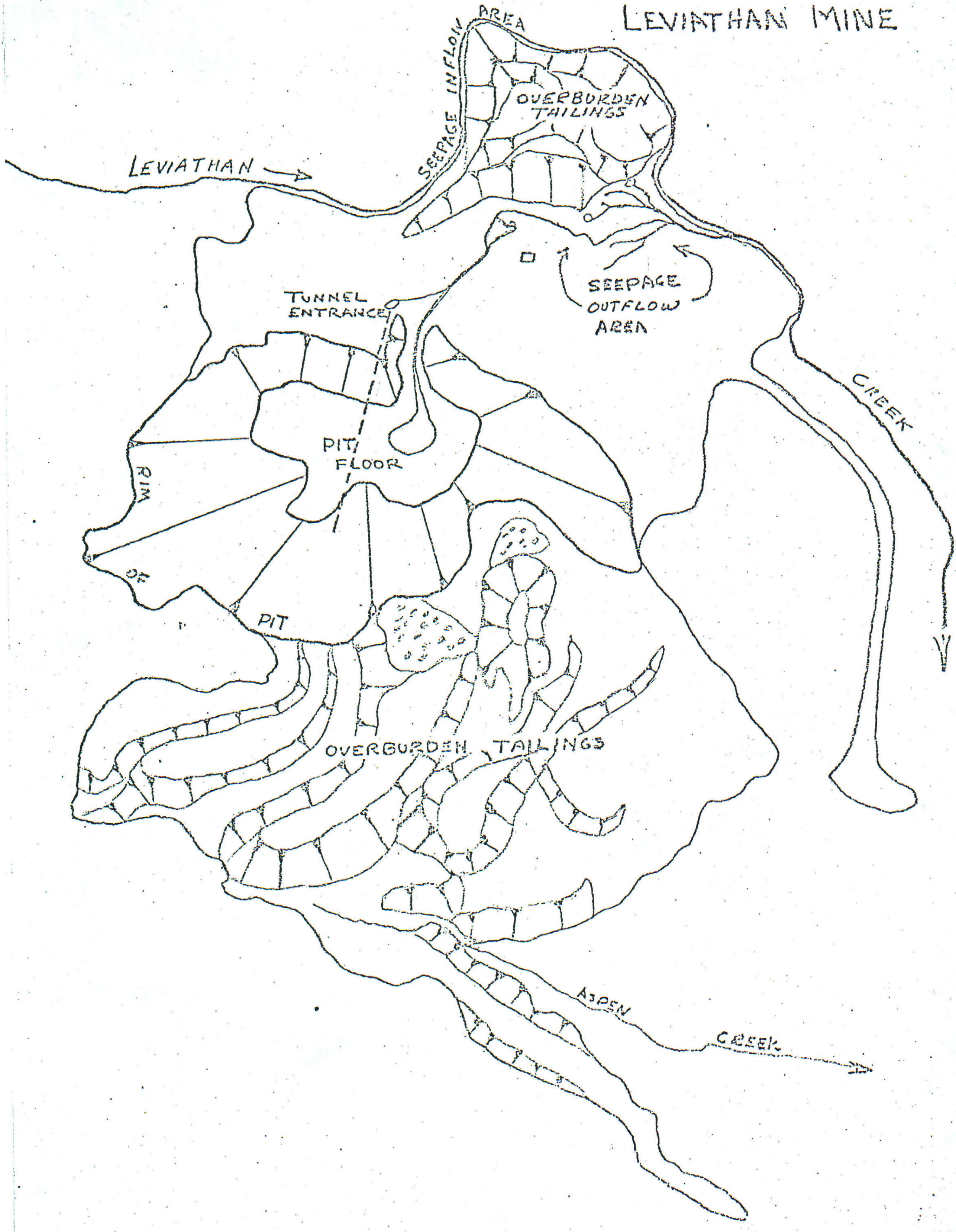


FIGURE I-C
LEVIATHAN MINE



D. SOURCES OF POLLUTION

The sources of pollution and a general description of their character are as follows:

1. Water flowing from mine tunnel
   This water is very acid and contains very high concentrations of materials toxic to plant and animal life. This pollution source flows all year.

2. Water from mine pit
   This water is quite acid and contains high concentrations of materials toxic to plant and animal life. This pollution source flows in the spring only.

3. Water seepage through tailing dump into Creek Bed
   This water is very acid in nature and contains materials in concentrations which are toxic to plant and animal life. This pollution source flows all year.

4. Surface water runoff from the area of the tailing dump piles
   This water is acid in nature and contains some harmful substances. This source of pollution occurs only during snow melt and rainstorm periods.

The first three sources must be corrected if Leviathan Creek and Bryant Creek are to be of beneficial use. The fourth source cannot easily be corrected and is not of major significance when compared with the others.

II BENEFICIAL USES OF RECEIVING WATERS

The beneficial uses of the waters of Leviathan Creek, Bryant Creek, and the East Fork Carson River have changed through time; a brief summary is as follows:

A. PRIOR TO MINE OPERATION

Agricultural Water Supply

Bryant Creek was diverted for irrigation of pasture lands at the River Ranch prior to operation of the mine. The East Fork Carson River has been used extensively for irrigation of pasture and crop land in the Carson Valley of Nevada.

Wildlife Sustenance

Leviathan Creek, Bryant Creek, and the East Fork Carson River have historically been a source of water to wildlife in the area. Leviathan and Bryant Creeks supported a substantial trout population prior to the mining operation. The East Fork Carson River is one of the more important trout fishing streams of both California and Nevada.

B. PRESENT

Agricultural Water Supply

Bryant Creek is presently diverted for irrigation of the River Ranch. It is a poor source of water supply and has resulted in poor crop growth and highly acid soil conditions. The East Fork Carson River has been measurably affected as a source of irrigation water supply and is used extensively. Livestock pastured on the River Ranch presently use Bryant Creek water since no other source is available. The water quality is unfit for this use. It is the opinion of the rancher that many of his cattle have died from drinking the water. The East Fork Carson River has not been measurably affected for this use and is presently used extensively for livestock watering.

Wildlife Sustenance

Bryant Creek presently contains concentrations of materials toxic to wildlife. The water above the mine is excellent for this use. The East Fork Carson River has not been measurably adversely affected for this use.

Aquatic organisms are totally absent from Bryant and Leviathan Creeks below the mine. Fish are present above the mine where the water supports a natural fauna. Trout have been driven from a portion of the East Fork Carson River downstream from the confluence of Bryant Creek.

Recreation

Leviathan Creek above the mine provides an esthetically pleasing and healthy environment for sportsmen and campers. Leviathan Creek below the mine is not used because of discoloration, acidity, and toxicity. The East Fork Carson River has been adversely affected for a distance of many miles below Bryant Creek. Above Bryant Creek, the Carson River is normally clear and clean. Below Bryant Creek, the river turns yellow, then milky.

C. FUTURE

If the pollution problems are corrected, Leviathan Creek, Bryant Creek, and the East Fork Carson River will increase in value. Within a period of a few years fauna should return and support a healthy fish population. Agricultural and recreational usage will be enhanced.

It is anticipated that the proposed Wataschema Dam will be constructed on the East Fork Carson River downstream from the confluence of Bryant Creek which will be partially flooded by the reservoir. Correction of the pollution problem will greatly increase the value of the reservoir for all beneficial uses. If the problem is not corrected, this proposed reservoir could be severely afflicted, possibly to the point of preventing its use for recreational purposes.

III HISTORY OF MINING OPERATION

A. 1863 to 1872

The Leviathan Mine was initially developed in 1863 as a source of copper sulfate for processing of silver ore at the Comstock Mines in Virginia City. A 400 foot adit was driven in search of commercial quantities but proved unsuccessful. By 1872 work on the property came to a standstill due to lack of copper and an over-abundance of sulfur. When abandoned, the mine consisted of two adits, the second being 1000 feet in length located 200 feet below the upper adit. The two adits were connected by a vertical raise.

During this period Leviathan Creek just below the mine area did show slight discoloration due to seepage of water from the canyon walls. The water from the mine area naturally contained high concentrations of sulfur and iron, but the quantities of pollutants were not such as to significantly adversely affect water quality. Bryant Creek at this time was a natural unpolluted stream which did support a natural fresh water flora and fauna and a healthy trout population.

B. 1872 to 1935

The mine was inactive during this period. No unnatural degradation to the stream occurred, and Bryant Creek did support a healthy trout population.

C. 1935 to 1941

The mine was reopened in 1935 for development of the sulfur body by the Calpine Corporation of Los Angeles through a sublease from Texas Gulf Sulfur Company. An extensive system of tunnels, drifts, and rises was constructed. In 1941 the Calpine Corporation gave up its sublease and the property reverted to Texas Gulf Sulfur Company. No degradation of Bryant Creek occurred during this period.

D. 1941 to 1945

The mine was inactive during this period.

E. 1945 to 1951

In 1945 the Siskon Mining Corporation, a subsidiary of Texas Gulf Sulfur Company, acquired the mine. It is not known whether the mine was idle during this entire period, but such appears to be the case. Bryant Creek continued to support a healthy trout population, and no man-caused pollution was evident.

F. 1951 to 1962

During this period the mine was owned and operated by Anaconda Copper Company. A fish kill occurred in the Carson River and Bryant Creek in 1952 when an old mine shaft was opened discharging a large quantity of highly acid and toxic waste into Leviathan Creek. This was the first indication of serious pollution problems.

In 1954 the company began operation of the mine as an open pit. Many of the old mine workings were removed, and the overburden material high in sulfur was dumped into the Leviathan Creek channel damming the creek and causing the water to seep through the overburden pile. The pollution problem became progressively worse, and in 1959 a second fish kill occurred along 10 miles of the Carson River below the confluence of Bryant Creek. An estimated 10,000 to 20,000 trash fish were reported killed; however, only a few dead trout were found, implying that the trout had been driven from Bryant Creek and the 10 mile stretch of the Carson River by toxic substances discharged continually from the mine from 1952 to 1959.

The fish kill prompted Anaconda to proceed with some corrective measures to prevent pollution. Several effective steps were taken and the condition of Leviathan and Bryant Creeks improved.

In 1962 the Lahontan Board requested that Anaconda apply for waste discharge requirements. Shortly thereafter and prior to requirements being established, the Anaconda Company sold the mine and removed the treatment and disposal facilities. Since that date the problem has become increasingly more serious.

Important details of this period are as follows:

June 19, 1952 - J. T. Leggett investigated the mine to check on a proposed domestic sewage disposal system to serve the mine camp. Mr. Leggett's report states that "it appeared that the operations from the mining of sulfur would not affect the surface or ground waters".

June 23, 1952 - Letter from the Lahontan Board to Anaconda Co. stating in part that "it appeared that the operations would not interfere with water qualities...", and further that a report on waste discharge would be requested if, "...in the future it appears that water qualities of this area might be affected..."

See July 1, 1954

January 19, 1953 - The Anaconda Co. applied for waste discharge requirements for the domestic waste disposal system.

May 5, 1953 - The Lahontan Board established requirements for disposal of domestic wastes from the mine camp.

July 1, 1954 - Letter from W. W. White (Nevada State Health Department) to T. J. Trelease (Nevada Fish and Game Commission). This letter states that observations of Leviathan Creek were made on July 25, 1952 prior to the mining activity. The letter states that "Leviathan Creek however was being affected by the seepage from the sidewalls of the canyon, this being indicated by a lower pH, a cloudiness, and a color in the water. At the time of my visit I was given to understand that there were no fish in the stream, there were certainly none seen, the vegetation was of a type which indicated that the natural water on that date affected growth, fish, and vegetation. At the time of my visit I did find the reddish, brown growths you referred to in Bonnie O'Reilly Creek (Leviathan Creek) in small seeps against the hill, both in the vicinity of the mine and below the mine deposits. Bear in mind, there was no activity in the canyon at all at the time of my visit, Anaconda was just beginning their construction operations. The creek water already showed alterations from normal as to Aspen Creek, it was my opinion at that time that there was some chemical alteration of the natural water, resulting in opaqueness, lower pH and color. The stream in question I believe served the Wallace Park properties, and it was my understanding that the water was usable for cattle, but that quality of this water was recognized as being somewhat impaired".

July 9, 1954 - Mr. Leggett inspected the mine and noticed that large amounts of tailings were being discharged into Leviathan Creek.

August 17, 1954 - Letter sent from T. J. Trelease, Nevada Department of Fish and Game, to Lahontan Board. The letter states that "On April 29th I personally visited the area concerned in answer to fish loses due to sulfur. At the time of the visit the water was running a very unnatural yellowish-red color. The material was so thick that it was completely opaque. Heavy deposits of the yellowish material were found on rocks, wood and other types of debris on this stream. Examination showed that the aquatic plant life in the stream was either dead or dying and aquatic insects were found to be in the same condition. Several dead insects were found and also several living ones. The living ones were heavily coated with the yellowish material. No dead fish, however were found at this time. While making the examination I contacted a Bureau of Reclamation Survey Crew that was working along the creek. Upon questioning them as to whether or not they had seen any dead fish in the stream, they informed me that they had. They stated that on April 21st while surveying along the creek they saw several trout that were washed into the debris along the creek's edge. I then asked them if the creek had been discolored for the entire time they had been working on it and they informed me that it definitely had not been, but that it always had a slightly milkish appearance. They said that on the 19th of April the stream started turning the yellowish color and continued to get worse. Further examination along its length led us to the mine and at that point the material seemed to disappear. The water, however, was quite strongly acid that issued from the base of the mine dump and was running clear. A short distance downstream and still issuing from sections of the mine dump, the yellowish material could be seen and this accumulated as the flow progressed further downstream".

August 19, 1954 - Letters from the Lahontan Board to California Department of Fish and Game and Nevada Fish and Game Commission regarding the fish kill in Leviathan Creek. The letters state that the Board does not believe that a fishery did exist prior to 1954 and asks for information regarding the subject from the two departments.

August 25, 1954 - Letter from Nevada Fish and Game Commission to the Lahontan Board stating that fish and aquatic life did exist in Leviathan Creek prior to 1954 and that dead and dying plant and animal life was apparent throughout the stream during the inspection of April 29, 1954.

September 22, 1955 - Letter from Lahontan Board to California Department of Fish and Game asking for historic information on the creek.

October 10, 1955 - Letter from California Department of Fish and Game to LRWQC Bd. stating that fish did exist in the recent past in the lower part of Leviathan Creek (Bryant Creek) and that the creek had a long history of "conditions unsuitable for best fish propogation".

November 3, 1955 - Letter from Lahontan Board to Nevada Fish and Game Commission stating that there appears to be no gross pollution below the confluence of Mountaineer and Leviathan Creeks and that typical aquatic growths were found during an investigation below this point.

The letter asks if the Nevada Department of Fish and Game would be agreeable to dedicating Leviathan Creek, to its terminus into the Carson River, for industrial waste purposes.

November 10, 1955 - Letter from Lahontan Board to Nevada State Dept. of Health asking for their comments on dedicating Leviathan Creek for industrial waste purposes.

November 10, 1955 - Letter from Lahontan Board to Anaconda Co. asking for supporting material to justify use of Leviathan Creek for industrial waste purposes.

November 14, 1955 - Letter from Anaconda to Lahontan Board saying basically that they are happy with the way the Regional Board has handled the problem and that they did not want to see a change in policy that would involve the State of Nevada.

December 7, 1955 - Letter from Nevada Department of Health to Lahontan Board stating that Mr. W. W. White, Nevada State Health Department, "visited the site on June 25, 1942. . . On that date, the stream was low, there were signs of chemical variances in Leviathan Creek from that of Aspen Creek. My observation was that Aspen from a normal unaffected watershed had a pH of 7.6 to 7.8, showed no signs of chemical alteration; Leviathan Creek at the mine site carried water that had in some manner been affected by addition of an acid reacting material, the water had a milky appearance, a pH of 7.0 to 7.2 in the upper portion at the mine site; there were signs of recovery downstream".

June 24 - 26, 1957 - Reports on file from extensive investigation of the area state that on these dates no fish or aquatic organisms were present in Leviathan Creek or Bryant Creek from the mine area to the Carson River. The reports state that prior to the overburden being dumped into Leviathan Creek, the creek contained normal populations of aquatic fauna and flora.

January 16, 1958 - Memo from California Department of Fish and Game to Lahontan Board asking for a status report on Leviathan Mine.

January 30, 1958 - Memo from Lahontan Board to California Department of Fish and Game asking for historical data on Leviathan Creek as a fish resource. The memo also states that the mine seepage "is not considered an industrial waste discharge".

February 21, 1958 - Memo from California Department of Fish and Game to Lahontan Board stating that they will attempt to take action under Section 5650 of the Fish and Game Code. Attached to the memo is a report by Artie Brown, Fish and Game Warden which states that prior to Anaconda dumping fill into Leviathan Creek there were fish and aquatic organisms in the creek below the mine area but that none now existed. The memo also states that Bryant Creek was clear prior to 1954. .

March 7, 1958 - Memo from Lahontan Board to California Department of Fish and Game stating that no serious problem has occurred and that Fish and Game has not shown Leviathan Creek to be an important fishery.

September 2, 1959 - Mr. Leggett inspected the site and noted that Anaconda had installed a diversion pipe to carry Leviathan Creek around the overburden pile and that seepage from the mine and tailings was being partially held in ponds for release during periods of high flows.

September 4, 1959 - Letter from Anaconda to Lahontan Board stating the willingness of the company to seal the channel around the overburden dump to prevent percolation of water through the dump.

September 10, 1959 - Letter from Lahontan Board to Anaconda endorsing their proposed diversion method and mentioning that California Department of Fish and Game has indicated that Leviathan Creek does have value as a fish resource.

November 25, 1959 - Memo from Lahontan Board to California Department of Fish and Game regarding a fish kill in the Carson River November 20, 1959. The dykes at the mine broke and the ponds discharged an estimated 5 million gallons of highly acid and toxic waste into Leviathan Creek. Aquatic life were destroyed for a 10 mile stretch of the Carson River.

December 8, 1959 - Letter from Lahontan Board to Anaconda stating that the company must work out some more fool proof methods of eliminating accidents such as that of November 20.

December 9, 1959 - Letter from Anaconda to Lahontan Board stating that they will be glad to meet to discuss the situation. The letter strongly objects to statements made by some that the company is causing a continuing problem since the accident occurred only once and the river immediately cleaned itself.

January 5, 1960 - Letter from Nevada State Health Department to Anaconda Company stating that Mr. Brooks Park was concerned with the problem. Cattle loses have been higher in the River Ranch than in other areas. The natural pasture lands are being destroyed by deposits on the land. Mr. Park questions the abandonment of the settling ponds by Anaconda. Anaconda is attempting unsuccessfully to dispose of the waste by injection into wells drilled several hundred feet deep just west of the new Leviathan Creek channel.

January 13, 1960 - Letter from Anaconda to Nevada Fish and Game Commission offering $4,000 for replanting trout in the Carson River but denying that the accidental discharge had any serious effect on the stream. The letter states that the company is considering several steps to correct the problems.

September 20, 1960 - Lahontan Board staff report on inspection states that two injection wells have been completed and are operating. A third well is being constructed. Water from the ponding of seepage is being used on the roads. All waste is to be disposed of by injection wells in the future. The by-pass channel for Leviathan Creek has been lined with clay to prevent percolation. The report states that "It appears that pollution to Leviathan Creek from Leviathan Mine may be eliminated entirely in the near future".

August 8, 1961 - Lahontan Board staff report on inspection states that the by-pass ditch was carrying water only half way around the overburden pile because the bentonite clay was washed out by flood waters during the spring of 1961. Lime is being added to the seepage water which is then settled in a pond prior to discharge to Leviathan Creek. The injection wells were sealing and not taking wastes at an acceptable rate.

September 26, 1962 - Lahontan Board staff report on inspection states that a large plastic pipe has been installed to carry Leviathan Creek across the tailing ponds. The creek bed below the mine has lost its red color and is now relatively clear. An unsuccessful attempt at sealing the adit was made. Drainage is being treated with lime before discharge to Leviathan Creek.

October 18, 1962 - Letter from Lahontan Board to Anaconda stating that it has been learned that the company intends to stop operating the mine. The company is asked to apply for waste discharge requirements.

November 20, 1962 - Letter from Anaconda to Lahontan Board informing the Board that the mine and all its responsibilities have been sold to William Chris Mann and Zella N. Mann of Woodfords.

G. 1962 to PRESENT

In 1962 the mine was purchased by Alpine Mining Enterprises, a California corporation. This corporation, the officers of which are listed below, presently owns the property.

President - Mr. James W. Neel
711 Magnolia Street
Modesto, California 95354

Vice-President - Mrs. Margaret N. Neel
711 Magnolia Street
Modesto, California 95354

Secretary-Treasurer - Mrs. Zella Mann
Star Route
Gardnerville, Nevada

The mine has been inactive since 1962 and the pollution problem has progressively worsened. No fish or aquatic life exists in Leviathan Creek or Bryant Creek below the mine site because of the acidity and toxicity of the mine drainage.

Damage has occurred to the River Ranch pasture lands due to the acidity and sediment in the water. Mr. Brooks Park, the ranch owner, reports that many cattle have died at the ranch and it is suspected that this is due to the toxicity of the water. The East Fork Carson River has been damaged for a stretch of several miles below Bryant Creek where the water is milky and the rocks discolored. Red sediments are apparent for a distance exceeding one mile downstream.

One attempt was made by the owners to correct the problem. This attempt was a total failure. The present owners have allowed the condition to steadily worsen and have taken no other steps to improve the condition.

The details of this period of ownership are as follows:

November 28, 1962 - Mr. Mann applied to the Lahontan Board for waste discharge requirements.

December 4, 1962 - Tentative waste discharge requirements were sent to Mr. Mann and all agencies involved.

December 11, 1962 - Letter from Mr. Mann to Lahontan Board stating that the tentative requirements appear satisfactory.

December 20, 1962 - Waste discharge requirements were established by the Board.

May 21, 1963 - Letter from Lahontan Board to Mr. Mann stating that the discharge requirements were being violated and requesting immediate correction.

August 22, 1963 - Matter discussed at Board Meeting but no action taken.

September 13, 1963 - Letter from Lahontan Board to Mr. Mann stating that the requirements were being violated and informing him that corrective measures were necessary or the staff would recommend that the Board issue a Cease and Desist Order.

October 2, 1963 - Letter from Nevada State Health Department to Lahontan Board stating that the requirements were being violated and requesting action to assure compliance.

November 18, 1963 - Letter from Lahontan Board to Mr. Mann stating that the Board would consider issuing a Cease and Desist Order at their meeting on December 5, 1963.

December 5, 1963 - Lahontan Board meeting. A Cease and Desist Order was not issued and the matter was deferred to the March meeting to allow time for correction.

March 20, 1964 - Lahontan Board meeting. A Cease and Desist Order was issued. The order allowed 180 days for correction.

September 23, 1964 - Lahontan Board meeting. A time extension of 160 days was given to the discharger.

March 30, 1965 - Lahontan Board meeting. It was reported that some corrective work was being done. The owners of the mine were directed to proceed as rapidly as possible to comply with the Cease and Desist Order.

June 22, 1965 - Lahontan Board meeting. The mine owners reported that the problems were solved and asked that the Cease and Desist Order be lifted. The Board instructed the staff to investigate to determine whether corrections had been completed.

September 21, 1965 - Lahontan Board meeting. The staff reported that although some corrective steps had been completed, the waste discharge requirements were still being violated. The mine owner reported that everything possible had been done with the funds available. The Board instructed the staff to certify the facts to the District Attorney of Alpine County for legal action.

September 1965 to November 1968 - During this period of time it appeared likely that the mine would be sold to a large firm and reopened. The matter was not referred to the Alpine County District Attorney since it was felt that such action would complicate the sale of the property.

November 26, 1968 - Letter from the Lahontan Board to Mr. J. Hillary Cook, District Attorney, Alpine County, asking that he proceed with legal action against Mr. William Chris Mann and Associates.

December 6, 1968 - Letter from the Lahontan Board to Mr. J. Hillary Cook, District Attorney, Alpine County, informing him that we recently learned that the mine was owned by Alpine Mining Enterprises and not by Mr. Mann and Associates. This is not a change in personnel but a change in the form of the ownership. The mine property was divided into two parcels and only the mine itself is owned by Alpine Mining Enterprises. The surrounding undisturbed land is owned by an officer of the corporation.

January 30, 1969 - Lahontan Board meeting. A Cease and Desist Order was issued to Alpine Mining Enterprises and the staff was instructed to immediately refer the matter to the District Attorney of Alpine County.

February 3, 1969 - Letter from Lahontan Board to Mr. J. Hillary Cook, Alpine County District Attorney, asking that he proceed immediately with legal action against Alpine Mining Enterprises.

March 11, 1969 - Letter from J. Hillary Cook, District Attorney, Alpine County, to the Lahontan Board stating that he declines to act.

March 14, 1969 - Letter from the Lahontan Board to Thomas C. Lynch, Attorney General, State of California, asking that he proceed with legal action against the discharger.

April 24, 1969 - Lahontan Board meeting. The staff informed the Board that the court case was being prepared.

September 3, 1969 - Bertram G. Buzzini, Deputy Attorney General, filed a petition for injunction with the Superior Court of Alpine County with Alpine Mining Enterprises as the defendants.

September 10, 1971 - Regional Board requested State Board to assist in obtaining funding to correct the pollution through a demonstration grant from the federal government.

January 3, 1972 - Regional Board submitted updated report on Leviathan Mine to State Board for use in the demonstration grant application.

August 7, 1972 - State Board received letter from Environmental Protection Agency stating that they needed additional information on an actual proposed corrective plan with cost estimates and a designation of the responsible party for conducting the demonstration project.

November 13, 1972 - Regional Board submitted additional information to State Board which inserted the material as chapters seven, eight, and nine of the Leviathan demonstration grant application.

IV WATER QUALITY CONDITION

This chapter summarizes the historic and present water quality condition of Leviathan Creek, Bryant Creek, and the East Fork Carson River. Detailed water quality data is contained in the appendix to this report.

A. PRIOR TO MINING OPERATION

No data is available prior to the initial opening of the mine in 1863; however, information is available on the water quality condition which existed prior to the overburden material being stripped from the pit and deposited in Leviathan Canyon in 1954.

One water quality sample was collected at Leviathan Creek just above Aspen Creek. This station would be the first to show the influence of pollution from the mine. The sample was analyzed for pH which is a measure of the acidic or basic characteristic of the water. A pH of 7.3 was recorded showing that the water below the mine was not being adversely affected.

Artie Brown, a warden for the California Department of Fish and Game stated that Bryant Creek below the confluence of Mountaineer Creek was unpolluted prior to the summer of 1954 and did contain a significant number of trout. In addition, signed statements were recently obtained from 4 Nevada fishermen stating that Bryant Creek was clear and the fishing good prior to the summer of 1954.

Correspondence in Regional Board files indicates that there was some slight discoloration of the water just below the mine site prior to 1954, and that acid springs were located in the vicinity of the mine. There is conclusive proof however, as shown in the above paragraph, that pollution did not exist unnaturally to an extent which adversely affects beneficial uses. The fact that trout were present in Bryant Creek is by far the most convincing evidence of good water quality prior to mining.

B. DURING MINING OPERATION

Pollution of Leviathan and Bryant Creeks began in the spring of 1954 when overburden material was stripped from the pit and dumped into the Leviathan Creek Canyon damming the creek. Two fish kills occurred in the Carson River below the confluence of Bryant Creek. The first fish kill, in 1952, resulted in dead fish in Bryant Creek which is further proof of fish life in Bryant Creek prior to the mining.

The Anaconda Copper Company spent a considerable sum of money to treat the waste discharge from the mine but no satisfactory solution was obtained. It is now felt that Anaconda did only what it felt to be necessary to avoid legal action against them.

A summary of the water quality conditions which existed during the period of operation by Anaconda is contained in the following table.

Table IV-1

Summary of Water Quality Data
During Operation of Mine
July 1954 to November 1962

		Leviathan Cr. Above Mine	Leviathan Cr. Below Mine	Bryant Cr. Below Mountaineer	Bryant Cr. At Diversion to Ranch
pH	Maximum	8.2	6.8	8.8	9.1
	Median	7.7	3.4	5.7	6.9
	Minimum	7.2	2.2	3.4	3.2
	No. of Samples	(12)	(73)	(90)	(13)
Sulfate mg/l	Maximum	13	4513	1331	732
	Median	8.4	2183	320	285
	Minimum	3.3	280	41	35
	No. of Samples	(13)	(60)	(76)	(13)
Turbidity Units	Maximum	16	770	350	108
	median	6.5	115	60	53
	Minimum	3.4	4.5	7	1.7
	No. of Samples	(4)	(54)	(51)	(12)
Total Iron mg/l	Maximum	2.0	470	0.2	22.3
	Median	0.3	0.12	0.02	0.58
	Minimum	0.08	0.01	0.01	0.01
	No. of Samples	(7)	(35)	(30)	(12)

The table shows clearly the degradation of Bryant Creek which occurred due to the waste flow from the mine. The pH above the mine averaged 7.7 which shows the water to be slightly basic in nature and excellent, from that standpoint, for all beneficial uses. Just below the mine the pH dropped to an average of 3.4 which is very acid and unacceptable for nearly all beneficial uses. Further downstream the pH increased due chiefly to dilution until at the diversion it had increased to an average of 6.9, which is acceptable to nearly all beneficial uses. Reductions to as low as 3.2 did occur at this point which will kill fish and result in other damage.

Sulfate concentrations increased from an average of 8.4 mg/l above the mine to 2183 mg/l just below the mine. Dilution below the mine reduced the concentration to an average of 285 mg/l at the diversion point. Increases in sulfate concentrations adversely affect beneficial uses. Depending upon the use, concentrations above approximately 250 mg/l are damaging.

Turbidity is a measure of water clarity, with low turbidity meaning quite clear water. The average turbidity above the mine was 6.5 units or quite close to the 5 units accepted as drinking water quality. Below the mine the turbidity was increased to an average of 115 units, signifying a very cloudy condition; and then it decreased, due to dilution, to an average of 53 units, which is also a quite muddy or cloudy condition.

In general terms, the table shows conclusively that the mine operation did have a definite damaging effect upon Bryant Creek during operation of the mine. Data were not collected showing the concentrations of toxic substances which were also undoubtedly present in extremely high concentrations during this period.

C. JANUARY 1970 CONDITIONS

In studies conducted in 1968 and 1969, it was found that no fish or aquatic life existed in Leviathan or Bryant Creeks, and high concentrations of iron, acidic material, and toxic substances continued to damage the Park ranch. Concentrations of many toxic substances were far in excess of that which would have permit fish life to return to Leviathan Creek. Consumption of the water at certain points would undoubtedly kill most animal life. The Carson River below Bryant Creek was discolored for miles, aquatic insects and fish were absent in the area of influence of the stream, and reddish-brown deposits emanating from the mine covered the rocks and river bottom for miles below Bryant Creek.

Since the Anaconda Copper Company sold the property to Chris and Zella Mann for $3000 in 1962, a great deal of water quality data has been collected. In addition, detailed surveys were conducted during the winter of 1968 and the summer and fall of 1969. Following is a detailed review of the results and their relation to the beneficial uses of the downstream waters.

1. Effect of Waste Discharge on Beneficial Uses

pH - The waste discharge has resulted in a change in the nature of the creek from neutral to highly acid as shown below:

Location	Min.	Median	Max.	No. of Samples
Upstream of discharge	7.2	7.6	7.9	10
Discharges	1.3	2.0	3.3	10
Creek below discharge	2.8	3.4	3.8	3
Point of diversion	3.2	4.5	7.2	4

Irrigation - Within the limits normally found in nature, the pH of a water will be acceptable for irrigation. Most soils have a significant ability to buffer an acid (low pH) water or a basic (high pH) water for a limited period of time. At the River Ranch continued use of acidic water has resulted in an acid condition in the soil and reductiion of yield of pasture grasses.

Stock and Wildlife Watering - This subject has not specifically been studied since it is not of great concern under natural conditions. Up to a point, pH is not of concern. The point at which the water becomes so acid that physical damage occurs from continual consumption is not known. The point at which the taste of the water becomes unacceptable to cattle is not known. Factually it can only be said that above the mine the pH of the water reflects its neutrality and showed it to be perfectly acceptable. Below the mine it was acid in nature and very likely physically damaging and undesirably in taste. Low pH does result in other toxic substances staying in solution, a fact which should be remembered in reviewing concentration of these materials.

Fish Sustenance - The permissible range of pH for fish depends upon many factors. The toxicity of many substances, including sodium sulfide (hydrogen sulfide at pH below 6), dissolved oxygen, nickel cyanide, and iron, all of which were present in the stream below the discharge, increases many fold as the pH of the water is reduced. The optimum range for trout propogation and sustenance is 6.5 to 8.5. A pH of 4.0 or less has been reported consistently to be toxic to trout and other fish.

ACIDITY AND ALKALINITY - Above the mine discharge the stream had an excess of alkalinity over acidity which is normal. The highly acid discharge causes a switch to excess acidity over alkalinity which is very abnormal especially in the extremes found in Leviathan Creek.

Location	Date	mg/l as $CaCO_3$ M.O. Acidity	mg/l as $CaCO_3$ Alkalinity
Upstream of discharge	12-5-68	5	60.0
Discharges	12-5-68	1000-17,000	0.0
Creek below discharge	12-5-68	410	0.0
Point of diversion	12-5-68	10	16.0
Upstream of discharge	6-12-69	0.0	45.0
Discharges	6-12-69	800-38,000	0.0
Creek below discharge	6-12-69	1155	0.0
Point of diversion	6-12-69	33	0.0
Upstream of discharge	9-22-69	----	50.0
Discharges	9-22-69	600-5310	0.0
Creek below discharge	9-22-69	1600	0.0
Point of diversion	9-22-69	5	0.0

Irrigation - Excessive acidity of waters containing nickel renders the nickel soluble, causing severe injury or death to plants. This fact most likely contributes to the loss of vegetation at the River Ranch. Other minerals such as copper, arsenic, magnesium, and iron are similar in their solubility and reactions in acid waters.

Stock and Wildlife Watering - Total lack of alkalinity and high acidity results in the heavy metals being kept in solutions in the water. Metals in solution are much more toxic than those in an insoluble form.

Fish Propagation - To protect the carbonate system and thus the productivity of water, acid should not be present in sufficient quantities to lower the total alkalinity below 20 mg/l. The discharge totally depleted all alkalinity, thus completely destroying the carbonate system and subsequent productivity of the water.

SULFATES - The waste discharge had resulted in a significant increase in the sulfate concentration as shown below:

Location	Concentration - mg/l Min.	Median	Max.	No. of Samples
Upstream of discharge	2.0	8.8	13	14
Discharges	26	750	2935	8
Creek below discharge	304	1010	1425	6
Point of diversion	170	234	344	7

Irrigation - Waters containing concentrations of sulfates less than 200 mg/l are considered excellent for agricultural purposes. Concentrations exceeding 500 mg/l are generally hazardous to plants. As can be readily seen, the waters upstream from the mine were of excellent quality, while those at the mine were totally unsatisfactory and those at the point of diversion were likely damaging.

Stock and Wildlife Watering - Concentrations below 500 mg/l are considered acceptable for stock watering. Stock has been weakened and eventually died from water containing from 2100 mg/l to 3590 mg/l. Waters upstream from the mine were totally satisfactory, while those in the mine vicinity and at the point of diversion ranged from harmful to acceptable.

Fish Propagation - The toxicity of sulfates to fish is dependent upon the element with which the sulfate ion is associated. Most waters which support a healthy trout population contain less than 100 mg/l sulfates. The accepted toxic limit for trout is 0.14 mg/l of copper sulfate. There was excessive copper in the water to assure levels in the stream far above this concentration. Sulfate concentrations above the mine were ideal for trout, while those below the mine were definitely toxic.

TOTAL DISSOLVED SOLIDS - The waste discharge had resulted in a great increase in the concentration of total dissolved solids as shown below:

Location	Concentration - mg/l 12-5-68	6-12-69	9-22-69
Upstream of discharge	125	46	116
Discharges	1525-4235	1678-26,400	1520-5080
Creek below discharge	1778	813	5130
Point of diversion	404	166	341

Irrigation - Waters are classified as excellent for irrigation if the concentration of TDS is 175 or less as was the case with the water above the mine, good from 175 to 525 mg/l, etc. Obviously, the waters above the mine were far superior to those below the discharge point.

Stock and Wildlife Watering - Dissolved solids are not thought to be injurious to animals below a concentration of 2500 mg/l, which had not been found to be exceeded at the diversion. Water in the stream below the discharge did, at times, greatly exceed the acceptable concentration.

Fish Propagation - Dissolved solids are not in themselves injurious to fish life in the ranges found in the stream; however, it is important to note that 95% of the U. S. waters which support good fishery contain less than 400 mg/l TDS. Fish which are acclimatized to low salinity waters cannot survive sudden exposure to high salinity. Fish could therefore not pass either upstream from the Carson River or downstream through the polluted area.

BORON - The waste discharge resulted in a significant increase in boron concentration.

Location	Concentration - mg/l 12-5-68	6-12-69	9-22-69
Upstream of discharge	0.2	<0.50	<0.5
Discharges	8.9-73	<0.5-5.5	1.6-10.0
Creek below discharge	2.8	0.65	3.5
Point of diversion	2.4	0.50	0.6

Irrigation - Agricultural authorities agree that for irrigation water the critical concentration is 0.5 mg/l; however, plants do vary in their sensitivity to boron. It is doubtful whether 0.5 mg/l can be applied continuously to soils without ultimately producing some plant injury regardless of the tolerance of the plant; and it must be remembered that the concentration in the soil solution will be many times greater than that of the applied water, particularly in areas of high evaporation and light soils such as the River Ranch. The maximum concentration safe for even the most tolerant plants, such as alfalfa, is 4.0 mg/l. The damage to the River Ranch from this constituent alone was extremely likely.

Stock and Wildlife Watering - Boron was not a problem to direct consumption by animals within the ranges found below the mine.

Fish Propagation - Boron was not detrimental to fish life within the ranges found below the mine.

ALUMINUM - The waste discharge resulted in an increase from that concentration which is below detectable limits to concentrations which are damaging to beneficial uses.

Location	Concentration - mg/l 12-5-68	6-12-69	9-22-69
Upstream of discharge	<0.01	0.7	0.43
Discharges	14.7-48	50-300	19.9-87
Creek below discharge	6.6	5.6	38.0
Point of diversion	0.38	6.7	3.4

Irrigation - Aluminum contained in waters stays in solution when the pH of the water is below 4.5. When in solution, aluminum reduces crop yield significantly (from 25% to 50%) at concentrations of 1.0 mg/l.

Stock and Wildlife Watering - Aluminum concentration of the water is not known to be directly harmful to stock in the concentrations which have been studied. At the high unnatural concentrations present in Bryant Creek, it would not be justified to state that aluminum was not damaging.

Fish Propagation - A concentration of 5.0 mg/l of aluminum will kill trout in 5 minutes. Exposure to concentrations much less (likely 0.1 mg/l) are toxic if exposed for periods of one day or more. Obviously aluminum concentrations in themselves totally prevent fish life in any portion of the creek.

COPPER - The waste discharge had resulted in great increases in the concentration of copper in Bryant Creek.

Location	Concentration - mg/l 12-5-68	6-12-69	9-22-69
Upstream of discharge	0.04	0.02	<0.01
Discharges	0.53-64	1.0-11.5	0.08-3.2
Creek below discharge	2.0	1.8	0.40
Point of diversion	0.11	0.09	0.05

Irrigation - Copper is toxic to plants in concentrations of 0.1 to 1.0 mg/l depending upon the specific plant. It is recommended that waters containing more than 0.1 mg/l not be used for irrigation. Obviously, the copper concentrations of Bryant Creek were directly damaging to plant life both along the creek and at the River Ranch.

Stock and Wildlife Watering - Copper was not directly detrimental to stock in the concentration found in Bryant Creek.

Fish Propagation - Toxicity of copper to fish varies with the fish species and the other constituents contained in the water. The accepted threshold limit above which toxicity has been reported is 0.02 mg/l, which is far below that concentration found in Bryant Creek.

IRON - The waste discharge contained extremely high concentrations of iron. Because of the acidity of the water, much of the iron remained in solution throughout the system.

	Concentration - mg/l		
Location	12-5-68	6-12-69	9-22-69
Upstream of discharge	0.20	0.26	0.28
Discharges	159-286	605-4170	95-1720
Creek below discharge	112	115	342
Point of diversion	92	32	34

Irrigation - Iron is not reported as being directly damaging to plant life; however no work has been done at the extremely high concentrations found in Bryant Creek since this condition is rare in nature and not a common problem.

Stock and Wildlife Watering - Cattle will not drink sufficient water if it is high in iron because of taste, but little data are available on acceptable concentrations. Threshold taste limits for people range from 0.1 to 1.0 mg/l. It was most likely that cattle were not drinking sufficient water at the River Ranch because of the extremely high concentrations and fluctuations.

Fish Sustenance - The toxicity of iron to fish is dependent upon the pH of the water which determines the solubility of the iron. Concentrations as low as 1 mg/l are toxic in acid waters such as Bryant Creek. The iron concentration of Bryant Creek in itself completely prohibited fish life.

MANGANESE - Manganese was not present above the mine in detectable concentrations. The waste discharge increased the concentration to harmful levels.

	Concentration - mg/l		
Location	12-5-68	6-12-69	9-22-69
Upstream of discharge	<0.01	<0.01	<0.05
Discharges	4.8-7.9	<0.5-2.9	4.5-8.2
Creek below discharge	4.0	<0.01	13.0
Point of diversion	0.10	<0.01	0.61

Irrigation - Concentrations of manganese above 0.50 mg/l are harmful to certain plants under certain conditions. Waters containing manganese in excess of 0.50 mg/l should be used with clear knowledge that damage to plant life, including toxicity, may occur.

Stock and Wildlife Watering - Manganese was not directly damaging to stock or wildlife in the concentrations present in Bryant Creek.

Fish Sustenance - The maximum recommended concentration of manganese in waters used as a fishery is 1.0 mg/l, which was exceeded below the discharge, thus prohibiting fish life in the stream.

ARSENIC - Arsenic was not present in detectable concentrations above the discharge. Concentrations in the creek below the discharge directly prohibited some uses.

Location	Concentration - mg/l 12-5-68	6-12-69	9-22-69
Upstream of discharge	0.01	0.01	<0.01
Discharges	0.02-70.0	0.52-110	0.1-63.5
Creek below discharge	----	1.2	0.76
Point of diversion	0.09	0.10	0.20

Irrigation - The recommended maximum arsenic concentration for irrigation water is 1.0 mg/l. Above that concentration plant damage and unproductive soils will result. That concentration was not exceeded at the diversion.

Stock and Wildlife Watering - Concentrations of arsenic above 1.0 mg/l may be directly toxic to animals. Obviously widlife using the water near the discharge would not have survived.

Fish Sustenance - Concentrations of arsenic in excess of 1.0 mg/l may be toxic to fish depending upon other factors. Arsenic concentrations therefore eliminated fish life from the stream.

Summary - It is important to remember synergism and antagonism when dealing with waste waters containing a large number of pollutants. In this case, the waters contain pollutants which can be considered individually, but more realistically we must consider the combined effect of all constituents. This is particularly important when dealing with heavy metals in low pH, or acid water since under this condition the metals remain in solution rather than precipitating out. In addition to the heavy metals, minerals including arsenic are present at toxic levels. In combination the many substances above or near toxic levels undoubtedly create a condition many times more toxic than is reflected by each constituent in itself. This was proven in the next portion of this chapter dealing with fish bio-assay work. This is also undoubtedly true for stock and wildlife watering and for irrigation water supply.

2. Toxicity of Discharge to Fish and Aquatic Life

In January 1969 the California Department of Fish and Game conducted a detailed survey of Bryant Creek. The results of the survey are summarized in the following table:

Location	Bottom Organisms	Bio-assay Test
Creek above discharge	Large variety present showing normal trout stream conditions.	All test fish survived showing the water to be non-toxic to fish.
Discharge from Mine	None present showing water toxic to aquatic insects.	TLm = 0.225% meaning that 1 part sample mixed with 444 parts water will kill ½ of test fish in 96 hours.

Location	Bottom Organisms	Bio-assay Test
Creek below discharge	None present showing water toxic to aquatic insects	TLm = 4.4% meaning that 1 part sample mixed with 23 parts water will kill ½ of test fish in 96 hrs.
Creek at diversion	None present showing water toxic to aquatic insects	10% of test fish died in undiluted sample showing the water to be approaching the threshold level of toxicity.

The Department of Fish and Game also took bio-assay samples from the Carson River and the mouth of Bryant Creek on September 23, 1969. The samples collected both upstream and downstream of Bryant Creek in the Carson River were not directly toxic to fish. The sample collected from the mouth of Bryant Creek gave a TLm of 52% in 24 and 48 hours meaning that a dilution of 52% Bryant Creek water and 48% distilled water will kill ½ of test fish in 24 or 48 hours.

The above data conclusively show that:

a. Waters above the discharge will (and do) support fish life including trout.

b. The discharge is extremely toxic to fish and aquatic life.

c. The stream just below the discharge is extremely toxic to fish and aquatic life.

d. The entire 9.3 mile length of stream from the mine to the point where the stream enters the Carson River is toxic to fish and aquatic life and has been totally destroyed as a fishery resource.

Bio-assay methods are a direct method of measuring the toxicity of a specific waste of constituent to a specific organism. Although the test can be performed on any organism, it is standard procedure in water quality work to use fish as the test organism and to measure their survival rate in various dilutions of a specific waste. The test measures the combined effect of all constituents present and is therefore more meaningful than interpretations of concentrations of specific mineral constituents.

There is no method of relating the toxicity to fish, to the toxicity to plants and animals. Fish are, generally speaking, more susceptible to pollutants than most plants and animals. The test is a good indicator of toxicity to other organisms. It is well accepted that waters which support healthy fish and aquatic environments are not toxic to humans or animals, however the contrary does not always hold true. The fact that fish died in a dilution of 444 parts water to 1 part of the waste shows the extreme toxicity of the discharge and leads one to believe the waste to be directly toxic to most plants and animals.

3. Violation of Waste Discharge Requirements

Resolution 62-12 as adopted by the Lahontan Regional Water Quality Control Board specified certain conditions to be met in Leviathan Creek just below the point of waste discharge. This section restates each requirement and the condition which presently exists in reference to that requirement.

a. The sulfate (SO_4) content in the waters of Leviathan Creek, as measured at the 10x10 culvert, shall not exceed 250 mg/l by reason of any waste waters resulting from this mining operation, past or present.

1970 conditions are as follows:

Minimum concentration	-	304 mg/l
Median concentration	-	1010 mg/l
Maximum concentration		1425 mg/l

This requirement was being grossly and continually violated.

b. The waters of Leviathan Creek shall not have a pH reading less than 6.5 nor more than 8.5 by reason of any waste water resulting from this mining operation, past or present.

1970 conditions just below the discharge and 7.8 miles downstream of the discharge are as follows:

	Below Discharge	7.8 mi. Downstream
Minimum	2.8	3.2
Median	3.4	4.5
Maximum	3.8	7.2

This requirement was being grossly and continually violated.

c. Waste water resulting from this mine shall not contain materials of such nature, or in such concentrations, as to render the receiving waters deleterious to present beneficial uses.

Section C-1 of this chapter includes a detailed review of the specific substances which were present in concentrations which adversely affect beneficial uses. The table below summarizes the conditions and concentrations which were considered damaging. The concentrations reported as acceptable were general and should not be used to refer to specific beneficial uses.

Constituent	Acceptable Concentration	Existing Concentration
pH	6.5-8.5	2.8-7.2
Acidity	0 mg/l	10-1155 mg/l as $CaCO_3$

Constituent	Acceptable Concentration	Existing Concentration
Alkalinity	Greater than 20 mg/l	0 mg/l
Sulfates	Less than 200 mg/l	170-1425 mg/l
Total Dissolved Solids	175 mg/l	166-1778 mg/l
Boron	0.5 mg/l	0.5-1.8 mg/l
Aluminum	1.0 mg/l	0.38-6.7 mg/l
Copper	0.1 mg/l	0.09-2.0 mg/l
Iron	1.0 mg/l	32-115 mg/l
Manganese	0.5 mg/l	0.01-4.0 mg/l
Arsenic	1.0 mg/l	0.09-1.2 mg/l

This requirement was being grossly violated.

The bio-assay work reported in Section C-2 of this report also proved violation of this specific requirement.

4. Effect of Waste Discharge on Agricultural Use of Water

An investigation into the effect of the pollution from the mine on the use of Bryant Creek for agricultural purposes was conducted. The study was directed toward the development of facts which would indicate either a positive or negative effect or no effect of the pollutants on the pasture and the cattle at the River Ranch. A compilation of historical operational data was made, and several experts in the fields of veterinary medicine and agronomy participated.

a. An extensive study of the pasture at the River Ranch was conducted by a consulting agronomist, and the problem was reviewed by the Douglas County Extension Agent. Their conclusions were that the pH values of soils in the pasture irrigated by Bryant Creek waters were lower than normal and that these low pH values were probably the cause of low forage yields from these areas. The acidity of the soil was considerably lower than that of other soil in the area not irrigated by Bryant Creek, and this level of acidity is considered the minimal level which would allow good range forage production. The ranch owner states that the quality and quantity of the pasture have continually declined since the over burden was placed in Leviathan Creek in 1954.

b. Examinations of some of the cattle which have died at the River Ranch were made. The results indicated that the cattle died of pulmonary emphysema, but a cause of the disease was not determined. An analysis of a portion of the stomach and liver of one cow revealed lead contents of 6.7 and 7.5 ppm respectively, which are levels that are higher than normal. The deaths, however, were not thought to be directly attributable to the lead. A compilation of cattle deaths at the River Ranch by the owner shows a total of 163 cattle having died at that location since 1954, or an average of about 10 per year. The highest year's total was 26 dead in 1968.

D. PRESENT CONDITIONS

The conditions in Leviathan Creek have not improved during the period since the 1968 and 1969 intensive studies. The abandoned Anaconda Leviathan Sulphur Mine continues to discharge highly mineralized acid mine drainage to the creek.

Board staff collected two series of samples for chemical analysis in 1975. The results of those samples are compared with past results in the table below.

pH:

Location	12-19-74	7-2-74	1968-1969*
Upstream of discharge	7.6	8.3	7.2
Discharges	2.7	2.8	1.3
Creek below discharge	2.7	---	2.8

* minimum values from page IV-3

SULFATES

Location	Concentration - mg/l 12-19-74	7-2-74	1968-1969*
Upstream of discharge	6.8	134	13
Discharges	4243	2790	2935
Creek below discharge	3119	---	1425

* maximum values from page IV-5

TOTAL DISSOLVED SOLIDS

Location	Concentration - mg/l 12-19-74	7-2-74	1968-1969*
Upstream of discharge	130	362	125
Discharges	4900	4845	26,400
Creek below discharges	4650	---	5130

* maximum values from page IV-6

COPPER

Location	Concentration - mg/l 12-19-74	7-2-74	1968-1969*
Upstream of discharge	---	0.00	0.04
Discharges	---	0.98	11.5
Creek below discharges	---	---	2.0

* maximum values from page IV-7

IRON

Location	Concentration - mg/l 12-19-74	7-2-74	1968-1969*
Upstream of discharge	0.35	0.4	0.26
Discharges	390	400	4170
Creek below discharges	375	---	342

* maximum values from page IV-8

MANGANESE

Location	Concentration - mg/l 12-19-74	7-2-74	1968-1969*
Upstream of discharge	---	1.2	<0.05
Discharges	---	23	8.2
Creek below discharges	---	---	13

* maximum values from page IV-8.

ARSENIC

Location	Concentration - mg/l 12-19-74	7-2-74	1968-1969*
Upstream of discharge	0.00	0.00	0.01
Discharges	1.2	---	110
Creek below discharges	1.2	---	1.2

* maximum values from page IV-9

When the Board staff collected samples and made a visual inspection of the abandoned Anaconda Leviathan Sulphur Mine on June 2, 1974, the following conditions were noted:

1. Leviathan Creek above the mine has a flow of approximately 0.5 cubic feet per second (cfs) while the flow of the creek immediately below the spoil materials, but above the mine discharge, was approximately 0.3 cfs. The combined flow from the acid mine leachate prior to entering Leviathan Creek was approximately 0.7 cfs.

2. There was no surface discharge from the pit area at the time of the inspection.

3. The major discharge from Leviathan Mine to Leviathan Creek was apparently comprised of two principal sources:

   a) The drainage from the collapsed mine tunnel, and
   b) Several outcroppings located at the toe of the overburden placed in the original drainage channel of Leviathan Creek.

4. The mine drainage was clear as it discharged from the tunnel and outcroppings, but became progressively more turbid (reddish-brown color) as it flowed downstream.

5. The creek bottom of Leviathan Creek above the Leviathan Mine appeared natural while the creek bottom of Leviathan Creek below the Leviathan Mine was blanketed with a reddish-brown precipitate.

6. A thin, dark green periphyton growth was apparent in the mine drainage flow.

7. There was no snow on the ground or evidence of recent precipitation. Climatic conditions were clear and sunny.

When Board staff collected samples and made a visual inspection of the abandoned Anaconda Leviathan Sulphur Mine on December 19, 1974, the following conditions were noted:

1. Leviathan Creek above the mine had a flow of approximately 0.5 cfs, while the flow of the creek immediately below the spoil materials, but above the mine discharge, was estimated to be less than 0.025 cfs. Virtually the entire flow in Leviathan Creek below the discharge location was the mine discharge itself.

2. There was no discharge from the pit area at the time of the inspection .

3. The major discharge from Leviathan Mine to Leviathan Creek was apparently comprised of two principle sources; the drainage from the collapsed mine tunnel and a large spring located at the bottom of the slope just below the crusher. There were several smaller springs located at the toe of the overburden which contributed to the flow to Leviathan Creek.

4. The mine drainage was clear, but there were sediments of various colors along the edge of the flow and the creek bed below the mine. Some of the colors included in the sediments coating the rocks were blue-green, yellow and reddish-brown.

5. It had snowed in the vicinity of the mine a few days prior to the inspection and the ground was saturated in many locations. There was still snow cover on the ground in most areas outside of the cleared areas of the mine.

V GEOLOGY OF LEVIATHAN MINE

A. REGIONAL GEOLOGY

The geology of the Topaz Lake 15 Minute Quadrangle was mapped by Garniss Curtis in 1961. A copy of his map slightly modified by J. R. Evans was published in "Guidebook Along the East-Central Front of the Sierra Nevada, Annual Field Trip of the Geological Society of Sacramento, June 18 and 19, 1966", and is included as Figure V-A. Figure V-B and V-C are detailed cross sections of the geologic structure.

In general, basement rock at the Leviathan Mine area is what Anaconda Company geologists have called andesite. A stratified 90-foot thick lake deposited tuff bed lies on the andesite and grades into a lake deposited agglomerate about 120 feet in maximum thickness. The clasts in this unit are rounded to angular fragments of brown, gray and black porphyritic volcanic rocks ranging to about one foot in size. The matrix is a gray tuffaceous sandstone. Overlying the agglomerate is another 100-foot thick bed of tuff. Prior to development of the open pit, silicified "cap rock" (160 feet thick) rested on the tuff.

Geologic information obtained from Anaconda Company suggests that mineralization took place in at least three stages.

The rocks in the area were leached by ascending silica-rich solutions presumably from an unexposed magana. The second process which may have taken place contemporaneously was the introduction of iron-rich hydrogen sulfide-charged solution. The hydrogen sulfide was oxidized with precipitation of sulfur in the altered acid leached tuff and formulation of water and other sulphide minerals. The tuff served as a sponge for solutions. Precipitation of sulfur in the pores and voids eventually caused the tuff to seal and restrict further upward movement of the mineralized gas and solutions. This resulted in more lateral and downward spreading of the area of mineral deposition. The last phase of sulfur deposition consisted of filling of the vents and fractures in the basement andesite with sulfur.

The mineralization of the lower part of the lake deposited tuff bed and portions of the underlying rock called andesite by Anaconda Company geologists outside of the "vent" areas and other anomalous data casts considerable doubt on the occurrence of "andesite". The mineralized tuff is mostly acid leached white and massive. However, locally it has been replaced by irregular shaped areas of opaline materials. These zones are remarkably similar to the so-called andesite. Also, in places sulfur has impregnated part of the so-called andesite similar to the tuff. The tuff has about 35 percent sulfur compared to about 25 percent for the andesite where mineralized. It is very probably that the material called andesite was a member of the lake deposited tuff that has been completely opalized by the silica-rich solutions.

B. DEVELOPMENT OF MINE

The Leviathan Mine was initially developed in 1863 as a source of blue vitriol (Chalcanthite Cu $SO_4 \cdot 5H_2O$) for processing of silver ore at the Comstock Mines at Virginia City. A 400-foot tunnel was driven in search for commercial quantities but proved unsuccessful. However, showings of primary copper minerals precipited development of the property. By 1872, work on the property came to a standstill. A story in the Alpine Chronical (July, 1872) reported the copper mine "bottoming" in sulfur. The 8th Report of the State Mineralogist dated 1888 (page 38) reported that the property had been "developed by two tunnels, six hundred and one thousand feet in length, respectively, the latter topping the ledge at its face a vertical depth from the surface of three hundred feet" as shown on Figure V-D.

In 1905, Lewis Aubury in "State Mining Bureau Bulletin No. 23" reported the mine idle with a 400-foot tunnel driven through a ledge 250 feet below the outcrop, and a 700-foot tunnel 200 feet below the upper tunnel. They were connected by a winze (a vertical shaft dug from top to bottom).

The 27th Report of the State Mineralogists (1931) reported that the old workings were being reopened by five miners. (Logan p. 491)

The mine was reopened in 1935 for development of the sulfur body by the Calpine Corporation of Los Angeles (through a sublease from Texas Gulf Sulfur Company). The main adit (Tunnel No. 3) was at the top of the sulfur body and was 3,000 feet long and had several drifts, rises, and stopes. The lower adit (Tunnel No. 5) is located near the bottom of the mineralized zone and is about 1,000 feet in length with several drifts and stopes. There are no records as to the location or elevation of Tunnel No. 4 which logically would be in the sulfur body. The workings are shown on Figure V-D and V-E.

In 1941, the Calpine Corporation gave up its sublease and the lease reverted back to Texas Gulf Sulfur Company. In 1945, Siskon Mining Corporation (subsidiary of Texas Gulf Sulfur Company) acquired the mine.

Mr. C. Chesterman, Geologist, California Division of Mines and Geology, was in the Leviathan Mine in 1948. It was idle at that time.

In 1951, the Anaconda Company purchased the property. They developed the sulfur body by open pit methods. The overburden was removed by contract in 1952 and early 1953 by Isabel Construction Company of Reno, Nevada.

Spoil from the open pit and overburden was dumped in the bed of Leviathan Creek. Photographs taken in September of 1954 show a lake backed up behind a portion of this mine dump. The entire canyon was filled with spoil, some of which is reported to have between 10 and 20 percent sulfur. All of the old copper mine workings were removed and this mineralized material dumped in the spoil areas.

During development of the open pit, partof the 3,000 foot long Tunnel No. 3 was removed. However, none of Tunnel No. 5 was exposed in the pit. The records given to the Board by Anaconda Company show that the bottom of the open pit was about 10 feet above Tunnel No. 5. Figures V-D and V-E. show clearly the workings which were excavated.

Sulfur ore was mined until 1962. The ore was drilled and blasted then loaded by power shovel into trucks for removal from the pit. The walls of the open pit started sliding as early as 1957. These landslides into the pit continued to be a problem until the mine was shut down in 1962. The original plan of excavation called for removal of sulfur ore to elevation 7,025, which would have removed and exposed portions of Tunnel No. 5 near the bottom of the sulfur zone. However, these landslides prevented implementation of this plan. No appreciable work has been done at the mine since 1962.

C. SOURCES OF POLLUTED WATER SEEPAGE FROM MINE

The watershed above the open pit and spoil area was checked in detail to ascertain if any structure or fault system could provide an avenue for percolation of surface water into the open pit. The andesite to the south of the mine area has been faulted as shown on Figure V-F.

The faults by their nature and location have fractured the andesite and also the incompetent acid leached tuff and other lake bed deposits which otherwise would prevent vertical migration of water to depth. Spring areas are found about the pit at locations where erosion has degraded the rock below the water table. The flowing springs in Sections 22 and 23, T10N, R21E, are at least 400 feet above the bottom of the pit indicating that all fractures in the lake bed deposits should be full of water below this elevation.

There is nothing in the records to show that mine seepage was a problem in any of the tunnels. The publications do show, however, that underground mining was extremely hazardous because of the highly flamable nature of the sulfur.

Mr. George L. Gary and others visited the mine September 30, 1939, to collect mineral specimens. They reported that secondary minerals were being formed in the mine tunnels on stelactites and stelagmites by the oxidizing action of surface water upon certain sulphide or sulfur-bearing minerals. (35th Report of State Mineralogist 1939, Pages 488 and 489) Sulfur was being mined at that time by Calpine Corporation.

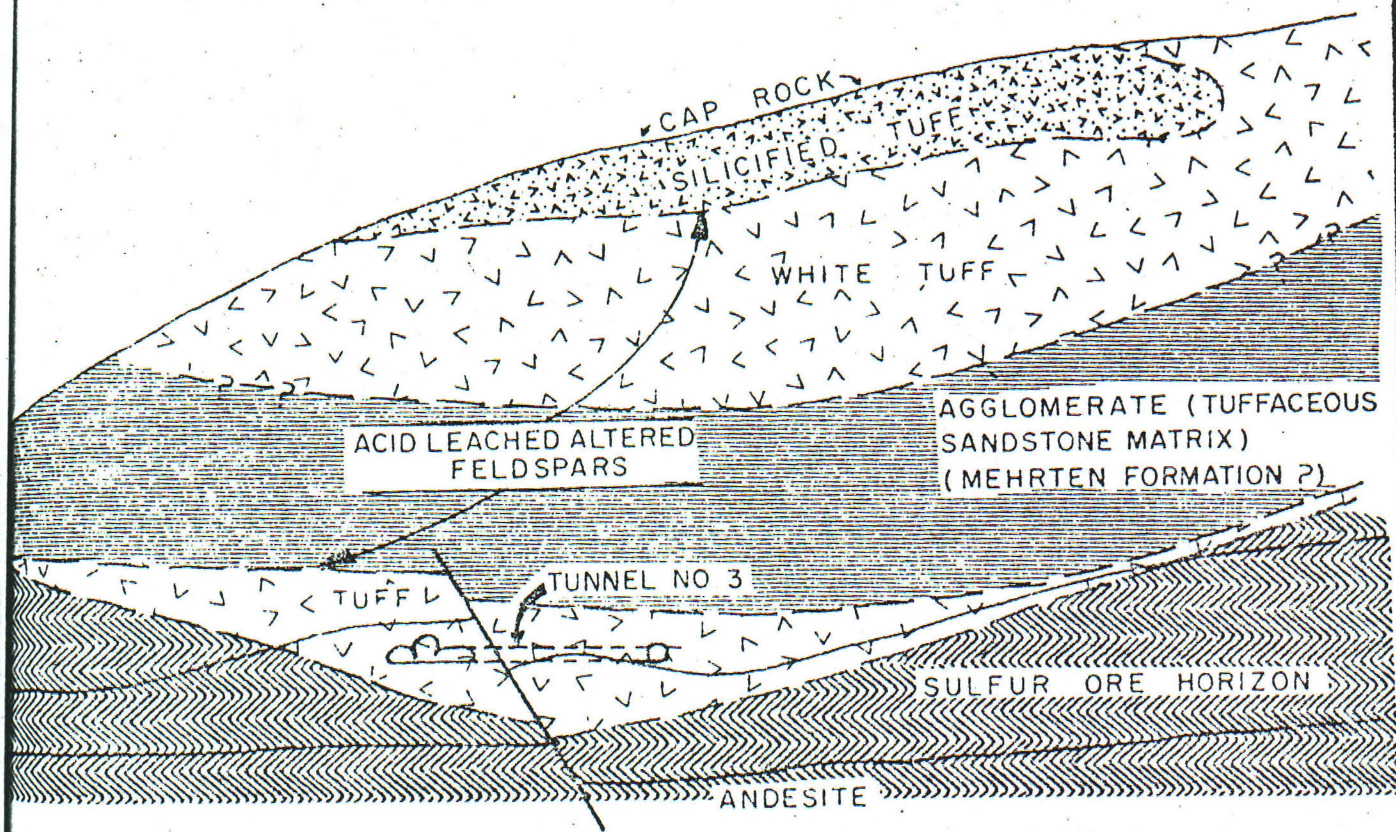
Mr. C. Chesterman, Geologist for California Division of Mines and Geology, was in the Leviathan Mine in 1948. It was idle at that time and only a portion of the tunnels were observed. He collected some of the rare hydrous iron and copper minerals and noted the formation of stelactites and stelagmites by seepage of surface water from above into the tunnels. He did not remember if any water was flowing from the tunnel but did remember the floor being wet.

From the nature of the fractured tuff it is logical that there would be some seepage of groundwater into the tunnel system. One of the fault zones was found in the underground workings as shown on Figures V-B and V-C. However, there is no record of problems with water at these locations.

Subsequent to start of open pit mining the highly fractural tuff has failed at over steep locations. These slides of fractured tuff now provide large areas of permiable material. Runoff into the open pit, snow melt, and rainfall percolate into this material. The slides are therefore providing a large reservoir for storage of water which then percolates through the fractured mineralized tuff and into the tunnel systems. Once in the tunnel system, the water finds its way to the surface through the abandoned tunnel No. 5.

As the water percolated throughout the rocks, minerals are dissolved. The iron pyrites readily change by oxidation to iron sulfates or to the hydrated oxide, limonite, with sulphuric acid set free. The acid solution leaches out the copper, iron, arsenic and other available elements and also enters into various reactions with the unaltered minerals below.

FIGURE V D PLATE



NOTE:
Geologic Cross Section — Courtesy of The Anaconda Company (Modified after Evans, 1966)

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

LEVIATHAN MINE
ALPINE COUNTY

SCALE
0 100 200 FEET

DATE: 9-18-69	DRAWN: G.C.W	CHECKED: A.L.F.	DWG.

VI HYDROLOGY

A program was conducted on stream flow measurements during the period from May 14 through September 26, 1969, in the Bryant Creek-Leviathan Creek watershed for the Leviathan Mine Hydrologic Study. The measurement program was designed to provide data for use by the Regional Board in its investigation of the Leviathan Mine.

Measurements were made to find the rate of flow at water quality sampling points and to determine the amounts of flow entering or being diverted from the selected points on the stream system.

Most of the flow records were obtained by spot measurements and were not designed to show daily fluctuations or precise volumes of total flow.

A. Description of Area

Figure VI-J is a map of the Bryant Creek-Leviathan Creek watershed and Figure VI-K is an enlarged map of the Leviathan Mine area.

Leviathan Creek raises near 8,000 feet elevation west of Leviathan Peak and north of Monitor Pass. It flows northerly for about 2 miles to where it crosses the road to the Leviathan Mine through a 30-inch culvert a short distance above the mine. The drainage area of the watershed above this point is 3.6 square miles. Leviathan continues on through the mine area for about 1½ miles, where Aspen Creek enters from the right side (facing downstream) just below the mine area. The drainage area through the mine area between the 30-inch culvert and the Aspen Creek watershed is 3.05 square miles with 0.65 square miles on the right side of the creek where the mine is located.

Aspen Creek has a watershed of 0.70 square miles. Leviathan Creek flows about 1½ miles below Aspen Creek to its confluence with Mountaineer Creek to form Bryant Creek. Leviathan Creek has a total drainage area of 10.5 square miles, and Mountaineer Creek has 10.5 square miles drainage area located east of Leviathan Peak near the Nevada State Line.

Bryant Creek flows about 5 miles to the United States Geological Survey (USGS) gaging station just above Doud Springs Creek with a total drainage area of 31.5 square miles.

Doud Springs Creek enters from the right. It has a drainage area of 3.2 square miles excluding the Double Spring Flat drainage that does not often contribute to the flow.

The upper River Ranch Ditch diverts from the left side of Bryant Creek just below Doud Springs Creek and carries water to irrigate the River Ranch on the East Fork Carson River above the mouth of Bryant Creek. Bryant Creek flows about 1½ miles below Doud Springs Creek to the East Fork Carson River. Another ditch diverts from the right side of Bryant Creek about one-quarter mile above the mouth to irrigate the land along East Fork Carson River below the mouth of Bryant Creek

Bryant Creek has a total watershed area of 36 square miles excluding the Double Spring Flat area.

B. Measurement Program

The stream flow measurement program was designed to identify the amounts of flow contributing to Bryant and Leviathan Creeks from various tributary areas with particular emphasis on the Leviathan Mine area.

A reconnaissance was made of the area on May 14, 1969. The continuous record from the USGS gaging station on Bryant Creek indicates that May 14 was the peak of the spring snow melt runoff. Estimates of some of the high flows were made at that time.

Weirs were installed in a number of the channels in the mine area on May 28 and 29. A waterstage recorder was installed on Leviathan Creek at the 30-inch culvert above the mine and obtained a continuous record of flow starting June 23, 1969.

Current meter measurements and portable Parshall flume measurements were made at the other measuring points

Measurements were taken at most of the measuring points at about two-week intervals. Additional measurements were taken at some points at less frequent intervals.

A number of flow measurements made by personnel of the Center for Water Resources Research, Desert Research Institute, University of Nevada on June 24-26, 1969, are also included in this report.

The flow records of the USGS station referred to earlier in this report were also used. The station is referred to by USGS as Bryant Creek near Gardnerville, Nevada. That record is continuous from May, 1961, through September, 1969, except February to June, 1963, when only monthly discharges are available.

C. Description of Points of Measurement

Measurements were made at seven points on Leviathan Creek, fourteen points within the mine area, six tributaries, one branch of a tributary, two on Bryant Creek and the River Ranch upper and lower ditches. These points are shown on Figures VI-J and VI-K and designated by numbers, letters and names and described in the following tabulation:

(1) Leviathan Creek at 30-inch culvert above mine.

(2) Leviathan Creek at upper end of mine spoil area.

(T_1) Unnamed tributary entering Leviathan Creek from left side (facing downstream) between 2) and 3)

(3) Leviathan Creek on new creek channel below spoil and above mine drainage.

(4) Leviathan Creek in spoil area just above measured inflow from mine.

(A_3) Water rising in flat area below spoil in creek channel.

(A_2) Water seeping through main part of spoil in old creek channel.

(A_1) Water flowing across surface of upper spoil area in old creek channel.

(AB) Major mine drainage to creek consisting of flow from pit and tunnel areas as well as (A_1) and (A_2).

(AB_1) Surface drainage from pit and tunnel area and (A_1) before it drops down to creek level.

(B_1) Surface inflow to pit from west.

(B_2) Surface inflow to pit from north.

(B_3) Surface inflow to pit from east.

(B_4) Water rising on south side of pit (mud pots).

(B_5) Outflow from pit.

(B_6) Outflow from collapsed mine tunnel.

(C_1) Water seeping from spoil on right side of old creek channel below old crusher.

(C_2) Major seepage entering creek from right side including (C_1) and a spring raising in right side of creek channel.

(C_3) Small seepage entering creek from spoil below (C_2).

(5) Leviathan Creek below spoil in creek.

(T_2) Unnamed tributary entering Leviathan Creek from left side between (5) and (6).

(6) Leviathan Creek at 10-foot box culvert under road above Aspen Creek.

Aspen Creek - Aspen Creek at mouth.

Aspen Tributary - Surface flow across landslide into Aspen Creek.

(T_3) Unnamed tributary entering Leviathan Creek from left side below Aspen Creek.

(7) LeviathannCreek at confluence with Mountaineer Creek.

Mountaineer Creek - Mountaineer Creek at confluence with Leviathan Creek.

Bryant Creek at Gage - Bryant Creek at USGS gage above Doud Springs Creek.

Doud Springs Creek - Doud Springs Creek at mouth.

River Ranch Upper Ditch - Head of diversion ditch to River Ranch on East Fork Carson River above mouth of Bryant Creek.

River Ranch Lower Ditch - Head of diversion ditch to land along East Fork Carson River below mouth of Bryant Creek.

Bryant Creek at Mouth - Bryant Creek below River Ranch Lower Ditch.

D. Presentation of Data

The data collected is presented on the figures and tables in the back of this report. Tables VI-1 and VI-2 are a tabulation of all the spot measurements collected in the study. Table VI-1 includes all the measurements except those of the mine drainage. Table VI-2 includes the flows rising from three areas of the mine; a) the spoil in the old creek channel, b) the collapsed mine tunnel and pit area and c) the spoil on the right side of the creek. The letters of the measurement points indicate which area they concern.

Figures VI-A through VI-D are hydrographs of most of the stations drawn from the spot measurements in Table 1 with the exception of Bryant Creek at the USGS gage that is plotted from preliminary data of mean daily flows at that station obtained from the USGS. Figure VI-E is a hydrograph of the continuous record of Leviathan Creek at the 30-inch culvert above the mine, with the upper line showing the maximum daily rate of flow and the lower line showing the minimum daily rate of flow. The spot measurements are also plotted on this hydrograph. This hydrograph is included to show the amount of daily fluctuations in the range within which the spot measurements on the main stream can vary from the average flow. The high flows generally occurred about 9:00 a.m. and the low flows at 5:00 p.m.

Figure VI-F is a plot of all the available measurements in area A of the mine with curves drawn to estimate the continuous mean daily flow and a curve of the total mean daily flow from area A derived from the other curves on the plates.

Figure VI-G is a plot of all the available data from area B and from area C after adding the appropriate data from each measurement day. Curves were then drawn from this data estimating the continuous mean daily flows from areas B and C of the mine. The curve from area A was then replotted and the three curves added to obtain a curve showing the estimated continuous total mean daily drainage from the mine. The difference between the measurements of Leviathan Creek in the new creek channel above all mine drainage (station 3) and Leviathan Creek below all mine drainage (station 5) was plotted and a curve drawn to estimate the mean daily difference in flows. This curve shows a comparison between the measured mine drainage and the gain in the creek through the mine area.

Figure VI-H is the curve developed on Fig VI-9 showing the total mine drainage and a curve showing the estimated seepage into the spoil area from Leviathan Creek drawn from the loss in that area during low flows. The area under these curves, calculated as flow in second-feet days x days x 2 acre-feet per second-foot day, represents the total volume of water in acre-feet that entered the mine spoil from Leviathan Creek and the total volume drainage from the mine for the period June 1 to September 30, 1969.

Figure VI-J is a map of the entire watershed showing the major features and the measuring points on the main stream system.

Figure VI-K is an enlarged scale map of the mine area showing the drainage locations and measuring points.

E. Discussion

For the purpose of this discussion, the stream flow is considered in two parts: 1) the surface runoff and 2) the base flow. The surface runoff consists of snow melt and storm runoff, and the base flow is that water stored in the ground that enters the streams.

The records of the USGS gage on Bryant Creek show that the flow on May 14 was probably the maximum peak attributable to snow melt. On this day, Leviathan Creek at the 30-inch culvert above the mine was flowing through the culvert nearly at its capacity. Even though past records of flow at the Bryant Creek gage show much higher flows during storms, it is likely that the observed flow at the 30-inch culvert on Leviathan Creek was observed at almost its maximum. If the flow had been much greater, the culvert would not have carried it, and water would have flooded across the road. There was no evidence of this happening.

The lack of flooding during storms on the upper part of Leviathan Creek can be explained by the high elevation of the watershed. Much of the precipitation in winter storms would fall as snow or at least fall on snow that would retard the runoff and reduce the peak flow. The snow melt runoff would therefore probably cause peak runoff in this upper area. As this year had a near record snowpack, it is likely that a greater runoff at this point on Leviathan Creek would be rare.

The base flow of Leviathan Creek exclusive of the mine area and Aspen Creek is relatively small as evidenced by the small flows in late summer.

Aspen Creek and Mountaineer Creek both have a relatively large base flow compared to their peak flows. The watersheds of these streams have more fill material and consequently more groundwater storage area to reduce the surface runoff flows and maintain the base flows at higher levels.

The flows from the mine area are nearly all base flows except for storm periods or early spring runoff.

A description of the drainage pattern in this area can best be made by referring to the map included on Fig VI-K of this report. The collapsed mine tunnel and the mine pit are considered to have derived their base flow from the pit area itself and from the area to the east of the pit. Flows from this area are designated with the letter B. Flows from the spoil dumped directly in the old creek channel are designated by the letter A. Flows from the spoil dumped on the right bank of the old creek channel are designated by the letter C. Some flows designated AB are flows from B combined with part of the flows from A.

Flows from the surface of the spoil in the creek bed area are included in A. These flows stopped about mid-July. Surface flow from the pit (B5) stopped about August 1.

The records of flow of Leviathan Creek above the mine presented on Figure VI-E show that mean daily flow receded to about 0.20 cfs by mid-August and remained nearly constant thereafter. Measurements at station (3) which is below the spoil in the channel but above any seepage to the creek show that practically none of this flow was in the new channel at this point. Nearly all of this flow was soaking into the spoil in the old creek channel. The flow from all the measurements in area A was less than the amount soaking into the spoil. It appears likely, therefore, that part of the water in area C is also coming from this source.

Figure VI-G shows that after about mid-July, the difference in the flow at stations 3 and 5 was very close to the sum of the flows from A, B and C. This indicates that most of the water from the base flow in the mine area was measured and is accounted for in the data presented.

Figure VI-H shows that in the June through September period, about 105 acre-feet of water flowed out of the mine area and that the flow that seeped into the spoil from Leviathan Creek was approximately 62 acre-feet. The other 43 acre-feet probably came from precipitation that fell directly on the watershed of the mine itself. No attempt was made to estimate the quantities of flow during the time no measurements were made or to correct the calculations for any time lage.

F. Summary

Stream flow records were collected at various places on the Bryant Creek-Leviathan Creek stream system. The data is presented in the form of tables and graphs with some interpretation of the records. The flow records in all but the Leviathan Mine area are straightforward and show nothing unusual.

Leviathan Creek was measured above, along and below the mine area, including the various places where mine drainage entered the creek.

The records of flow of Leviathan Creek in the mine area probably include the peak flow to be expected except in rare cases but probably not the minimum.

The waters comprising the mine drainage probably enter the ground as precipitation on the mine pit and its tributary area, from precipitation on the surface of the immediate mine area, and from seepage of the flow of Leviathan Creek itself as it skirts the spoil area in the old creek channel.

It appears that the flow from the collapsed mine tunnel and the pit comes from the pit area and its watershed. The flow from the spoil area in the old creek channel apparently comes mostly from Leviathan Creek water soaking into the spoil. The flow from the spoil on the right bank of the creek apparently comes partly from the Leviathan Creek water soaking into the spoil and partly from water soaking directly into the spoil from the immediate area.

Measurements on Leviathan Creek itself through the mine area indicate that there is apparently no significant drainage entering the creek that was not accounted for in the measurements. The records appear to be reasonable, and the data presented in this report appear to identify the hydrologic conditions in the area of the study with reasonable accuracy.

Table VI-1
Flow Measurements
Bryant Creek Leviathan Creek Stream System

In Cubic Feet Per Second

Station 1/	May 14	May 28	May 29	June 12,13 2/	June 24 4/	June 26	July 8,9 2/	July 14	July 23,24 2/	August 7,8 2/	August 21	September 4,5 2/	September 22,23 2/ 4/
(1)	22 3/	9.8		3.2		1.27	0.86		0.43	0.34	0.19	0.15	0.14
(2)					1.72		0.91		0.39	0.22	0.16	0.13	0.135
T_1					0.18								
(3)					2.26		0.93		0.49	0.12	0.012	0.005	0.010
(4)					2.41							0.040	0.047
(5)					3.08		1.49		0.84	0.45	0.35	0.33	0.289
T_2					0.54						0.036		
(6)			16.1	5.9	3.26		1.96	1.80	0.83	0.46	0.46	0.40	0.427
Aspen Creek	5.5 3/		1.73	1.50	1.10	1.15	0.8	0.61	0.61	0.40	0.58	0.48	0.55
Aspen Tributary	0.5 3/		0.19	0.19			0.060	0.0742	0.0993	0.06	0.060	0.047	0.037
T_3					0.14								
(7)	65 3/		22.2	10.5	4.82		3.65		1.84	1.33	0.857	0.90	0.95
Mountaineer Cr.	25 3/		14.5	8.8	5.26		4.45		2.98	2.82	2.29	2.06	2.87
Bryant Creek at Gage	160		59	23		13.5	13.3		8.5	7.1	6.6	5.8	5.8
Doud Springs Creek						0.21							0.47
River Ranch Upper Ditch	0		0	7.1		5.09	6.46		4.3	4.3	4.3	0	0
River Ranch Lower Ditch						4.02							0
Bryant Creek at Mouth						5.52							

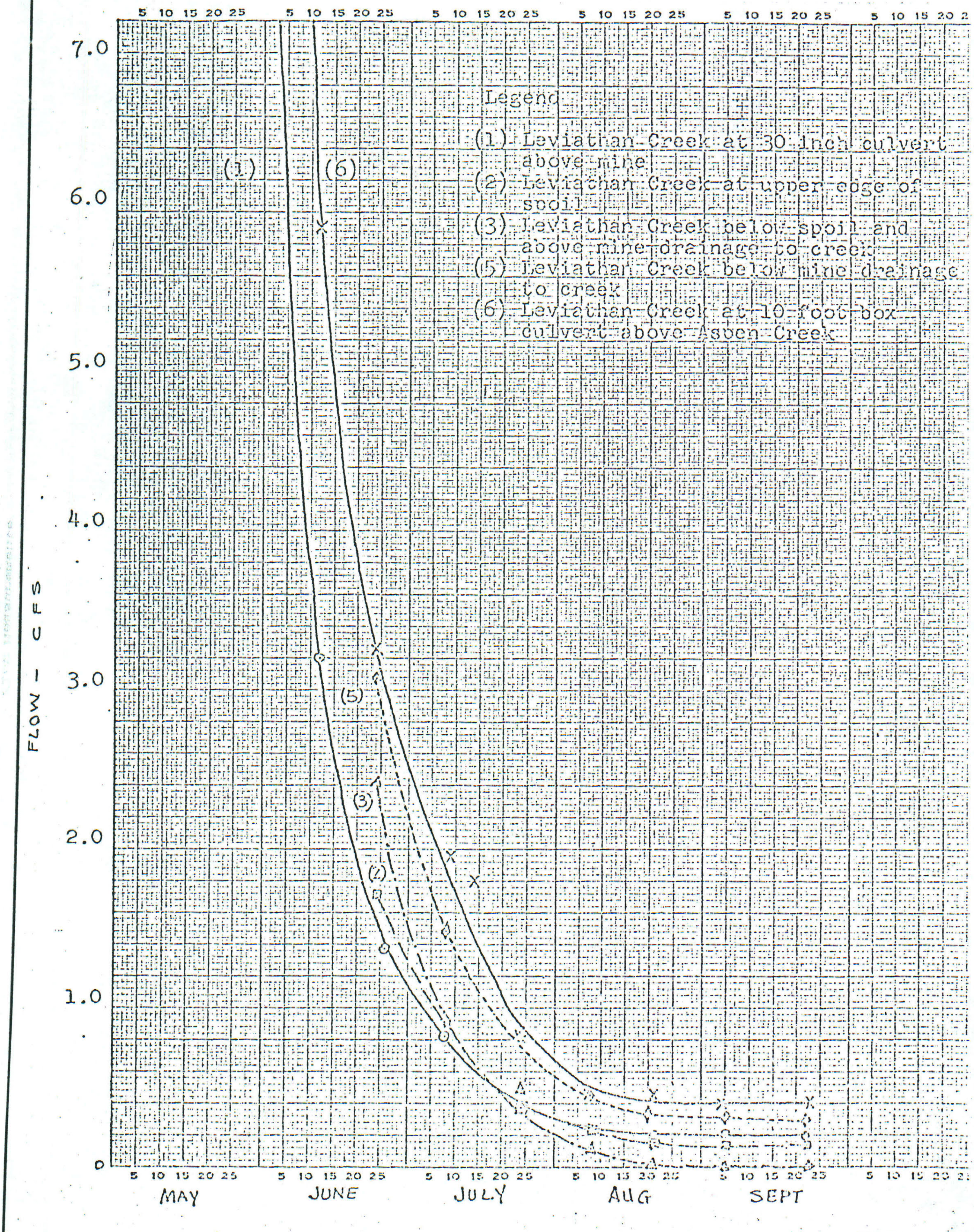
1/ See Plate 9 and tabulation on page 4 for location and description
2/ Measurement made on one of two dates
3/ Estimated
4/ Water quality samples taken on these dates

Flow Measurements
Leviathan Mine Drainage

In Cubic Feet Per Second

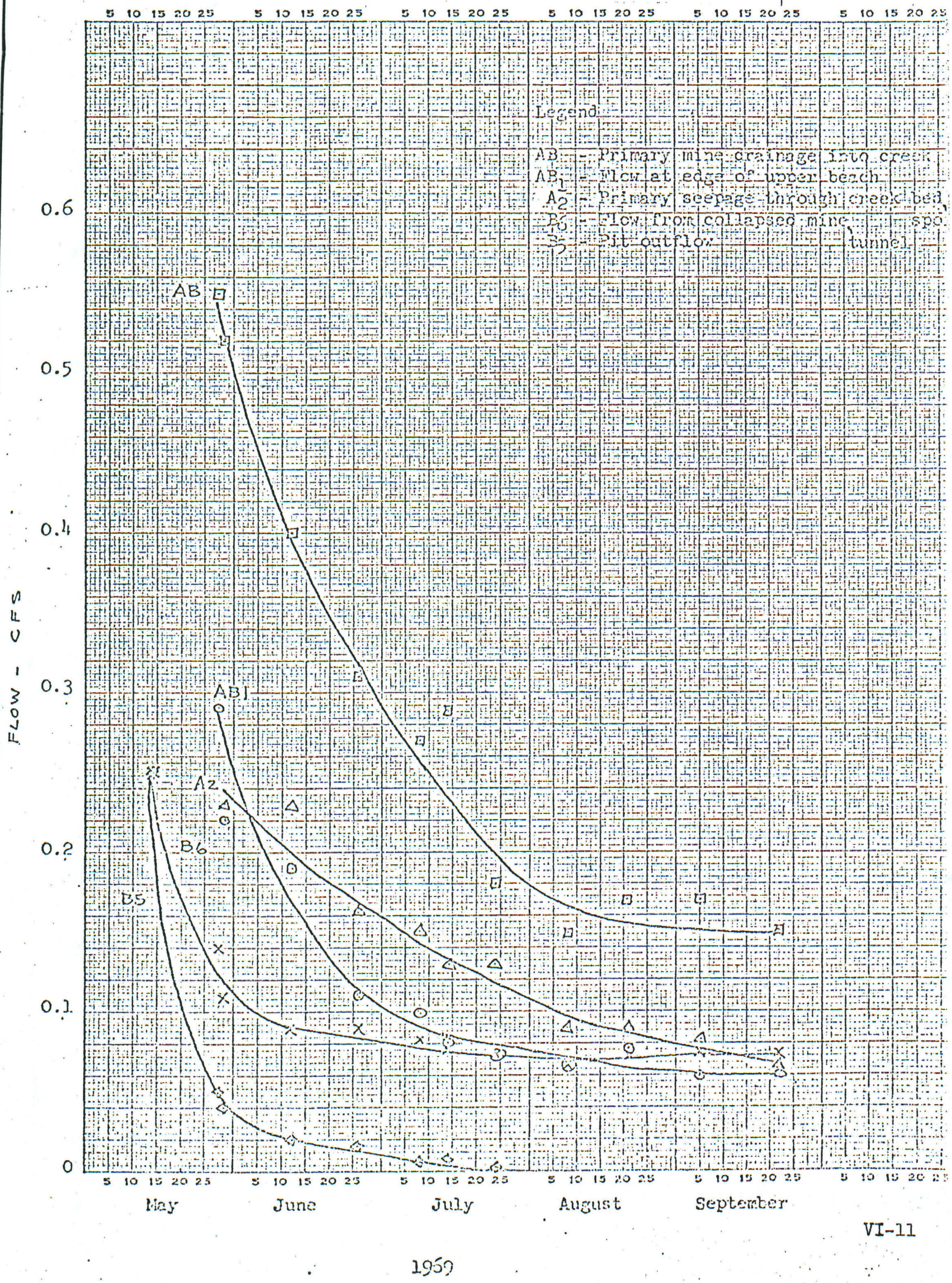
	May			June			July			August		September	
STATION/1	14	28	29	12&13/2/4	24	26	8&9/2	14	23&24/2	7&8/2	21	4&5/2	22&23/2/4
A_3					0.033				0.05		0.036	0.020	0.029
AB		0.55	0.50	0.40	0.297	0.31	0.27	0.29	0.19	0.15	0.17	0.17	0.15
A_2			0.23	0.23	0.191	0.163	0.151	0.13	0.129	0.090	0.090	0.082	0.067
AB_1		0.29	0.22	0.19	0.113	0.11	0.10	0.08	0.0742	0.067	0.078	0.060	0.060
A_1					0.0033		0.0033		0	0	0	0	0
B_6	0.25/3	0.14	0.11	0.09	0.110	0.090	0.082	0.0781	0.0742	0.067	0.074	0.074	0.074
B_5	0.25/3	0.05	0.04	0.02	0.024	0.008	0.003	0.0085	0.0013	0	0	0	0
B_4				0.0009		0.0005	0 (wet)		0.0002		Pools	Pools	Pools
B_3				0.0005		0 (wet)	0 (wet)		0 (wet)	0		0	0
B_2				0.0014		0.0005/3	Trickle		Trickle	0		Trickle	Trickle
B_1				0.0022		0.0005/3	0.0004/3		0.0004/3	Trickle	Trick-le	Trickle	Trickle
C_1			0.13	0.15	0.123	0.109	0.099		0.0904	0.110	0.10	0.082	0.082
C_2								0.1185	0.1185			0.090	0.090
C_3					0.018							Trickle	Trickle

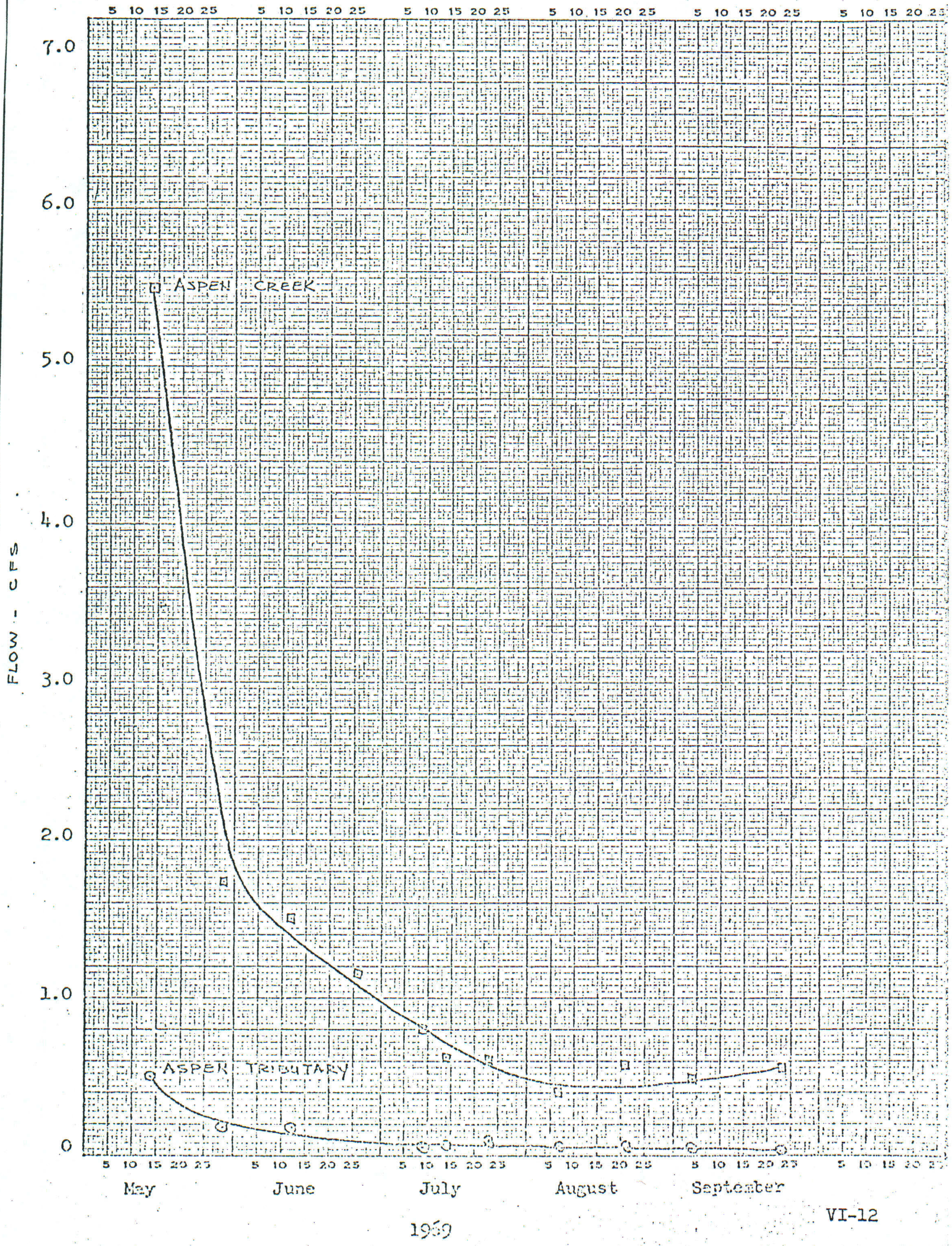
/1 See Plate 10 and Tabulation on Page 4 for location and description.
/2 Measurements made on one of the two dates.
/3 Estimated.
/4 Water quality samples taken on these dates.


FLOW - CFS
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
5 10 15 20 25
MAY
JUNE
JULY
AUG
SEPT
(1)
(6)
(5)
(3)
(2)
Legend
(1) Leviathan Creek at 30 inch culvert above mine
(2) Leviathan Creek at upper edge of spoil
(3) Leviathan Creek below spoil and above mine drainage to creek
(5) Leviathan Creek below mine drainage to creek
(6) Leviathan Creek at 10-foot box culvert above Aspen Creek

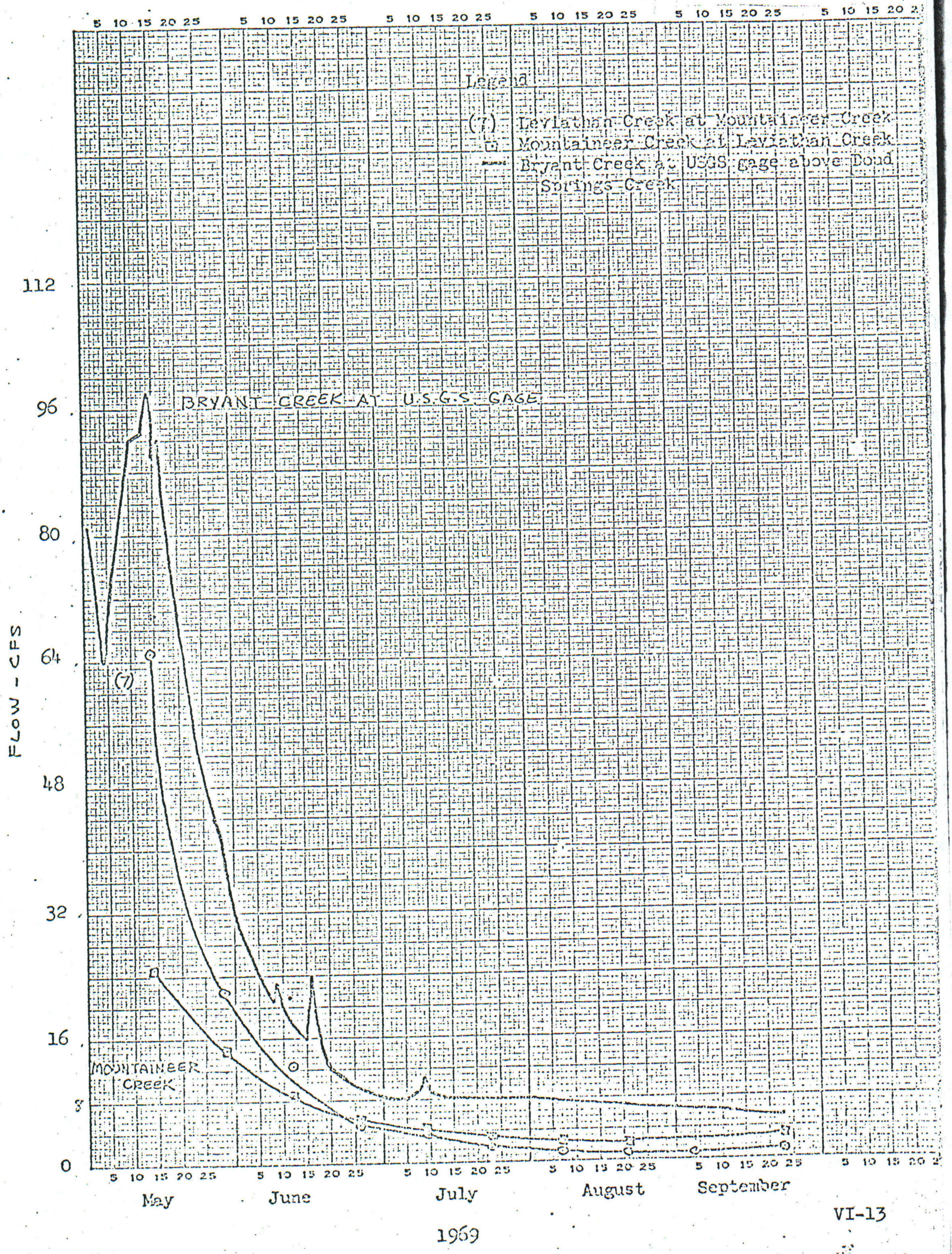
1969

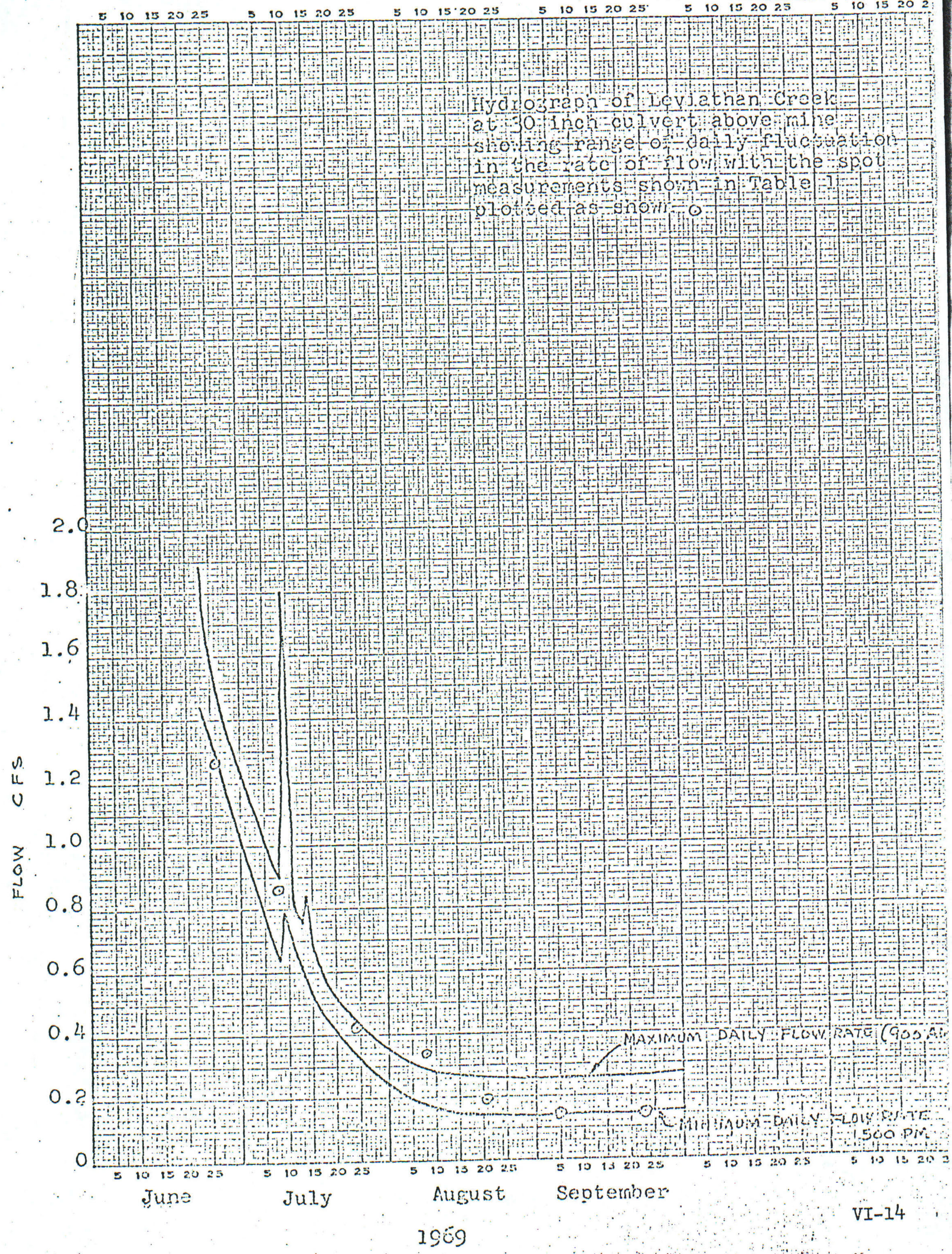
FIGURE VI-B

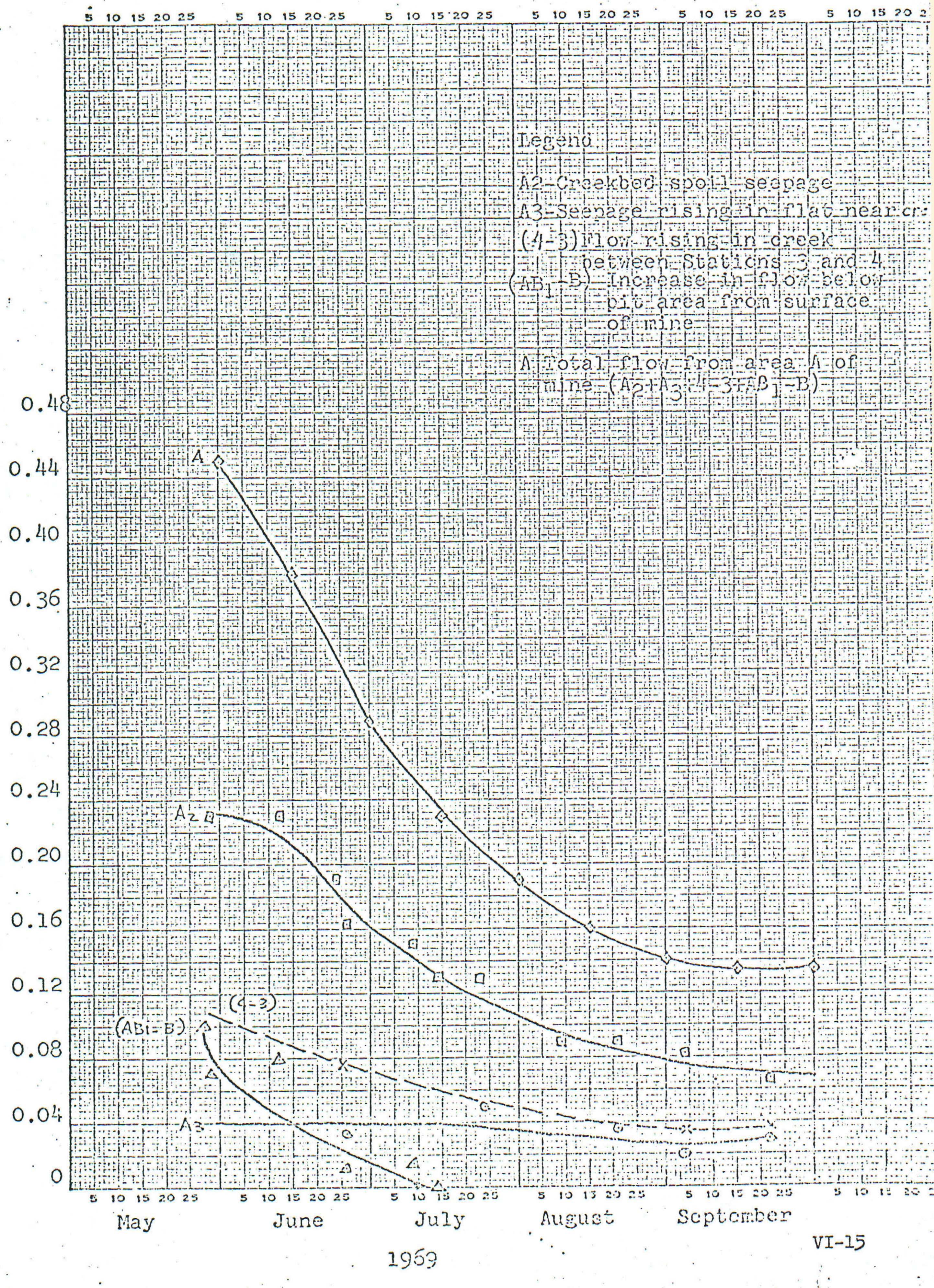

Legend
AB - Primary mine drainage into creek
AB1 - Flow at edge of upper beach
A2 - Primary seepage through creek bed, spo
B6 - Flow from collapsed mine tunnel
B5 - Pit outflow
FLOW - CFS
0.6
0.5
0.4
0.3
0.2
0.1
0
5 10 15 20 25
May
June
July
August
September
AB
AB1
A2
B6
B5
1969

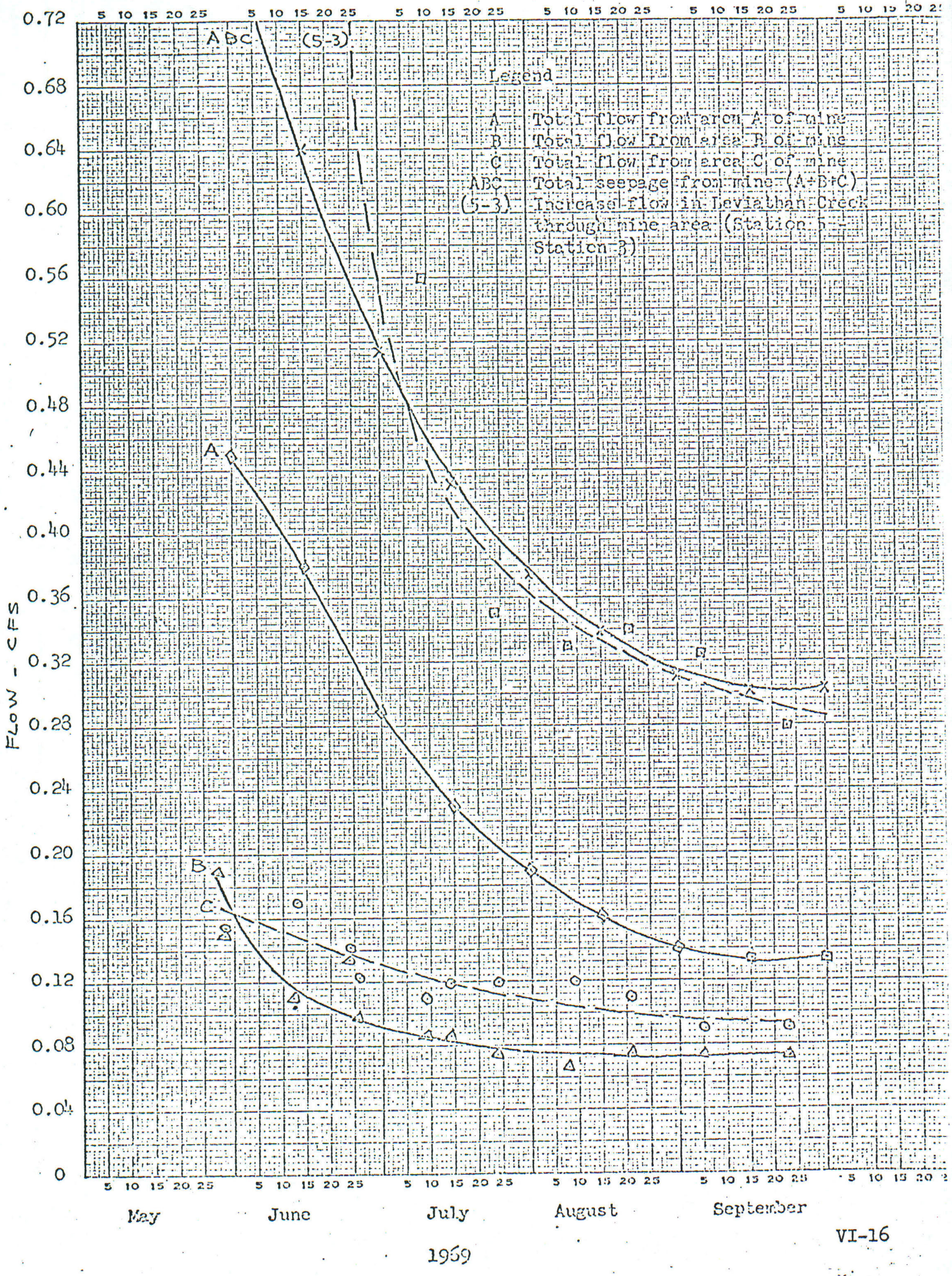


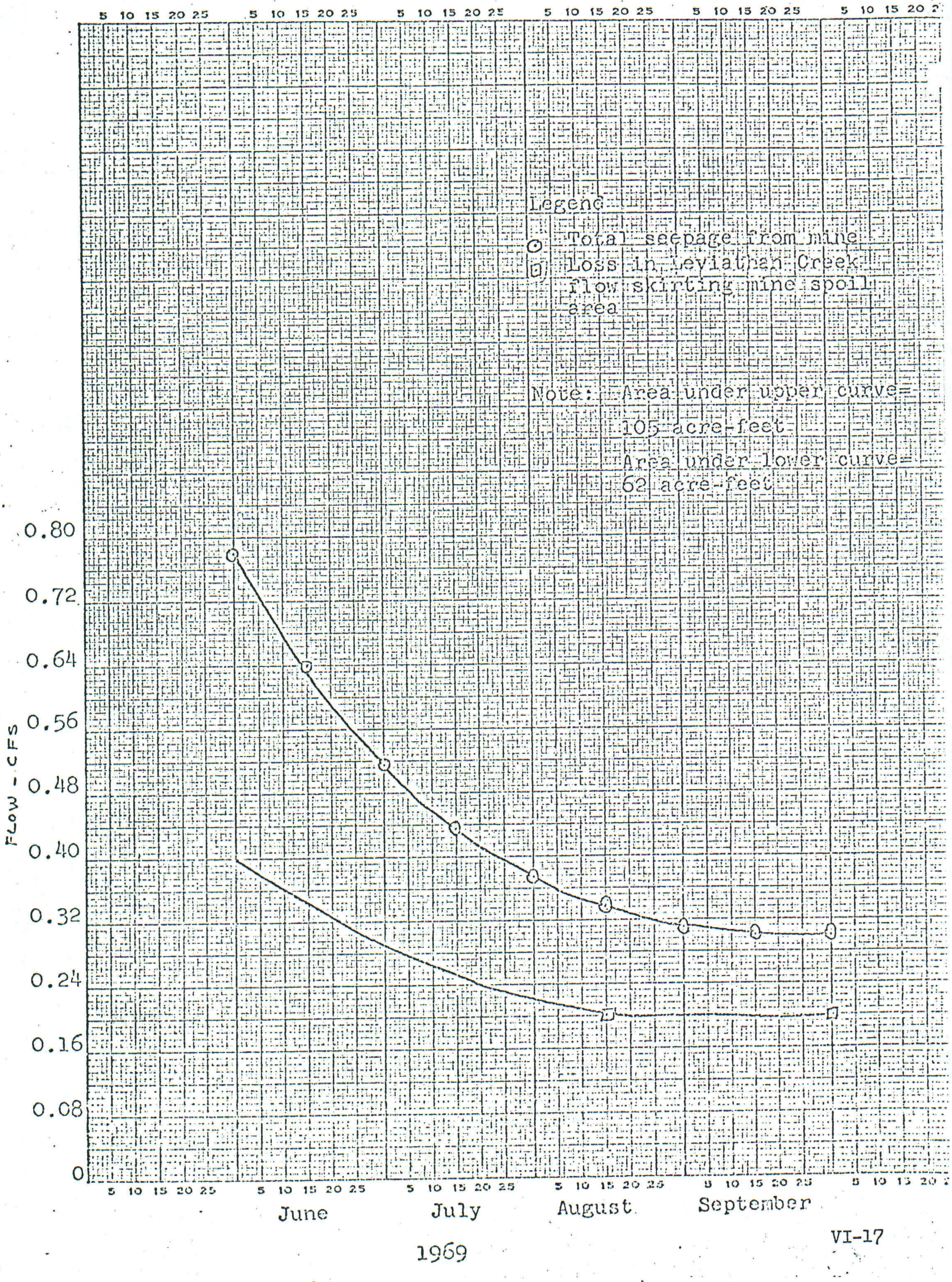
FLOW - CFS
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
ASPEN CREEK
ASPEN TRIBUTARY
5 10 15 20 25
May
June
July
August
September
1969


5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 2
Legend
(7) Leviathan Creek at Mountaineer Creek
□ Mountaineer Creek at Leviathan Creek
— Bryant Creek at USGS gage above Doud Springs Creek
BRYANT CREEK AT U.S.G.S. GAGE
(7)
MOUNTAINEER CREEK
FLOW - CFS
112
96
80
64
48
32
16
8
0
5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 2
May
June
July
August
September
1969


Hydrograph of Leviathan Creek
at 30 inch culvert above mine
showing range of daily fluctuation
in the rate of flow with the spot
measurements shown in Table 1
plotted as shown ⊙
FLOW CFS
MAXIMUM DAILY FLOW RATE (900 A
MINIMUM DAILY FLOW RATE
1500 PM
June
July
August
September
1969


Legend
A2-Creekbed spoil seepage
A3-Seepage rising in flat near cr
(4-3) Flow rising in creek between Stations 3 and 4
(AB1-B) Increase in flow below pit area from surface of mine
A Total flow from area A of mine (A2+A3+4-3+AB1-B)
0.48
0.44
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0
A
A2
(4-3)
(AB1-B)
A3
5 10 15 20 25
May
June
July
August
September
1969


0.72
0.68
0.64
0.60
0.56
0.52
0.48
0.44
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0
FLOW - CFS
ABC
(5-3)
A
B
C
Legend
A Total flow from area A of mine
B Total flow from area B of mine
C Total flow from area C of mine
ABC Total seepage from mine (A+B+C)
(5-3) Increase flow in Leviathan Creek through mine area (Station 5 - Station 3)
5 10 15 20 25
May
June
July
August
September
1969


Legend
Total seepage from mine
Loss in Leviathan Creek
Flow skirting mine spoil area
Note: Area under upper curve= 105 acre-feet
Area under lower curve= 62 acre-feet
FLOW - CFS
0.80
0.72
0.64
0.56
0.48
0.40
0.32
0.24
0.16
0.08
0
5 10 15 20 25
June
July
August
September
1969

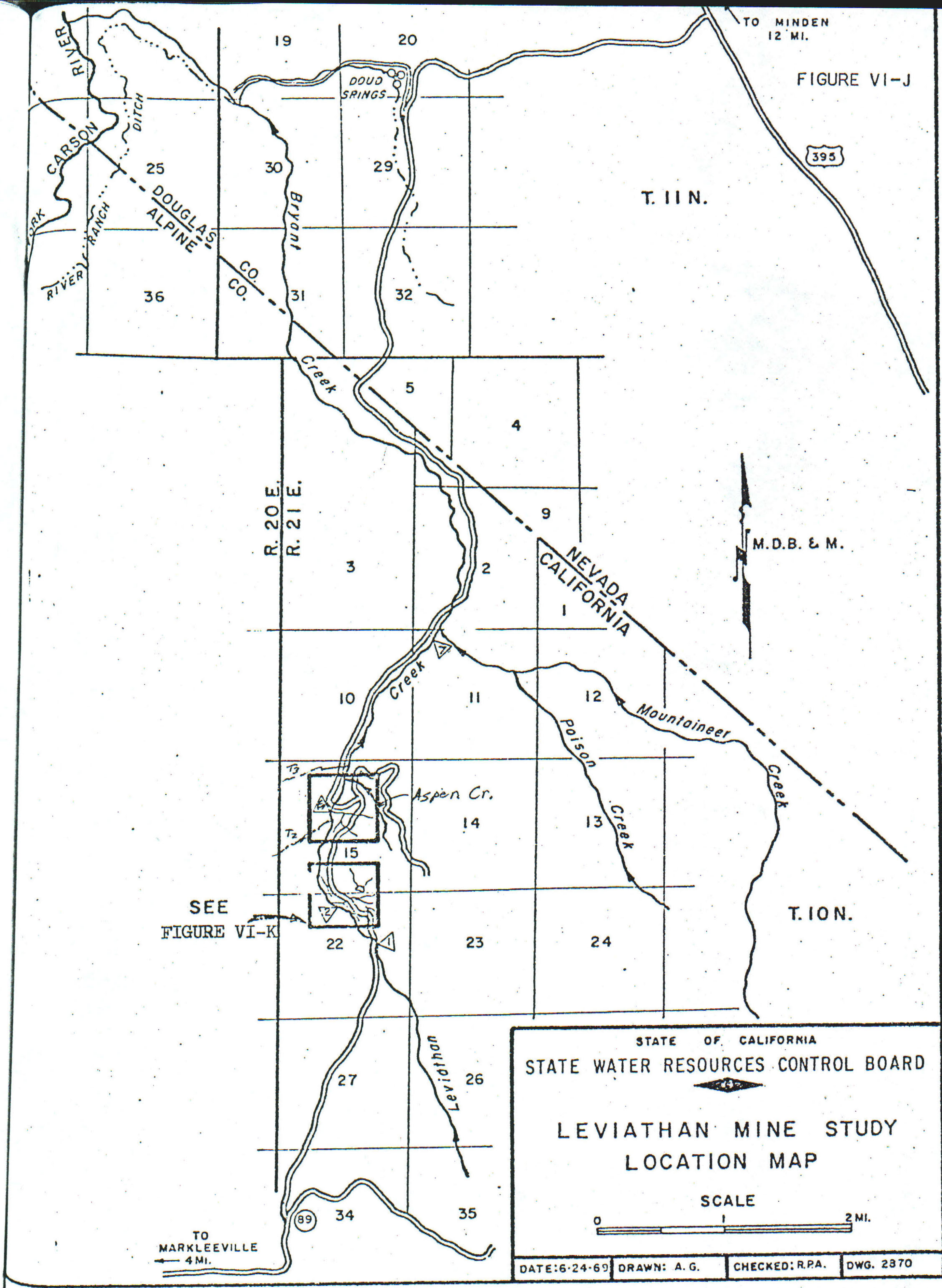
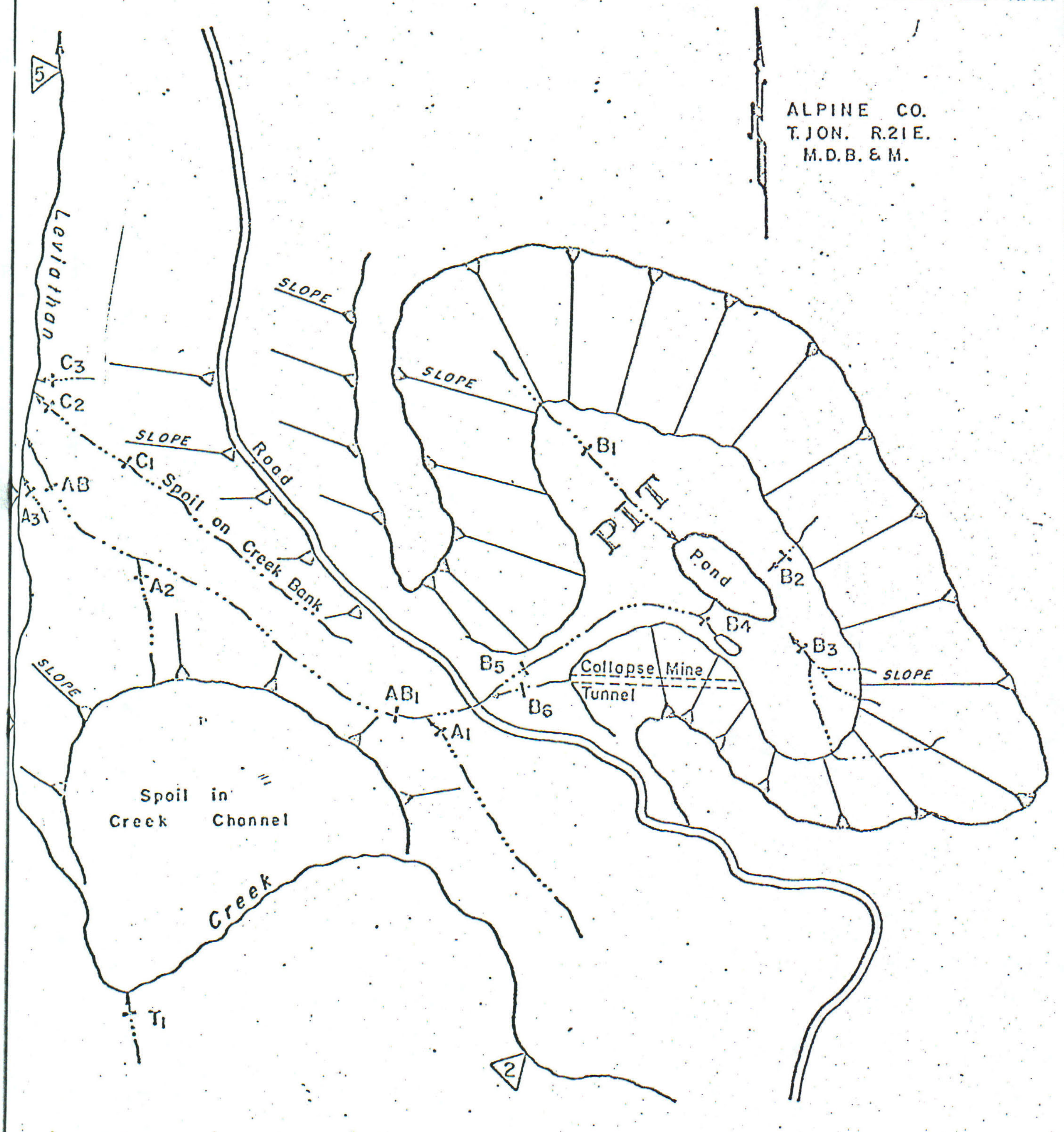


FIGURE VI-J
TO MINDEN 12 MI.
395
T. 11 N.
T. 10 N.
M.D.B. & M.
R. 20 E.
R. 21 E.
CARSON RIVER
RIVER RANCH DITCH
DOUGLAS CO.
ALPINE CO.
DOUD SPRINGS
Bryant Creek
NEVADA
CALIFORNIA
Creek
Aspen Cr.
Mountaineer Creek
Poison Creek
Leviathan
SEE FIGURE VI-K
TO MARKLEEVILLE 4 MI.
89
19
20
25
30
29
36
31
32
5
4
9
3
2
1
10
11
12
14
13
15
22
23
24
27
26
34
35
STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
LEVIATHAN MINE STUDY
LOCATION MAP
SCALE
0
1
2 MI.
DATE: 6-24-69
DRAWN: A. G.
CHECKED: R.P.A.
DWG. 2370



STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

LEVIATHAN MINE STUDY

INSET I

SCALE

Approx. 1" = 400'

DATE: 10-9-69	DRAWN: A.G.	CHECKED: R.P.A.	DWG. 2873

VII NECESSARY CORRECTIVE MEASURES

Correction of the problem will require that each of the sources of pollution be eliminated or at least controlled to some degree. Some of the sources are interrelated and cannot be considered separately. Conversely, some corrective actions will contribute to the control of more than one source of mineralized discharge. The elimination of the infiltration of Leviathan Creek waters above the mine will eliminate up to 2/3 of the flow of discharges from the Anaconda Leviathan Sulphur Mine and at the same time provide a better quality of water at the lower end of the mine to mix with any portion of the mine drainage which cannot be controlled. As the correction of this problem proceeds, it may be determined that all sources need not be completely corrected since some items appear to be minor and will be insignificant if the major problems are rectified. Various discharge sources and alternative solutions are as follows:

A. SEEPAGE FROM BELOW TAILING PILE IN CREEK BED

From flow data generated in past studies, it can be seen that approximately 50% of the flow of acid mine drainage emanates from this area. Review of this same flow data in conjunction with chemical analysis of the waste streams shows that at least 50% of the total sulfate loading to the creek is contributed by this source.

The pollutants in the seepage originate from overburden material high in mineral content. Leviathan Creek seeps through the dump, leaching acid and toxic substances from the waste dump. Correction of this problem requires that Leviathan Creek be intercepted above the abandoned mine and conveyed beyond the lower reaches of the mine in some type of impervious conduit before it is allowed to be reintroduced to the natural creek bed.

A flume, pipeline, and ditch might be constructed to prevent percolation of Leviathan Creek through the overburden. Sealing the existing channel by the use of rip-rap and grouting would eliminate the periodic maintenance necessary to keep a pipe inlet from becoming clogged with debris, and hydrologic design would be simplified. Another solution would be to construct a straight channel through the overburden material to a point below the waste materials. This channel would also have to be sealed to prevent percolation of the fresh waters of the creek into the spoil materials. This can be accomplished through the utilization of natural materials or some of the artificial liners commercially available at the present time. Either of these sealing methods would have to be protected by appropriate filter blanket and rip-rap coverings. A concrete-lined channel would also accomplish the same purpose but would be more expensive.

B. SEEPAGE FROM ABANDONED TUNNEL

This source of pollution contributes approximately 30% of the total sulfate loading and extremely large quantities of toxic substances to Leviathan Creek. This source is therefore a major concern.

The abandoned tunnel is located directly beneath the mine pit. Water which enters the pit and is not evaporated, flows out of the pit entrance (see C) or seeps through the pit floor. Toxic acid-forming substances are leached out of the soils as this water passes through them and are then intercepted by and discharged via the abandoned tunnel.

One solution for this problem is to place an impermeable seal in the end of the tunnel. It must be recognized that this will possibly result in an increase in flow from the pit (see C below). A second solution is to collect the water from the tunnel and dispose of it by evaporation. Assuming that problem 'C' is corrected by regrading and selective sealing of the pit area designed to promote rapid runoff, it appears the best proposal is to seal the tunnel outlet. This will allow that portion of the water which would have escaped through the tunnel to be handled with the other drainage from the pit area. A second plug in the tunnel within the pit area should be considered especially if the tunnel is exposed during any regrading of the pit.

C. SURFACE DRAINAGE FROM PIT

This source contributes an estimated zero to 20 percent of the acidic materials and large quantities of toxic substances to Leviathan Creek. The amount of the discharge varies significantly during the year and normally stops in late summer, thus explaining the varying contribution. This source has a high priority and is directly related to problem 'B' as previously explained.

There are alternative solutions to this problem. The most obvious solution is to construct a dam across the entrance to the pit, thus eliminating this source of water and backing water in the pit where it can evaporate. There are some problems associated with this proposal. Any dam constructed across the pit entrance could possibly fail. A failure would not only create additional problems in the creek, but would also probably cause extensive fish kills, similar to those which have occurred in the past, in the Carson River. Also, ponding of the water would increase the amount of percolation.

A different form of control would be to do the regrading and sealing mentioned in 'B' above. The object of this proposal is to promote runoff of precipitation prior to its having a chance to percolate into the soils of the area. This would not completely eliminate this source but could greatly reduce the total pollutant load in Leviathan Creek. It would have the added benefit of adding the greatest unit loading of pollutants at times when the unaffected flows would usually be their highest levels, thereby reducing the impact on the stream.

Small diversion ditches should be placed around the rim of the pit area to preclude any surface flow from surrounding areas entering the pit. It is important, no matter what other alternatives are selected for the interior of the pit itself, to minimize the amount of water entering the pit.

D. RUNOFF FROM DUMP AND SPOIL AREAS

The percentage of the problem related to this source is not known; but during certain times of the year, it may be as high as 25 percent. It is felt that correction of the other sources may well reduce the problem to the point where a re-evaluation can be made as to the necessity of any major control measures in this area.

Solutions which may be effective on this source include the following:

I. Collection below the mine of all highly polluted water and transport to an area for land disposal where ground water problems will not arise.

II. Collection below the mine of all highly polluted water followed by disposal by evaporation.

III. Collection below the mine of all highly polluted water followed by treatment to remove deleterious substances and discharge to Leviathan Creek.

IV. Isolation of the toxic areas from precipitation and groundwater by the selective utilization of regrading, soil compaction, sealing, interception trenches and artificial drains.

The proper solution to the problem is likely a combination of some of the alternatives presented herein. A detailed engineering study would be necessary to find the most economical solution. In general, the physical corrective steps would be preferred since they offer a permanent solution to the problem with the least cost for continual maintenance and operation.

An additional control measure that should be investigated subsequent to the implementation of the above items is the feasibility of placing a small dam upstream of the Leviathan Mine for low flow augmentation. When the major control measures are in place and operational, this may be the only additional control measure which would revitalize the creek.

E. RECOMMENDED CONTROL ACTIONS

The actions recommended for each of the major individual problems are as follows:

I. Seepage from below tailings pile in creek: Construct a sealed, rip-rapped ditch through the tailings area from above any spoil area to a point below the present major discharge location.

II. Seepage from abandoned tunnel: Seal the tunnel at the point where the discharge presently emanates and within the pit area if it is uncovered during pit regrading.

III. Surface drainage from pit: Regrade the interior of the pit and the pit entrance to promote rapid runoff of any precipitation that falls in the pit area, also construct a small interceptor trench(s) above the pit area to preclude sheet flow from entering the pit.

IV. Runoff from dump and spoil areas: Immediately extend the small interceptor trench(s) listed in 'III' to prevent sheet flow from areas surrounding the mine site from entering areas where they can contact acid-producing waste materials. Upon completion of control measures proposed in 'I', 'II', and 'III', evaluate the total discharge to determine the extent of additional necessary measures in this area.

VIII CONCLUSIONS

It has been positively shown that the pollution of Leviathan and Bryant Creeks has resulted from the mining activity at the Anaconda Leviathan Mine. Prior to initiation of surface mining at the site, the quality of water in the creeks was good and supported a healthy aquatic environment. Since the early 1950's they have been polluted and will not support any aquatic life. The beneficial use of the waters for recreation, wildlife sustenance, and agricultural purposes has been degraded or destroyed.

This resultant pollution is a very serious problem and every effort should be made to correct it. In the past, the affected streams did constitute an important asset which should be available for future use. It is definately reasonable to expect correction of the pollution to attain improved water quality considering the demands which could be made on those waters and the total values involved.

The proposed objectives for Bryant Creek which are recommended in the draft comprehensive plan envision the correction of the problem and improvement of water quality to allow most beneficial uses and to prevent nuisance. The plan also mentions the proposed corrective facilities and the estimated costs. The water quality objectives could be reasonably achieved considering the costs of improvements versus the value of the resource.

APPENDIX A

COST ESTIMATES

Channel Construction

2,000 feet of trapezoidal channel with a bottom width of 10 feet, a total depth of 8 feet and side slopes of 2:1 Use 2000' x 208/27 = 15,400 yd^3	
Basic earth work - (15,400 cu.yds. @ $10/cu.yd.)	$ 154,000
75 feet of trapezoidal channel with a bottom width of 20 feet, a total depth of 15 feet and side slopes of 2:1	
Basic earth work - (1700 cu.yds. @ $10/cu.yd.)	17,000

Channel Lining

2,000 linear feet of trapezoidal channel with a bottom width of 10 feet, a total depth of 5 feet and side slopes of 2:1	
1 ft. of clay placed in three lifts covered by 1 ft. of sand - (8600 sq.yds. @ $2/sq.yd.)	17,200
Artificial liner covering clay material (94,000 sq.ft. @ $1/sq.ft. in place)	94,000
Channel erosion protection with 1 foot total thickness of filter blanket material and interlocking rip-rap material (2,000 linear feet @ $15/lin.ft.)	30,000

Total Channel Cost	$ 312,200
Say -	$ 320,000

Sealing Abandoned Mine Shaft	
Pressure grout the mine shaft outlet -	$ 50,000
Pit Drainage	
Regrading within pit area - (50,000 cu.yds. @ $3/cu.yd.)	150,000
Selective sealing in pit area - (5,000 sq.yds. @ $2/sq.yd.)	10,000
Small interceptor trench 3,000' - (1,000 du.yds. @ $6/cu.yd.)	6,000
Total Pit Protection Cost -	$166,000
Say -	$170,000
Total Initial Cost of Project -	$540,000

APPENDIX B

POSSIBLE ALTERNATIVE BOARD ACTIONS

Although this scheduled hearing is primarily a hearing pursuant to the provisions of Section 13305 Water Code, the Regional Board may, at the conclusion of the hearing, elect to follow one or more alternative courses to proceed on the matter.

Alternatives: The options which are available to the Board include, but are not limited to, the following:

1. Procedure Under 13305 Water Code:

   A. The Board may continue the meeting for any purpose it deems necessary or advisable without making a final decision at this meeting.

   B. If the Board is satisfied that it has sufficient evicence to make final disposition of the matter (i.e., has heard and considered the evidence and objections or protests to the action, if any) provided that the discharger has not made satisfactory representation as to his ability, or willingness, to clean-up and abate the discharge, the Board shall request the County of Alpine to abate the condition of pollution or nuisance.

   C. If the county does not abate the condition within a reasonable time, the Board shall by resolution apply to the State Board. The Regional Board has considerable discretion as to the manner of implementing the referral to the State Board.

   D. Follow-up with appropriate action under subdivision (F) and (G) Section 13305 Water Code may be undertaken.

2. Clean-Up and Abatement Order (Section 13304 Water Code)

   The Board may issue a clean-up and abatement order to the appropriate discharger with a time schedule for compliance and procedure for referral to the Attorney General is necessary.

3. * Referral to Attorney General for Violation of Section 13385 Water Code:

   If the Board makes a finding that the discharger is in violation of Section 13385 Water Code, it may refer the matter to the Attorney General for civil action for monetary damages not to exceed $10,000 per day.

4. * Cease and Desist Order Section 13301 Water Code:

   The Board may order a hearing for the purpose of determining whether another cease and desist order should be issued.

5. * Referral to Attorney General for Failure to File Application for NPDES Permit:

The discharger was requested to file application for a NPDES Permit and failed or refused to do so. An action may be taken against the discharger for failure to file as required by Section 13376 Water Code.

* Note: In the event the Board elects to proceed under paragraph 3, 4, or 5 above, it is recommended that the Board continue the matter to the next regular Board meeting at South Lake Tahoe for a public hearing.

6. Consideration of Recommending Conveyance by Deed of Portion of the Affected Property:

Although it has no legal commitment to do so, the discharger may consider conveying by gift deed a portion of the affected property to the State of California or some other public entity.

Mr. B. Buzzini, Deputy Attorney General, should be consulted as to the procedure and effects of this proposal for a conveyance to the State of California, should it be made, before serious consideration is given to this method of solving the problem. In the event any other public entity is considered or suggested, the appropriate legal agency should be consulted.

7. Pursue Environmental Protection Agency (EPA) Demonstration Grant:

A possible source of funding the improvements would be through an EPA Demonstration Grant. EPA would consider an application if at least the following three conditions were met:

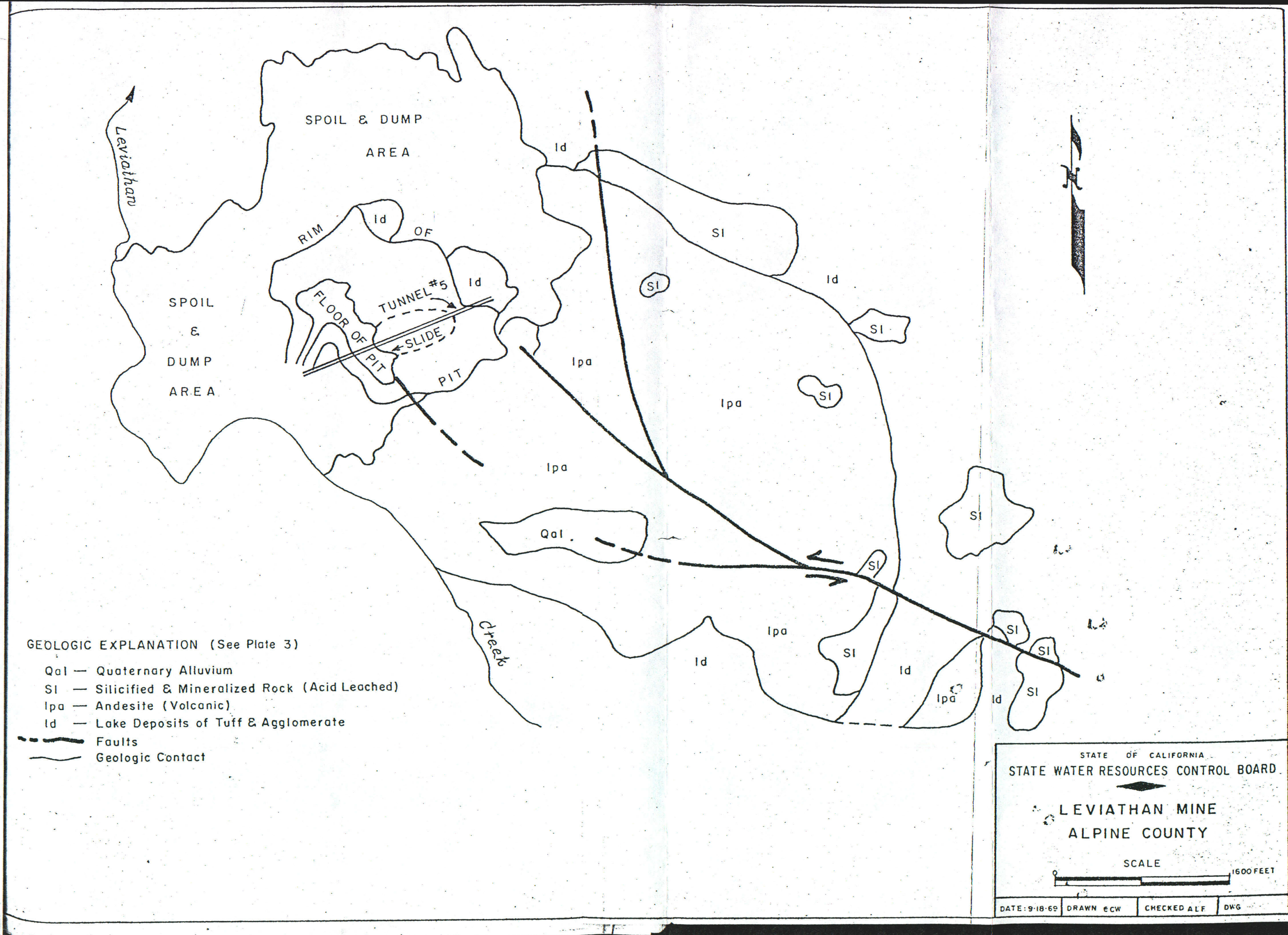
(a) The State (or other applicant) must guarantee control and maintenance of the project improvements for an extended period of time. This would probably require acquisition of the property by a public agency.

(b) The application must provide twenty-five percent (25%) of the required corrective funds.

(c) The funded corrective measures must result in the demonstration of innovative technology.

Pending Litigation: Civil Litigation (No. 23) Superior Court, County of Alpine, filed 9-3-69) involving Alpine Mining Engerprises, Inc. as defendant is presently pending. The issues have not been adjudicated. The present hearing does not prejudice this case; however, any action by the Board which contemplates additional legal action should be correlated with the Attorney General in order that he may take appropriate action concerning the litigation.

Discussion: Under the facts of this case, some of the alternatives presented may well be considered to be inappropriate since ordinarily they apply to cases which are before the Board as matters of first impression. It is recommended this be taken into consideration when weighing the above or other possible alternatives.



Leviathan
Creek
SPOIL & DUMP AREA
SPOIL & DUMP AREA
RIM OF PIT
FLOOR OF PIT
TUNNEL #5
SLIDE
Id
Ipa
SI
Qal
GEOLOGIC EXPLANATION (See Plate 3)
Qal — Quaternary Alluvium
SI — Silicified & Mineralized Rock (Acid Leached)
Ipa — Andesite (Volcanic)
Id — Lake Deposits of Tuff & Agglomerate
Faults
Geologic Contact
STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
LEVIATHAN MINE
ALPINE COUNTY
SCALE
0
1600 FEET
DATE: 9-18-69
DRAWN ECW
CHECKED ALF
DWG

FIGURE V-E

PLATE 2

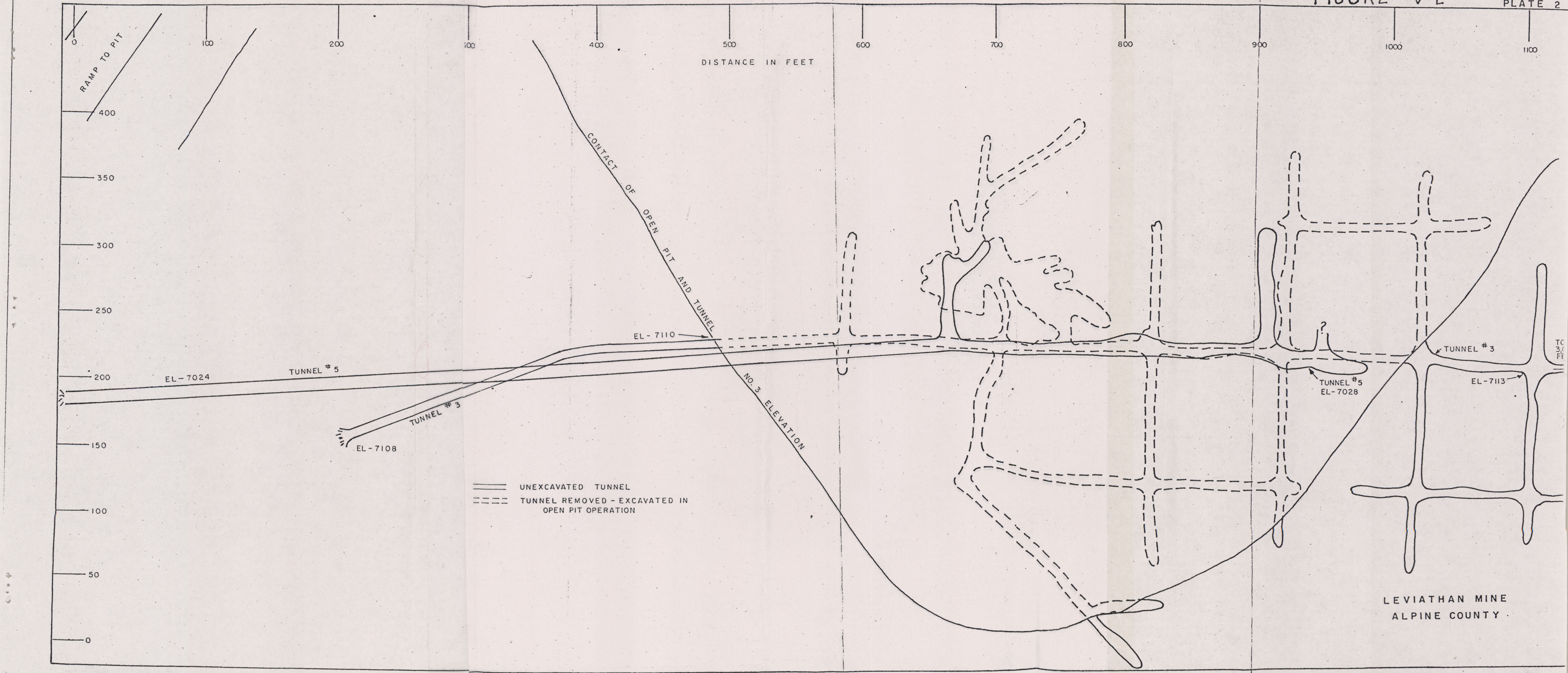


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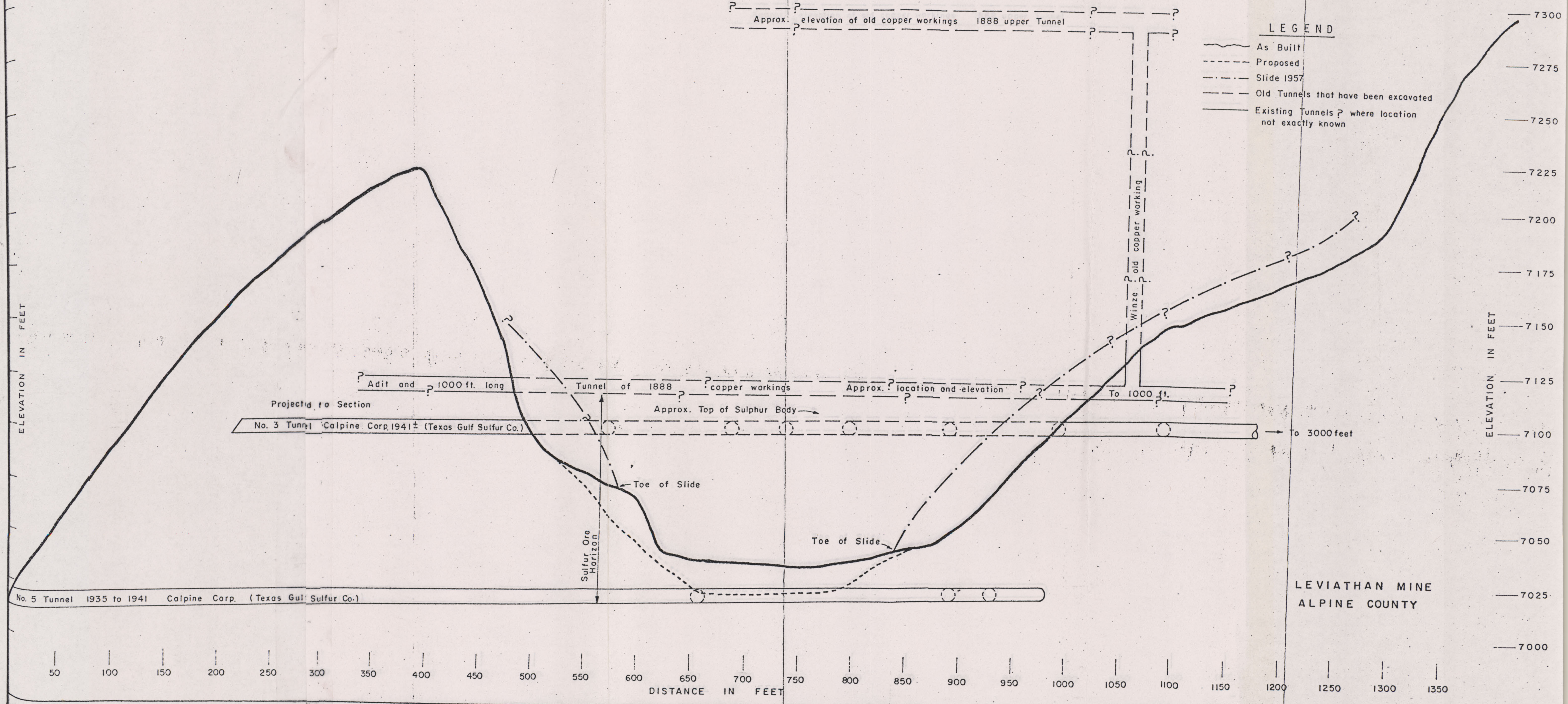
FIGURE V-D PLATE



LEVIATHAN MINE
ALPINE COUNTY

99990048

FIGURE V-C PLATE

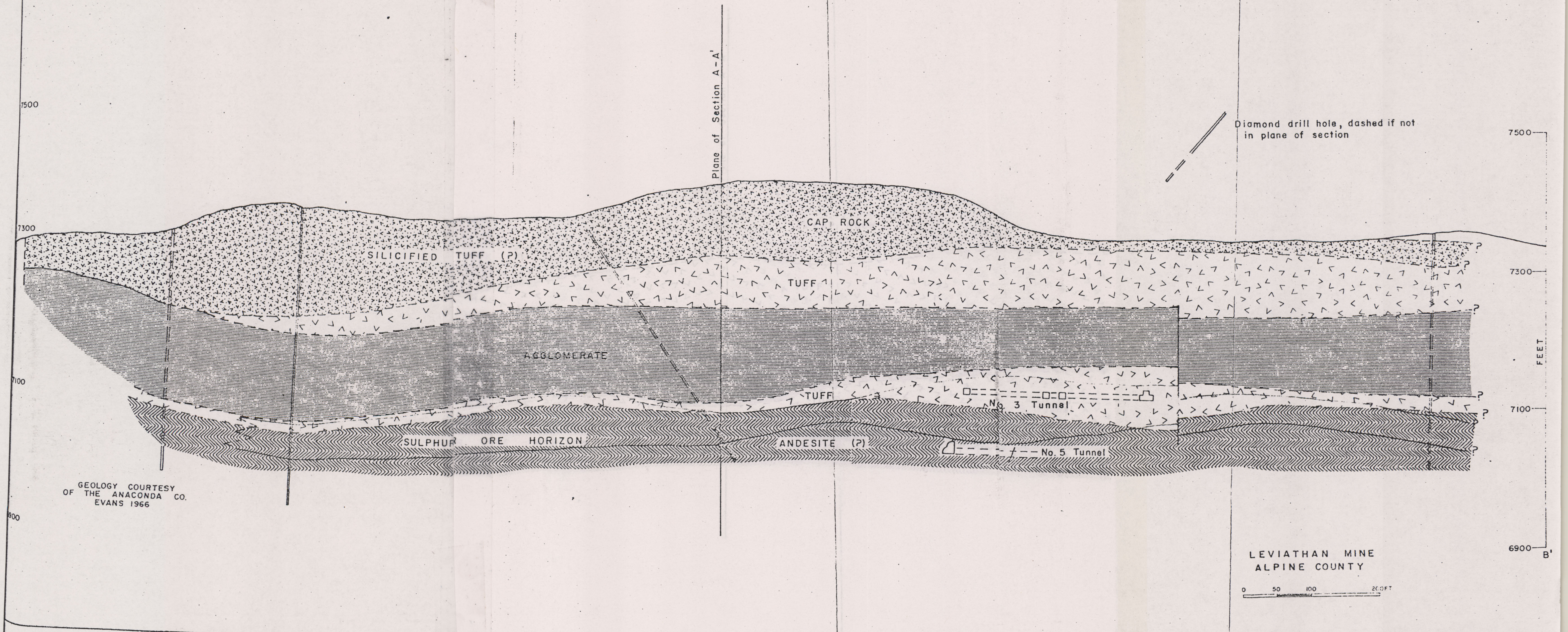



FIGURE V-A Plate 3
GEOLOGIC MAP OF THE MONITOR PASS AREA, CALIFORNIA AND NEVADA
EXPLANATION
Quaternary
Qal Alluvium
Ql Landslide
Qt Talus
Pliocene
Miocene
Tertiary
b o Basalt intrusion
ad Andesite dome
dd Dacite dome
rd Rhyolite dome
df Dacite flow
abf Autobrecciated flows
sl Silicified & mineralized rocks
lpa Andesite of Leviathan peak area
ld Lake deposits in Leviathan Peak area;
ccc / cclb conglomerate & lake beds at Cottonwood Creek
avu Andesitic rock undifferentiated
par Pre-avu Rhyolite
Jurassic to Triassic? Cretaceous
gd / pqm / qm Granodiorite, porphyritic quartz monzonite, quartz monzonite
ms / mv Metasedimentary and metavolcanic rocks
Geologic contact, dashed where approximate
Fault, dashed where probable or concealed, question marked where inferred.
Mine
0 1 2
Scale in Miles
Contour Interval: 100'
N
Base map from U.S.G.S. Calif.-Nev. Markleville Quad. N3830-W11930/30, 1893
Geology taken from unpublished map by Garniss Curtis, 1951, slightly modified by J.R. Evans, 1966
Leviathan Peak
8985
Leviathan Mine
Monitor Pass
Historic Marker
Haypress Flat
Morning Star
Curtz
Leviathan Mine Turnoff
Topaz Lake
Little Alkali Lake
West Walker River
VALLEY
Talus
395
38°40'
119°40'