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Granite Industry Wastewater Treatment

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GRANITE INDUSTRY WASTEWATER TREATMENT

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ABSTRACT

A study of wastewater discharge in the granite industry has been conducted to determine wastewater characteristics, methods of pollution abatement and disposal methods for waste granite sludge.

The project included a study of overall water use in a granite plant, water optimization studies, and water reduction studies. Laboratory testing was conducted for waste characterization and liquid solids separation techniques. A pilot plant was designed, constructed and operated to test the efficiency of plant scale separation procedures. A prototype plant was designed and constructed to test the possibility of complete water reuse in the granite industry. Successful operation of both plants indicates that a practical method of treating granite waste effluent has been developed and that complete recycle of treated effluent is possible and economically feasible.

Studies were performed to determine the possibility of by-product use of waste granite sludge. Two uses were found for the sludge, but an economic evaluation indicated that there was insufficient raw material to establish a by-product industry.

A survey of sludge disposal methods in the industry showed that some modification of waste disposal facilities, and more cooperation by the industry, would improve the sludge disposal procedures. A modified type of settling lagoon was recommended.

This report was submitted in fulfillment of Project No. 12080 GCH under the sponsorship of the Environmental Protection Agency.

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SECTION I

CONCLUSIONS

As a result of a study of water use and waste discharge in the granite industry the following conclusions have been reached:

1. A saving of 25 to 50% can be realized in overall water use by careful attention to water conservation practices and minor changes in equipment.

2. The present practice of primary clarification in a settling lagoon or pit will not produce a waste effluent that is compatible with present effluent standards of the Vermont Department of Water Resources.

3. Chemical treatment of the partially settled waste discharge with ferric chloride and lime will produce a waste effluent which is well within acceptable standards.

4. Operation of a prototype pilot plant showed that an effluent of satisfactory quality for complete reuse in plant processing could be produced.

5. By-product use studies of waste granite sludge failed to find a product that would be economically feasible to produce.

6. Studies of ultimate sludge disposal indicated that more industry cooperation, design changes and better construction of waste lagoons would greatly improve waste sludge disposal.

SECTION II

RECOMMENDATIONS

1. Although there is no present water shortage in the area, the granite industry should be urged to adopt water conservation practices because of financial considerations (easier and less costly waste treatment with less rock flour discharged), and to avoid future water supply problems.

2. The industry should adopt chemical treatment of waste effluent to produce an effluent compatible with state water quality standards and to reduce stream pollution in the area.

3. Where space and financing are available, each processing plant should consider the installation of a complete water recycle and reuse system, to further conserve water and provide financial benefits.

4. Although no by-product use for waste sludge was found, several promising leads were investigated, and it is recommended that this study be continued on an industry-wide basis.

5. Modest design changes and cooperative waste sludge disposal are recommended, to alleviate the existing problems in ultimate disposal.

SECTION III

INTRODUCTION

The granite industry is undoubtedly the leading mineral industry in the State of Vermont, considering the number of persons employed in the industry and the net value of the product. In excess of one hundred firms are engaged in quarrying or processing granite or in furnishing services to the industry.

Prior to the depression of the 1930's the industry was widely dispersed throughout the State, numerous quarries existed and several types and hues of granite were processed. With the economic recovery accompanying the period following World War II, the industry tended to concentrate in the Barre area and most types of stone except the type known as Barre Grey decreased in popularity. As a result, nearly all of the stone quarried in the State now comes from a few quarries in the Graniteville-Websterville area of Barre Town, and the processors purchase their raw material from one or two quarry companies. Since granite processing is, in part, a wet processing procedure, this concentration of industry has resulted in a major pollution problem in the area of Barre Town and Barre City; an area drained by a small tributary of the Winooski River known as the Stevens Branch.

Processing in the granite industry involves the operations of quarrying, sawing, shaping, surface preparation, decorating and final cleaning. Quarrying is not primarily a wet process, although some water is used for lubrication while drilling, and for dust control. The stone is drilled, wedged and split from the quarry sides and transported, generally by truck, to the processor.

Sawing is performed today almost entirely by wire saws, which are capable of better control and adjustment, and waste less usable stone. The hardened wire, frequently mounted on wheels hundreds of feet apart to distribute wear and thus prolong wire life, cuts through the stone using a relatively coarse grade (90 mesh) carborundum as the cutting agent, in a slurry of stone dust and water. This lubricates the wire and keeps it from whipping or vibrating and thus enlarging the cut. Since a great deal of the slurry in this operation is recirculated to obtain additional use of the carborundum, the volume of waste discharge is not great. However, final washdown of the stone at the conclusion of the sawing process introduces a surge of heavily polluted water.

Two other methods of sawing find limited use in granite processing. One method, formerly widely used, involves the use of multiple strips of hardened steel, in a regular back and forth sawing action, in former years using sand, but today using carborundum, as the cutting agent.

Water is required for lubrication and cooling, and a moderate flow of polluted waste water is discharged. This type of machine, generally called a gang saw, has generally been replaced by the multiple-strand wire saw. For limited use in sawing small stones, the so-called "diamond" saw is used. This circular saw with a cutting edge consisting of tungsten carbide or diamond dust, does not use carborundum as a cutting agent, but does require water for lubrication and cooling. Since the waste stream contains only the stone dust produced by the sawing operation, and since a rather large volume of water is required for cooling purposes, the waste stream is not as heavily polluted as the waste discharges from other sawing operations.

Shaping the stone may be entirely a dry operation using hammers, chisels, etc., or it may involve a wet grinding process known in the granite industry as "planing". The "planer" is a tungsten carbide grinding wheel up to six inches in width, mounted on an adjustable track which may be used to produce the commonly observed curved surfaces on monumental stones. Use of the planer requires a large volume of water for cooling and dust control, and produces a large volume of waste water containing very fine particles of stone dust.

Surface preparation of the stone involves grinding and polishing operations using a slowly-rotating circular steel plate and various grinding and polishing agents. Initial grinding usually involves the use of fine (130 mesh) carborundum, while the final polishing is done with tin oxide powder. Only enough water is used to provide necessary lubrication, and since considerable recirculation is practiced to obtain maximum use of the polishing agent, the waste discharge, although rather heavily polluted, is small in volume.

A related process known as "steeling" uses fine steel balls in place of the carborundum as the grinding agent. This process produces a desirable white color on the stone surface and is frequently used to provide a contrasting surface. Since the ground-off stone dust would darken and stain the surface if allowed to contact it, no recirculation is used in this procedure. However, at the conclusion of the "steeling" process, the fine steel balls are washed clean and recovered for reuse.

Decorating the stone involves cutting designs, letters and numbers into the finished surface of the stone, using pneumatic chisels or by sandblasting. Neither of these procedures produces a liquid waste discharge, since the stone dust is collected by a vacuum system.

The last step in processing the stone is final cleanup. The stone is washed, rust stains are removed with dilute hydrochloric acid, and traces of the rubber masks used in sandblasting are removed using benzene or ligroin. For final washdown, most or the companies have adopted a high-pressure, high-velocity water jet which minimizes the volume of waste water. The use of organic solvents and hydrochloric acid, however, introduces the only chemical contaminants to the waste stream. The total volume is small compared to the total waste discharge.

For many years it has been the custom to discharge the combined waste water to the nearest stream. In addition to the polluted waste waters described above, large volumes of relatively unpolluted water are also discharged. The sources include cooling water for the air compressors used in all plants, prime water and cooling water for the pumps, and varying volumes of clean water resulting from a practice of letting hoses continue to run when not in use. Although none of the discharges are metered, an estimate from municipal water system billings indicates that more than a million gallons a day are discharged in Barre City alone, with additional waste discharges in the surrounding area. It is estimated that total waste discharges from the industry exceed 1.5 million gallons per day.

In 1958 the Vermont Water Resources Department initiated a study of the waste characteristics in the granite industry, and an extensive survey was conducted in 1959 with the aim of determining the extent and severity of the stream damage. Little previous attention had been given to this waste discharge, since the primarily inorganic waste did not reduce the oxygen content of the water. It was immediately apparent, however, that stream damage had been caused by the waste discharge. Desirable trout species had declined because the silt layer on the stream bed had covered the gravel spawning areas, and aquatic plants, insects, etc., were practically non-existent. Extreme turbidity severely reduced sunlight penetration, and the abrasive particles had weakened and depleted the remaining fish population by gill abrasion and irritation. It was estimated that approximately 30,000 cubic yards, or about 20,000 tons, of waste solids are discharged annually. The granite industry was warned that pollution abatement would be required. The classification order for the Stevens Branch and tributaries issued on August 7, 1962, required the granite industry to install acceptable pollution abatement facilities prior to July 1, 1965.

Initial design criteria for treatment facilities recommended a settling lagoon with a 30-minute detention time, an effluent turbidity not to exceed 700 Jackson turbidity units (J.T.U.), and settleable solids essentially zero. Compliance and regulation were, however, somewhat spotty.

Preliminary laboratory work by the Vermont Department of Water Resources indicated that a ten-minute settling period would remove over 95% of the suspended solids, with an average residual turbidity of about 700 J.T.U. and a small amount of settleable solids in the supernatant liquid. However, very little time was devoted to a study of the volume or characteristics of the sludge produced. It was soon evident that the capacity of a thirty-minute lagoon was completely inadequate to provide the needed sludge storage, unless the lagoon was cleaned daily or oftener. But an even more serious problem developed with attempts to handle the sludge. Since one component of the sludge is partially-used carborundum, the sludge is very abrasive. Cleaning the lagoons with the usual types of mechanical equipment resulted in accelerated wear on moving parts and additional expense to the contractor. The sludge dewaters rather slowly, and the fine material is readily resuspended. Transportation of the partially dewatered sludge generally resulted in excessive spillage and leakage, creating additional expense for the contractor. The material would not slip from steel truck bodies, requiring removal by shovel or the use of disposable plastic liners. Disposal sites required sizable dikes to block leakage of sludge to nearby streams. A hazard was created at the disposal site, since under a surface crust the material remained liquid for many days, behaving like quicksand. Although none of the problems appeared to be completely unsolvable, the expense involved caused the plant operators to delay lagoon cleaning as long as possible.

During the period 1962-1965, prior to implementation of the classification order, several pilot-plant projects were developed through the cooperation of the Vermont Department of Water Resources, the research committee of the Barre Granite Association, and individual granite processing companies. Three types of commercial settling tanks were evaluated, two being rectangular tanks with mechanical sludge collectors, and one circular tank with a conical hopper for sludge collection. None of these tanks proved to be an improvement on the excavated lagoon. Although effluent quality was acceptable during quiescent settling, any attempt to remove sludge resulted in resuspension of fine material, difficult or impossible sludge removal, or equipment breakdown. The combination of heavy, coarse material and extremely fine, light material could not be handled by equipment designed to handle sanitary waste. Continuous operation of the mechanical collectors resulted in a completely unsatisfactory effluent; but if the sludge was allowed to collect for any period of time, the thixotropic sludge set and could not be moved without breakage of the collection mechanism. Similarly, when using the cylindrical tank, the sludge coned consistently and could only be removed by the use of water jets; a procedure which resulted in a completely unsatisfactory effluent. Further attempts to use commercial settling equipment were discontinued.

A pilot study was also made during this period to evaluate the possibility of centrifuge separation. Very little improvement could be noted in the waste stream, the effluent turbidity and solids being nearly as high as the influent figures.

In addition to the pilot plant studies described above, a laboratory study of chemical flocculating agents was undertaken by the Vermont Department of Water Resources' laboratory staff. Twenty-three different substances were evaluated for their flocculating ability on granite waste. These included the inorganic compounds lime, alum and ferric chloride; insoluble materials such as bentonite, kaolin and celite; and a large number of the so-called synthetic polyelectrolytes. Thirteen of the compounds tested showed some degree of flocculating ability on one or more waste streams. However, the study indicated that no one material could be depended upon to effectively flocculate all types of waste. The type and amount of processing in a plant results in different types of waste streams which require quite different treatment. It was concluded that the use of chemical flocculants would require an individual evaluation for each plant.

In 1968, with the employment of additional personnel, an industrial waste section was established in the Vermont Department of Water Resources. An immediate project was to reduce pollution from the granite industry. First steps involved completion of the lagoon installation program, with lagoons designed for a 12 to 24-hour detention period. Lagoon cleaning was emphasized, and a new disposal site made available. A laboratory survey of all existing lagoon effluents was performed during August, 1968. Results of the laboratory survey indicated that an average turbidity of about 400 Jackson units, and an average suspended solids of about 400 mg/l, could be expected in the effluent of a properly-operated settling lagoon. However, no solution was found to the problems involved in ultimate sludge disposal, and it proved to be difficult to maintain an acceptable schedule of lagoon cleanout. But it was found that where space was available and the plant owners were not concerned with the aesthetic appearance of the area, the most economical method of disposal involved the use of two lagoons, a settling lagoon and a sludge-holding lagoon. After drying for several months, the sludge could be easily handled by the usual equipment and could be used as landfill.

At this time a decision was made to apply for a federal grant for a research project to study problems of waste treatment in the granite industry. The proposed study would include an inventory of processes and equipment used by the industry, overall water use, optimization and reduction of process water use, characteristics of waste water, solid-liquid separation techniques, analysis of supernatant liquids and sludges, supernatant clarification, byproduct use of sludge, and ultimate sludge disposal. Technical and economic feasibility studies and a pilot plant study would be executed, to test the selected treatment process. Applicant for the grant would be the Vermont Department of Water Resources, with the University of Vermont and the Barre Granite Association to cooperate in carrying out the technical phases of the project. One granite plant of average production capacity, which included all of the process operations producing liquid waste, would be selected as the site of the project. Engineering laboratory facilities available at the University of Vermont would be used for technical testing and evaluation. Overall purpose of the study would be to produce a liquid effluent suitable for discharge to the waters of the State, to investigate possible byproduct uses for granite waste sludge, and to determine the most effective economically feasible method of sludge disposal. Offer and acceptance of the grant was made in early November, 1970, as Grant No. 12080 GCH.

SECTION IV

PRELIMINARY STUDIES

Upon acceptance of the grant, the granite processing firm of Nativi & Sons, Inc., was selected as the project site. Unfortunately, soon after initiation of the project, Nativi enlarged by acquiring a nearby plant, and expanding and separating their processing. This resulted in some additional work, as certain water-use measurements had to be repeated at the newly-acquired plant. With this exception, the project proceeded as planned, although there were some unavoidable delays in securing necessary equipment.

The Barre Granite Association employed DuBois & King, Engineers and Planners, of Randolph, Vermont, to perform the engineering services required for the project. Preliminary work performed by DuBois & King included plant inventory of equipment and processes, water-use reduction studies, and pilot plant design.

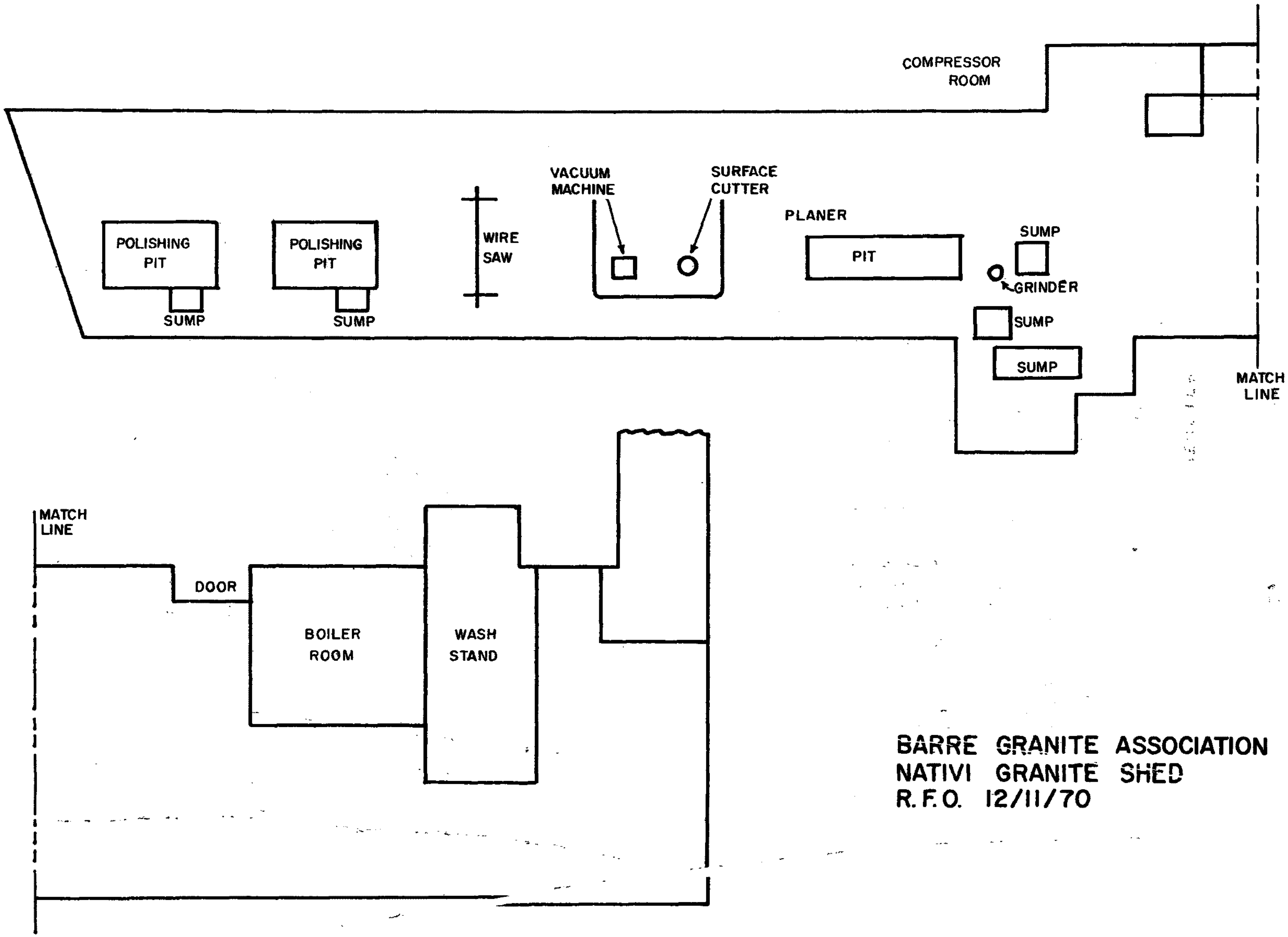
The civil engineering department of the University of Vermont performed waste characterization studies, solid-liquid separation studies, and supernatant and sludge analyses. Byproduct uses for sludge were also explored to the extent possible with available time and resources.

Plant Equipment and Process Inventory

The Nativi plant originally selected for the project site contained one single-strand wire saw, two polishing machines, one planer, several stations for hand and pneumatic chisel work, and a wash stand.

Since the hand and chisel work does not involve a liquid discharge, this section of the plant is not detailed in the plant layout pictured in Figure I. Since a custom sandblasting company occupied part of the same building, Nativi subcontracted the sandblasting work; and since this does not involve a liquid discharge, it also is omitted from the figure. Both of these processes, however, are major dust producers and have long been considered a major reason for the high incidence of silicosis. Each granite plant is now required by the Department of Health to maintain an extensive and efficient dust collection system.

The Granite Industries of Vermont plant, acquired by Nativi and operated in conjunction with the parent company, contained four polishing machines with larger beds than those of the Nativi plant, a single-strand wire saw and a seven-strand saw. A site was available for an additional multiple-strand wire saw, but it was not being used at the time. (Figure II).



BARRE GRANITE ASSOCIATION
NATIVI GRANITE SHED
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Fig. 1

The multiple-strand saw is needed to saw large blocks of granite into several slabs of the desired widths. These slabs are further sawed by the single-strand saws into blanks slightly larger than the desired final size of the headstone. (Although some granite is used in construction of both buildings and road curbings, about 99% of the industry is involved in the manufacture of granite monumental headstones). The abrasive material used is generally 90-mesh carborundum, with added stone dust to stabilize the wire. Extensive recirculation is practiced to obtain maximum use of the abrasive, and only enough fresh water is added to maintain the desired consistency of the liquid mixture. At the conclusion of the sawing operation the stone is washed off, and only at this time is a relatively large volume of polluted water discharged.

The seven-strand wire saw operation is generally similar to operation of single-strand saw, with the additional requirements of the added strands of wire. Since the several slabs can be washed at one time, washing the cut stone is a somewhat more efficient process.

The several polishing machines are similar in operation, in that all use a slowly rotating steel disk which may be moved over the surface of the carefully positioned stone. The process varies with the type of abrasive used. Several steps may be performed by the same machine using different abrasives, or the stone may be moved to another machine for each additional process.

After next sawing to an approximate size, the surface of the stone is smoothed and evened using an abrasive material, generally 130-mesh carborundum. Recirculation of the abrasive slurry is practiced to obtain maximum reuse of the abrasive material. The stone surface may be used as it comes from this process, or it may be further processed by polishing or steeling. The steeling process uses small steel balls as the abrasive agent, and produces a whitish surface which may be desirable for contrast purposes. Since the abraded stone dust, if brought into contact with the steeled surface, would make it darker, no recirculation is practiced in this process and the volume of waste discharge is somewhat greater than from other similar processes. However, steeling is performed on surfaces already ground smooth, and does not require a long grinding process. Since the steel balls can be washed clean and reused after completion of the grinding process, only a slight additional amount of waste discharge is involved.

Finish polishing is performed using tin oxide abrasive. For all except the final polishing and buffing, the liquid is recirculated to obtain reuse of the polishing agent. Polishing darkens the surface and imparts additional contrast to the finished stone. Use of rouge as a polishing agent has been largely discontinued.

The processing step using the greatest amount of water and having the greatest volume of liquid waste discharge is a process known as "planing". This is essentially a grinding process using a rather wide

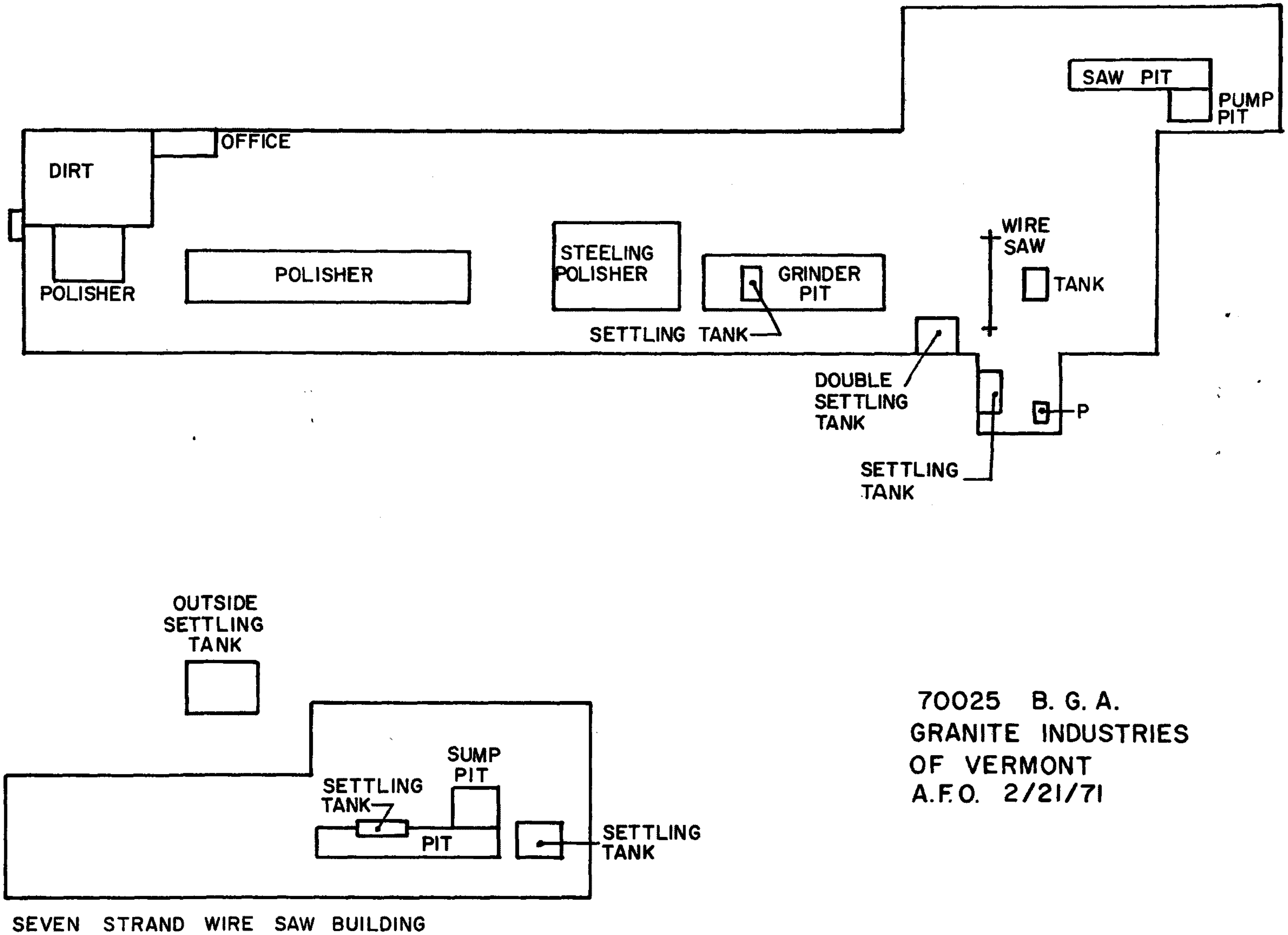

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Fig. 2

tungsten carbide grinding wheel. The wheel is mounted on a track which allows it to be moved forward and backward, or the track may be modified to grind a curved surface on the stone. To cool the surface of the stone and the grinding wheel, and to prevent discharge of fine dust particles to the air, a large stream of water is directed upon the stone surface. Because the water is not recirculated, a large volume of waste discharge containing the fine stone particles is produced by the planer. This material is so fine that planer waste does not settle readily and produces most of the residual turbidity after primary settling of the total waste stream.

The one other wet processing step is final cleanup. By the time it reaches this final step the stone has received several washings, and the small amount of residue is a result of the chisel or sandblasting operations used in "decoration" (lettering or other carving). Some stains, however, may be present as a result of contact with rusty metal. These stains may be removed by treatment with dilute hydrochloric acid, which is then discharged with the waste stream. If a sandblasting step has been performed, some of the rubber masking material may remain on the stone. This is removed by the use of organic solvents such as benzene, toluene or ligroin, which may also be added to the waste stream.

A final washdown completes the cleaning operation. Most of the plants, including Nativi, use a small high-pressure stream of water for final cleaning, so that the volume of waste is not large. The presence of hydrochloric acid, organic solvents and occasional small amounts of detergents, however, introduces a new form of chemical pollution.

Although not directly involved in the granite processing, several other sources of liquid discharges were discovered. Since a great deal of liquid, both water and waste, is circulated within a granite processing plant, several pumps to circulate the liquid material are required. To maintain the prime of these pumps for immediate use, a stream of fresh water is circulated through them when not otherwise in use. To operate air-powered equipment in the plant, compressors requiring large volumes of cooling water are used. This is generally discharged with the waste stream, although not polluted except with a small amount of residual heat. Practices differ at the various plants, some of which may separate certain discharges and combine others, while some combine all in one discharge stream. At the Nativi plant the compressor cooling water and the wash-stand discharge are separated from the remaining waste stream and not discharged to the waste lagoon. All other waste streams including the excess pump priming water are discharged to the waste settling lagoon outside the plant.

SECTION V

WATER USE OPTIMIZATION AND CONSERVATION STUDIES

Since no estimates or measurements were available with respect to water use by each type of equipment, the first plant modification for the research project involved the installation of water meters on each of the water lines supplying individual pieces of equipment. The meters were read daily from January through June 1971 and average water use calculated. These results may be found in the appendix Tables I - X. Attempts were also made to calculate an average rate of discharge per unit of stone processed but results varied so widely that no meaningful results could be obtained. Wire Saw (Tables No. IV and V) readings taken over a six month period at the wire saw at the Nativi plant averaged about one gallon per minute discharge while operating. Similar readings over a two month period at the single strand wire saw at the Granite Industries of Vermont (G.I.V.) plant gave about the same results. Since considerable recirculation is practiced in this operation and since the practice of allowing hoses to run unchecked during the sawing operation had been discontinued at these plants there was little opportunity for major reduction in water use in this operation. Some operators are experimenting with various methods of abrasive concentration such as cyclone separation but the amount of water to be saved appears to be negligible.

An attempt was made to evaluate water use by the seven strand wire saw. However, time of operation was so variable that no meaningful averages could be calculated. A measurement of discharge rate while the machine was operating gave a value of six gallons per minute, a figure in reasonable agreement with the figures obtained for the single strand saws. (Table X).

<u>Polishers</u> - Water use for these machines varied markedly with the operation being performed. (Tables VI, VII, VIII and IX) For the operations where considerable recirculation was practiced the average discharge in all cases was a fraction of a gallon per minute. Thus surface grinding, polishing and buffing vary from 0.1 to 0.3 gallons per minute average discharge. Steeling on the other hand, where no recirculation is practiced, averages a little over one gallon per minute discharge. Again, because of the recirculation presently practiced, little reduction in water use can be expected.

<u>Planer</u> - Water use for the planer which was expected to be high averaged about eight gallons per minute. Since the water use seemed to be excessive for the results sought, it appeared possible to materially reduce water use in this instance. Microscopic examination of fine material obtained from the planer waste indicated no evidence of heat deformation, an indication that the amount of water needed for cooling

might be reduced. However, it was necessary to maintain a sufficient water volume to trap the fine particles produced in the grinding operation. Since this appeared to be at least partly a problem of the shape and character of the water flow, it was decided to use fog nozzles in an attempt to reduce the overall water use and at the same time, maintain a large volume of wet space. Fog nozzles were secured and tried, but failed to provide sufficient protection against dust particles and were discontinued. Nozzles to produce a fan spray were then installed and two nozzles adjusted to provide a fan for each side to cover the grinding wheel. Initially, these nozzles worked satisfactorily and reduced water use by more than fifty percent. However. as the wheels wore down and decreased in diameter, the fan spray which had originally just covered the width of the wheel now extended well beyond the edge and a great deal of the water was wasted. This reduced the efficiency to such an extent that more water was required. Partial compensation was effected by adjusting the nozzle so that one edge of each fan was parallel to the edge of the grinding wheel, thereby reducing loss as the wheel decreased in diameter. It was, however, necessary to supply additional water through a central nozzle as the wheel neared its minimum diameter. Evaluation of the data contained in Table II indicates that average water use was reduced from eight gallons per day to about four gallons per day at the end of the period. Instantaneous use rates, however, were reduced from an original rate of greater than 20 gallons per minute to a rate of about five gallons per minute, a savings of 75% of the water used.

Other Water Uses - Because of the location and construction of the final wash stand at the Nativi plant, no samples could be collected and tested so no water use data were collected. At this plant the wash stand waste is discharged to a small dry well away from the stream and is not connected to the total waste discharge. Although the total volume is small, the nature of the waste might be a significant contribution to the waste stream at certain plants.

Table I shows the amount of water used for compressor cooling at the Nativi plant. Although an average rate of six gallons per minute is indicated, the water is not polluted and will not require treatment unless mixed with the polluted waste discharge. At the Nativi plant the compressor cooling water is discharged to an area away from the stream and separate from the polluted waste discharge, but in many plants this discharge constitutes a major portion of the total waste stream. Separation and reuse of this water is possible since the temperature increase is very small.

Table III gives the water used by the pump designated as the planer sump pump. This is the water necessary to maintain the prime on the pump used to pump the planer waste discharge from the collection sump to the waste treatment lagoon. In normal operation the water is turned on at the beginning of the work day and allowed to run full force while the planer is being operated. Since this water passes through the pump and mixes with the polluted waste discharge, it is somewhat polluted and needs to be discharged to the treatment facility. However, once the pump is full and in operation only a small stream or no water at all may be needed to maintain the pump prime and much of the water presently discharged could be saved. As can be seen from Table III, average daily use varied from a rate of four gallons per minute to a peak rate of seventeen gallons per minute. Although part of this variation is a result of variation in daily operation, some of the lower rates resulted from efforts by employees to reduce the water use. It is felt that significant water savings can be made in this area by careful adjustment of water usage to maintain only the stream necessary to maintain a prime on the pump.

SECTION VI

WASTE CHARACTERIZATION STUDIES

This laboratory work was performed at the University of Vermont in Burlington under the direction of Dr. Arthur Condren. A qualified chemistry technician was employed to perform the chemistry tests and other sections of the Civil Engineering Department cooperated in making the special measurements required.

Research investigation began during December, 1970, after needed equipment had been purchased. Initial studies were qualitative and semi-quantitative so that the researchers could obtain a more firm grasp of the wastewater to be dealt with. Grab samples were obtained on various occasions and the following average values were obtained.

Table A

	Wire Saw	Polisher	Planer
Total Solids mg/l	64,796.0	718.0	2,455.0
Suspended Solids mg/l	63,421.0	648.0	2,308.0
pH	7.6	6.2	8.2

Settling studies were performed on the wire saw samples and typical data are presented below for a sample containing 69,050 mg/l suspended solids. The supernatant, after 24 hours of settling, still had a suspended solids concentration of 10,644 mg/l. This supernatant also had a turbidity of 30,000 mg/l (SiO_2).

Table B

Time (Min.)	Interface Height (Ml)
0	1000
5	840
15	680
15	520
20	360
25	230
30	190
35	158
40	142
60	129
120	118
180	115

A mass balance of the solids showed that the sludge fraction was 51.8 percent solids, 48.2 percent water.

Composite sampling was conducted on February 3, 5, and 8, 1971 and the analytical results are presented below:

Table C

Wire Saw	Susp. Solids (mg/l)	pH	Alkalinity	Turbidity
2/3/71	20,832	8.7	55	8,400
2/5/71	45,235	9.5	83	33,000
2/8/71	39,717	9.6	65	26,000
Polisher				
2/3/71	5,173	8.2	61	12,000
2/5/71	12,179	8.5	62	96,000
2/8/71	4,194	8.1	58	40,000
Planer				
2/3/71	3,882	8.9	118	2,200
2/5/71	10,329	7.9	75	2,900
2/8/71	2,120	7.6	70	540

Settling curves for the polisher and planer wastewater samples were conducted and representative data are presented below (Studies performed in Imhoff Cones):

Table D

	Solids Interface(ml)	
Time (Min.)	Polisher	Planer
1	0.3	0.65
2	1.0	1.30
3	1.8	2.00
4	2.4	2.50
5	3.1	2.90
10	7.5	4.30
15	33.0	5.30
20	33.0	6.00
25	27.0	6.50
30	24.0	6.80
35	23.0	7.00
60	22.0	8.00
120	21.0	8.90

The turbidity remaining in the supernatant fraction after 24 hours of settling was, on the average, still in excess of 20,000 mg/l for the polisher wastewater and 1,000 mg/l for the planer wastewater.

The flow data in gallons per day for these days was as follows:

Table E

	2/3/71	2/5/71	2/8/71
Wire Saw	696	554	688
Polisher	---	---	---
Planer	4039	3351	1346

The meter for the polisher had not been installed; however, an approximate volume for this process was 600 gallons per day.

Based on the averages for flow and suspended solids, the wire saw generated 186 lb. of solids per day; for the polisher 36 lb. per day; and the planer 156 lb. per day. Data on areas of granite processed on these days was available and the average waste generation for each process was as follows:

Table F

Wire Saw - 3.8 lb. ss/sq.ft. of granite sawed

Polisher - 0.3 lb. ss/sq.ft. of granite polished

Planer - 5.8 lb. ss/sq.ft. of granite planed.

It is interesting to note that in spite of the relatively low concentration of solids in the waste discharge from the planer, the total amount of solids produced per day is very close to that produced by the wire saw, while the solids produced per unit of processed stone exceeds that of the wire saw.

Grain size analysis of the suspended material in the granite wastewater gave the following average results:

Table G

Particle Size (mm)	% Finer (By Weight)
0.0300	90
.0230	80
.0175	76
.0135	60
.0100	50
.0178	40
.0056	30
.0038	20
.0023	10
.0016	5

Specific gravity of the suspended material gave the following average results:

Table H

1.	Air dried sample	G_s - 2.82
2.	Oven dried sample	G_s - 2.88
3.	"Natural" sample	G_s - 2.75

An Atterberg limit test indicated that the suspended solids were non-plastic in nature. The fact that the waste solids exhibit no plasticity and the use of a dispensing agent for grain size analysis indicates that the particles have very low surface chemistry activity.

Additional analyses of specific waste streams may be found in the Appendix under Table XI. Because of the wide daily variations, the averages calculated for each machine have little significance in most cases. Two items, however, are worthy of note. Nearly all pH's are well on the alkaline side, a significant factor in later studies of solids-liquid separation techniques. Average turbidity for the composite sample supernatant and for most of the other supernatants averaged over 100 units. Since the Vermont Water Resources Board has established a limit of 100 turbidity units for any waste discharged to the waters of the State, this indicated that simple settling would not provide adequate treatment.

Solids-Liquid Separation

As noted above previous work by the Vermont Department of Water Resources had indicated that chemical flocculating agents could be used to improve solids-liquid separation in granite wastes, but that the different characteristics of waste from the various plants required an individual evaluation and a different treatment process for each waste.

Preliminary work at the University of Vermont indicated that this condition did not exist for plant waste which had been treated by primary settling. All solid-liquid separation tests, therefore, were performed on the supernatant from samples which had already been treated by a simple settling process.

Primary tests were made using the common waste treatment chemicals, lime, alum, and ferric chloride. These all worked satisfactorily and in each case a final turbidity of less than 10 units could be obtained. Test results are given in the Appendix, Table XII. As noted in Table XII, ferric chloride gave the best results at the lowest concentration and was selected as the chemical to be used in the pilot plant operation. In view of the excellent results obtained with the few chemicals tested, no further examinations were performed using the more expensive polyelectrolytes.

SECTION VII

PILOT PLANT DESIGN AND OPERATION

As a result of the laboratory tests performed at the University of Vermont , chemical treatment of the settling lagoon effluent was adopted as a design concept. However, during the earlier plant evaluation studies, a different concept involving industry-wide group treatment was considered. It appeared possible at one time to reduce water use to about 25% of the present usage. This would involve a total waste discharge in the City of Barre of about 250,000 gallons per day. It was estimated that a discharge of this size could be accepted at the municipal treatment plant, which was in the process of being enlarged and upgraded to secondary treatment. Each plant would then pretreat its waste by primary settling for 24 hours and discharge the partially clarified supernatant to the municipal wastewater treatment plant for final treatment. When it became apparent that not more than 50% of the water use could be eliminated, this concept was abandoned.

To some extent the emphasis of the research project had been changed after the project was initiated. One of the major problems to be studied was handling and treatment of the waste sludge. The adoption by the Vermont Water Resources Board in May, 1971, of new and more restrictive water quality regulations which provided that no waste effluent with a turbidity in excess of 100 units could be discharged to the waters of the state, required that additional emphasis be placed on improving effluent quality. To a certain extent this resulted in some de-emphasis of the sludge studies.

Since the design concept adopted for pilot plant testing required additional treatment at the local plant, a design was developed for a locally fabricated treatment plant to treat a flow of five gallons per minute of settled supernatant from the Nativi settling lagoon. Initially, the plan was to use commercial pilot plant equipment of the proper type, but inquiry indicated that no commercial equipment was available at the time required. The following design criteria were therefore developed for a locally fabricated treatment facility, including auxiliary equipment:

Pump: (Used to pump lagoon effluent to pilot plant) Denver SRL 1½ x 1¼" @ 1,100 RPM

Pipe: Plastic 1" PCV - 100 P.S.I.

Chemical Feed Pumps as follows:

Ferric Chloride - B.I.F. Model 1210 solution feed, from 55 gal. drum storage tank. $FeCl_3$ solution approximately 3.55% (39% stock solution diluted with ten parts water).

Lime - B.I.F. Model 1203 slurry feed, from 55 gal. drum storage tank. Lime slurry to contain 1% CaO.

Rapid Mix Tank - 20 gal. drum. Detention time four minutes.

Lightning Mixer - ½ to 3/4 h.p. @ 1,800 R.P.M.

Flocculation Tank - 55 gal. drum. Detention time eleven minutes.

Fractional H.P. Mixer geared to 10 R.P.M. with paddle area of 240 sq. ft. per day.

Sludge Return - gravity flow to plant sump through plastic pipe. From sump to lagoon by centrifugal pump used to pump plant waste stream.

Large Sedimentation Tank - Capacity 770 gallons; detention time 2½ hours, surface area 9.6 sq. ft., surface overflow rate 750 gallons per sq. ft. per day.

Above detention times, overflow rates, etc., are based on a standard flow rate of 5 gallons per minute. The plant is pictured under Fig. III.

This pilot plant was erected adjacent to the Nativi plant on the same side of the building as the settling lagoon. To protect the installation from vandalism and to protect neighborhood children from the hazards of an "attractive nuisance", the plant was completely enclosed in a roofless plywood structure with entrance from inside the granite plant only. Additional protection was afforded by using a wooden ladder for access to the upper part of the installation and locking it inside the plant at night. Construction of the pilot plant took place during July, 1971, and testing began on August 3, 1971.

Influent for the pilot plant was obtained by pumping from the effluent end of the Nativi settling lagoon. As noted above, settling removes about 95-98% of the total weight of solids. However, the influent stream to the pilot plant had a turbidity in excess of 1,000 units. Under the regulations adopted by the State of Vermont, Water Resources Board, this turbidity must be reduced to 100 units or less before discharge to a stream.

Operational data for the pilot plant are contained in Tables XIII - XXXIII in the appendix. Ferric chloride and lime were the only chemicals used, since laboratory testing had established ferric chloride as the most efficient coagulant. The data indicated that a concentration of about 25 mg/1 was necessary to maintain optimum treatment. The data also indicates that ferric chloride alone will give equally good treatment, undoubtedly because the normally high pH of the waste stream maintains adequate alkalinity. However, the data

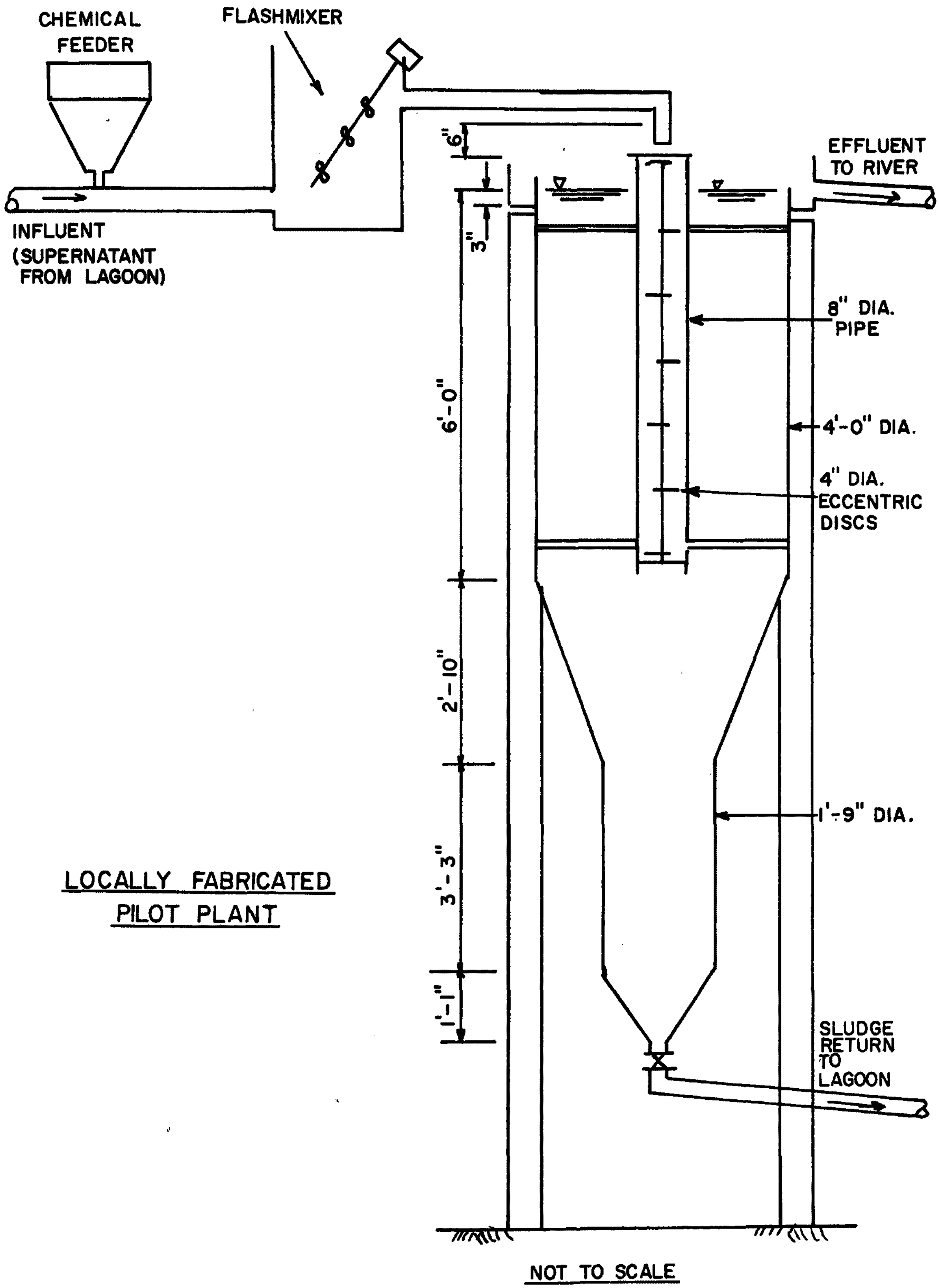

CHEMICAL FEEDER
FLASHMIXER
INFLUENT (SUPERNATANT FROM LAGOON)
EFFLUENT TO RIVER
6"
3"
6'-0"
2'-10"
3'-3"
1'-1"
8" DIA. PIPE
4'-0" DIA.
4" DIA. ECCENTRIC DISCS
1'-9" DIA.
SLUDGE RETURN TO LAGOON
LOCALLY FABRICATED PILOT PLANT
NOT TO SCALE

Fig. 3

from Table XX indicates that lime alone in moderate quantities will not give adequate treatment under the operating conditions existing in the pilot plant process.

As indicated in the data contained in Table XIII - XXXIII, a turbidity of approximately 10 units could be obtained under normal operating conditions. This is considerably better than required by the water quality regulations. However, it allows a comfortable safety margin should a temporary malfunction occur and it also presented the possibility of water reuse, a possibility which warranted further investigation.

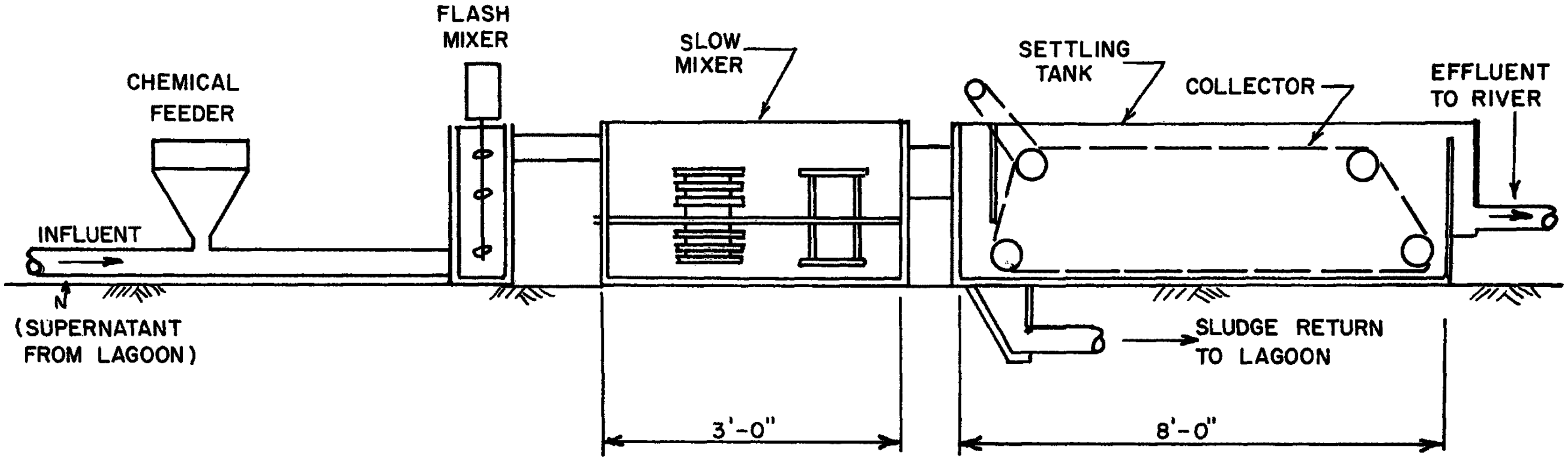
Link-Belt Pilot Plant (Figure IV)

Although an inquiry directed to several equipment companies had indicated that no commercial equipment would be available during the desired period, we were informed in late June, 1971, that a pilot plant would be available from the Link Belt Company. Because of previous unsatisfactory results with commercial equipment, it was decided to rent this pilot plant for the minimum period to insure that commercial equipment would operate satisfactorily with the proposed treatment process. The pilot plant equipment arrived in Barre in July and was installed inside the Nativi plant near the location of the locally fabricated plant. Normal capacity of this plant was 1.5 gallons per minute with auxiliary equipment designed to give normal detention times. Data for this equipment is given in Tables XXXIV-XXXIX in the Appendix. This equipment was operated from July 30, 1971 to August 11, 1971 with no major problems developing, and then returned. The data indicated that a concentration of approximately 20 mg/1 ferric chloride were required for optimum clarification--a figure close to the 25 mg/1 required by the larger pilot plant.

Prototype Pilot Plant

The excellent results obtained from the pilot plant operation indicated as noted above, that an effluent of sufficient purity could be obtained to permit reuse of the water in the processing operations. Most of the granite plants purchase city water for plant processing use, and an extensive program of water reuse in the granite industry would greatly reduce demands upon the city municipal water system, demands which the city had found difficult to meet in recent years and which had required expensive modifications of the water supply system. It was therefore decided that a locally designed and fabricated prototype plant would be constructed with adequate capacity to treat the entire waste discharge from the Nativi & Sons, Inc. plant. Since an inside pump of adequate capacity was available at the Nativi plant, the installation of a minimum amount of pumping equipment would permit full scale testing of reuse of treated wastewater. The larger plant would

Fig. 4



NOT TO SCALE

LINK - BELT PILOT PLANT

also permit a test of settling tubes and an estimate of the ultimate capacity of the treatment plant equipment.

Specifications for the prototype plant were as follows:

Design flow - 23 gallons per minute

Rapid Mix Tank - 6 cu. ft. capacity, detention time - 2 minutes

Flocculation Tank - 46 cu. ft. capacity, detention time - 15 minutes

Clarifier - 280 cu. ft. capacity

Surface area - 55 sq. ft.

Surface overflow rate - 600 gallons per day per sq. ft.

Detention time - 2 hours

As actually constructed, the flocculation tanks were considerably undersized and provided a detention time of only five minutes at the design flow of 23 GPM. At the water temperature prevailing during the winter, this does not provide adequate floc formation. Since cold weather was approaching, the equipment was fabricated and installed in a small enclosed addition to the Nativi plant to allow cold weather operation without freeze-up. This plant is illustrated in Figures V-VII. It was fabricated locally from plates of sheet steel and was erected by local labor. Operational data are contained in Tables XL - XLV.

Operation of this treatment plant indicated that the granite processing plant could operate satisfactorily on treated wastewater effluent. However, since the acid ferric chloride solution tended to progressively lower the pH with each cycle of reuse, it was necessary to increase the lime dosage somewhat and to use lime continuously, in contrast to the pilot plant experience with a once through waste treatment. The colder temperature of the influent waste during the winter reduced the flocculation rate sufficiently to require about a 100% increase in ferric chloride dosage.

Although the plant was designed to operate at a rate of approximately 10,000 gallons per day, it was found possible to operate at nearly double that rate without seriously affecting the treatment. At that rate, however, the flocculation tanks were barely adequate and it is suggested that size of the flocculation tanks be increased to insure proper floc formation at the maximum operating rate. Use of tube settlers proved to have little observable effect on a settling tank of this size, possibly because of the reduction of tank area and volume at the edges of the tube banks. Since few of the plants have

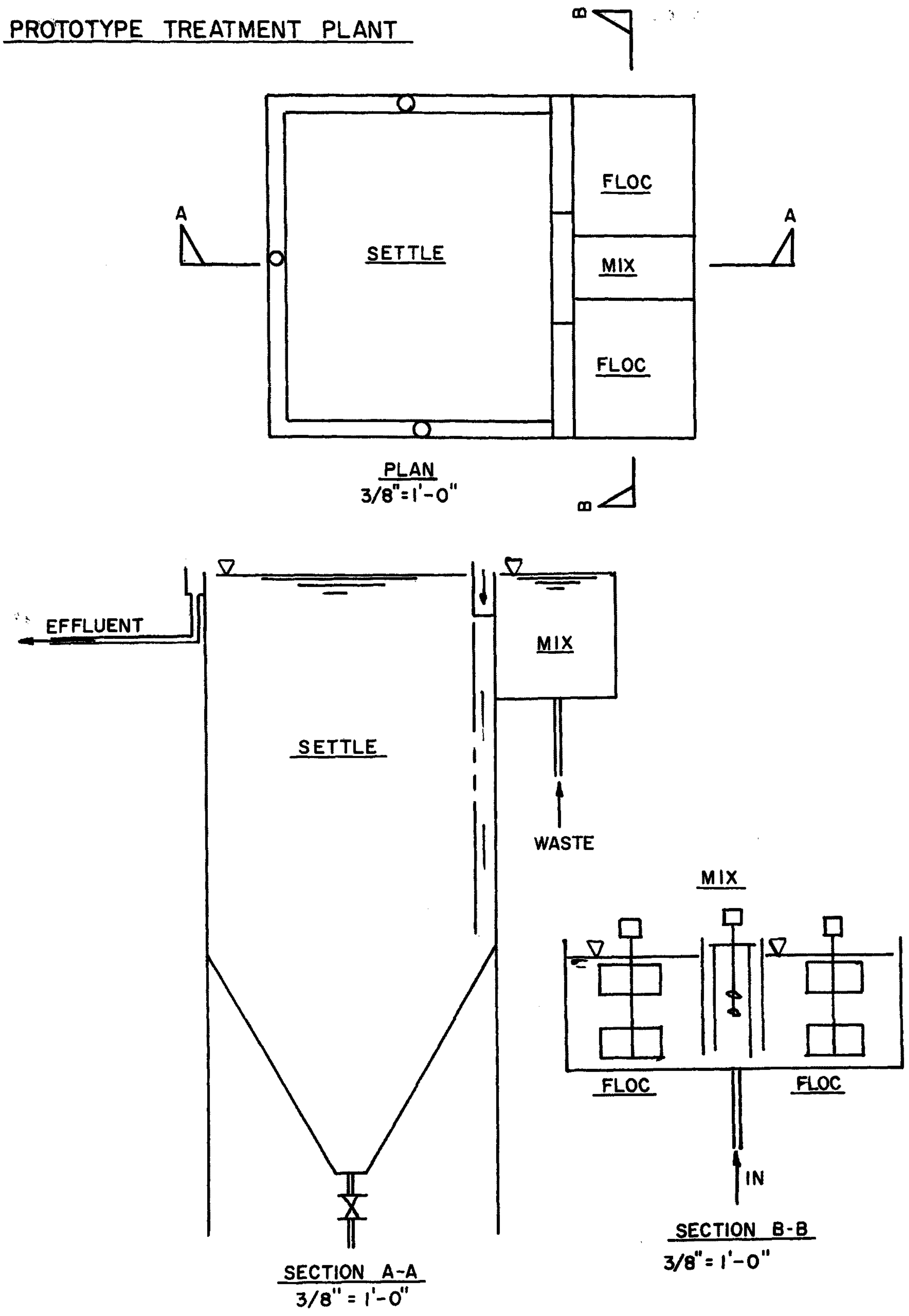

PROTOTYPE TREATMENT PLANT
B
A
SETTLE
FLOC
MIX
FLOC
A
PLAN
3/8"=1'-0"
B
EFFLUENT
MIX
SETTLE
WASTE
MIX
FLOC
FLOC
IN
SECTION B-B
3/8"=1'-0"
SECTION A-A
3/8" = 1'-0"

Fig. 5

a discharge rate in excess of 20,000 gallons per day, not more than one or two plants will require a larger capacity treatment facility.

In order to insure uninterrupted plant operation, certain refinements were added to the recirculation system by Nativi & Sons, Inc. These included a variable pressure reducer to regulate water pressure in the plant, a low water float actuated valve to add city water to the clear well when needed, a high water shut-off to suspend operation of the treatment facility if the clear well is full and a low pressure alarm in the water line to detect malfunction of the recirculating pump. These added controls provided almost completely automatic operation of the waste treatment and water reuse system and reduced supervisory time to a minimum. Operation of the recirculation pump at a constant 175 pound pressure and use of the pressure reduction valve provided more efficient water use than use of city water at an average pressure of 115 pounds.

Costs of Operation

An added benefit from construction and operation of the prototype treatment facility was the opportunity to obtain relatively firm cost figures for construction and operation of this type of waste treatment facility. Capital costs for this facility were as follows:

Fabrication of Settling Tanks	$1,600.00
Chemical Feed Pumps	588.00
Chemical Mix Stirrers (Motor and Stirrer)	165.00
Chemical Holding Tanks	12.00
Waste Pump (Treatment Facility Influent Pump)	300.00
Tube Settlers	500.00
Electrical Wiring	250.00
Total Cost	$3,415.00

The use of tube settlers is optional and, as noted above, does not appear to increase settling capacity appreciably. Elimination of the tube settlers will reduce the above costs to less than $3,000.00. However, some construction may be required to house the facility for winter operation. For use as a complete recirculation system, a clear well may have to be constructed and additional controls may be desirable to insure uninterrupted operation without the necessity of close supervision. These additions will increase capital costs, but they should not exceed $5,000.00 for a facility of this size.

Estimated operating costs for this facility when processing approximately 10,000 gallons per day of waste effluent were calculated to be as follows:

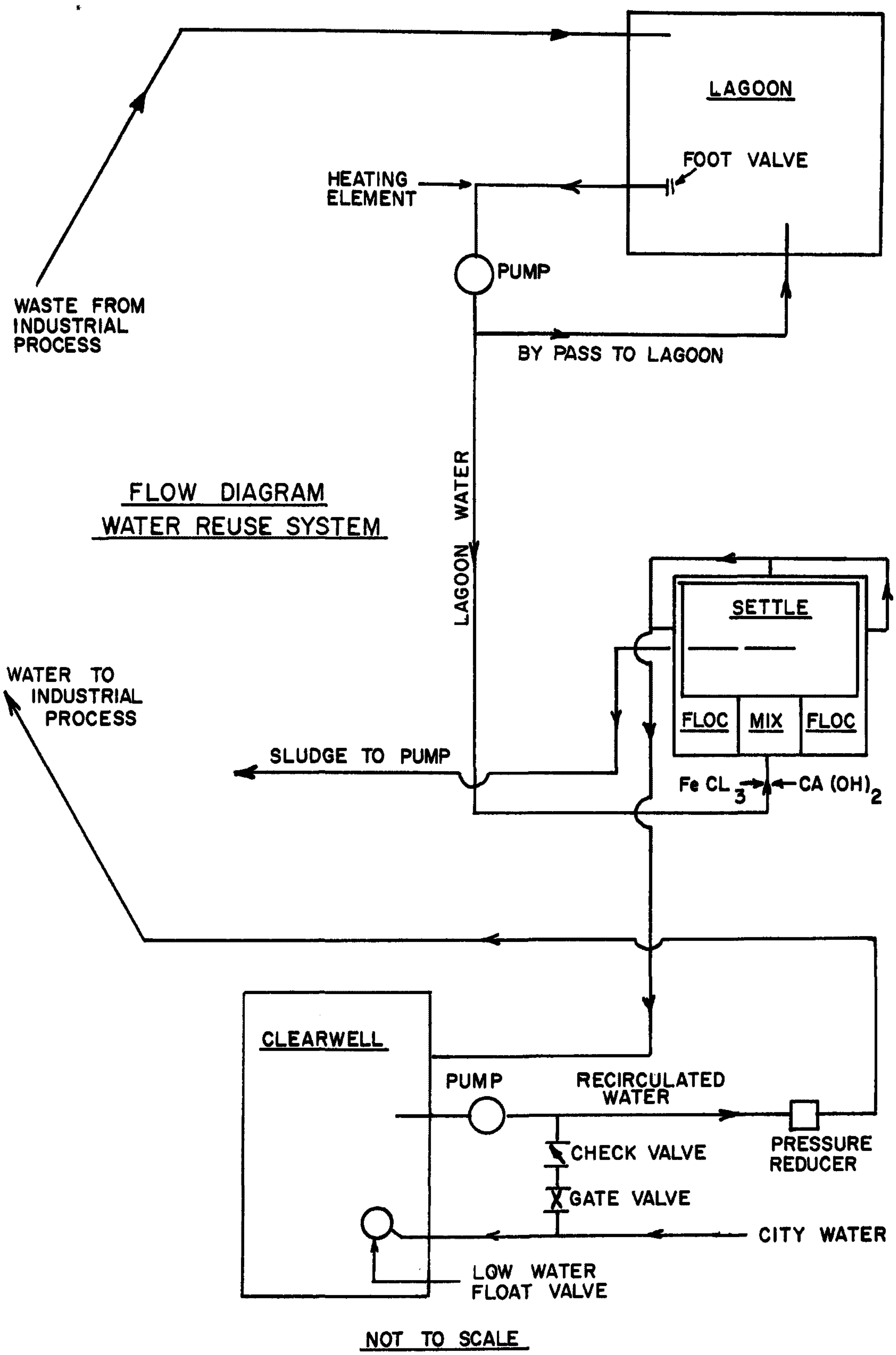

LAGOON
FOOT VALVE
HEATING ELEMENT
PUMP
WASTE FROM INDUSTRIAL PROCESS
BY PASS TO LAGOON
FLOW DIAGRAM
WATER REUSE SYSTEM
LAGOON WATER
SETTLE
FLOC
MIX
FLOC
WATER TO INDUSTRIAL PROCESS
SLUDGE TO PUMP
Fe CL 3
CA (OH) 2
CLEARWELL
PUMP
RECIRCULATED WATER
CHECK VALVE
PRESSURE REDUCER
GATE VALVE
CITY WATER
LOW WATER FLOAT VALVE
NOT TO SCALE

Fig. 6

Ferric Chloride	$2.00 per day
Lime	.03 per day
Electricity	.75 per day
Total Operating Cost	$2.78 per day

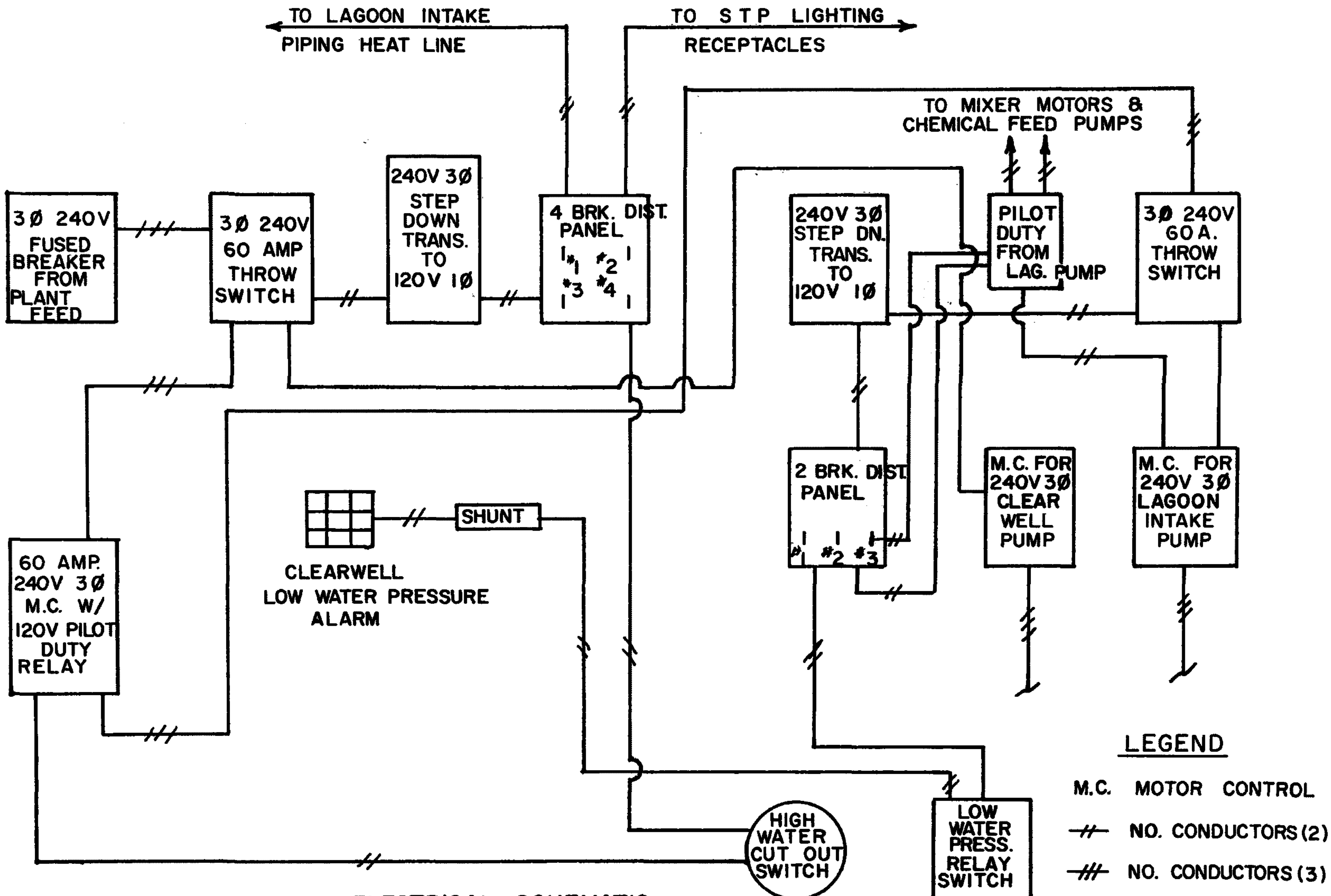
The operating cost figures were determined for the facility during winter operation and during the complete recirculation trial when ferric chloride addition was at the maximum and when continuous addition of lime was required. Summer operation or operation of the facility without recirculation would reduce operating costs somewhat.

The reuse of treated wastewater in a granite plant is regarded with mixed feelings by many plant operators. In addition to the above mentioned benefits to the City of Barre through reduced demands upon the city water system, direct benefits to the operator include reduced water purchases, constant water quality, improved water pressure, and control of water pressure for more efficient use. Disadvantages from the manufacturer's point of view include increased cost for water treatment, extra space requirements for treatment facilities and for the clear well and associated equipment, and the capital expenditure required for the new equipment, repiping, rewiring, etc. Water use for Nativi averaged nearly 20,000 gallons per day prior to installation of the water reuse system. At the prevailing water rates for the City of Barre, annual cost for this volume of water is nearly $600.00. If we assume that a complete water reuse system would reduce water purchases by 90%, a net saving of about $550.00 per year at prevailing rates is realized.

At this saving, the capital cost of the Nativi system could be recovered in about six years. According to Vermont tax law, pollution control facilities are not assessed as capital improvement, thus the installation of this equipment should not increase the tax liability of the company.

Since the capital costs and water use will vary widely from company to company, the above figures are only an approximation of the savings that can be realized.

Fig. 7



ELECTRICAL SCHEMATIC

NOT TO SCALE

SECTION VIII

BY-PRODUCT USE STUDIES

Studies on the by-product use of waste granite sludge were performed at the University of Vermont, College of Engineering.

Following the waste characterization tests described above several types of by-product use were investigated. One successful use involved the addition of small amounts of waste solids to the glazing material for pottery. The granite solids imparted an attractive bluish-green color to the glazed pottery. Unfortunately total demand for this use would not be expected to exceed a few pounds a year.

A more desirable investigation from the point of view of large volume use involved the possibility of creating a ceramic material for use in tile and ceramic pipe. Initial studies which involved heating a mixture of granite solids and water indicated that a firing temperature in excess of 1900^{o} F was required to produce a suitable product. Under proper condition and using the proper mixture an attractive maroon red tile with a gray center could be produced which had satisfactory hardness. The addition of 2% bentonite to the mixture of granite dust and water produced a "mud" of the desired plasticity to allow proper moulding for the production of the desired forms.

Although a usable tile product could be produced certain problems developed during further investigation. The tile produced proved to be more porous than desired, absorbed liquid including oil readily and stained badly. Variations in batches of starting material resulted in wide variations in finished products, some of which were extremely brittle, while others deformed badly during firing. It appeared that it would be necessary to develop some form of cooperative pooling of waste sludge by the industry in order to produce a satisfactorily uniform product.

In order to determine the economic feasibility of attempting to develop a ceramic by-product industry, Professor W. E. Brownell of Alfred University, was employed to conduct the economic evaluation. Dr. Brownell estimated that a capital investment of $3,500,000 would be required to construct a plant using 250 tons per day of waste solids in order to compete with established tile producers. Since previous studies in the industry had indicated that only 10% of this amount of waste solids was available, it did not appear the further studies of tile manufacture were indicated. It therefore appeared that for the immediate future at least, the industry would be required to dispose of waste solids by the least objectionable method, probably as landfill material.

SECTION IX
SLUDGE DISPOSAL METHODS

A survey of the waste sludge disposal methods presently in use by the granite industry was conducted by DuBois & King for the Barre Granite Association. As noted before several problems had developed in the process of cleaning the existing waste lagoons. Attempts to resolve these problems by the individual manufacturers had resulted in several improvements in procedure although none of them was considered completely satisfactory. To avoid spillage of the liquid waste the contractors had used sealed dump trucks, tank trucks and self-propelled concrete mixers with some success. Each system increased the cost of sludge removal either because of increased time and personnel or the use of expensive equipment. The survey by DuBois & King attributed the sludge disposal problems to three main areas as follows:

1. Poor lagoon design. No apparent attempt had been made to design lagoons to facilitate sludge handling and removal.

2. Failure to maintain adequate cleaning schedules. Lack of cooperation and excess sludge deposits greatly increased the cost of lagoon cleaning.

3. Failure to dewater sludge before handling.

The survey indicated that the operators who had had the fewest problems and least expense had used a two lagoon system allowing the sludge to dewater thoroughly before hauling it away. This indicated that a properly designed double lagoon system with a realistic cleaning schedule would minimize the handling problems. A suggested design for such a lagoon system is included as Figure VIII. The Barre Granite Association is presently developing a cooperative program of lagoon cleaning and maintenance for the industry in Barre.

SECTION X

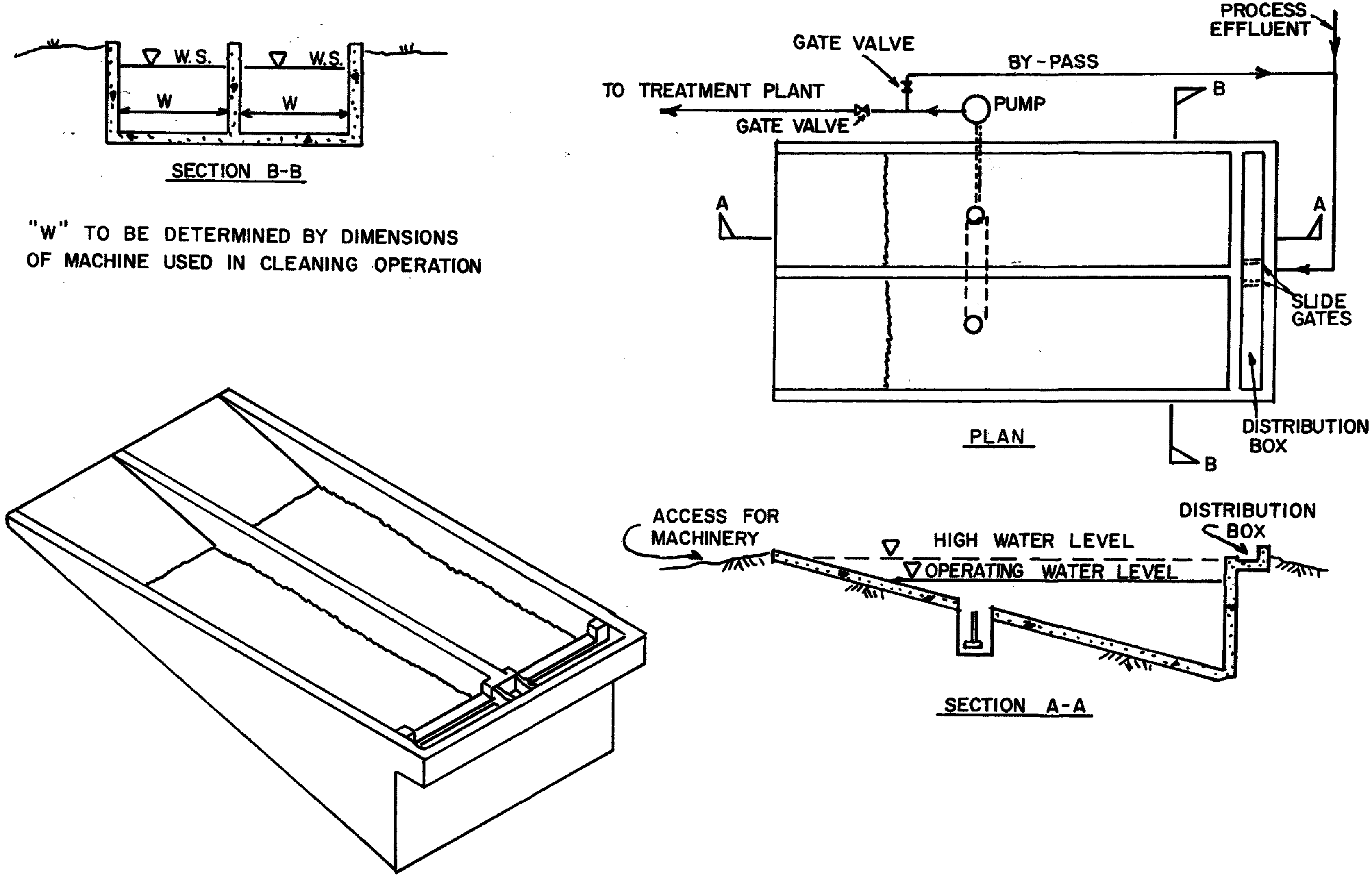
LEGAL CONSIDERATIONS

In April of 1970, the Vermont legislature passed a pollution control act that was widely hailed as the first pay-to-pollute legislation in the United States. Although the actual payment of pollution charges has been postponed and modified by successive legislatures the legal authority for assessing pollution charges still exists for polluters who do not maintain a satisfactory schedule of pollution abatement. The following calculation of the pollution charge is an estimate based on present law and regulations for an average discharge in the Barre area.

Average suspended solids (settling lagoon effluent) 400 mg/l
Average daily discharge (for calculation purposes) 10,000 G.P.D.
B.O.D. - pounds per day -0
Suspended solids - pounds per day - 33.3
Daily charge per pound of B.O.D. and suspended solids - .033
Daily charge - 1.10
Annual charge (250 days operation) - $275.00

The daily charge per pound is taken from a graph which proportions the charge rate to the average flow of the receiving stream. However, since nearly all plants in the Barre area discharge to the same stream, the Stevens Branch of the Winooski River, the daily rates would be identical and the total charge would be the ratio of their discharge to the 10,000 gallons per day used for calculation purposes. Plants discharging to the Jail Branch would pay a higher rate because of a lower dilution factor, while plants discharging to the Winooski River would have a lower rate. Maximum and minimum rates were established by the 1972 legislature and present charges are based on these rates.

However, attractive as these rates might appear to a firm faced with a major capital expenditure for pollution abatement equipment the law does not provide for the permanent or long term payment of pollution charges. The law specifically provides that a Temporary Pollution Permit shall be issued only for the minimum time necessary to provide adequate abatement facilities. Failure to maintain a reasonable schedule of construction could subject a firm to prosecution for violation of a permit. Penalty for permit violations or discharging without a permit is a not more than 6 months in prison or 25,000 for each day in violation. The present project has provided a method of treatment which will allow granite processing firms to comply with present water quality standards and also an opportunity to recover part of the expense by water reuse and the avoidance of pollution charges or fines for illegal discharges.



TYPICAL LAGOON

Fig. 8

SECTION XI

ACKNOWLEDGEMENTS

Major direction of the project in the Barre area was by officials of the Barre Granite Association, Mr. Milton Lyndes, Manager and Mr. Glenn Sulham, Manager of Member Services. Engineering services by the firm of DuBois & King, Engineers and Planners of Randolph were under the direction of Joseph S. King, Vice President with Mr. Robert R. Lamson as Project Engineer. Technicians assisting in the project included Richard Oberman, Richard Sawyer and Thomas Mancini.

The assistance of Mr. Silvio Nativi, President of Nativi & Sons, Inc., and Granite Industries of Vermont is gratefully acknowledged. In addition to on-the-spot assistance as manager of the participating companies he provided much needed support as president of the Barre Granite Association and member of the Association research committee. The following employees of Nativi & Sons provided much needed assistance in installing equipment and maintaining supervision during operational studies: Francis Grenier and Fritz Anderson. In addition the following firms in the area provided essential services such as plumbing, pipe fitting, transportation of equipment, construction, etc.: Rock of Ages Corp., Smith, Whitcomb & Cook, Dessureau Machines, Inc. and Roland Valliere, Contractor.

Dr. Arthur J. Condren was in charge of the project for the University of Vermont. Analytical measurements were made by Vivienne Bouchard. Mr. William C. Walker, a senior engineering student at the University of Vermont assisted in design and construction of the pilot plants and following graduation acted as operator in charge of pilot plant operation. He also conducted the survey of sludge disposal methods for DuBois & King.

Project Officer for the Environmental Protection Agency was Allyn Richardson of E.P.A.'s Region One Office. The assistance of Arthur H. Mallon, P.E. of E.P.A. headquarters is also acknowledged.

SECTION XII

REFERENCES

1. Unpublished Data - Vermont Water Resources Department

2. Nemerow, Theories and Practices of Industrial Waste Treatment, Chapter 9-1.

3. Manual of Water ASTM STP 442, Chapter IV and V.

4. Nemerow, Liquid Waste of Industry, Theories, Practices and Treatment, Chapter 6-4.

5. IBID, Chapter 11

SECTION XIII

GLOSSARY AND ABBREVIATIONS

B.O.D. - Biochemical Oxygen Demand

Carborundum - An extremely hard synthetic material made of silicon and carbon.

Classification - A legal process by which the State after a period of testing and study, assigns use designations to the different types of waters in the State.

Composite Sample - A laboratory sample which is secured by adding small increments to the sample container at equal intervals over a specified period of time.

Cyclone - A centrifugal type separator used to separate heavy carborundum from lighter stone dust in the waste stream.

Detention Time - The time necessary to completely fill a water treatment facility at the average flow rate or the time necessary to completely change the total amount of water in the facility.

Effluent - The final discharge waste stream after treatment.

Flocculant - A substance which by altering the electrical characteristics of a colloid allows the particles to collect together and precipitate.

Gang Saw - An older type of sawing equipment in which the sawing is done by strips of steel using a back and forth motion, also using an abrasive material such as sand or carborundum and water and granite dust as a lubricant.

Grab Samples - A laboratory sample which is secured by collecting all of the samples at one time.

Granite - An igneous, crystalline stone extensively used in the production of monumental headstones.

Imhoff Cones - Graduated cone-shaped glassware generally used for settleable solids determination.

Influent - The waste stream before treatment.

J.T.U. - Jackson Turbidity Units

mg/l - Milligrams per liter, a common unit of measurement for small amounts of material.

Optimization - Adjustment to provide the best results for the least expenditure.

Pilot Plant - A facility similar in design and equipment but generally smaller in size and capacity, in which a process may be tested under the same conditions which will exist in the full scale plant.

Planer - A granite processing machine which uses a grinding wheel to shape and smooth the surface of the stone.

Polyelectrolyte - A synthetic long chain polymer which, by virute of its unique electrical characteristics possesses the ability to flocculate collidal suspensions.

Quarry - A natural deposit of useful stone, used as a source of raw material, generally in the form of open pit mining.

Recirculation - Recycling or reuse of waste water formerly discharged to the stream. It involves discharging the treated waste water to a central storage tank and repumping into the plant water system.

Sand Blasting - A method of cutting letters or decorative designs in stone using a high velocity stream of sand particles as the cutting agent.

Settleable Solids - The volume of solid material that settles in a fixed period, generally one hour.

SECTION XIV

APPENDIX

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TABLES XIII - XXXIII	PILOT PLANT OPERATIONAL DATA
TABLES XXXIV - XXXIX	LINK BELT PILOT PLANT DATA
TABLES XL - XLV	PROTOTYPE PILOT PLANT DATA

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Table I. MACHINE: COMPRESSOR - METER #2

Nativi & Son, Inc.

Date	Gallons used	Average gpm*
1/13/71	4106.52	8.55
1/14/71	4061.64	8.46
1/15/71	3934.48	8.19
1/18/71	4114.00	8.57
1/19/71	3971.88	8.27
1/20/71	2852.20	8.02
1/21/71	3859.68	8.04
1/22/71	3769.92	7.85
1/25/71	3889.60	8.10
1/26/71	3859.68	8.04
1/27/71	4398.24	9.16
1/28/71	3590.40	7.48
1/29/71	3485.68	7.26
2/01/71	3575.44	7.44
2/02/71	3485.68	7.26
2/03/71	3216.40	6.70
2/04/71	3193.96	6.70
2/05/71	3231.36	6.73
2/08/71	3029.40	6.31
2/09/71	3223.88	6.71
2/10/71	3149.08	6.56
2/11/71	3104.20	6.46
2/12/71	2902.24	6.04
2/15/71	3006.96	6.26
2/16/71	2760.12	5.75
2/17/71	3036.88	6.32
2/18/71	3021.92	6.20
2/19/71	2999.48	6.24
2/22/71	3074.28	6.40
2/23/71	2917.20	6.07
2/24/71	2864.84	5.96
2/25/71	2977.04	6.20
2/26/71	2962.08	6.17
	Plant closed for two weeks	
3/19/71	3208.92	6.68
3/22/71	3074.28	6.40
3/23/71	3014.44	6.28
3/24/71	3208.92	6.68
3/25/71	3089.00	6.44
3/26/71	3074.00	6.42
3/29/71	2932.00	6.11
3/30/71	3052.00	6.36
3/31/71	3201.00	6.68

Table I (continued). MACHINE: COMPRESSOR - METER #2

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
4/01/71	2970.00	6.19
4/02/71	3007.00	6.27
4/05/71	2835.00	5.90
4/06/71	2985.00	6.20
4/07/71	2738.00	5.72
4/08/71	2842.00	5.92
4/09/71	2910.00	6.07
4/12/71	2648.00	5.53
4/13/71	2551.00	5.32
4/14/71	2603.00	5.44
4/15/71	2618.00	5.47
4/16/71	2573.00	5.37
4/19/71	3007.00	6.27
4/20/71	2753.00	5.75
4/21/71	2887.00	6.02
4/22/71	2895.00	5.91
4/23/71	2715.00	5.66
4/26/71	2745.00	5.73
4/27/71	2790.00	5.82
4/28/71	2925.00	6.10
4/29/71	2723.00	5.68
4/30/71	2857.00	5.95
5/02/71	2653.00	5.61
5/03/71	2685.00	5.60
5/04/71	2685.00	5.60
5/05/71	2708.00	5.65
5/06/71	2596.00	5.42
5/10/71	2566.00	5.35
5/11/71	2581.00	5.38
5/12/71	2558.00	5.34
5/13/71	2558.00	5.34
5/14/71	2607.00	5.43
5/17/71	2607.00	5.43
5/18/71	2655.00	5.53
5/19/71	2670.00	5.56
5/20/71	2670.00	5.56
5/21/71	2693.00	5.61
5/24/71	2528.00	5.27
5/25/71	2536.00	5.28
5/26/71	2607.00	5.43
5/27/71	2607.00	5.43
5/28/71	2573.00	5.36
6/01/71	2498.00	5.22
6/02/71	2566.00	5.35

Table I (continued). MACHINE: COMPRESSOR - METER #2

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
6/03/71	2558.00	5.34
6/04/71	2513.00	5.25
6/07/71	2468.00	5.15
6/08/71	2506.00	5.23
6/09/71	2431.00	5.07
6/10/71	2461.00	5.14
6/11/71	2506.00	5.23
6/14/71	2409.00	5.02
6/15/71	2356.00	4.91
6/16/71	2371.00	4.94
6/17/71	2446.00	5.10

* Assumed Average 480 min./day

Table II. MACHINE: PLANER - METER #3

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
1/13/71	4136.44	8.61
1/14/71	4682.48	9.75
1/15/71	3351.04	6.98
1/18/71	3089.24	6.43
1/19/71	4076.60	8.49
1/20/71	4465.56	9.30
1/21/71	3440.80	7.16
1/22/71	1353.88	2.82
1/25/71	2296.36	4.78
1/26/71	3867.16	8.05
1/27/71	3620.32	7.54
1/28/71	4001.80	8.33
2/03/71	4039.20	8.42
2/04/71	3403.40	7.09
2/05/71	3351.04	6.98
2/08/71	1346.40	2.80
2/09/71	3403.40	7.09
2/10/71	2992.00	6.23
2/11/71	3493.16	7.27
1/12/71	2124.32	4.42
2/15/71	3747.48	7.80
2/16/71	4488.00	9.35
2/17/71	4772.24	9.94
2/18/71	3530.56	7.35
2/19/71	3897.08	8.11
2/22/71	3478.20	7.24
2/23/71	4114.00	8.57
2/24/71	2971.88	8.27
2/25/71	4091.56	8.52
2/26/71	3680.16	7.66
	Plant closed for two weeks	
3/19/71	3156.56	6.57
4/22/71	3620.32	7.54
3/23/71	2872.32	5.98
3/24/71	2066.80	6.38
3/25/71	1690.00	3.52
3/26/71	2955.00	6.15
3/29/71	2483.00	5.19
3/30/71	3478.00	7.25
3/31/71	3366.00	7.02
4/01/71	3411.00	7.10

Table II (continued). MACHINE: PLANER - METER #3

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
4/02/71	1765.00	3.68
4/05/71	2895.00	6.03
4/06/71	3860.00	8.03
4/07/71	4189.00	8.72
4/08/71	4772.00	9.94
4/09/71	3411.00	7.10
4/12/71	3605.00	7.51
4/13/71	4249.00	8.85
4/13/71	2547.00	5.10
4/14/71	2547.00	5.10
4/15/71	4062.00	8.49
4/16/71	3164.00	5.60
4/19/71	1653.00	3.45
4/20/71	1451.00	3.03
4/21/71	1563.00	3.26
4/22/71	1227.00	2.56
4/23/71	935.00	1.95
4/26/71	2020.00	4.21
4/27/71	1608.00	3.35
4/28/71	1885.00	3.93
4/29/71	1616.00	3.37
4/20/71	1563.00	3.26
5/02/71	1728.00	3.60
5/03/71	1945.00	4.05
5/04/71	1892.00	3.95
5/05/71	1668.00	3.48
5/06/71	1661.00	3.47
5/10/71	1010.00	2.11
5/11/71	1571.00	3.28
5/12/71	1833.00	3.83
5/13/71	1922.00	4.01
5/14/71	3609.00	7.53
5/17/71	3609.00	7.53
5/18/71	4742.00	9.88
5/19/71	3329.00	6.94
5/20/71	2805.00	5.86
5/21/71	3067.00	6.36
5/24/71	1863.00	3.88
5/25/71	2229.00	4.65
5/26/71	2323.00	4.85
5/27/71	2322.00	4.85
5/28/71	1429.00	2.98
6/01/71	1990.00	4.15
6/02/71	1608.00	3.38

Table II (continued). MACHINE: PLANER - METER #3

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
6/03/71	1354.00	2.82
6/04/71	1735.00	3.62
6/07/71	1578.00	3.29
6/08/71	2977.00	6.20
6/09/71	1518.00	3.16
6/10/71	2132.00	4.44
6/11/71	1638.00	3.42
6/14/71	1945.00	4.05
6/15/71	2498.00	5.22
6/16/71	1915.00	3.99
6/17/71	1489.00	3.11
6/18/71	1489.00	3.11

* Assumed average 480 min./day

Table III. MACHINE: PLANER SUMP PUMP - METER #4

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
2/04/71	5041.52	9.33
2/05/71	4802.16	8.89
2/08/71	2805.00	5.19
2/09/71	2632.96	4.87
2/10/71	2565.64	4.75
2/11/71	2618.00	4.84
2/12/71	2468.40	4.57
2/15/71	2558.16	4.73
2/16/71	2333.76	4.32
2/17/71	2445.96	4.52
2/18/71	2468.40	4.57
2/19/71	2550.68	4.72
2/22/71	2573.12	4.76
2/23/71	2513.28	4.65
2/24/71	2543.20	4.70
2/25/71	2550.68	4.72
2/26/71	2505.80	4.64
	Plant closed for two weeks	
3/18/71	--	--
3/19/71	4742.32	8.78
3/22/71	4787.20	8.86
3/23/71	4675.00	8.65
3/24/71	4787.20	8.86
3/25/71	4593.00	8.50
3/26/71	4668.00	8.65
3/29/71	4166.00	7.72
3/30/71	4136.00	7.66
4/01/71	3964.00	7.35
4/02/71	4077.00	7.56
4/05/71	9328.00	17.30
4/06/71	6745.00	12.50
4/07/71	6515.00	12.08
4/08/71	6611.00	12.23
4/09/71	6777.00	12.51
4/12/71	6897.00	12.74
4/13/71	6597.00	12.21
4/14/71	6754.00	12.51
4/15/71	6665.00	12.35
4/16/71	6717.00	12.42
4/19/71	2251.00	4.17
4/20/71	6485.00	12.00
4/21/71	5326.00	9.88
4/22/71	1907.00	3.53

Table III (continued). MACHINE: PLANER - METER #4

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
4/23/71	2177.00	4.03
4/26/71	3381.00	6.26
4/27/71	3351.00	6.22
4/28/71	3493.00	6.47
4/29/71	3261.00	6.05
4/30/71	1922.00	3.56
5/02/71	2910.00	5.39
5/03/71	2925.00	5.42
5/04/71	2947.00	5.46
5/05/71	5909.00	10.94
5/10/71	5467.00	10.11
5/11/71	7061.00	13.09
5/12/71	7173.00	13.27
5/12/71	6201.00	11.50
5/13/71	6590.00	12.20
5/17/71	6590.00	12.20
5/18/71	7084.00	13.11
5/19/71	6986.00	12.95
5/20/71	7226.00	13.38
5/21/71	6971.00	12.91
5/24/71	6351.00	11.75
5/25/71	6395.00	11.81
5/26/71	6530.00	12.09
5/27/71	6530.00	12.09
5/28/71	6500.00	12.19
6/01/71	5180.00	9.60
6/02/71	2573.00	4.77
6/03/71	3104.00	5.77
6/04/71	3082.00	5.71
6/07/71	3059.00	5.68
6/08/71	3134.00	5.81
6/09/71	3029.00	5.61
6/10/71	3119.00	5.78
6/11/71	3059.00	5.68
6/14/71	3029.00	5.61
6/15/71	3022.00	5.60
6/16/71	3014.00	5.59
6/17/71	3052.00	5.65

* Assumed average 540 min/day

Table IV. MACHINE: WIRE SAW - METER #5

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
2/03/71	695.64	1.28
2/04/71	628.32	1.16
2/05/71	553.52	1.02
2/08/71	688.16	1.27
2/09/71	628.32	1.16
2/10/71	590.92	1.09
2/11/71	635.80	1.17
2/12/71	800.36	1.48
2/15/71	845.24	1.56
2/16/71	800.36	1.48
2/17/71	807.84	1.49
2/18/71	561.00	1.03
2/19/71	755.48	1.39
2/22/71	613.36	1.13
2/23/71	590.92	1.09
2/24/71	665.72	1.23
2/25/71	733.04	1.35
2/26/71	912.56	1.68
	Plant closed for two weeks	
3/18/71	--	--
3/19/71	837.76	1.55
3/22/71	785.40	1.45
3/23/71	979.88	1.81
3/24/71	688.16	1.27
4/14/71	755.00	1.40
4/15/71	763.00	1.41
4/16/71	763.00	1.41
4/19/71	576.00	1.07
4/20/71	494.00	0.91
4/21/71	651.00	1.20
4/22/71	516.00	0.96
4/23/71	606.00	1.12
4/26/71	486.00	0.90
4/27/71	583.00	1.08
4/28/71	568.00	1.05
4/29/71	688.00	1.27
4/30/71	651.00	1.20
5/03/71	494.00	0.92
5/04/71	808.00	1.50
5/05/71	621.00	1.15

Table IV (continued). MACHINE: WIRE SAW - METER #5

Nativi and Son, Inc.

Date	Gallons used	Average gpm*
5/06/71	561.00	1.04
5/07/71	568.00	1.05
5/10/71	404.00	0.75
5/11/71	591.00	1.09
5/12/71	763.00	1.41
5/13/71	546.00	1.01
5/14/71	673.00	1.25
5/17/71	568.00	1.05
5/18/71	673.00	1.25
5/19/71	748.00	1.39
5/20/71	688.00	1.27
5/21/71	748.00	1.39
5/24/71	598.00	1.11
5/25/71	636.00	1.18
5/26/71	726.00	1.35
5/27/71	598.00	1.11
5/28/71	688.00	1.27
6/01/71	621.00	1.15
6/02/71	718.00	1.33
6/03/71	524.00	0.97
6/04/71	703.00	1.30
6/07/71	736.00	1.36
6/08/71	546.00	1.01
6/09/71	681.00	1.26
6/10/71	561.00	1.04
6/11/71	748.00	1.39
6/14/71	741.00	1.37
6/15/71	815.00	1.51
6/16/71	688.00	1.27
6/17/71	643.00	1.19

* Assumed average 540 min./day

Table V. MACHINE: SINGLE STRAND WIRE SAW (MACHINE #3) - METER #2

G.I.V.

Date	Gallons used	Average gpm*
2/23/71	621.00	1.15
2/24/71	651.00	1.20
2/25/71	606.00	1.12
2/26/71	494.00	0.91
4/06/71	344.00	0.64
4/07/71	224.00	0.42
4/08/71	292.00	0.54
4/09/71	471.00	0.87
4/10/71	254.00	0.47
4/12/71	389.00	0.72
4/13/71	419.00	0.78
4/15/71	322.00	0.60
4/16/71	489.00	0.91
4/20/71	307.00	0.57
4/21/71	247.00	0.46
4/22/71	292.00	0.54
4/23/71	673.00	1.25
4/26/71	501.00	0.93
4/27/71	591.00	1.09
4/28/71	673.00	1.25
4/29/71	471.00	0.87

No reading taken 4/25 - 5/11

No reading taken 5/11 - 6/16

* Assumed average 540 min/day

Table VI. MACHINE: GRINDER - METER #3

G.I.V.

Date	Gallons used	Average gpm*
2/23/71	561.00	1.17
2/24/71	725.00	1.51
2/25/71	430.00	0.90
2/26/71	569.00	1.18
3/09/71	37.00	0.08
3/10/71	22.00	0.05
3/11/71	45.00	0.09
3/12/71	45.00	0.09
3/13/71	45.00	0.09
3/15/71	45.00	0.09
3/16/71	60.00	0.12
3/17/71	82.00	0.17
3/18/71	52.00	0.11
3/19/71	82.00	0.17
3/22/71	8.00	0.02
3/23/71	67.00	0.14
3/24/71	45.00	0.09
3/25/71	52.00	0.11
3/26/71	30.00	0.06
3/29/71	82.00	0.17
3/30/71	105.00	0.22
3/31/71	45.00	0.09
4/01/71	37.00	0.08
4/02/71	120.00	0.25
4/05/71	90.00	0.19
4/06/71	45.00	0.09
4/07/71	52.00	0.11
4/08/71	45.00	0.09
4/09/71	37.00	0.08
4/12/71	60.00	0.12
4/13/71	52.00	0.11
4/14/71	52.00	0.11
4/15/71	45.00	0.09
4/16/71	37.00	0.08
4/19/71	82.00	0.17
4/20/71	37.00	0.08
4/21/71	194.00	0.40
4/23/71	52.00	0.11
4/26/71	52.00	0.11
4/27/71	45.00	0.09
4/28/71	37.00	0.08
4/29/71	45.00	0.09
4/30/71	37.00	0.08

Table VI (continued). MACHINE: GRINDER - METER #3

Date	Gallons used	Average gpm*
5/03/71	90.00	0.19
5/04/71	22.00	0.05
5/05/71	45.00	0.09
5/06/71	22.00	0.05
5/07/71	60.00	0.12
5/10/71	112.00	0.23
5/11/71	75.00	0.16
5/12/71	30.00	0.06
5/14/71	52.00	0.11
5/17/71	75.00	0.16
5/18/71	60.00	0.12
5/19/71	37.00	0.08
5/20/71	90.00	0.19
5/21/71	120.00	0.25
5/24/71	67.00	0.14
5/25/71	67.00	0.14
5/26/71	45.00	0.09
5/27/71	45.00	0.09
5/28/71	67.00	0.14
6/01/71	67.00	0.14
6/02/71	49.00	0.10
6/03/71	49.00	0.10
6/04/71	52.00	0.11
6/07/71	67.00	0.14
6/08/71	37.00	0.08
6/09.71	60.00	0.12
6/10/71	60.00	0.12
6/11/71	52.00	0.11

* Assumed average 480 min./day

Table VII. MACHINE: STEELER - METER #4

G.I.V.

Date	Gallons used	Average gpm*
3/30/71	284.00	0.59
3/31/71	224.00	0.47
4/01/71	681.00	1.42
4/02/71	157.00	0.33
4/05/71	142.00	0.30
4/06/71	217.00	0.45
4/07/71	494.00	1.02
4/08/71	482.00	1.01
4/09/71	482.00	1.01
4/12/71	426.00	0.89
4/13/71	150.00	0.31
4/14/71	367.00	0.76
4/15/71	135.00	0.28
4/16/71	696.00	1.45
4/19/71	426.00	0.89
4/20/71	703.00	1.46
4/21/71	688.00	1.43
4/22/71	785.00	1.63
4/23/71	741.00	1.54
4/26/71	703.00	1.46
4/27/71	666.00	1.39
4/28/71	165.00	0.34
4/29/71	658.00	1.37
4/30/71	651.00	1.36
5/03/71	838.00	1.75
5/04/71	711.00	1.48
5/05/71	688.00	1.43
5/06/71	226.00	1.54
5/07/71	696.00	1.45
5/10/71	226.00	1.51
5/11/71	673.00	1.40
5/12/71	688.00	1.43
5/13/71	636.00	1.32
5/14/71	681.00	1.42
5/17/71	696.00	1.45
5/18/71	696.00	1.45
5/19/71	688.00	1.42
5/20/71	301.00	0.64
5/21/71	576.00	1.20
5/24/71	75.00	0.16
5/25/71	546.00	1.14
5/26/71	681.00	1.42

Table VII (continued). MACHINE: STEELER - METER #4

G.I.V.

Date	Gallons used	Average gpm*
5/27/71	673.00	1.40
5/28/71	666.00	1.39
6/01/71	606.00	1.26
6/02/71	905.00	1.89
6/03/71	681.00	1.42
6/04/71	755.00	1.57
6/07/71	793.00	1.65
6/08/71	628.00	1.31
6/09/71	636.00	1.33
6/10/71	673.00	1.40
6/11/71	666.00	1.39

* Assumed average 480 min./day

Table VIII. MACHINE: BUFFER - METER #5

G.I.V.

Date	Gallons used	Average gpm*
3/30/71	22	0.05
3/31/71	262	0.55
4/01/71	67	0.14
4/02/71	165	0.34
4/05/71	97	0.20
4/06/71	90	0.19
4/07/71	60	0.12
4/08/71	67	0.14
4/09/71	52	0.11
4/12/71	135	0.28
4/13/71	105	0.22
4/14/71	97	0.20
4/15/71	127	0.26
4/16/71	120	0.25
4/19/71	82	0.17
4/20/71	82	0.17
4/21/71	135	0.28
4/22/71	284	0.59
4/23/71	75	0.16
4/26/71	75	0.16
4/27/71	52	0.11
4/28/71	90	0.19
4/29/71	37	0.08
4/30/71	142	0.30
5/03/71	254	0.53
5/04/71	209	0.44
5/05/71	52	0.11
5/06/71	91	0.20
5/07/71	299	0.62
5/10/71	75	0.16
5/11/71	90	0.19
5/12/71	60	0.12
5/13/71	284	0.59
5/14/71	60	0.12
5/17/71	292	0.61
5/18/71	67	0.14
5/19/71	67	0.14
5/20/71	75	0.16
5/21/71	269	0.56
5/24/71	180	0.38
5/25/71	75	0.16

Table VIII (continued). MACHINE: BUFFER - METER #5

G.I.V.

Date	Gallons used	Average gpm*
5/27/71	105	0.22
5/28/71	381	0.79
6/01/71	52	0.11
6/02/71	247	0.52
6/03/71	172	0.36
6/04/71	45	0.09
6/07/71	82	0.17
6/08/71	67	0.14
6/09/71	60	0.12
6/10/71	150	0.31
6/11/71	60	0.12

*Assumed average 480 min./day

Table IX. MACHINE: FINING (FINAL POLISHING) - METER #6

G.I.V.

Date	Gallons used	Average gpm*
3/30/71	105	1.22
3/31/71	67	0.14
4/01/71	45	0.09
4/02/71	37	0.08
4/05/71	37	0.08
4/06/71	75	0.16
4/07/71	45	0.09
4/08/71	52	0.11
4/09/71	60	0.12
4/12/71	52	0.11
4/13/71	52	0.11
4/14/71	30	0.06
4/15/71	37	0.08
4/16/71	60	0.12
4/19/71	60	0.12
4/20/71	67	0.14
4/21/71	7	0.01
4/22/71	90	0.19
4/23/71	37	0.08
4/26/71	120	0.25
4/27/71	60	0.12
4/28/71	67	0.14
4/29/71	60	0.12
4/30/71	67	0.14
5/03/71	52	0.11
5/04/71	37	0.08
5/05/71	52	0.11
5/06/71	60	0.12
5/07/71	37	0.08
5/10/71	67	0.14
5/11/71	37	0.08
5/12/71	30	0.06
5/13/71	37	0.08
5/14/71	37	0.08
5/17/71	30	0.06
5/18/71	22	0.05
5/19/71	30	0.08
5/20/71	37	0.08
5/21/71	45	0.09
5/24/71	30	0.06
5/25/71	45	0.09
5/26/71	37	0.08

Table IX (continued). MACHINE: FINING (FINAL POLISHING) - METER #6

G.I.V.

Date	Gallons used	Average gpm*
5/27/71	30	0.06
5/28/71	37	0.08
6/01/71	60	0.12
6/02/71	45	0.09
6/03/71	45	0.09
6/04/71	52	0.11
6/07/71	52	0.11
6/08/71	90	0.19
6/09/71	30	0.06
6/10/71	37	0.08
6/11/71	52	0.11

Table X. MACHINE: 7-STRAND WIRE SAW (MACHINE #1) METER #1

Date	Gallons used
3/30/71	314
3/31/71	501
4/01/71	105
4/02/71	396
4/05/71	411
4/06/71	232
4/07/71	411
4/08/71	434
4/09/71	314
4/12/71	404
4/13/71	239
4/14/71	389
4/15/71	194
4/19/71	419
4/20/71	262
4/21/71	374
4/22/71	598
4/26/71	78
4/27/71	239
4/28/71	299
4/30/71	9
5/06/71	263
5/24/71	297
5/25/71	322
5/26/71	441
5/27/71	142
6/07/71	321
6/08/71	60
6/09/71	568
6/10/71	494
6/11/71	269
6/16/71	183

6 GPM flow.

Since the use of the 7-strand wire saw varies greatly from day to day no average minutes per day could be determined. Measurement of the discharge volume while the saw was operating indicated an average flow of 6 GPM.

Table XI

	Raw Waste			24-Hr. Settled Waste		
	Suspended Solids, mg/l	Turbidity mg/l as SiO_2	pH	Supernatant SS, mg/l	Supernatant Turbidity, mg/l	Sludge Volume ml/l
GIV 7-Strand Saw	106,891	127,000	10.8	206	33	185
	213,070	137,000	10.8	36	72	260
	50,342	16,500	10.9	85	3,820	90
	263,304	100,000	10.8	441	790	250
	82,548	81,000	9.9	29	39,500	125
	63,722	80,000	--	21	33	---
	163,601	85,000	--	18,703	22,800	---
GIV Single Strand Saw	6,450	5,100	8.0	7	14	25
	4,705	3,100	8.5	7	15	18
	8,490	5,500	9.8	24	19	15
	2,544	2,000	7.7	22	60	35
	16,182	9,300	8.3	28	45	70
GIV Grinder	3,205	58,000	10.4	1,782	4,750	70
	85,970	100,000	11.1	1,066	1,010	100
	45,218	33,000	10.5	43	1,060	90
	41,140	40,000	10.6	2,480	4,600	21
	130,615	135,000	10.1	522	63,500	82
GIV Buffer	4,651	5,500	7.5	29	20	30
	17,545	20,000	9.8	787	375	65
	5,014	2,650	7.8	21	40	17
	9,536	3,250	10.0	10	66	20
	14,856	7,000	9.6	61	15	41
GIV Steeler	8,133	4,000	8.6	18	140	30
	28,502	16,000	9.8	173	78	58
	8,294	5,800	7.8	19	106	50
	43,415	15,000	10.0	3,214	1,800	90
	123,574	72,000	9.6	54	1,600	18
GIV Composite Sample	48,153	188,000	--	3,184	210	--
	146,021	95,000	--	19,728	46,800	--
	145,990	110,000	--	--	34,000	--
Nativi Single-Strand Saw	49,137	35,000	10.1	123	195	80
	68,629	43,750	10.2	34	165	80
	43,210	20,000	9.7	90	950	42
	50,647	30,000	9.8	32	395	24
	17,784	3,600	8.4	68	850	64

Table XI (continued)

	Raw Waste			24-Hr. Settled Waste		
	Suspended Solids, mg/l	Turbidity mg/l as SiO_2	pH	Supernatant SS,mg/l	Supernatant Turbidity,mg/l	Sludge Volume ml/l
Nativi Planer	5,647	1,550	8.2	34	110	18
	9,036	5,100	8.0	102	180	10
	8,078	2,200	8.3	50	243	5
	7,416	3,250	9.2	25	58	8
	7,162	3,100	8.8	119	100	9
	19,994	6,000	--	2,907	1,960	--

Table XII. JAR TESTS

I. Sodium Aluminate $Na_2O\ Al_2O_3\ 3H_2O$

Dose, mg/l	Turbidity, mg/l as SiO_2
0	210
25	30
50	20
100	10
200	5
300	5

Note - all samples were adjusted to pH 7 to obtain these results.

II. Aluminium Sulfate $Al_2\ (SO_4)\ _3\ 18H_2O$

Dose, mg/l		Turbidity, mg/l
	A	
0		8,500
375		350
750		15
1125		10
1500		--
1875		10
2250		8
	B	
0		7,500
375		350
750		18
1125		7
1500		--
1875		4
2250		4

III. Lime $Ca\ (OH)_2$

Dose, mg/l	Turbidity, mg/l	pH
0	1,900	6.7
63	100	9.1
125	12	9.8
188	5	10.7
250	4	11.0
313	4	11.0
373	4	12.0

Table XII (continued). JAR TESTS

IV. Lime-Alum

A.

Lime, mg/l	Alum, mg/l	Turbidity, mg/l	pH
0	0	375,000	8.3
63	188	2,000	7.5
125	375	110	7.5
188	564	19	7.5
250	750	6	7.5
313	939	6	7.5
375	1025	4	7.6

B.

Lime, mg/l	Alum, mg/l	Turbidity, mg/l	pH
0	0	6,850	7.5
63	188	3,120	8.0
125	375	24	7.6
188	564	25	7.8
250	750	8	7.7
313	939	8	7.4
375	1025	6	7.4

C, D, E

Lime, mg/l	Alum, mg/l	Turbidities, mg/l		
		C	D	E
0	0	1500	2740	1380
63	188	9	32	9
125	375	7	12	9
188	564	7	12	7
250	750	7	20	7
313	939	7	9	5
375	1025	7	7	5

pH's between 7 and 8 for all treated samples.

V. Ferric Chloride-Lime

$FeCl_3$, mg/l	$Ca(OH)_2$, mg/l	Turbidity, mg/l	pH
0	0	600	8.6
63	188	7	8.6
125	375	6	8.7
188	564	5	8.3
250	750	4	8.5
313	939	4	8.5
375	1025	4	9.4

Note - Best and fastest floc formation; sample settled clear in 10 min. least amount of sludge formed.

Table XII (continued). JAR TESTS

VI. Ferric Sulfate-Lime

$Fe_2(SO_4)_3$, mg/l	$Ca(OH)_2$, mg/l	Turbidity mg/l	pH
0	0	600	8.6
63	188	6	6.8
125	375	5	6.7
188	564	4	6.5
250	750	4	6.2
313	939	4	5.8
375	1025	4	5.5

Table XIII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Tuesday, August 3, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	10% F.S. * = 19 mg /l $FeCl_3$
Lime	60% F.S. @ 78 spm = 67 mg/l

Time	Turbidity mg/l Effluent	Raw
10:30	4	
11:00	4	
11:30	4	
12:00	5	
12:30	4	
1:00		
2:00	Shut Down for Maintenance	
3:00		
4:00		
Average	4	

* F.S. - Full Stroke

Table XIV. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Wednesday, August 4, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	$FeCl_3$: 10% F.S. - 19 mg/1
Lime	60% F.S. = 67 mg/1

Turbidity mg/1

Time	Effluent	Raw
9:30	5	
10:00	8	
11:00	8	
12:00	8	
1:00		
2:00	Afternoon Was Spent Making	
3:00	Adjustments to Chemical Feed Rate	
Average	8	

Table XV. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Thursday, August 5, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	$FeCl_3$: 25% F.S. = 32 mg/l
Lime	40% F.S. = 64 mg/l

	Turbidity mg/l	
Time	Effluent	Raw
8:00		
9:00	Tanks were Empty from Previous	
10:00	Maintenance and Had to be Filled	
11:00		
12:00		
1:00	9	
1:30	8	
2:00	7	
2:30	5	
3:00	5	
3:30	5	
Average	6.5	

Turbidity of the Raw at 2:00 = 750 mg/l

Average % of Removal = 99.0

Table XVI. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

<u>Samples Taken</u>	Friday, August 6, 1971
<u>Tested</u>	On Site
<u>Flow</u>	5.0 gpm
<u>Dosage</u>	$FeCl_3$: 25% F.S. - 32 mg/1
<u>Lime</u>	40% F.S. = 64 mg/1

Time	Turbidity mg/1 Effluent	Raw
8:30	5	
9:00	4	
9:30	4	
10:00	4	
10:30	4	
11:00	4	
11:30	4	
12:00	4	
12:30	4	
1:00	4	
1:30	4	
Average	4	

Table XVII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Monday, August 9, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	$FeCl_3$: 25% F.S. - 32 mg/l
Lime	35% F.S. - 64 mg/l

	Turbidity mg/l	
Time	Effluent	Raw
11:00	3	
12:00	4	
12:30	4	
1:00	4	
1:30	4	
2:00	4	
2:30	4	
3:00	4	
3:30	4	
4:00	4	
Average	4	

Table XVIII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Tuesday, August 10, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	$FeCl_3$: 25% F.S. = 32 mg/l
Lime	35% F.S. = 64 mg/l

Turbidity mg/l

Time	Effluent	Raw
9:30	4	
10:00	4	
10:30	-	
11:00	7	
11:30	7	
12:00	7	
12:30	4	
1:00	4	
1:30	4	
2:00	4	
2:30	5	
3:00	5	
3:30	5	
4:00	4	
Average	5	

Table XIX. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Wednesday, August 11, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	$FeCl_3$: 18% F.S. = 21 mg/l
Lime	30% F.S. = 63 mg/l

Turbidity mg/l

Time	Effluent	Raw
9:00	8	
9:30	8	
10:00	6	
10:30	4	
11:00	4	
11:30	4	
12:00	4	
12:30	4	
1:00	4	
1:30	5	
2:00	5	
2:30	6	
3:00	6	
3:30	7	
4:00	7	
Average	5.5	

Raw Turbidity 800.0 mg/l

Average % Removal = 99.3

Table XX. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

<u>Samples Taken</u> Monday, August 16, 1971

<u>Tested</u> On Site

<u>Flow</u> 5.0 gpm

<u>Dosage</u> $FeCl_3$: No Feed 7:05 to 9:30 15% F.S. 9:30-4:00=19 mg/l

<u>Lime</u> 30% F.S. = 63 mg/l

	Turbidity mg/l	
Time	Effluent	Raw
8:00	6	620
9:30	149	610
9:45	400	--
9:55	-	--
10:30	440	810
11:30	380	880
1:00	210	1000
1:30	200	940
2:30	150	1020
3:00	65	900
3:30	44	900
4:00	31	1300
Average	145	898

Average % Removal = 84

Table XXI. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken

Tested

Flow

Dosage $FeCl_3$: 17% F.S. = 20 mg/l

Lime 30% F.S. - 63 mg/l 7:00-9:50

	Turbidity mg/l	
Time	Effluent	Raw
8:00	23	1740
8:30	23	1860
9:00	21	1340
9:30	30	1300
10:00	21	1560
10:30	25	1630
12:00	19	1340
1:00	21	1400
1:30	20	1300
2:00	17	1340
2:30	19	1300
3:00	22	1320
3:30	17	1420
4:00	21	1220
Average	21	1434

Average % Removal = 98.5

Table XXII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken — Wednesday, August 18, 1971

Tested — On Site

Flow — 5.0 gpm

Dosage — $FeCl_3$: 17% F.S. = 20 mg/1

Lime — 30% F.S. = 63 mg/1

	Turbidity mg/1	
Time	Effluent	Raw
8:30	16	1080
9:00	10	1020
9:30	19	920
10:00	18	980
10:30	23	1980
11:00	16	2080
11:30	15	1560
12:00	15	1560
12:30	--	---
1:00	13	1560
1:30	12	1400
2:00	12	1360
2:30	13	1280
3:00	--	---
3:30	13	1280
4:00	--	----
Average	15	1389

Average % Removal = 98.9

Table XXIII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken — Friday, August 20, 1971

Tested — On Site

Flow — 5.0 gpm

Dosage — $FeCl_3$: 40% F.S. = 51 mg/l

Lime — 0

Time	Turbidity mg/l Effluent	Turbidity mg/l Raw
7:30	--	--
8:00	30	860
8:30	21	1120
9:00	15	860
9:30	12	1020
10:00	12	860
10:30	12	700
11:00	12	860
11:30	12	720
12:00	--	--
12:30	12	860
1:00	12	860
1:30	12	960
2:00	11	980
3:00	10	980
Average	13	895

Average % Removal 98.5

Table XXIV. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken — Monday, August 23, 1971

Tested — On Site

Flow — 5 gpm

Dosage — $FeCl_3$: 30% F.S. = 38 mg/l

Time	Turbidity mg/l Effluent	Raw
9:00	5	960
9:30	5	960
10:00	5	800
10:30	5	820
11:00	5	900
11:30	8	1300
12:00	8	1200
12:30	9	1050
1:00	12	900
1:30	12	950
2:00	12	1000
2:30	10	1000
3:00	12	1300
Average	7.5	1011

Average % Removal = 99.3

Table XXV. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Wednesday, August 25, 1971
Tested	On Site
Flow	5.0 gpm
Dosage	$FeCl_3$: 20% F.S. = 25 mg/l 8:00 1:30
	$FeCl_3$: 40% F.S. = 51 mg/l 1:30 4:00

Time	Turbidity mg/l Effluent	Raw
9:00	5	2200
9:30	6	1400
10:00	30	1100
10:30	40	1300
11:00	150	1400
11:30	98	1340
12:00	52	1040
12:30	50	----
1:00	50	----
1:30	50	----
2:00	51	1300
2:30	40	1350
3:00	22	1400
3:30	17	----
Average	47	1383

Average % Removal = 96.6

Table XXVI. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken — Thursday, August 26, 1971

Tested — On Site

Flow — 5.0 gpm

Dosage — $FeCl_3$: 50% F.S. = 64 mg/l

Time	Turbidity mg/l Effluent	Turbidity mg/l Raw
9:30	10	1900
10:00	14	1900
10:30	9	1500
11:00	9	1720
10:30	9	1800
12:00	--	----
12:30	--	----
1:00	8	2100
1:30	9	1500
2:00	9	1500
2:30	10	1750
3:00	10	1750
3:30	19	1550
Average	10.5	1725

Average % Removal = 99.4

Table XXVII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken: Monday, September 27, 1971

Tested: Tuesday, September 28, 1971

Flow: 5.0 gpm

Dosage: 30% of full stroke = 38 mg/1

	Turbidity mg/1	
Time	Effluent	Raw
8:00	9	1700
9:00	4	1700
10:00	9	1700
11:00	9	1500
12:00	9	1500
1:00	10	1500
2:00	11	1700
3:00	8	1700
4:00	9	1750
Average	9	1639

Deionized H_2O = .8

Average % Removal = 99.5

Table XXVIII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Tuesday, September 28, 1971
Tested	Wednesday, September 29, 1971
Flow	5.0 gpm
Dosage	$FeCl_3$: 30% of F.S. = 38 mg/l

	Turbidity mg/l	
Time	Effluent	Raw
8:00	8	1100
9:00	11	1500
10:00	10	1500
11:00	10	1200
12:00	8	1100
1:00	9	1100
2:00	9	1500
3:00	6	1200
4:00	7	1600
Average	9	1311

Average % Removal = 99.3

Table XXIX. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Wednesday, September 29, 1971
Tested	Thursday, September 30, 1971
Flow	5.0 gpm
Dosage	30% F.S. = 38 mg/1

Time	Turbidity mg/1 Effluent	Raw
8:00	8	1200
9:00	8	1200
10:00	7	1600
11:00	8	1600
12:00	6	1600
1:00	10	1800
2:00	8	1600
3:00	9	1600
4:00	7	1600
Average	8	1533

Average % Removal = 99.5

Table XXX. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Friday, October 1, 1971
Tested	Monday, October 4, 1971
Flow	5.0 gpm
Dosage	25% F.S. = 32 mg/1

	Turbidity mg/1	
Time	Effluent	Raw
8:00	4	900
9:00	-	900
10:00	15	1000
11:00	8	1500
12:00	53	1200
1:00	8	1200
2:00	8	1200
3:00	6	1800
4:00	5	1300
Average	8	1222

Average % Removal = 99.3

Table XXXI. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken   Monday, October 4, 1971

Tested   Tuesday, October 5, 1971

Dosage   20% F.S. = 25 mg/l

Time	Turbidity mg/l Effluent	Raw
8:00	17	1400
9:00	14	1400
10:00	14	1400
11:00	12	1400
12:00	15	1400
1:00	11	1400
2:00	16	1400
3:00	16	1400
4:00	13	1400
Average	14	1400

Average % Removal = 99.0

Table XXXII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken	Tuesday, October 5, 1971
Tested	Thursday, October 7, 1971
Flow	5.0 gpm
Dosage	15% of F.S. = 19 mg/1

	Turbidity mg/1	
Time	Effluent	Raw
8:00	14	800
9:00	19	1200
10:00	19	1400
11:00	17	1400
12:00	17	1200
1:00	15	1400
2:00	17	2000
3:00	17	2000
4:00	19	1950
Average	17	1483

Average % Removal = 99.9

Table XXXIII. PILOT PLANT OPERATION DATA

Nativi and Son, Barre, Vermont

Samples Taken — Wednesday, October 6, 1971

Tested — Thursday, October 7, 1971

Flow — 5.0 gpm

Dosage — 10 % F.S. = 13 mg/l

Time	Turbidity mg/l Effluent	Raw
8:00	9	1200
9:00	9	1200
10:00	60	1300
11:00	69	1800
12:00	46	1600
1:00	43	1800
2:00	53	1600
3:00	45	1800
4:00	40	1900
Average	42	1578

Average % Removal = 97.3

Table XXXIV. LINK-BELT PILOT PLANT

Date	7/30/71
Flow	.75 gpm
Dose	$FeCl_3$ = 13 mg/l
Lime	67 mg/l

Time	Effluent Turbidity mg/l
10:30	7.5
11:00	6.0
11:30	6.0
12:00	6.0
12:30	6.5

Table XXXV. LINK-BELT PILOT PLANT

Date	8/4/71
Flow	.75 gpm
Dose	$FeCl_3$ = 13 mg/l
Lime	67 mg/l

Time	Effluent Turbidity - mg/l
9:30	8.5
10:00	11.5
10:30	11.5
11:00	11.5
12:00	11.5

Table XXXVI. LINK-BELT PILOT PLANT

<u>Date</u>	8/5/71
<u>Flow</u>	1 gpm
<u>Dose</u>	$FeCl_3$ = 32 mg/l
<u>Lime</u>	64 mg/l

Time	Effluent Turbidity - mg/l
1:00	6.0
1:30	5.0
2:00	5.0
2:30	5.0
3:00	5.0
3:30	5.0

Table XXXVII. LINK-BELT PILOT PLANT

Date	8/6/71
Flow	1 gpm
Dose	$FeCl_3$ = 32 mg/l
Lime	64 mg/l

Time	Turbidity - mg/l
8:30	5.0
9:00	4.0
9:30	8.5
10:00	6.0
10:30	4.0
11:00	4.5
11:30	5.5
12:00	5.5
12:30	5.5
1:00	5.5
1:30	5.5

Table XXXVIII. LINK-BELT PILOT PLANT

Date	8/9/71
Flow	1.4 gpm
Dose	$FeCl_3$ = 32 mg/1
Lime	64 mg/1

Time	Turbidity - mg/1
12:00	9.5
12:30	4.5
1:00	4.5
1:30	4.5
2:00	4.0
2:30	4.0
3:00	4.0

Table XXXIX. LINK-BELT PILOT PLANT

Date	8/11/71
Flow	1.0 gpm
Dose	$FeCl_3$ = 20 mg/l
Lime	62 mg/l

Time	Turbidity - mg/l
9:00	7.5
9:30	7.5
10:00	7.5
10:30	7.5
11:00	7.5
11:30	7.5
12:00	7.5
12:30	4.5
1:00	4.0
1:30	4.0
2:00	3.5
2:30	4.0
3:00	4.0
3:30	4.0
4:00	4.0

Table XL

Samples Taken: 2/14/72

Dose: $FeCl_3$: 47 mg/1

$CaOH_2$: 25 mg/1

Flow: 10 gpm

Turbidity mg/1

Time	Effluent	Raw
8:00	12	450
9:00	12	538
10:00	12	725
11:00	12	625
12:00	12	625
1:00	23	688
2:00	17	975
3:00	17	1,088
4:00	16	-
Average	15	714

% Removal - 97.9

OFR - 576 gal./ft.^{2}/day

D.T. Floc. - 12 min.

D.T. Clarifier - 112 min.

Table XLI

Samples Taken: 2/15/72

Dose: $FeCl_3$: 47 mg/1

$CaOH_2$: 25 mg/1

Flow: 10 gpm

Turbidity mg/1

Time	Effluent	Raw
8:00	8	-
9:00	11	-
10:00	10	-
11:00	10	-
12:00	12	-
1:00	14	-
2:00	14	-
3:00	16	900
4:00	11	800
Average	12	

% Removal

OFR - 576 gal./ft.^{2}/day

D.T. Floc. - 12 min.

D.T. Clarifier - 112 min.

Table XLII

Samples Taken: 2/15/72

Dose: $FeCl_3$: 47 mg/l

$CaOH_2$: 25 mg/l

Flow: 10 gpm

	Turbidity	
Time	Effluent	Raw
8:00	-	-
9:00	8	625
10:00	18	475
11:00	25	563
12:00*	250	-
1:00*	450	-
2:00	-	-
3:00	37	750
4:00	22	625
Average	22	608

*Malfunction of $FeCl_3$ feeding system caused an extreme overdose eliminating all flocculation. Problem was corrected and system returned to normal operation. Abnormal values not averaged.

% Removal - 97%

OFR - 864 gal./ft.^{2}/day

D.T. Floc. - 8 min.

D.T. Clarifier - 73 min.

Table XLIII

Samples Taken: 2/17/72

Dose: $FeCl_3$: 47 mg/1

$CaOH_2$: 25 mg/1

Flow: 15 gpm

Turbidity mg/1

Time	Effluent	Raw
8:00	17	575
9:00	37	475
10:00	32	700
11:00	30	625
12:00	35	725
1:00	20	775
2:00	16	1400
3:00	29	1075
4:00	24	975
Average	27	814

% Removal - 96.7

OFR - 864 gal./ft.^{2}/day

D.T. Floc. - 8 min.

D.T. Clarifier - 75 min.

Table XLIV

Samples Taken: 2/22/72

Dose 15 gpm

Flow: 47 mg/1 lime

Turbidity

Time	Effluent	Raw
8:00	24 mg/1	600 mg/1
9:00	24 mg/1	800 mg/1
10:00	18 mg/1	800 mg/1
11:00	18 mg/1	800 mg/1
12:00	18 mg/1	900 mg/1
1:00	20 mg/1	900 mg/1
2:00	20 mg/1	1160 mg/1
3:00	20 mg/1	1160 mg/1
Average	20	890

% Removal - 98.0

OFR - 864 gal./ft.^{2}/day

D.T. Floc. - 8 min.

D.T. Clarifier - 75 min.

Table XLV

Samples Taken: 2/28/72

Dose: $FeCl_3$: 47 mg/1

$CaOH_2$: 25 mg/1

Flow: 15 gpm

Turbidity

Time	Effluent	Raw
8:00	11.5	380
9:00	8.5	600
10:00	20.0	800
11:00	19.0	750
12:00	19.0	1000
1:00	19.0	1100
2:00	17.0	1100
3:00	17.0	1100
4:00	20.0	1300
Average	17	903

% Removal - 98.5

OFR - 864 gal./ft.^{2}/day

D.T. Floc. - 8 min.

D.T. Clarifier - 75 min.

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15. Supplementary Notes

Environmental Protection Agency report number, EPA-660/2-74-040, May 1974

16. Abstract A study of wastewater discharge in the granite industry has been conducted to determine wastewater characteristics, methods of pollution abatement and disposal methods for waste granite sludge.

The project included a study of overall water use in a granite plant, water optimization studies, and water reduction studies. Laboratory testing was conducted for waste characterization and liquid solids separation techniques. A pilot plant was designed, constructed and operated to test the efficiency of plant scale separation procedures. A prototype plant was designed and constructed to test the possibility of complete water reuse in the granite industry. Successful operation of both plants indicates that a practical method of treating granite waste effluent has been developed and that complete recycle of treated effluent is possible and economically feasible.

Studies were performed to determine the possibility of by-product use of waste granite sludge. Two uses were found for the sludge, but an economic evaluation indicated that there was insuffieient raw material to establish a by-product industry.

A survey of sludge disposal methods in the industry showed that some modification of waste disposal facilities, and more cooperation by the industry, would improve the sludge disposal procedures. A modified type of settling lagoon was recommended.

This report was submitted in fulfillment of Project No. 12080 GCH under the sponsorship of the Environmental Protection Agency.

17a. Descriptors *Water pollution, *Pollution abatement, Granite processing, Water pollution sources, Water pollution control, Water pollution effects, Water Conservation, Waste water disposal, Granite processing sludge disposal, Water reuse.

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