CITY OF DOVER
NEW HAMPSHIRE

COCHECO RIVER DIVERSION STUDY

April, 1970

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Engineers and Planners
Portland - Bangor - Presque Isle
Maine

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TO
GOVERNMENT
AND
INDUSTRY

April 22, 1970

Mr. Donald E. Chick, City Manager
City of Dover
Municipal Building
Dover, New Hampshire 03820

Cocheco River Diversion
Preliminary Report

Dear Mr. Chick:

As authorized by the City Council, we have undertaken a preliminary engineering and planning study of diversion of the Cocheco River in downtown Dover, New Hampshire. The following report discusses various potential diversion alignments, including their respective advantages, disadvantages, and costs.

The diversion studies have also included land use analysis of the adjacent areas, and of the land to be created by stream diversion. The project has been evaluated for its overall impact on the City of Dover, and recommendations have been made for consideration by the Council and Planning Department.

We are pleased to have the opportunity to be of service to the City of Dover on this project. We would be pleased to meet you and other officials to discuss the report at your convenience.

Very truly yours,

Edward C. Jordan Co., Inc.

E. C. Jordan, President

ECJ/REH:lhw

Enclosure

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SUMMARY

The following statements are a summary of the key findings of the Cocheco River Diversion Study.

1. Any diversion or hydraulic structure on the Cocheco River at Dover must be designed to pass 11,000 cubic feet per second which would occur at a frequency of once in 100 years.
2. It is technically possible to divert the Cocheco River from a point below the Eastern Building arch to the river channel northerly of the Washington Street bridge.
3. The diversion would be accomplished by tunnel procedures in a 25-foot dimension horseshoe section located in a straight alignment in the vicinity of the Main-Portland Street intersection.
4. The high velocities in the structure will require extensive exit channel work including an energy dissipator.
5. Removal of the dam downstream of Central Avenue will have only minor effect on the upstream river level.
6. Significant lowering of the river level upstream of Central Avenue would require removal of the natural ledge dike in the vicinity of Central Avenue.

7. The benefits gained by dam and ledge dike removal do not warrant the expense of such removal.

8. The excavated material from the diversion can be placed in the abandoned river channel. However, an additional 150,000 cubic yards of fill would be required to create about 4 1/2 acres of new land and allow the Washington Street bridges to be abandoned.

9. The basic project cost for stream diversion plus channel filling is estimated at $1,610,000. Overall redevelopment cost is estimated at $2,510,000.

10. Use of the made land in the river channel should be coordinated with overall redevelopment of the area. Redevelopment would include open space areas, active and passive recreational areas, additional off-street parking, marina facilities, housing and commercial areas.

11. An approximate cost-benefit ratio for the diversion project is estimated at 0.44 to 1. That is, only 44 cents of benefit is achieved by 1 dollar of expenditure. This ratio does not economically justify the diversion project unless indirect intangible benefits are given great weight.

12. The basic redevelopment plan for the area can be achieved while maintaining the river in its present channel with only minor modifications. Redevelopment costs without diversion are estimated at about $1,500,000.

13. The cost of obtaining extensive new land by filling or narrowing the river channel is generally in excess of its probable value. Thus, filling operations should be minimized in any redevelopment plan.

14. Federal grants-in-aid to assist the City in redevelopment of the study area may be available under several agencies.

RECOMMENDATIONS

Based upon our analysis of the Cocheco River Diversion Project and Redevelopment of the Study Area, we would make the following recommendations:

1. The City should not undertake the diversion of the Cocheco River from its present course. The costs of doing so cannot be reasonably justified by the benefits gained.
2. The City should replace the existing Washington Street bridges with new modern structures.
3. The City should replace the existing Central Avenue bridge with a new modern structure.
4. The City should replace the existing masonry stacks at the steam plant with a new stack and forced draft system.
5. The City should develop the area between Henrylaw Avenue and the river into both an active recreation area and a passive open space area.
6. The City should give consideration to a redevelopment program for the area northerly of Washington Street and easterly of Main Street. Such redevelopment should provide parking

facilities, open space and landscaped areas, possible marina and associated facilities, possible high density housing and related commercial development.

7. The City should cooperate with the State to encourage pollution control efforts on the Cocheco River and to encourage development of a fishery in the river.

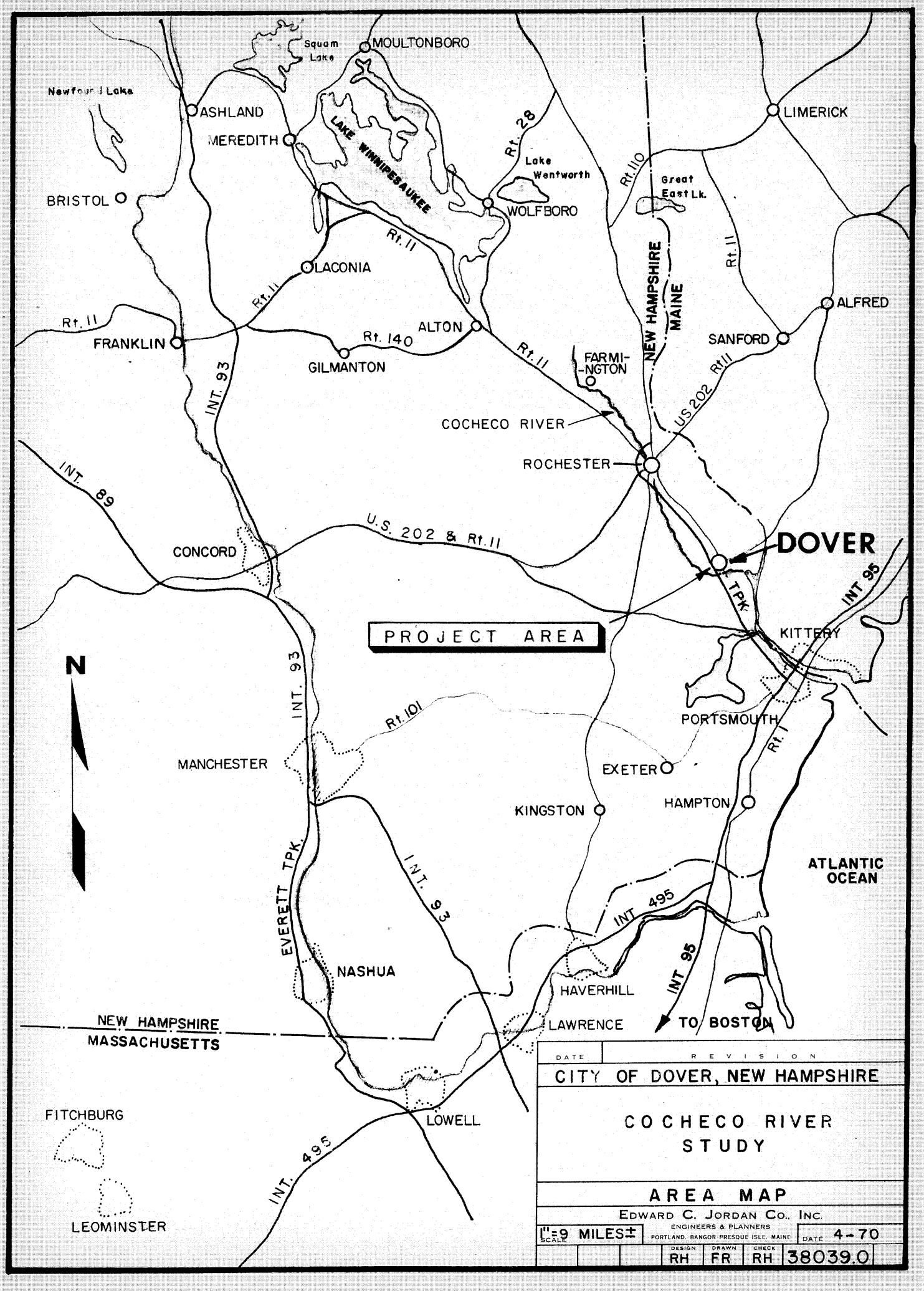
8. The City should carefully evaluate the potential of Federal and State aid programs to assist the City in its redevelopment efforts in the study area.

INTRODUCTION

The City of Dover, New Hampshire, is located in the southern part of the State at the head of tide on the Cocheco River. Figure 1 shows the geographical project location. Dover is typical of numerous New England river basin communities whose location and existence were determined by early industry and its need for water for power and processing. Early community development was oriented toward support of industrial activity in the area rather than the social needs of its people. Such river basin communities are characterized by a random inter-dispersal of industrial, commercial, and residential land uses. Generally speaking, these communities have either declined in stature with the passing of localized industrial activity, or have diversified their economic base, grown, and prospered in varying degrees. In many instances the growth of these communities has been in a manner that is unsatisfactory by today's urban design standards. Dover appears to be an example of such growth evolving from a localized industrial complex.

The City of Dover has recognized its deficiencies and has taken positive steps to assure a better City. A permanent planning staff has been created, and comprehensive planning efforts have been undertaken. The City has also embarked on an urban renewal project in the central business district. The subject of this report is a continuation of the City's planning efforts.

The Cocheco River flows through the heart of Dover. A low head dam exists just downstream of Central Avenue which creates a small impoundment in the central business district. This impoundment provided water



DATE	REVISION

CITY OF DOVER, NEW HAMPSHIRE

COCHECO RIVER STUDY

AREA MAP

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SCALE	DESIGN	DRAWN	CHECK	DATE
1"=9 MILES±	RH	FR	RH	4-70

38039.0

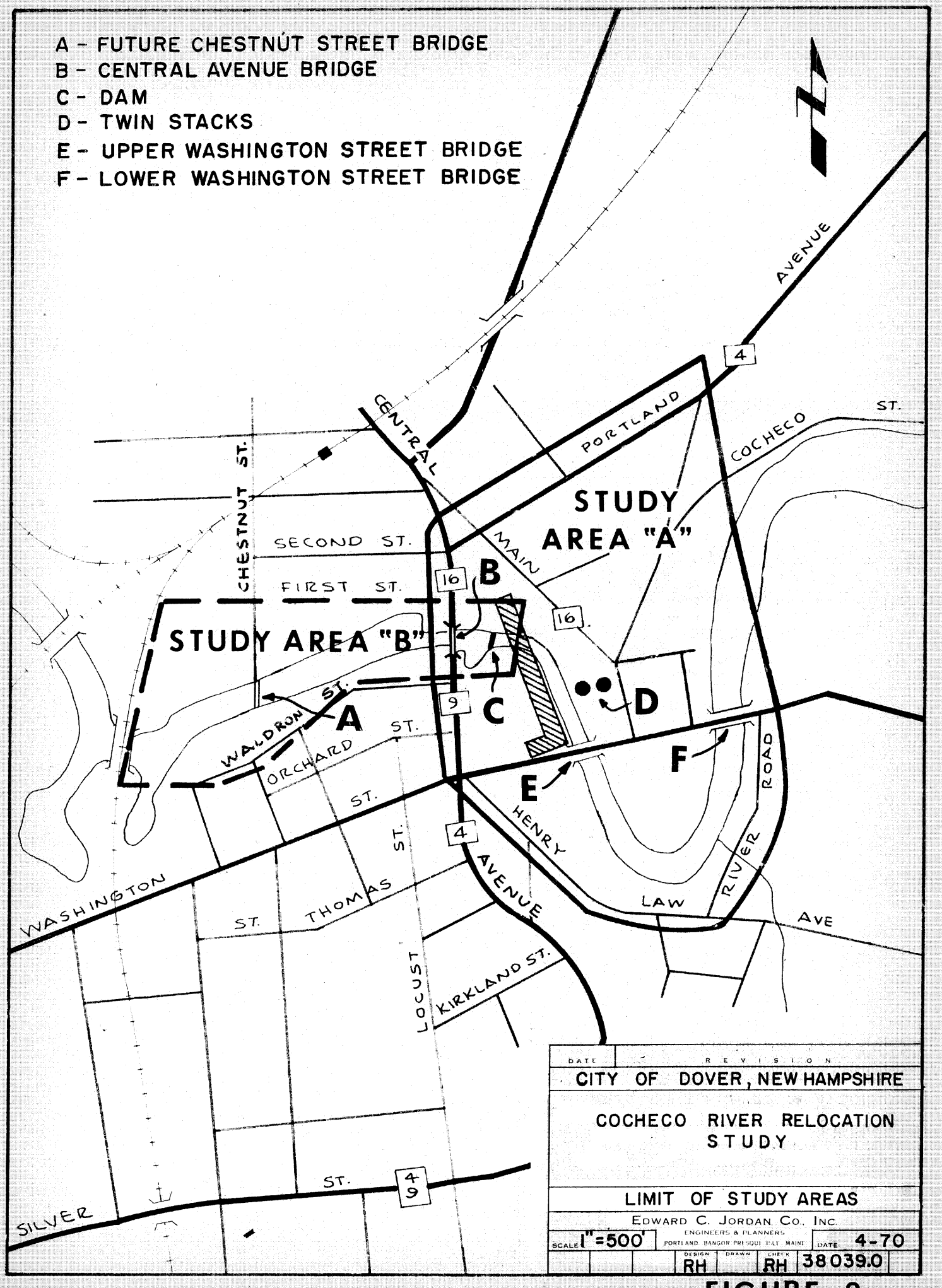
storage for industries located just downstream of the dam. The river passes beneath the Eastern Company building in an arch structure which is a part of the building complex. The building area is essentially the head of tide.

After passing beneath the arch the channel turns nearly 90 degrees to the south and makes a wide bend to the north again. This river bend forms a peninsula which is fully urbanized with industrial and commercial establishments as well as limited residential housing. The general study area is shown on Figure 2.

The City of Dover maintains three highway bridges across the Cocheco in the vicinity of the central business district, two on Washington Street and one on Central Avenue. Recent structural studies have shown these bridges to be in poor condition and in need of extensive repair or replacement.

The Dover Planning Department suggested the possibility of diverting the Cocheco River directly through the peninsula which would eliminate the necessity of the two bridges on Washington Street. Such a diversion would also allow creation of land by filling the old river channel. The City Council decided that a more detailed evaluation of the proposal was warranted.

In July 1968 the City conferred with the Edward C. Jordan Co., Inc., Engineers and Planners of Portland, Maine, concerning a preliminary design and planning study. A proposal was submitted by the Jordan Company and was accepted by the City. Work began on the project in the spring of 1969. This report presents the results of this study.



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CITY OF DOVER, NEW HAMPSHIRE

COCHECO RIVER RELOCATION STUDY

LIMIT OF STUDY AREAS

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1"=500'	RH		RH	4-70

38039.0

FIGURE 2

HYDROLOGIC STUDIES

GENERAL

The Cocheco River has a drainage area above the City of Dover of about 180 square miles. The river becomes tidal in nature at Dover before entering Great Bay on the Piscataqua River. The Preliminary Design of the contemplated diversion structure required a hydrologic analyses of the watershed to predict design flood flows which must be passed. The following paragraphs summarize these studies which were prepared by Mr. Charles E. Fogg, P.E., Special Consultant to the Jordan Company for the Dover Project.

FLOOD FLOWS

The amount of flow passing from a given watershed varies with time depending on rainfall and runoff conditions. The frequency of occurrence of a given flow is also of importance in the design of hydraulic structures. For example, a certain flow is probable each year; a higher flood flow would be expected once every five years; a still higher flood flow would be expected once in ten years, etc.

The greatest flood of record on the Cocheco River occured in 1896. At this time the river crested at a level about nine feet over the dam just below Central Avenue. It is estimated that this flow was about 14,000 CFS (Cubic Feet Per Second). By comparison, the flood of March, 1936, reached an estimated flow of 5,500 CFS with a crest of about 5 1/2 feet above the dam.

It is estimated that the 14,000 CFS flow of 1896 had a frequency of occurrence of about once in 200 years on the average. The 5,500 CFS of

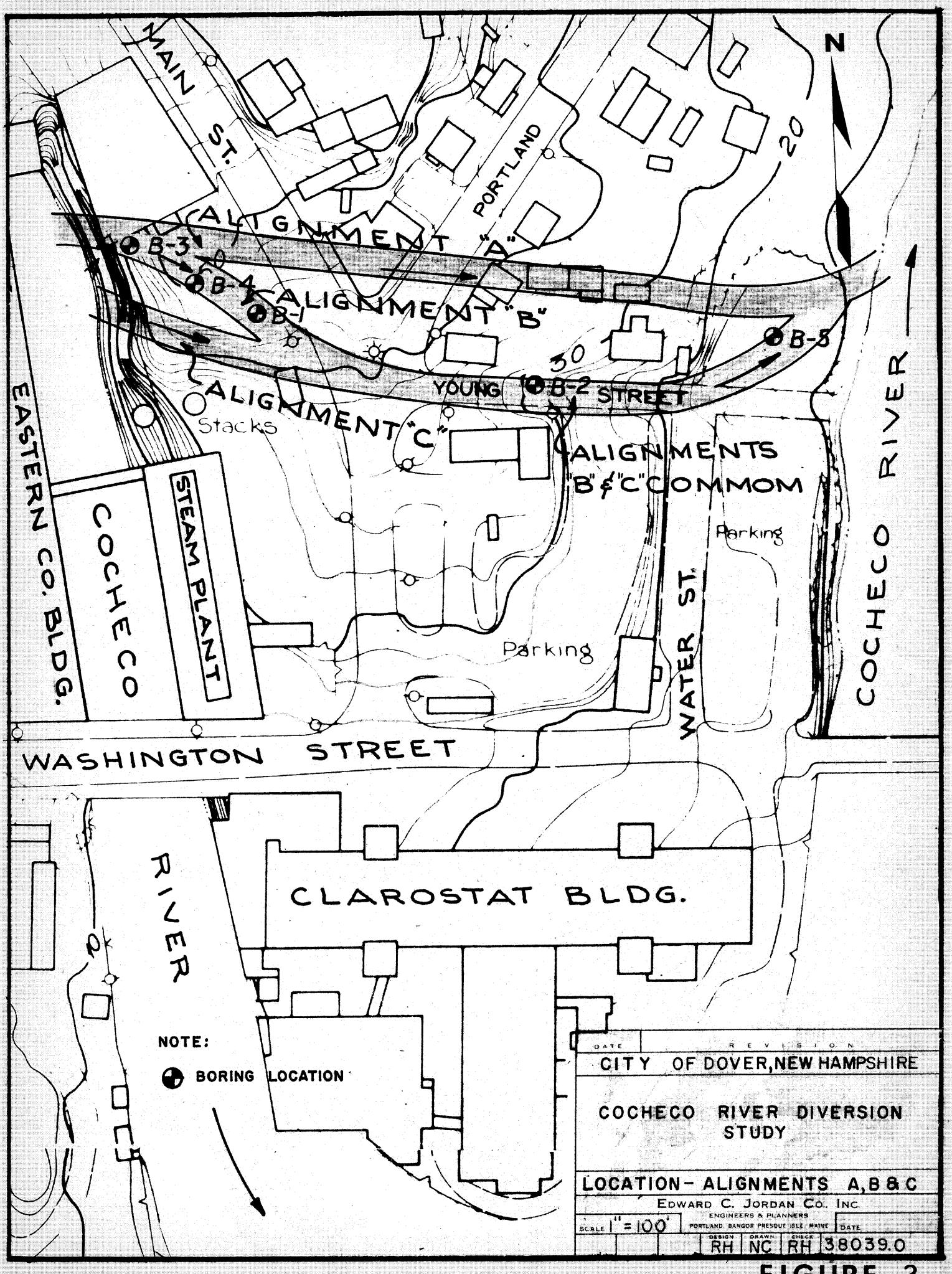
March 1936 has a frequency of occurrence of about once in 20 to 30 years on the average.

We would recommend that the channel diversion structures on the Cocheco River be designed to pass a flood of a frequency of occurrence of once in 100 years without surcharging. Computation by both the Kennison-Colby and Benson and Potter formulas indicate this flow to be about 11,000 CFS. This figure was selected for preliminary design. Discussions were held with representatives of the U. S. Army Corps of Engineers and the Soil Conservation Service of the Department of Agriculture in arriving at the recommended design flow and frequency.

CHANNEL RELOCATION ALIGNMENTS

The basic diversion proposal suggested an alignment directly across the peninsula from the vicinity of the existing arch passage to the channel across the river from the Public Works yard. Topography in the area indicated an alignment in the vicinity of Young Street would be desirable. However, the hydraulics of this location appeared less than desirable. As a result of site evaluation three basic alignments were selected in the vicinity of the Main and Portland Street intersection. These alignments are shown on Figure 3.

Study of topographic plans of the urban area suggested that a more ambitious diversion scheme appeared technically possible. It would be possible to intercept the Cocheco River just upstream of the upper bridge of the Boston and Maine Railroad and pass it through a tunnel structure under the rail yard to Second Street, down Second Street to Main Street, then across-lots to Portland Street entering the river channel again opposite the City pollution control plant.


MAIN ST.
PORTLAND
N
20
ALIGNMENT "A"
B-3
B-4
ALIGNMENT "B"
B-1
B-5
30
YOUNG STREET
B-2
ALIGNMENT "C"
Stacks
EASTERN CO. BLDG.
COCHECO
STEAM PLANT
ALIGNMENTS "B" & "C" COMMOM
Parking
WATER ST.
COCHECO RIVER
Parking
WASHINGTON STREET
CLAROSTAT BLDG.
RIVER
NOTE:
BORING LOCATION
DATE
REVISION
CITY OF DOVER, NEW HAMPSHIRE
COCHECO RIVER DIVERSION STUDY
LOCATION - ALIGNMENTS A, B & C
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SCALE 1" = 100'
DATE
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38039.0

FIGURE 3

Evaluation of this alignment was not a part of our initial assignment. However, the Central Avenue bridge is in poor repair and must be extensively renovated or replaced. Also, traffic studies indicated that a new bridge will be required in the vicinity of Chestnut Street to facilitate traffic flow in the central business district. Thus, it appeared that preliminary evaluation of the longer diversion was warranted. This alignment is shown on Figure 4.

CHANNEL SECTION SIZING

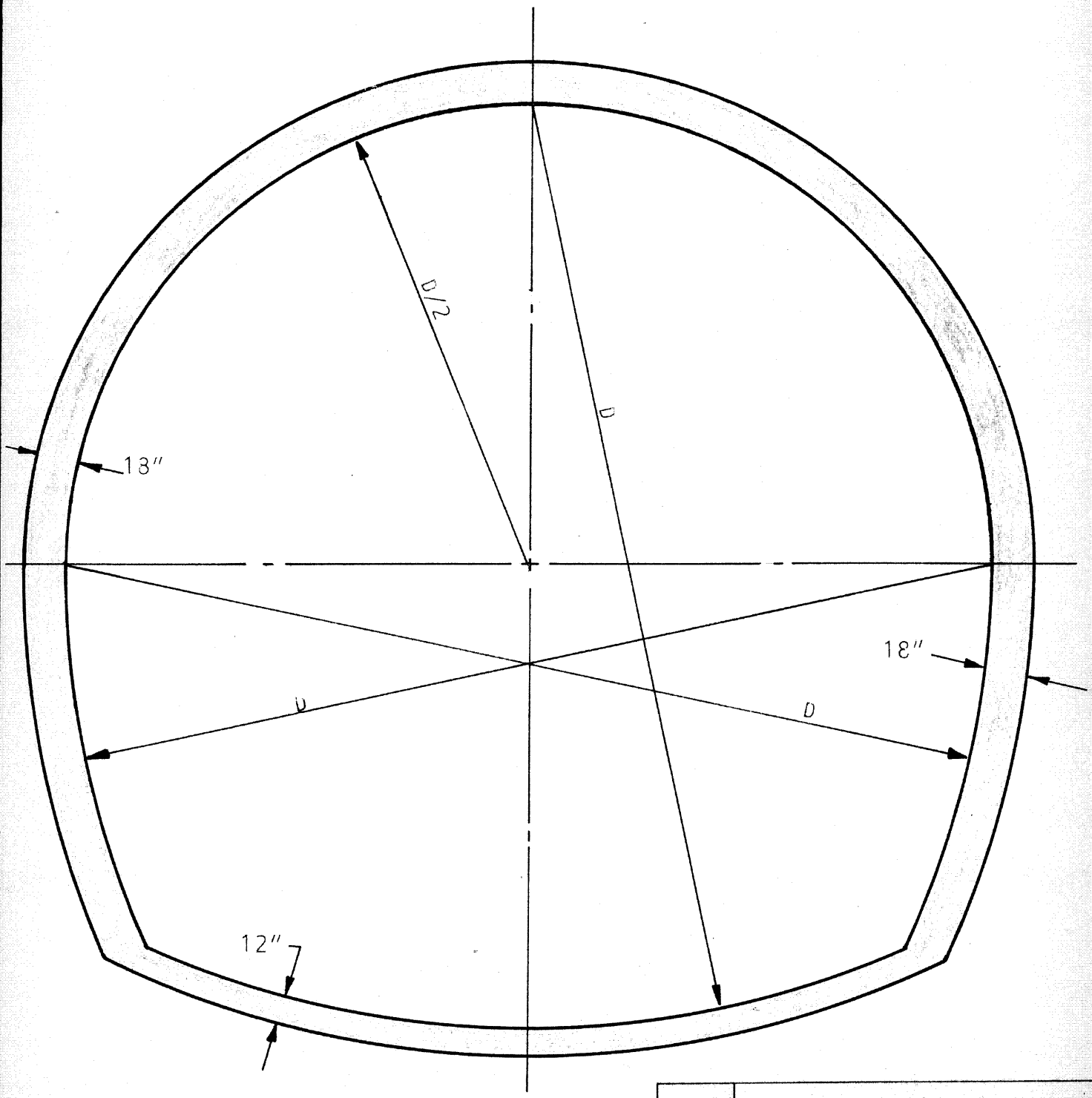
Preliminary hydraulic studies were made to determine tentative channel or conduit sizing required to pass the design flood flow of 11,000 CFS. Two basic channel shapes were evaluated, namely, rectangular and horseshoe, so-called.

Hydraulic profiles for rectangular sections of 30, 40 and 60-foot widths were prepared for Alignment C as shown on Figure 2. This alignment appears to be the one best suited for a rectangular section. Figure 5 indicates the various water surface profiles expected. It should be noted that a 30-foot width is the minimum possible without flooding out the existing archway under the factory building. Such surcharging would not be desirable. The depth of flow in a 30-foot channel would be about 12 feet. Velocity of flow would approach 28 feet per second at design flow. This is an extremely high velocity which will dictate careful structural design of the channel. The high velocities expected will also dictate construction of an energy dissipation device at the outlet of the channel. All computations assume a concrete lined channel, both bottom and sidewalls.

Hydraulic analysis of the horseshoe sections indicates that sizing will vary significantly depending on entrance conditions and on the alignment. Figure 6 shows a typical horseshoe section. Alignments A and B would provide a relatively smooth transition from the existing arch to the horseshoe entrance. This would require concrete wall construction, but would greatly increase hydraulic capacity. Alignment C would create a turbulence pool in the vicinity of the arch and consequently would provide no effective transition. Alignment A, which provides a smooth transition and a straight course, would tentatively require a basic 25-foot horseshoe dimension. Alignment B, with a reasonable transition, but with a curved course, would tentatively require a 30 to 32-foot basic dimension. Alignment C with no transition, would require a minimum 32-foot basic dimension.

Alignment D would be relatively efficient hydraulically and a 24-foot basic horseshoe dimension appears reasonable. Use of this alignment would require a barrier earth fill just downstream from the entrance. It is also noted that the old channel, although filled, would still be the drainage course for surface runoff for the central business district. Thus, either a piped or an open channel drain would be required. To provide flushing action it may be desirable to provide a gate structure in the barrier dam so that controlled flow could be passed. This factor is discussed further under Land Use. Tentative hydraulic profiles of the horseshoe sections for each alignment are shown on Figures 7, 8, 9 and 10.

It should be noted that flow in any channel or horseshoe section will have a high super-critical velocity of 25 to 28-feet per second at design conditions. The impact of this flow where it re-enters the river



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TYPICAL TUNNEL SECTION

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SCALE	DRAWN	CHECK	DATE
1" = 8' = 0"	SV	RH	4-70
	RH		38039.0

FIGURE 6

channel will be severe and special precautions for energy dissipation must be taken. The horseshoe sections will be ended back some distance from the river bank and a transition to an open rectangular channel will be provided. This channel will flare or widen as it approaches the river. This will cause a hydraulic jump in the flow thus reducing discharge velocity. It will probably be necessary to provide additional energy dissipation facilities at the outlet if river turbulence is to be minimized. It will probably be desirable to curve the discharge channel to direct flow downstream rather than directly against the opposite bank.

Curving of either the closed channel, or the open exit channel, will cause super elevation, or piling up, of water on one side of the channel. This must be considered in design of the channels. It must also be noted that the elevation of the river will vary with the tide. The combination of high, super-critical velocities, possible curving of the exit channel, varying tide levels, and a desire to control turbulence in the river creates an extremely complex design condition. Development of final plans for the diversion must carefully consider the interplay of the variables mentioned. It is possible that model studies of the diversion system, and particularly the exit channel and energy dissipation devices, may be worthwhile as part of the final design studies. Such work is, of course, beyond the scope of this preliminary report.

EFFECT OF DAM REMOVAL

Preliminary study was directed at anticipated river flow conditions if the dam just downstream of Central Avenue was removed. Investigations showed that the dam is only about 4 feet high and rests on a natural rock

dike at that location. The crest of the dam is at elevation 34.7, more or less. The dam could be removed and the ledge removed to about elevation 30.0 without undue difficulty. If this were accomplished, the river level upstream would be lowered slightly over 3 feet at design flow conditions. At low flow conditions, the upstream river level would be lowered the same amount as the dam lowering, about 4.7 feet.

Soundings upstream indicate that a significant pool depth would remain after dam removal. The rock dike creates a natural barrier at the location. The bottom of the upstream impoundment is some 10 to 20 feet lower than the crest of the ledge dike. Thus, removal of the dam and ledge to elevation 30 will not have pronounced effect on the upstream area. While the level would be lowered and the width reduced some, a significant pool will remain.

Soundings also indicate that the ledge barrier extends upstream from the dam beneath the Central Avenue bridge. In this urban setting, removal of the ledge barrier sufficient to allow draining of the pool would be extremely difficult and costly. While this would shorten the span of the contemplated Chestnut Street bridge, it will not eliminate the need for a significant structure. The key design criteria for the Chestnut Street bridge will be the flood flow which must be passed and the highway approach conditions. Lowering the water level about 3 feet will not appreciably affect the bridge design. The savings in bridge cost would, in all likelihood, not be sufficient to offset the cost of dam, ledge, bridge and building removal which would be required to lower the pool.

It is understood that the old penstocks which furnished water to the mill buildings are still in place, although little accurate information

on them is available. Utilization of these conduits could lower the pool level somewhat during the flow conditions. However, their capacity is limited and would not affect the river level during flood flow conditions.

Study was also made to evaluate the effect of removing the dam and smoothing the ledge downstream of Central Avenue to provide a smoother transition from the dam location into the arch under the building. This work would have only minor affect (less than one foot) on the expected water levels at design flow. Thus, this ledge excavation work for channel improvement would not appear to be warranted.

Consideration was also given to existing drain and sewer discharges to the Cocheco River above Central Avenue. If the water level were lowered appreciably the existing outfalls would be exposed. This would be an esthetic problem as long as combined waste water were being discharged. It would be less of a problem after the sanitary sewer intercepting program were complete. However, it might be desirable to lower the drain lines so that even storm drain outfalls are submerged.

Study also showed that if the dam and ledge barrier were removed it would be possible to run a sanitary intercepting sewer from the area above Central Avenue through the diversion channel. This would eliminate the need of a pumping station in the area. However, the interceptor line through the channel will be costly and will service no new areas. It is doubtful if any appreciable cost savings could be realized by the gravity interceptor through the channel. Any savings certainly would not justify the cost of dam and ledge barrier removal.

DIVERSION CONSTRUCTION TECHNIQUES

Channel diversion such as proposed for the Cocheco River in Dover will require a major excavation effort in a compact urban setting. Two basic excavation procedures have been considered for the project, namely, open cut and tunneling.

Borings were taken by Northeast Soil Services of Brewer, Maine, along the primary cutoff location in the vicinity of Main and Portland Streets. The location of these borings is shown on Figure 3. These borings indicate ledge about 3 to 10 feet below the surface. Rock cores were also taken for analysis. A copy of the boring logs and soils analysis are attached to this report as Appendix A. The rock cores are on file at the Portland Office of Jordan Gorrill Associates, Soils Engineers.

Open cut procedures could be utilized on all alignments described in the foregoing section except Alignment D, the long diversion, for which tunneling would, in all likelihood, be required. An open cut channel would be rectangular in the lower section with widths ranging from a minimum of 30 feet for Alignment A, which is straight, to 35 feet, more or less, for the curved alignments. The open cut method would require cuts of up to 55 feet in depth. It would not be considered reasonable to leave such a cut open in the urban area. It would be esthetically undesirable and potentially dangerous, even with security fencing. Thus, we would consider it mandatory to cover the channel over most of its length. This should be accomplished by concrete construction, as steel framing would be a continual corrosion and maintenance problem, in many ways similar to the existing Central Avenue

bridge. To support backfill and traffic loading for the 30 to 35 foot span would require a reinforced concrete arch section.

It is noted that open cut procedures could be used on Alignments A and B only if the existing brick structure is removed. Alignment C could be installed by open cut without removing the building, although the hydraulics of this alignment are the poorest of those studied. Open cut procedures would also create interruption potential for utilities such as water and sewer and would accentuate the traffic problem as Main Street would be cut off for a period of time.

Tunnel excavation would be in the form of a horseshoe section as described earlier. To assess this method the Jordan Company consulted with the Perini Corporation of Boston, contractors with a large amount of experience in tunneling work. It can be concluded that rock tunneling procedures are adaptable to any of the studied alignments. Tunneling would be the only acceptable procedure for Alignment D.

It is considered possible to accomplish Alignment A by tunneling procedures without removing the existing structures over the tunnel, although careful blasting techniques would be required. Due to the increased size required for curved Alignment B it would probably be necessary to remove the existing structure adjacent to the existing channel. It is also noted that tunneling control on curved alignments is more difficult and costly than a straight alignment.

Alignment C could be tunneled, although a 32-foot unit would be required and some limited curvature would exist. The existing building would not be disturbed by Alignment C.

Tunneling procedures would be much less disruptive to the area than would open cut procedures. The tunnel would be far enough below ground surface so that underground utilities would not be appreciably disturbed. Auto and pedestrian traffic on the surface would be essentially unimpeded. It should be noted, however, that even if a basic tunneling procedure is adopted some open cut channel work will be required for the exit channel. In general, the open exit channel will begin when the depth of cover is insufficient for continued tunneling. The exit channel may be partially covered, although much of it will remain open for economy. The location of the exit channel away from Main Street will minimize esthetic and safety problems, particularly if the land use control and landscaping of the area are considered a part of the project. This is discussed in a later section of the report.

A comparative cost analysis was made of open cut versus tunnel procedures for Alignment A. While actual costs may vary depending on a contractor's evaluation of the problems of each system, we believe that open cut procedures would cost 15 percent to 20 percent more than tunnel procedures. This, combined with the public inconvenience caused by open cut work, indicates that tunnel procedures would be best suited to the diversion project. Cost data presented in later sections of the report are based on tunnel procedures.

A sidelight worthy of note is the location and condition of the two masonry stacks at the municipal power plant adjacent to the existing channel at Washington Street. It is our opinion that these stacks would be a hazard during channel construction in the area. This would be the case

regardless of the excavation procedures used. Prior to construction of the channel diversion the stacks should be removed and replaced with a steel stack with an induced draft system. The new stack would be designed and guyed to be stable during blasting operations. Reports on the condition of the stack suggest that replacement may be in order even if channel diversion were not attempted.

COST ANALYSIS OF ALTERNATE ALIGNMENTS

BASIS FOR ESTIMATES

Capital cost estimates have been prepared for the alternate flow diversion structures and their appurtenant channel filling requirements. As initial study and soils analysis indicated tunneling techniques best suited to any diversion structure, we retained Mr. D. C. Cannon of the Perini Corporation as special consultant on tunnel costs. The costs carried in this report for the tunnel structures are based on Mr. Cannon's recommendations.

The cost of entrance and exit structures for the diversion are based on estimated unit costs for excavation and reinforced concrete work, typical of those received for similar work in New England. Allowances have also been made for diking or water control. It should be emphasized that costs given in this report are not based on working drawings and specifications and are preliminary in nature. However, we believe they reasonably reflect the magnitude of the project and will provide a sound basis for more detailed planning.

An allowance has been made for engineering and contingencies which will be required for project implementation. We have allowed a factor of 25 percent for these items on the flow diversion phase of work, and 20 percent for other more routine work items.

Certain land or right-of-way will have to be acquired for any of the proposed alignments. As the cost of such acquisition varies so widely with local conditions, we have not included this item specifically in our estimates. However, for river diversion this cost should be relatively small

in comparison with the total project. Certain legal investigations into the right of riparian owners along the old stream channel should be accomplished prior to construction. These costs are also not included in the estimates of this report.

CAPITAL COSTS - FLOW DIVERSION STRUCTURES

The comparative capital costs of the alternate alignments for flow diversion are given in Table 1. It should be noted that Alignments A, B and C are directly comparable, while Alignment D represents a much more extensive tunnel system. Analysis of Alignments A, B and C indicates the least cost route to be Alignment A. This alignment permits the longest enclosed tunnel and shortest exit channel. This would be a desirable feature of Alignment A.

TABLE 1

COMPARATIVE CAPITAL COSTS

ALTERNATE DIVERSION ALIGNMENTS

ALIGNMENT A

Entrance Transition	$ 100,000
Tunnel	550,000
Exit Channel - Energy Dissipator	325,000
New Stack, Etc. and Steam Plant	25,000
Construction Subtotal	$ 1,000,000
Engineering and Contingencies (25%)	250,000
Estimated Total Cost - Alignment A	$ 1,250,000

ALIGNMENT B

Entrance Transition	$ 120,000
Tunnel	700,000
Exit Channel - Energy Dissipator	530,000
New Stack, Etc. and Steam Plant	25,000
Construction Subtotal	$ 1,375,000
Engineering and Contingencies (25%)	340,000
Estimated Total Cost - Alignment B	$ 1,715,000

ALIGNMENT C

Entrance Transition	$ 75,000
Tunnel	480,000
Exit Channel - Energy Dissipator	530,000
New Stack, Etc. and Steam Plant	25,000
Construction Subtotal	$ 1,110,000
Engineering and Contingencies (25%)	280,000
Estimated Total Cost - Alignment C	$ 1,390,000

ALIGNMENT D

Entrance Structure	$ 200,000
Tunnel	2,600,000
Exit Channel - Energy Dissipator	300,000
Construction Subtotal	$ 3,100,000
Engineering and Contingencies (25%)	775,000
Estimated Total Cost - Alignment D	$ 3,875,000

CAPITAL COSTS - OLD CHANNEL FILLING

The excavated material from any of the diversion alignments would be placed as fill in the old river channel. The cost of this placement is included in the diversion structure costs. However, study indicates that this spoil material represents only a small portion of the total fill required to bring the old channel up to a reasonable grade for further use. About 150,000 cubic yards of supplemental material will be required.

After filling the old channel to a reasonable level it will still be lower than the surrounding ground and will thus collect surface drainage. A storm drain system will be required in the old channel to provide for this surface water flow.

By filling the channel, the old bridges will not be required. These would be removed and replaced with new roadway on a fill. Alignments A, B, and C would permit both Washington Street bridges to be removed. Alignment D would allow the Central Avenue bridge and the proposed Chestnut Street bridge to be abandoned in addition to the Washington Street bridges.

Once the filling, drainage and bridge removal were complete, the created land would be in rough grade form ready for development. The capital cost of this site preparation work is given in Table 2.

TABLE 2

CAPITAL COST ESTIMATES

CHANNEL FILLING AND BASIC SITE WORK

ALIGNMENTS, A, B, AND C

Furnish and Place Fill	$ 200,000
Install Site Drains	50,000
Remove Washington Street Bridges	20,000
Street Construction at Bridge Sites	30,000
Construction Subtotal	$ 300,000
Engineering and Contingencies (20%)	60,000
Estimated Total Cost	$ 360,000

ALIGNMENT D

Furnish and Place Fill	$ 600,000
Install Site Drains	450,000
Remove Bridges	50,000
Street Construction at Bridge Sites	50,000
Construction Subtotal	$ 1,150,000
Engineering and Contingencies (20%)	230,000
Estimated Total Cost	$ 1,380,000

SUMMARY - BASIC PROJECT COSTS

The above tables present cost breakdown for both the diversion structures and the appurtenant channel filling and bridge removal. This work would rough grade the new land making it ready for development, but

would make no surficial improvements. This work is designated as the "BASIC PROJECT". Land use and associated development costs are carried in a later section. The Basic Project Costs are summarized in Table 3.

TABLE 3

SUMMARY BASIC PROJECT COSTS

ALIGNMENT A	
Diversion Costs	$ 1,250,000
Site Costs	360,000
Total Basic Project Costs	$ 1,610,000
ALIGNMENT B	
Diversion Costs	$ 1,715,000
Site Costs	360,000
Total Basic Project Costs	$ 2,075,000
ALIGNMENT C	
Diversion Costs	$ 1,390,000
Site Costs	360,000
Total Basic Project Costs	$ 1,750,000
ALIGNMENT D	
Diversion Costs	$ 3,870,000
Site Costs	1,380,000
Total Basic Project Costs	$ 5,250,000

RECOMMENDED CHANNEL ALIGNMENT

Based on the cost analysis of the previous section we recommend Alignment A be adopted if the flow diversion is to be implemented. Of the shorter alignments it proves the most economic and is hydraulically the most efficient.

We do not believe the benefits gained by the longer diversion of Alignment D can possibly offset the basic project cost of over five (5) million dollars. It is also noted that Alignment D would limit downstream use of water for both the industrial plants and the steam plant. While this could perhaps be overcome by other action, it further discourages consideration of Alignment D.

LAND USE STUDIES

GENERAL

The basic objectives of the Cocheco River Diversion Study can be summarized as follows:

1. The elimination of the capital and maintenance costs of bridge replacement over the lower Cocheco River.
2. The creation of new land in the old river bed which could be used in a manner that will enhance the urban core area.
3. Minimization of upstream bridge and utility costs by lowering the river level.

Full evaluation of the project as it may meet these basic objectives must be related to land use planning in both the project area and the surrounding areas. Land use proposed for the created land must be compatible, or complimentary, to adjacent areas, and must be a part of an overall development plan.

We have accomplished limited land use planning in the project area below Central Avenue. While this land use planning is preliminary in nature, we believe it represents an illustration of the type of usage which would compliment the urban core area.

On this basis we have prepared certain cost-benefit relationships for the project. It is recognized that final development plans may vary significantly from the illustrative plans shown. However, we believe the cost-benefit relationships will remain essentially valid for any reasonable development program within the concepts presented.

EXISTING LAND USE

This section briefly describes the present usage of land in the study area and adjacent environs. This data serves as a basis for preliminary land development proposals. Plan 1, at the rear of the Report, illustrates the existing land use.

The central business district of Dover is concentrated in a strip along Central Avenue from the vicinity of Second Street to the vicinity of City Hall. The westerly side of Central Avenue is more heavily developed with shops, stores and offices. A limited amount of off-street parking is provided on the easterly side of Central Avenue.

Directly east of the Central Avenue business district is an industrial area. Two major industrial structures dominate the area. These are the buildings now occupied by the Eastern Company and by the Clarostat Company. These structures are typical of late 1800 or early 1900 industrial buildings generally developed for the textile industry. The municipal steam plant is also located in this industrial complex. Although the industrial structures are quite old they appear reasonably well maintained and will continue to be a significant part of the economic life of the community, and will continue to affect the character of land use in the area.

The area northerly of Washington Street and easterly of Main Street is primarily residential in nature with a few small shops. However, a good number of the buildings in this residential area appear substandard, and the residential character of the area is greatly affected by the adjacent industrial use and its demand for parking. As the Eastern and Clarostat buildings were constructed prior to the advent of the automobile, parking was not

provided. As modern day transportation in Dover is primarily via automobile, a severe parking problem has developed in the area. Both on-street and off-street parking in the area has accelerated the general blight of residences in the area.

The area southerly of Washington Street, between Henrylaw Avenue and the river, is mostly open space with some recreational usage. The municipal recreation center and indoor pool are located in the vicinity of the intersection of Washington Street and Henrylaw Avenue. The remaining river bank around the bend to the vicinity of the easterly Washington Street bridge is essentially undeveloped open space. The area southerly of Henrylaw Avenue is residential in nature.

The easterly bank of the river down stream from the lower Washington Street bridge is utilized for municipal purposes, namely, the public works garage and the pollution control plant.

PRELIMINARY DEVELOPMENT PLANS

General

Study of the existing land use plans indicates that redevelopment of the project area will be constrained by certain characteristics of the present land use patterns. These constraints are summarized as follows:

1. The Eastern Company and Clarostat Buildings must remain and will be a dominating feature of the project area.

2. The municipal pollution control plant location is fixed, and the generally central location of the public works area adjacent to the plant dictates continued use of the easterly river bank northerly of Washington Street for municipal purposes.
3. The area between Henrylaw Avenue and the river is currently used for recreational purposes near Washington Street, and may be legally restricted for intensive usage other than open space.

Review of land use patterns in light of the basic project objectives indicated that Washington Street should be continued as a through street and that both bridges could be eliminated by the diversion project with proper channel filling. Diversion of the river would also allow creation of about 4 to 5 acres of new land in the old river channel.

Study of the area indicates that additional off-street parking is needed both to service the central business district and the industrial concerns in the area. Redevelopment of the area should provide for this parking in conjunction with the current urban renewal project westerly of Central Avenue.

We also believe that further development of planted open spaces, or a "green belt", should be included in any redevelopment plan. Such a green belt would ease the domination of the area by the large industrial buildings. This domination by the industrial buildings will become even more severe if expanded parking is provided without concurrent provision of green areas to break up the general starkness of the area.

It is also apparent that continued use of the residential area in the vicinity of Main and Portland Streets is limited in its present form. Housing in the area that is not currently substandard will, in all likelihood, become so. The need for residential units in the area can probably best be provided by new high density units in the redevelopment area.

Redevelopment With Stream Diversion

Utilizing the existing land use plans, and the project objectives and constraints discussed previously, we have developed a preliminary redevelopment plan for the project area assuming that the stream diversion has been accomplished and the old stream bed has been filled. This tentative redevelopment proposal is shown on Plan No. 2 at the rear of the report.

The key feature of this redevelopment plan is an open space green belt along the old river channel from the westerly Washington Street bridge around the bend to the easterly bridge. Use of this area would be divided between passive recreation or open space and active recreation. The area would be landscaped and provided with walkways and benches. A portion of the area would be developed for "tot lots" for younger children, and tennis courts, softball fields and other active game areas. The active recreation area would be closely coordinated with the existing pool and recreation center. A small parking facility would be included to service the recreation areas. The parking area would preferably be located adjacent to Henrylaw Avenue, or could be located on the filled area away from the street if necessary.

Additional parking would also be provided in the development plan. In the filled stream bed, adjacent to the vicinity of the easterly Washington Street bridge, parking would be provided for workers in the Clarostat Building. The area between the steam plant and the Eastern Company Building would also be developed for limited parking. This parking area is close enough to Central Avenue to serve the business district, and it may be desirable to reserve it for such use.

The redevelopment plan also provides additional parking in the vicinity of Washington Street between Main Street and the river. This would replace the few existing substandard buildings in the area. All of the parking lots would be reasonably landscaped to relieve the monotony of such areas.

The Cocheco River is tidal to the vicinity of the Eastern Company Building arch. The U. S. Government maintains a channel from the confluence of the Cocheco River and the Piscataqua River to the vicinity of the easterly Washington Street bridge, a distance of about 3 miles. The Government Channel varies from 50 to 75 feet in width with a 7-foot depth at mean low water. The Channel project was adopted in 1890 and initial work completed in 1906. The U. S. Army Corps of Engineers conducted a hydrographic survey on the channel in 1967 and 1968. This survey indicated that some siltation of the channel had occurred since 1906. About one-half of the length of the channel did not meet the 7-foot channel depth designation. However, most of the channel does have water depths of over 5 feet.

The Cocheco River channel provides access to the Piscataqua River, Great Bay, and eventually to the Atlantic Ocean. With increased demand for boating and water based recreation, the City of Dover should consider

utilizing its proximity to large, protected water areas and the access provided by the Government Channel by development of a marina facility. While the channel is not at authorized depth, it is usable by most small and moderate sized recreational type boats. With reasonable maintenance dredging or excavation it could be restored to its authorized depth and width.

The development plan suggests the installation of a marina facility on the westerly side of the river below Washington Street. This marina facility would be blended in with the landscaped green belt to provide more open space in the area. The marina facility would consist of a boat launching ramp, piers and docks for access and boat tie-up, service buildings and parking areas. The extent of shore facilities would be gaged to demand or usage of the marina. Future development could include a restaurant and club house. It is proposed to provide a landscape screening on the easterly bank of the river across from the marina to shield the public works area and the pollution control plant. Such screening is desirable to enhance the esthetics of the marina area.

The overall development plan indicates removal of all of the residential units between Portland Street and the river. It is recognized that such acquisition creates a relocation problem for the residents. This factor must be considered in the City's Public Housing Program.

There is likely a need for residential units in the project area. The location provides easy pedestrian access to the central business district, and to two significant industrial employers. The creation of a green belt and recreational facilities, both water and land based, will compliment residential units and will provide the esthetic environment now missing in the area.

As space is limited in the area, it is likely that high density housing would be most adaptable. A moderate or high-rise structure would not be out of place and may even compliment the massive existing structures of Eastern Company and Clarostat. The tentative development plan shows such housing in the area bounded by Portland, Main and School Streets.

To compliment the central business district the area bounded by Main, School, Mechanic Streets and Portland Avenue would be developed commercially. Commercial usage of this area is now present, but would be expanded as demand allowed. The area easterly of Mechanic Street is now single and multi-unit residential. This area would continue in residential use with rehabilitation of existing units, and addition of new units emphasized.

It is emphasized that the redevelopment program described above and shown on Plan 2 is tentative only showing potential use patterns. In the final program the City Planning Board, City Council and potential developers may adjust or alter the program to best meet the needs of the City.

Cost-Benefit Analysis

The foregoing development plan with channel diversion meets the general project objectives. However, the cost of meeting the objectives must be weighed against the development costs. We have prepared a preliminary overall cost analysis indicating the approximate cost-benefit ratio of the diversion project and development proposal. This analysis is described in this section.

The basic project as described in an earlier section consists of the channel diversion, rough grading of the old channel, installation of

basic surface drainage, and the removal of the existing Washington Street bridges. The cost of this basic project has been estimated at $1,610,000.

We have estimated costs for development of the green belt recreational areas and the basic marina costs. These costs are summarized in Table 4. Estimates include basic development of the green belt, marina, and industrial area parking. Residential and commercial redevelopment in the Main-Portland Street triangle is not included due to its wide variability and the likelihood of encouraging private development.

The costs shown do not include land acquisition and relocation costs. This data can be more accurately provided by the City Assessor or the Urban Renewal Authority. Thus, the total project cost (excluding land and relocation) for the basic diversion project and redevelopment of the area is estimated at about 2.5 million dollars.

The City will accrue certain direct benefits from the project as well as many indirect benefits. The reconstruction of the two Washington Street bridges will not be required if the diversion project is accomplished. The lower bridge is estimated at about $200,000 and the upper bridge is estimated at about $100,000. Thus, a direct benefit of about $300,000 is gained by elimination of bridge construction. In addition, about 4 1/2 acres of new land is created for City use. The remaining value to the City of the diversion project is the value of this land which, in turn, is related to the value of the usage to which it may be put.

It is difficult to place a firm value on the created land. However, for analysis, assume a value of $2 per square foot which is probably a liberal amount. With this assumption a value of about $400,000 could be

TABLE 4

ESTIMATED DEVELOPMENT COSTS *

WITH STREAM DIVERSION

CHANNEL SITE DEVELOPMENT

Parking Lots	$ 150,000
Recreational Facilities	50,000
Site Work - Landscaping	100,000
Subtotal	$ 300,000

MARINA DEVELOPMENT

General Site Development	$ 150,000
Service Buildings	50,000
Pier and Marine Work	100,000
Parking Areas	50,000
Subtotal	$ 350,000

PARKING - VICINITY MAIN-WASHINGTON

Parking Areas	$ 90,000
Landscaping	10,000
Subtotal	$ 100,000

SUMMARY

Estimated Construction Costs	$ 750,000
Engineering & Contingencies (20%)	$ 150,000
Project Total	$ 900,000

* Land and relocation costs not included.

realized which, when combined with the bridge benefits, amounts to a total benefit of about $700,000. This can be compared with the basic project cost of $1.6 million dollars to arrive at a tentative cost-benefit ratio. This cost benefit ratio is about 0.44 to 1. That is, only 44 cents of benefit is derived for each dollar spent. Thus, the indirect benefits to the City of being able to redevelop the green belt and recreation area must amount to at least $900,000 to achieve a cost benefit ratio of 1 to 1. While these indirect benefits exist, it is difficult to justify this amount, particularly if alternate procedures could secure the project objectives at less cost.

Redevelopment Without Stream Diversion

The high cost of the channel diversion project in relation to the benefits gained indicated that re-evaluation of the development should be accomplished assuming the channel was not diverted. We have prepared an alternate redevelopment plan for the area without diversion. This is discussed in the following paragraphs and is shown on Plan No. 3 at the rear of the Report.

Hydraulic studies of the Cocheco River for stream diversion also indicate that the peak flows could be passed from the archway around the bend to below the easterly Washington Street bridge in a somewhat narrower channel than now exists. Thus, by channel work and selective filling it would be possible to create a reasonable amount of land without total stream diversion.

The development of a green belt recreational area would appear completely compatible with an open channel in the present location. It is estimated that an additional 2 acres of land could be created in the area which combined with the present space area adjacent to Henrylaw Avenue would be adequate for recreational development.

As pollution control projects on the Cocheco River become completed the water quality should be sufficient to allow reintroduction of a fishery in the river. Such a fishery could be beneficial to recreational usage of the green belt.

Parking in the vicinity of the Clarostat Building could be provided in a similar manner by channel adjustment. Parking between the steam plant and the Eastern Building could not be provided in this plan as it was in the stream diversion plan.

The remaining redevelopment plan without stream diversion, including the marina and residential area, would be identical with the plan with diversion. The essential elements of land use and development are provided in a similar manner in both plans.

Cost-Benefit Analysis

We have prepared a cost-benefit analysis of the basic redevelopment plan without stream diversion in a similar manner to the analysis with stream diversion. The overall estimated project costs (without land acquisition and relocation) are shown in Table 5.

The total redevelopment cost without diversion is seen as $1,548,000 as compared to $2,510,000 with stream diversion. The basic project cost, i.e., bridge replacement or substitution and channel improvements, can be compared

TABLE 5

REDEVELOPMENT COSTS *

WITHOUT STREAM DIVERSION

BASIC CHANNEL SITE IMPROVEMENTS

Channel Improvements	$ 360,000
Lower Washington Street Bridge	180,000
Upper Washington Street Bridge	100,000
Subtotal	$ 640,000
Engineering and Contingencies (20%)	128,000
Basic Channel Total	$ 768,000

MADE LAND DEVELOPMENT

Landscape - Recreational Development	$ 100,000
Parking Areas	100,000
Subtotal	$ 200,000
Engineering and Contingencies (20%)	40,000
Total - Made Land Development	$ 240,000

MARINE DEVELOPMENT

Same as Table 4	$ 420,000

PARKING VICINITY MAIN-WASHINGTON

Same as Table 4	$ 120,000

SUMMARY

Redevelopment Costs $1,548,000

* Land acquisition and relocation costs not included.

as $1,610,000 with diversion and $768,000 without diversion. Thus, it can be seen that the basic project objectives and the ultimate redevelopment of the area can be accomplished at much less cost by not diverting the Cocheco River channel.

The benefits received by the basic project are the replacement of the existing Washington Street bridges and the creation of about 2 acres of made land. The value of the bridges is about $360,000. For comparative purposes at $2 per square foot the land value would be about $180,000, making a total value of about $540,000. When compared with a basic project cost of $768,000, a cost-benefit ratio of about 0.7 to 1 is achieved. Assuming that only basic costs are considered, this cost-benefit ratio cannot justify the project, although it comes much closer to doing so than the diversion project does. Again, however, the project must be evaluated in light of the overall benefit and betterment to the City to fully redevelop the area.

Summary Cost Analysis

In actuality the analysis indicates that land created in the river channel, either with full diversion, or with channel improvement, is not worth the cost of creating it. In most ways the redevelopment concepts contained in this Report can be achieved without significant land creation in the river. The existing open space between Henrylaw Avenue and the river can be improved and developed for recreational usage. Only minimal river channel changes would be required.

Industrial area parking can be provided on existing land or on minor amounts of new land created by channel improvements. Proper design

and lanscaping of these parking areas can blend them reasonably well with redevelopment plans. Thus, it is our belief that reasonable development of the study area can be achieved without stream diversion and with only limited existing channel improvements.

INTERESTED FEDERAL AND STATE AGENCIES

REGULATORY AGENCIES

The proposed diversion and channel improvements will be located in tidal water. Such construction, particularly as related to the established navigation channel, will come under the jurisdiction of the U. S. Army Corps of Engineers. It is likely that project planning review and approval of the Corps will be necessary for work in the area. Conferences should be held with Corps officials prior to final planning of any project in the area.

The State of New Hampshire will also be concerned with the project through its Water Supply and Pollution Control Commission and its Fisheries Agency. Coordination with appropriate State agencies should be achieved with any stream related project.

POTENTIAL PARTICIPATING AGENCIES

Redevelopment of the study area either with or without stream diversion will be a major undertaking for the City of Dover. It would be desirable for the City to carefully evaluate any Federal aid programs which may be available to assist in the capital cost of implementation. We have made a preliminary review of programs which may have application to the Dover project. It must be emphasized, however, that the vagaries of Federal programs are such that firm eligibility criteria are difficult to determine in the early stages of project development. We would suggest that the project be reviewed in detail with the various agencies to determine which may be most applicable.

The possible aid programs and agencies are summarized as follows:

1. U. S. Army Corps of Engineers. The Corps of Engineers is the controlling agency in maintaining the designated Cocheco River Navigation Channel. Maintenance and improvement dredging which would help marina development would be accomplished through this agency. Government financial participation in this work would be quite likely if funds were available.

2. The Department of Housing and Urban Development administers an open space land program as provided in the Housing Act of 1961 as amended. This program is handled by the Community Resources Development Administration of HUD for the purpose of acquiring, developing and preserving open space land for public use. This open space should help provide recreational, conservation and scenic areas and should assist in preventing urban blight.

3. The Department of Housing and Urban Development also administers an urban beautification program which is directed at street landscaping, plantings, upgrading parks and malls, etc.

4. The Bureau of Outdoor Recreation of the Department of Interior has created a Land and Water Conservation Fund. The funds of this program are administered by a designated State agency, usually the appropriate State Parks Agency. These funds may

be made available for recreation projects which are consistent with an overall State plan for outdoor recreation.

5. Redevelopment of the project area could also be included in an urban renewal project under the Housing Act of 1949. The City of Dover is now involved in the urban renewal process and this area may be a logical future program for the Renewal Authority.

6. The State of New Hampshire Department of Public Works and Highways may assist the City in reconstruction of the Washington Street bridges to some degree.

APPENDIX A

BORING LOGS

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 1 OF: 3

BORING No. 1 DATUM: BORING INSPECTOR: DATE 5-7-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH		DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
									CASING SIZE $2\frac{1}{2}$"
	0'0"	2"	Top of ground						SPOON 2" O. D. 1 3/8" I. D.
	0'2"		Tar	17	12"				
		3'6"	Brown gravely silty sand	7	"				
				71	"	24 30	6" 6"	1D	
	3'8"			159	8"	80	6"		
							24"	1R	Recovery 24" or 100%
			Rock						
							24"	2R	Recovery 24" or 100%
							60"	3R	Recovery 60" or 100%
		52'0"							
			Losing wash water returns				60"	4R	Recovery 60" or 100%
			from 16' down thru to						
			bottom of exploration						
							60"	5R	Recovery 60" or 100%
	25'0"						60"	6R	Recovery 60" or 100%

HAMMER: CASING 300 # AVG. FALL 16 ins. SAMPLER 140 # AVG. FALL 30 ins.

REMARKS

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌯ Ground Water Surface

over

Northeast Soil Services

BORING LOG

Job # 664

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 2 OF: 3

BORING No. 1 DATUM: BORING INSPECTOR: DATE 5-7-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								CASING SIZE $2\frac{1}{2}$"
	25'0"	Continued						SPOON 2" O. D. 1 3/8" I. D.
		Rock						
						60"	7R	Recovery 60" or 100%
						60"	8R	Recovery 60" or 100%
						60"	9R	Recovery 60" or 100%
						60"	10R	Recovery 60" or 100%
	50'0"							

CASING 300 # AVG. FALL 16 ins.

SAMPLER 140 # AVG. FALL 30 ins.

REMARKS

52'6"

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌶ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire

STRUCTURE: River Diversion

SHEET No. 3 OF: 3

BORING No. 1 DATUM:

BORING INSPECTOR: DATE 5-7-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
	50'0"	Continued						CASING SIZE 2½" SPOON 2" O. D. 1 3/8" I. D.
						60"	11R	Recovery 60" or 100%
		Rock 52'6"						
						36"	12R	Recovery 36" or 100%
	55'8"							
		Bottom of exploration						

HAMMER: CASING 300 # AVG. FALL 16 ins.

SAMPLER 140 # AVG. FALL 30 ins.

REMARKS

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌯ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 1 OF: 2

BORING No. 2 DATUM: BORING INSPECTOR: DATE 5-8-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								CASING SIZE 2½"
	0'0"	Top of ground						SPOON 2" O. D. 1 3/8" I. D.
	0'2"	Tar	28	12"				
		Brown gravely silty sand	7	"				
			11	"	4 2	6" 6"	1D	
	4'0"		12	"	3	6"		
		Brown silty sand	17	"				
			12	"	3 3	6" 6"	2D	
			17	"	7	6"		
			19	"				
	9'0"		22	"				
		Brown silty sand & shale	60	"				
			45	"	27 18	6" 6"	3D	
	11'5"		200	5"	22	6"		
		Rock				24"	1R	Recovery 24" or 100%
						36"	2R	Recovery 36" or 100%
						60"	3R	Recovery 60" or 100%
	25'0"					60"	4R	Recovery 60" or 100%

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌶ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 2 OF: 2

BORING No. 2 DATUM: BORING INSPECTOR: DATE 5-8-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
	25'0"	Continued						CASING SIZE 2½" SPOON 2" O. D. 1 3/8" I. D.
		Rock				60"	5R	Recovery 60" or 100%
		25' 2						
						30"	6R	Recovery 30" or 100%
						18"	7R	Recovery 18" or 100%
	36'5"							
		Bottom of exploration						

HAMMER: CASING 300 # AVG. FALL 16 ins.
SAMPLER 140 # AVG. FALL 30 ins.

REMARKS

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌶ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 1 OF: 2

BORING No. 3 DATUM: BORING INSPECTOR: DATE 5-12-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								CASING SIZE $2\frac{1}{2}$"
	0'0"	Top of ground						SPOON 2" O. D. 1 3/8" I. D.
		Sand & weathered rock	20	12"				
		5'0"	21	"				
	3'0"		50	"				
						12"	1R	Recovery 12" or 100%
		Rock						
						48"	2R	Recovery 48" or 100%
						60"	3R	Recovery 60" or 100%
		47'6"						
						60"	4R	Recovery 60" or 100%
						60"	5R	Recovery 60" or 100%
	25'0"							

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌯ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 2 OF: 2

BORING No. 3 DATUM: BORING INSPECTOR: DATE 5-12-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								HAMMER CASING 300 # AVG. FALL 16 ins. SAMPLER 140 # AVG. FALL 30 ins. REMARKS CASING SIZE 2½" SPOON 2" O. D. 1 3/8" I. D.
	25'0"	Continued						
		Rock						
						60"	6R	Recovery 60" or 100%
						60"	7R	Recovery 60" or 100%
		40'						
						60"	8R	Recovery 60" or 100%
						42"	9R	Recovery 42" or 100%
						18"	10R	Recovery 18" or 100%
						60"	11R	Recovery 60" or 100%
	50'0"					24"	12R	Recovery 24" or 100%

Bottom of exploration

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌶ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 1 OF: 3

BORING No. 4 DATUM: BORING INSPECTOR: DATE 5-15-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
	0'0"	Top of ground						CASING SIZE 3½"
		2'0" Hot top & gravel Fill	30	12"				SPOON 2" O. D. 1 3/8" I. D.
	2'0"		140	"				
		Rock				24"	1R	Recovery 17" or 71%
						24"	2R	Recovery 27" or 113%
						24"	3R	Recovery 22" or 92%
						24"	4R	Recovery 25" or 104%
		5'8"				24"	5R	Recovery 25" or 104%
						24"	6R	Recovery 24" or 100%
						24"	7R	Recovery 24" or 100%
						12"	8R	Recovery 12" or 100%
						24"	9R	Recovery 24" or 100%
						12"	10R	Recovery 12" or 100%
						24"	11R	Recovery 24" or 100%
						24"	12R	Recovery 24" or 100%
	25'0"							

HAMMER: CASING 300 # AVG. FALL 16 ins.

SAMPLER 140 # AVG. FALL 30 ins.

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌯ Ground Water Surface

over

Northeast Soil Services

BORING LOG

Job # 664

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 2 OF: 3

BORING No. 4 DATUM: BORING INSPECTOR: DATE 5-15-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								CASING SIZE 3½"
	25'0"	Continued						SPOON 2" O. D. 1 3/8" I. D.
						24"	13R	Recovery 24" or 100%
		Rock						
						24"	14R	Recovery 24" or 100%
						24"	15R	Recovery 24" or 100%
						24"	16R	Recovery 24" or 100%
						24"	17R	Recovery 24" or 100%
						24"	18R	Recovery 18" or 75%
		58'						
						24"	19R	Recovery 24" or 100%
						24"	20R	Recovery 24" or 100%
						24"	21R	Recovery 24" or 100%
						24"	22R	Recovery 20" or 83%
						24"	23R	Recovery 24" or 100%
						24"	24R	Recovery 24" or 100%
	50'0"					24"	25R	Recovery 24" or 100%

HAMMER: CASING 300 # AVG. FALL 16 ins.; SAMPLER 140 # AVG. FALL 30 ins.

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌶ Ground Water Surface

over

Northeast Soil Services

Job # 664

BORING LOG

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 3 OF: 3

BORING No. 4 DATUM: BORING INSPECTOR: DATE 5-15-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								CASING SIZE 3½"
	50'0"	Continued						SPOON 2" O. D. 1 3/8" I. D.
		Rock				24"	26R	Recovery 24" or 100%
						18"	27R	Recovery 16" or 89%
						24"	28R	Recovery 24" or 100%
						24"	29R	Recovery 24" or 100%
	60'0"					30"	30R	Recovery 30" or 100%
		Bottom of exploration						

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⩧ Ground Water Surface

over

Northeast Soil Services

BORING LOG

Job # 664

LOCATION: Dover, New Hampshire STRUCTURE: River Diversion SHEET No. 1 OF: 1

BORING No. 5 DATUM: BORING INSPECTOR: DATE 5-16-69

STRATIFICATION ELEVATION	STRATIFICATION DEPTH	DESCRIPTION OF MATERIALS (TYPE, COLOR & CONSISTENCY)	CASING BLOWS	CASING PENETRATION	SAMPLER OR SPOON BLOWS	SAMPLER OR SPOON PENETRATION	SAMPLE NO. *	HAMMER / REMARKS
								HAMMER CASING 300 # AVG. FALL 16 ins. SAMPLER 140 # AVG. FALL 30 ins. REMARKS CASING SIZE 2½" SPOON 2" O. D. 1 3/8" I. D.
	0'0"	Top of ground						
	0'3"	3" Tar	32	12"				
		19" Brown gravely silty sand	32	"				
	3'0"	2'	18	"	4 7	6" 6"	1D	
		Brown silty sand	9	"	2	6"		
		5'0"	12	"				
			14	"	12 6	6" 6"	2D	
			12	"	7	6"		
	8'0"		9	"				
		Gray silty sand	5	"				
			6	"				
		6'0"	7	"	4 7	6" 6"	3D	
			19	"	7	6"		
			31	"				
	14'0"		116	"				
						18"	1R	Recovery 16" or 89%
		Rock						
		6'4"				18"	2R	Recovery 17" or 94%
						27"	3R	Recovery 27" or 100%
	20'0"					9"	4R	Recovery 9" or 100%
		Bottom of exploration						

* Designate dry samples by D. Wash samples by W. 3½" undisturbed tube samples by U. Rock cores by R. 2" tube samples by C. ⌯ Ground Water Surface

over

Results of Water Pressure testing in connection with the River Diversion project in Dover, New Hampshire

May 21, 1969

Job # 664

Hole # 3 AX Hole in Rock 3' overburden

Gauge at ground level 15 PSI

Depth to top of packer	Aug water loss in GPM for 5' interval
45'	None
40'	None
35'	None
30'	None—Pressure dropped from 15 PSI to 0 PSI in 1 min. 15 sec.
25'	0.29 gal/min. for 5 min.
20'	0.12 gal/min. for 4 min.
15'	Could not get packer to seat

Water loss with packer set at 30' to bottom of hole 0.08 GPM for 5 min. period

Hole # 4 NX hole in Rock 2' overburden

Gauge at ground level

Depth to top of packer	Aug water loss in GPM	PSI
55'	0.01 GPM for 4 min.	15
50'	0.01 GPM for 4 min.	15
45'	No loss	15
40'	No loss	15
35'	0.04 GPM for 4 min.	15
30'	No loss	15
25'	0.03 GPM for 5 min.	15
20'	0.025 GPM for 7 min.	15
15'	0.01 GPM for 4 min.	10
10'	0.11 GPM for 6 min	10
5'	0.34 GPM for 4 min.	10

Packer set at 35' to bottom of hole

1 st min.	0.23	15 PSI
2 nd min.	0.17	
3 rd min	0.16	
4 th min	0.12	
5 th min	0.03	