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The Vibration Monitoring Experts

Blasting and Mitigation Plan
Millennium Pipeline Project
Haverstraw Bay Crossing

Prepared for:

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April 15, 2002

BLASTING AND MITIGATION PLAN
FOR
MILLENNIUM PIPELINE PROJECT
HAVERSTRAW BAY CROSSING

Project Description

The proposed route for the Millennium Pipeline Project (Millennium) would cross the Hudson River at Haverstraw Bay between Rockland and Westchester Counties, following a 2.1-mile route from Bowline Point on the western side of the Bay to the Veterans Administration hospital property on the eastern shore (Figure 1). As part of that crossing, Millennium confirmed that consolidated rock would be encountered for approximately 185 feet of the easternmost portion of the crossing. The anticipated location for this rock is shown on Millennium's drawings 8525-CAD-5534 and 8525-CAD-5535, a copy of which is attached as Figures 2 and 3 for convenience. As shown on those drawings, the total expected quantity of rock in this excavation is estimated at a maximum of 260 cubic yards.

Although Millennium has agreed to attempt rock removal using the environmental bucket, it is possible that blasting will be required to fracture the rock to facilitate its removal. As part of its planning efforts, Millennium has contracted with Vibra-Tech Engineers, Inc. to prepare this blasting and mitigation plan.

General Guidelines

All blasting for the Millennium Pipeline Project at Haverstraw Bay will be performed in compliance with applicable federal, state, and local regulations, including transportation and storage of explosives. Blasting, explosive-handling and monitoring operations will be conducted in accordance with the latest Occupation Safety and Health Administration (OSHA) standards, 29CFR 1926.900-1926.914; Directive 495 standards of the National Fire Protection Association (NFPA); New York State Industrial Code Title 12 - Part 39; Article 16 of the Labor Law of the State of New York, to the extent these apply.

All blasting operations will be conducted under the control and supervision of a person licensed by the State of New York pursuant to Section 458 of the Labor Law of the State of New York (the contractor).

All personnel, vehicles, and equipment in the blast area will be cleared to a safe distance prior to detonation of the shot. Prior to blasting an audible warning signal will be sounded in accordance with an agreed upon procedure. The following is a suggested procedure.

2 Long Signals – First Warning
3 Minutes to Blasting

1 Long Signal – Final Warning
1 Minute to Blasting

2 Short Signals – All Clear

In addition to the audible warning system, the blasting contractor will erect proper, durable signs of adequate size stating that blasting operations are being carried out in the area. These signs will be posted at points clearly visible to all approaching the site.

Anticipated Blast Loading Plan

The alignment of the Millennium pipeline crossing in Haverstraw Bay will encounter the principal rock of the Manhattan formation, mica schist. When blasting underwater for a trenching operation, a typical range of 3.0 to 7.0 lbs. of explosives is required to fracture one cubic yard of bedrock. The total expected quantity of rock in this excavation is estimated at 260 cubic yards. If possible, blasting of the area should be done in one blast. Since the depths of water decrease from approximately 10 feet at the western end of the trench to zero feet at the eastern shore, it may have to be done in more than one blast. Some of the drilling and loading of the holes will be done from a barge in the deepest water , but the use of the barge won't be possible in the shallow areas. The final grade to be achieved varies from 0 feet to approximately 8 feet below existing topographic conditions. In order to effectively blast rock in a method that balances safety, compliance and productivity, the proper amount of explosives must be applied to the rock.

The explosive material will be confined in the borehole by a finite minimum amount of stemming material. We anticipate this amount to be 3 to 7 feet depending on hole depths. Stemming material will be a graded, clean crushed stone product. The holes will be stemmed with a 3/8" or 1/4" crushed stone.

Diagrams showing the proposed drill pattern including spacing, burden and timing sequence along with a sketch of a typical loaded borehole showing the amount of explosives, location of primers, length of stemming column and subdrill depth are attached as Figures 4 and 5 and presented in tabular form below.

Diameter of Boreholes:	3.5 inch to 4.0 inch	
Depth of Boreholes:	Minimum 6 feet	Maximum 11 feet
Spacing of Boreholes:	Minimum 3 feet	Maximum 5 feet
Burden:	Minimum 3 feet	Maximum 5 feet
Stemming:	Crushed Stone	3 to 7 feet
# of holes:	Maximum 200	
Holes per delay:	1 to 2	
Maximum lbs/delay:	Maximum 35 lbs.	
Subdrill:	Minimum 3 feet	
Blasting System:	Nonelectric	
Delay Intervals:	25 ms or greater	

Since the explosive contractor has not been chosen for this project, details of particular explosive products and product information sheets are not included in this blasting plan. However, the explosive products selected must have excellent water resistance, and also be resistant to pre-compression and propagation. The initiation system must be able to withstand the water environment at Haverstraw Bay.

The anticipated blasting plan is a conservative design based on typical parameters used for trench blasting underwater. This typical blast design provides the fundamental basis for calculating pressure levels and predicting environmental impact. The actual blasting designs will be determined by the chosen blasting contractor based on the field conditions encountered, his experience, and the equipment available to him. No set blast design will accommodate all conditions. Adjustments are commonly made as a project advances. The expertise of the blasting contractor is most important.

Overpressure Predictions

Pressure levels resulting from the detonation of explosives underwater decay with distance just as vibration or air overpressure decay with distance on land. The primary factors that control the pressure levels at a given location are the amount of explosive detonated per delay period, the distance from the given location to the explosive charge, and the depth of burial of the explosive charge. Based on the typical data for underwater blasting from Oriard[1], the following formula can be utilized to predict peak pressure levels resulting from a given cube-root scaled distance. This regression formula addresses levels expected from explosive charges that have an adequately buried charge. (I.e., properly stemmed)

[1] Oriard, L.L. (2002). Explosives Engineering, Construction Vibrations and Geotechnology. Cleveland, OH: International Society of Explosive Engineers.

$$P = 2250\left[\frac{D}{W^{\frac{1}{3}}}\right]^{-1.13}$$

Where P = Predicted Pressure Level (in pi)
D =Distance From Blast Area (in feet)
W = Maximum Lbs./Delay

Based on the maximum 35 lbs./delay given in the anticipated blast loading plan, the following table lists predicted pressure levels for various distances.

Distance from blast area (feet)	Predicted Pressure Level (psi)
50	103
100	47
200	22
300	14
400	10
500	8

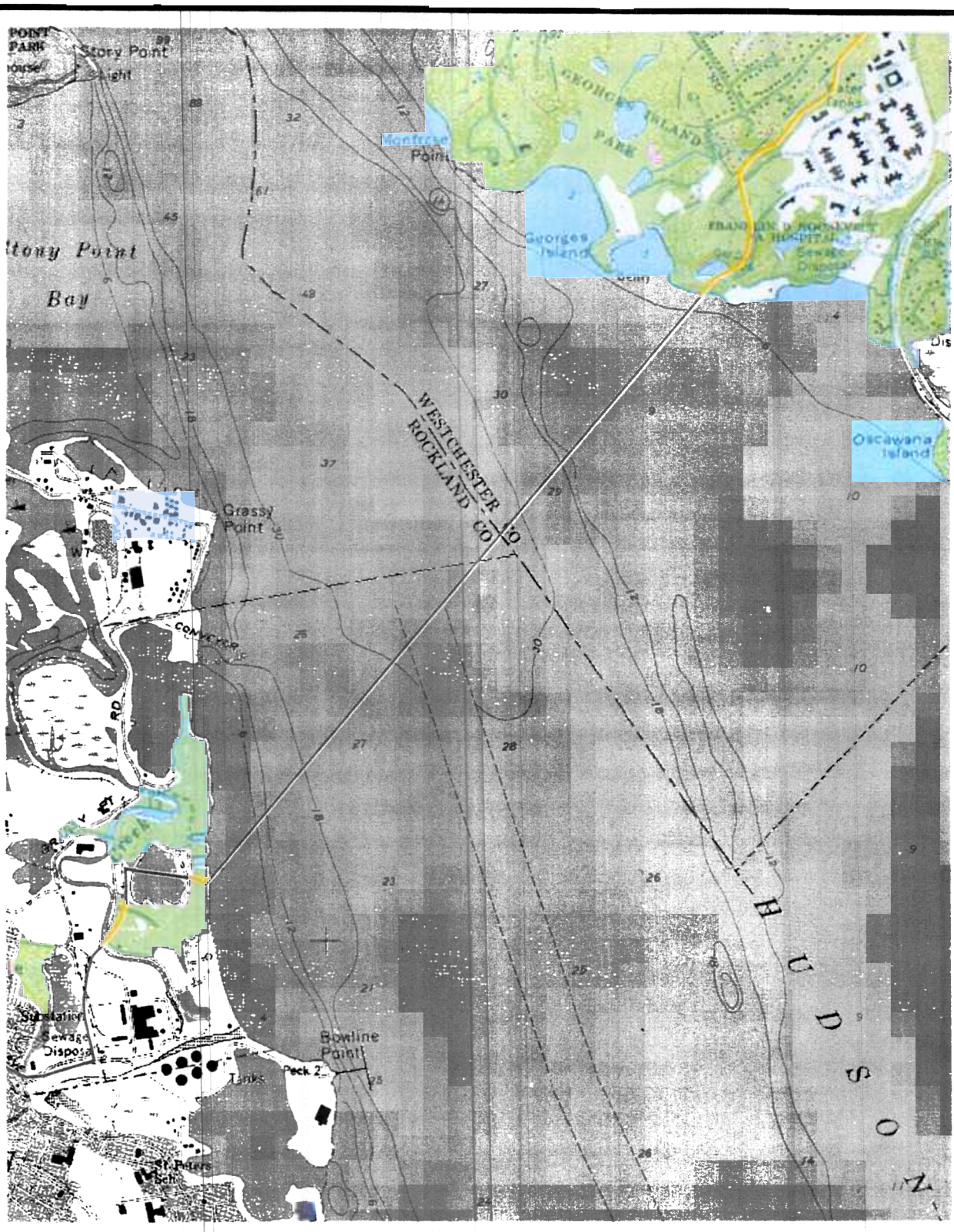
Mitigation Measures

The blasting plan described above is designed to effectively fracture rock while minimizing the pressure levels resulting from the detonation of explosives. These procedures are recommended in order to reduce the overall environmental impacts of the crossing. In addition, prior to blasting a side scan sonar survey of the area will be conducted (as is required by the DEC Water Quality Certificate) to ensure that no concentrations of fish are present in the immediate vicinity of the blast. If the side scan sonar confirms the presence of fish in the immediate vicinity, noise generating devices will be utilized to scare the fish away.

To further attenuate the pressure wave generated by the detonation of explosives, an air bubble curtain will be utilized to cordon off the blast area. The air bubble curtain serves two useful purposes. The first is to help keep the fish out of the immediate area of the blast. The second is to attenuate the pressure wave produced by the blasting process. It is common to note a 10 times or greater reduction in pressure with an effective air curtain. Typically, the greater the number of air bubbles, the greater the reduction in water pressure. Research from Keevin and Hempen[2] evaluated the effectiveness of air bubble curtains in shallow water for reducing explosive pressures and associated fish kill. Test results from the detonation of a 2 kg (4.4 lbs) explosive charge in 1.25 meters (4.1 feet) of water with the use of an air curtain showed considerable

[2] Keevin, T.M. & Hempen, G.L. (1997). The environmental effects of underwater explosions with methods to mitigate impacts St. Louis, MO: U.S. Army Corps of Engineers.

reductions in peak pressure, impulse, and energy flux density plus significant reductions in fish mortality. Based on actual recorded levels, significant peak pressure reductions were realized. At 6.5 meters (21.3 feet), levels were reduced from 3147 psi to 44 psi, a 98.6% reduction, and at 14 meters (45.9 feet) from 315 psi to 39 psi, an 87.5% reduction. Mortality for bluegill fell from 100 percent without the bubble curtain to 0 percent with the bubble curtain.



LEGEND

Proposed Millennium Pipeline as Filed 11/98

(MP 387.5 to MP 390.5)

NO.	DATE	DESCRIPTION	DWN	APPD.	APPD.

REVISIONS

MILLENNIUM PIPELINE

MILLENNIUM PIPELINE COMPANY

Figure 1
Hudson River Blasting Plan

DRAWN	CFC	DATE 4/17/02	CHECKED	REH	DATE 4/17/02
APPD	REH	DATE 4/17/02			

SCALE 1 : 24,000
JOB NO.
MILLENNIUM DWG NO
AREA | DISTRICT
DRAWING NO. 8525-GIS-5653
GIS NO.
SHT 1 OF 1 SHTS
PROJ ENGR JRA
DATE 4/17/02

f:\engr\hudson\nys_dos\nysdos_hudson_crossing.apr
i:\engr\gis projects\vpsaves\library\5653.prt

Typical Drill Pattern and Delay Timing

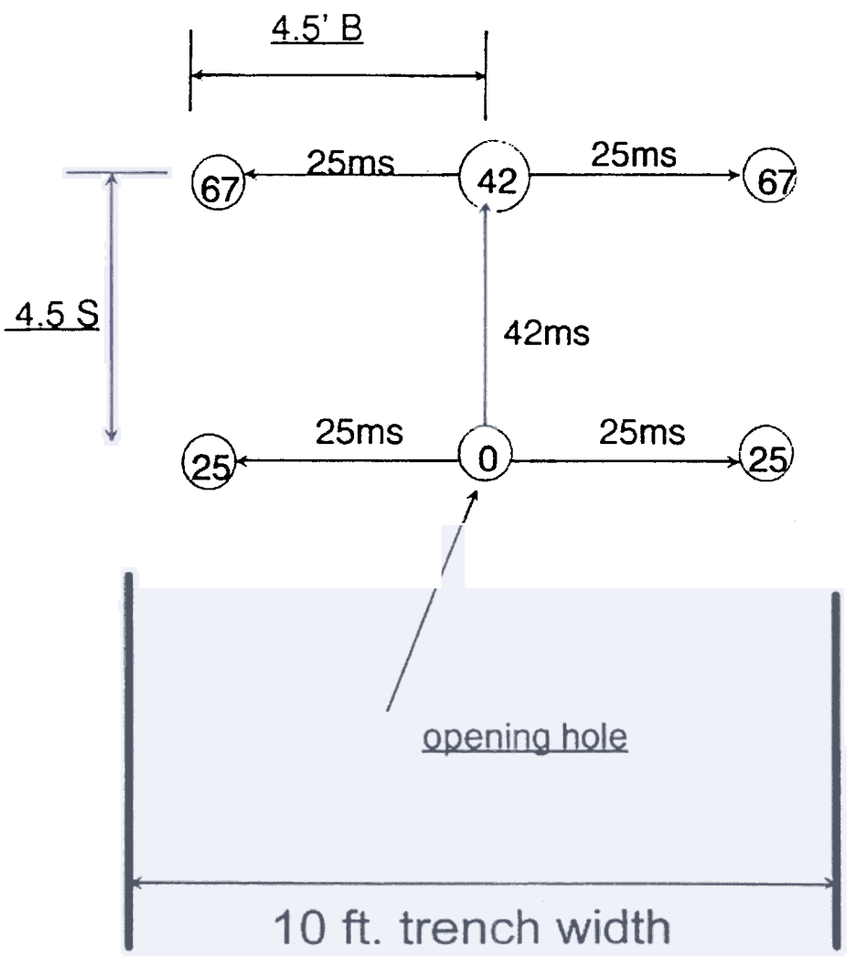


Figure 4

Typical Loaded Hole

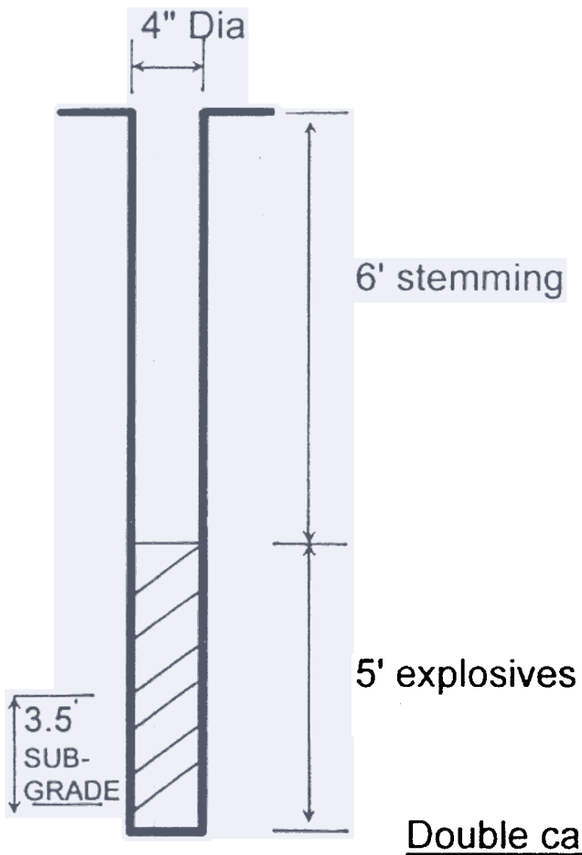


Figure 5