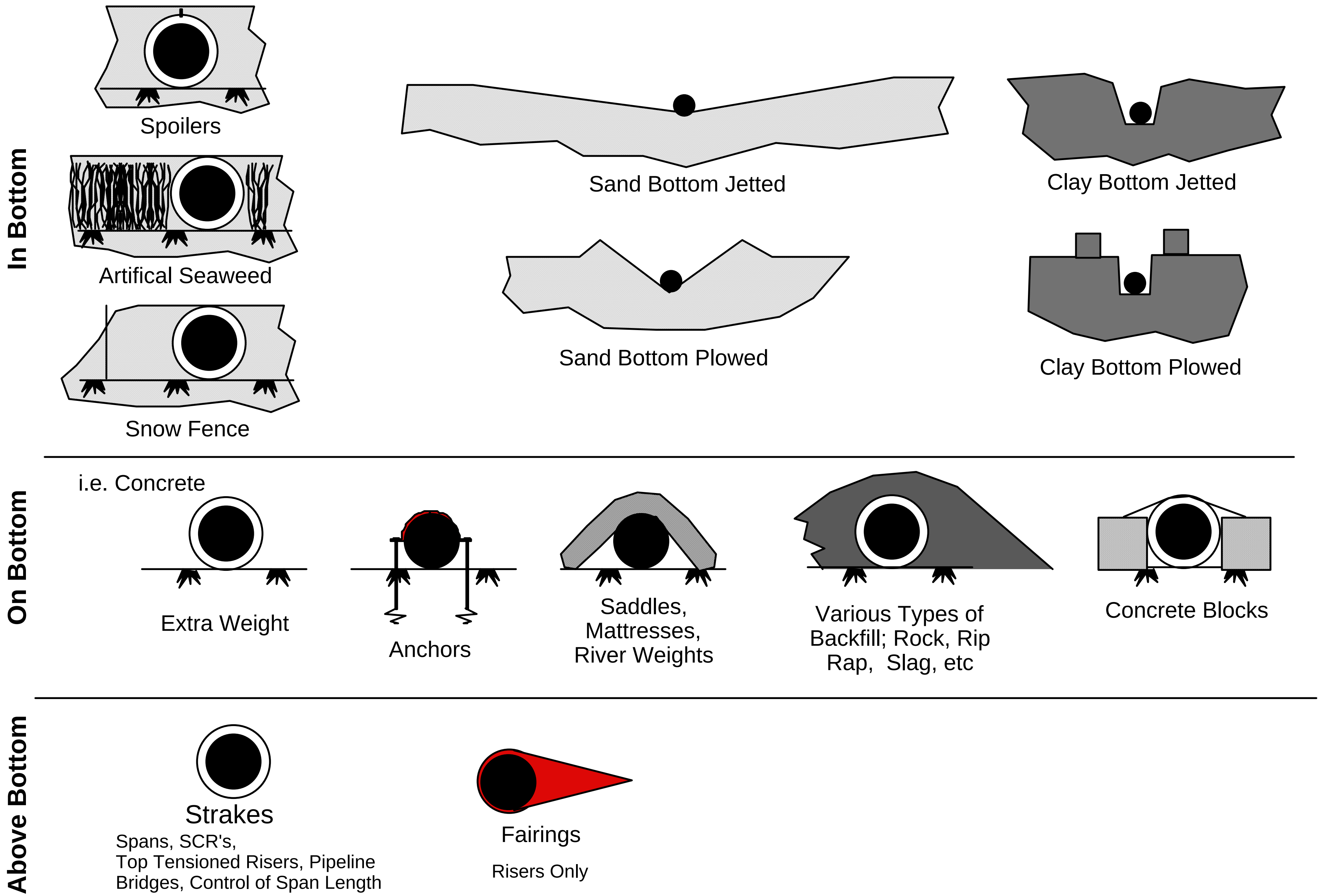
Outline R.J.Brown Lecture MMS-VIV

- Factors effecting VIV.
- Evolution of strakes for dampening VIV. Range of uses.
- Early observations of pipeline instabilities and solutions for determining forces on pipelines
- Offshore pipeline installation methods and procedures.
- Offshore riser installation methods and procedures.
- Typical pre installations of strakes on pipelines and risers.
- Typical post installation of strakes on pipeline spans in the VIV range
- Methods of trenching to avoid VIV.

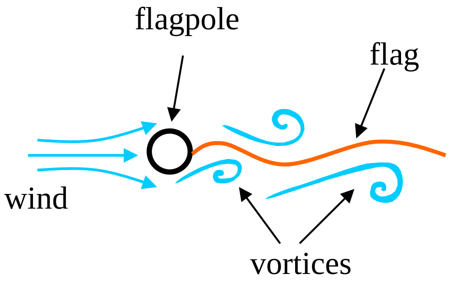
Factors effecting VIV.

Marine Pipeline Stabilization Systems



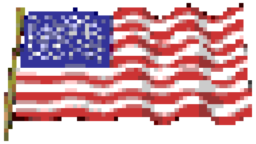
Vortex Shedding

- As a flow stream passes an obstacle such as a cylinder or a pipe in its path, vortices are formed behind the obstacle. As the flow speed increases, vortices are alternately shed on each side.



- A flag that waves in the wind is a good example of vortex shedding.

- The flagpole is the obstacle. As the wind passes it is shed into vortices that make the flag wave.



Factors Effecting VIV

- Pipe diameter and wall thickness
- Pipe surface roughness
- Residual tension in pipe
- Span lengths
- Current velocities

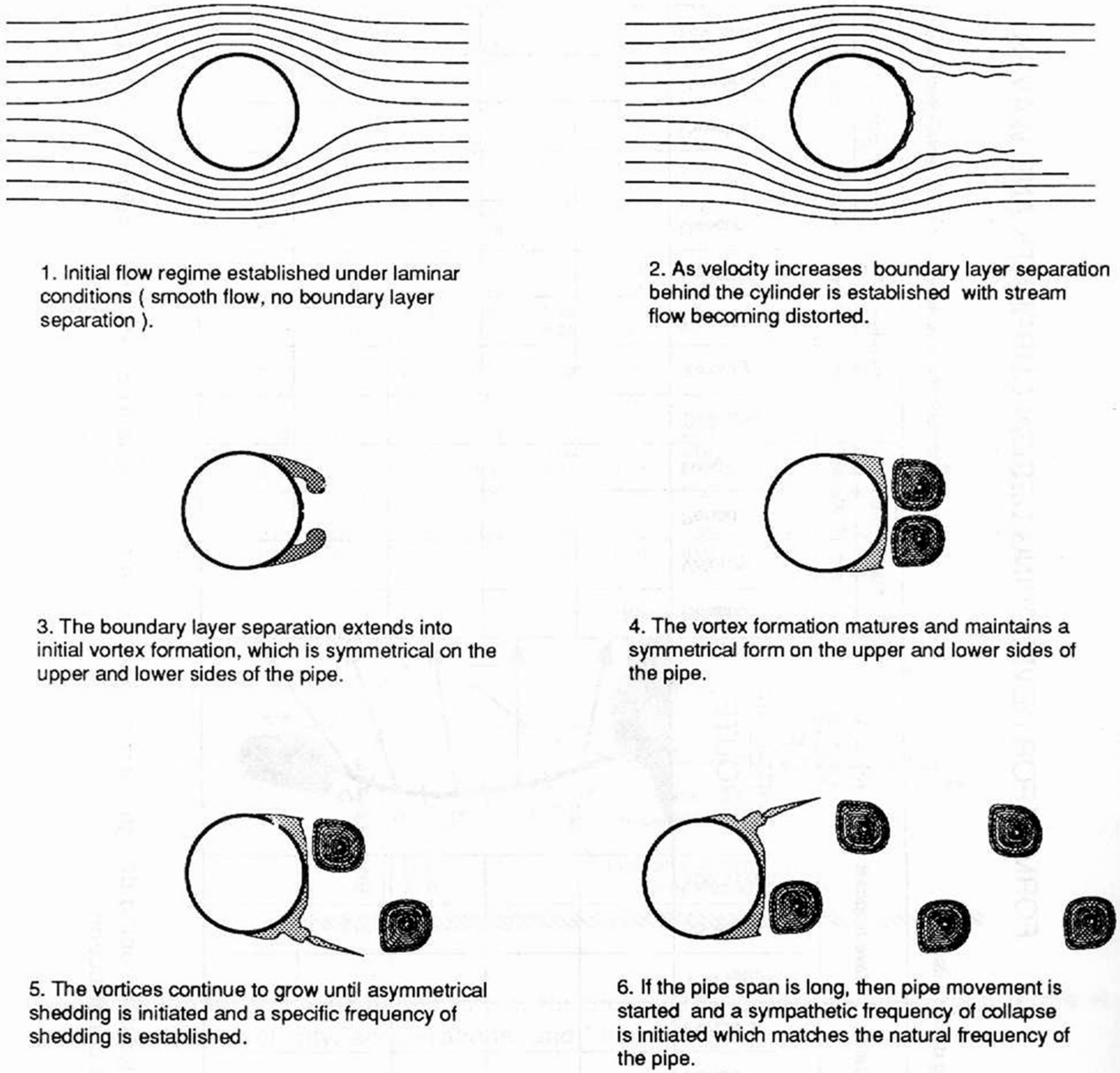
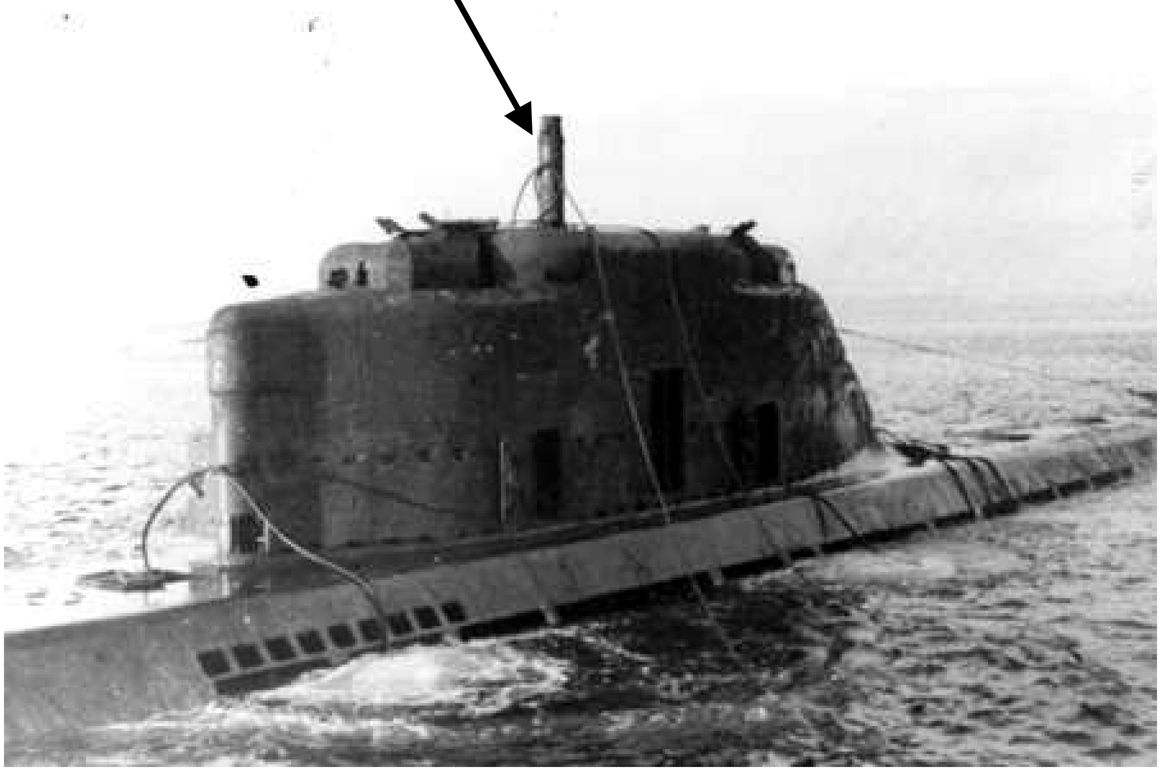


Figure 14. Current flow around the pipeline showing the change in flow regime from laminar, to boundary layer separation, to formation of vortices through vortex shedding.

Evolution of strakes for dampening VIV. Range of uses.

Non Oilfield use of Strakes

- Submarine Periscopes (WW2)
- Smoke Stacks (1960's)
- Bridges
- Antennas



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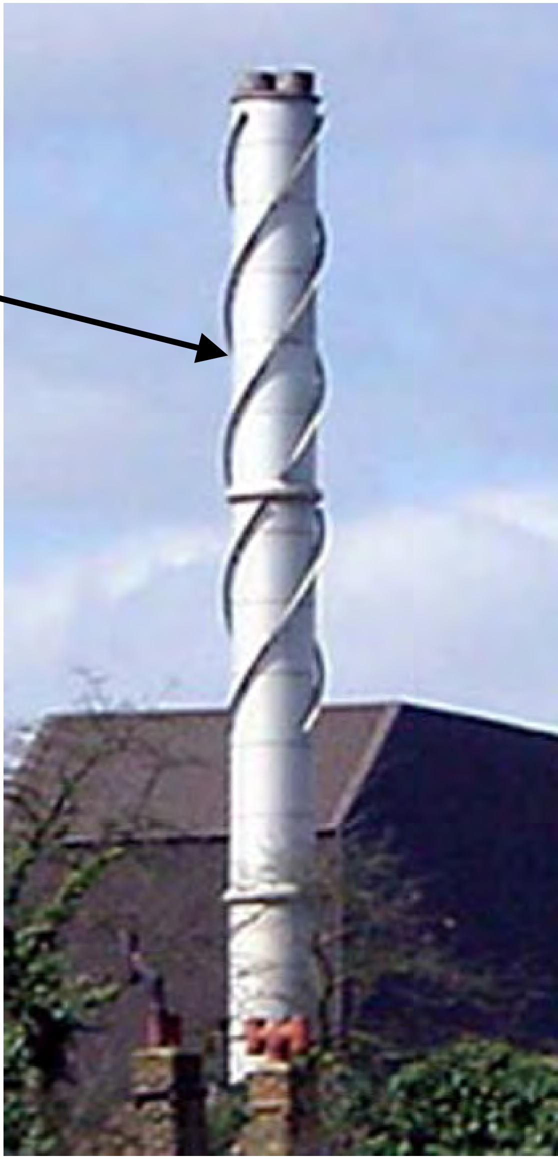
- Antennas

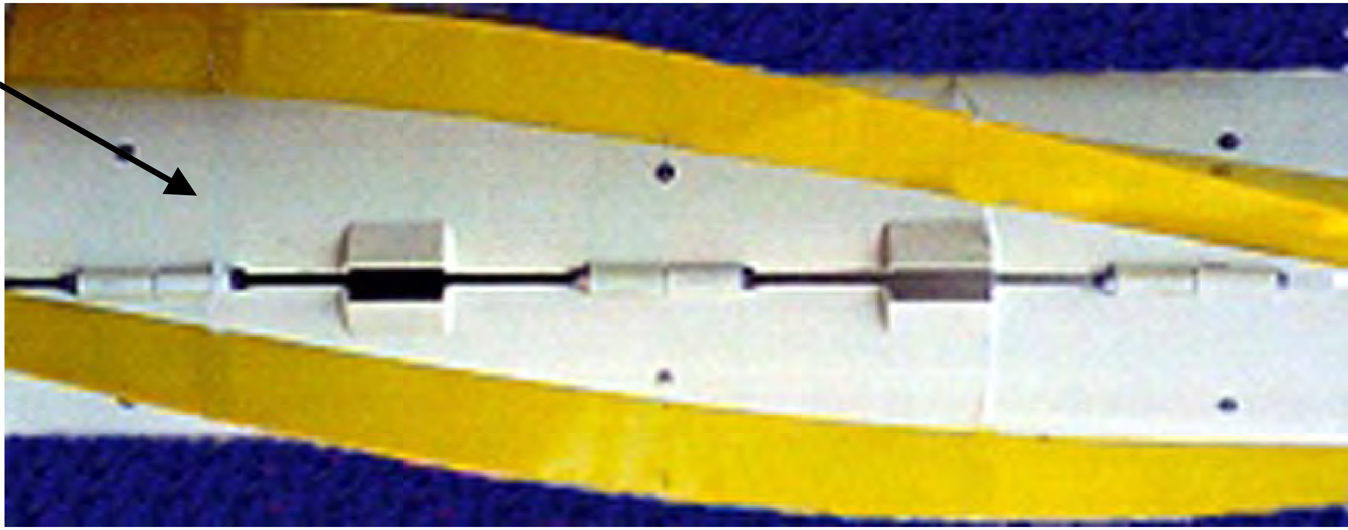


Oilfield application of Strakes

- Drilling Risers
- Pipelines
- SCR,s
- Jumpers
- Spars
- Flare Booms
- Production Top Tensioned Risers

Oilfield application of Strakes

- Drilling Risers
- Pipelines
- SCR,s
- Jumpers
- Spars
- Flare Booms
- Production Top Tensioned Risers



Oilfield application of Strakes

- Drilling Risers
- Pipelines
- SCR,s
- Jumpers
- Spars
- Flare Booms
- Production Top Tensioned Risers

Oilfield application of Strakes

- Drilling Risers
- Pipelines
- SCR,s
- Jumpers
- Spars
- Flare Booms
- Production Top Tensioned Risers

Oilfield application of Strakes

- Drilling Risers
- Pipelines
- SCR,s
- Jumpers
- Spars
- Flare Booms
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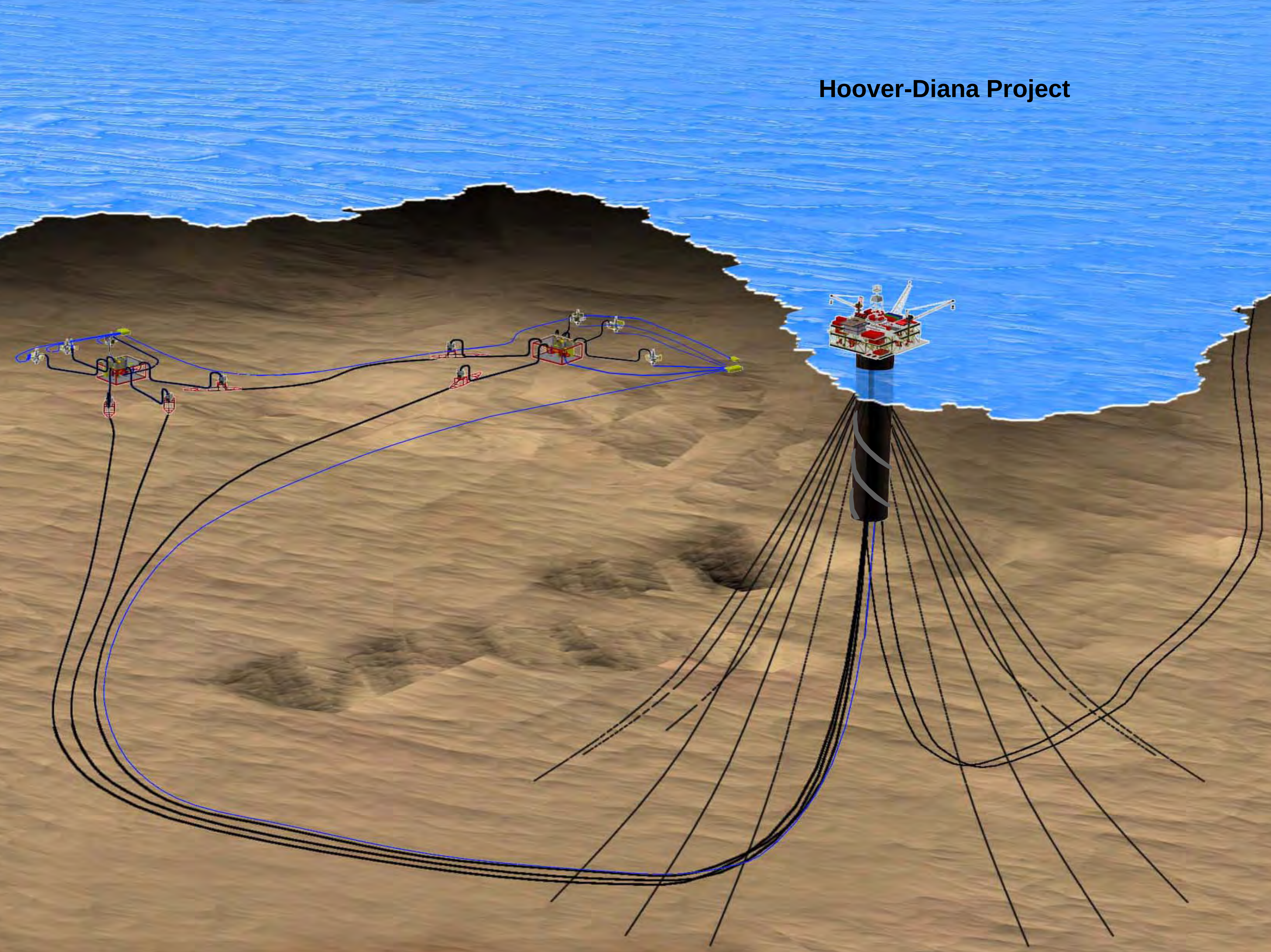
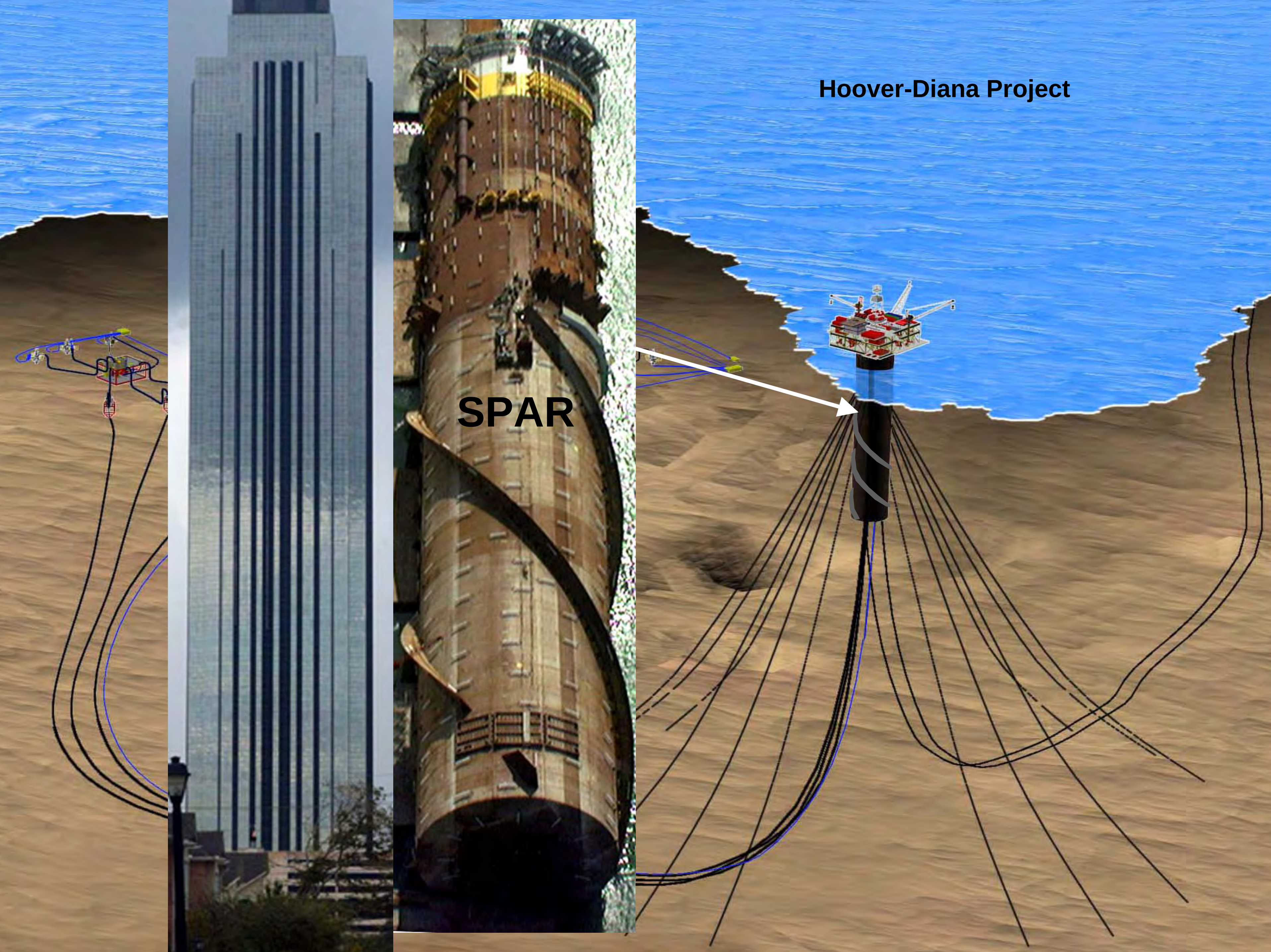
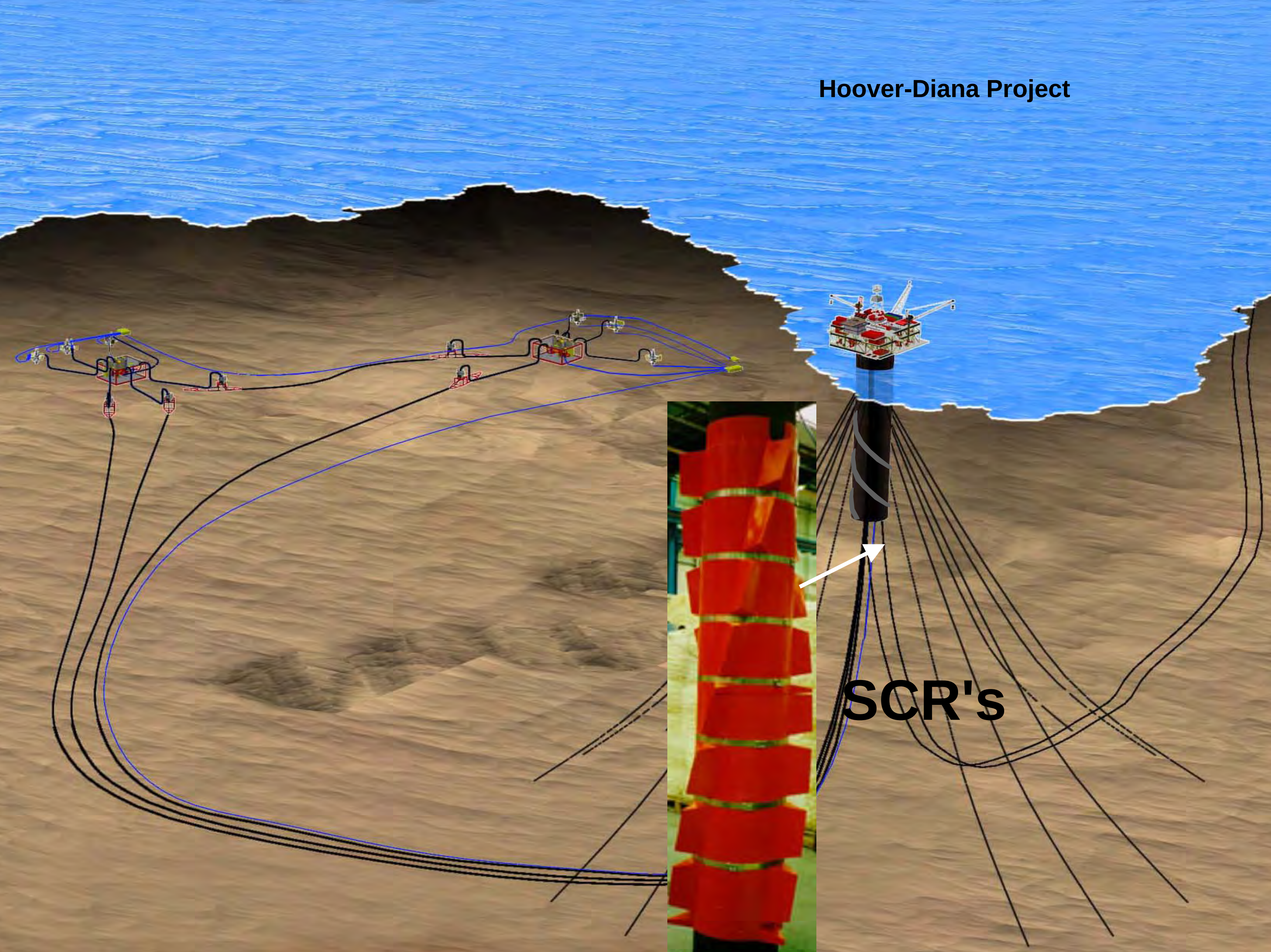
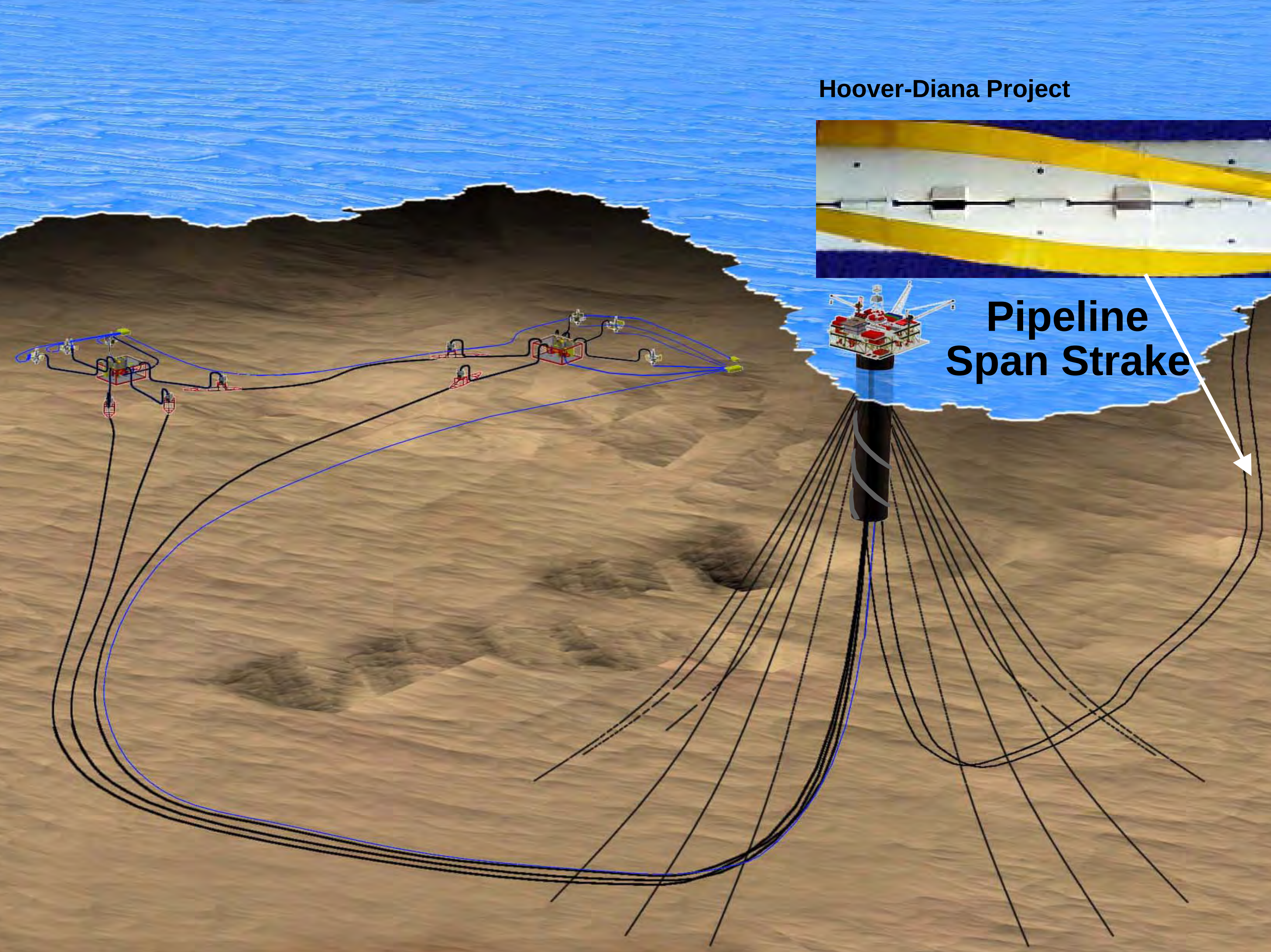

Hoover-Diana Project



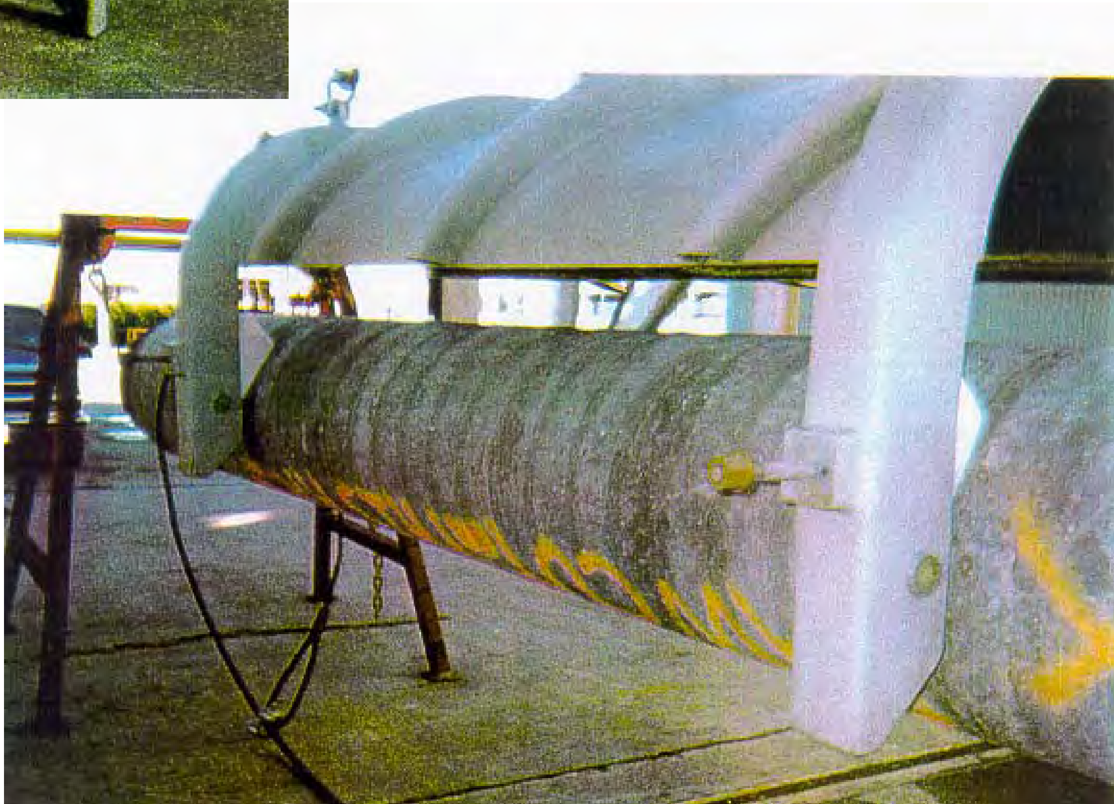
Hoover-Diana Project
SPAR

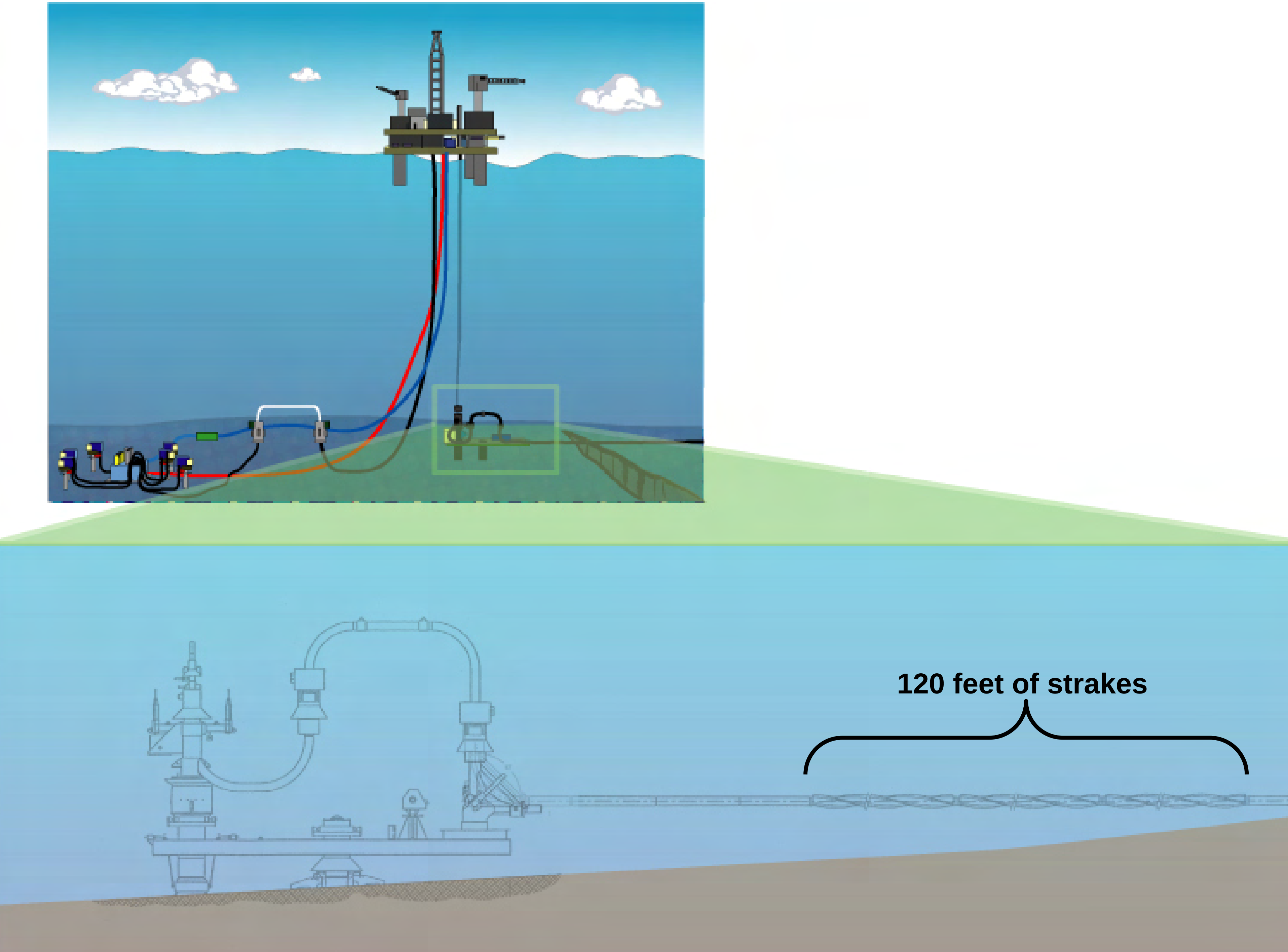

Hoover-Diana Project
SCR's



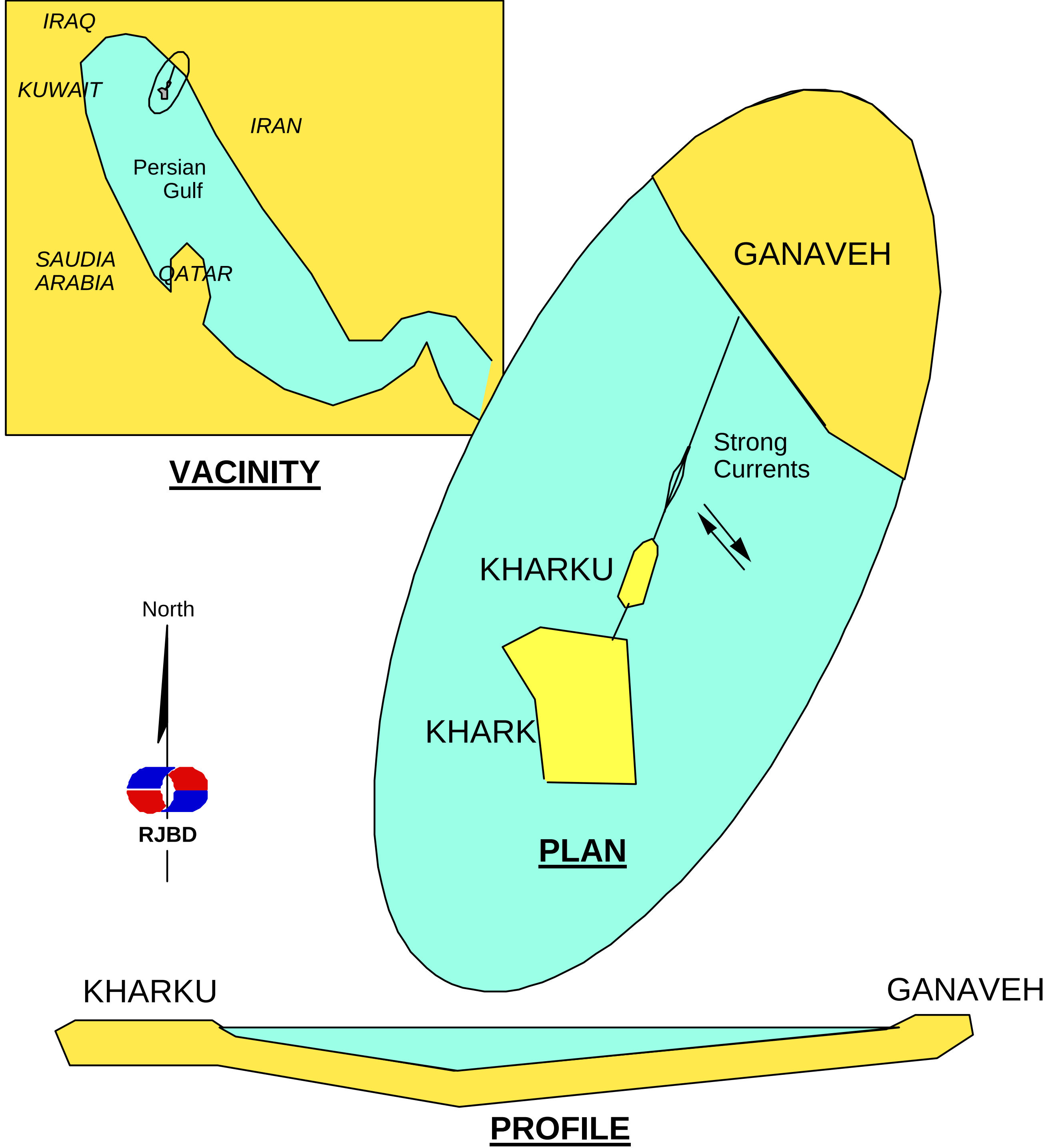
Hoover-Diana Project
Pipeline
Span Strake


Mississippi
Mobile
Texas
New Orleans
Houston
Port
Lavaca
North
Gulf of Mexico




120 feet of strakes

Early observations of pipeline instabilities and solutions for determining forces on pipelines


IRAQ
KUWAIT
IRAN
Persian Gulf
SAUDIA ARABIA
QATAR
VACINITY
GANAVEH
Strong Currents
KHARKU
KHARK
PLAN
North
RJBD
KHARKU
GANAVEH
PROFILE

American Society of Civil Engineers
Journal of the Pipeline Division
Proceedings Vol.93 No.PL1 Mar.1967

Hydrodynamic Forces on a Submarine Pipeline

By Robert J. Brown M. ASCE

CONCLUSIONS

1. The pipe on the marine bottom exhibits properties of lift and drag similar to that of a wing on an airplane.
2. In the range of Reynolds numbers tested, the coefficient of drag with the pipe on the bottom is less than that of the pipe suspended with flow around both top and bottom.
3. The coefficient of lift exceeds the coefficient of drag by approximately 50% in the range of Reynolds numbers tested.
4. Spoilers on the pipe alter considerably the hydrodynamic forces and their coefficients.
5. Varying the location of spoilers on the pipe causes considerable difference in the magnitude of drag and lift.
6. The coefficient of drag for the 6-in. and 10-in. pipe, within the Reynolds number range of 0.6×10^5 to 3.0×10^5 varied from 0.90 to 0.55.
7. The coefficient of lift for the same pipe sizes and Reynolds numbers varied from 1.3 to .8.

This initial experimentation indicates the need to explore additional avenues including new spoiler types, pipe surface conditioning, varying the cross-sectional shape, partial burial, localized erosion in proximity of pipe, positioning of pipe off bottom, and bundling of pipes.

VOL.93 NO.PL1. MAR.1967

JOURNAL OF THE PIPELINE DIVISION

PROCEEDINGS OF
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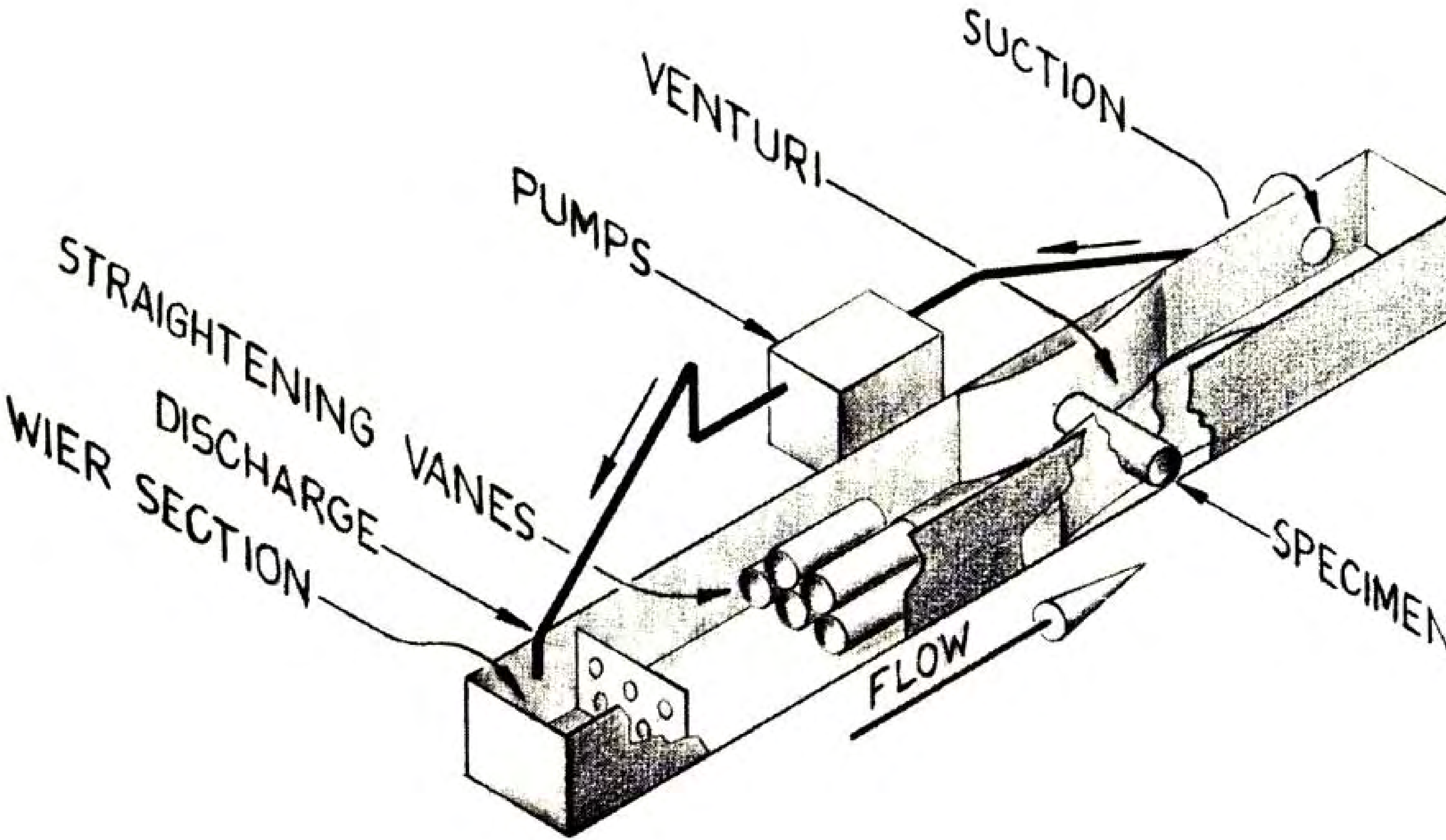
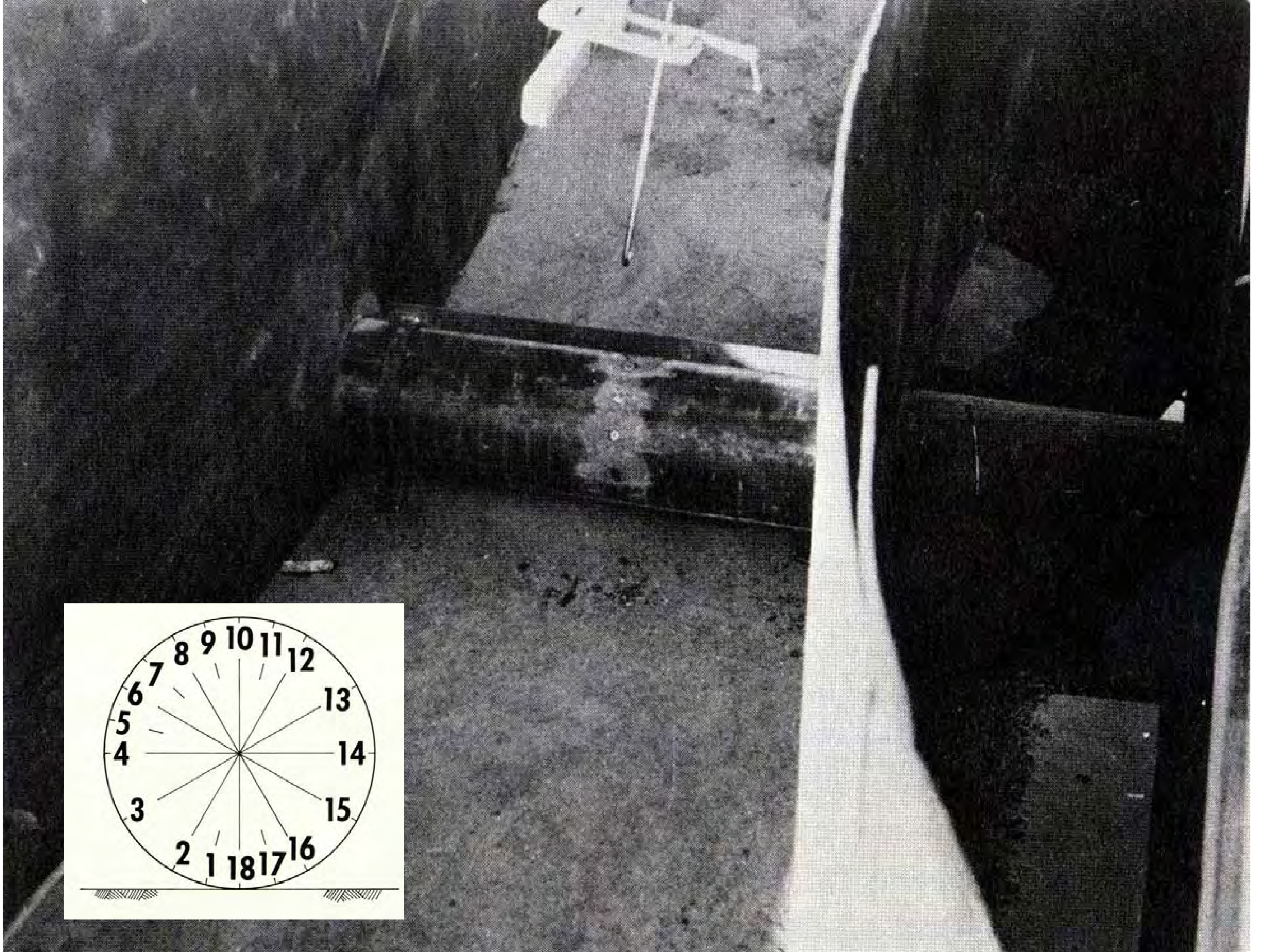
OF CIVIL ENGINEERS


SUCTION
VENTURI
PUMPS
STRAIGHTENING VANES
DISCHARGE
WIER SECTION
SPECIMEN
FLOW


1
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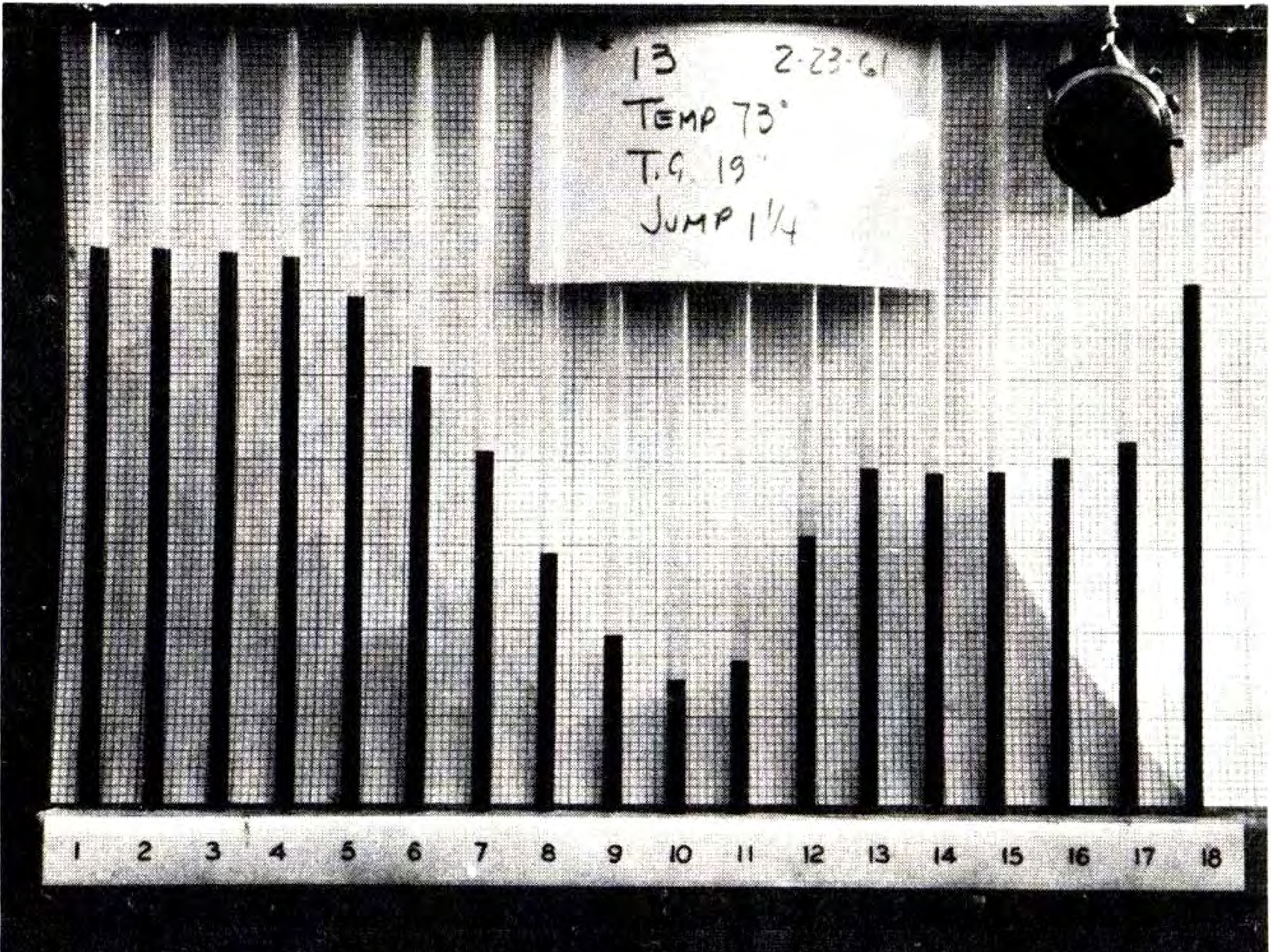
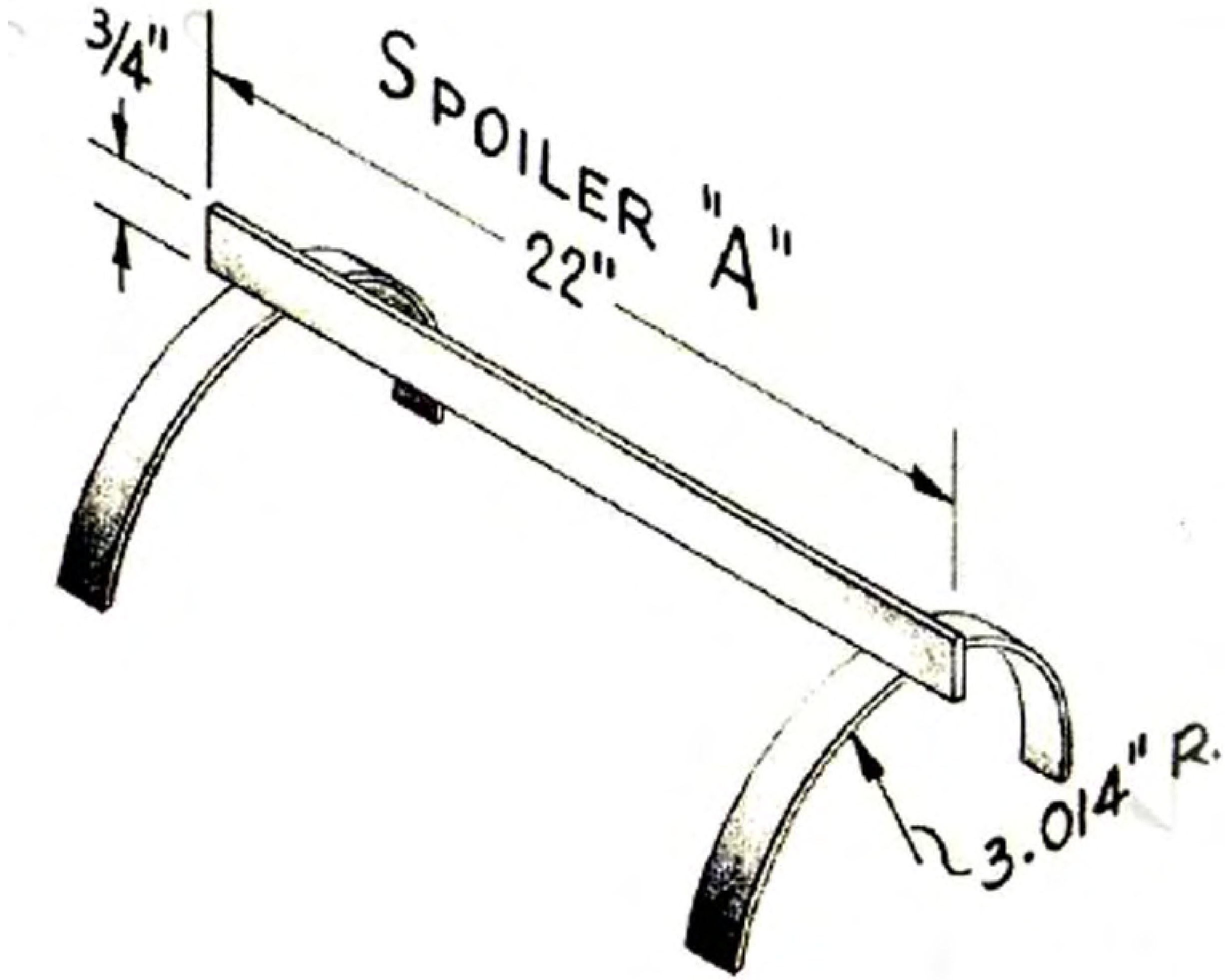
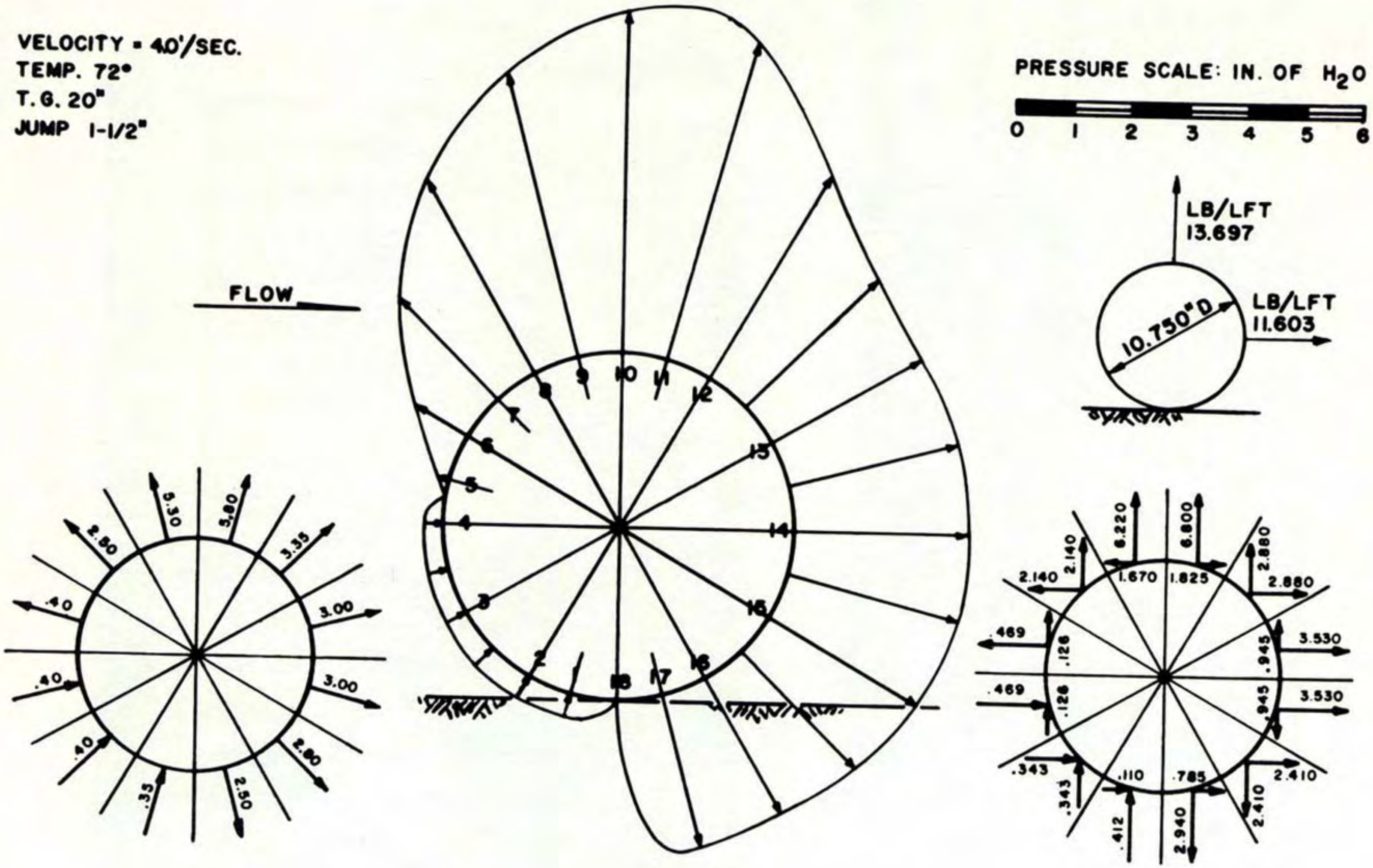
18


13 2-23-61
TEMP 73°
T.G. 19"
JUMP 1¼
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18



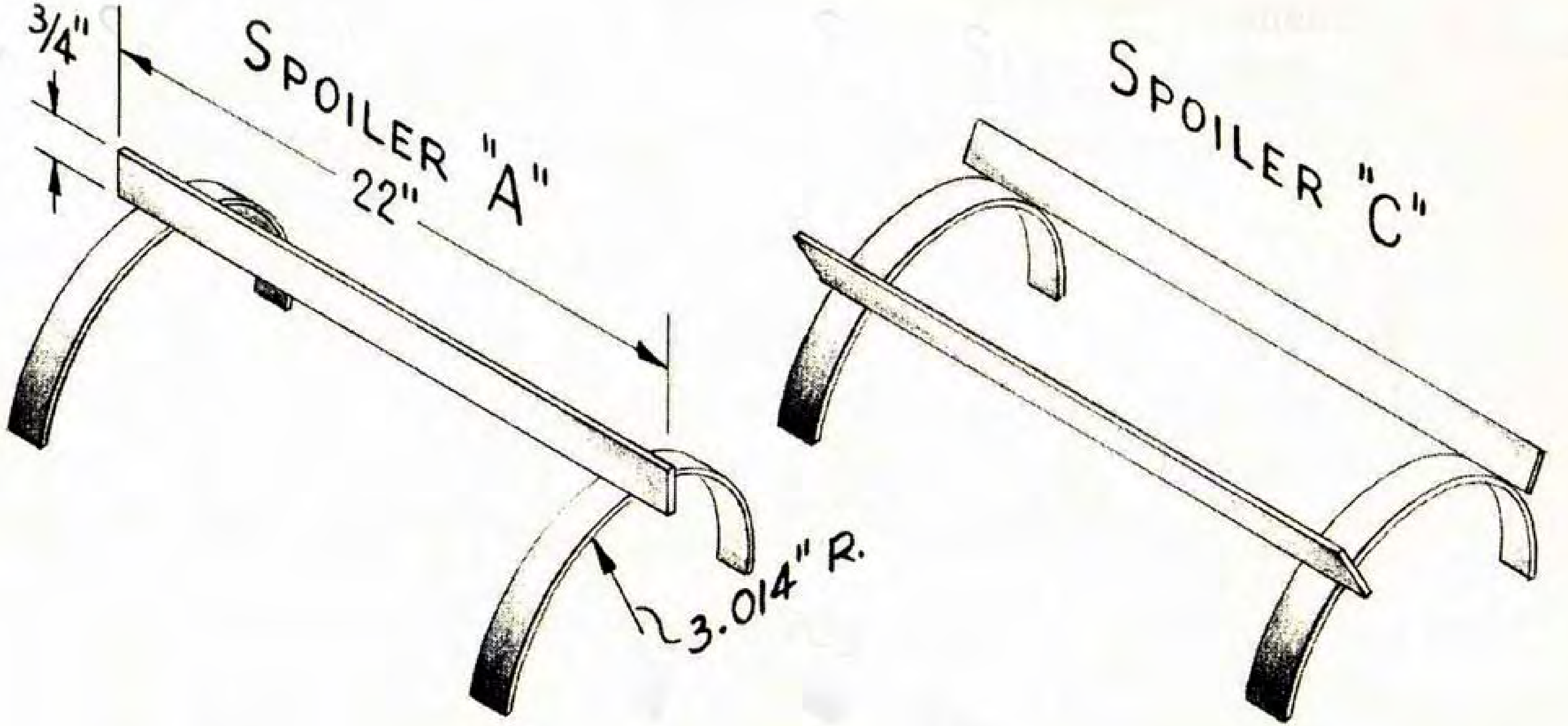
CONCLUSIONS

This initial experimentation indicates the need to explore additional avenues including new spoiler types, pipe surface conditioning, varying the cross-sectional shape, partial burial, localized erosion in proximity of pipe, positioning of pipe off bottom, and bundling of pipes.



VELOCITY = 4.0'/SEC.
TEMP. 72°
T.G. 20"
JUMP 1-1/2"
FLOW
PRESSURE SCALE: IN. OF H_2O
0 1 2 3 4 5 6
LB/LFT
13.697
LB/LFT
11.603
10.750"D
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
5.30
5.80
2.80
3.35
.40
3.00
.40
3.00
.40
2.80
.35
2.50
6.220
6.800
2.140
2.140
1.670
1.825
2.880
2.880
.469
.126
.945
3.530
.469
.126
.945
3.530
.343
.343
.110
.785
2.410
2.410
.412
2.940

FIG. 7



3/4"
SPOILER "A"
22"
3.014" R.
SPOILER "C"

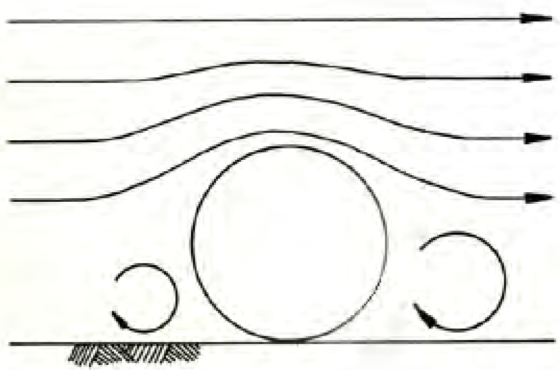


FIG. 9

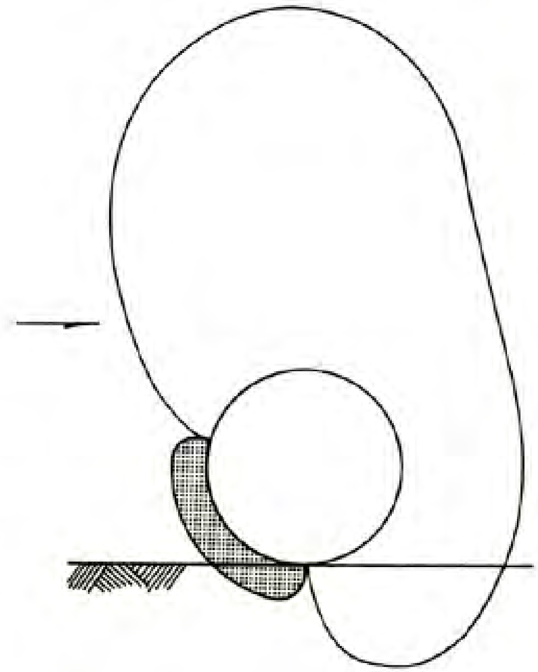
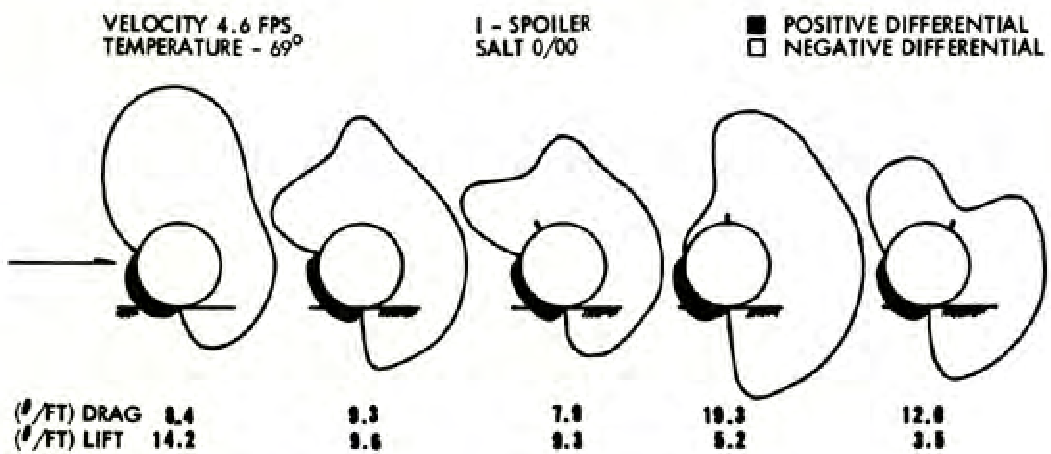


FIG. 10


VELOCITY 4.6 FPS
TEMPERATURE - 69°
I - SPOILER
SALT 0/00
POSITIVE DIFFERENTIAL
NEGATIVE DIFFERENTIAL
(#/FT) DRAG 8.4 9.3 7.9 10.3 12.0
(#/FT) LIFT 14.2 9.6 9.3 5.2 3.5

July 8, 1969 B. L. GOEPFERT ET AL 3,454,051

UNDERWATER PIPELINE WITH SPOILERS

Filed April 8, 1966

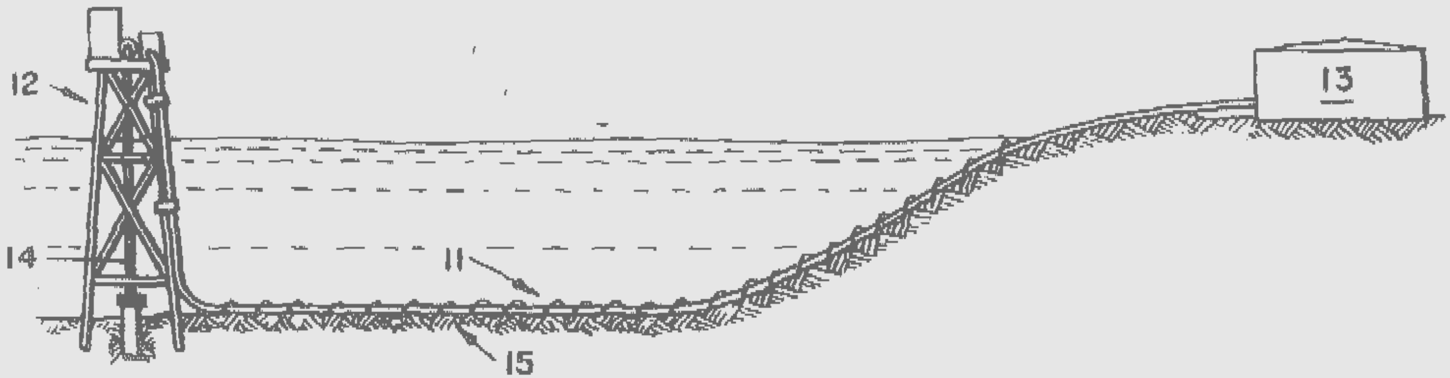


FIG. 1

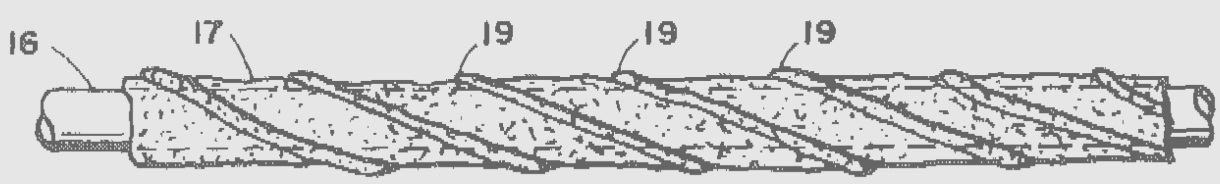


FIG. 2

Shell Goepfert Patent

3,454,051

3

For example, if twelve-inch pipe is coated the minimum pitch would be one spoiler revolution per 7 feet of length, but if two-inch pipe is used the spoilers complete a minimum revolution in 14 inches of pipe length.

The pipe may be coated continuously along a section of pipe as shown in FIGURE 2, or, in the alternative, it may be coated at spaced intervals as shown in FIGURE 4. The latter construction permits precoating of pipelines which may be subsequently joined by welding as shown at 20 or other suitable means. In addition, by spacing the coating it results in a more flexible coated pipeline apparatus capable of being more readily laid on the floor of a body of water from a lay barge.

In operation, when the pipeline apparatus is installed on the floor of a body of water as shown in FIGURE 1, the combined effects of the weight coating 17 and the spoilers 19 substantially eliminate or minimize the underwater forces tending to displace the pipeline from its original laid position. In addition to the spoilers reducing the lift coefficient, the spoilers also provide an increased frictional area which cooperates with the ocean floor to resist displacement of the pipeline along the floor. Also, if the pipeline becomes partially or even fully buried due to soft bottom conditions, the weight of the sand acting on the spoilers tends to hold the pipeline in place.

We claim as our invention:

1. An underwater pipeline apparatus positioned on the floor of a body of water for transporting a fluid between two points, said apparatus comprising:

an elongated tubular pipe section forming at least a section of said pipeline,

weight-coating means carried

coextensive with at least a p

be subjected to forces produ

and

at least one radially-extending

4

wardly of said coating means to reduce the lift coefficient of said pipe section and minimize the water movement forces tending to displace said pipe section,

said ridge being at least a part of a helix having an axis concentric with said pipe section,

2. The apparatus as defined in claim 1 wherein said pipe section is formed of steel and said coating and ridge are made of a hydraulic cementitious material.

3. The apparatus as defined in claim 1 wherein said coating and ridge are molded onto said pipe section.

4. The apparatus as defined in claim 1 wherein said coating and ridge are sprayed onto said pipe.

5. The apparatus as defined in claim 1 including at least three longitudinally spaced ridges, each said ridge being at least a part of an individual helix having a pitch equal to between 7 and 15 times the pipe diameter.

6. The apparatus as defined in claim 5 wherein said coating has a rough exterior finish.

7. The apparatus as defined in claim 6 wherein said pipe has sufficient flexibility to be installed from a lay barge to the floor of said body of water.

References Cited

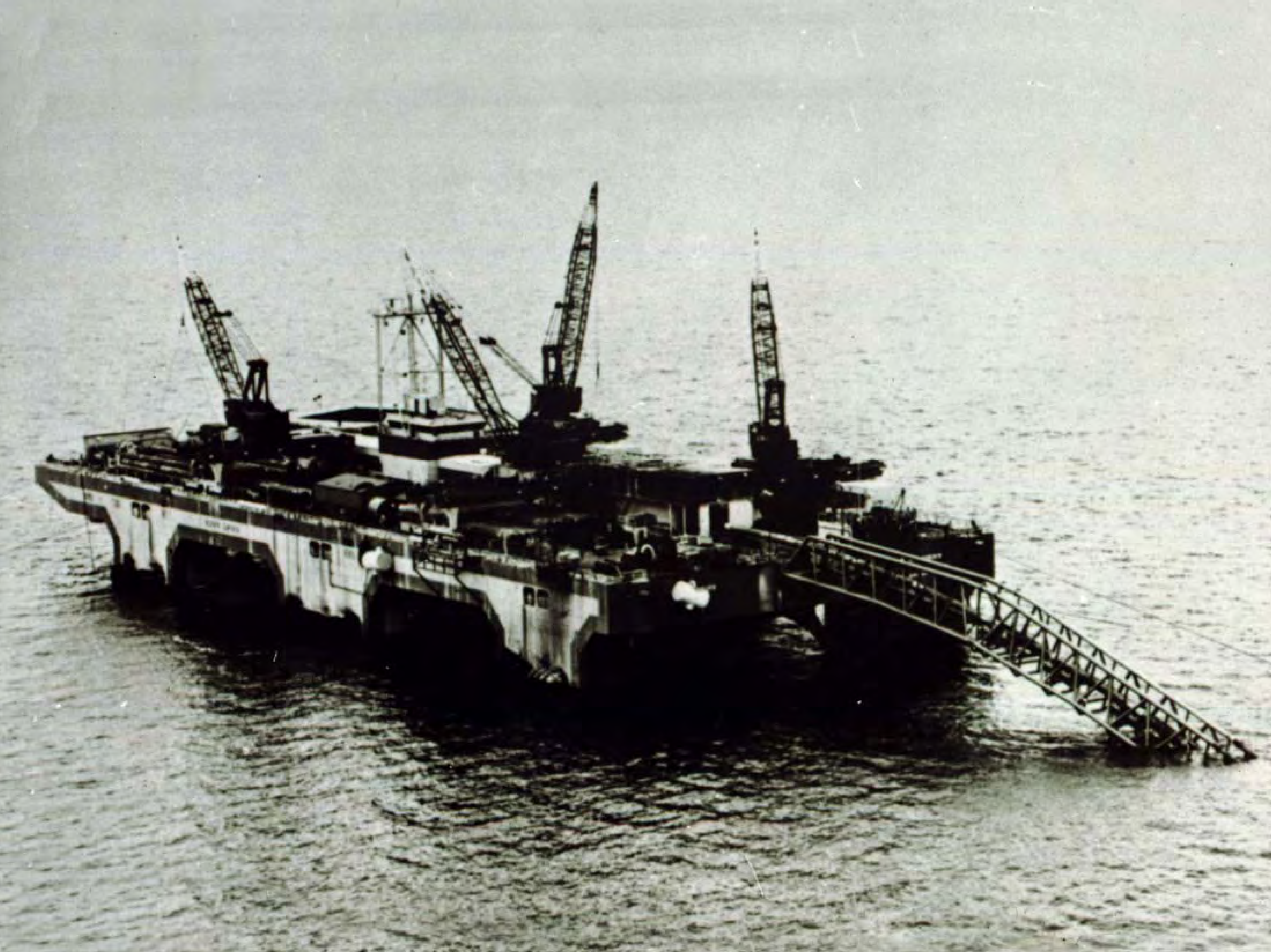
UNITED STATES PATENTS

1,904,675	4/1933	Boyer	138—178 XR
2,910,835	11/1959	Timothy	61—72.3
2,982,971	5/1961	Garaway	4—172
3,232,637	2/1966	Pennington et al.	138—178 XR
3,240,512	3/1966	Pennington et al.	138—178 XR
3,267,969	8/1966	Mallard	138—178

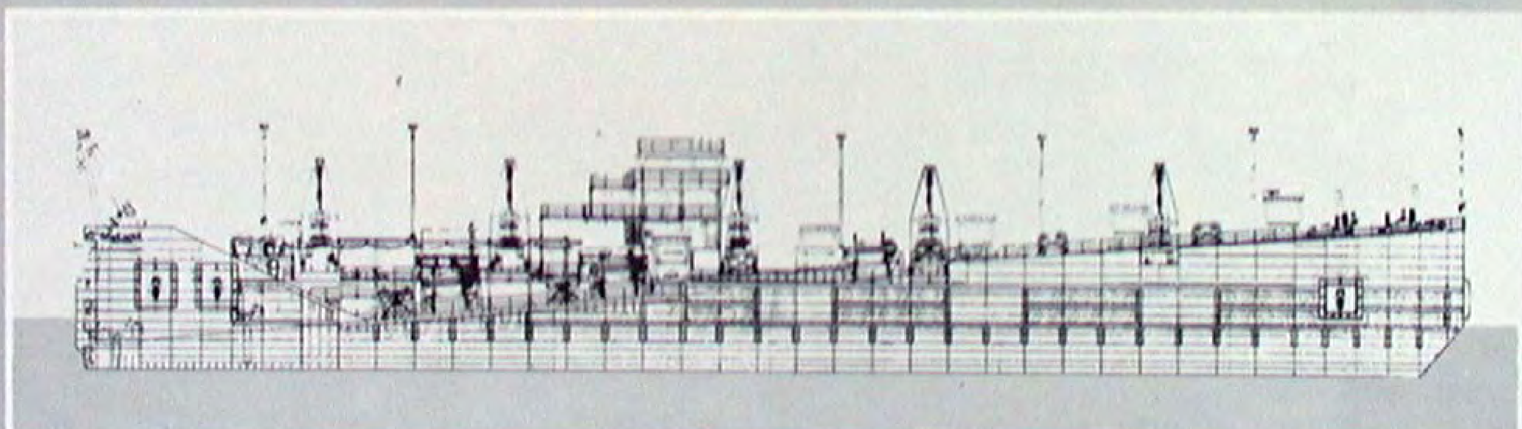
… substantially eliminate or minimize the underwater forces tending to displace the pipeline from its original laid position.

Offshore pipeline installation methods and procedures.

“S” Lay

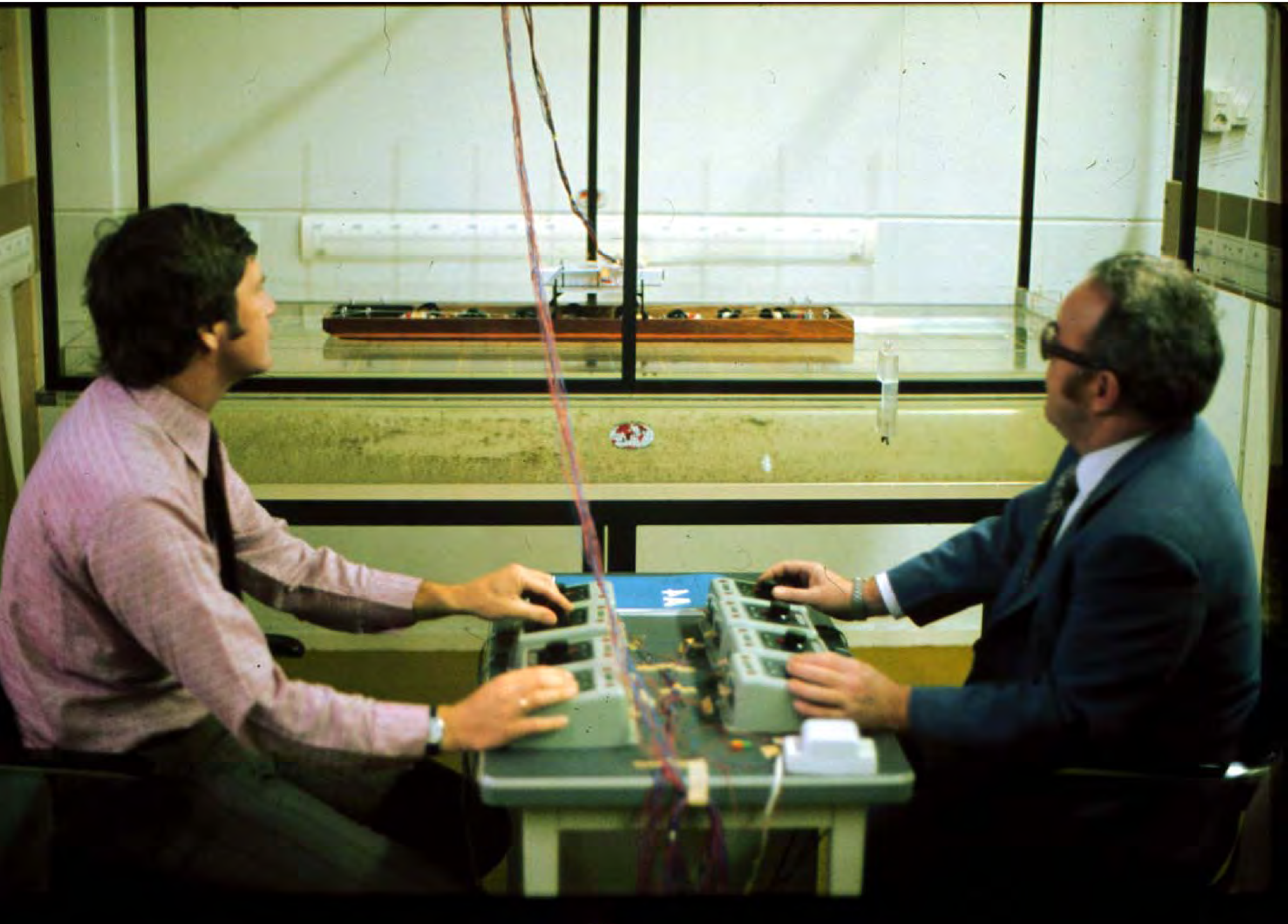


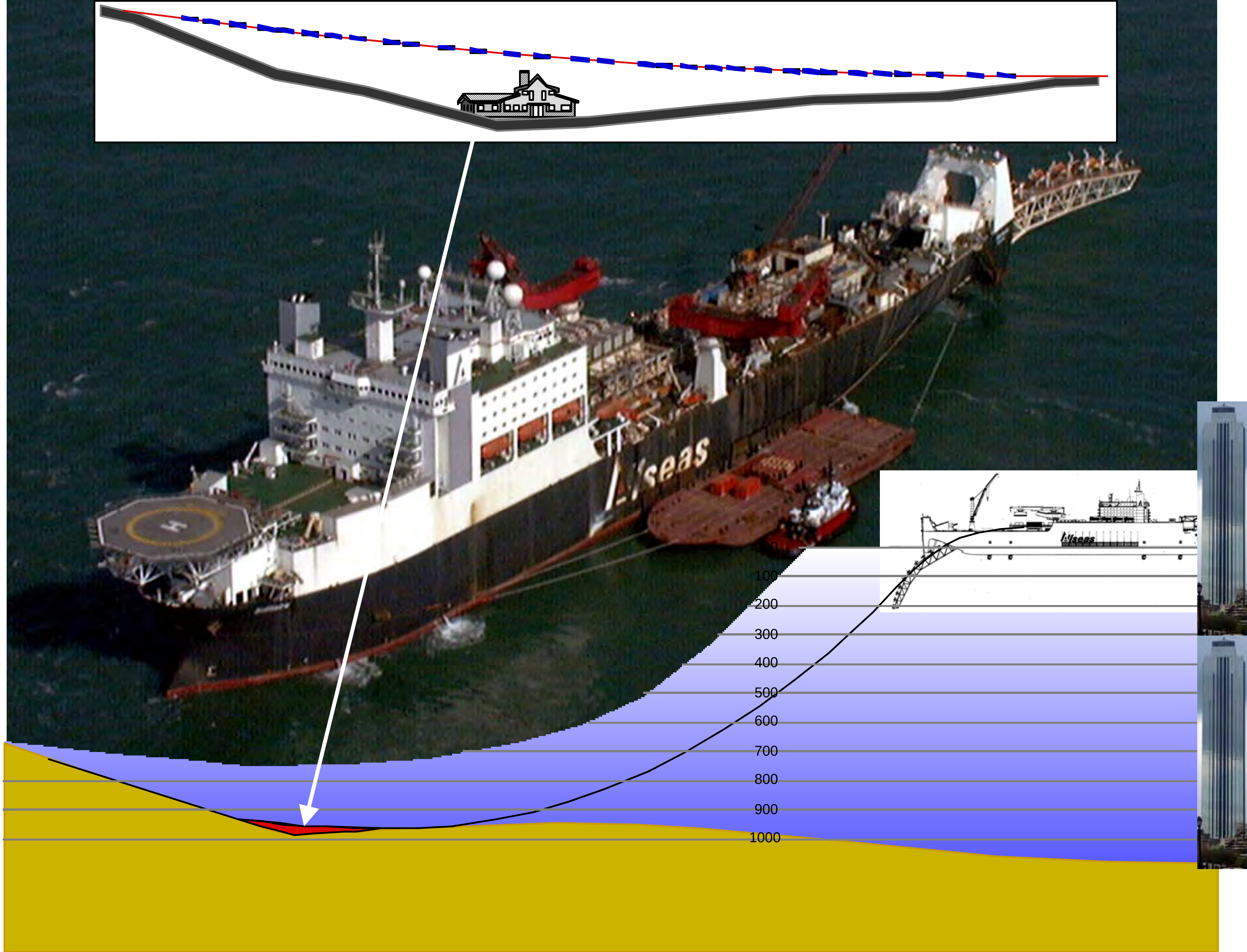
LAY BARGE WITH FIXED STINGER FOR USSR



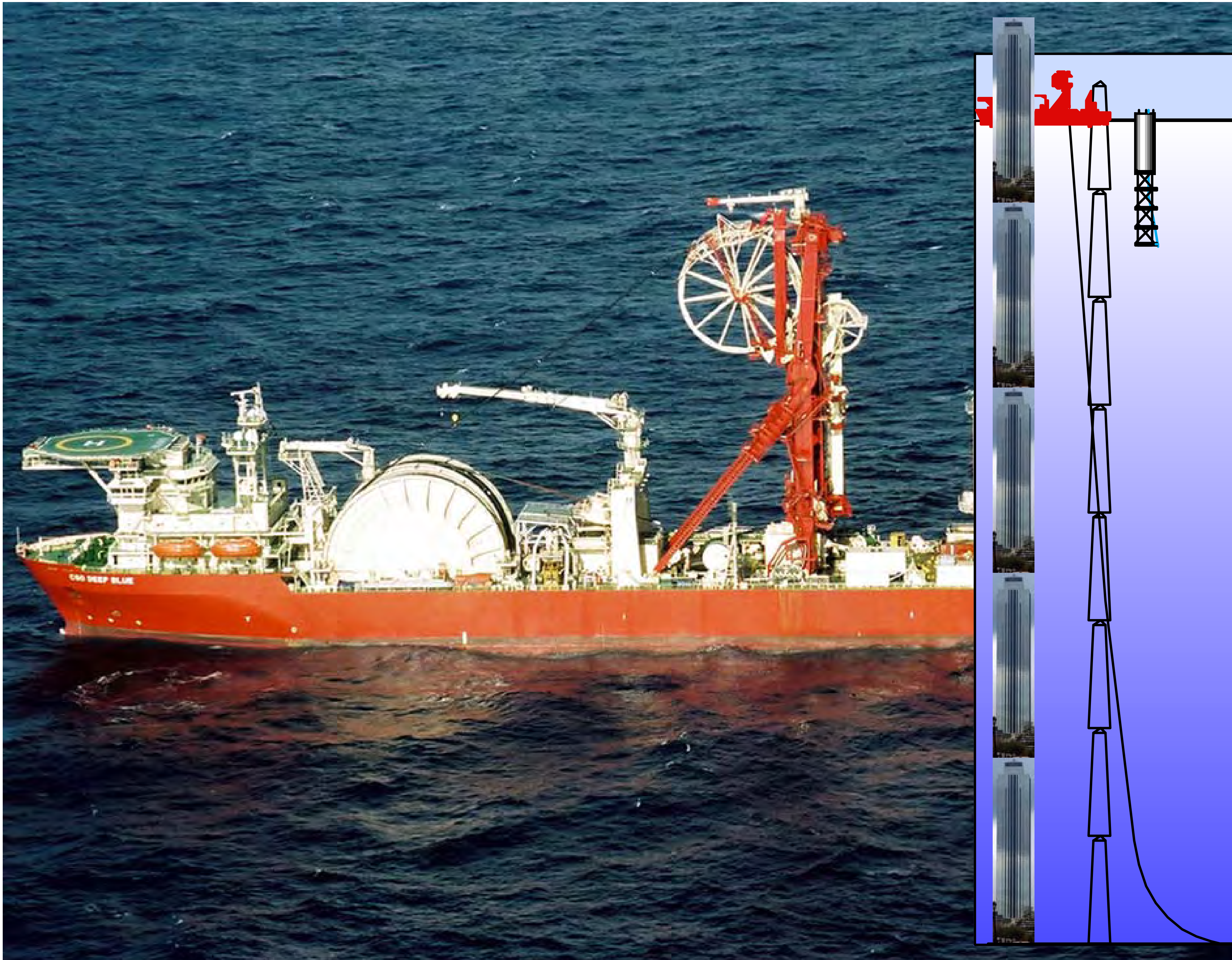
CLIENT: Sudoimport, via IHC

VESSEL: 'Suleyman Vezirov'




Allseas
0
100
200
300
400
500
600
700
800
900
1000

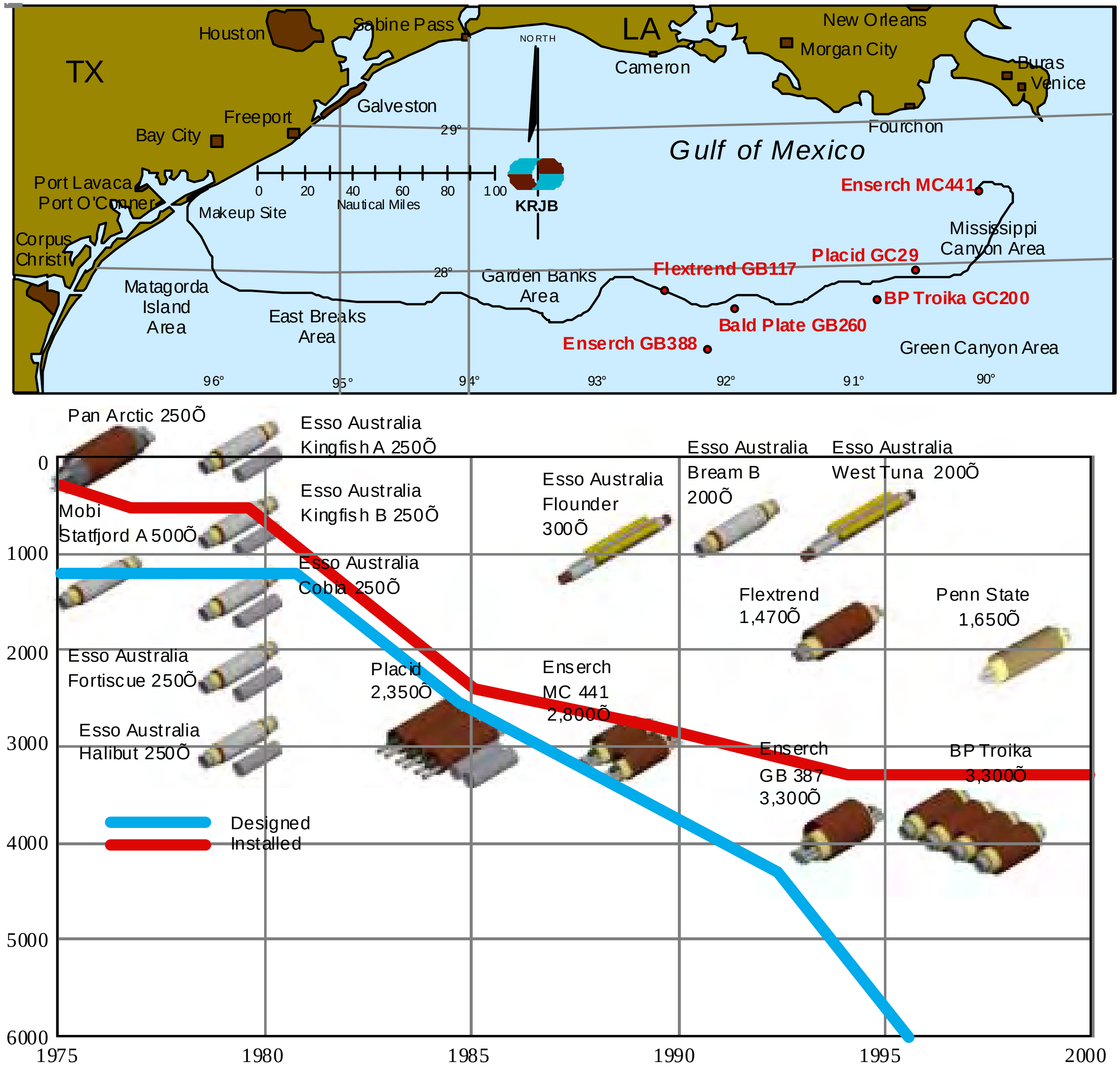
“Reeling”

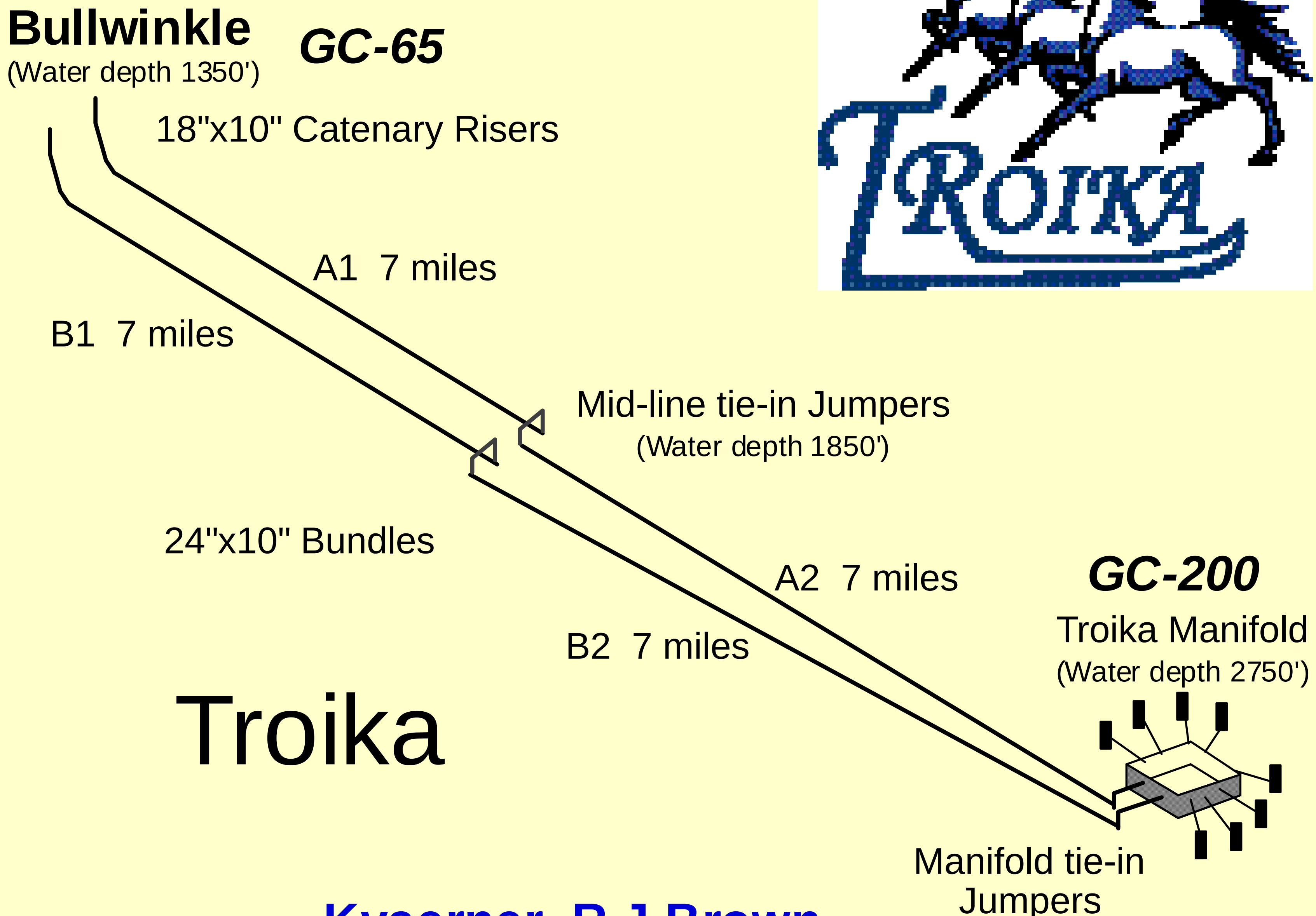

CSO DEEP BLUE

“J” Lay


SAIPEM
7000
Saipem

“Tow”


TX
Houston
Sabine Pass
LA
New Orleans
Morgan City
Cameron
Buras
Venice
Galveston
Freeport
Bay City
Fourchon
Gulf of Mexico
NORTH
KRJB
0 20 40 60 80 100
Nautical Miles
Port Lavaca
Port O'Conner
Makeup Site
Corpus Christi
Matagorda Island Area
East Breaks Area
Garden Banks Area
Mississippi Canyon Area
Green Canyon Area
Enserch MC441
Placid GC29
Flextrend GB117
BP Troika GC200
Bald Plate GB260
Enserch GB388
29°
28°
96°
95°
94°
93°
92°
91°
90°
Pan Arctic 250Õ
Esso Australia Kingfish A 250Õ
Esso Australia Kingfish B 250Õ
Mobil Statfjord A 500Õ
Esso Australia Cobia 250Õ
Esso Australia Fortiscue 250Õ
Esso Australia Halibut 250Õ
Placid 2,350Õ
Esso Australia Flounder 300Õ
Enserch MC 441 2,800Õ
Esso Australia Bream B 200Õ
Esso Australia West Tuna 200Õ
Flextrend 1,470Õ
Penn State 1,650Õ
Enserch GB 387 3,300Õ
BP Troika 3,300Õ
Designed
Installed
0
1000
2000
3000
4000
5000
6000
1975
1980
1985
1990
1995
2000

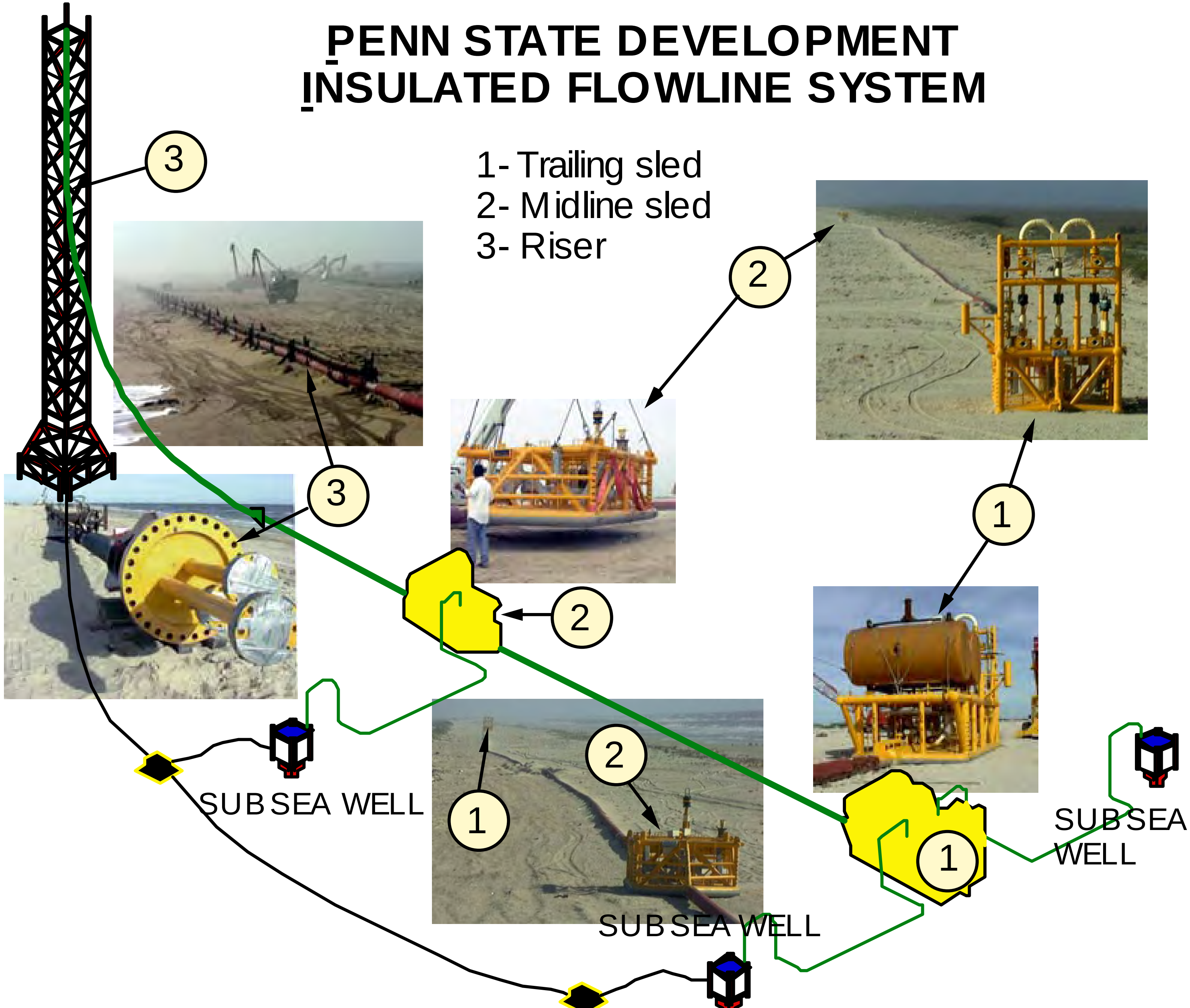


Kvaerner R J Brown

a division of Kvaerner Earl and Wright, Inc.

PENN STATE DEVELOPMENT INSULATED FLOWLINE SYSTEM

1- Trailing sled
2- Midline sled
3- Riser

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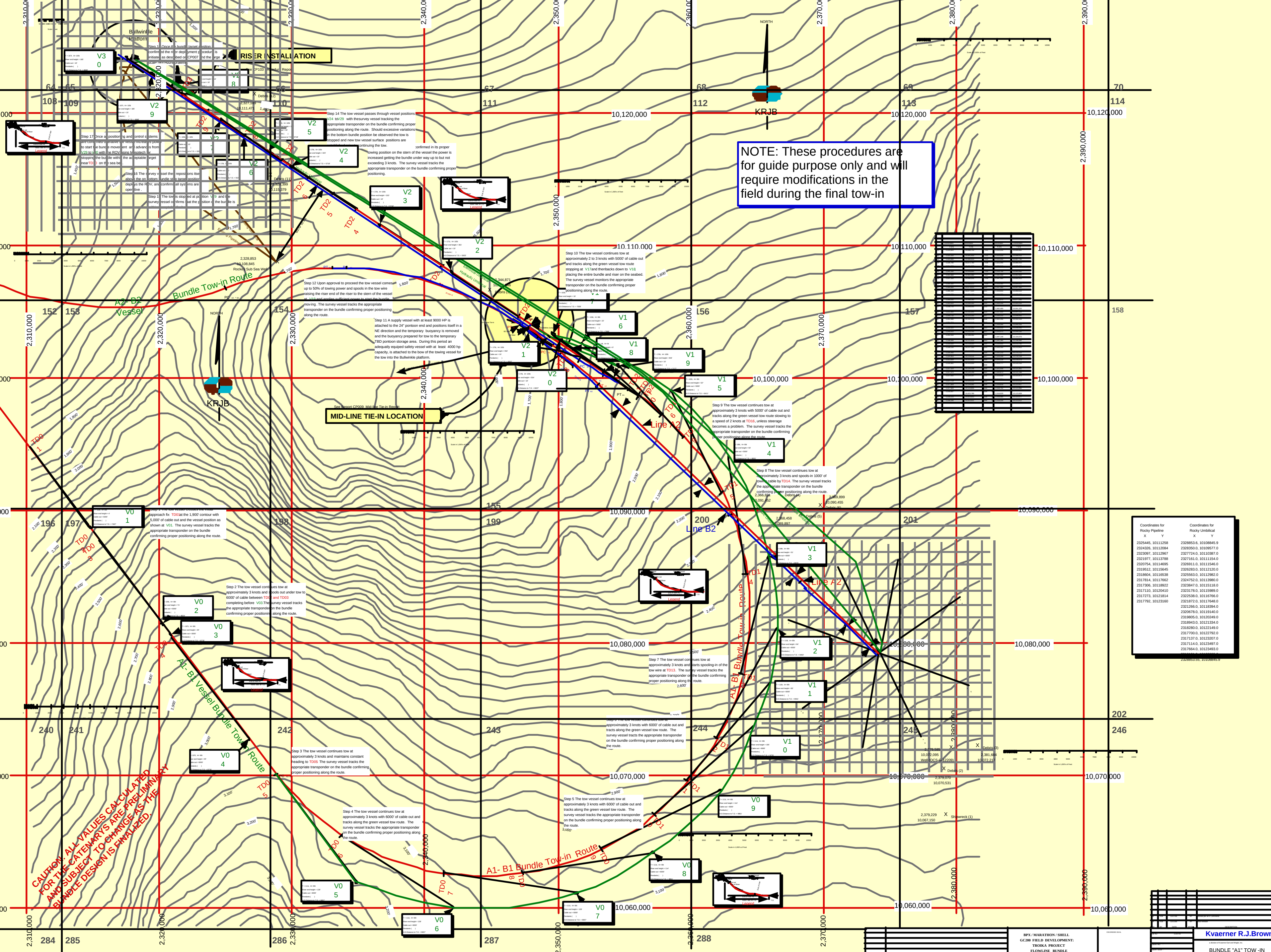
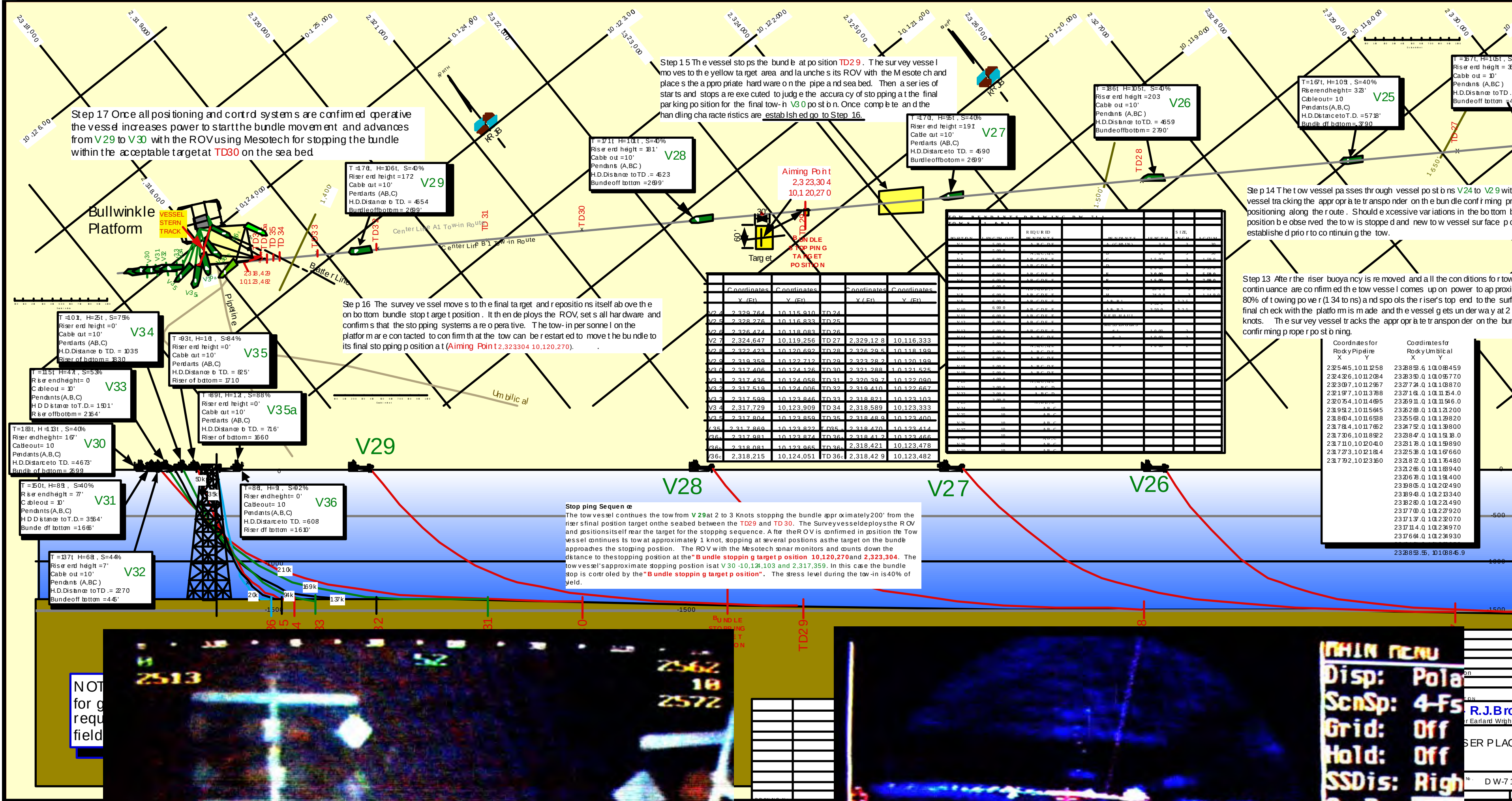
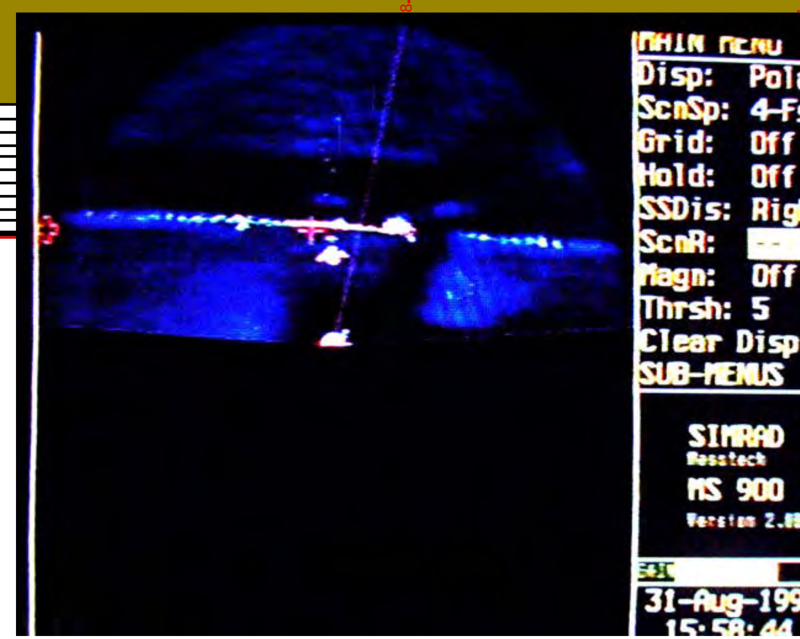


RISER INSTALLATION
Bullwinkle Platform
NOTE: These procedures are for guide purpose only and will require modifications in the field during the final tow-in
NORTH
KRJB
Bundle Tow-in Route
A2- B2 Vessel
MID-LINE TIE-IN LOCATION
Line A2
Line B2
A1- B1 Vessel Bundle Tow-in Route
A1- B1 Bundle Tow-in Route
CAUTION: ALL VALUES CALCULATED FOR THE CATENARYS ARE PRELIMINARY AND SUBJECT TO CHANGE AS THE BUNDLE DESIGN IS FINALIZED.
Coordinates for Rocky Pipeline
Coordinates for Rocky Umbilical
10,120,000
10,110,000
10,100,000
10,090,000
10,080,000
10,070,000
10,060,000
2,310,000
2,320,000
2,330,000
2,340,000
2,350,000
2,360,000
2,370,000
2,380,000
2,390,000
Kvaerner R.J.Brown
BPX / MARATHON / SHELL
GC200 FIELD DEVELOPMENT:
TROIKA PROJECT


Bullwinkle Platform
VESSEL STERN TRACK
Step 17 Once all positioning and control systems are confirmed operative the vessel increases power to start the bundle movement and advances from V29 to V30 with the ROV using Mesotech for stopping the bundle within the acceptable target at TD30 on the sea bed.
Step 15 The vessel stops the bundle at position TD29. The survey vessel moves to the yellow target area and launches its ROV with the Mesotech and places the appropriate hardware on the pipe and sea bed. Then a series of starts and stops are executed to judge the accuracy of stopping at the final parking position for the final tow-in V30 position. Once complete and the handling characteristics are established go to Step 16.
Aiming Point 2,323,304 10,120,270
Target
BUNDLE STOPPING TARGET POSITION
Step 16 The survey vessel moves to the final target and repositions itself above the on bottom bundle stop target position. It then deploys the ROV, sets all hardware and confirms that the stopping systems are operative. The tow-in personnel on the platform are contacted to confirm that the tow can be restarted to move the bundle to its final stopping position at (Aiming Point 2,323304 10,120,270).
Step 14 The tow vessel passes through vessel positions V24 to V29 with vessel tracking the appropriate transponder on the bundle confirming positioning along the route. Should excessive variations in the bottom position be observed the tow is stopped and new tow vessel surface position established prior to continuing the tow.
Step 13 After the riser buoyancy is removed and all the conditions for tow continuance are confirmed the tow vessel comes up on power to approximately 80% of towing power (134 tons) and spools the riser's top end to the surface final check with the platform is made and the vessel gets underway at 2 knots. The survey vessel tracks the appropriate transponder on the bundle confirming proper position.
Stopping Sequence
The tow vessel continues the tow from V29 at 2 to 3 Knots stopping the bundle approximately 200' from the riser's final position target on the seabed between the TD29 and TD30. The Survey vessel deploys the ROV and positions itself near the target for the stopping sequence. After the ROV is confirmed in position the Tow vessel continues its tow at approximately 1 knot, stopping at several positions as the target on the bundle approaches the stopping position. The ROV with the Mesotech sonar monitors and counts down the distance to the stopping position at the "Bundle stopping target position 10,120,270 and 2,323,304". The tow vessel's approximate stopping position is at V30 -10,124,103 and 2,317,359. In this case the bundle stop is controlled by the "Bundle stopping target position". The stress level during the tow-in is 40% of yield.
V29
V28
V27
V26
Pipeline
Umbilical
Center Line A1 Tow-in Route


2513
2562
10
2572
JS 100% OCEANEERING #117
5:39:34
9-01-97

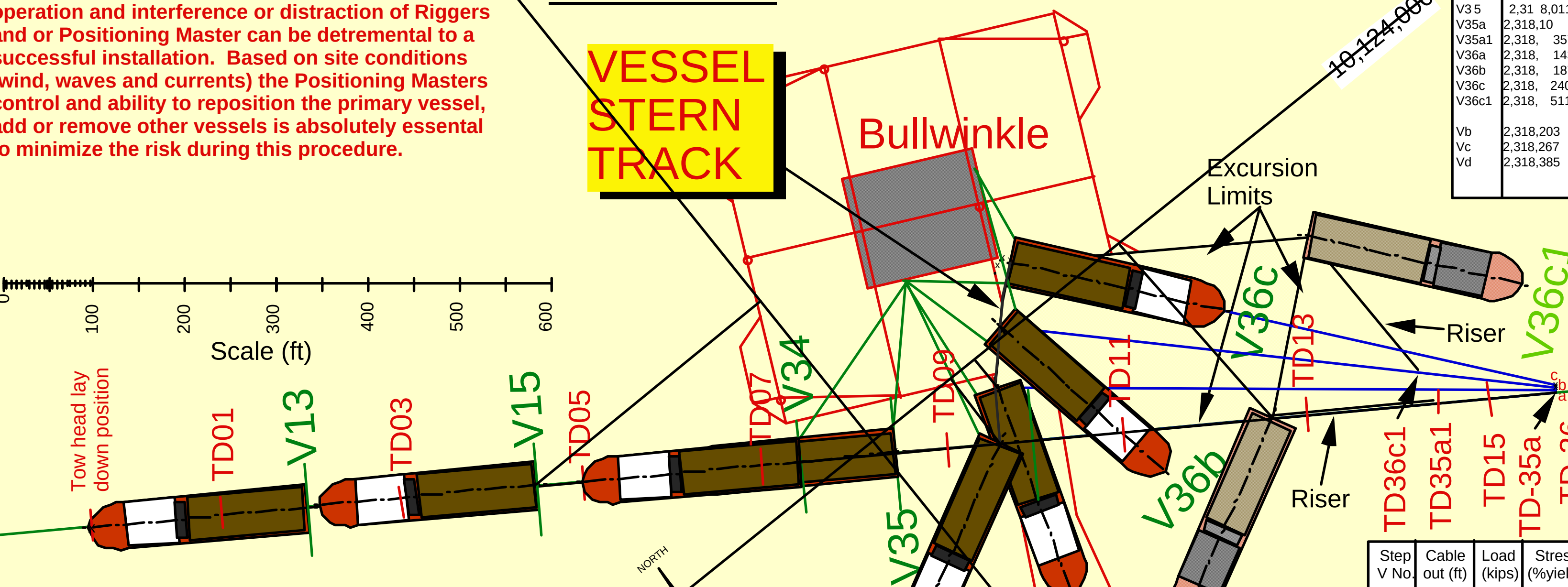

MAIN MENU
Disp: Pola
ScnSp: 4-Fs
Grid: Off
Hold: Off
SSDis: Righ
ScnR:
Magn: Off
Thrsh: 5
Clear Disp
SUB-MENUS
SIMRAD
Mesotech
MS 900
Version 2.08
31-Aug-1997
15:58:44

Erect Riser

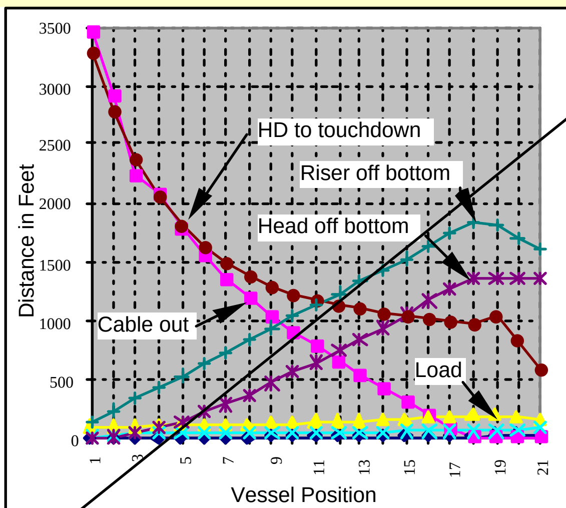
TOW VESSEL ALLOWABLE EXCURSION

CAUTION: This procedure is a very intense operation and interference or distraction of Riggers and or Positioning Master can be detremental to a successful installation. Based on site conditions (wind, waves and currents) the Positioning Masters control and ability to reposition the primary vessel, add or remove other vessels is absolutely essental to minimize the risk during this procedure.

VESSEL STERN TRACK



	Vessel		Touch Down	
	X	Y	X	
V13	2,317, 476	10,124, 331	2,3 18,387	10,12 3,725
V15	2,317,68 2	10,124, 193	2,318,552	10,123,617
V34	2,317, 936	10,124, 025	2,318,798	10,123,456
V35	2,31 8,011	10,12 3,975	2,318,697	10,123,519
V35a	2,318,10 7	10,123,91 2	2,318,620	10,123,426
V35a1	2,318, 357	10,123, 746		
V36a	2,318, 143	10,12 3,962	2,318,619	10,123,425
V36b	2,318, 187	10,124,0 13	2,318,624	10,123,422
V36c	2,318, 240	10,12 4,059	2,318,62 5	10,123, 419
V36c1	2,318, 511	10,123, 879		
Vb	2,318,203	10,123,678		
Vc	2,318,267	10,123,747		
Vd	2,318,385	10,123,830		



Step V No.	Cable out (ft)	Load (kips)	Stress (%yield)	Head off bottom (ft)	HD to touchdown (ft)	Riser off bottom (ft)
1	3470	105	20	4	3288	140
2	2908	104	33	20	2789	240
3	2245	104	41	50	2377	340
4	2082	106	46	95	2060	440
5	1796	108	48	152	1819	540
6	1564	112	49	220	1636	640
7	1369	116	50	297	1494	740
8	1200	122	51	381	1383	840
9	1048	128	53	472	1294	940
10	915	134	55	564	1225	1035
11	791	140	56	657	1174	1135
12	675	147	56	752	1136	1235
13	560	153	55	850	1103	1335
14	446	160	56	952	1074	1435
15	332	167	58	1057	1047	1535
16	218	174	60	1165	1021	1635
17	104	180	63	1274	996	1735
18	11	189	64	1365	973	1835
34	10	189	64	1365	1035	1830
35	10	172	84	1365	825	1710
36	10	160	105	1365	610	1610

Note: It is of prime importance that the vessel's stern follows the track shown on the procedure above The heading of the vessel during the yawing process is a function of the vessel yawing power, control, wind, sea state and currents. The vessel captian is the sole judge of the vessel heading during the backin maneuver.

REV	BY	DATE	APVD	DESCRIPTION
2	RJB	8/28/97	RP	Revised scaling and TD coordinates / J.C.
1	RJB	8/7/97	RP	Revised vessel and TD coordinates / J.C.
0	RJB	7/2/97	RP	Approved for construction

BPX / MARATHON / SHELL
GC200 FIELD DEVELOPMENT:
TROIKA PROJECT
FLOW LINE BUNDLE

ENGINEERS SEAL

JOB NO.:	2130700
CLIENT NO :	
CLIENT SIGN :	
PROJ MGR :	
PROJ ENG :	R.P. J.C.
LEAD ENG :	R.B.
DESIGNED BY:	R.B.

Kvaerner - R.J.Brown
a division of Kvaerner Earl and Wright, Inc.

BUNDLE A-1 RISER PLACEMEN

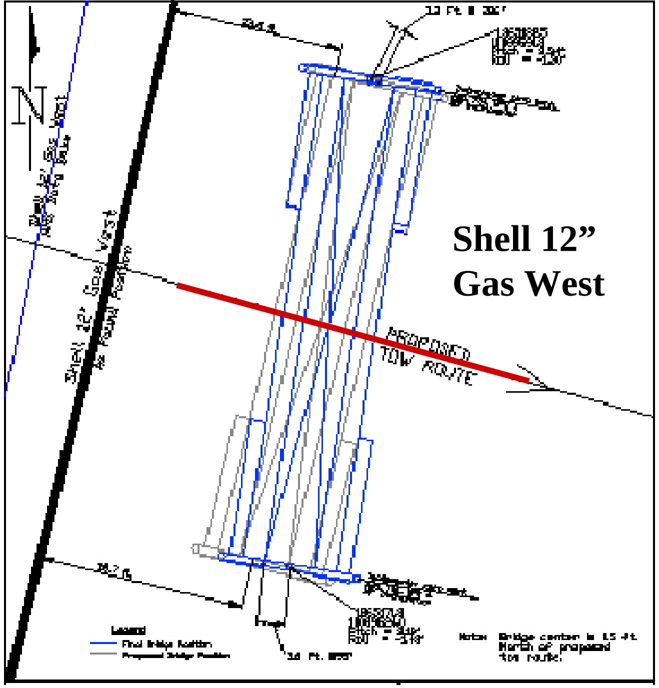

ENSCO

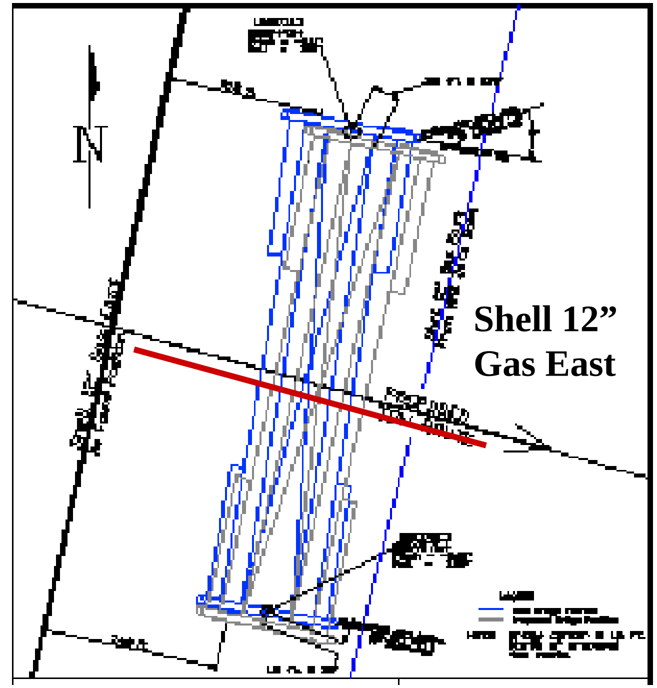

EEX 12” OIL

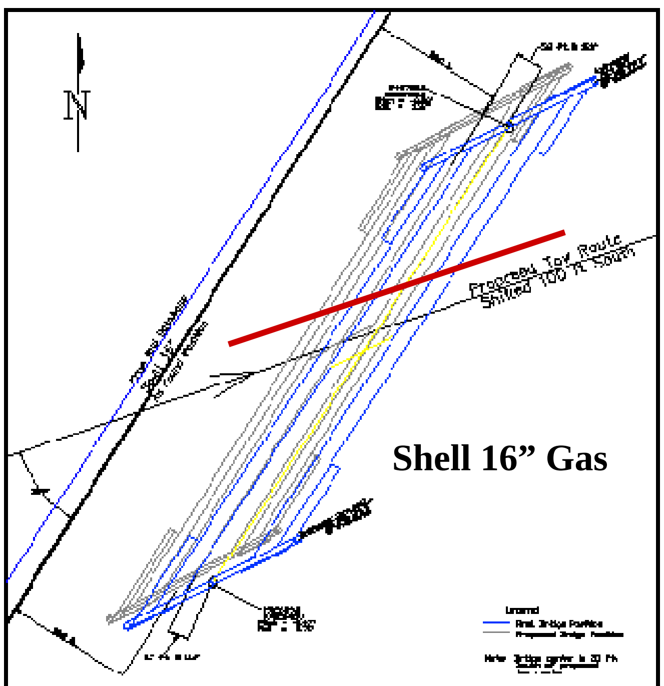

EEX 12” OIL

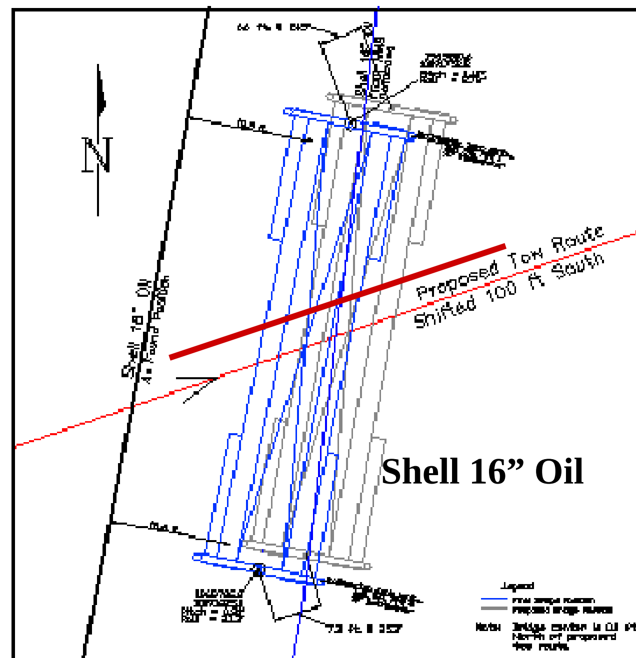
EEX 12” GAS

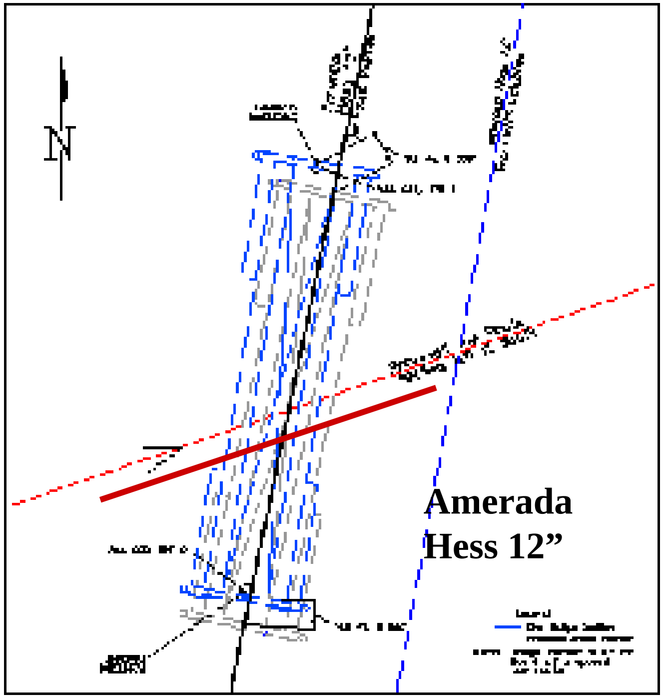

AMERADA HESS 12”


N
Shell 12"
Gas West
PROPOSED
TOW ROUTE

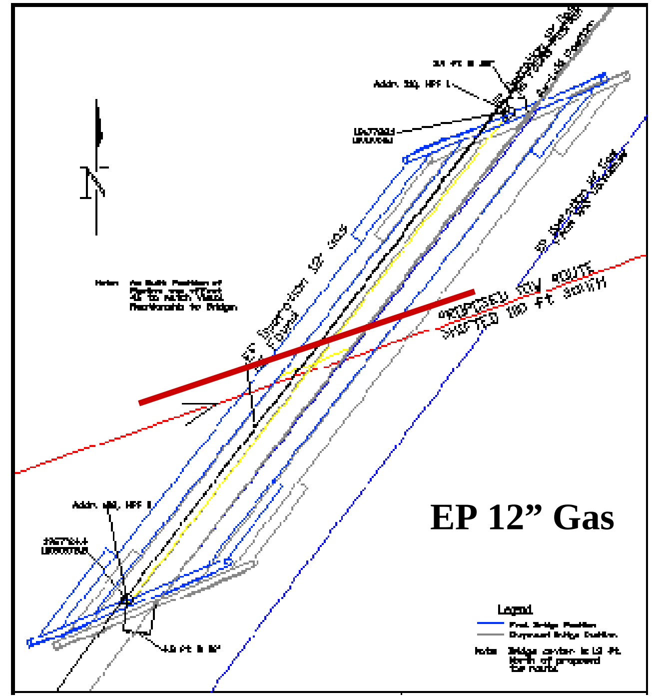

N
Shell 12"
Gas East
PROPOSED
TOW ROUTE


N
Shell 16" Gas
Proposed Tow Route
Shifted 100 ft South

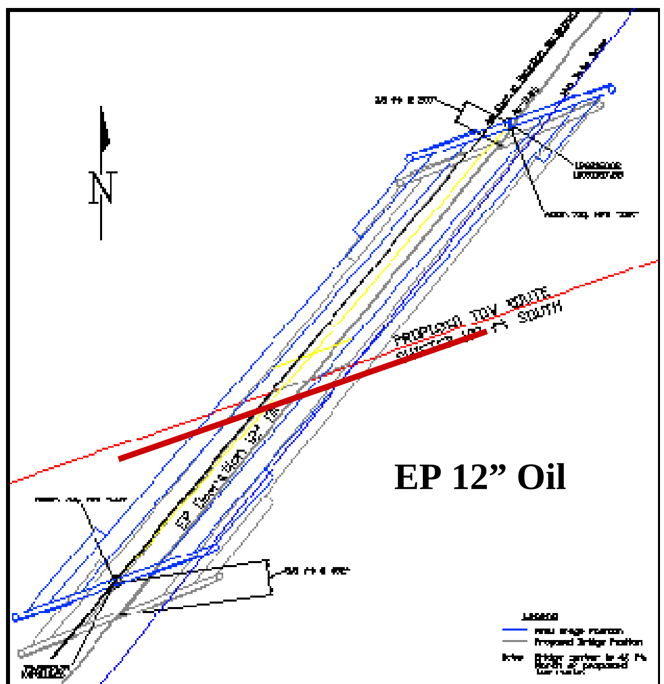

N
Shell 16" Oil
Proposed Tow Route
Shifted 100 ft South



Amerada Hess 12”
N
Legend



EP 12” Gas
N
PROPOSED TGV ROUTE
SHIFTED 100 FT SOUTH
Legend



EP 12” Oil
N
PROPOSED TGV ROUTE
SHIFTED 100 FT SOUTH
Legend


EEX 12” GAS


EEX 12” GAS


EEX 12” GAS


EEX 12” OIL


EEX 12” OIL