STATE OF THE ART OF REMOVING LARGE PLATFORMS LOCATED IN DEEP WATER

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Executive Summary

This report is developed to provide a review of the state-of-the-art in decommissioning technology for the removal of offshore platforms located in deep water. The emphasis is on the Pacific Outer Continental Shelf Region (POCSR), but comparisons are made for the Gulf of Mexico. Three platforms (Hidalgo, Gail and Harmony) located in the POCSR have been selected to provide specific cases for evaluating cost and other issues related to different platform removal methods.

Although the three platforms selected for detailed evaluation are located in the POCSR, the cost algorithms generated by this study can be used to develop decommissioning estimates for deepwater platforms located in the POCSR and in the Gulf of Mexico Outer Continental Shelf region (GOMR).

Specific areas of technology reviewed include lifting, transportation, disposal, and explosive and non-explosive severing techniques. The three removal methods evaluated (using the best technology currently available) were Complete Removal, Partial Removal (reefing-in-place) and Remote Reefing (or reefing off-site).

TSB prepared decommissioning cost estimates for the selected platforms and cases, including an evaluation of cost sensitivity (risk) issues and the cost of alternative technologies (i.e., explosive versus non-explosive severing methods). TSB also assessed environmental and human safety risks for current and evolving decommissioning technology, and prepared specific recommendations for industry and federal/state support for future developments.

The decommissioning cost summary for the three platforms and methods evaluated is shown in Table 1.1.

Table 1.1 – Decommissioning Summary Results ($MM)

Platform	Water Depth (ft.)	Total Weight (tons)	Complete Removal	Partial Removal	Remote Reefing
Hidalgo	430	21,050	44	15	18
Gail	739	30,000	57	15	20
Harmony	1,198	65,050	123	20	35

While a number of new technologies are currently being developed for the removal of offshore platforms, TSB has determined that standard removal technologies remain the best option for decommissioning deepwater platforms at the present time. Existing heavy lift vessels such as the Thialf, Siapem 7000, Hermod, Balder, and DB 50 are the most cost-effective and dependable topsides and jacket removal technology available at the present time. Additionally, explosives remain the safest, most dependable, and reliable severing technique available today in general.

Many of the alternative heavy-lift technologies reviewed may someday prove to be safer, more cost-effective ways to remove topsides and jackets. The designed load capacities for many of these systems are more than adequate for the topsides associated with deepwater platforms. However, deepwater jacket removal tends to be problematic for all alternatives reviewed.

Of the three removal techniques reviewed, Partial Removal is rated the highest in the majority of evaluation categories reviewed (see Section 5).

Overall, TSB found that the Partial Removal scenario, combined with proven heavy lift, severing, and subsea technologies, is currently the safest, most cost-effective way to remove offshore platforms located in deepwater. However, since a number of the new technologies reviewed are close to becoming viable, an ongoing assessment of these technologies will be necessary to remain abreast of the deepwater decommissioning state-of-the-art in the future.

Section 1 – Introduction

1.1 Project Issues

Offshore platform decommissioning is a challenge under any circumstances in terms of planning and executing the work in an environmentally sensitive, safe, and economical way. In the context of the large deepwater platforms in the POCSR, this is particularly true. Among the issues that must be faced are:

1.1.1 Lack of Local Infrastructure

There are currently no derrick barges of significant capacity or other types of major marine construction equipment based on the West Coast, and none are likely to be in the foreseeable future. Additionally, there are currently no onshore facilities in California (or Mexico) capable of accepting jackets or topsides of these sizes, even in small pieces. The nearest such facility is in Portland, Oregon, eight to ten days sailing time away.

1.1.2 Challenging Marine Environment

While most people think of the offshore California marine environment as being relatively calm, it is in fact very challenging to the type of large construction equipment and operations required for offshore platform decommissioning. Research has shown that conditions vary widely, with areas such as Point Arguello being subjected to rough seas, long period swells, and dense fog much of the year.

1.1.3 Limited Availability of Equipment

There are only four derrick barges in existence today, worldwide, with lifting capacities in excess of 5,000 short tons. These are generally committed to projects years in advance. This lack of equipment will drive innovations both technically and commercially.

1.1.4 Environmental Regulation Constraints

California has a large number of regulations and a wide variety of federal, state, and local agencies enforce them. This has a direct impact on the application of decommissioning technologies and the resulting economics. This presents a major challenge to project planning and management.

1.1.5 Depth Challenges

The industry has limited experience in applying decommissioning technologies at depths beyond 300 feet. New systems and procedures will likely be required for both explosive and non-explosive severing techniques. Safety will drive the use of divers and remotely-operated equipment.

1.1.6 Lack of Artificial Reef Legislation

Unlike the Gulf of Mexico oil and gas producing states, California currently has no enabling legislation for a rigs-to-reef program for offshore facilities. Such legislation is currently being discussed, but the timeline for its enactment is uncertain. This presents a major challenge to project planning and economics.

1.2 Project Objectives

The overall goal of the project was to determine and examine the relevant issues for deepwater decommissioning and to quantify them in the context of economics, risk, and available technology. The following specific goals were achieved in this study:

- Develop decommissioning plans for selected POCSR deepwater platforms using the best technology currently available.
- Prepare decommissioning cost estimates for selected platforms and cases, including an evaluation of cost sensitivity (risk) issues and the cost of alternative technologies (i.e., explosive versus non-explosive severing methods)
- Assess environmental and human safety risks for current and evolving decommissioning technology
- Provide a review of the state-of-the-art in decommissioning technology for the following deepwater applications:
    - Lifting, transportation, and disposal
    - Explosive and non-explosive severing techniques
- Prepare specific recommendations for industry and federal/state support for future developments

1.3 Scope of Work

The Scope of Work for the study is as follow:

- Select platforms to be evaluated
- Select removal technology
- Evaluate removal technology
- Develop decommissioning plans and cost estimates
- Analyze safety and environmental issues
- Describe other removal technologies, their current development status, and prospects

Working with the MMS, TSB selected the Gail, Hidalgo, and Harmony platforms as the three structures that would best cover the range of issues involved in decommissioning deepwater platforms. A review of these platforms and an overview of all existing deepwater platforms in the POCSR and GOMR is provided in Section 2. Deepwater platforms in this study are defined as those in water depths greater than 400 feet with jacket weights of 10,000 short tons or greater.

The technology areas reviewed were heavy lift technologies, explosive and non-explosive severing techniques, and subsea technologies. The evaluation of these technologies is included in Sections 8, 9, and 10, respectively.

The decommissioning plans developed for the three platforms selected are provided in Section 5. Algorithms created to generalize the decommissioning estimates are included in Section 6. A review of the challenges associated with the decommissioning of these platforms is provided in Section 7.

Analyses of safety and environmental issues and assessments of developmental needs are included throughout this report.

1.4 Methodology Selection

Figure 1.1 shows a Decommissioning Decision Tree which identifies all of the decommissioning methods that were considered for inclusion in this study. Topsides containing oil and gas processing equipment are assumed to be taken ashore and scraped in all cases. Three methods for jacket disposal were selected to cover the range of cost and what are expected to be the most likely choices in the actual execution of POCSR platform decommissioning. These methods are equally applicable to the GOMR. The selected methods are:

- Complete Removal
- Partial Removal, and
- Remote Reefing.

Details of the assumed approach to execution of each of these methods are discussed in Sections 3.0 and 4.0. All of the assumed methodology are consistent with current practice in the GOMR. However, it is important to note that contractors who operate the large heavy lift vessels may not agree with the methods assumed, e.g., picking the jackets up and "hopping" them into shallow water so that all cuts are made in air. In general, the operators of the large heavy lift vessels have relatively little experience in platform decommissioning and what they have was primarily gained in the North Sea. The only relevant North Sea decommissioning is that of the Esso Odin platform in the Norwegian sector. This platform was removed by cutting the jacket into many pieces *in situ*. This was considered to be the safest and most cost effective method when the work was performed. Some HLV operators have suggested this method for the POCSR platforms. Lifting and transporting the jackets "on the hook" has been regarded as unsafe, even though it is common practice in the Gulf of Mexico. An evaluation of the Esso Odin project is currently being undertaken by the Health and Safety Executive (HSE) in the UK. We believe that this study will raise questions about the safety of *in situ* cutting of jackets, particularly in deep water. This will present a challenge to platform owners in terms of keeping costs within the bounds predicted by this study. Nevertheless, the cost reported here should be achievable through proper planning and engineering and a high level of cooperation between the contractors and platform owners. The rapid development of alternative heavy lifting technology will also help in this area.

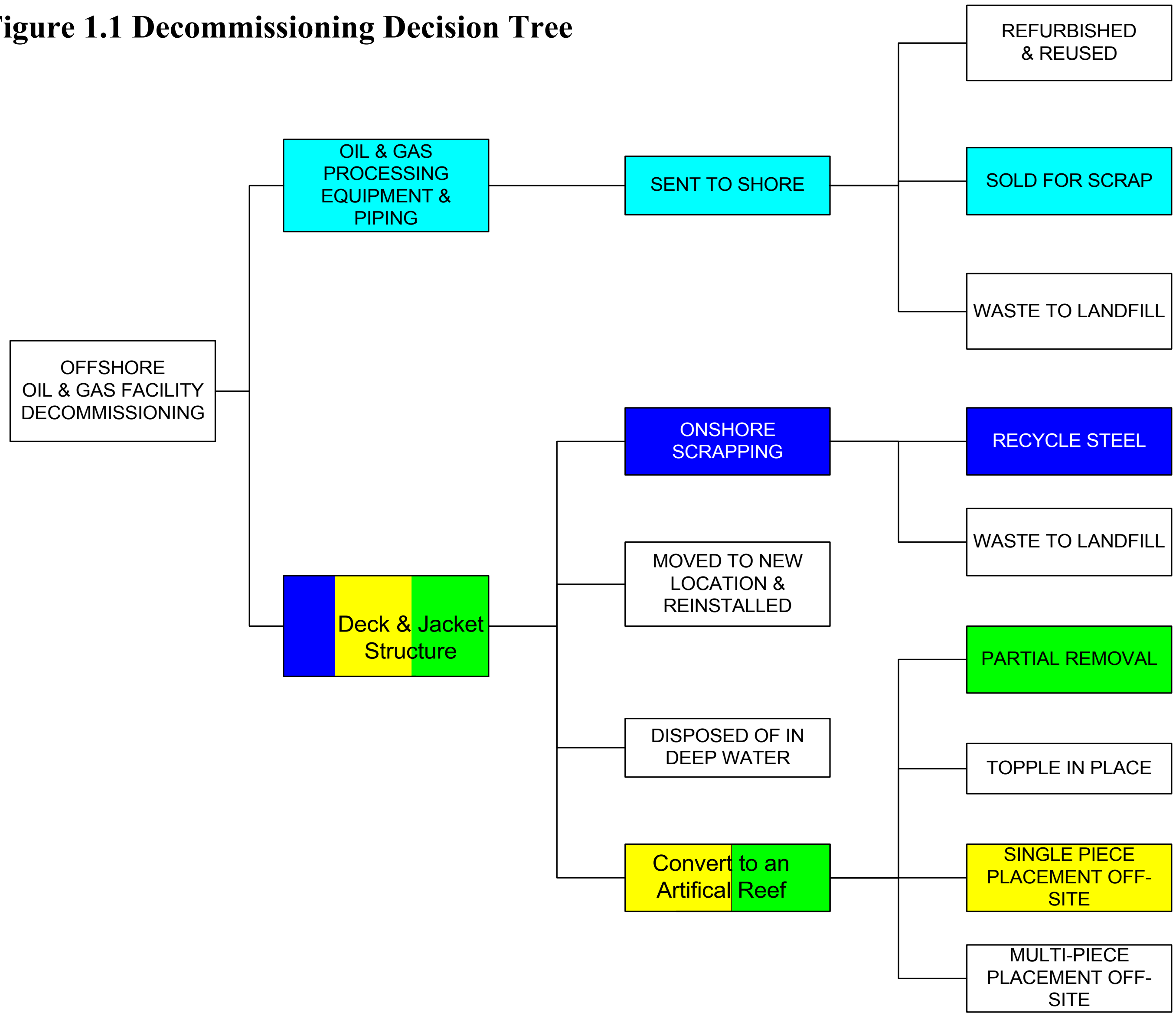
1.5 Conclusions

While a number of new technologies are currently being developed for the removal of offshore platforms, it is our judgement that conventional removal technologies remain the best option for decommissioning deepwater platforms. Existing heavy lift vessels such as the Thialf, Siapem 7000, Hermod, Balder, and DB50 are currently the most cost-effective and dependable topsides and jacket removal systems available. Additionally, explosives remain the safest, most dependable, and reliable severing technique available today.

Of the three removal techniques reviewed, Partial Removal was rated the highest in the majority of evaluation categories reviewed (see Section 5).

Overall, TSB found that the Partial Removal scenario, combined with conventional heavy lift vessels, severing, and subsea technologies, is currently the safest, most cost-effective way to decommission offshore platforms located in deepwater. However, since a number of the new technologies reviewed are close to becoming viable, an ongoing assessment of these technologies will be required to remain abreast of the deepwater decommissioning state-of-the-art in the future.

Figure 1.1 Decommissioning Decision Tree



Section 2 – Deepwater Platforms Overview

Introduction

This section summarizes the platforms used in this study. Included are:

- A definition of deepwater platforms
- A listing of all deepwater platforms in the Pacific Outer Continental Shelf Region (POCSR) and the Gulf of Mexico Outer Continental Shelf region (GOMR)
- A summary of the platforms used in this study
- A review of the potential to extrapolate the results of this study

2.1 Definition of Deepwater Platforms

For this study, deepwater platforms are defined as those with jacket weights exceeding 10,000 short tons located in water depths exceeding 400 feet.

By this definition, there are currently 8 deepwater platforms in the POCSR and 15 deepwater platforms in the GOMR. There are other types of platforms in the water depth or weight range described in the POCS, GOMR and other parts of the world, but for this study, only domestic conventional steel-jacketed platforms are considered.

2.2 Summary of Deepwater Platforms in the POCSR and GOMR

The following tables provide the names, water depth, and jacket weight for all deepwater platforms located in the POCSR and the GOMR.

Table 2.1 – Deepwater Platforms- POCSR

Platform	Water Depth (ft)	Jacket Weight (st)
Hidalgo	430	10,950
Hermosa	603	17,000
Harvest	675	16,633
Eureka	700	18,500
Gail	739	18,300
Hondo	842	12,200
Heritage	1,075	32,420
Harmony	1,198	42,900

Table 2.2 – Deepwater Platforms- GOMR

Platform	Water Depth (ft)	Jacket Weight (st)
GB 236 A	682	13,228
GB 189 – Tick	718	11,023
GC 19 – Boxer	751	14,881
GC 18 A	761	16,755
EW 873 – Lobster	774	16,535
EB 165 – Snapper	863	20,503
EB 159 – Cerveza Ligera	925	14,991
EB 160 – Cerveza	935	19,952
MC 280 – Lena	997	23,366
MC 109 – Amberjack	1,027	23,810
MC 194 – Cognac	1,027	33,620
VK 780 – Spirit	1,036	19,012
VK 989 – Pompano	1,289	39,890
GC 65 – Bullwinkle	1,348	54,427
GB 260 – Baldplate	1,647	57,267

2.3 Selected Platforms

The three platforms selected to cover the range of issues discussed in this report are **Hidalgo**, **Gail**, and **Harmony**. These platforms were selected to encompass the wide range of decommissioning options available and to provide a thorough review of issues related to decommissioning deepwater offshore structures. The water depths range from 430 feet to 1,198 feet. Table 2.3 provides data for the selected platforms.

The term *originating pipelines* refers to pipelines that start at the stated platform with respect to where the material (oil, gas, etc.) originates. Pipelines may transit through another platform, but the decommissioning liability remains with the owner of the platform at which the pipeline originates. If a platform being decommissioned has pipelines connected to it that do not originate at that platform, owners of these pipelines have two options – they can tie-in to the remaining pipeline that leads to shore or abandon the pipeline altogether. In either case, the owner of the originating pipeline retains the decommissioning liability for the pipeline in its entirety. Therefore, if the owner of an originating pipeline ties into an existing to-shore pipeline, they assume the decommissioning liability for the entire pipeline from their platform to shore.

Table 2.3 – Data Summary for Selected Platforms

Platform	WD (ft)	Number of Main/Skirt Piles (Outer Diameter)	Number of Modules	Number of Conductors	Number of Originating Pipelines
Hidalgo	430	8/8 (60"/72")	7	10	2 (16", 10")
Gail	739	8/12 (60"/72")	5	22	3 (8", 8", 8")
Harmony	1,198	8/20 (72"/84")	10	51	2 (12", 20")

2.3.1 – Hidalgo

Hidalgo is an 8-main and 8-skirt pile ("8+8") drilling and production ("D&P") platform installed in 1986 at a water depth of 430 feet. The platform is located 6 miles from shore in the Santa Maria Basin. Jacket lift weight (including piles) and topsides weight (deck and modules) is estimated at 12,950 and 8,100 tons respectively. There are 10 conductors to remove and 2 originating pipelines to decommission.

Figure 2.2 shows the location of the Hidalgo platform.

2.3.2 – Gail

Gail is an 8-main and12-skirt pile ("8+12") D&P platform installed in 1987 at a water depth of 739 feet. The platform is located 10 miles from shore in the Santa Barbara Channel. Jacket lift weight (including piles) and topsides weight (deck and modules) are estimated at 22,300 and 7,700 tons respectively. There are 22 conductors to remove and 3 originating pipelines to decommission.

Figure 2.2 shows the location of the Gail platform.

2.3.3 – Harmony

Harmony is an 8-main and 20-skirt pile ("8+20") D&P platform installed in 1989 at a water depth of 1,198 feet. The platform is located 6 miles from shore in the Santa Barbara Channel. Jacket lift weight (including piles) and topsides weight (deck and modules) are estimated at 55,250 and 9,800 tons respectively. There are 51 conductors to remove and 2 originating pipelines to decommission. Additionally, there are 4 other pipelines connected to Harmony that orignate at other platforms. Table 2.4 lists the pipelines terminating at Harmony. The decision as to whether these pipelines will be abandoned or if they will tie-in to other pipelines at the time Harmony is decommissioned is up to the owner of the platform at which the pipeline originates.

Figure 2.2 shows the location of the Harmony platform.

Table 2.4 – Pipelines Terminating on Harmony

Originating Platform	Terminating Platform	Outer Diameter (in)	Length (ft)	Product
Shore	Harmony	12.78	237,553	Water
Hondo	Harmony	14	20,906	Oil/Water
Heritage	Harmony	20	82,510	Oil/Water
Heritage	Harmony	12.75	67,672	Gas

2.4 Extrapolation of Results

Although this report focuses only on three deepwater platforms located in the POCSR, TSB has generated algorithms that can be used to assess the cost of decommissioning the remaining deepwater platforms in both the POCSR and the GOMR. Factors reviewed in this study such as jacket removal options and heavy lift vessel selection are applicable to all existing deepwater platforms in these areas.

For a thorough review of the algorithms discussed above, please refer to Section 6 of this report.

Figure 2.1 Distribution of Offshore Installations

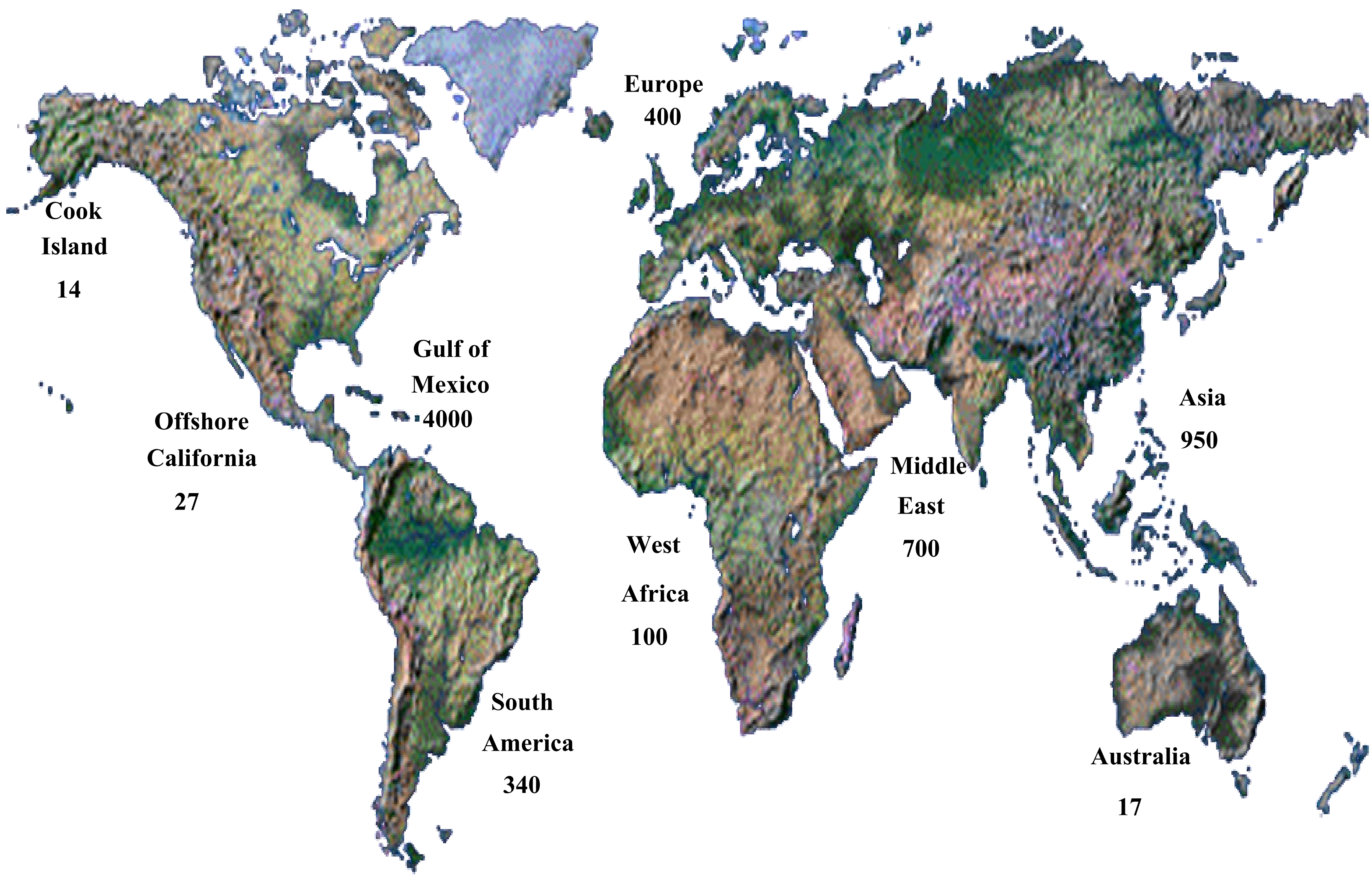


Figure 2.2 Hidalgo, Gail and Harmony Platform Location

Section 3 – Decommissioning Methodology

Introduction

The following section gives a brief overview of the decommissioning methodology used to derive the estimates for the decommissioning and removal of the Hidalgo, Gail, and Harmony deepwater platforms. Cost components that should be accounted when developing offshore platform decommissioning estimates are as follows:

- Project Management & Engineering
- Heavy Lift Vessel mobilization
- Cargo Barge Mobilization
- Well P&A
- Platform Removal Preparation
- Pipeline Abandonment
- Conductor Removal
- Platform Removal
- Site Clearance and Verification
- Onshore Disposal

TSB considered three removal alternatives for each platform; Complete Removal, Partial Removal, and Remote Reefing. The alternatives studied vary only in the method the jacket is removed. Site Clearance and Onshore Disposal depend on the removal alternative selected. The platform removal preparation, well plugging and abandonment (P&A), pipeline decommissioning, and topsides removal are the same for all three alternatives.

3.1 Project Management & Engineering

The project management/engineering component of a decommissioning program consists of the following phases:

- Decommissioning Planning
- Decommissioning Engineering
- Permitting
- Preliminary Engineering
- Bidding
- Contractual
- Offshore Supervision
- Post-job reporting

3.1.1 Decommissioning Planning

This is the initial phase of the decommissioning project. All information available for each platform to be decommissioned (structural drawings, installation records, process flow diagrams, pipeline maps, etc.) is first gathered and reviewed. Based on the information retrieved, an Approval for Expenditure (AFE) for each platform will be developed and submitted to the platform owner for approval. In cases where multiple platforms are to be decommissioned, this AFE will consider grouping the platforms to realize any economies of scale, and various types of removal scenarios (i.e., Complete Removal, Partial Removal, and Remote Reefing) are evaluated. All assumptions made are noted on the AFE(s). Concurrently, a detailed project schedule is developed.

After the AFE(s) are approved, the platforms are inspected above and under water to appraise the overall platform condition, drilling and production deck dimensions, equipment location, padeyes, risers, etc. A detailed topsides inspection punchlist is submitted to and agreed upon with the platform owner prior to these inspections.

TSB recommends a pre-contracting underwater survey of the jacket and seafloor for larger and older platforms. The dive crew would survey the sea floor for debris that would hamper the platform removal and inspect the jacket for flooded members and conductors that are severed below the waterline.

For conventional steel-jacket platforms located in shallow depths in the Gulf of Mexico, TSB recommends a six-month lead-time for decommissioning planning. However, deepwater decommissioning planning requires a longer lead-time because of the limited equipment availability. In the POCSR long lead times will be required because of environmental issues and the resulting permitting process, even for shallow water platforms. For example, it took Chevron 2-3 years to develop plans and obtain all the requisite permits to decommission the Chevron 4-H platforms. Therefore, a minimum of 3 years lead-time is recommended for planning the decommissioning of deepwater platforms. For complete removal, equipment contracting alone will require 2-3 years leadtime, or more.

3.1.2 Decommissioning Engineering

Deck and jacket weights, the center of gravity, and the center of buoyancy are needed for the larger platforms. This information is necessary in that there are often no records identifying the actual deck and jacket weights.

A lift analysis is developed by a structural engineer; all calculations are reviewed and approved by the project manager.

3.1.3 Permitting

Permits required by the MMS for the decommissioning of offshore structures are as follows:

- Well P&A Sundry Notices and Procedures
- Pipeline Abandonment Permits
- Platform Removal Permits

- Reefing Permits (if applicable)
- Incidental Take Statement
- Site Clearance Verification Procedures

Each platform, well, and pipeline will require their specific permits. The project management group prepares all permits, along with any necessary attachments. The permit requests are submitted to the platform owner for review and approval. Once approved, the project management group submits the requisite number of copies to the appropriate MMS office for approval and issuance of permits. The POCSR has additional permitting requirements to comply with the National Environmental Protection Act (NEPA) and the California Environmental Quality Act (CEPA).

3.1.4 Bidding

The client and the project management group work together to determine the manner by which bids will be developed to take advantage of the amount of work to maximize economies of scale.

The project management group prepares a suggested list of qualified contractors for each phase of the job; the platform owner then reviews, revises (if necessary) and approves the list. The bid books are prepared by the project management group and are submitted to the owner for approval. Once approved, the approved contractors are sent the Requests for Quotation (RFQs).

Proposals submitted based on these RFQs are reviewed by the project management group who develops a spreadsheet containing all contractors' rates. This spreadsheet, along with a recommendation for award, is sent to the platform owner for review and award of the work.

3.1.5 Pre-job Meetings

Prior to commencing any offshore work, pre-job meetings are conducted with each contractor, the project management group, and the platform owner's representatives. The goal of these meetings is to establish that all parties involved understand the Scope of Work, operational and safety procedures, reporting requirements, etc. The project management group is responsible for coordinating these meetings by contacting the parties involved, setting the time and location of the meeting, preparing the meeting agenda, and recording and distributing meeting notes.

3.1.6 Offshore Supervision

Members of the project management group can act as representatives for the platform owner during decommissioning operations. They select the proper mix of offshore supervisors (i.e., HLV supervisors, diving superintendents, etc.) who will witness the offshore operations and report all activities to the project management group and the platform owner.

3.1.7 Project Closure

Each decommissioning phase requires a report be submitted to the MMS. These reports are submitted to the platform owner for review and approval. Once approved, the project management group submits the reports to the appropriate MMS office.

3.2 Well Plugging and Abandonment (Well P&A)

Well P&A is not considered as a factor in this study, and is therefore not included in the cost estimates. However, TSB has assumed that all wells on each platform will be plugged and abandoned using either conventional rig-based P&A methods or using rigless techniques prior to cutting and removing the conductors.

Based on the current inventory, the number of wells that must be plugged and abandoned for this project is as follows:
- Hidalgo – 10 wells
- Gail – 21 wells
- Harmony – 26 wells

3.3 Platform Removal Preparation

An inspection of the platform is made, above and below water, to determine the condition of the platform and identify potential problems with the salvage. Depending on the water depth, divers or a remote-operated vehicle (ROV) perform the underwater portion of the inspection.

All additional work that can be performed prior to the arrival of the HLV is completed during the Platform Removal Preparation phase. All personnel and equipment are mobilized and housed in the existing platform quarters.

The crew flushes and cleans all piping and equipment that contained hydrocarbons. All modules to be removed separately from the deck are cut loose using oxygen-acetylene torches. The piping, electrical, and instrumentation interconnections between modules are also cut. All work needed to prepare the modules for lifting, such as installing lifting eyes, etc., is done at this time.

3.4 Pipeline Decommissioning

All pipelines connected to the platform are decommissioned. The decommissioning crew flushes the line by pumping (pushing) a cleaning plug (*pig*) through the line with seawater. Divers or an ROV will then expose the ends of the pipeline and cut the line above the riser bend and approximately ten feet out from the base of the jacket. The riser bend is removed and the cut end of the pipeline is plugged and buried three feet below the mudline.

For the pipelines that run to shore, the line is cut just beyond the surf zone and plugged. The portion of the line that extends into the surf zone is removed to the beach line. The remaining line is plugged and buried.

The following summarizes the number of pipelines originating from each platform that will need to be decommissioned for this project:
- Hidalgo – 2 pipelines (16", 10")
- Gail – 3 pipelines (8", 8", 8")
- Harmony – 2 pipelines (12", 20")

Pipelines terminating on these platforms should be accounted at the originating platform.

3.5 Conductor Removal

All conductors are completely removed up to 15 feet below the mudline. A combination of jacks and the platform's drilling ring and crane are used to pull the conductors. This work should be completed prior to the arrival of the heavy lift vessel (HLV). Removing conductors with jacks and a drilling rig generally follows the same methodology as removing conductors with jacks and a bullfrog crane. The jacks onboard may not be able to pull the combined weight if the conductor is grouted. The conductor is pulled upward until a 40-foot section is exposed. The rig is used until the jacks can pull the weight of the entire conductor. The conductor is cut using external mechanical cutters. The cut section is then removed by the drilling rig or platform crane and placed on the deck. The platform crane places the cut section on a workboat (or away from the work area). This procedure (rig up, jack upward, cut and remove) is repeated until the entire conductor is removed.

The following summarizes the number of conductors for each platform that will need to be decommissioned for this project:

- Hidalgo – 10 conductors
- Gail – 22 conductors
- Harmony – 51 conductors

3.6 Mobilization

Cargo barges are outfitted at a fabrication yard with steel load spreaders to support the point loads of the jacket and deck. A tugboat tows each cargo barge to the offshore location. TSB assumed that the cargo barges are mobilized from the Northwest coast. The total number of barges necessary for the removal of the Hidalgo, Gail, and Harmony platforms is shown in Table 4.1 below. TSB estimated a mobilization duration of 6 to 7 days per barge from the Northwest coast to the platform site.

The heavy lift vessel (HLV), along with its anchor-handling tugs, is mobilized from the North Sea, Gulf of Mexico or the Far East (depending on the jacket removal method) to the West Coast. The HLV's crew is mobilized to be onsite and board the HLV when it arrives on site.

The Complete Removal method assumed the HLV is mobilized from Rotterdam to the Pacific west coast through the Cape of Good Hope. The 13,350 n. mile voyage was estimated to take 94 days each way. The other two methods assumed the HLV is mobilized from the Gulf of Mexico to the Pacific west coast through the Cape of Good Hope. The 13,300 n. mile voyage was estimated to take 94 days each way.

Table 3.1 – Barges Necessary for Complete Removal

Platform	Topsides	Jacket
Hidalgo	1 – 300x100 2 – 400x100	2 – 300x100 4 – 400x100
	3 total	**6 total**
Gail	2 – 300x100 1 – 400x100	2 – 300x100 3 – 400x100 1 – 400x120 1– 400x150
	3 total	**7 total**
Harmony	4 – 400x100	2 – 400x100 1 – 400x20 1 – 450x120 1 – 450x150 1 – 530x120 1 – 530x150 1 – 500x120 1 – 580x160 1 – 650x120
	4 total	**10 total**

3.7 Setting up the Heavy Lift Vessel

When the heavy lift vessel (HLV) arrives on site, its anchor-handling tugboat sets up the anchoring system. This anchoring system holds the HLV in position during the platform removal process. The HLV's anchoring system consists of eight anchors, each connected to a mooring winch by a cable. Each anchor is equipped with a pendant wire that is long enough to reach from the seabed to the surface, where it is supported by a buoy. The anchor-handling tug picks up the anchors by securing the pendant wire and winching up the anchor. The anchor-handling tug then carries the anchor to the pre-established location. This process is repeated for each of the HLV's anchors. Pre-mooring piles will be installed at predetermined locations to prevent any unnecessary damage (anchor scars) to the seabed.

3.8 Removing Deck and Modules

Topsides removal follows the installation process in reverse sequence. Each module is removed and placed on a cargo barge. The module is secured by welding pieces of steel pipe (or plate) from the module to the deck of the cargo barge. The deck section or support frames (cap trusses) are then removed by cutting the welded connections between the piles and the deck legs with oxygen-acetylene torches. All decks/captrusses are removed in the same configuration as they were installed. Slings are attached to the deck/cap truss lifting eyes and to the HLV crane. The HLV's crane lifts the deck sections from the jacket. The deck is then seated in the load spreaders and secured by welding steel pipe from the deck legs to the deck of the cargo barge.

3.9 Disposing of Deck and Modules

The cargo barge transports the deck and modules 979 nautical miles to a scrap yard near Portland, Oregon. The modules may be lifted with cranes or skidded off the barge to the yard. Finally, the deck is skidded off the barge to the yard. All of the structural components and modules are cut into small pieces and disposed of as scrap.

3.10 Jacket Removal

The alternatives studied by TSB vary only in the method the jacket is removed. The platform removal preparation, well P&A, pipeline decommissioning, and topsides removal are the same for all alternatives. The following explains the alternatives selected – Complete Removal, Partial Removal, and Remote Reefing.

3.10.1 Complete Removal

After removing the topsides, the explosives are prepared and installed. When explosives are used during a platform removal, regulations require an observation for resident marine mammals for a period of 48 hours prior to the detonation of explosive charges. It is recommended that the observation be conducted and completed prior to the HLV arrival.

Explosive are placed in the main pile and skirt piles at least 15 ft below the mudline. If the mud plug inside the piles is not deep enough to allow the explosive charge to be placed at the required depth, the mud plug is jet/air lifted.

A pre-blast aerial survey is conducted immediately prior to the explosive detonation. This survey is performed using a helicopter with a National Marine Fisheries Service (NMFS) observer onboard. This survey is to determine if there are marine mammals in the area. If marine mammals are found to be within 1,000 yards of the platform, the explosive detonation is delayed. The detonation delay will last until the marine mammals are safely out of the area. Once the marine mammals have moved beyond the 1,000-yard radius extending out from the platform, the explosives are detonated and a post-blast aerial survey is conducted.

The jacket is then made buoyant to reduce the bottom weight. To maximize buoyancy, the water inside each pile is evacuated. Closure plates are then welded on the top of the piles. After the plates are installed, the water is evacuated from the legs using compressed air. A hose from an air compressor is connected to a valve on a closure plate welded to the top of each pile. The valve is opened and compressed air is forced into the piles. As the air pressure inside the pile increased, the water is forced out of the pile at the point where the pile was severed by the explosive charge. When all of the water is evacuated, air bubbles appear on the surface of the water near the jacket.

Having deballasted the jacket, it is then lifted off the sea floor by the heavy lift vessel (HLV). It is assumed that the Thialf or S7000 will be used to remove the Harmony platform; the Balder or Hermod will be used for Gail and Hidalgo. The jacket is supported by the HLV's crane and swung to the stern of the HLV. Rope hawsers are passed around two of the jacket legs and secured to the stern of the HLV. The jacket is then boomed away from the stern of the HLV until the hawsers are tight. The rope hawsers keep the jacket from swinging and being pulled out of the boom radius by its movement through the water. The HLV's anchors are shifted and the jacket is towed to shallower water.

At the new location, the jacket is ballasted and set on the sea floor. The water depth at the new location is such that the horizontal elevation to be cut is several feet above the water. Welders set up scaffolds around the jacket legs and begin cutting the jacket legs. Additionally, the jacket is cut in half vertically to create two 4-leg sections. The diagonal braces running between each set of rows are also cut.

After the legs and piles have been cut and the diagonal braces removed, the jacket section is rigged, lifted, removed, and sea-fastened on a cargo barge. For an eight-leg jacket, two four-leg sections are removed at the bottom elevations. The cargo barge is then sent to the onshore disposal yard. Cargo barge loadouts for each platform are presented as **Figures 3.3-3.5**.

At times, the jacket is severed at each horizontal elevation because of its dimensions. The procedure mentioned above is repeated until the jacket is completely removed and placed on cargo barges. The jacket is deballasted, picked up, towed to shallower water, set, cut in two (vertically), and removed in sections. This process is illustrated in **Figures 3.6 and 3.7**; the cutting locations for each platform in this study are shown as **Figures 3.8-3-10**. Each time the jacket is moved, the HLV’s anchors are repositioned. In each figure, the HLV’s anchor pattern is shown as a black circle. Hidalgo, Gail and Harmony are hopped 5,7 and 9 times respectively.

After the last piece is set on the cargo barge, the HLV picks up its anchors and moves to the next platform. The salvage procedures are the same for each platform, varying only by the number of cuts required to prepare the jacket for transport to shore.

3.10.2 Partial Removal

After removing the topsides, the top 85 feet of the jacket is removed. For an eight-pile platform, this is completed by cutting the top portion of the jacket into two four-pile sections. All cuts are performed before the vessel (a large tug, approximately 12,000 hp) arrives on site to minimize the amount of time the tug is used. Additionally, rigging is setup in advance of the tugs arrival and is designed to release once the jacket section topples over.

After the jacket is segmented (braces cut) and jacket legs are severed (using either non explosive cutting methods [i.e., mechanical, abrasive, or diamond wire]), the tug arrives on site and hooks up its tow line to a sling attached to one of the jacket sections. The tug then pulls this section over, and it falls to the sea floor. This process is repeated for the other section. **Figures 3.15 through 3.17** illustrate the Partial Removal sequence.

3.10.3 Remote Reefing

After removing the topsides, the explosives are prepared and installed. When explosives are used during a platform removal, regulations require an observation for resident marine mammals for a period of 48 hours prior to the detonation of explosive charges. It is recommended that the observation be conducted and completed prior to the HLV arrival.

Explosives are placed in the main pile and skirt piles at 15 ft below the mudline. If the mud plug inside the piles is not deep enough to allow the explosive charge to be placed at the required depth, the mud plug is jet/air lifted.

A pre-blast aerial survey is conducted just prior to the explosive detonation. This survey is performed using a helicopter with a National Marine Fisheries Service (NMFS) observer onboard. This survey is to determine if there are marine mammals in the area. If marine mammals are found to be within 1,000 yards of the platform the explosive detonation is delayed. The detonation delay will last until the marine mammals are safely out of the area. Once the marine mammals have moved beyond the 1,000-yard radius extending out from the platform, the explosives are detonated and a post-blast aerial survey is conducted. The HLV is demobilized at this time.

The jacket is then made buoyant to reduce the bottom weight. To maximize buoyancy, the water inside the piles is evacuated. Closure plates are welded on the top of each pile. After installing the plates, the water is evacuated from the legs using compressed air. A hose from an air compressor is connected to a valve on a closure plate welded to the top of the pile. The valve is opened and compressed air is forced into the piles. As the air pressure inside the pile is increased, the water is forced out of the pile at the point where the pile was severed by the explosive charge. When all of the water is evacuated, air bubbles appear on the surface of the water near the jacket.

Pull tugs tow the jacket to a designated remote reef site.

At the site, the jacket is lowered by ballasting the piles and the base is set on the sea floor. The jacket is left on its side at the reef location, and a marker buoy is placed on location above the jacket.

3.11 Site Clearance / Site Clearance Verification.

Site Clearance is the last task in the offshore decommissioning process. This procedure is divided into three phases: Side Scanning the work area (Reconnaissance), Inspecting and Cleaning Up the work area (Assessment/Remediation), and Trawling the work area (Verification).

In the Pacific Outer Continental Shelf Region (POCSR), site clearance will consist of:
- Pre-demolition side-scan sonar (SSS) survey of the area surrounding the platform
- Pipeline survey (divers to survey pipelines near shore)
- Post-demolition SSS survey
- Deployment of ROV(s) and/or divers to remove identified obstructions
- Test-trawling

The Reconnaissance phase is generally performed before the decommissioning work begins and after the platform is removed. In each case, the procedures used to survey the area for debris are the same. A work boat carrying a survey crew with side scan sonar surveys the area to be cleared (work area) for potential obstructions 0.5 m or larger. From the center point of the work area, the workboat surveys a 1.5-mile radius in lines running from north to south and east to west (**Figure 3.20**). Spacing between the survey line is generally 75 feet and swath coverage is 200%.

After the platforms are removed, the work site is re-surveyed to identify any debris that resulted from the decommissioning of the platform. The survey results are then compared with the pre-decommissioning survey. Any hit identified to be 0.5 m or larger is recorded and will be removed during the second phase.

The platform water depths should not restrict the use of the side scan sonar. At deeper depths, the cable controlling the SSS is made longer to allow it to be as close to the sea bed as necessary. Other bottom survey equipment such as a Mesotech or Magnetomer are available but are limited and may not be as effective as a SSS.

Mesotech can only survey a radius of 30 meters. This makes it unpractical to use because of the large areas to survey. The Magnetomer has a larger survey area but is limited to identifying only metal. Other non-metal debris will not be identified.

After the work area has been surveyed and the targets to be removed are identified. A dive boat with an ROV and dive crew is sent to assess the target and clean up the area. The debris is picked up either by divers or ROVs. Duration for this process will vary depending on the number of targets identified. In the Gulf of Mexico, generally older platforms have more targets that are identified and removed. The platforms in this study will be less than 20 years old by the time they are decommissioned and should not have a great deal of material to remove.

The final step in site clearance is trawling (**Figure 3.21**). This procedure verifies that the bottom is clean and clear from any oil/gas related sea floor debris that may interfere with commercial fishing. A trawling vessel pulls four heavy-duty nets trawls north to south 2,640 feet and then south to north 2,640 feet. The vessel then proceeds to trawl east to west 2,640 feet and then west to east 2,640 feet. A pass is made every 80 feet and a report of each line is recorded. Site clearance is not performed in the field until all platforms have been removed.

The Partial Removal and Remote Reefing alternatives require the location where the platform was installed to be surveyed, cleaned and verified. Since the platform is partially removed, site clearance and verification is required only in the 1.5-mile radius from the platform. This ensures the removal of any debris that may have fallen from the platform throughout the years.

The Complete Removal Scenario requires surveying, cleaning and trawling at each location the platform is set and cut. Each time the jacket is set on the bottom the jacket is cut and there is potential for debris to fall. For this reason, TSB assumed the clearance and verification of each work site. **Figures 3.22 – 3.24** shows the area that is cleared and verified for each platform.

3.12 Onshore Disposal

3.12.1 Topsides Offloading and Dismantling

Cargo barges carrying the modules and cap truss are offloaded using a crawler crane that is located next to the bulkhead. Rigging used to remove the modules offshore may not have been removed. If the current rigging configuration can be used, then the modules are offloaded with the crawler crane and then the rigging is removed. After the modules are offloaded they are transported to a location in the scrap yard where they will be dismantled.

Module dismantling involves removing and properly disposing of asbestos, PCB's, and other hazardous materials. These hazardous materials should have complete traceability from their source to final disposal. Any non-ferrous materials are removed for recycling. Major machinery and equipment are removed and any that are found appropriate for refurbishment and resale are stored. Machinery and equipment that are not suitable for resale are cut up as scrap and recycled. The module frame is dismantled and the remaining steel is cut to the required length for processing and recycling at a steel mill.

3.12.2 Jacket Offloading and Dismantling

Cargo barges carrying the jacket sections are off loaded at the disposal site using a large capacity crawler crane. The jacket sections are placed on multi-axle trailers or dollies and towed by tractor to a dismantling area. Jacket dismantling involves first the removal and disposal of any marine growth from the jacket sections. Each jacket section is then rigged and cut in a logical manner that promotes safety and reduces dismantlement time. The individual braces or brace sections that are removed would weigh 40-50 tons each. At the same time, grout between the main piles and the jacket legs are removed. The jacket braces, brace sections and legs are cut to a suitable length for processing and recycling.

Figure 3.1 - Topsides Removal

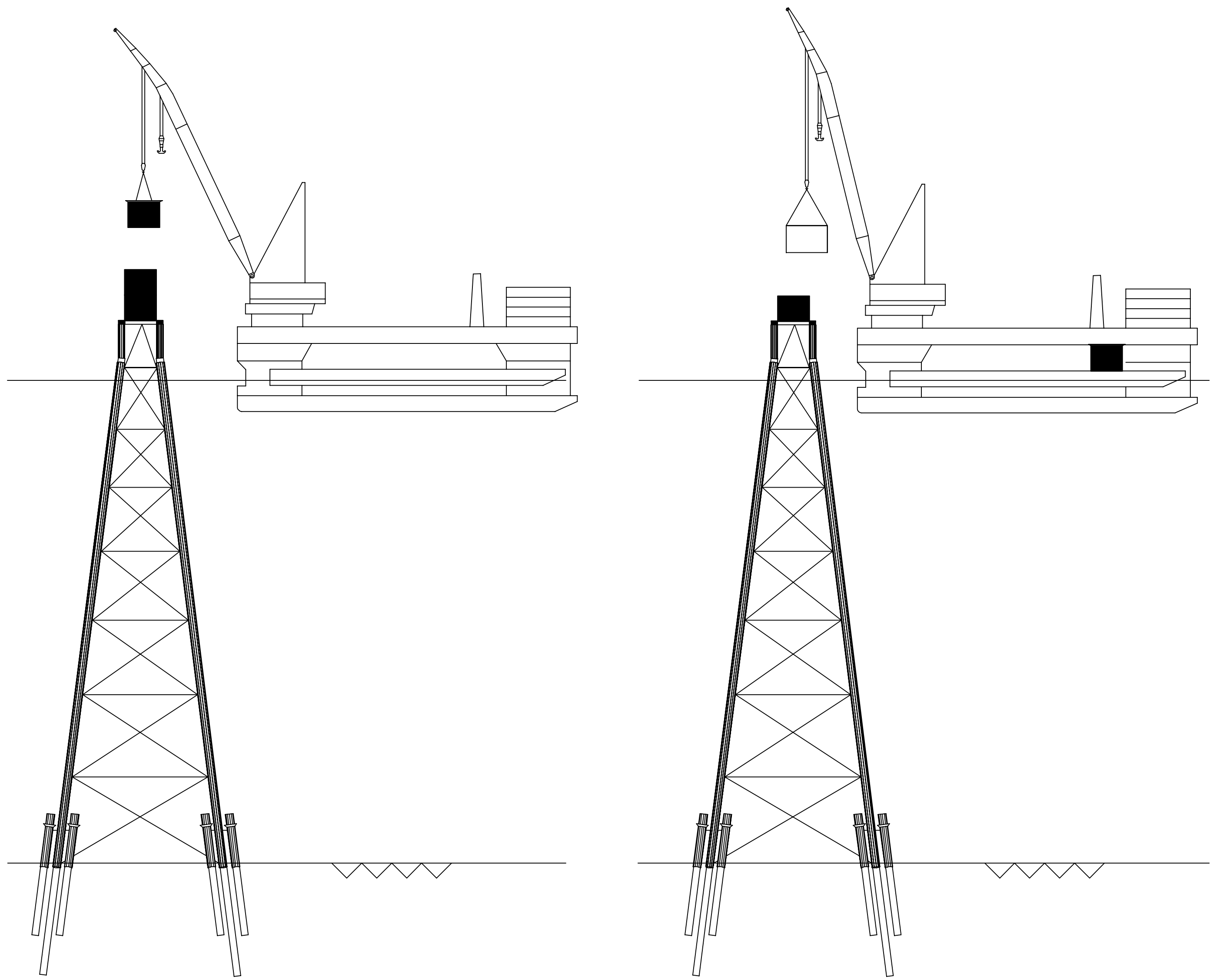


Figure 3.2 - Topsides Removal

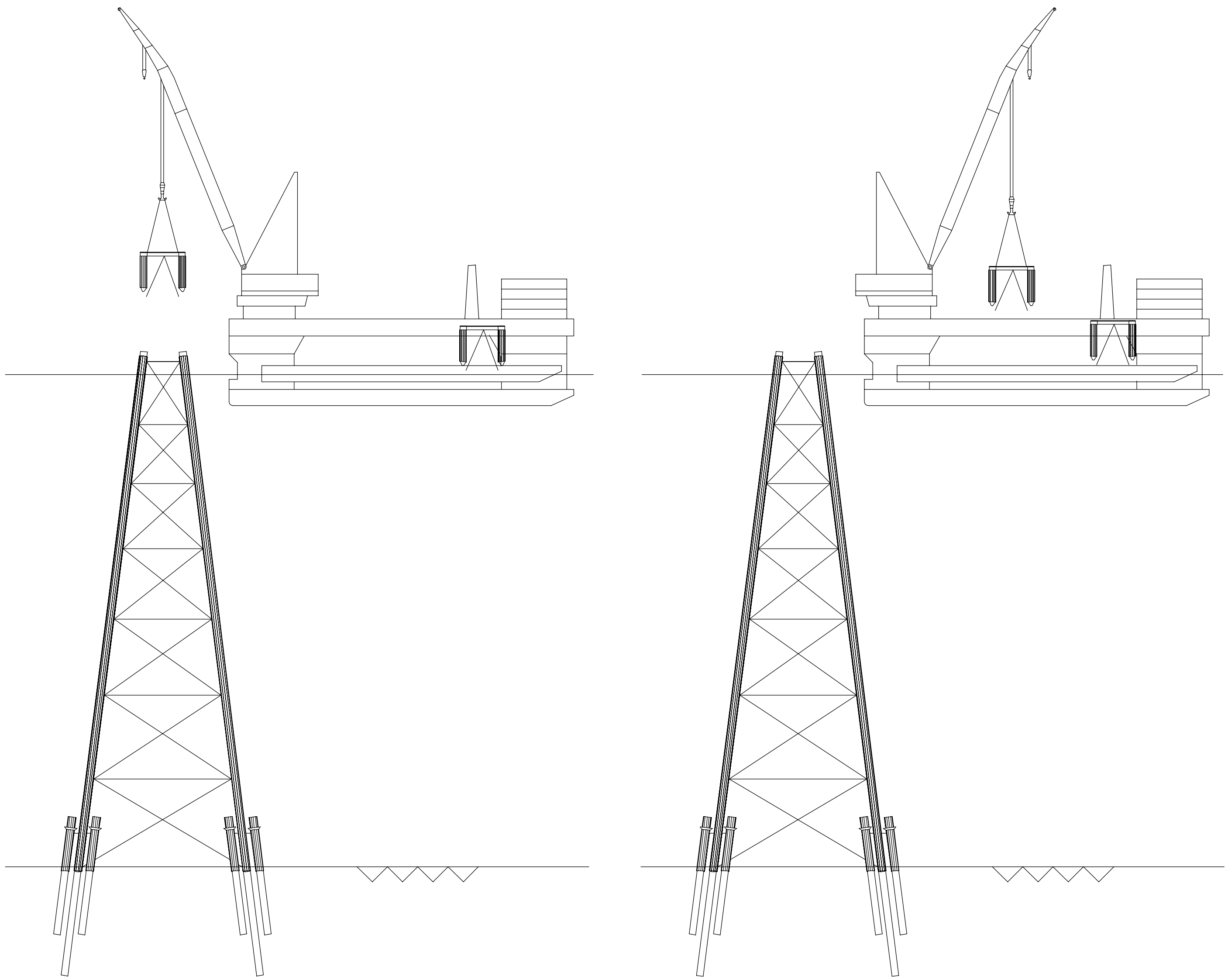


Figure 3.3 - Cargo Barge Loadout
Hidalgo Topsides

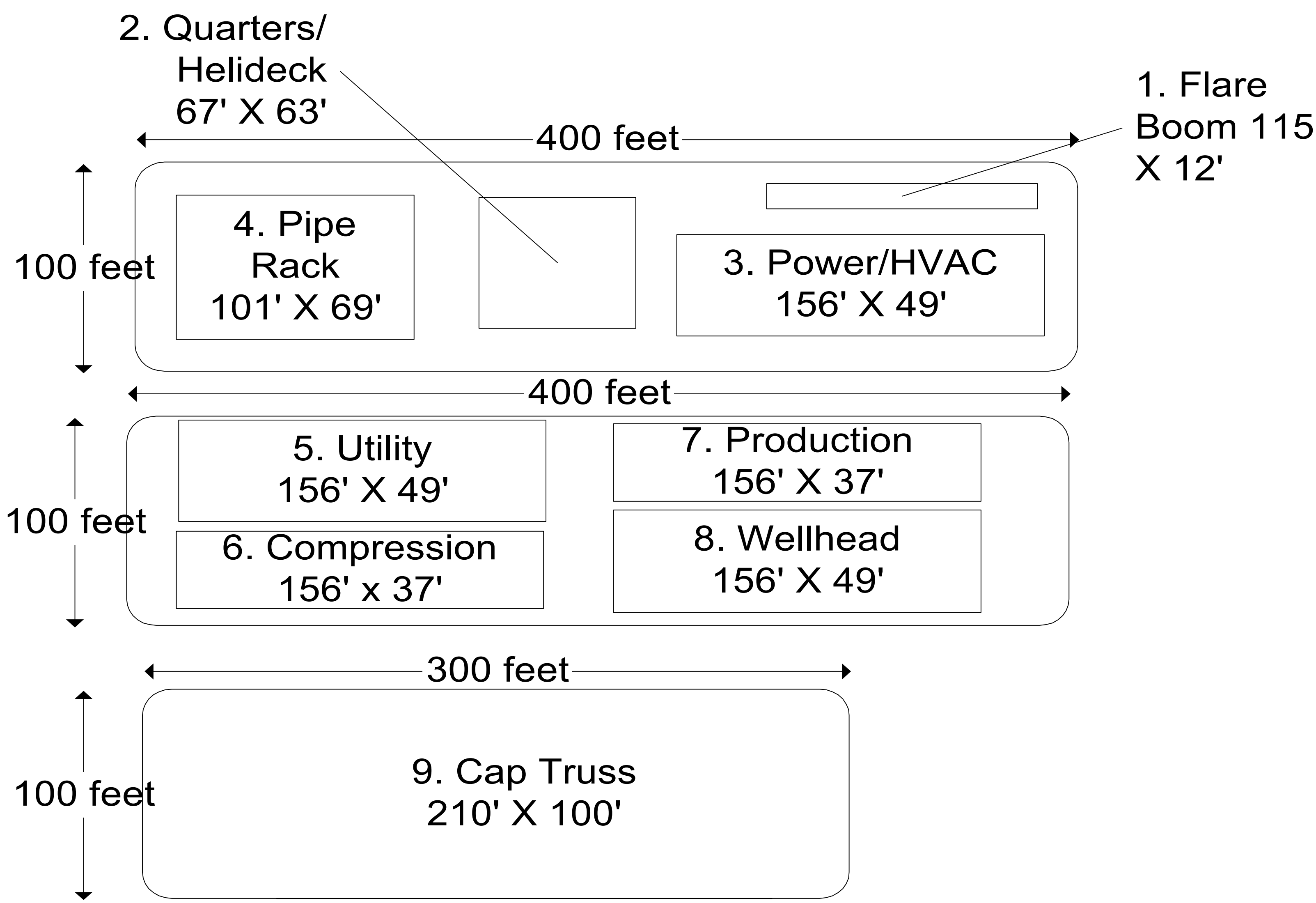


Figure 3.4 - Cargo Barge Loadout - Gail Topsides

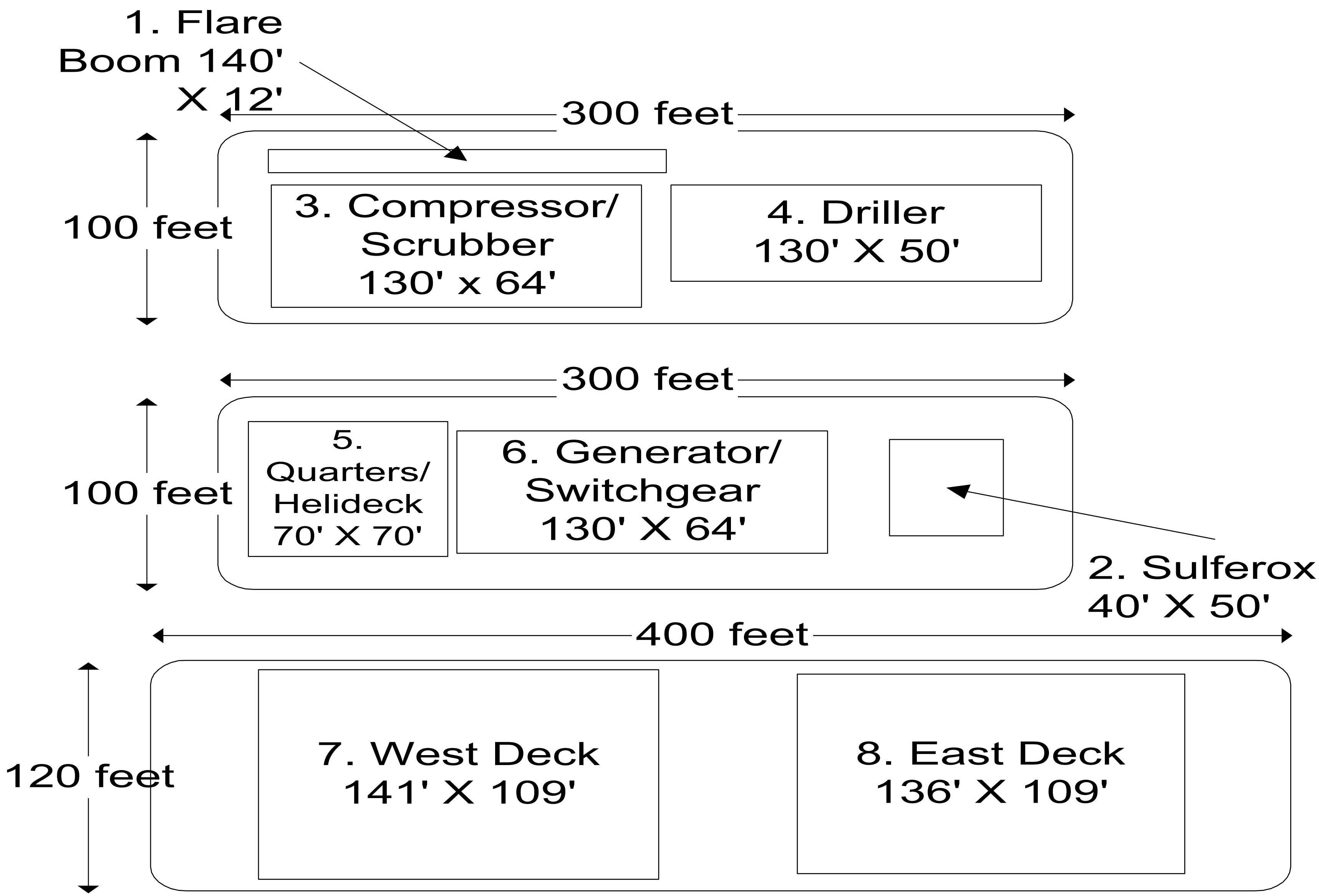


Figure 3.5 - Cargo Barge Loadout
Harmony Topsides

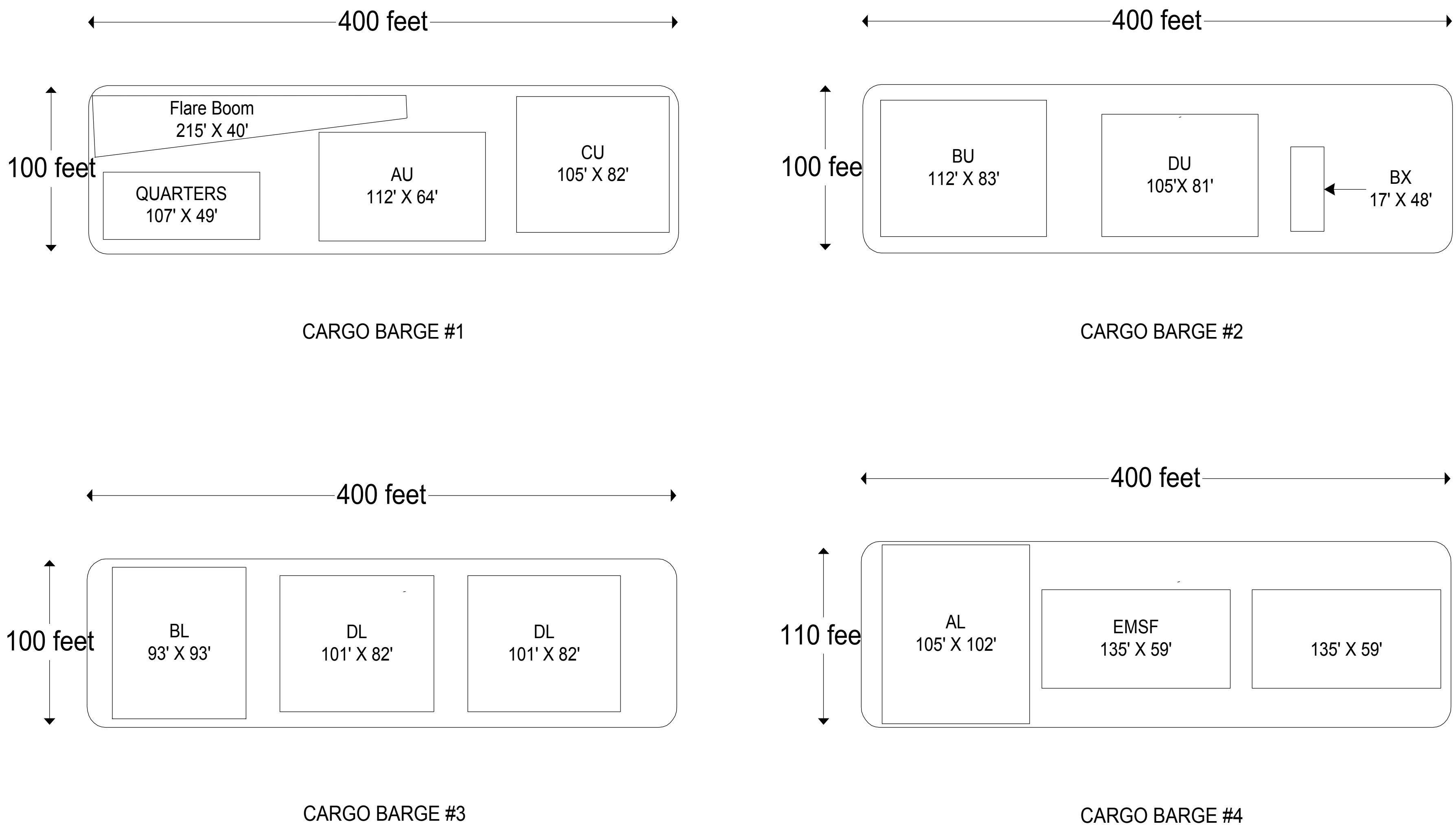


Figure 3.6 - Complete Removal

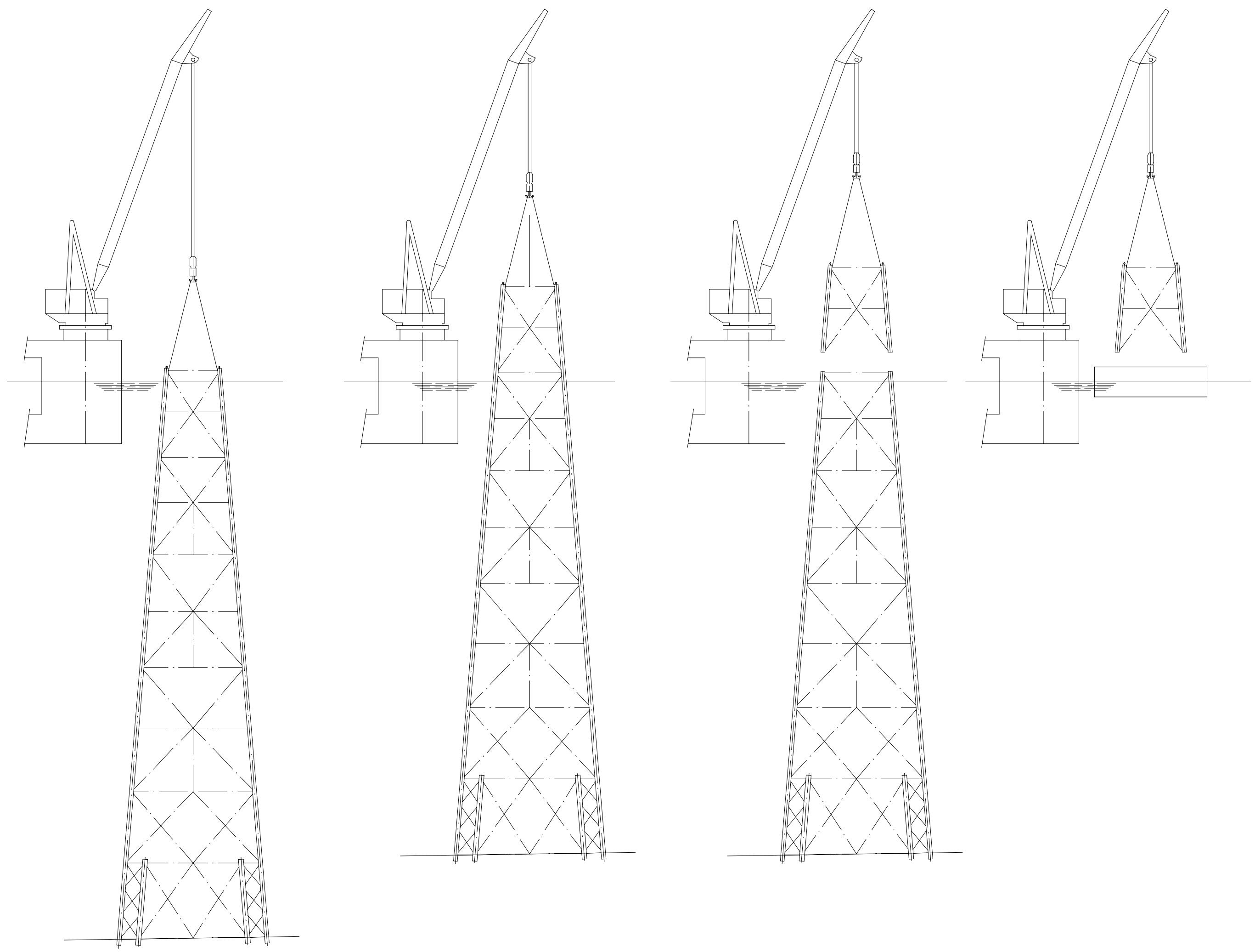
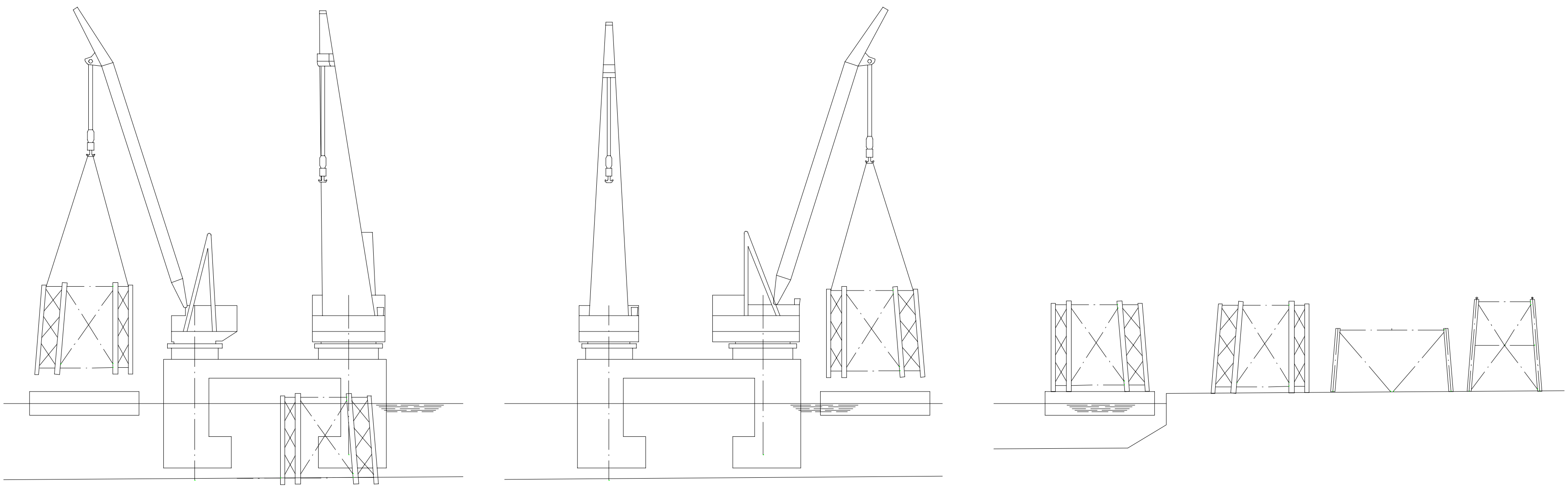


Figure 3.7 - Complete Removal



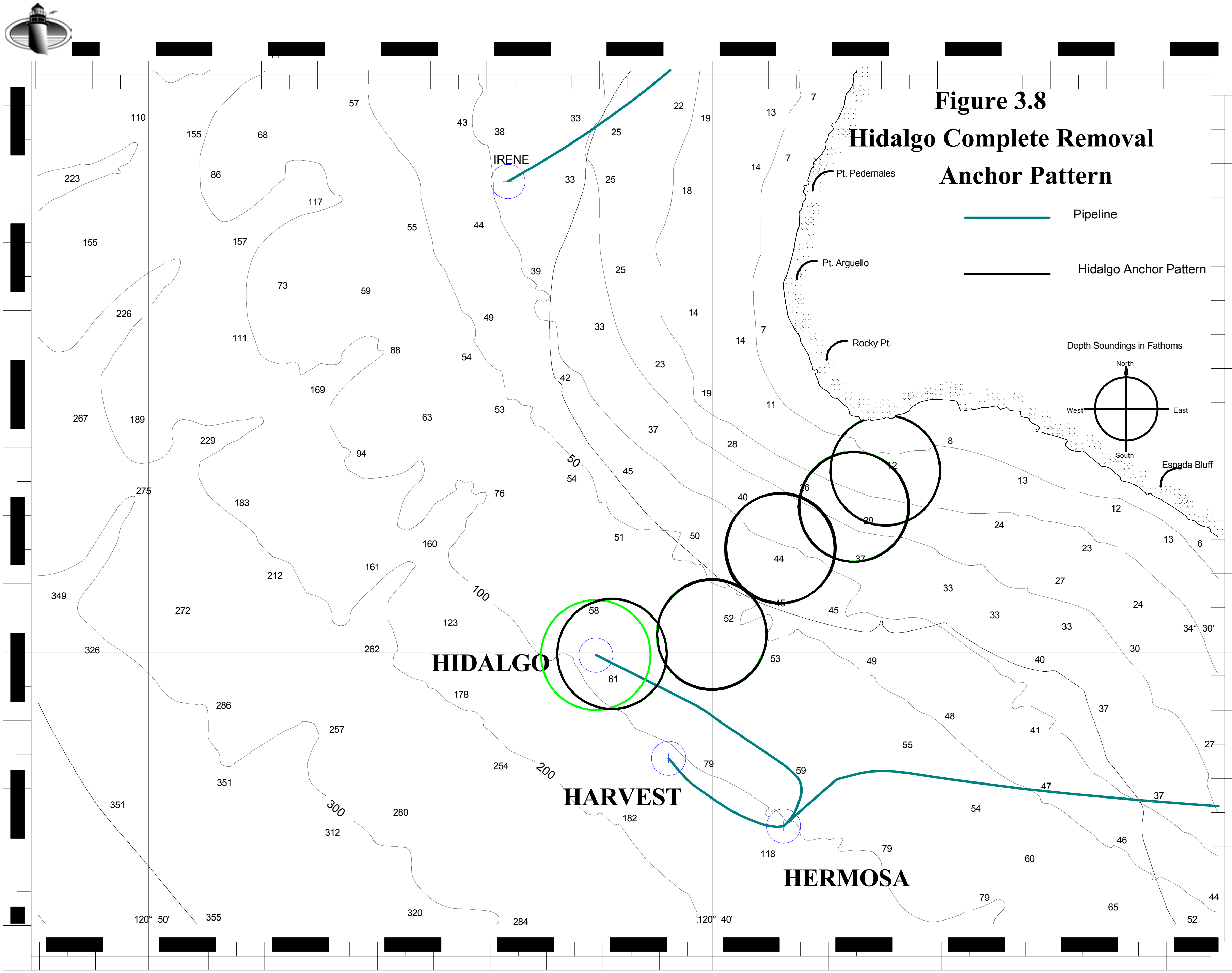


Figure 3.8
Hidalgo Complete Removal Anchor Pattern

Figure 3.9
Gail Complete Removal Anchor Pattern

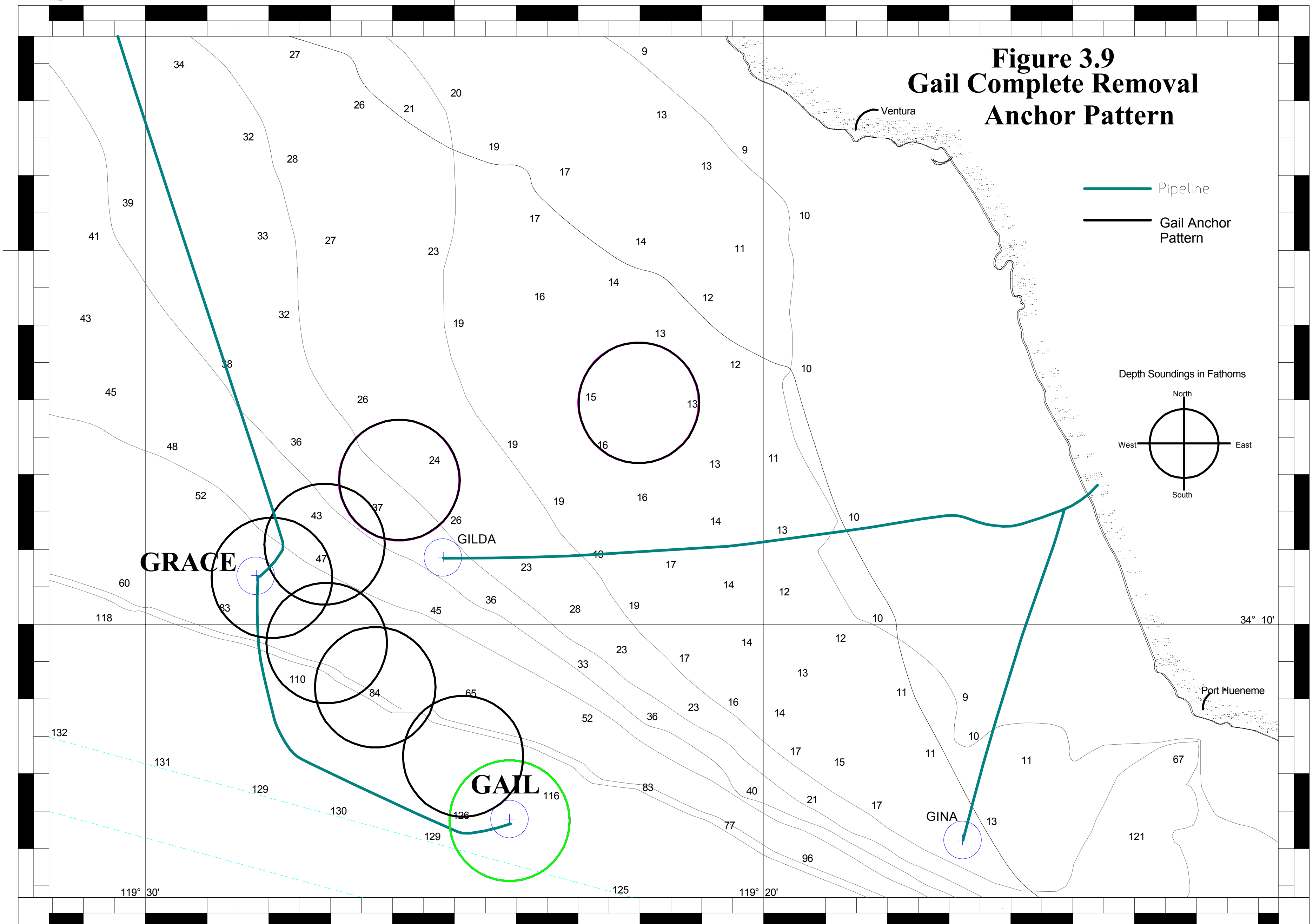


Figure 3.10

Harmony Complete Removal Anchor Pattern

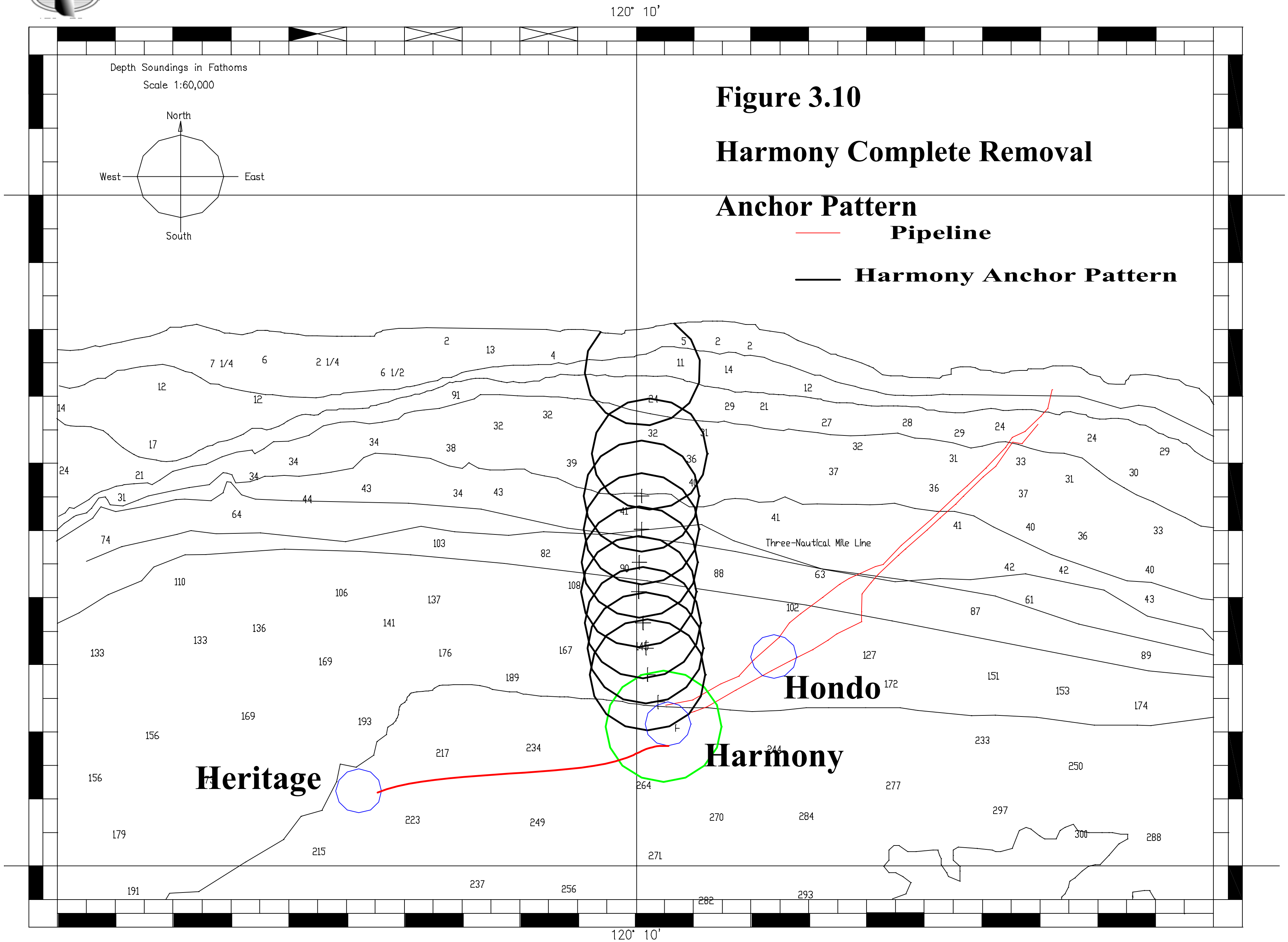


Figure 3.11 - Cargo Barge Loadout
Hidalgo Jacket

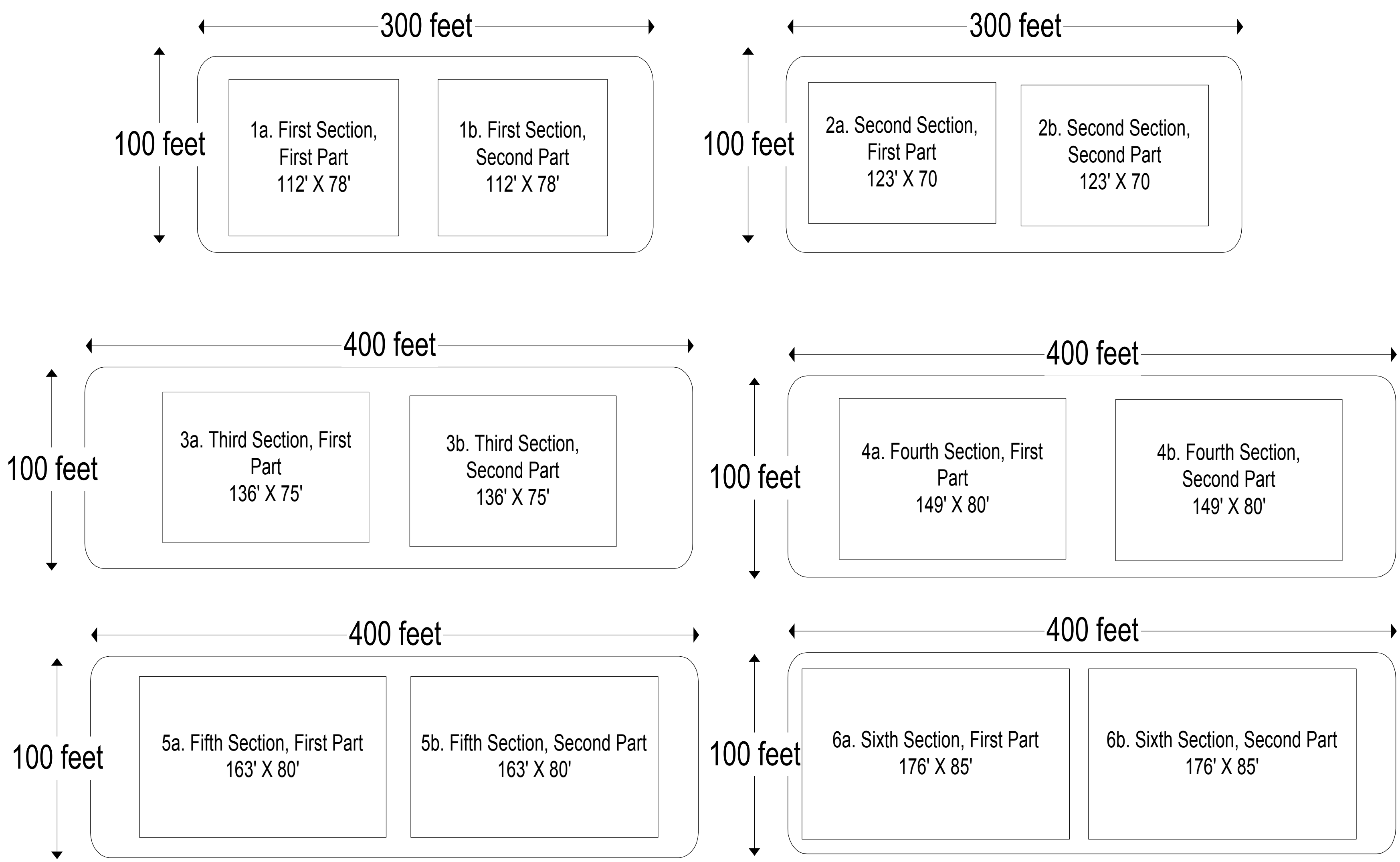


Figure 3.12 - Cargo Barge Loadout
Gail Jacket

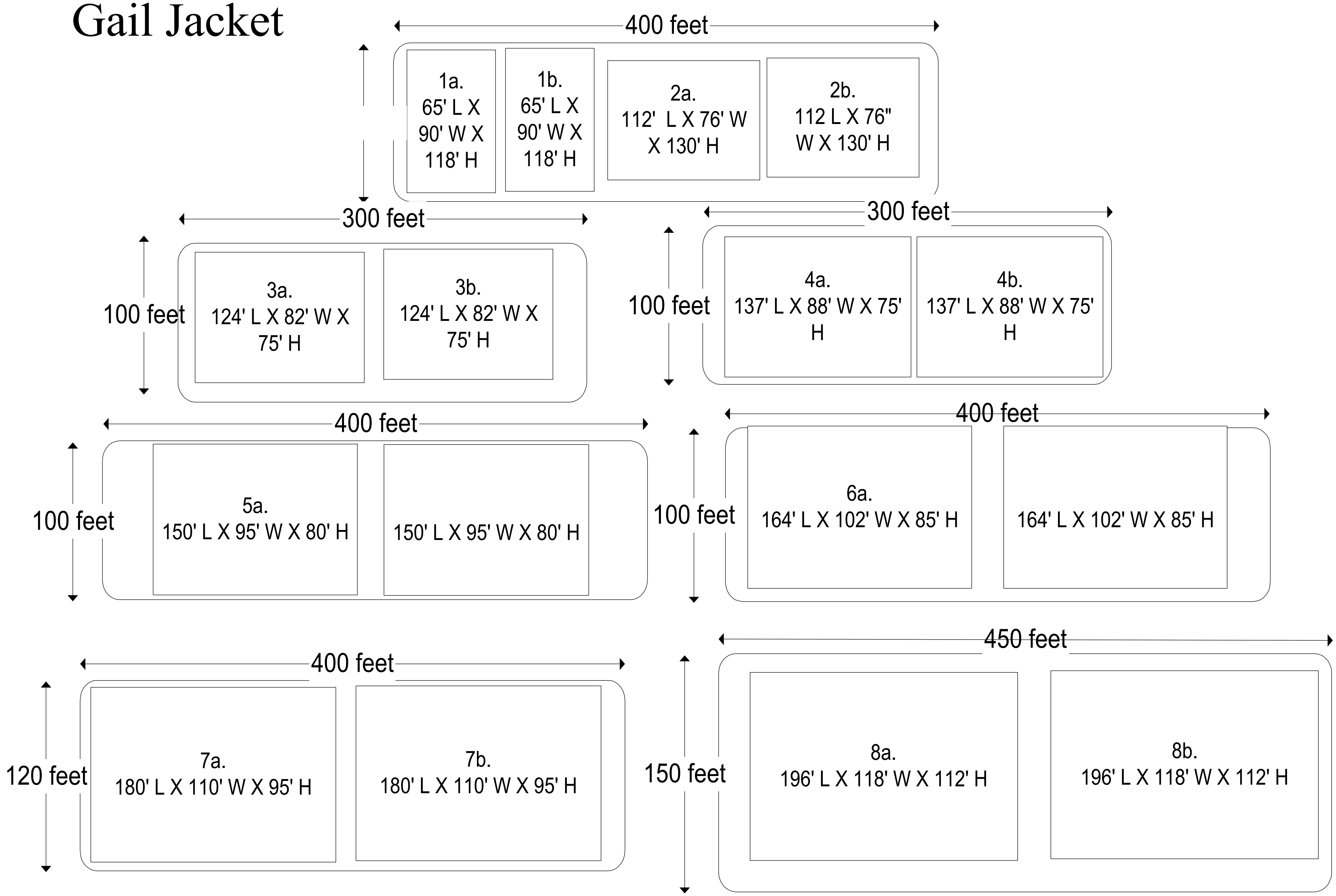


Figure 3.13 - Cargo Barge Loadout - Harmony Jacket

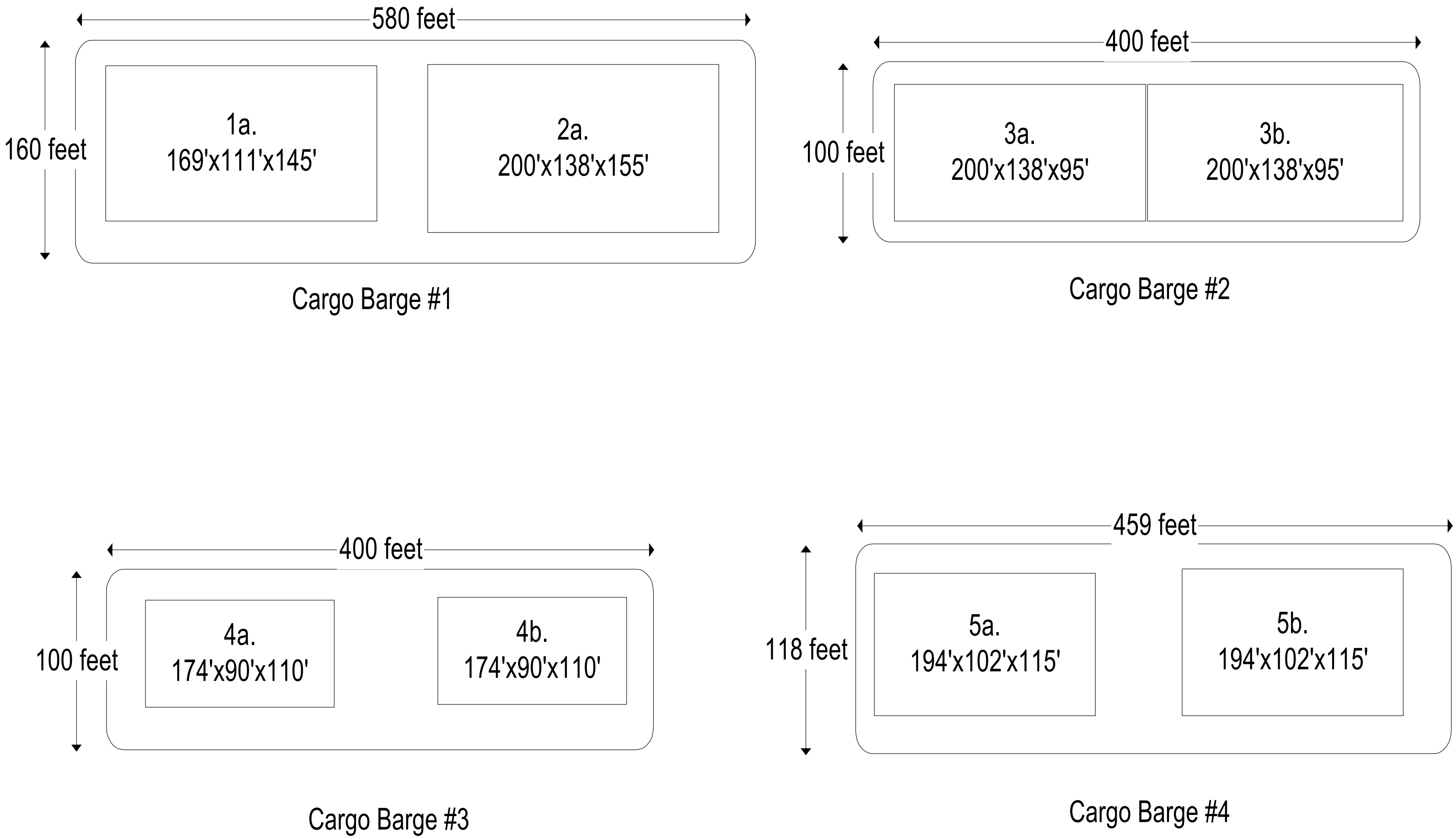


Figure 3.14 - Cargo Barge Loadout - Harmony Jacket

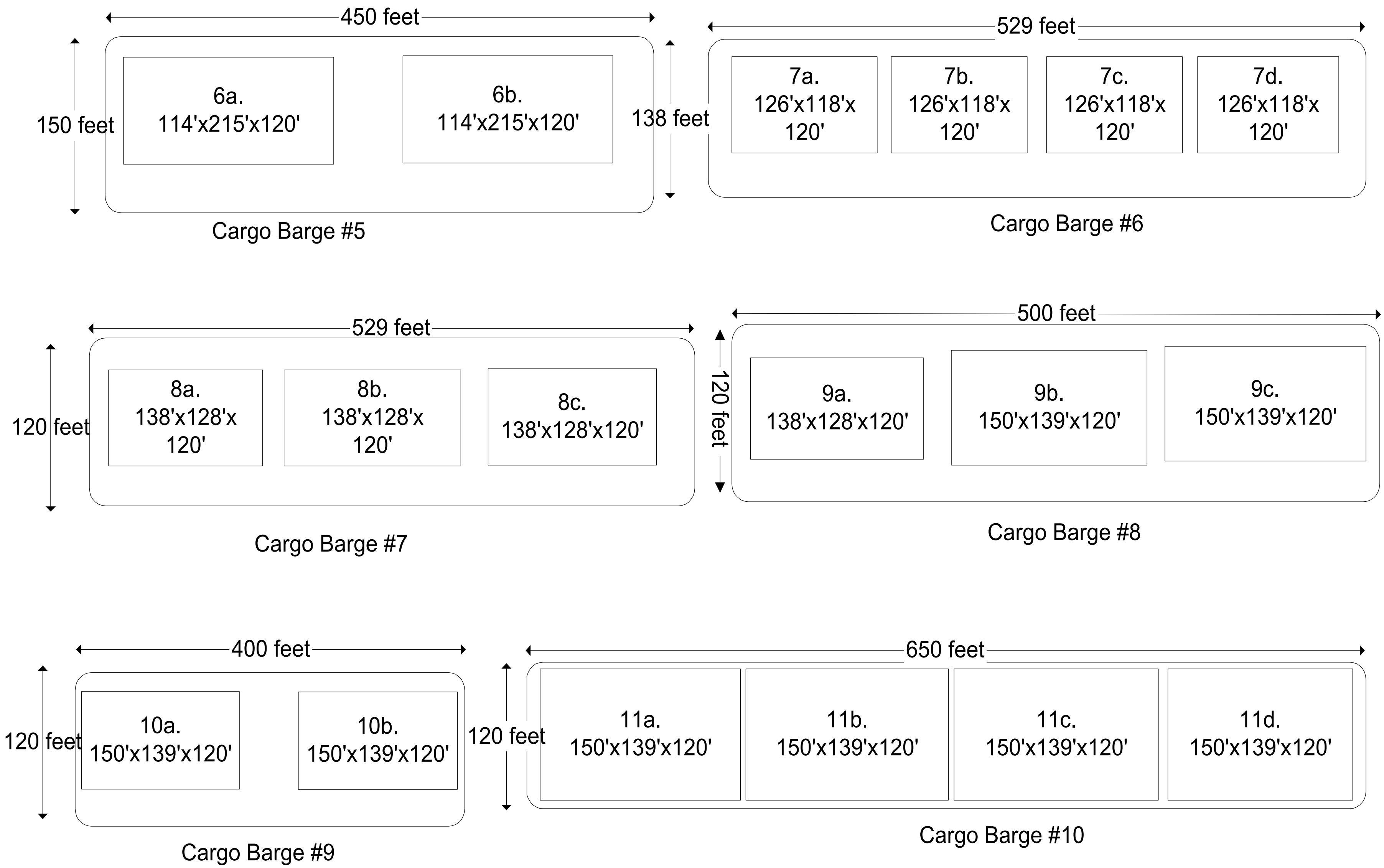


Figure 3.15 - Partial Removal

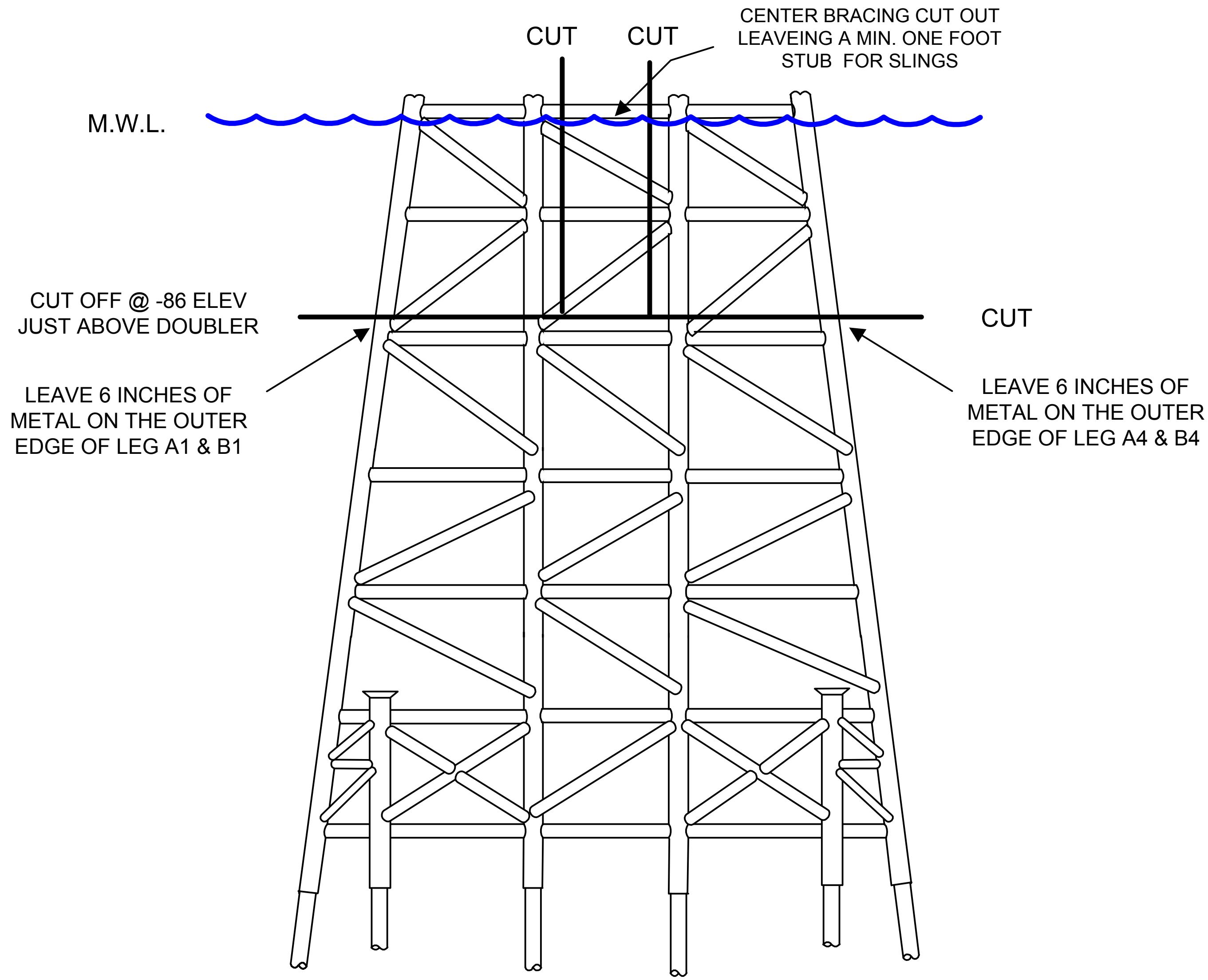


Figure 3.16 - Partial Removal

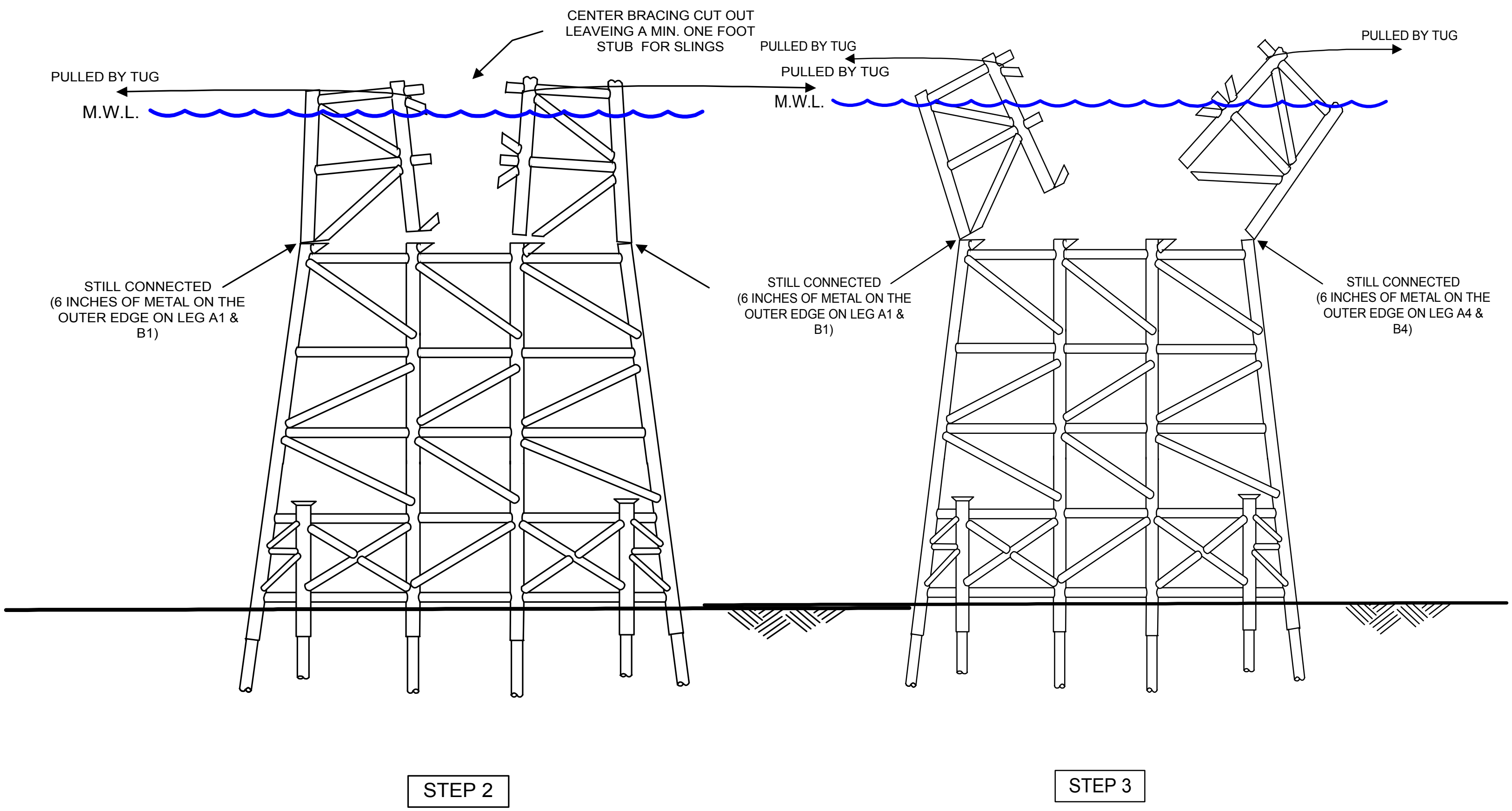


Figure 3.17 - Partial Removal

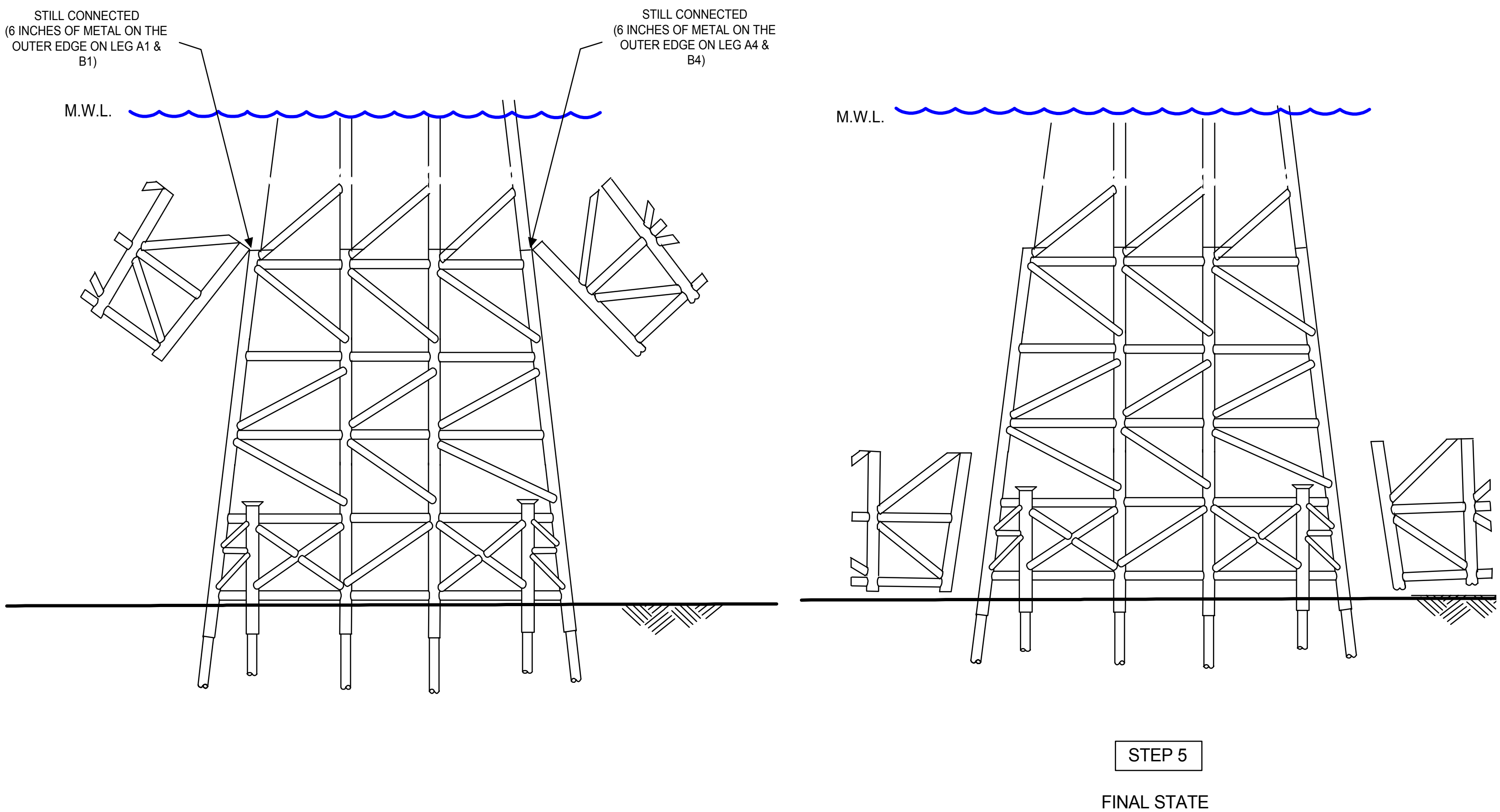


Figure 3.18 - Remote Reef

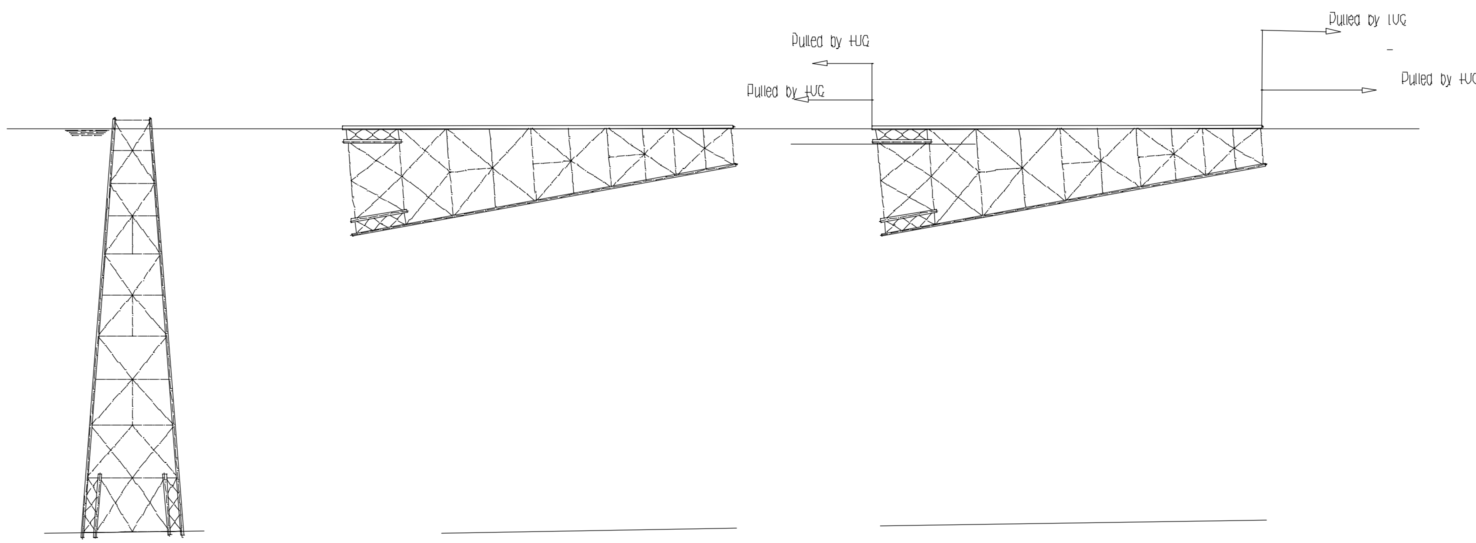


Figure 3.19 - Remote reef

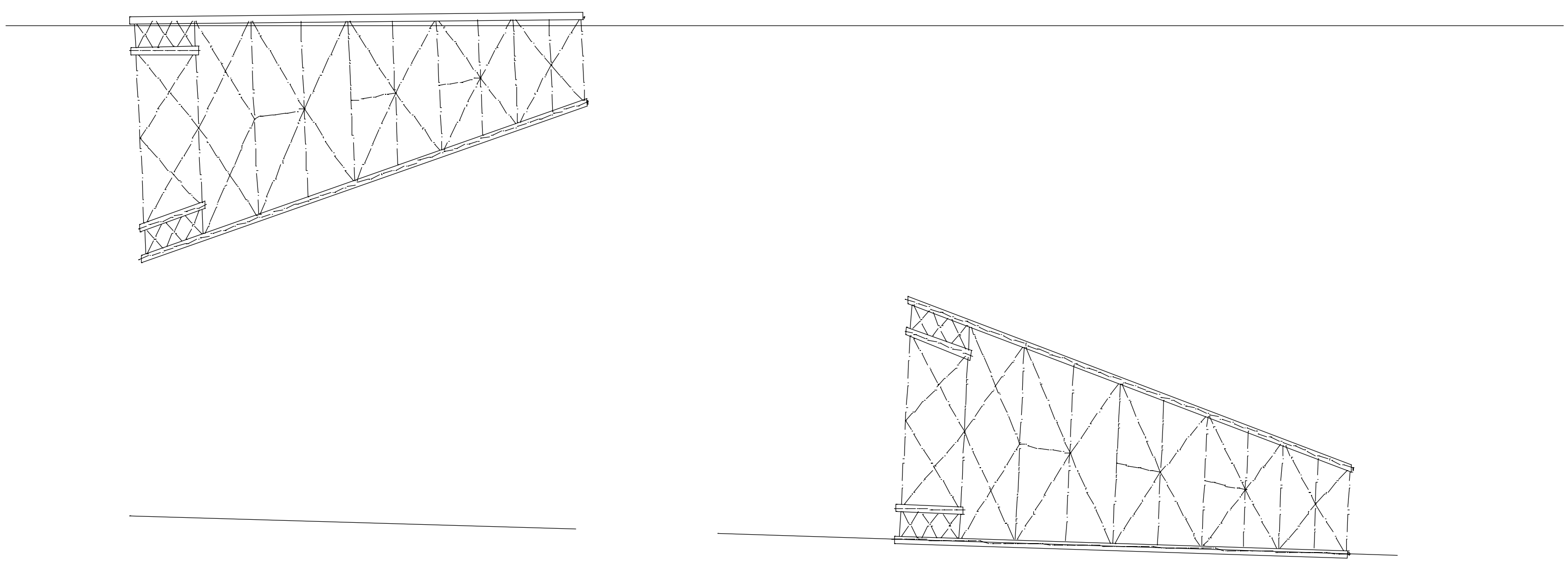


Figure 3.20 - Side Scan Sonar Grid

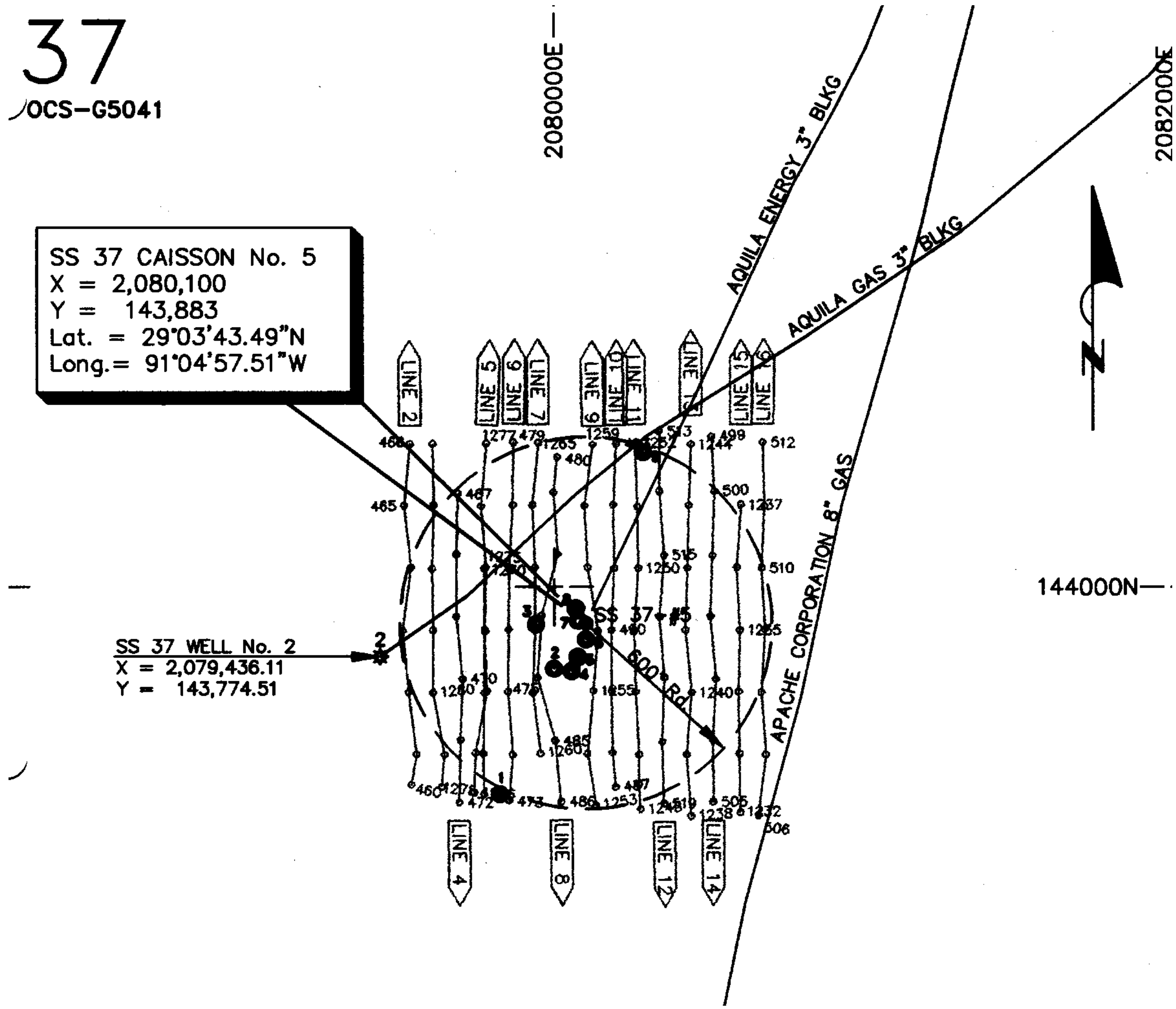
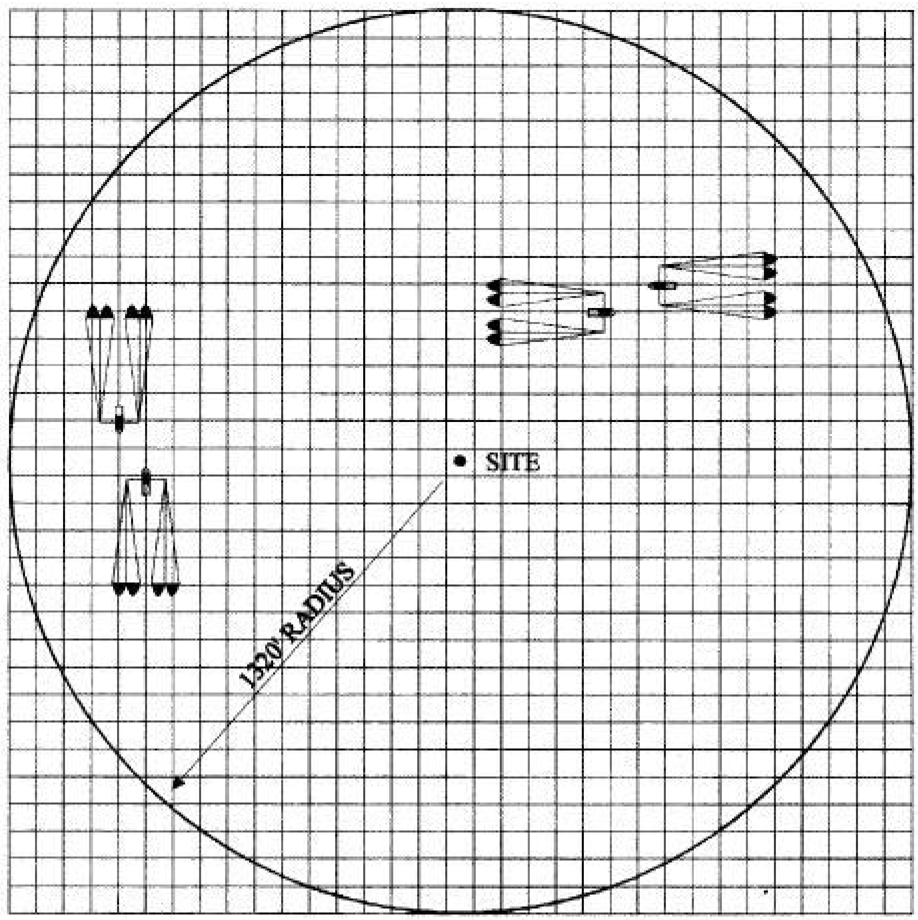


Figure 3.21- Site Clearance Trawling Grid



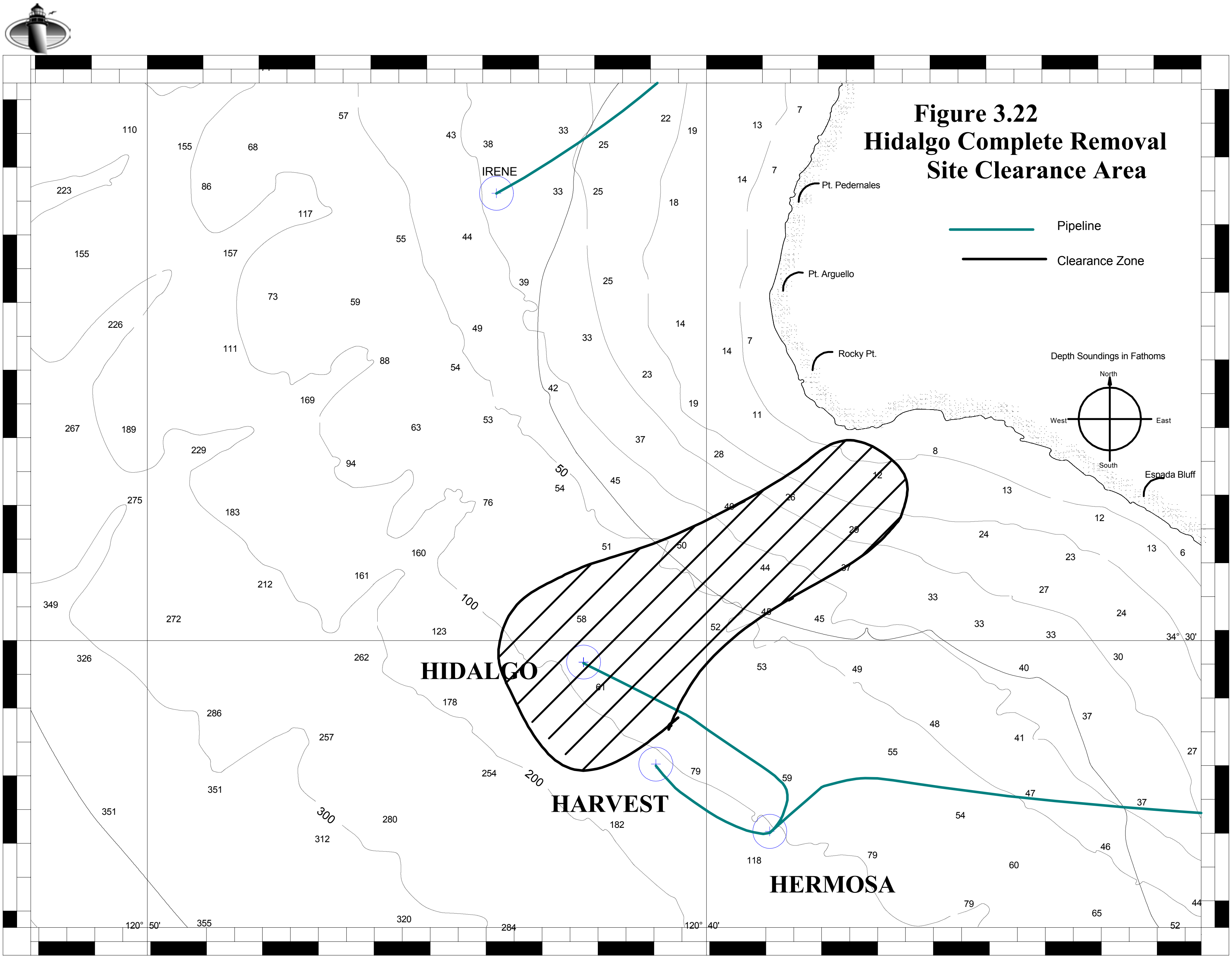
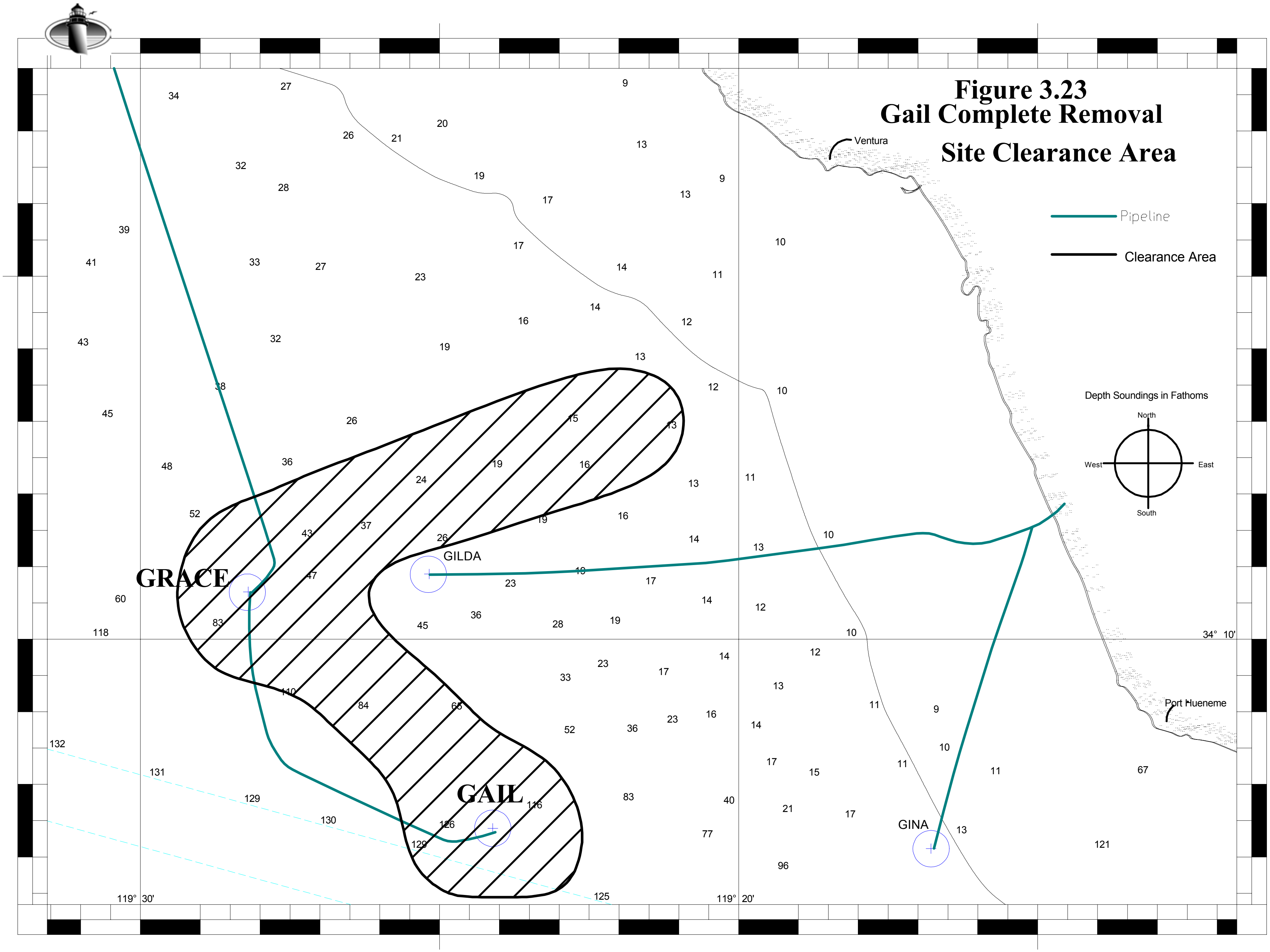


Figure 3.22
Hidalgo Complete Removal Site Clearance Area

Figure 3.23
Gail Complete Removal
Site Clearance Area



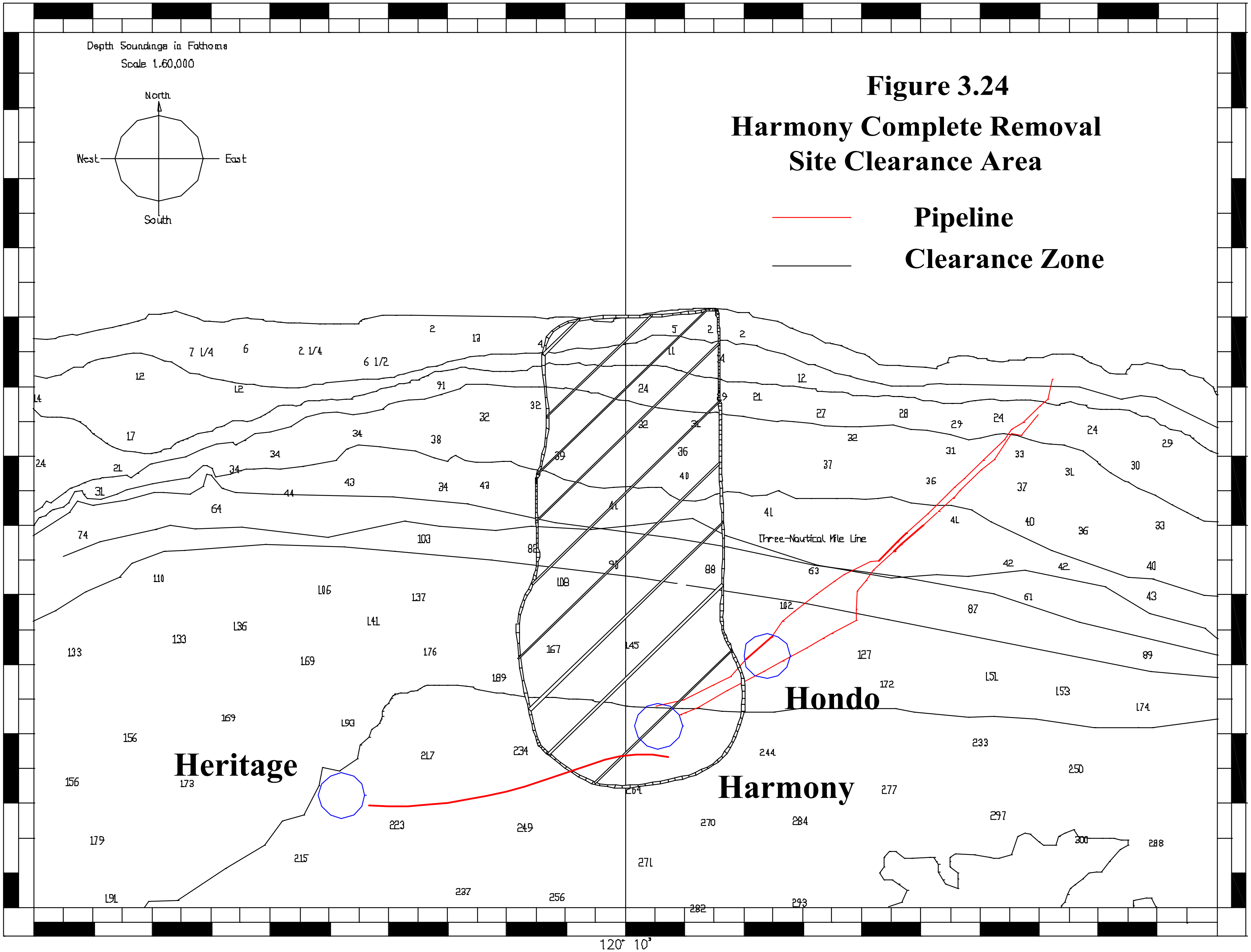


Figure 3.24
Harmony Complete Removal Site Clearance Area

Section 4 – Cost Summary

Introduction

This section presents the decommissioning estimate results developed for the three platforms in the study. A detailed cost breakdown for each decommissioning method is included by platform. Assumptions and factors driving the estimates are discussed. Comparisons are then made between TSB's estimates and those derived by others.

4.1 Cost Results Summary

The decommissioning methods estimated were Complete Removal, Remote Reefing, and Partial Removal. Please refer to Section 3 for a detailed description of the decommissioning methodology for each of these alternatives. Table 4.1 summarizes the decommissioning cost for each platform by removal method.

Table 4.1 – Decommissioning Summary Results ($MM)

Platform	Water Depth (ft.)	Total Weight (tons)	Complete Removal	Partial Removal	Remote Reefing
Hidalgo	430	21,050	44	15	18
Gail	739	30,000	57	15	20
Harmony	1,198	65,050	123	20	35

The removal method selected is a driving factor of each estimate. The Complete Removal scenario requires more HLV work, more cuts to be made to jacket legs and conductors, more cargo barges and more travel time to tow all platform components to shore. Additional costs include site clearance/verification activities at each location the jacket is set down and cut and scrapping fees. The larger each platform is, the higher the Complete Removal cost.

Partial Removal is the least expensive option. Cutting operations, HLV and cargo barge usage, and site clearance/verification time are minimized.

While the Remote Reefing option is less expensive than the Complete Removal scenario, HLV usage, and travel time make this removal method more expensive than Partial Removal.

More information about how the removal method relates to decommissioning costs is located in **Section 4.3**.

Additionally, the size of the platform directly correlates to its decommissioning cost. Deeper water depths often denote larger, more complex structures, which require larger heavy lift vessels and more conductor cutting. All of these factors increase the cost of platform removal. More information about how the jacket size affects decommissioning costs is located in **Section 4.4**.

4.2 Assumptions

Assumptions made in developing the decommissioning estimates are as follows:

4.2.1 Cost

- Costs in Year 2000 dollars.
- Gulf of Mexico rates plus 25% are used for the decommissioning spread.
- Spread of $500,000/day for S7000/Thielf.
- Spread of $250,000/day for Balder/Hermod.
- Spread of $110,000/day for 2000-ton capacity derrick barge.
- Mobilization spread 80% of vessel spread, which includes anchor-handling tug and derrick barge skeleton crew.
- Pipeline abandonment includes only originating pipelines. Cost to abandon pipelines terminating at the platform should be accounted for at the originating point.
- Permit costs are not included.
- "Rigs-to-Reef" donation is not included.
- Onshore facilities and pipeline beach approach abandonment costs are not included.
- Cost to remove shell mounds is not included.
- Cost for the restoration of the kelp forest is not included.
- Cost to pre-install mooring piles is not included.
- Well P&A costs are not included.

4.2.2 General

- Adequate marine equipment is available.
- Permits will be received within 48 months.
- Well P&A and platform removal preparation are not critical-path items (i.e., they will be started whenever necessary to avoid delay).
- Three to five platforms are removed concurrently.
- The Platform Removal Preparation phase for the last platform will be completed right before the derrick barge arrives onsite for platform removal.
- All conductors are vertical and cemented in place.
- Cargo barges will be mobilized from the upper West Coast.
- Single derrick barge mob/demob will be from Rotterdam or New Orleans.
- Infield mobilization is included in the platform removal time.
- Trawl testing will be carried out for all cases, in addition to site clearance utilizing side-scan sonar and divers to remove debris.
- No site remediation is required other than site clearance.
- Provisions for miscellaneous derrick barge work are 15% of the total task costs associated with the derrick barge on site.

- Mobilization costs are shared among 5 platforms.
- Mobilization will take approximately 94 days
- Demobilization will take approximately 94 days
- Net scrapping costs of steel is $300/ton
- Provisions for weather downtime are 6% of the total task costs associated with the derrick barge on site.
- Project management and engineering are included as 8% of the total decommissioning cost, excluding derrick barge mobilization/demobilization cost.

4.2.3 Platform Removal Preparation

- Diesel, water, and chemical tanks will be drained and flushed by platform operator.
- Crew will be housed in the platform quarters.
- Temporary generators will supply power.
- Temporary potable water tanks will be used.
- More than one module will be prepared for removal at a time.
- Modules are structurally sound and require no reinforcement prior to lifting.

4.2.4 Conductor Removal

- Wells have been plugged and abandoned.
- Conductors have been successfully cut 15 feet below the mudline.
- Workboat assigned to operations is used to transport cut sections.
- Platform living quarters are used to house conductor removal crew.

4.2.5 Pipeline Abandonment

- Pipelines originating from platforms are estimated
- Pipelines have been pigged on a regular basis.
- Pipelines are not buried.
- Pipeline and power cables will be abandoned and left in place.
- There is adequate storage for fluids on both platform ends.

4.2.6 Jacket Removal

4.2.6.1 Complete Removal

- Explosive pile, member, and conductor severing will be used.
- Jackets can be taken into shallower water in stages for segmenting.
- Platform will be scrapped on the upper West Coast.
- Credit for the scrap steel ($100/ton) is included in the cost estimate.
- Onshore facilities cleanup and disposal costs are not included.
- Crawler crane onshore has enough lifting capacity.

4.2.6.2 Partial Removal

- Jackets are cut at or below the -85 foot water depth level to meet U.S. Coast Guard requirements.

- Non-explosive cutting is used. Explosives are not needed to cut the jacket leg and piles.
- Top portions of jackets are set on bottom besides the remaining portion.
- Conductors are cut at the same elevation as jackets and top portion removed.

4.2.6.3 Remote Reefing

- Explosive pile and conductor severing will be used.
- Conductors will be removed from jackets.
- Jackets will be towed in one piece to an offshore location/reef site by derrick barge and scuttled.

4.2.7 Site Clearance/Verification

- Pre-demolition side-scan sonar (SSS) survey of the area surrounding the platform
- Pipeline survey (divers to survey pipelines near shore)
- Post-demolition SSS survey
- Deployment of ROV(s) and/or divers to remove identified obstructions
- Test-trawling will occur to verify that the site is free of debris

4.3 Decommissioning Results and Discussion by Removal Method

Tables 4.2 through 4.5 compares the decommissioning component cost by removal method for each platform. A complete breakdown of the tasks involved in each cost component can be found in the decommissioning estimates in the Appendix of this report

What follows is a comparison of the cost components by decommissioning method. Tables 4.2 – 4.4 are referenced for this discussion. Explanations of the differences between removal methods are the same for all platforms discussed.

4.3.1 HLV Mobilization and Demobilization

The Complete Removal method considers the use of a large Semi-Submersible Crane Vessel (SSCV). Remote Reefing and Partial Removal assume that a 2,000-ton capacity derrick barge is needed to remove the topsides.

4.3.2 CB, Crew, and Equipment Mobilization and Demobilization

More cargo barges are required when removing the platform completely. The Remote Reefing and Partial Removal scenarios only need to mobilize cargo barges to handle the topsides. Since the Remote Reefing scenario severs and removes the conductors completely, the equipment mobilization cost is slightly higher.

4.3.3 Topsides Decommissioning/Platform Removal Preparation

This decommissioning phase has the same cost for all three methods. The decommissioning method selected does influence the cost for this phase.

4.3.4 Pipeline Decommissioning

Pipeline decommissioning is independent of the type of platform removal method selected. Therefore, this phase of the decommissioning process has the same cost for all three methods.

4.3.5 Conductor Removal

All conductors have to be removed when considering the Complete Removal and Remote Reefing methods. In both cases, the jackets are moved in their entirety from their original location; not removing the conductors will only hinder moving the jacket.

There are significant cost savings associated with having to remove only the upper segment of the conductor and allowing the segment below the -85 foot level to remain in place. Table 4.3 and 4.4 show that cost savings increase as the water depth increases (i.e., conductor severing and removal costs are higher for deeper water depths).

4.3.6 Platform Removal

It is obvious that the more work-intensive the removal method is, the higher the cost will be. Complete Removal assumes that a SSCV removes the platforms, whereas the Remote Reefing and Partial Removal methods use a DB 2000. In addition, it takes more than three times the duration to completely remove the platform versus the other two methods. The combination of the higher equipment spread rates and longer duration makes the complete removal method the most expensive. Table 4.2 summarizes the total time to remove each platform by removal method.

Table 4.2 – Platform Removal Duration (derrick barge days)

Platform	Complete Removal	Remote Reefing	Partial Removal
Hidalgo	60	22	19
Gail	77	22	19
Harmony	96	27	21

4.3.7 Onshore Disposal

The Complete Removal takes the entire topsides, conductors, and jacket to shore for disposal. The other two methods take only the topsides and conductors to shore. The only difference is that the Remote Reefing method assumes the entire conductor is salvaged, whereas the Partial Removal method only takes 200 ft of each conductor to shore. The remainder is left in place with the rest of the jacket section.

4.3.8 Site Clearance/Verification

Site Clearance costs are the highest in the Complete Removal method because the jacket is moved each time it is cut. This method assumes that each site the jacket is set on the seabed (for cutting the upper elevation) has to be cleared and verified that no debris is left on the seafloor. Both Remote Reefing and Partial Removal clear the site only at the platform's original location.

4.3.9 Project Management and Engineering

Project management and engineering are calculated as 8% of the entire project cost excluding mobilization/demobilization costs. Therefore as the costs to decommission a platform increase (dictated by size of platform, water depth, and removal method selected), so does the cost of project management and engineering.

Costs for this decommissioning component are highest in the Complete Removal scenario because more engineering is required to cut the jacket into sections and more on-site supervision is required.

Table 4.3 – Hidalgo Decommissioning Costs Results by Method ($)

Cost Component	Complete Removal	Partial Removal	Remote Reefing
SSCV Mob/Demob	7,520,000	4,042,752	4,042,752
CB, Crew and Equipment Mob/Demob	2,566,912	756,277	776,802
Well P&A	NA	NA	NA
Topside Decommissioning/Platform Removal Prep	2,032,884	2,032,884	2,032,884
Pipeline Decommissioning	1,037,185	1,037,185	1,037,185
Conductor Removal	1,005,000	435,000	1,005,000
Platform Removal	17,931,105	1,902,110	3,877,113
Onshore Disposal	8,028,156	2,994,000	3,063,588
Site Clearance	1,593,807	973,769	973,769
Project Management and Engineering	2,530,251	749,996	959,163
Total	**44,245,300**	**14,923,974**	**17,768,257**

Table 4.4 – Gail Decommissioning Cost Results by Method ($)

Cost Component	Complete Removal	Partial Removal	Remote Reefing
SSCV Mob/Demob	7,520,000	4,042,752	4,042,752
CB, Crew and Equipment Mob/Demob	2,671,502	794,098	774,098
Well P&A	NA	NA	NA
Topside Decommissioning/Platform Removal Prep	1,776,756	1,776,756	1,776,756
Pipeline Decommissioning	1,266,942	1,266,942	1,266,942
Conductor Removal	3,358,667	957,000	3,358,667
Platform Removal	23,403,352	1,819,834	3,779,271
Onshore Disposal	11,150,784	2,893,332	3,196,536
Site Clearance	2,086,746	973,769	973,769
Project Management and Engineering	3,443,460	775,011	1,148,155
Total	**56,678,210**	**15,299,494**	**20,316,947**

Table 4.5 – Harmony Decommissioning Cost Results by Method ($)

Cost Component	Complete Removal	Partial Removal	Remote Reefing
SSCV Mob/Demob	15,040,000	4,042,752	4,042,752
CB, Crew and Equipment Mob/Demob	4,531,206	1,170,236	1,170,236
Well P&A	NA	NA	NA
Topside Decommissioning/Platform Removal Prep	2,657,268	2,657,268	2,657,268
Pipeline Decommissioning*	1,862,445	1,862,445	1,862,445
Conductor Removal	11,679,000	2,218,500	11,679,000
Platform Removal	53,546,489	2,214,680	5,276,298
Onshore Disposal	23,961,144	3,885,842	5,109,720
Site Clearance	2,334,236	973,769	973,769
Project Management and Engineering	7,683,246	1,105,000	2,204,680
Total	**123,295,033**	**20,130,493**	**34,976,168**

4.4 Decommissioning Results and Discussion by Platform

Tables 4.6 through 4.8 compare the decommissioning component cost by platform for each removal method. A complete breakdown of the tasks involved in each cost component is located in the decommissioning estimates in the Appendix of this report.

What follows is a comparison of the cost components by platform. Tables 4.6 – 4.8 are referenced for this discussion. Explanations of the differences between removal methods are the same across platforms.

4.4.1 HLV Mobilization and Demobilization

The Hidalgo and Gail removal scenarios assume the use of a Balder size vessel to completely remove the platforms. Harmony assumes the use of a Thialf/S7000 vessel. Mobilization costs for the other two decommissioning methods are the same for the three jackets since a smaller vessel is needed to remove the topsides.

4.4.2 CB, Crew and Equipment Mobilization and Demobilization

Hidalgo requires 3 and 7 cargo barges for the topsides and jacket respectively. Gail needs one additional cargo barge to transport the jacket to shore. Harmony needs 4 cargo barges to remove the topsides and 10 to handle the jacket. For this reason the cost differences is greater in the Complete Removal Scenario. Partial Removal and Remote Reefing methods only need to mobilize the cargo barges to handle the topsides.

4.4.3 Topsides Decommissioning/Platform Removal Preparation

The number of modules on the platform drives this cost component. Hidalgo, Gail and Harmony have 7, 5 and 9 modules respectively. The cost is the same across removal methods.

4.4.4 Pipeline Decommissioning

Hidalgo Gail and Harmony have 2, 3 and 2 originating pipelines respectively. The main cost factor is the time to clean and flush the pipelines, which is based on the pipeline's length and outer diameter. The other tasks, cut and plug each end, does not vary.

4.4.5 Conductor Removal

The length and number of conductor determine the conductor removal cost. Hidalgo has 10 conductors in 430 feet water depth that need to be removed while Harmony has more than five times as many conductors to remove in water depths three times as deep (1,198 feet). The results are conductor removal costs for Harmony that are ten times that of Hidalgo.

4.4.6 Platform Removal

As discussed in Section 4.3, the more intensive the removal method the higher the cost. Just as well, the larger the platform, the longer it takes to remove it which, in turn, means the removal cost will increase incrementally. Hidalgo and Gail assume a smaller SSCV is used to remove them. The cost difference of approximately $5 MM is driven by the number of cuts needed to remove the jacket. The difference in water depth between Hidalgo and Gail is about 300 feet. The vast increase in cost for Harmony is due to the need of the larger SSCV and increase in jacket cut sections. Both of these factors contribute Harmony's removal cost of $53 MM.

Platform removal costs in the Remote Reefing and Partial Removal methods vary slightly and are not as dependent on the water depth. Differences in cost in each method amongst platforms are due to the number of modules to remove.

4.4.7 Onshore Disposal

This cost component is based on the total tonnage removed and disposed. Differences in cost are due to the number of cargo barges that need to be offloaded. Scrap costs are a constant $/ton. As expected, Hidalgo Onshore Disposal costs will be the lowest amongst the three platforms.

Since only the topsides and conductors are disposed onshore in the Remote Reefing and Partial Removal methods, the disposal costs are not spread out.

4.4.8 Site Clearance/Verification

The size of the jacket drives this cost component in the Complete Removal method, in that the deeper the jacket the higher the number of sections created. The site is cleared at each location the jacket is set and cut. As shown in Table 4.6, the Site Clearance costs increase as the installation depths increase.

Tables 4.7 and 4.8 do not show any difference in Site Clearance cost because of the removal method selected. Hidalgo, Gail and Harmony have the same Site Clearance cost in these methods because the site is cleared only at the original platform location.

4.4.9 Project Management and Engineering

Project management and engineering are calculated as 8% of the entire project cost excluding mobilization/demobilization costs. Therefore as the costs to decommission a platform increase (dictated by size of platform, water depth, and removal method selected), so does the cost of project management and engineering.

Table 4.6 Complete Removal Decommissioning Cost Results by Platform ($)

Cost Component	Hidalgo	Gail	Harmony
SSCV Mob/Demob	7,520,000	7,520,000	15,040,000
CB, Crew and Equipment Mob/Demob	2,566,912	2,671,502	4,531,206
Well P&A	NA	NA	NA
Topside Decommissioning/Platform Removal Prep	2,032,884	1,776,756	2,657,268
Pipeline Decommissioning	1,037,185	1,266,942	1,862,445
Conductor Removal	1,005,000	3,358,667	11,679,000
Platform Removal	17,931,105	23,403,352	53,546,489
Onshore Disposal	8,028,156	11,150,784	23,961,144
Site Clearance	1,593,807	2,086,746	2,334,236
Project Management and Engineering	2,530,251	3,443,460	7,683,246
Total	**44,245,300**	**56,678,210**	**123,295,033**

Table 4.7 - Partial Removal Decommissioning Cost Results by Platform ($)

Cost Component	Hidalgo	Gail	Harmony
SSCV Mob/Demob	4,042,752	4,042,752	4,042,752
CB, Crew and Equipment Mob/Demob	756,277	794,098	1,170,236
Well P&A	NA	NA	NA
Topside Decommissioning/Platform Removal Prep	2,032,884	1,776,756	2,657,268
Pipeline Decommissioning	1,037,185	1,266,942	1,862,445
Conductor Removal	435,000	957,000	2,218,500
Platform Removal	1,902,110	1,819,834	2,214,680
Onshore Disposal	2,994,000	2,893,332	3,885,842
Site Clearance	973,769	973,769	973,769
Project Management and Engineering	749,996	775,011	1,105,000
Total	**14,923,974**	**15,299,494**	**20,130,493**

Table 4.8 – Remote Reefing Decommissioning Cost Results by Platform ($)

Cost Component	Hidalgo	Gail	Harmony
SSCV Mob/Demob	4,042,752	4,042,752	4,042,752
CB, Crew and Equipment Mob/Demob	776,802	774,098	1,170,236
Well P&A	NA	NA	NA
Topside Decommissioning/Platform Removal Prep	2,032,884	1,776,756	2,657,268
Pipeline Decommissioning	1,037,185	1,266,942	1,862,445
Conductor Removal	1,005,000	3,358,667	11,679,000
Platform Removal	3,877,113	3,779,271	5,276,298
Onshore Disposal	3,063,588	3,196,536	5,109,720
Site Clearance	973,769	973,769	973,769
Project Management and Engineering	959,163	1,148,155	2,204,680
Total	**17,768,257**	**20,316,947**	**34,976,168**

4.5 Cost Comparisons

The Minerals Management Service (MMS) Pacific OCS Region prepared a decommissioning cost report for Pacific OCS platforms in March of 1999 that estimated ranges of costs for each phase of the decommissioning process.

In addition to using their own methodologies and algorithms to establish decommissioning costs for Hidalgo, Gail, and Harmony, TSB developed decommissioning estimates to establish what these costs would be using the MMS formula. Platform inventory was the same for both estimates.

Using the formula provided by the MMS, estimates were generally 25%-30% lower than those derived by TSB independently. Differences between the TSB estimates and the estimates generated using MMS guidelines were primarily due to three identified factors:

- Higher project management and engineering costs
- Increased conductor removal costs
- Higher heavy lift vessel spread rate

Section 5 – Decommissioning Methodology Evaluation and Comparison

Introduction

This section compares and evaluates the removal methods considered in this study based on evaluation categories that may ultimately influence final methodology selection. The category selection and ranking process is first discussed. The three decommissioning methods are then evaluated and ranked for each evaluation category. A discussion detailing the factors that determined the ranking completes this section.

5.1 Evaluation Category Selection and Ranking

Decommissioning specialists made up of TSB staff, other consultants, service companies, and operators have previously discussed the issues that influence decommissioning method selection. Seven categories were identified and ranked in order of importance from 5 to 1 (5 being the most important). Table 5.1 presents the evaluation categories used to evaluate the three decommissioning methods considered in this study.

Table 5.1 Decommissioning Categories Evaluated

Category	Issues
Safety	How safe is the method selected to personnel? Is the equipment reaching its safety limits?
Technical Feasibility	How much planning and engineering is required? Are there any physical limitations? Is this method currently within the State of the Art?
Environmental Impacts	What impacts will this method have on the environment, air pollution, marine flora and fauna? Are these environmental impacts due to the equipment, methodology, etc.?
Permitting	What are the permitting requirements? How easily can they be obtained? What agencies and jurisdictions are involved?
Disposal Option	How much material is going onshore, to the reef site, etc? Are there yards capable of handling the material?
Cost	What resources, tasks, and/or methods drive the cost? Can cost be estimated accurately?
Scheduling	Can the platform be removed during the construction season? How much lead-time is needed for contracting, to establish permitting, etc?

Safety was considered the most important of the seven evaluation categories. The method ultimately selected must not present any excessive or unknown safety issues to the personnel. The three methods selected have all been deemed safe, but ultimately (because of the work involved in accomplishing the platform decommissioning), one method will be safer than the others.

Technical Feasibility and **Environmental Impact** were considered as the next most important categories and thus were given an equal rank of 4. Technical Feasibility considers the work required in planning, and executing the deck and jacket removal. Cutting, handling and dismantling of the jacket was factored as an integral part of the method evaluation. In the case of the particular method evaluated, there are no major technical issues. However, this is not always the case.

Air/water pollution and impact on the local or nearby marine life was considered in evaluating the decommissioning methods. Ultimately, the method selected should pose the least practical impact on the surrounding environment.

Permitting and **Disposal Option** are categories that were ranked as having average importance in the evaluation. Regardless of the method selected, each will require permits from various agencies with numerous requirements. Due to the large quantities of material being handled, the Disposal category was deemed more important than cost and schedule.

Cost is a significant factor in evaluating and selecting the decommissioning method. However, it was considered that the aforementioned factors should carry more weight in selecting the method to use. If the method selected happens to be the least expensive method it should be justified by the higher ranked categories such as Safety and Environmental Impact and not by cost alone.

Scheduling was considered as the category that least influenced the decommissioning methodology selection. The operator can begin planning to decommission the platforms before it ceases production. There are certain tasks that can be accomplished prior to cessation of production that will not affect the critical path. However, because of the complexity of the platform removal, permitting requirements, and lack of local infrastructure in the POCSR, it is recommended that planning should begin at lease three years prior to commencing any offshore work.

5.2 Decommissioning Evaluation

Using the categories listed above, each decommissioning method was compared to the other two and ranked 1, 3, or 5 (5 being the best case method). The ranking for each method was then multiplied with the weighted value for each task. The resulting numbers (shown in *italics*) were then added to determine the total score. The decommissioning method with the highest values is considered to be the best option. Table 5.2 presents the results of this evaluation.

The table and numerical rating system is not specific to the POCSR except for permitting. The other categories will tend to have the same ratings regardless of location. The issues discussed in Section 5.3 apply to other offshore areas outsides the POCSR.

Table 5.2 Decommissioning Method Evaluation

	Complete Removal	Partial Removal	Remote Reefing
Safety	(1)	(5)	(3)
(5)	*5*	*25*	*15*
Technical feasibility	(1)	(5)	(3)
(4)	*4*	*20*	*12*
Environmental impact	(1)	(5)	(3)
(4)	*4*	*20*	*12*
Permitting requirements	(5)	(2)	(3)
(3)	*15*	*6*	*9*
Disposal Option	(1)	(5)	(4)
(3)	*3*	*15*	*12*
Cost	(1)	(5)	(4)
(2)	*2*	*10*	*8*
Schedule	(1)	(4)	(5)
(1)	*1*	*4*	*5*
Rank total	**(11)**	**(31)**	**(28)**
Weighted total	***34***	***100***	***73***

5.3 Category Evaluation Discussion

Complete Removal, Partial Removal, and Remote Reefing compare equally in all decommissioning phases except jacket removal. The following discussion highlights the issues where the differences exist between the three decommissioning methods categorically.

5.3.1 Safety

Safety is considered the most important factor in selecting the decommissioning method. Safety issues evaluated are directly related to the complexity of the work, duration to complete the work, and equipment required.

Partial Removal was considered as the safest of the three methods. This method considers cutting the jacket at (-) 85 below the waterline, a depth commonly accessed by commercial divers. Since explosives are not used, the local marine life is not affected; in fact, a major portion of the habitat is maintained.

Remote Reefing was scored in the middle of this category, in that divers are used longer and at greater depths and the local marine environment is affected. Divers will assist attaching bouyancy bags to the jacket. This extra work requires the use of divers at depths greater than the (-) 85 feet (Partial Removal) for longer periods of time. Additionally, the explosives used to sever the piles will greatly affect the local marine habitat.

Complete Removal is deemed the least safe method due to large the amount of work required to remove the jacket. The HLV handles, cuts, lifts and loads the jacket in many sections. This will require extensive of personnel. If the jacket were cut up in-situ, the safety issue would be even more of a factor.

Lloyd's Register report (Lloyd's July, 1997) concluded, "the results show risks to safety are approximately 50% higher for the total removal compared to the partial removal options. This is mainly due to the higher exposure of the workforce to offshore hazards during the total removal of the jacket." The Lloyd's study considered North Sea Platforms in less than 400' water depth. In this deep water study, the risks may be even higher in that the exposure of the workforce to offshore hazards is greater for the deepwater platforms. In addition, the differences between deepwater complete removal and partial removal are much greater that the conventional method analyzed by Lloyd's.

5.3.2 Technical Feasibility

Issues considered for this category are the planning, engineering and execution required to complete the jacket removal. Partial Removal was considered the most feasible method. Cutting the jacket at the specified location only requires the use of divers for a short period of time at the specified depth.

Remote Reefing is more challenging in that ballast calculations are required to determine the additional buoyancy needed to re-float the jacket. Deballasting the jacket at the reef site will also need to be planned and engineered.

Complete Removal was ranked as the most technically challenging method. An engineering study in considerable detail will be necessary to determine how the jacket will be cut (size, weight, and location). Locations to cut the jacket are then established based on the jacket sections configurations. Rigging and handling the jacket sections will at times be very challenging to the HLV. Removal in-situ would be more challenging.

5.3.3 Environmental Impact

Three issues were considered for this category: air pollution, use of explosives, and impact on the attached flora and fauna and other marine life. Reefing jackets in place (*in situ*) has the least impact on the environment. The marine equipment utilized is on the job for site less time than for the Complete Removal scenario. In addition, the work is performed in one place, unlike in the Remote Reefing scenario. This avoids the emission of pollution in other areas outside the general platform location (as found in the Complete Removal and Partial Removal scenarios). The less time the equipment is on site, the less impact it will have on the environment.

Explosives are not used to sever the piles in the Partial Removal method, in that the jacket is not removed. The Complete Removal and Remote Reefing methods sever the piles with explosives, which in turn affect the local marine habitat, killing marine life in close proximity to the jackets during detonation. Remaining marine life is also affected since their habitat has been removed. By reefing in place (Partial Removal), the artificial reef environment created when the platform was first installed is preserved. Furthermore, the additional jacket piece may provide the right conditions to enhance the current artificial reef.

5.3.4 Permitting Requirements

Issues considered in evaluating this category where the number of agencies involved and the process by which the method will be permitted. In the Gulf of Mexico, the MMS Regional office is the lead agency by which the platform decommissioning method is approved. More agencies (federal, state, county, etc.) and special interest groups are involved in the Pacific OCSR.

In the POCSR, the Complete Removal method is the permitting mechanism identified to be most straightforward in accordance with existing regulations. Partial Removal and Remote Reefing requires that a reef program similar to the Texas or Louisiana Artificial Reef Program be established and the guidelines approved.

Remote Reefing can place the jacket at a designated reef site. For this reason it was scored in the middle. Partial Removal will require that the platform location be designated as a reef site. Texas and Louisiana require reviewing the reef according to guidelines and ultimately decide if the platform site is acceptable. Our subjective review scored Partial Removal as the method that will be harder to permit, unless high value is placed on issues such as environmental impact.

5.3.5 Disposal Option

The amount of material being removed and taken to shore was the issue in evaluating this category. While Partial Removal and Remote Reefing send the topsides to shore, Remote Reefing sends the all of the jacket and conductors to shore for recycling. Partial Removal was given a high score of 5, while Remote Reefing scored next. Complete Removal will require the most effort to dismantle and recycle the platform. For this reason, Complete Removal scored the lowest in this category.

5.3.6 Cost

Complete Removal, Partial Removal, and Remote Reefing costs for the Hidalgo, Gail, and Harmony platforms are listed in Table 5.2.

Table 5.3 – Decommissioning Summary Results ($MM)

Platform	Water Depth (ft.)	Total Weight (tons)	Complete Removal	Partial Removal	Remote Reefing
Hidalgo	430	21,050	44	15	18
Gail	739	30,000	57	15	20
Harmony	1,198	65,050	123	20	35

Partial Removal is the least expensive of the three methods and thus scored the highest. Since Remote Reefing is very close to Partial Removal a score of 4 was assigned. As expected, Complete Removal (the most work-intensive method and, as a result, the most expensive) scored a 1.

5.3.7 Schedule

Assuming that three to five platforms will be decommissioned concurrently, the schedule will influence the method selected. Partial Removal can be completed in the least amount of time (20 days per platform) and thus scored a 5 in this study. Remote Reefing was assigned a score of 4 in that the time to remove the platform is very close to Partial Removal (23 days). Complete Removal scored a one, in that it takes as least three times longer than the other two methods.

5.4 Conclusions

Based on the evaluation and criteria described above, Partial Removal was determined to be the most practical decommissioning method reviewed.

Section 6 –
Decommissioning Algorithms by Cost Component

Introduction

Included in this section are the algorithms used to generate the decommissioning cost estimates for the removal of the Hidalgo, Gail, and Harmony platforms.

As discussed in Section 2, these algorithms can be used to develop accurate decommissioning estimates for all deepwater platforms located in the Pacific Outer Continental Shelf Region (POCSR) and the Gulf of Mexico Outer Continental Shelf Region (GOMOCSR).

6.1 Mobilization

Mobilization costs are driven by the size of the heavy lift vessel (HLV) used; HLV selection is based on the heaviest lift required for the decommissioning.

For the Complete Removal scenario, each jacket is moved to shallower water as it is cut into manageable sections. The Thialf/Siapem 7000 was chosen for this study with regards to jackets weighing more than 20,000 tons (nine total platforms in the POCSR and GOMOCSR [see Tables 2.1-2.2]; water depths exceeding 997 ft.). For jacket weights less than 20,000 tons (14 total in the POCSR and GOMOCSR [see Tables 2.1-2.2], water depths ranging from 427-997 ft.), it is possible to use vessels like the Balder and Hermod for the estimate.

For the Partial Removal and Remote Reefing scenarios, the heaviest lifts are the topsides modules. Each of these removal scenarios requires that the vessel selected can lift the heaviest module for the platforms decommissioned. For these estimates, vessels such as the DB 50 and the Hercules are selected.

The mobilization rate is based on 80% of the day rate of these vessels, and mobilization is assumed to be:

- For Complete Removal (i.e., Thialf, Siapem, Balder, and/or Hermod) – from Rotterdam via Cape Horn (total distance13,500 nautical miles each way – 94 days)
- For Partial Removal (i.e., DB 50 and Hercules) – from Gulf of Mexico via Cape Horn (total distance13,300 nautical miles each way – 94 days)

Additionally, these algorithms are based on the assumption that at least five platforms can be decommissioned concurrently.

Please refer to Table 6.1 for the Mobilization algorithms resulting from this study.

6.2 Cargo Barge Requirements

The number of cargo barges necessary for decommissioning a deck is estimated based on the number of modules (**Figure 6.1**) or the overall deck weight (**Figure 6.2**), but not both. The water depth of the platform (**Figure 6.3**) or the overall jacket weight (**Figure 6.4**) determines the number of cargo barges required to remove a jacket. Please note that the costs listed include preparing the cargo barge with load spreaders and clean up after its use.

As would be expected, the larger the topsides or jacket, the more cargo barges are required for removal.

6.3 Platform Removal Preparation

Platform removal preparation can be estimated by either the number of modules (**Figure 6.5**) or topsides weight (**Figure 6.6**). Those platforms with modular decks should use the number of modules to calculate this cost ($300,000 per module); conventional deck platforms should use the weight of the platform ($250 per ton) to calculate platform removal preparation costs.

6.4 Pipeline Decommissioning

A trend line for the Pipeline decommissioning phase could not be established due to the various sizes and lengths (not enough data points available). The driving factor for estimating pipeline decommissioning costs is the volume of fluids used to clean the line (OD multiplied by pipeline length).

6.5 Conductor Removal

Conductor length drives the number of sections to be cut, stored and offloaded. The cost of conductor removal should be estimated at $200 per foot (**Figure 6.7**).

When considering conductor removal costs, the length of the conductors is the driving factor. The total length is estimated by totaling the following lengths:

- Topsides to waterline
- Overall water depth
- 15 ft below mudline

6.6 Platform Removal

6.6.1 Complete Removal

The estimated platform removal cost for the Complete Removal scenario is based on water depth. Deeper depths dictate a larger jacket, which requires more sections to be severed. As shown in **Figures 6.8-6.9**, costs are calculated by $1,400/ton (based on total jacket weight) or by $800/ton (using the total platform weight), respectively.

6.6.2 Remote Reefing

When determining costs for a Remote Reefing scenario, the estimate cannot be based on water depth. The concentration of the work is focused on removing the topsides and towing the jacket to the reef site. Therefore, it is assumed that jackets are towed to the remote reef site in one section regardless of size. To calculate Remote Reefing costs, the following numbers are appropriate for the algorithms:

- $500/ton based on topsides weights (**Figure 6.10**)
- $610,000/module (**Figure 6.11**)

6.6.3 Partial Removal

As in the Remote Reefing scenario, the estimate is not based on water depth. The concentration of the work performed is focused on removing the topsides and cutting the jacket. The only assumption is that the jackets are cut near the (-) 85 ft elevation (regardless of size). To calculate Partial Removal costs, the following numbers are appropriate for the algorithms:

- $230/ton based on topsides weights (**Figure 6.12**)
- 285,000/module (**Figure 6.13**)

6.7 Site Clearance

Calculations for estimating Site Clearance are based on the number of locations at which the jacket is set. For the Complete Removal scenario, the jacket is set on the seafloor each time the jacket is cut horizontally. The number of times the jacket is cut is determined by the size of the jacket. The cost applied to this phase averaged $280,000 per site in this study. The number of horizontal elevation cuts on each jacket, is driven by the water depth. Hidalgo, Gail and Harmony were cut horizontally 5,7 and 9 times respectively. **Figure 6.14** shows the Site Clearance and Verification costs by water depth.

The Partial Removal and Remote Reefing scenarios only consider the original platform location (in that Site Clearance only takes place where work is performed). This cost was estimated to be $973,000. The unit cost in the Complete Removal method is lower because the sites overlap.

6.8 Onshore Disposal

Onshore Disposal estimates are based on the total platform weight (including conductors, jacket, piles, and deck). Estimates are based on current expenses/costs ($400/ton disposal – $100/ton credit – net $300/ton).

The Complete Removal scenario assumes all platform components are taken to shore. Partial Removal only considers topsides and top conductor sections are taken to shore. The Remote Reefing scenario considers topsides and all conductors (total lengths) are taken to shore.

Please refer to **Figure 6.15** to determine costs for Onshore Disposal.

6.9 Project Management and Engineering

Project Management should be calculated as 8% of the total project cost excluding mobilization/demobilization costs. These costs should include the following

- Weight take offs
- Module lifting analysis
- Jacket cut and lifting analysis
- Bidding and contracting work
- Project oversight

6.10 Gulf of Mexico Cost Adjustments

The preceding discussion focused on the Pacific region, which apply in most part to the Gulf of Mexico region with the exception of HLV mobilization. Table 6.1 lists the mobilization cost for the Gulf of Mexico Region. The other cost components can be estimated by adjusting the cost selected by a discount of 20%.

Table 6.1
U.S. Minerals Management Service
State of the Art of Removing Large Platform in Deep Water

Pacific OCS Region

Removal Method	Jacket Weight	Representative Vessel	Assumed Mob and Demob Duration (days)	Transit Spread Rate ($M/Day)	Gross Cost ($MM)	Unit Cost ($MM)
Complete Removal	>20,000	Thielf/Saipem*	188	400	75.2	15.0
Complete Removal	<20,000	Balber/Hermod *	188	200	37.6	7.5
Partial Removal	All	DB 50/Hercules **	188	110	20.7	4.1
Remote Reef	All	DB 50/Hercules **	188	110	20.7	4.1

Gulf of Mexico OCS Region

Removal Method	Jacket Weight	Representative Vessel	Assumed Mob and Demob Duration (days)	Transit Spread Rate ($M/Day)	Gross Cost ($MM)	Unit Cost ($MM)
Complete Removal	>20,000	Thielf/Saipem ***	66	400	26.4	5.3
Complete Removal	<20,000	Balber/Hermod ***	66	200	13.2	2.6
Partial Removal	All	DB 50/Hercules	2	110	0.2	0.2
Remote Reef	All	DB 50/Hercules	2	110	0.2	0.2

* from Rotterdam to Los Angeles via Cape Horn
** from New Orlean to Los Aneles via Cape Horn
*** from Rotterdam to New Orleans

Figure 6.1 - Deck Cargo Barge Mobilization Cost

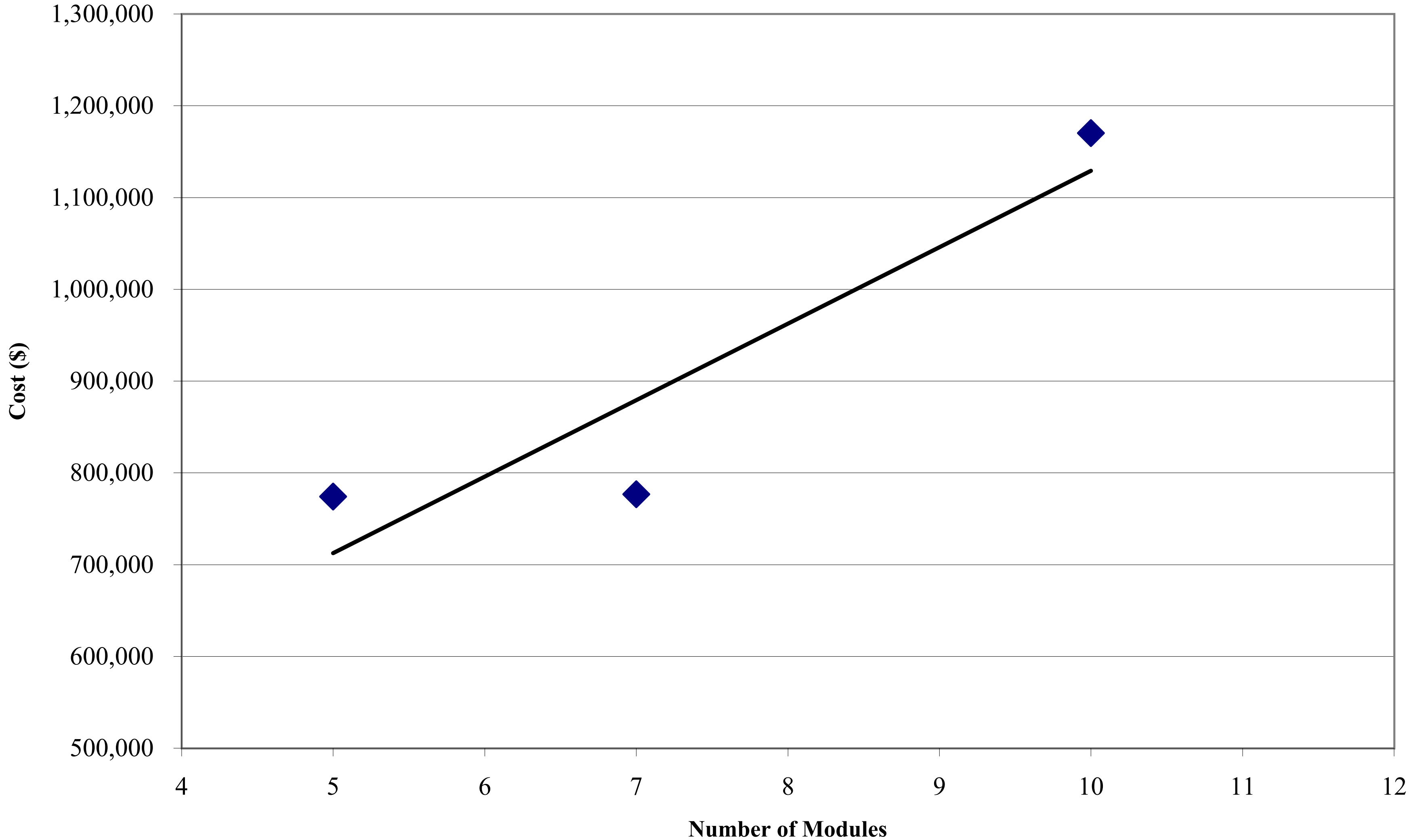


Figure 6.2 - Deck Cargo Barge Mobilization Cost

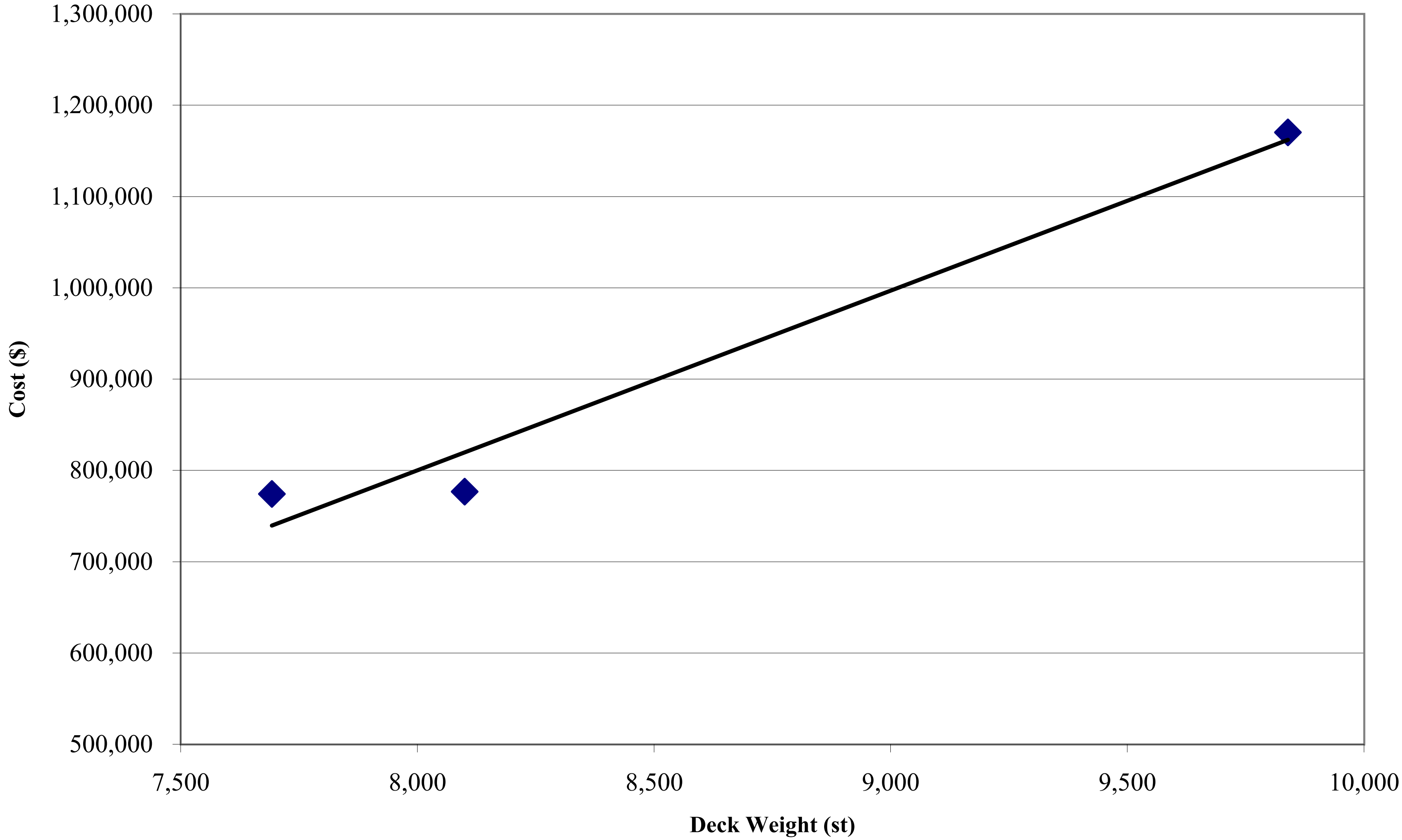


Figure 6.3 - Jacket Cargo Barge Mobilization Cost (Complete Removal)

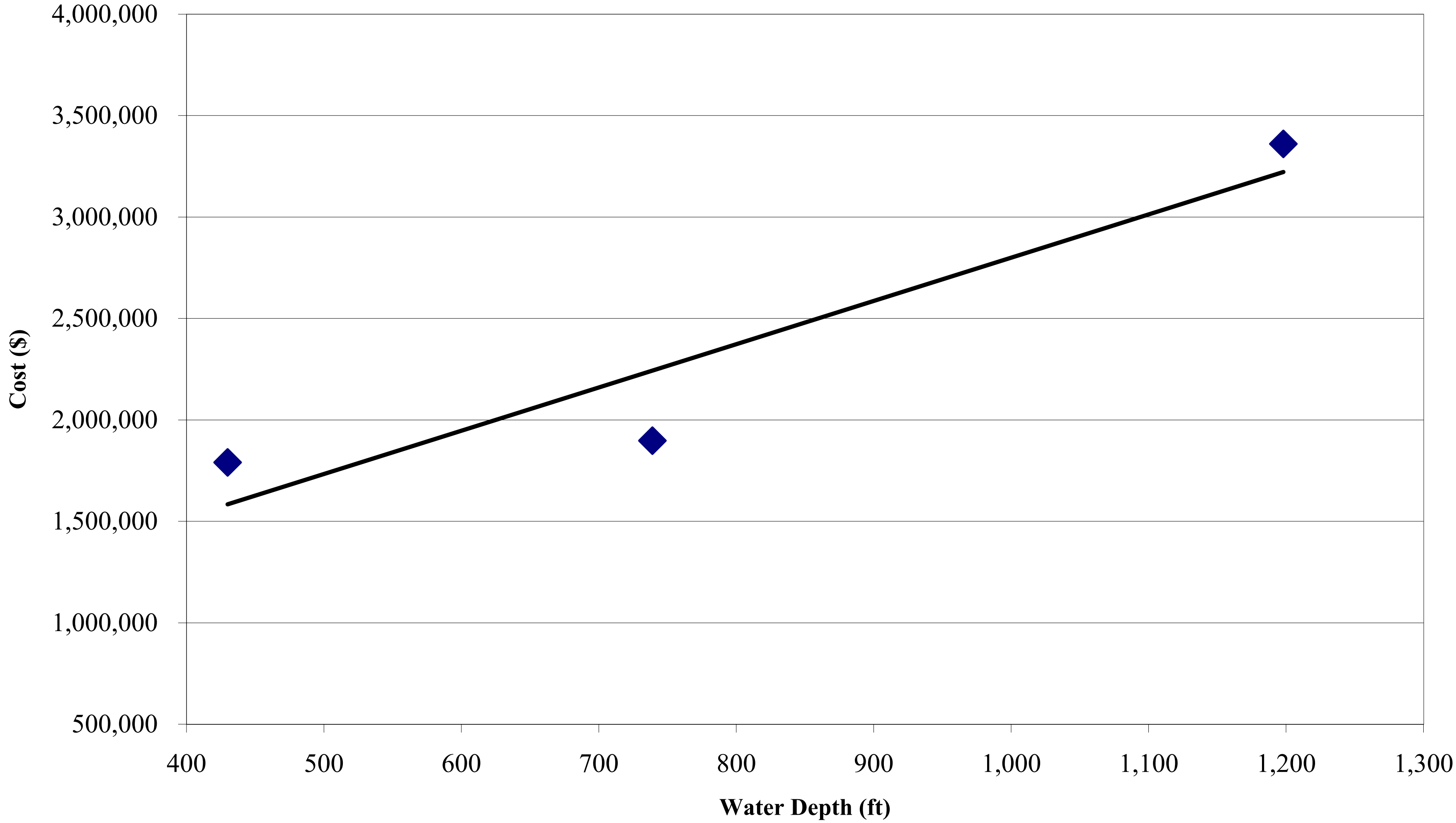


Figure 6.4 Jacket Cargo Barge Mobilization Cost
(Complete Removal)

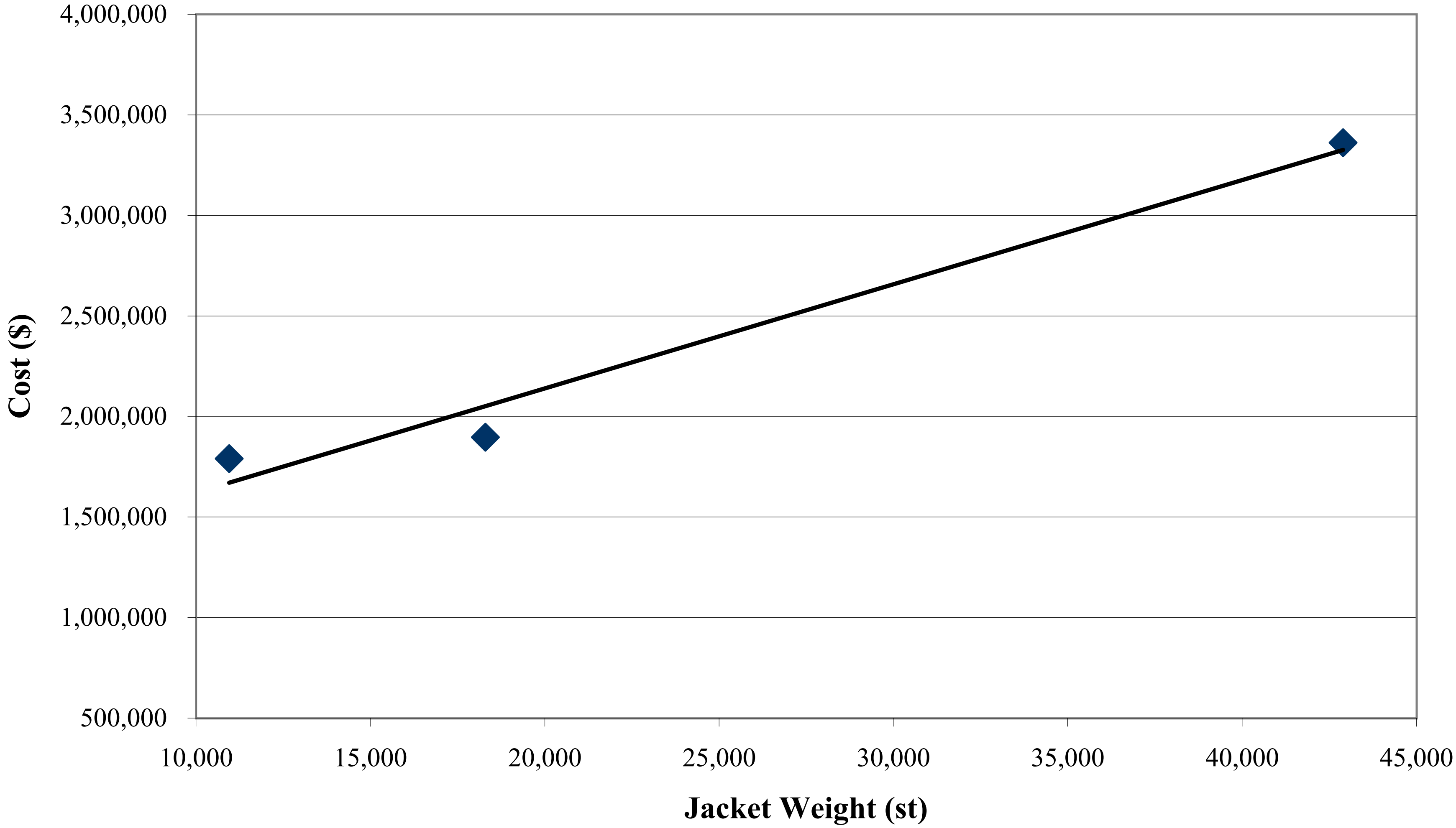


Figure 6.5 - Platform Removal Preparation Cost

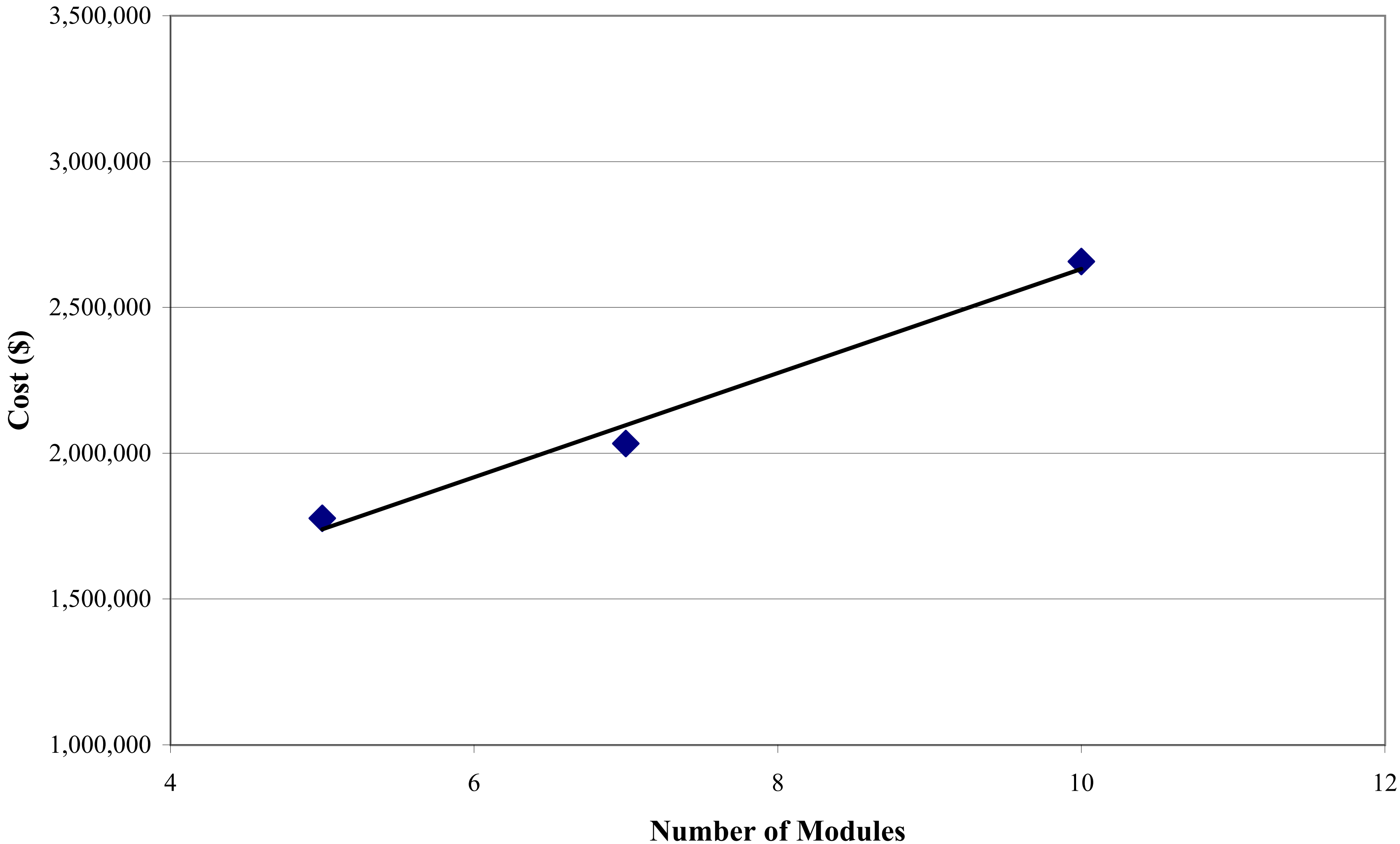


Figure 6.6 - Platform Removal Preparation Cost

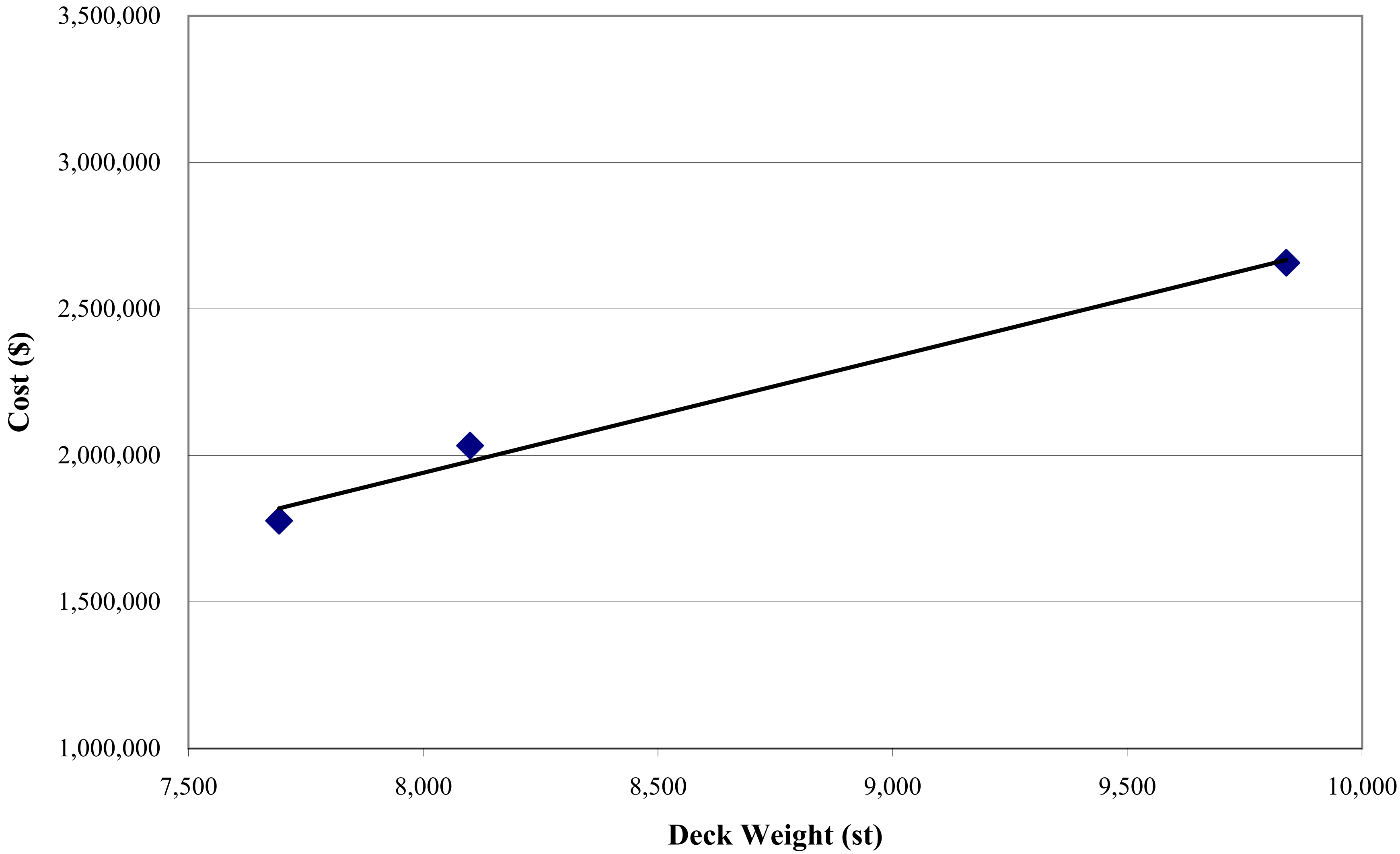


Figure 6.7 - Conductor Removal Cost

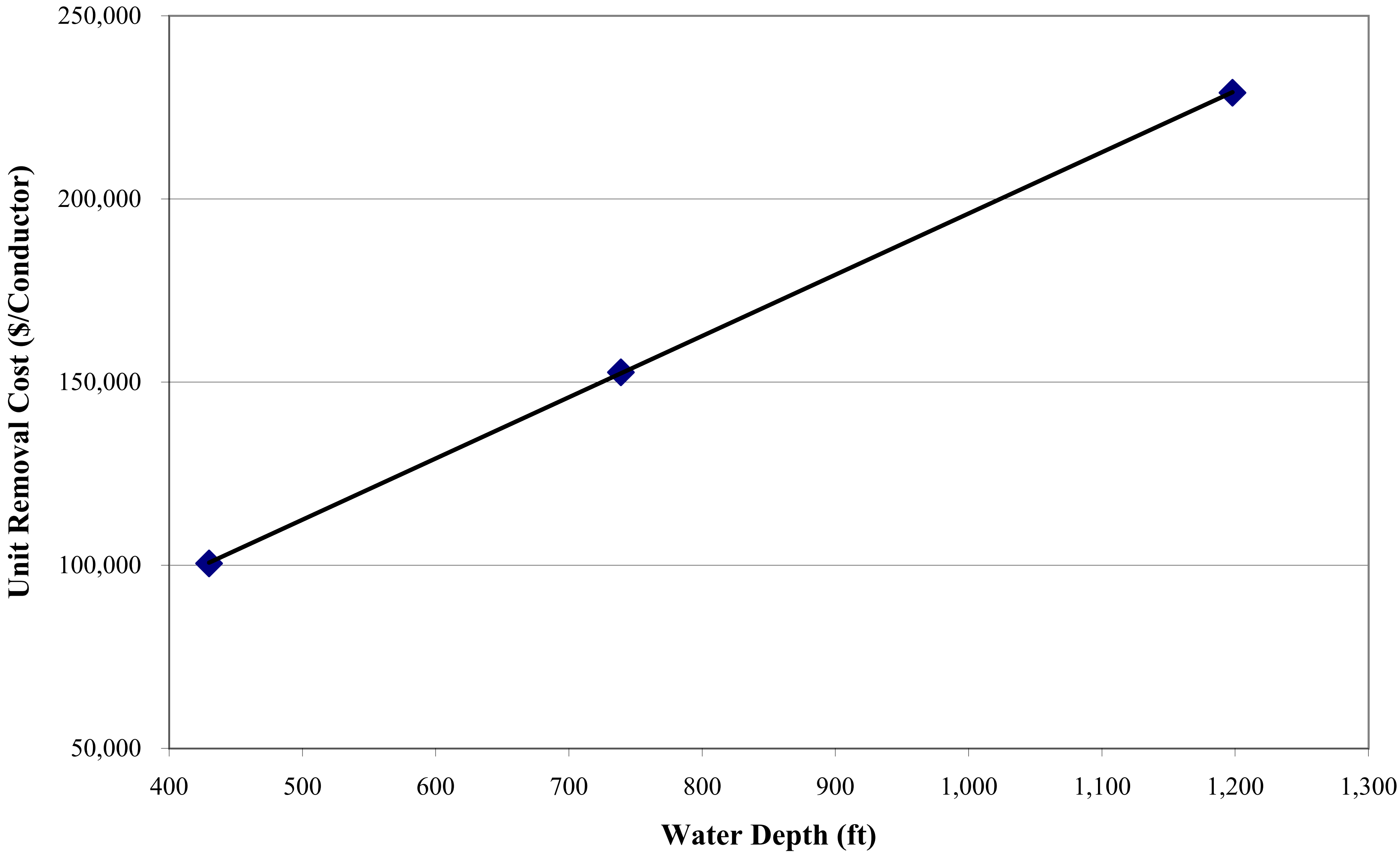


Figure 6.8 - Platform Removal Cost
(Complete Removal Method)

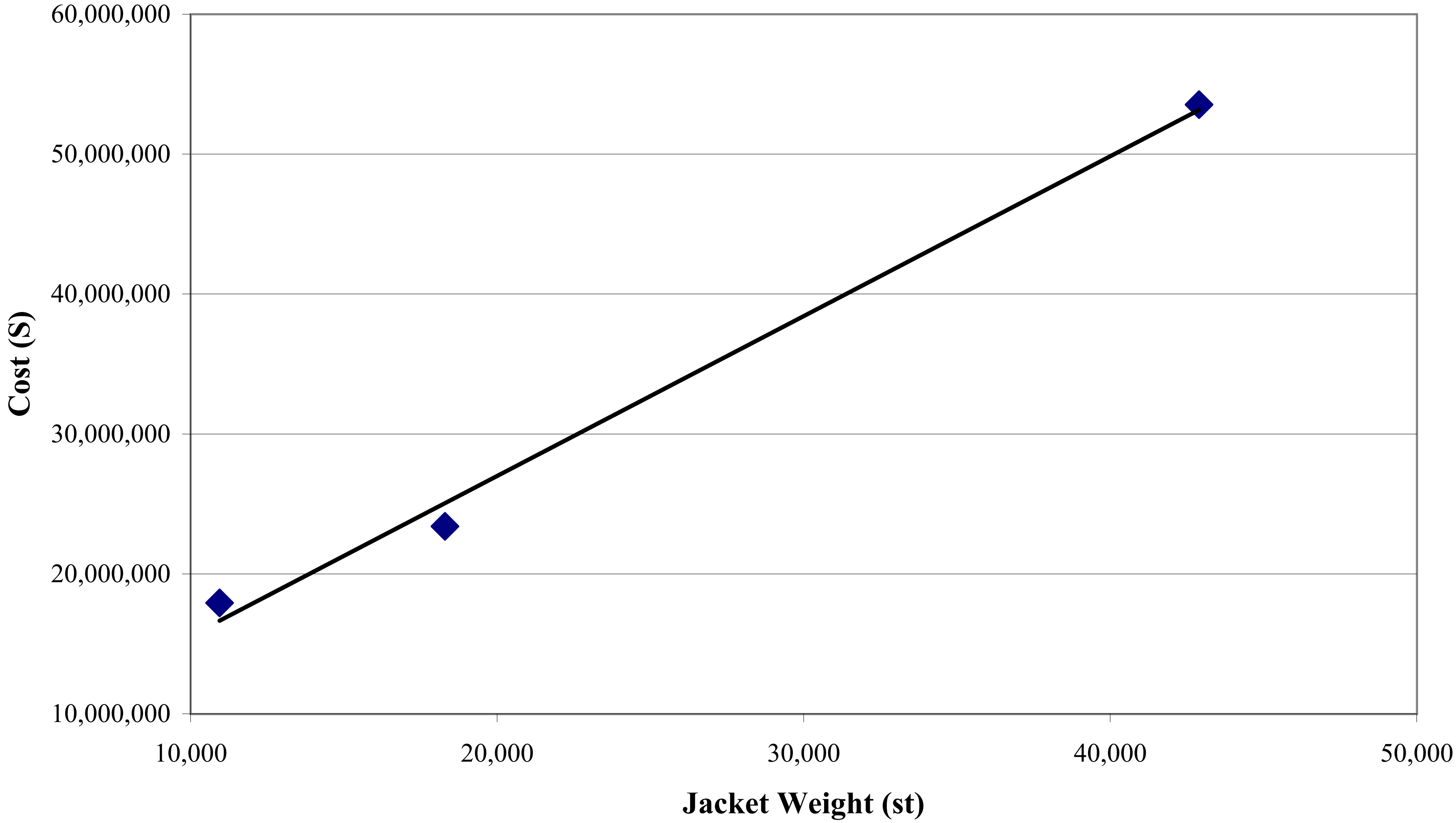


Figure 6.9 - Platform Removal Cost
(Complete Removal Method)

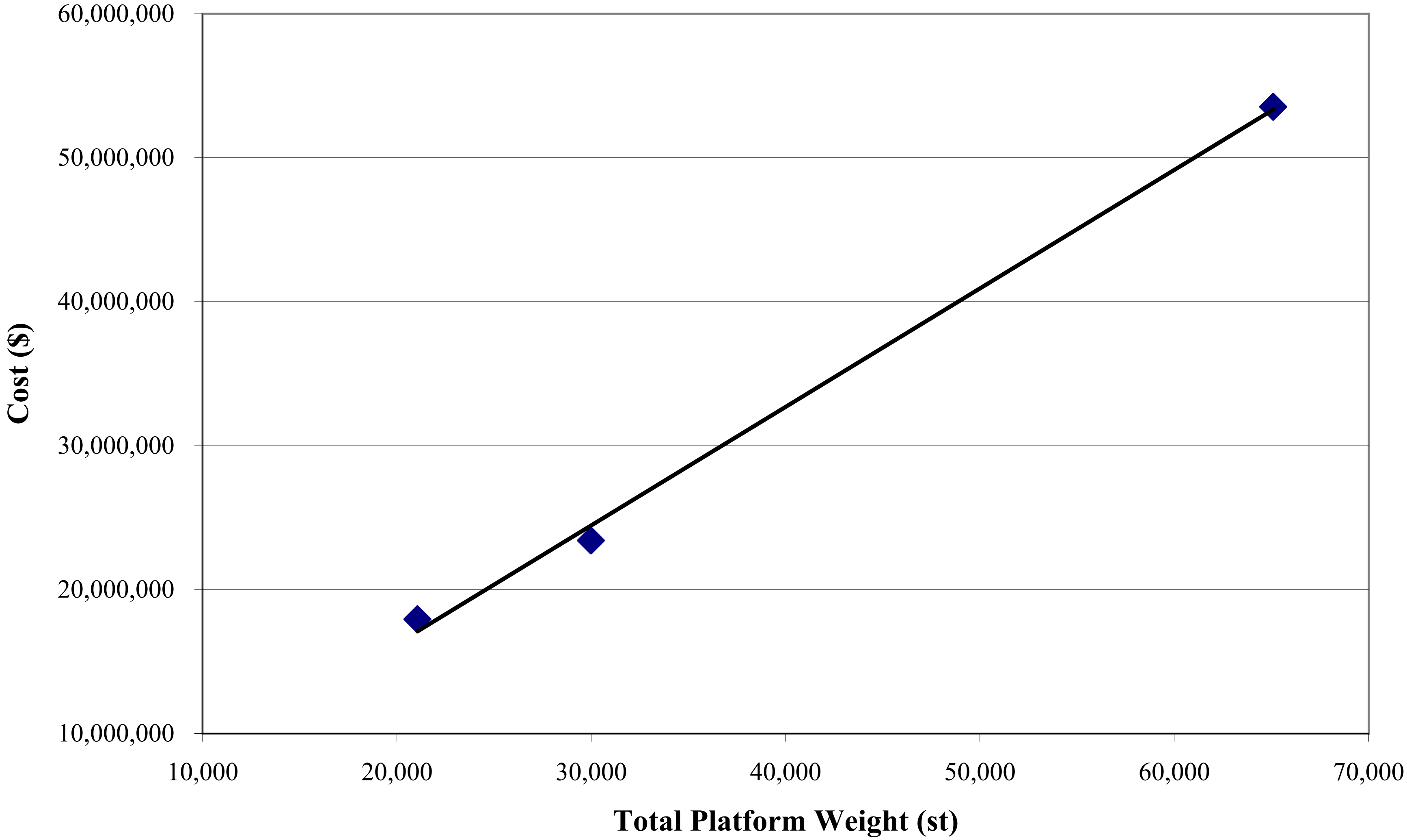


Figure 6.10 - Platform Removal Cost
(Remote Reef Method)

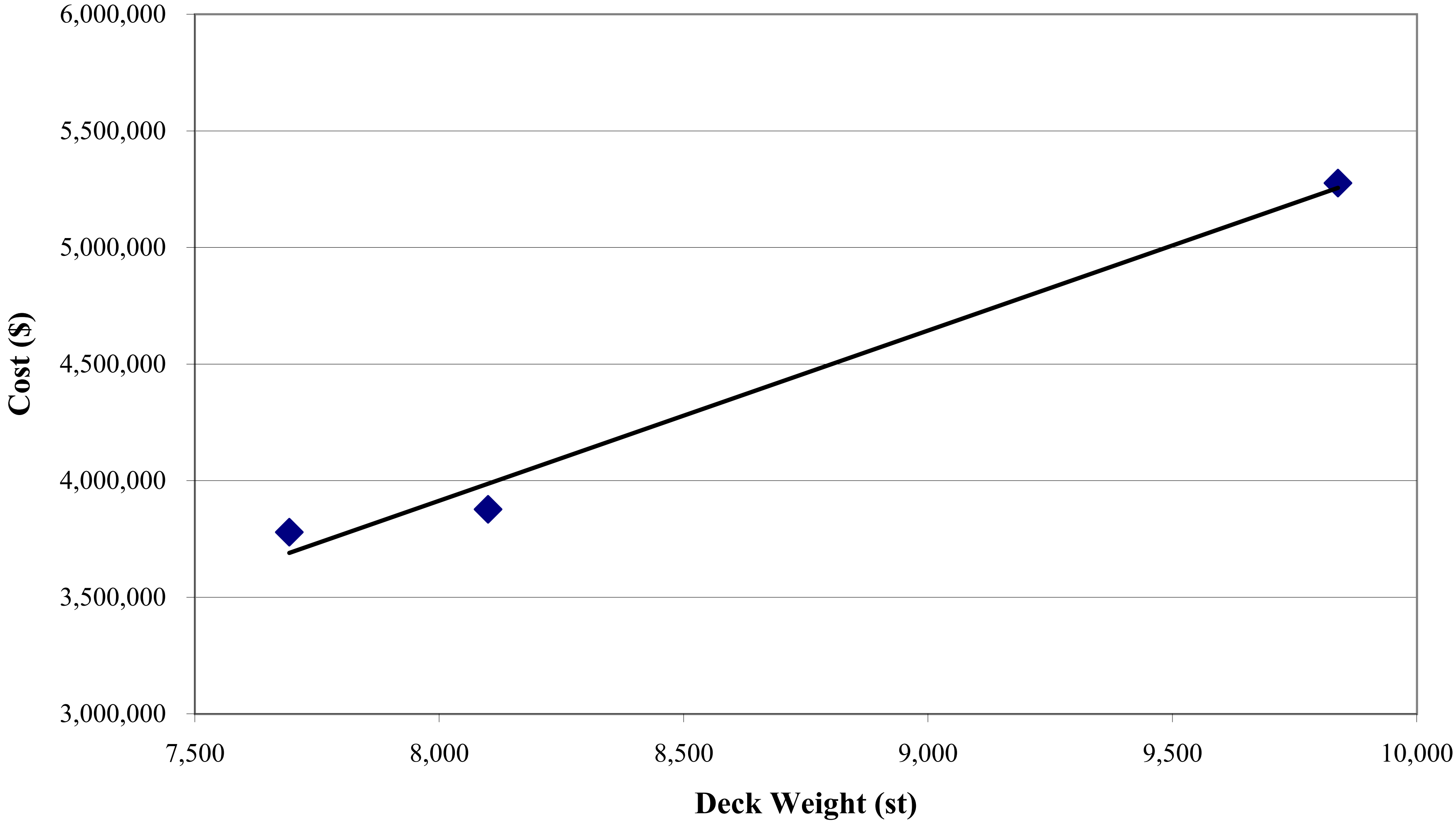


Figure 6.11 - Platform Removal Cost
(Remote Reef Method)

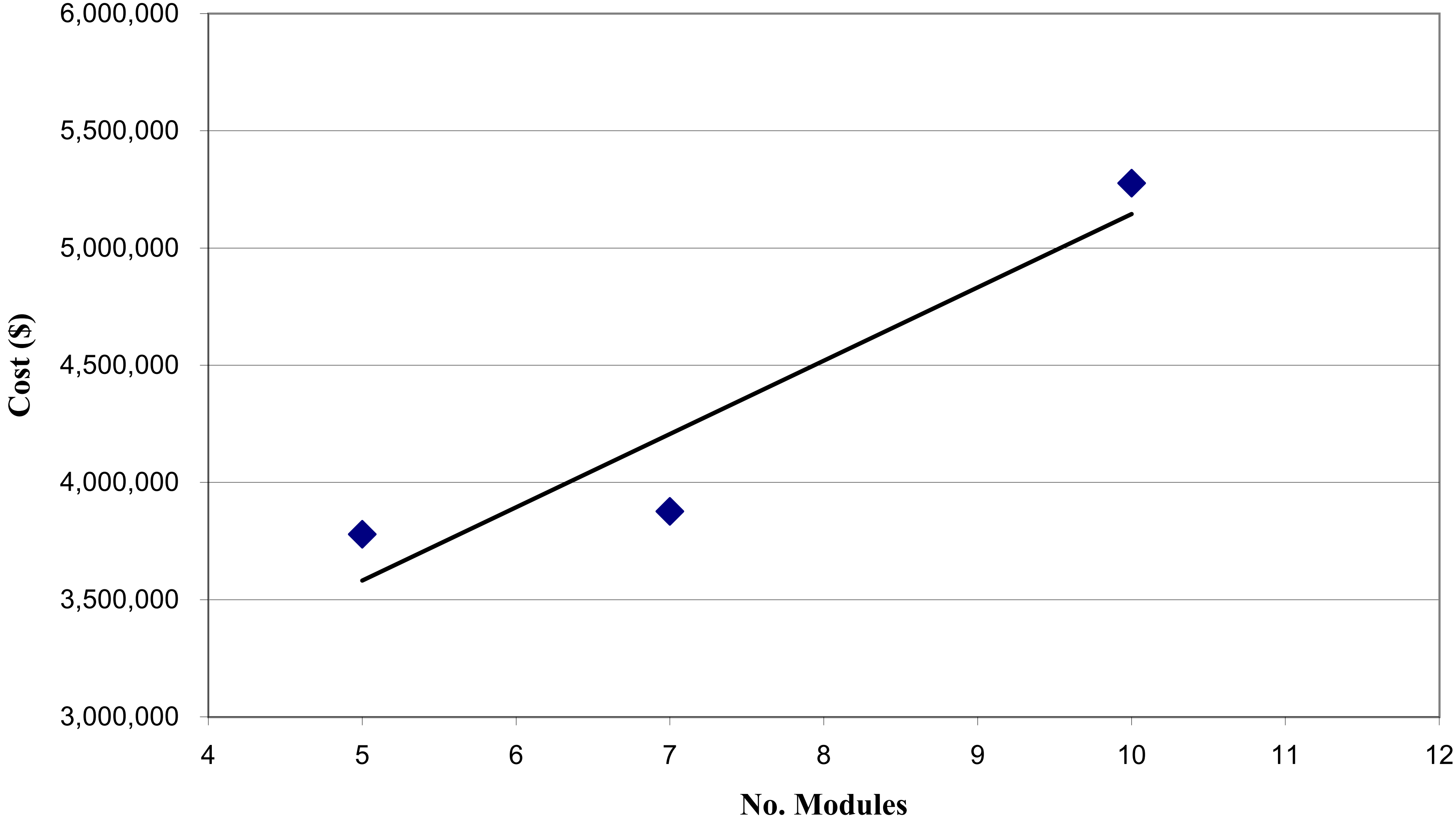


Figure 6.12 - Platform Removal Cost
(Partial Removal Method)

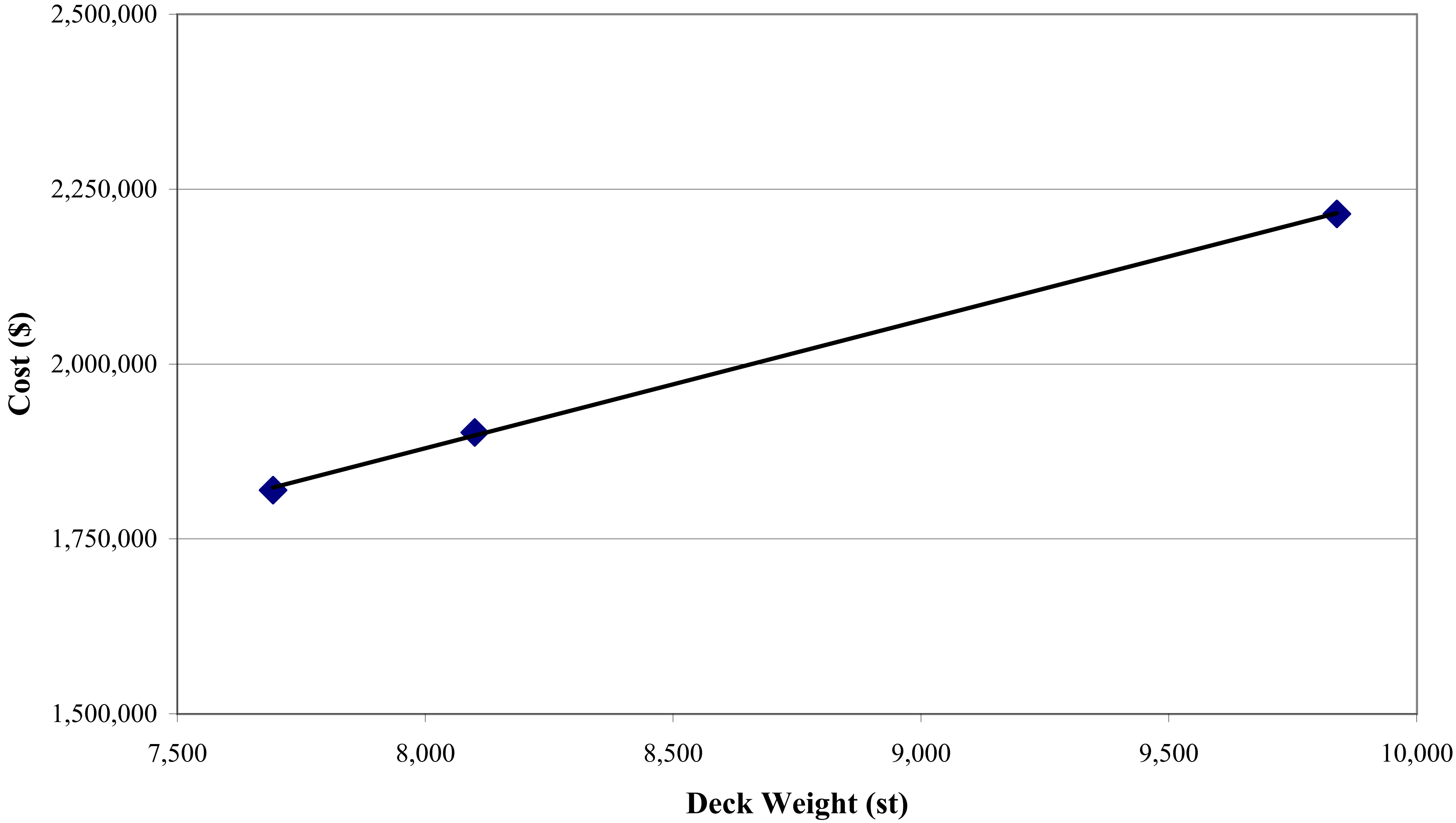


Figure 6.13 - Platform Removal Cost
(Partial Removal Method)

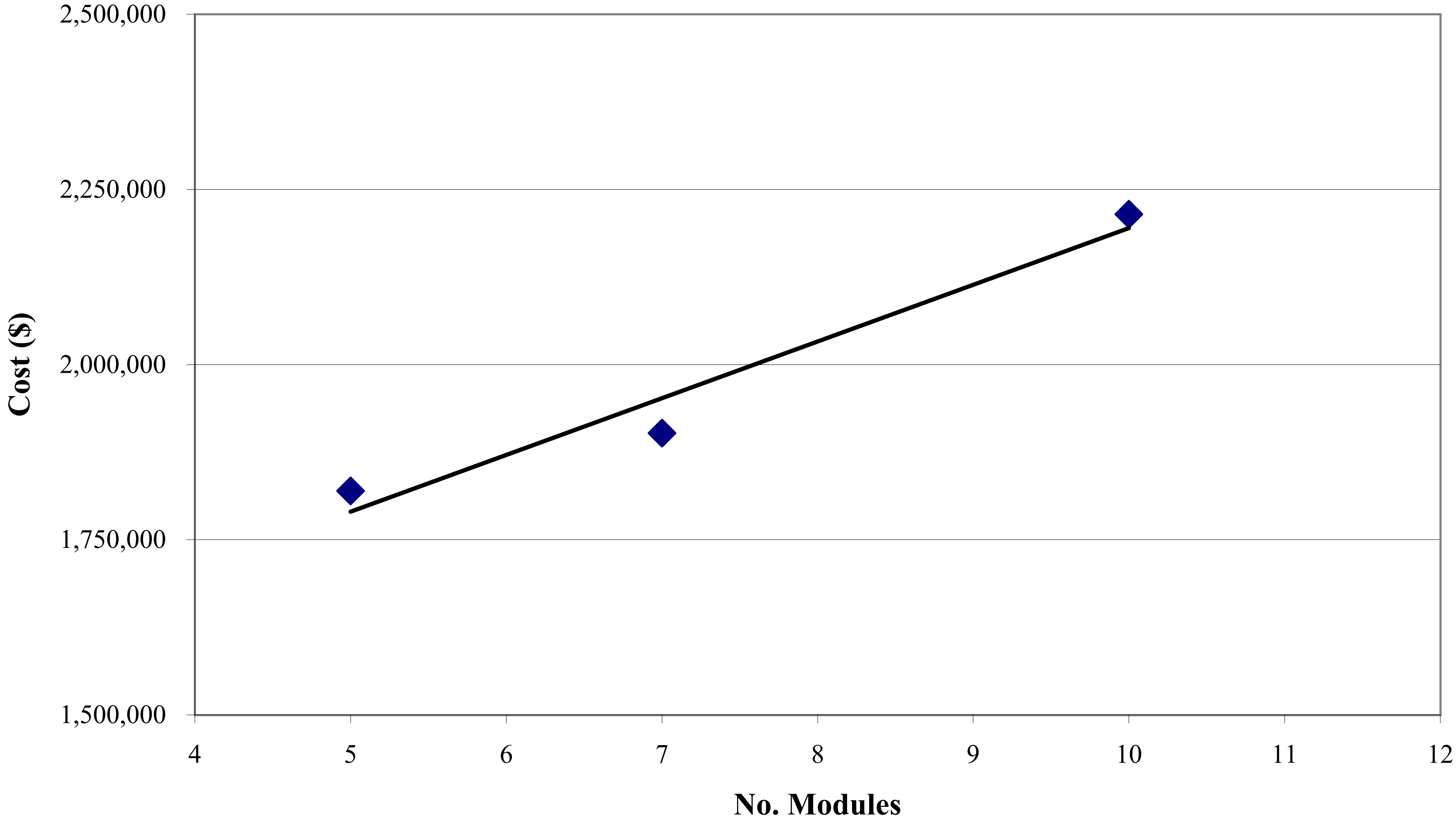


Figure 6.14 - Complete Removal Site Clearance and Verification

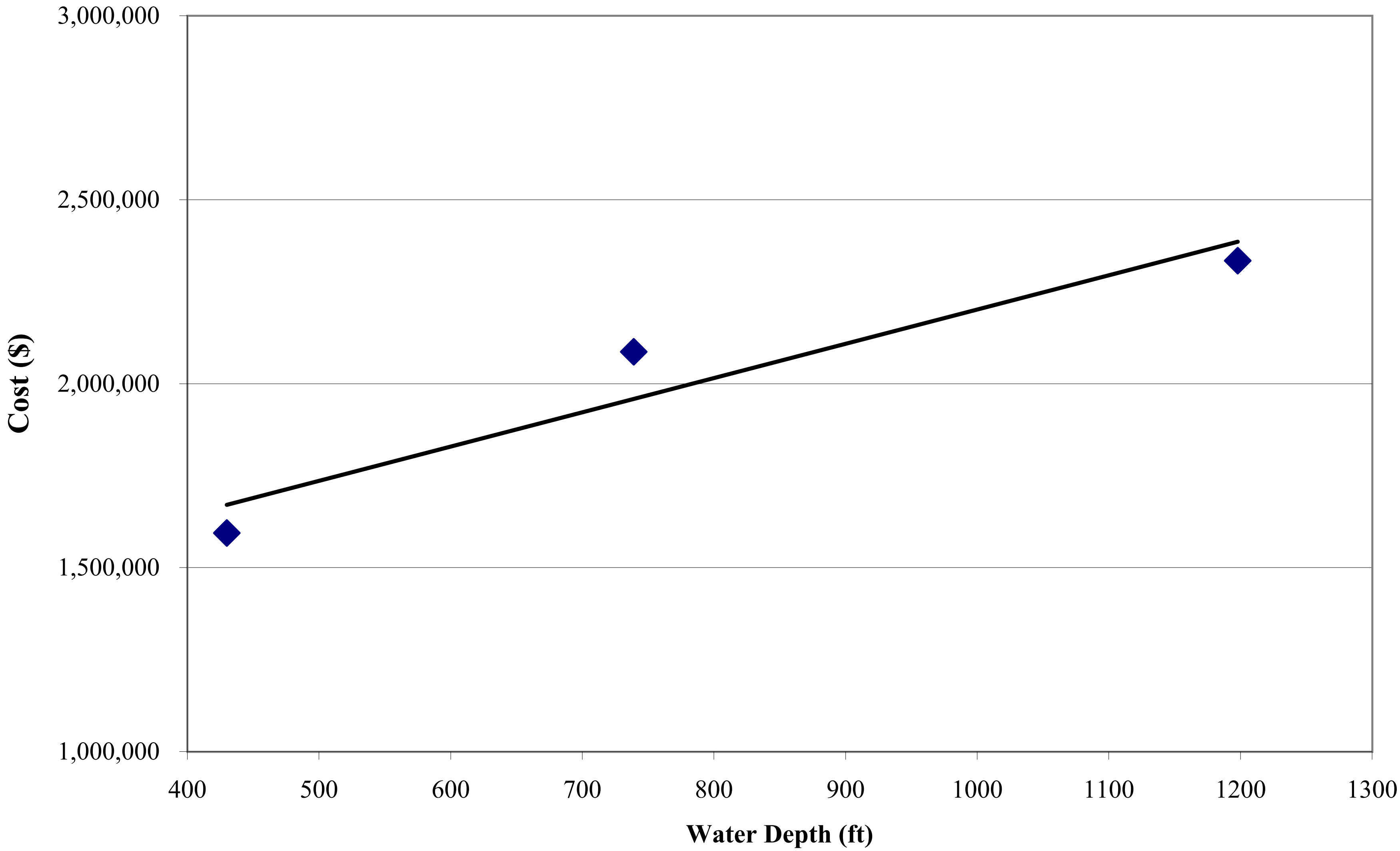
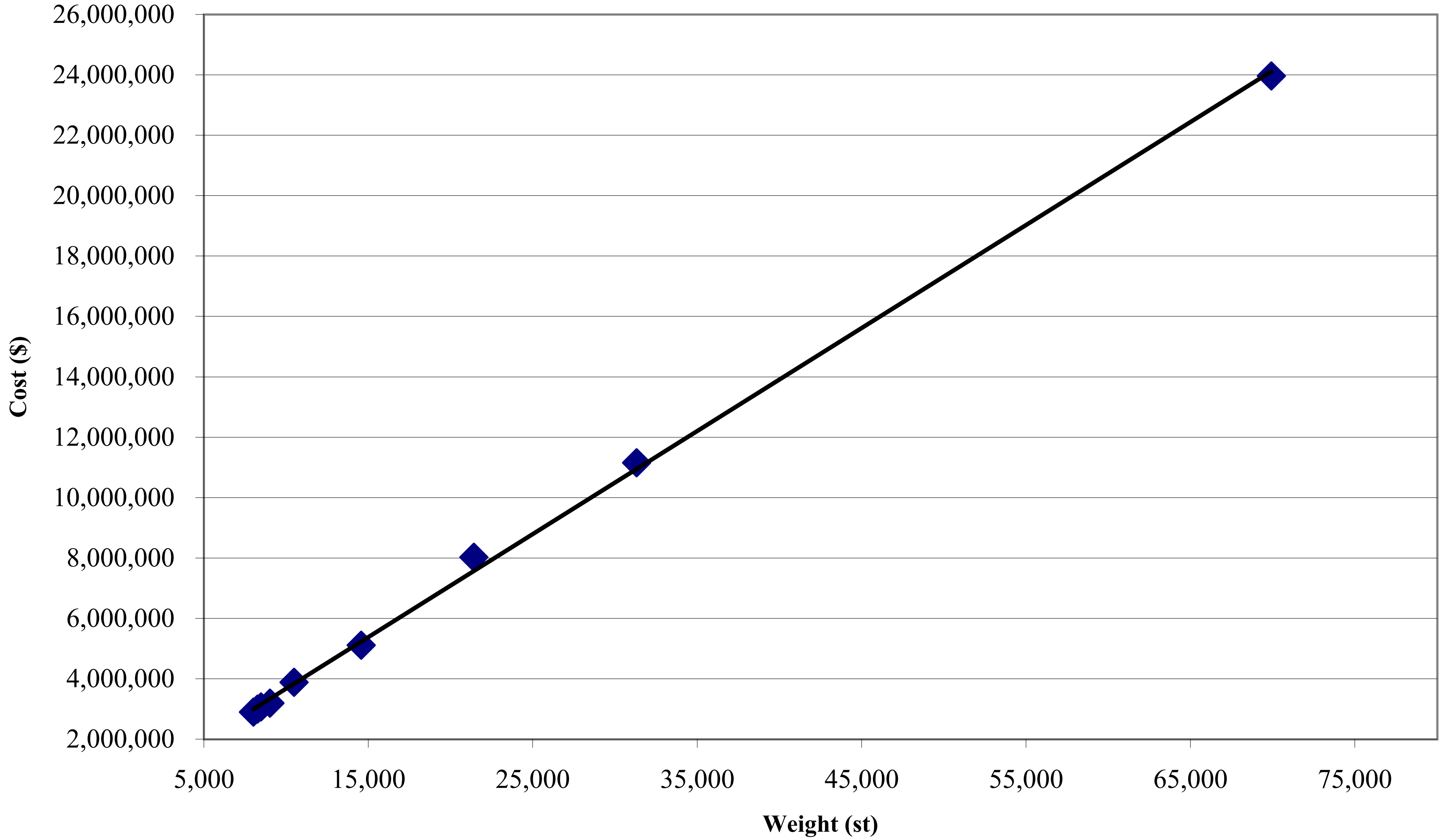


Figure 6.15 - Onshore Disposal Cost
(All Methods)



Section 7 – Decommissioning Issues

Introduction

This section presents the obstacles that may arise in decommissioning deepwater platforms. Carefully planning and managing the project can successfully accomplish these issues. However, there are instances that new methods and or technologies are needed to successfully accomplish the tasks. The decommissioning issues are presented by the cost components described in this report.

7.1 Platform Removal Preparation

Platform Removal Preparation is one of the first tasks in the decommissioning process. In planning for this phase, areas such as accommodations, air quality, and handling and disposing of cleaning fluids need to be addressed.

As simple as it may seem, accommodations may present logistical problems if the crews are not allowed to reside on the platform. Transporting crews from shore will require additional support vessels that will add to the total air emissions, schedule and ultimately cost.

POCSR operators should be aware that upon ceasing operations the air quality permits allowing platform operations also ceases. For this reason, all vessel purging and cleaning should be completed as part of the platforms current operations and thus permitted under the current air quality permit. GOMR operators currently do not face this air quality permitting restrictions.

The fluids and agents used to purge and clean the vessels must be disposed properly. Most are water based and non-toxic. The fluids can be safely disposed by pumping them downhole through an injection well. Another solution is to contain them in Coast Guard approved tanks, transport the tanks to shore and dispose of the fluids properly. The later will require additional planning in permitting and locating of a disposal site.

7.2 Conductor Removal

As stated in Section 3, it is recommended that the conductors are cut and removed prior to the Heavy Lift Vessel (HLV) arriving at the site. Cutting, pulling, removing and storing the conductor will require detailed planning. Most often the deepwater platforms will have may more conductors than shallower water platforms. The shear number, length, and sections to handle make this phase a challenge.

7.2.1 Cutting Conductor 15 Feet Below the Mudline

Cutting the conductors with explosives will cause the cut point to flare out which may impede pulling it through the conductor guides. If the flared section cannot go through the guide, an

ROV or a diver in a hard suit can cut it. Another solution is to use initially an abrasive or mechanical tools, inplace of explosives, to cut the conductors internally below the mudline. At this time, these tools have not been reliable and at time successful at shallow depths.

In addition, it is difficult to prove that the abrasive/mechanical cut was successful. When using explosives, the conductor drops as proof that it has been cut. This does not happen when using abrasive or mechanical cutting methods. To prove that it has been cut the conductors would have to be jacked up. The lack of proving a cut and untested depths makes an abrasive/mechanical cut secondary to an explosive cut.

7.2.2 Pulling, Cutting, and Storing the Conductor

The platform crane will not be able to lift the entire conductor. For this reason, the combination of the drilling rig and jacks are assumed in this study. The drilling rig can not be removed prior to completing this phase.

Once the conductor is pulled, it is cut in 40-ft sections until it is completely removed. The external cuts can be made with a cutting torch or an external cutting tool (diamond wire, abrasive or mechanical.) Selecting the best method will depend on its reliability and ease of use.

Having cut the conductor in many 40-ft sections, storing and removing the sections should be coordinated with the support vessel. The platform may not have enough area to store the large numbers of conductor sections. The platform crane can offload to the support vessel, which can then take cut sections to nearby yard for storage

7.3 Pipeline Abandonment

Pipeline abandonment issues for deepwater decommissioning are directly related to the size of the line and the depths in which they are installed. Most deepwater platforms will be several miles from the onshore processing facility. This results in a pipeline that has a relatively large volume to be cleaned.

7.3.1 Amount of Volume Pumped Through Each Line

The volume of water used to flush and purge the pipeline has to be disposed properly since it will have some hydrocarbons mixed with the flushing fluid. The fluids pushed through the line can be received at the terminating platform and processed. The separated product (water, gas, oil) can then be sent to shore. If the terminating platform can not process the fluids, they could be pushed to the onshore facility for processing. A less expensive solution is to pump the fluids downhole through one of the injection or non-producing wells. As a last option, the fluids can be stored in Department of Transportation approved tanks or in a storage barge. Once captured, the stored fluids can be taken to shore for proper processing and disposal.

Agencies that permit the pumping of fluids into non-producing wells include the MMS (for federal waters) and the California State Land Commission. *Note: there are no regulations as to* *the volume of fluids used. The amount used is based on the judgement of the operator with respect to achieving the desired result.*

7.3.2 Cutting and Plugging the Pipeline at Water Depths

The pipeline will be cut at each end and plugged. Due to the great depths, the conventional method of sending a diver to cut and plug the pipeline can not considered. The solution is an ROV or a hard suit equipped with a cutting tool. Once the pipeline end is cut the ROV can plug the line.

7.3.3 Removing the Pipeline

This study assumes that the pipelines can be left in-situ once they are flushed and plugged. There are several technical issues that may come up if removing the pipelines is required. The process would follow a reverse lay operation. The lay-barge will first recover the line and remove it in sections by walking its anchors through the whole length of the line. This process increases the likelihood of damaging the seabed with the barge anchors. In addition, the pipeline will have to be cleaned such that no hydrocarbons are present. Any residual product may be labeled as a "spill".

7.4 Topsides Removal – All Scenarios

Topside removal as discussed in Section 3 follows the installation process in reverse. The main issue in this phase is to make sure that the platform is ready for the HLV, i.e., the drilling rig is removed, modules are ready for removal, and that there are no fluids in the processing equipment.

7.5 Platform Removal – Complete Removal Scenario

From the initial rigging requirements through the cutting, handling, loading and disposing of the jacket sections, the whole jacket removal phase presents issues that must be carefully planned and managed.

7.5.1 Selecting Jacket Cut Points

Identifying where the jacket will be cut will drive the jacket removal method. The jacket sections will determine the tow route and the depths the jacket must be placed to make the horizontal cuts above the waterline. The size and number of cargo barges is dependent on the number and dimensions of the cut jacket section. In addition, the jacket has to be cut in such manner that the HLV (and ultimately the onshore yard) can handle. Jacket sections must also fit on the cargo barge and be sturdy enough to make the sea voyage.

7.5.2 Lifting the Jacket

The jacket will be rigged, lifted, and towed to shallow water for each horizontal cut. The HLV will have to rig to either pre-installed padeyes or use pile-gripping tools. Each lifting point will require a tool. A spreader frame can be used so that the HLV can handle the multiple tools with the crane. The spreader frame design would have to be adjustable since the jacket's horizontal elevations increase as it gets cut toward the bottom.

7.5.3 Moving and Setting the Jacket

The jacket will be towed to the pre-determined location that has the required water depth that will allow the section above water to be cut. Anchor mooring should be installed prior to commencing the decommissioning. In addition, the location selected should have the contour so that the jacket is level.

7.5.4 Cutting the Jacket

The method described in Section 3 assumes that the jacket is cut above water with welders. This increases the welder's risk by working them outside a fixed environment. At all times the HLV should be holding the jacket. This method is deemed far safer than cutting the jacket in-place. Cutting the jacket in-place will require the use of external cutting tools such as a diamond wire or an external abrasive cutter. In addition, the external cutting tools will have to be assisted by divers or remotely operated vehicles (ROVs).

The size and number of cargo barges is dependent on the number and dimensions of the cut jacket section. In addition, the jacket has to be cut in such manner that the HLV and ultimately onshore yard the can handle. Jacket sections must also fit on the cargo barge and be sturdy enough to make the sea voyage.

7.6 Platform Removal – Partial Removal

Identifying the jacket cut points is an important issue in planning the Partial Removal method. Selecting the optimum location will minimize diver's and cutting tool's onsite duration. The depth at which the jacket is cut should provide a minimum clearance of 85 feet to avoid placing a permanent lighted buoy as required by the U.S. Coast Guard.

Toppling forces for each section must calculated to confirm that the tugs selected have the capacity to topple the jacket. Another critical task is verifying that the cuts have been made. A diver or ROV should verify that each steel member is completely cut.

7.7 Platform Removal – Remote Reefing

Remote Reefing will require several engineering analyses to accomplish this phase. A weight and bouyancy take-off should be calculated to determine the actual weight (jacket, internal piles, grout, marine growth, etc.) and bouyancy. These calculations will show the needed bouyancy required and the placement of bouyancy bags or tanks to upend and tow the jacket.

Rigging and towing the jacket must also be planned since a HLV will not be used. Padeyes can be pre-welded to the jacket during the Platform Removal Preparation phase.

The tow route should be selected during the engineering review. A bottom survey of the selected tow route should be completed prior to removing the jacket. This survey will identify any obstructions on the sea floor. A new tow route can be selected if the obstruction will hinder the safe towing of the jacket to the designated reef location.

7.8 Site Clearance/Verification

No major obstacles were identified for this decommissioning phase. The Complete Removal method requires that the platform site and any location where the jacket is cut be cleared. Any trash that is retrieved from the sea floor will need to be properly disposed.

7.9 Onshore Disposal

Material disposal is the last critical task in the decommissioning process. The lack of local infrastructure in the West Coast requires that the deck and jackets be taken to the upper Northwest coast in Portland for disposal. Even then the large amounts of materials that will be brought to shore will be a challenge to the dismantling yard. Offloading and handling the cut jacket sections will at times be difficult due to the odd configuration.

Section 8 – Heavy Lift Technology

Introduction

The load weights associated with deepwater platform installations and removals limit the number of existing heavy lift vessels (HLVs) that can be used in these operations. Section 8.1 provides a review of conventional HLVs that can be used to decommission deepwater platforms like Hidalgo, Gail, and Harmony.

In addition to evaluating conventional HLVs (i.e., semi-submersibles), a review of alternative heavy lift vessels that are currently being developed is presented in Section 8.2. Included are brief descriptions of each of these technologies, and an assessment of the potential to apply them to the removal of deepwater platforms.

8.1 – Standard Heavy Lift Technologies

A limited selection of heavy lift vessels (HLVs) working around the world today can perform the tasks required for removing deepwater platforms. Table 8.1 presents a summary of the heavy lift vessels available that can perform the lifts required for the Hidalgo, Gail, and Harmony platforms.

The HLV(s) selected should have the capacity to lift the largest module and jacket sections. The heaviest module lift for the Hidalgo and Gail platform removals is on the Gail platform (1,790 ton dry lift weight). The heaviest module on the Harmony platform weighs 1,320 tons (dry lift weight). Additionally, if the jacket is to be removed in as large pieces as possible, the resulting jacket sections will weigh more than the heaviest module.

For the Complete Removal scenario, a Hermod- or Balder-type SSCV (**Figure 8.2**) was used to derive the decommissioning cost estimates for the Hidalgo and Gail platforms. The Thialf or the Siapem 7000 (**Figure 8.1**) was selected for the Harmony Complete Removal scenario.

The use of SSCVs to remove the platforms is not the only option. TSB evaluated the feasibility of removing the platforms using 2,000-ton capacity tugs in the Partial Removal and Remote Reefing alternative removal methods.

Any HLV considered will be required to be modified to meet local air emission requirements. This could be potentially very costly in that a catalytic converter may have to be adapted to each engine above 5 hp. Dynamically Positioned Vessels will most likely require more retrofitting than anchored vessels. These additional costs for DPV could discourage their use. Most vessels listed in Figure 8.1 through Figure 8.3 have DP capabilities but are typically anchored for decommissioning projects. This will be an issue in their certification.

Table 8.1 Heavy Lift Vessels Considered for Topsides/Jacket Removal

Operator	Vessel	Hull	Max. Lift (ST)
Heerema	Hermod	Semi	4000/ 5000
Heerema	Balder	Semi	3000/ 4000
McDermott	DB 101	Semi	3500
Heerema	Thialf	Semi	6600/ 6600
McDermott	DB 50	Mono Hull	4400
Saipem	Saipem 7000	Semi	7000/ 7000

8.2 – Alternative Heavy Lift Technologies

The following section offers a summarized review of alternative heavy-lift technologies currently being developed for offshore platform installations and removals.

8.2.1 Versatruss

Versatruss is a balanced, symmetrical, underside lift concept that makes use of a truss formation to lift a heavy load. In application, this system employs three readily available components:

- Standard cargo barges, which provide the lifting platforms
- Steel A frames, which provide the structural support
- Hydraulic winches, which supply the lifting force

Booms and the deck structure form the upper portion of the truss; the lower segment is created by Versatruss rigging and a tension cord inserted between the platform legs (**Figure 8.5**). This arrangement results in an extremely efficient distribution of load into the deck.

Once attached to the deck, synchronized winches are engaged, causing the barges to move together and shortening the lower span of the truss. When this happens, the booms rotate on their heel pins, increasing the boom angle and generating vertical lift. The process is fully reversible at any time, with lifting or set-down taking a relatively short period of time.

Because of the basic nature of this system, it can be designed to accommodate the largest topsides currently in existence.

Once lifted, topsides can be:

- Towed to shore (or to another location if re-installation is the goal) in a catamaran configuration
- Lowered onto a cargo barge
- Lowered onto a cargo barge and unhooked from the Versatruss system

The Versatruss system has been used successfully in several of topsides removal and installation projects. The largest of these lifts were the removal of a 1,225-ton deck from Amoco's Eugene

Island 367 platform in August 1997 and the installation of a 5,330 tonne topsides for Chevron in Lake Maracaibo, Venezuela, in September 2000.

During the Lake Maracaibo platform installation project, planned Versatruss applications included the transportation and installation of jackets and topsides for three platforms. Although the topsides installations proved successful, during the transportation of the Versatruss jacket installation system to Venezuela, the system tore itself apart and was lost (*Offshore Engineer*, Oct 2000).

Versatruss has been effective in increasingly larger topsides removal and installation applications, but, to date, has no proven solution for the removal and/or transportation of jackets.

8.2.1.1 Advantages

- Efficient – in principal, no upper limit to its capacity requirements
- By multi-sheaving the blocks, it is possible to minimize the winch and line-pull-load capacity
- Redundancy – multiple booms and multiple connection points allow for the loss of individual elements of the Versatruss system without a system failure
- Available – currently in use

8.2.1.2 Disadvantages

- System requires extensive operational support
- Jacket removal methods have proven ineffective in the field.
- No accommodations; need support vessel(s) to accommodate personnel
- Practical application of the technology to date has been limited
- Weather limitations in the hook-up stage

8.2.1.3 Conclusions

The Versatruss heavy lifting system is a proven, efficient method for removing and installing topsides. Multi-sheave blocks can minimize winch loads, and multiple booms and connection points give it redundancy not found in the other HLVs described in section 8.2. Additionally, there is no theoretical limit to the load capacity of this system. However, the Versatruss system is not will suited for removing jackets. The Kinematics of the system make it difficult to provide a jacket lifting capability that would be effective in practical applications that require lifting jackets out of the water. Therefore, for Complete Removals, another HLV will be needed. Nevertheless, the Partial Removal and Remote Reefing operations might significantly benefit from the use of the Versatruss system.

8.2.2 GM Heavy Lift

The GM Heavy Lift vessel (GMHL), developed by ProSafe and the engineering company Global Maritime Heavy Industries (GMHI) uses existing, proven technology in a new way. The design uses an existing semi-submersible with a U-shaped extension (**Figure 8.7**) that can remove a platform's topsides in a single lift. The extension is lowered below the bottom of the topsides by deballasting, positioned under the topsides and raised to a point where the topsides can be secured to the U-shaped extension. Once secured, the topsides is lifted off of the jacket and can then be moved to shore or set onto a cargo barge.

The GMHL is designed to lift loads up to 12,000 tonnes; the system itself displaces 40,100 tonnes

The GMHL does not have a self-contained propulsion system; it needs to be towed by tugboats. It offers multi-purpose capabilities, in that it can house crew and equipment for topsides removal preparations, offer a power supply for the crane and other removal equipment, and support remotely operated vehicle (ROV) operations. Additionally, the GMHL does not need to be anchored due to the inclusion of a dynamic positioning system.

8.2.2.1 Advantages

- Minimum offshore preparation work on topsides facilities
  - Single piece lifting
  - No cleaning and separation of process facilities
  - No re-installation of lift point sand rigging on each module
- High operability and flexibility
  - Single lift topsides removal up to 12,000 tonnes (approximately 13,225 short tons)
  - Attached to the semi-submersible support vessels, it can be used as a multi-service vessel (MSV) during preparatory phases
  - Provides sufficient support for power generation, crane assistance, ROV support, etc.
  - Has accommodations for necessary offshore personnel
  - Flat deck available for storage of temporary equipment, etc.
- Low cost
  - Based on using an existing accommodation combined with a lifting structure
  - No integration of the various systems, marine, load transfer, and accommodation
  - Residual value – can be used as an accommodation platform

8.2.2.2 Disadvantages

- Lifting vessel still needs to be selected (monohull or semi-submersible)
- Cost of converting new vessel presently undetermined
- Cost may be higher than use of a standard semi-submersible
- Method to connect to topsides is still being developed
- Jacket removal is limited by current design
  - Cannot lift deepwater platforms in one piece
- Weather limitations: Hs = 3.0 m; Vw = 12m/sec
- Operational period: 30 hours
  - Positioning phase: 14 hours
  - Load-transfer phase: 12 hours
  - Final lift-off phase: 4 hours
- Maneuverability
  - Must be assisted by 1 to 2 tugs
- Onshore yard may not be capable of handling all the modules at one time.

8.2.2.3 Conclusions

The GMHL is a good alternative to removing the topsides in one lift. However, preparation costs will increase if the GMHL is used as an MSV to prepare the platform removal. Also, upon loading the topsides, the GMHL would have to offload them either onto a cargo barge or at the onshore dismantling yard.

The GMHL may not be as efficient as an SSCV when moving the jacket or handling the jacket and the cut sections. There exists the possibility that the GMHL may be competitive when complete removal in-situ is required. However, the daily spread rate will have to be significantly lower than a SSCV's day rate if the GMHL is to be considered a viable alternative HLV.

8.2.3 Pieter Schelte

The Pieter Schelte (**Figure 8.8**), designed by Excalibur Engineering, BV, is a platform removal and installation vessel formed by joining two large tankers together to form a stable platform. Topsides and jackets can be removed in discrete single lifts and transported to shore or to another location.

The design of the HLV ties together two large tankers at the stern, leaving the bow open to accept extremely large topsides. The vessel deballasts itself below the deck, raises (ballasts) to a point where the jacket can be secured to the vessel, and further ballasts to raise the topsides off the jacket.

The rear of the vessel includes a lifting arm that is raised above the jacket (once the topsides is removed and the piles have been severed). Once in position, rigging is lowered and attached to the top of the jacket, secured, and the jacket is raised to a point where it can be pulled over onto the jacket storage section of the Pieter Schelte. The vessel then moves to shore or to another offshore location for offloading and disposal or re-installation.

This Pieter Schelte can be used for decommissioning operations by lifting topsides up to 48,000 tonnes (approximately 53,000 short tons) and removing jackets up to 25,000 tonnes (approximately 28,000 short tons).

Surveys of short-listed tankers are currently underway. Once these tankers are selected, detailed vessel engineering will commence. The lift system conceptual engineering is currently being completed; detailed engineering will commence in late summer 2000. Per the current design and construction schedule, this system will be completed and operational by the 2003 North Sea summer season.

8.2.3.1 Advantages

- Minimum offshore preparation work on topsides facilities
  - Single piece lifting
  - No cleaning and separation of process facilities
  - No re-installation of lift point sand rigging on each module
- Minimum subsea cutting operations

  - Single-piece jacket removal up to 150 m
- Maximum safety to personnel
  - Very limited human activities offshore
- Maximum protection of the environment
  - Handling of hazardous materials only within the onshore dismantling yard
- Possible reuse of topsides and jackets

8.2.3.2 Disadvantages

- May have high maintenance costs
- May have higher day rate than other alternatives discussed in Section 8.2
- Jacket removal limited by lifting arm design (jacket complete removal in a single piece may be not be practical

8.2.3.3 Conclusions

The Pieter Schelte heavy lift vessel offers a good alternative to lifting the topsides in one unit. Unlike the HLV alternatives described to this point, the Pieter Schelte does not have to offload the topsides before lifting the first jacket section. Additionally, jacket cut sections could be skidded to the back of the vessel, allowing it to lift the remaining jacket portion to be immediately towed to shallow water to repeat the jacket removal process.

However, the Pieter Schelte may be a very expensive HLV to fabricate and maintain, and its day rate may potentially be higher than that of standard HLVs.

8.2.4 Marine Shuttle

The Marine Shuttle (**Figure 8.9**), designed by Marine Shuttle Operations, Inc. (MSO), is a steel hull U-shaped vessel designed for the transportation, installation, and removal of large offshore structures weighing up to 22,000 tons (using the ballast system). The structure comprises sections of tubulars 10 meters in diameter; tied directly to ballast tanks and ballast pumps. Water is pumped in during ballast operations and dumped for deballasting. This structure is unmanned and is not self-powered.

Topsides removal is completed by deballasting the Marine Shuttle along a flat plane corresponding to the water surface, and then maneuvering the structure to a position directly below the topsides. The Marine Shuttle is then ballasted (raised) to a point where it can be attached to the topsides. Once connected, the topsides can be towed to shore or offloaded onto a cargo barge.

Jacket removal techniques use the Marine Shuttle in a slightly different way. The open portion of the U-shaped is deballasted to tip over (dive) below the waterline. The structure is then positioned over the top portion of the jacket and attached to the jacket legs. Piles are severed either from the sea floor (depending on jacket size) or at the required water depth depending on which removal alternative is selected. The Marine Shuttle is then ballasted (raised), carrying the jacket (or the top jacket section) with it. The jacket (or jacket section) is then towed to shore.

The Marine Shuttle can be used during decommissioning operations by lifting topsides and jackets up to 22,000 tons.

The Marine Shuttle is expected to be ready by 2002/2003, depending on driving market factors.

8.2.4.1 Advantages

- Minimum offshore preparation work on topsides facilities
  - Single piece lifting
  - No cleaning and separation of process facilities
  - No re-installation of lift point sand rigging on each module
- Lifting capacity of up to 22,000 tons
- Lift large units in one piece, reducing time, cost, and risk
- Makes reuse a more likely alternative
- MSO expects 1 year to complete a job, including 4 weeks of offshore work
- Lower maintenance cost (efficient design)
- Designed for harsher weather conditions and wave heights
- Good reception by major oil companies (i.e., Phillips, BP, Shell, Elf)
- Designed to remove jackets up to 150 meters

8.2.4.2 Disadvantages

- Cannot remove deepwater jackets in one lift
- Must offload topsides before continuing work on jacket
- May not easily move and handle jacket pieces
- No accommodations; need support vessel(s) to accommodate personnel

8.2.4.3 Conclusion

The Marine Shuttle heavy lift vessel offers a good alternative to lifting the topsides in one unit. However, it will have to offload the topsides either on to a cargo barge or onshore before it can continue working on removing the jacket.

For jacket removal operations, the Marine Shuttle must dive to attach to the jacket and rise to the surface for transport or offloading. In that deepwater platforms have jackets that exceed the Marine Shuttle's maximum load capacity, this process of deballasting and ballasting will have to be repeated multiple times for complete jacket removals. Therefore, moving and handling the jacket sections with the Marine Shuttle may not be as efficient as standard jacket removal techniques using SSCVs.

8.2.5 MPU Heavy Lifter

The MPU Heavy Lifter (**Figure 8.10**), built by MPU Enterprise, AS, is a U-shaped concrete hull unit with 4 columns, 2 hydraulic-operated truss-type steel lifting frames with a large underwater body and a small water plane area. The MPU has no propulsion system; therefore, it needs to be towed by tugboats. Travel speed is approximately 3-4 knots.

The MPU has been developed for the removal of topsides and jacket structures using single-lift technology (lifting by ballasting/deballasting the vessel). The MPU is currently in Phase 3 of its development. Phase 2 results show that the system is feasible and well suited for topsides and jacket removal.

The cost to fabricate the MPU (including engineering) is currently estimated at $70 million. The fabrication time for this vessel has been determined to be 14 months (start to finish). Based on an October 25, 1999 press release, MPU construction is scheduled to begin in summer 2000.

8.2.5.1 Advantages

- Minimum offshore preparation work on topsides facilities
  - Single piece lifting
  - No cleaning and separation of process facilities
  - No re-installation of lift point sand rigging on each module
- Multi-purpose (decommissioning, installation, reuse, storage and production)
  - Single lift- up to 12,000 tonnes (approximately 13,225 short tons)
  - Hull capacity up to 40,000 tonnes (approximately 44,100 short tons)
- Lower fabrication cost and operations cost
  - Developers estimate the cost for removal and transport of a 12,000 topsides at approximately 38 million NOK based on 1999 rates
  - Shorter fabrication schedule (14 months)
  - Vessel unmanned during transit and transfers
  - Concrete hull makes the MPU insensitive to fatigue and requires no maintenance, thereby ensuring a long life for the vessel and reduces operational costs

8.2.5.2 Disadvantages

- Lifting capacity due to deballasting the hull depends on the freeboard of the vessel during lifting and the center of gravity (CG) of the unit to be lifted
- The shape and dimensions of the MPU vessel are based on a survey of existing jackets and topsides installed in the North Sea- weight and size of jacket and topsides are the main parameters for sizing the MPU
- Jacket removal is limited by current design
- No accommodations; need support vessel(s) to accommodate personnel

8.2.5.3 Conclusions

The MPU heavy lift vessel offers a good alternative to lifting the topsides in one unit. However, it will have to offload the topsides either on to a cargo barge or onshore before it can continue working on removing the jacket.

The MPU Heavy lift vessel current design parameters are based on North Sea platform designs. The deepwater platforms considered in this study are installed in water depths up to three times as deep as in the North Sea. Moving and handling the jacket sections with the MPU may not be as efficient as standard jacket removal techniques using SSCVs.

8.2.6 John Gibson Strand Jacks

John Gibson Projects Limited (JGP) offers a range of standard strand jacks (**Figure 8.11**) that can extend the lifting/lowering capacity of one or all of the aforementioned alternative HLVs to 300 meters and beyond. This technology has proven extremely effective in tension-bridge construction projects, and is now being applied to offshore platform installations and removals.

The John Gibson Strand Jacks (JGSJs) include: a range of seven standard strand jacks (safe working capacities from 30 to 750 tonnes per jack); self-contained, diesel-driven power packs; cable handling and storage systems; and central control and monitoring capabilities.

Conceptually, JGSJs would be used in conjunction with either the Marine Shuttle, the MPU, the GM Heavy Lift vessel, or the Pieter Schelte. These vessels can provide the platform by which the JGSJs are set. JGSJs could potentially enhance the jacket removal capabilities of any or all of these systems.

8.2.6.1 Advantages

- Technology proven in the construction of tension bridges
- Can be used in conjunction with a number of alternative heavy lift vessels (i.e., GM, MPU, Pieter Schelte) to improve their jacket lifting capabilities

8.2.6.2 Disadvantages

- Technology not yet applied to the alternative HLVs listed

8.2.6.3 Conclusions

John Gibson Strand Jacks might allow many of the alternative HLVs described in Section 8.2 to overcome many of their jacket removal limitations. JGSJs are proven to be reliable, but more investigations are required as to how these units can be used efficiently for deepwater platform removal operations.

8.2.7 Buoyancy Devices

8.2.7.1 Buoyancy Bags

Buoyancy bags, manufactured by companies like Seaflex Ltd., are inflatable subsea buoyancy systems that can be attached to jacket members, conductors or pipelines. Once attached and inflated, these units can lift sections (or, in the case of jackets, potentially the entire structure) to the surface. The bags are offered in either open-bottom or fully enclosed configurations. These units can be connected to piles or conductors by using divers or remotely operated vehicles (ROVs).

These units have proven to be a successful lifting alternative in North Sea pipeline removal and maintenance operations. Current stock exceeds 3,000 tonnes lift capacity.

Buoyancy bags are inexpensive to fabricate and maintain. However, inclimate weather conditions can create lifting variables that could potentially create difficulties for the jacket-handling vessels in raising the jacket. Movement created by underwater currents or uneven air expansion inside the bags could make it difficult to ensure that the jacket does not surface directly underneath the buoyancy bag-handling vessel or another on site vessel.

8.2.7.2 Controlled Variable Buoyancy System (CVBS)

The Controlled Variable Buoyancy System (CVBS) is a patented concept being developed to provide an innovative and cost effective means of offshore structure removal. It does this by providing buoyancy that is attached to strategic points on the structure. The magnitude of buoyant lift can be closely controlled throughout all stages of the removal operation.

The CVBS consists of groups of buoyancy chambers, clamps, inflatable air bags, pipework, valves, and a sophisticated control system. A group of chambers equipped with clamps, local controls and piping systems is referred to as an Intelligent Buoyancy Unit (IBU).

An Intelligent Buoyancy Unit consists of 4 no. 2.5m OD, 16m long shells (**Figure 8.12)**. Three of the shells are perforated with a number of holes to allow water to flood freely in and out of the shell, and one of the shells is solid. The perforated shells have a domed end at the top fitted with an insert suitable for bolting on pipework and valving.

The main body of the GRP shell is 20mm thick and the domed ends are 40mm thick. The shell will be filament wound with continuous glass fiber reinforcement.

The GRP shells are held in position and connected to the jacket leg via 2 friction clamps, which are hinged to assist in the installation procedure. A steel band is fixed around the GRP shell and is then connected into the main body of the clamp by means of stiffener plates. Each clamp has stud bolts that lock into position on closure. With the clamp closed, using a hydraulic cylinder, a work-class ROV will torque each of the studs thus securely fixing the unit to the leg.

The Control System (**Figure 8.12**) consists of the following:

- **Master Control System (MCS)** – The Master Control System is located remotely onboard the Multi- Purpose Support Vessel (MSV) or Diving Support Vessel (DSV) and communicates with the Master Control Module via a radio telemetry link.
- **Master Control Module (MCM)** - The unit is located on the structure to be moved. It is PLC based and is connected to each of the IBU units. This allows the Master Control Module to control the IBU unit Inputs and Outputs, valve operations, reading pressure values, and valve operation status information.
- **Intelligent Buoyancy Unit (IBU)** Control Pods – These pods contain all the electronics necessary to control valve operations and to read back data from pressure transducers.

A trial lift using one GRP buoyancy tank to lift some 70 tonnes from the seabed in 50 m of water in Scotland will be undertaken during November 2000. The trial will incorporate the full control system, which will be tested during the trial operation.

8.2.7.3 Advantages

- Potentially inexpensive lifting alternative – no need for HLVs to remain on site after topsides are removed.
- Environmentally friendly

8.2.7.4 Disadvantages

- Technology not yet proven to work in platform decommissioning
- Uncertainties exist regarding jacket surfacing logistics
- Maximum lifting weights limit the size of the jacket (or jacket section) that can be lifted (depending on size/number of bags or CVBSs used)

8.2.7.5 Conclusions

Buoyancy bags provide an efficient alternative lifting systems for pipelines, but the system is yet to be proven to be able to lift items (i.e., jackets and/or jacket sections) of any considerable size.

While the Controlled Variable Buoyancy System (CBVS) might be able to overcome some of the challenges presented by buoyancy bags (i.e., better control over the lift), this technology has yet to be proven in field tests. Accordingly, these buoyancy devices are not considered feasible alternative lifting technology for this study.

8.3 Conclusions

Many of the alternative heavy-lift technologies reviewed may someday prove to be safer, more cost-effective ways to remove topsides and jackets. The designed load capacities for many of these systems are more than adequate for the topsides associated with deepwater platforms. However, deepwater jacket removal tends to be problematic for all alternatives reviewed (not considering the possibility of incorporating John Gibson Strand Jacks into the design of these vessels).

Only the Versatruss deck-lifting system has been used successfully for offshore platform removal operations; the other systems are in various stages of development and testing. Additionally, the idea of considering any of these systems as the primary option for removing the Hidalgo, Gail, and Harmony platforms could potentially create scheduling problems if the systems are not ready by the time these platforms are ready to be decommissioned.

As a result, the standard, proven heavy lift vessels included in Section 8.1 are the most reliable heavy lift options currently available and have been used to develop the cost estimates included in this study.

Figure 8.1 - Siapem 7000 and Thialf Semi-Submersible Crane Vessels

Figure 8.2 - Hermod and Balder Semi-submersible Crane Vessels

Figure 8.3 - DB 50 and Hercules Derrick Barges

Figure 8.4 - Alternative Heavy Lift Vessels Availability Timeline

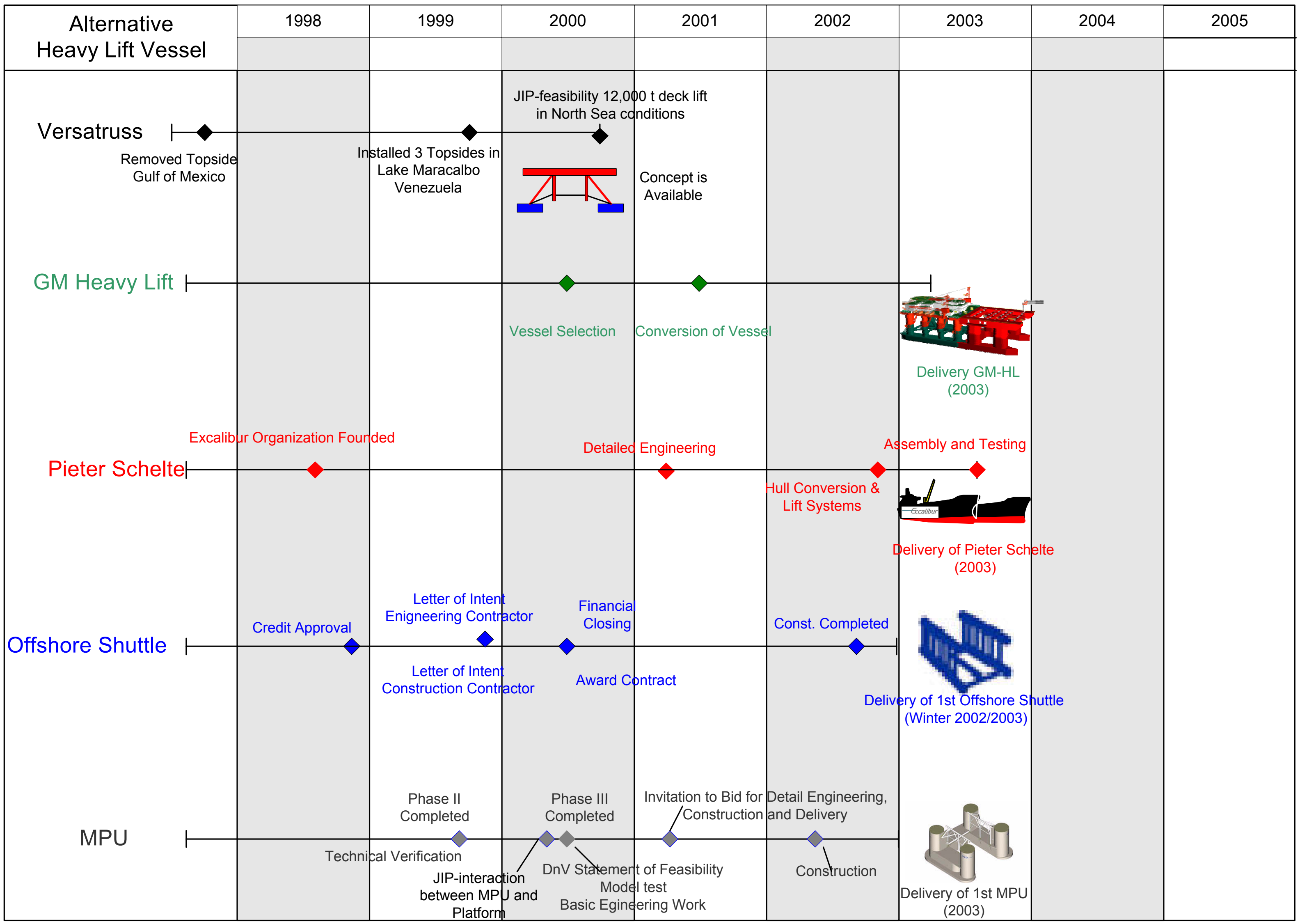


Figure 8.5- Versatruss Deck Lifting System

• Cargo Barge Dimensions (LxW):	Based on Job (180 ft x 54 ft)
• A Frame(s)	Designed for specific lift
• Topsides/Jacket Lifting Capacity:	20,000 T

Figure 8.6- Versatruss Jacket Lifting System

- **Cargo Barge Dimensions (LxW):** **Based on Job (180 ft x 54 ft)**
- **A Frame(s)** **Designed for specific lift**
- **Topsides/Jacket Lifting Capacity:** **20,000 T**

Figure 8.7 GM Heavy Lift

• **Dimensions (LxWxD):**	**223 ft x 221 ft x 120 ft**
• **Draught:**	**63.15 ft**
• **Displacement:**	**40,100 mT**
• **Topsides Lifting Capacity:**	**12,000 mT**

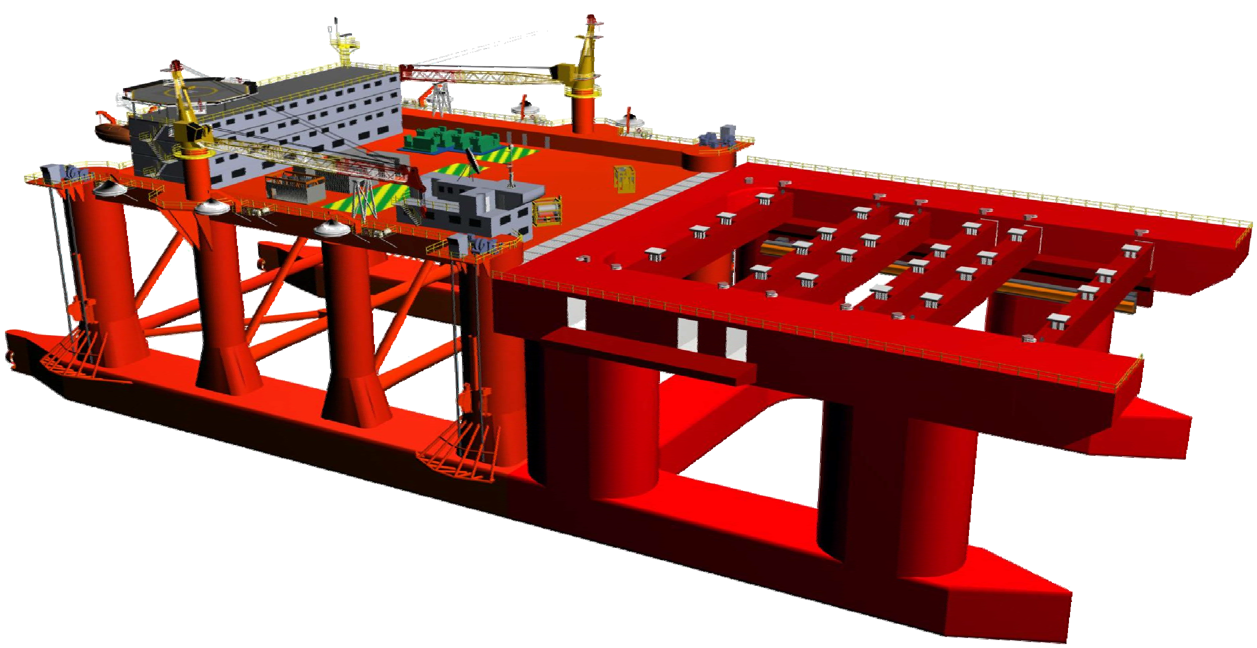


Figure 8.8- Pieter Schelte

- **Dimensions (LxWxD):** **1100 ft x 387 ft x 94 ft**
- **Displacement:** **600,000 mT**
- **Topsides/Jacket Lifting Capacity:** **48,000/25,000 mT**

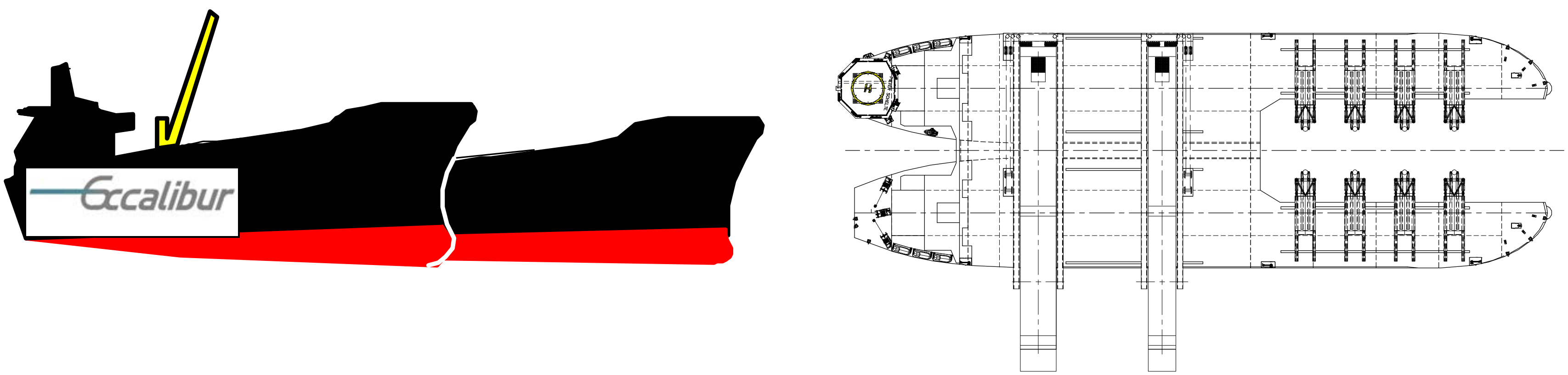


Figure 8.9- Marine Shuttle

- **Dimensions (LxBxD):** **480 ft x 280 ft x 200 ft**
- **Draught:** **36 ft**
- **Displacement:** **20,555 mT**
- **Topsides/Jacket Lifting Capacity:** **22,000/10,000 mT**

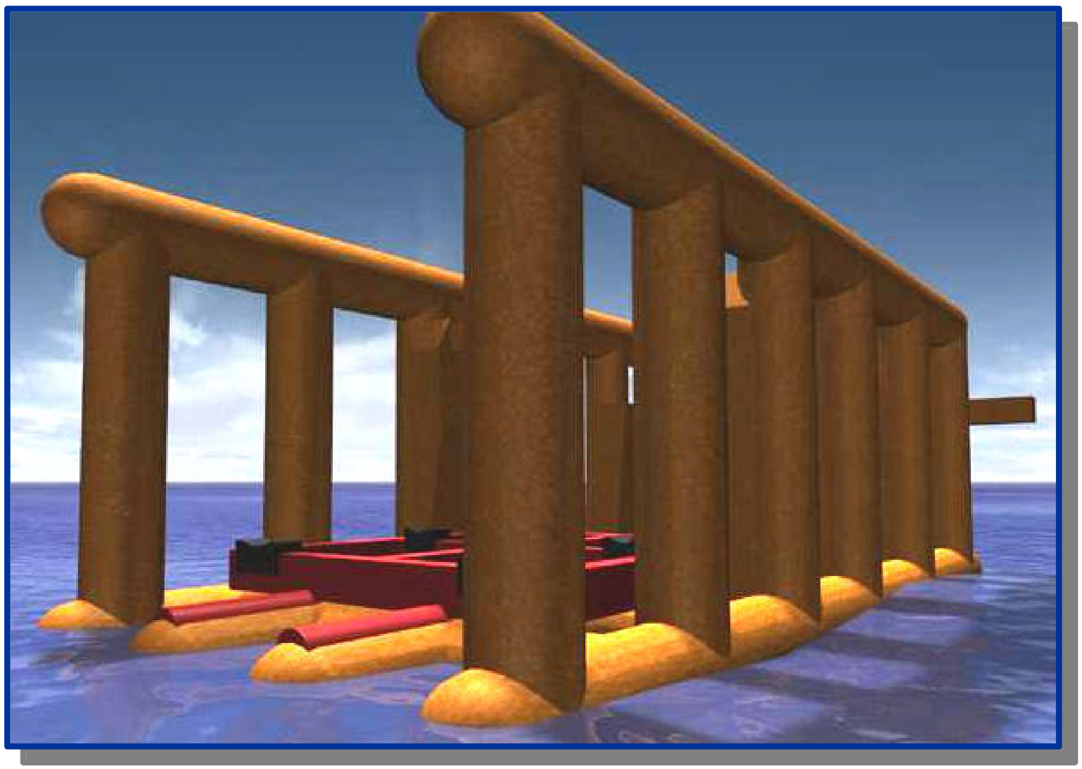


Figure 8.10- MPU Heavy Lifter

- **Dimensions (LxWxH):** **285 ft x 315 ft x 130 ft**
- **Draught:** **27.5 ft**
- **Displacement:** **38,000 mT**
- **Topsides Lifting Capacity:** **12,000 mT**

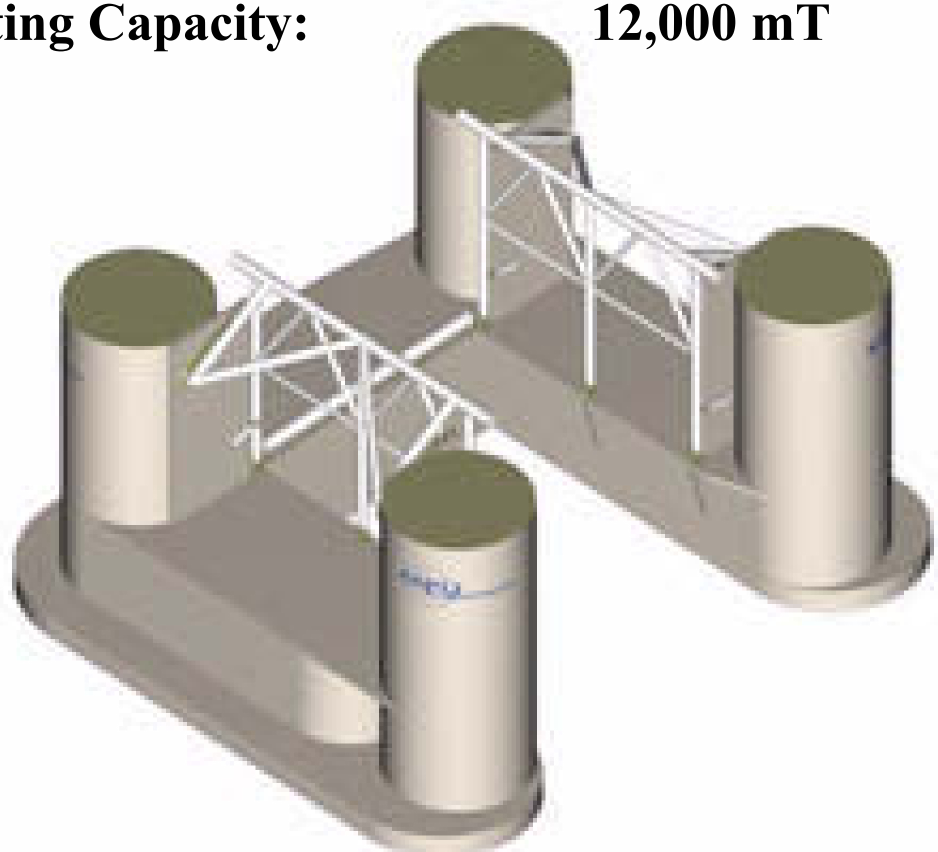
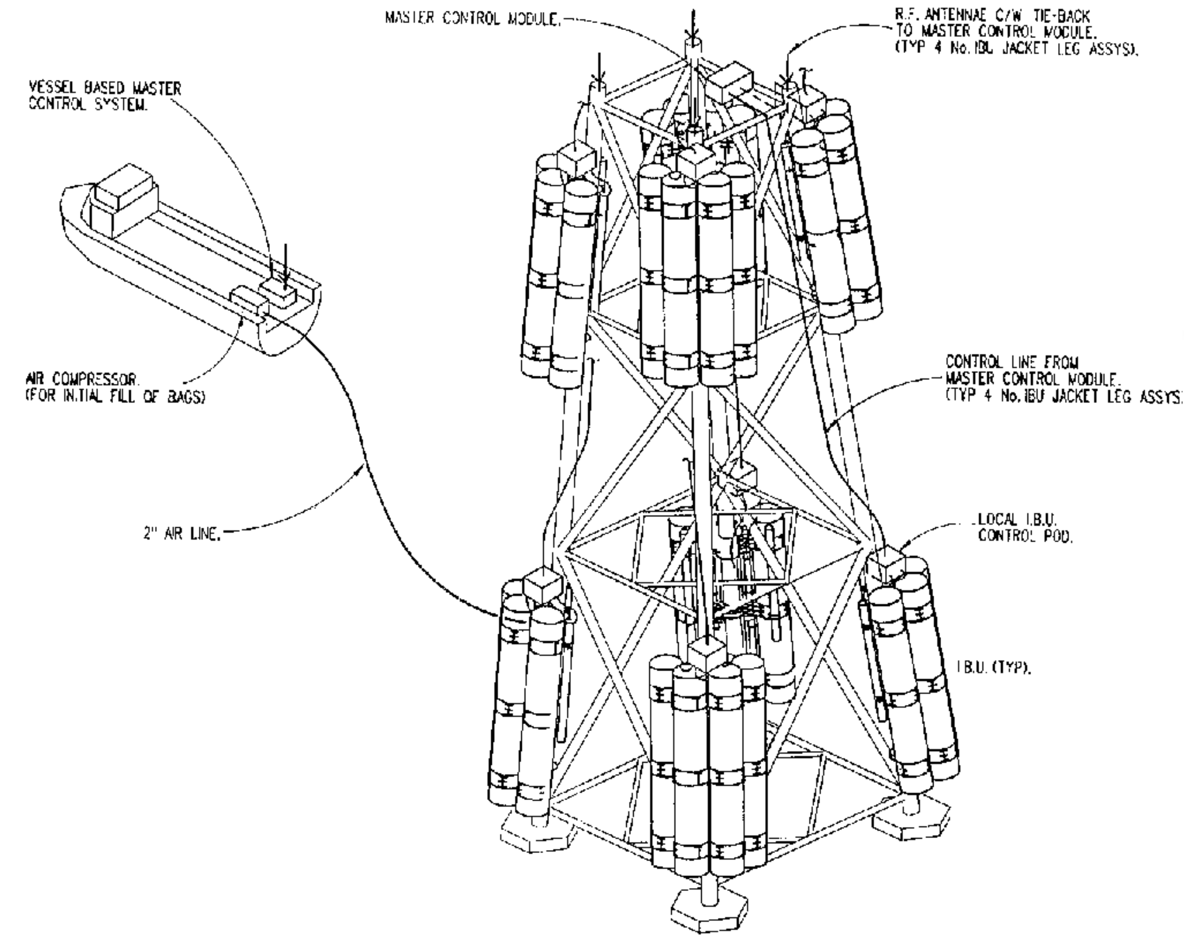
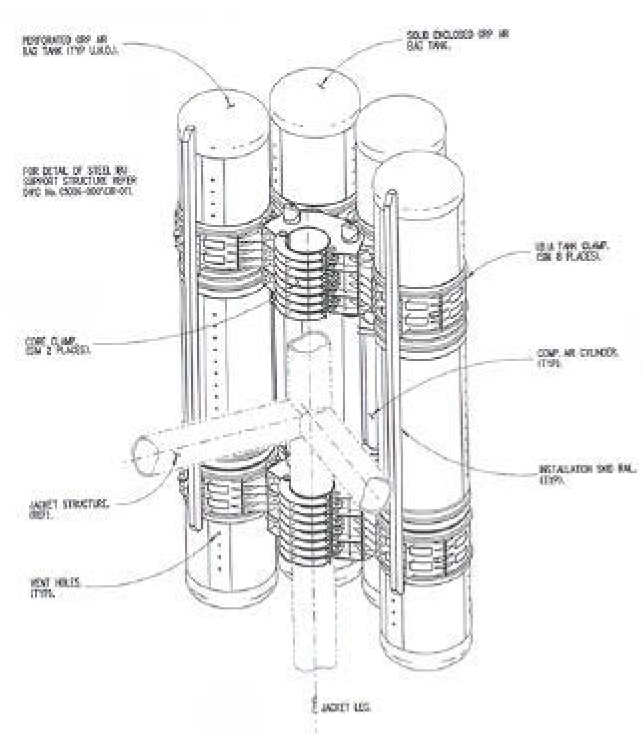


Figure 8.11- John Gibson Strand Jacks

Figure 8.12- Control Variable Bouyancy System (CVBS)





Section 9 – Severing Technology

Introduction

This section reviews the different cutting methodologies considered in this study. TSB reviewed cutting techniques considered effective and applicable to offshore platform decommissioning. For any cutting technique to be effective, it must be:

- Safe
- Reliable
- Repeatable
- Flexible and adaptable under field conditions
- Environmentally sensitive
- Economical

The cutting techniques considered are grouped into two general categories: explosive and non-explosive. Available explosive methods are bulk charges, configured bulk charges, and shaped charges. Current non-explosive methods applicable to this study include diamond wire, mechanical cutters, and abrasive slurry cutters.

9.1 Explosive Methods

The following section is a summary of the report provided by DEMEX. The complete report is provided in the Appendix of this report.

9.1.1 Introduction

Using explosives to remove large platforms in deepwater will certainly be a reality within the near future. In fact, the removal of deepwater subsea structures has already begun. One such example is the removal of the Garden Banks 387 subsea template this year. This Gulf of Mexico structure, located in over 2,000 feet of water, incorporated several innovated approaches to using explosives in extreme water depths. These approaches involved the use of remotely operated vehicles (ROVs), dynamically positioned vessels, wire line units, and detonation of multiple charges with delays.

When discussing the use of explosives relative to deepwater platforms, a primary consideration is the final disposition of the platform. Present options for the disposal of these deepwater platforms include total removal, partial removal, remote reefing, or reuse of the structure [option deemed not applicable to this study]. Additionally, the equipment used to perform the removal dictates explosive usage options. These operational considerations should be established before a specific course of action involving explosives is finalized. Government restrictions involving explosive usage offshore must also be addressed before final operating procedures are established.

The Gulf of Mexico has been the proving ground for platform removals. During the years between 1986 and 1999, approximately 1,414 structures were removed; approximately 66% of these removal operations used explosives.

Explosives are widely used to decommission platforms because they are safe, reliable, and cost effective. The use of explosives reduces the amount of time divers are used during the cutting process, thereby minimizing human risk. Their reliability has been established by the fact that they have been successfully employed to remove over 930 platforms in the Gulf of Mexico to date. Additionally, the cost of severing piles and conductors is generally less than 1% of the total platform removal cost. Time is the driving cost factor when discussing severance; delays in vessel spreads are the primary reason for cost overruns. A failure in the complete severance of a pile or conductor is usually charged to the owner of the platform. These costs can be enormous, as time and material rates for large crane vessels can exceed $500,000 dollars per day.

9.1.2 Explosive Charge Types

9.1.2.1 Bulk Charges

Bulk charges (**Figure 9.1**) are a single mass of explosive material detonated at a single point. The energy release from this type of charge is not well directed. Rather, bulk charges rely on the "brute strength" of the explosive to overcome the target material by a shattering and tearing effect.

Bulk charges are cylindrical in design. These charges vary in length and diameter to achieve the best fit for a wide range of typical offshore tubulars. Charge diameters range in size from 4" to 12".

Smaller bulk charges can be arranged to create a larger diameter (**Figures 9.2 – 9.3**). This technique allows the technician to configure the cast explosive material for whatever conditions may arise. For instance, in some cases it might be advisable to use smaller charges in a circular ring configuration to maximize the explosive concentration and proximity to the target material as shown.

9.1.2.2 Double-Detonation Bulk Charges

The use of a double-detonation bulk charge creates more "cutting power" pound-for-pound than an ordinary bulk charge. Double detonating the bulk charge is accomplished by using instant non-electric detonators at opposite ends of the charge. This detonation creates a confluence of energy at the center of the charge, which is dissipated radially outward directly perpendicular into the target material. It is this directing of explosive energy that makes double-detonating bulk charges more effective.

9.1.2.3 Shock Wave Enhancement/Focusing Devices

The shock wave enhancement/focusing (SWED) device combines the best features of the above charges with the added benefit of extreme confinement to concentrate all of the explosive energy on the target material. Using increased confinement, multiple-point detonation, and the actual water inside of the tubular to direct energy; this device is the most reliable bulk explosive severance device available to date.

9.1.2.4 Tamping

The energy released by a bulk charge can be enhanced by the use of tamping or confinement. A bulk charge is used with a metal and/or concrete plug above the charge. The addition of this tamping increases the duration of the impulse that is released by the explosive towards the target material.

9.1.2.5 Shaped Charges

The most effective use of explosives for severing is the shaped charge (**Figure 9.4**). The shaped charge uses the energy produced by the detonation to drive a liner at high velocity at the target. The liner striking it at this accelerated velocity then cuts the target.

While the quantity of explosives required to do the cutting can be reduced, shaped charges have a multitude of manufacturing and design criteria that can drastically affect performance. The design criterion for shaped charges also requires knowledge of target specifications. Manufacturing of shaped charges can take weeks and can cost five times as much as conventional bulk charges.

The various types of shaped charges are listed below.

Rotationally Symmetric (Conical)

This type of charge produces the greatest penetration of all shaped charges due to the 360 degrees of radial convergence forming the jet. Variation in the conical liner angle will result in varying properties of the jet. A small angle will produce a very small, deeply penetrating jet, while a large angle will produce a larger hole with shallower penetration.

Linear Charge

A *running* linear charge is a roof-shaped liner of a given length used to cut plates or sheets of metals or other materials. The horizontal velocity of the detonation contributes to penetrating effectiveness. It normally comes sheathed in lead in a coil form. Its length is limitless.

A simple cutting charge (or *non-running* linear charge) has a roof-shaped liner two- to three-times the liner width. The horizontal detonation velocity decreases the cutting effectiveness in this configuration. This charge would have much more explosive above the liner for the increased power required to cut and to provide a more uniform (flat) detonation wave into the liner.

Planar Symmetric Conical Charge

A regular rotationally symmetric shaped charge may be modified to cut in a linear fashion with the addition of massive confinement. The two opposite sides parallel to the central axis have 90 degrees of heavy steel plating affixed to the outside of the charge. This results in uneven collapse of the liner and a fan shape jet toward the target, producing a slit instead of a round hole.

Self-Forging Fragment Charge

This type of shaped charge uses a high-tensile liner and an extremely large cone angle. In this charge, the angle is so great that there is no jet formation and the entire liner is turned into a projectile. These charges are more effective on soft targets (such as earth) and are not often employed in metal cutting operations.

Radial Shaped Charge

Information to be provided by DEMEX (Stingray Program 1997 – 2000)

9.1.3 Deepwater Issues

Explosives have been used in deepwater in a variety of applications. Primarily, the work conducted relative to offshore structures has been for wells. Conductor wells have been successfully severed in water depths exceeding 2,850 feet. Explosive charges have been set using divers, remotely operated vehicles (ROVs), atmospheric diving systems (ADSs), and off the end of drill pipes from drilling vessels (with the aid of underwater cameras).

9.1.3.1 Applicable Deepwater Projects

While it is true that no known deepwater platforms have been decommissioned to date, there have been several platforms removed in water depths in excess of 200'. There have also been a multitude of projects where the knowledge and experienced gained can be applied to deepwater removals. Examples are as follows:

Table 9.1 – Deepwater Projects

Location	Water Depth (ft)	Project Type	Comments
Brazos A-76	165	Platform Removal	Outside 42" 175# shaped charges, diver set
HI 492	195	Platform Topple	First *Rigs-to-Reefs* project in Texas waters
HI 520A	235	Platform Removal	8-pile, 4-skirts
HI 343A	237	Platform Removal	8-pile with multiple conductors, reefed
WC 595	245	Platform Removal	8-pile, 10-conductors, reefed
WC 609	280	Platform Removal	8-pile, 6-conductors
HI 567A	288	Platform Removal	8-pile, 11-conductors, topple for reef
WC 616	294	Platform Removal	8-pile, 8-skirts, topple for reef
EI 392A	340	Platform Removal	4-piles, 4-skirts, reefed

WC 624A	340	Platform Removal	4-piles, 4-skirts, reefed
SMI 190	359	Stub Removal	Diver set
Ver. 395	420	Stub Removal	Diver set
SS 364	450	Stub Removal	Outside 30" shaped charge set by WASP
EB 947	783	Stub Removal	From drill rig
GB 387	2,081	Template Removal	3-conductors, ROV set, multiple detonation

9.1.3.2 Effect of Water Depth on Explosives & System Selection

The explosive selected for deepwater applications must be one which is not desensitized by water, components do not separate under pressure, and does not become more sensitive with the expected increase in hydrostatic pressure. This would rule out many of the binary explosive mixtures and blasting gels.

It may become necessary to place the detonator underwater. Most common detonators are not designed for use in water depths over 400 feet; however, seismic detonators can withstand depths of 5,000 feet or more. Factors to consider in detonator selection are:

- Metal shell material, diameter, and wall thickness (i.e., will the hydrostatic pressure to be encountered crush the detonator?)
- Method of sealing around the wires going into the detonator (i.e., will water be forced into the detonator housing, thereby desensitizing the initiating explosive?)
- In the case of non-electric detonators, the housing seal as well as the pressure rating of the shock tube are factors limiting most non-electric detonators to a maximum of 270 feet
- Only resistorized electrical detonators should be used. With unresistorized electrical detonators, galvanic force from anodic jacket protection could provide energy required for detonation.

There are a number of initiation systems used, depending on the type detonator. These include:

- Common electric detonators can be initiated at the surface by almost any electrical means. This requires connecting two-conductor wires from the detonator to the place of initiation.
- Both remote and acoustical firing systems are available for electric detonators. In this type of initiation system, limiting factors are the distance from the detonator to the receiver and the distance between the receiver and the transmitter. System costs and deployment methods are problems with the acoustic system.
- Exploding bridge wire (EBW) systems require a firing module and a control unit. The maximum distance between the firing module and the EBW detonator is 300 feet; the maximum distance between the firing module and the control unit is 3,000 feet.

9.1.4 California Removal History

In July of 1996, Chevron's Hope, Heidi, and Hilda platforms were removed with the aid of explosives. The water depths were shallow, 99 feet to 132 feet, and all explosive shots were done in accordance with the following specifications (DEMEX 1996):

- A licensed California blaster directed the use of explosives.
- Marine wildlife observers monitored the area before, during, and after detonation of charges. No detonations occurred without the approval of the marine wildlife observers.
- Detonations were delayed until no marine mammals were within 1,000 yards of the platform.
- A sonic warning device was provided to scare pinnipeds away from the vicinity of the blast site. The device was deployed per the direction of the marine wildlife observer.
- High-velocity explosives were used.
- Detonations occurred during daylight hours only.
- Explosives were not used during the gray whale migration season from November to May.
- Personnel and equipment were provided to gather and dispose of all marine animals killed or injured as a result of the explosive detonations.

9.1.5 Cost Review

Deriving applicable cost matrix's for platform removals using explosives is difficult due to the high number of variables involved. These variables are especially relevant when obtaining cost figures for shaped charges. To obtain accurate numbers, these variables and the related constants must be identified to generate an accurate formula. The following graph illustrates different costs for two different bulk charge types in approximately 250 feet of water.

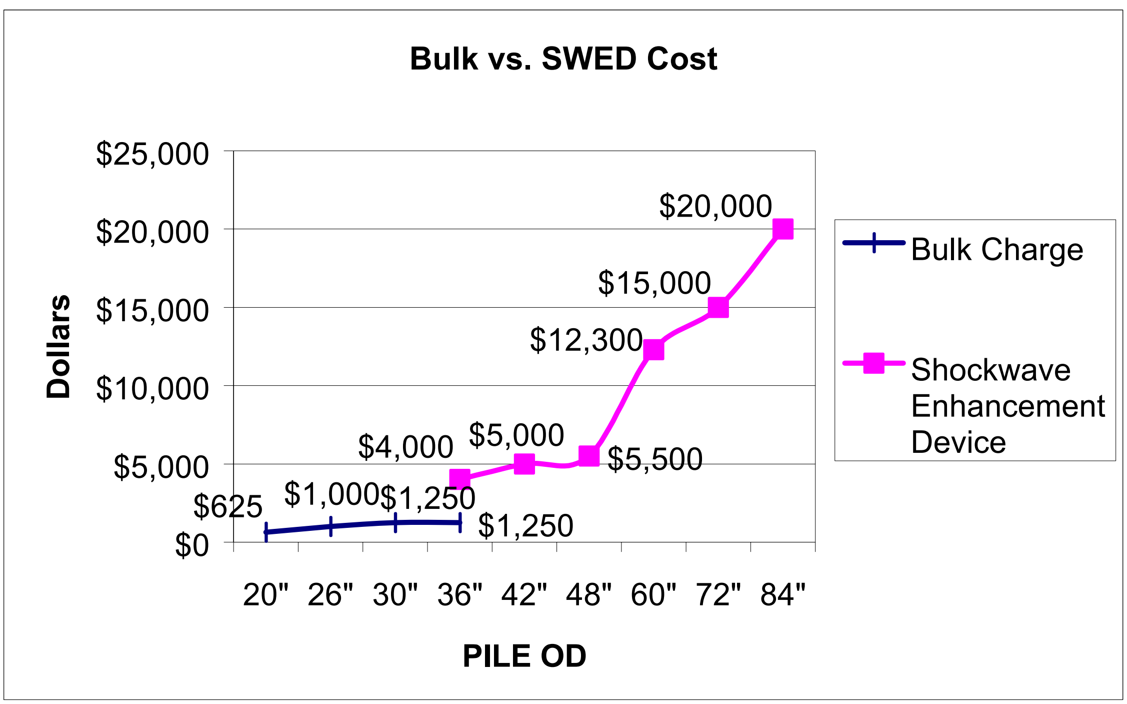


Figure Bulk Charge vs. Shockwave Enhancement Device Cost

9.1.5.1 Effect of Water Depth on Cost

The effect of water depth for charges that weight under 100 pounds does not significantly change. These charges are lowered with rope, which is a minimal cost factor. The detonating cord is also a minimal cost component. Significant cost increases are are relative to charge size and weight. Setting a standard Shock Wave Enhancement Device (SWED) device weighing less than 600 pounds only requires a ¼-inch wire cable. However, the larger the piles and the corresponding increase in charge weight would require larger cable, and increasing cable diameter to over 1 inch can have a significant affect on overall cost.

9.1.5.2 Cost Increase due to Target & Charge Diameter

When using a SWED-type device for large diameter piles, size and weight becomes relative – bigger is not necessarily better. The SWED devices are constructed with large-diameter plates in varying thickness. As plate diameter and thickness increases, costs escalate due to difficulties in machining and handling the device. Plate diameters over 6 feet are considered special order and require a long lead-time.

The equipment just to handle these sizes and weights is expensive. Cost reductions could be achieved by forging these devices or certain components. Explosive costs increased considerably in examining deepwater platforms because the weight required to sever the target reliably is doubled and tripled from the standard 50 pounds presently used in the Gulf of Mexico.

9.1.5.3 Shaped Charge Cost

The variables that affect cost increase exponentially when discussing shaped charges. However, of all the uses of explosives, the shaped charge has developed the most scientific and practical applications. Shaped charges can be used as precision devices or what DEMEX refers to as “down and dirty” charges.

9.1.6 Case Studies (Summary)

This section outlines the requirements for an explosive removal of Hidalgo, Gail, and Harmony. No considerations are made regarding limitations relative to explosive weight.

9.1.6.1 General Assumptions

The following assumptions are made in order to properly analyze the Hidalgo, Gail, and Harmony platforms as candidates for using explosives to sever piles during the removal process:

- Government weight restrictions are not a consideration for the explosive charges.
- Explosive charge weights are presented in a range, low to high.
- Costs are for using shock wave enhancement (SWED) charges as they have the best history and greatest success percentages for large diameter piles.
- The cost of backup charges is not included in this study.
- Pipelines in the vicinity are not considered.
- National Marine Fisheries Service (NMFS) procedures will be followed.
- All government permits will be obtained.

- All explosive charges will be set internally to the piles.
- For the main piles, the deck will be removed or full access to piles otherwise obtained.
- Damaged stabbing guides are not considered.
- The explosive charges will not be set inside the stabbing guides.
- All piles will be jetted to at least 20' below the mud line.
- All piles will be gauged with a "dummy" charge of the same dimensions as the explosive charge.
- A crane or some other suitable means will be used to set the explosive charges.
- Total explosive charge weights will range between 6,000 and 12,000 pounds, which will require wire rope diameter to be between ¾ inches to 1-1/8 inches.
- Explosive charges will not be left in piles for over 1 week.
- Adequate time for manufacturing of charges and mobilization are not considered.
- All cost will be in Year 2000 dollars.
- **Safety** is the number-one priority.

9.1.6.2 Hidalgo

Explosive Charge Details

The main piles (8) of this structure will require explosive devices whose outside diameter is 51 inches. The explosive weight for these charges is estimated to be 67 to 99 pounds each. The total weight of each device will be approximately 5,700 pounds.

The skirt piles (8) of this structure will require explosive devices whose outside diameter is 63 inches. The explosive weight for these charges is estimated to be 83 to 123 pounds each. The total weight of each device will be approximately 8,400 pounds.

Operational Considerations

Severing Piles with Bulk Charges

DEMEX believes that the most suitable charge for this type of operation is a shock wave enhancement/focusing (SWED) device. This type of explosive requires approximately 6-months lead-time to be manufactured. It is estimated that two days will be necessary to prepare the charges before loading them into the piles. Total time to set all charges is approximately 14 hours.

Severing Piles with Shaped Charges

Shaped charges for severing the piles are an alternative to bulk explosive devices. However, the major cause of failures in shaped charges is water intrusion thereby causing the shaped charge jet not to adequately form. Additionally, at these water depths, shaped charge canisters must be designed to overcome these pressures. Time and a number of operational considerations are unknown.

Detonating the Explosive Devices

Because of water depth and possible damage to detonating cord, 100-grain special cord with a thick plastic coating will be used. The initiation of the detonators will be accomplished through the use of a remote firing system. The removal vessel could conceivably be miles away from the detonations.

Total Estimated Cost

The total estimated cost for using explosive severing techniques for the removal of the Hidalgo platform is $276,264.

9.1.6.3 Gail

Explosive Charge Details

The main piles (8) of this structure will require explosive devices whose outside diameter is 51". The explosive weight for these charges is estimated to be 67 to 99 pounds each. The total weight of each device will be approximately 5,700 pounds.

The skirt piles (12) of this structure will require explosive devices whose outside diameter is 63". The explosive weight for these charges is estimated to be 83 to 123 pounds each. The total weight of each device will be approximately 8,400 pounds.

Operational Considerations

Severing Piles with Bulk Charges

DEMEX believes that the most suitable charge for this type of operation is a shock wave enhancement/focusing (SWED) device. This type of explosive requires approximately 6-months lead-time to be manufactured. It is estimated that two days will be necessary to prepare the charges before loading them into the piles. Total time to set all charges is approximately 26 hours.

Severing Piles with Shaped Charges

Shaped charges for severing the piles are an alternative to bulk explosive devices. However, the major cause of failures in shaped charges is water intrusion thereby causing the shaped charge jet not to adequately form. Additionally, at these water depths, shaped charge canisters must be designed to overcome these pressures. Time and a number of operational considerations are unknown.

Detonating the Explosive Devices

Because of water depth and possible damage to detonating cord, 100-grain special cord with a thick plastic coating will be used. The initiation of the detonators will be accomplished through the use of a remote firing system. The removal vessel could conceivably be miles away from the detonations.

Total Estimated Cost

The total estimated cost for using explosive severing techniques for the removal of the Gail platform is $363,499.

9.1.6.4 Harmony

Explosive Charge Details

The main piles (8) of this structure will require explosive devices whose outside diameter is 63”. The explosive weight for these charges is estimated to be 83 to 123 pounds each. The total weight of each device will be approximately 8,400 pounds.

The skirt piles (20) of this structure will require explosive devices whose outside diameter is 75”. The explosive weight for these charges is estimated to be 99 to 147 pounds each. The total weight of each device will be approximately 12,000 pounds.

Operational Considerations

Severing Piles with Bulk Charges

DEMEX believes that the most suitable charge for this type of operation is a shock wave enhancement/focusing (SWED) device. This type of explosive requires approximately 6-months lead-time to be manufactured. It is estimated that two days will be necessary to prepare the charges before loading them into the piles. Total time to set all charges is approximately 52 hours.

Severing Piles with Shaped Charges

Shaped charges for severing the piles are an alternative to bulk explosive devices. However, the major cause of failures in shaped charges is water intrusion thereby causing the shaped charge jet not to adequately form. Additionally, at these water depths, shaped charge canisters must be designed to overcome these pressures. Time and a number of operational considerations are unknown.

Detonating the Explosive Devices

Because of water depth and possible damage to detonating cord, 100-grain special cord with a thick plastic coating will be used. The initiation of the detonators will be accomplished through the use of a remote firing system. The removal vessel could conceivably be miles away from the detonations.

Total Estimated Cost

The total estimated cost for using explosive severing techniques for the removal of the Harmony platform is $715,622.

9.2 Non-Explosive Methods

Non-explosive methods presently used consist of diamond wire, abrasive (slurry) cutters, mechanical cutters, and oxy-arc torch (diver cutting).

9.2.1 Diamond Wire Cutting

The diamond wire cutting system (DWCS [**Figures 9.5 – 9.6**]) is an external cutting tool that can be used to cut jacket legs, piles, and diagonal members above and under water. Divers or a remotely operated vehicle (ROV) can install the DWCS. The DWCS consists of a leg clamping unit and a diamond wire cutter.

The frame is designed to clamp on the member being cut. The cutting wire consists of a steel wire rope with a diameter of approximately ¼-inch onto which is threaded a series of steel rings approximately ¼-inch long. These rings are embedded with diamonds, and are separated by a spacer sleeve that places the rings 1-inch apart.

The cutting system is designed to allow the wire to rotate along the perimeter of the frame. The wire rotates about the pulley wheels. A ROV can be used to set the leg clamp and cutter in the proper position on the member to be cut. Once installed, the DWCS's wire speed, working pressure, and flow rate is controlled from the surface.

Diamond wire cutting has been used since the early 1990's in the North, Adriatic, and Red Seas. Since then, the DWCS has been used for the removal of offshore platforms, caissons, conductors, risers, etc. However, until recently, the DWCS had not been used in the Gulf of Mexico (GOM). It was last used in the GOM to externally cut 82" and 48" caissons installed in 120 feet of water. Cutting times were approximately 20 and 2.5 hours for the 82" and 48" caissons respectively.

The DWCS has many possible uses for deepwater platform decommissioning. The cutting system can be used to sever large platform legs and piles while divers sever the diagonal members. An ROV can be fitted with the cutting tool (**Figure 9.7**) and sent down to cut the diagonal members at depths where divers cannot work safely. The same ROV configuration can be used to cut the pipeline ends.

Benefits of this cutting tool over other cutting methods are many. There seems to be no limitation in the size of the cut or material to cut, as long as the cutting tool can be fixed to the cut member. Water depth may not be an issue when using this tool; an ROV or diver wearing a hard suit can take and set the tool at the desired location. By-products generated by the DWCS are only the fine cuttings from the object being cut, minimizing damage to the environment.

Limitations of the DWCS are based on its external cutting design. If piles are to be severed below the mudline, jetting will need to be performed to allow the cutting device and frame to be attached to the pile. Additional jetting may be necessary depending on the size of the ROV or other subsea device being used to attach the unit. An additional limitation of the DWCS is its current control system.

Developments currently underway promise to overcome any limitations in the DWCS's present design. A sub-bottom cutter (SBC) is currently in development, which will facilitate cuts below the mudline. Additionally, a computerized cutting control system promises to provide faster cuts that are more successful in the near future.

9.2.2 Abrasive Cutting

Abrasive cutting employs mechanisms that inject cutting materials into a water jet and abrasively wear away steel . There are two types presently in use: high volume-low pressure and low volume-high pressure. The first type of abrasive cutter disperses high volumes of sand or slag mixed with water volume (80 to 100 gallons/minute) at relatively low pressure (4,000 to 10,000 psi). The second type of abrasive jet cutters use low volumes of garnet or other abrasive materials injected at the nozzle at relatively high water pressure (50,000 to 70,000 psi).

An internal abrasive cutter (**Figure 9.8**) is spooled into the open pile to 15 feet below the mudline. Once the unit is in position, the centralizer arms are extended. The mixing units and pump are then started. Water is pressurized and forced through a hair-thin opening, producing a powerful waterjet stream. Small particles of abrasive are added to the high velocity jet stream and the cutting begins.

The external abrasive cutting tool works on the same principle as the internal tool. Using the same feeding system, the external abrasive cutter is attached using a series of tracks that wrap around the member to be severed. This system must be attached by a diver, which limits the depth at which this system can be used safely.

Limitations for both the internal and external abrasive cutters include uneven cutting, clogged hoses, and water depth limits. Limitations also include the minimum inside diameter that can be accessed approximately seven inches, combined with the outside diameter that can be cut. In shallow water depths, abrasive cutters have been proven to be an effective alternative to explosive pile severing. In some circumstances, conversations with abrasive jet contractors reveal the unsatisfactory use of these cutters in water depths greater than 400 feet. Improvements to the systems generally will eventually allow the abrasive cutters to work in deeper water depths.

There also exists the problem of verifying that the cut has been made when using an internal abrasive cutter. Unlike explosives, the conductor or pile often does not drop, confirming that the cut was successful. With an abrasive tool, the width of the cut is small and combined with the soil friction, a visual response generally does not occur. To verify the cut, the conductor is pulled with either the platform crane or hydraulic jacks. The lift force must overcome the conductor weight and the soil friction. At times, this force is many times more than the actual conductor weight. It is generally assumed that the cut is not successful if the conductor can not be lifted with a force two times the conductor weight. The abrasive cutting tool is either re-deployed to make another complete run, or explosives are used to complete the cut.

9.2.3 Mechanical Cutting

Mechanical cutting employs hydraulically actuated, carbide-tipped tungsten blades to mill through tubular structures. This method has been used most successfully on small-diameter caissons with individual wells and shallow water well-protector platforms with vertical piles.

Figure 9.9 illustrates how the internal mechanical cutting tool is lowered into an open pile. The power swivel is supported and connected to the top of the pile. The power swivel turns the drill string so that the milling blades are forced outward hydraulically to cut the pile or well; centralizers on the tool keep it concentric inside the pile or well.

Limitations for the mechanical cutter include uneven cutting (from lateral movement of uncemented strings), replacement of worn blades, larger lifting equipment necessary to set the system, and more time required to make each cut.

9.3 Conclusions

Several cutting techniques were reviewed in this section. Explosives are predictable, flexible, and reliable. Current industry practice uses explosives to sever piles below the mudline at any water depth. Until other techniques provide the reliability and effectiveness of explosives, these methods will continue to be used for pile severing.

Abrasive and mechanical cutters are not as reliable as explosives to sever piles. Although they have been proven effective (generally on platforms located in relatively shallow water), deepwater simulation tests have demonstrated that there are a number of operational issues that need to be resolved for each of these alternative cutting methods. Additionally, there are more delays with these systems if they fail, and a complete cut during the first pass is less likely to occur than if explosives are used.

The DWCS is an alternative cutting tool that has great potential for deepwater use, specifically for severing jackets and pipelines. It is relatively easy to install (diver- and ROV-friendly) and current frame designs fit the pile sizes associated with the platforms included in this study. Although the DWCS might soon become a standard tool for efficiently severing piles, conductors, and pipelines, further testing is necessary before it can be considered a viable alternative cutting method for deepwater platform removals.

While some (or all) of these alternatives may someday provide a viable alternative to explosive pile severing, potential increases in cost and diver risk currently make these alternatives less attractive than explosives for the removal of deepwater platforms.

Figure 9.1 – Bulk explosive charge

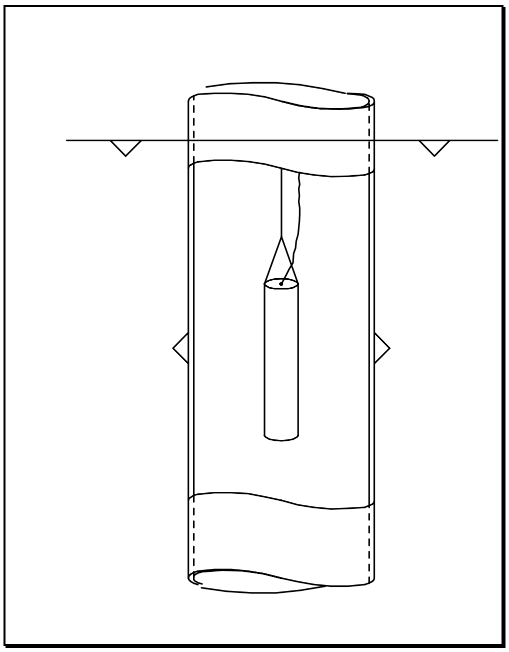


Figure 9.2 – Configured bulk charge

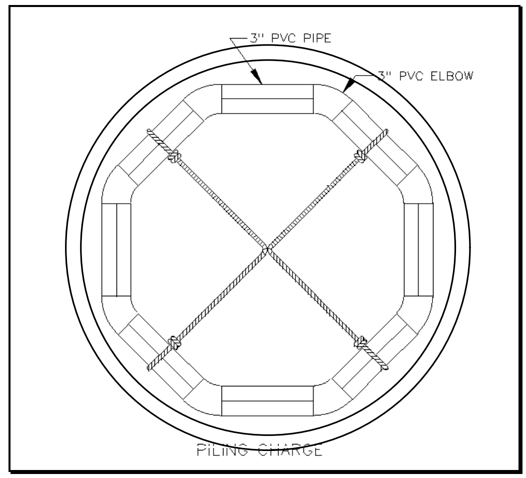


Figure 9.3 – Bulk Charge Configurations

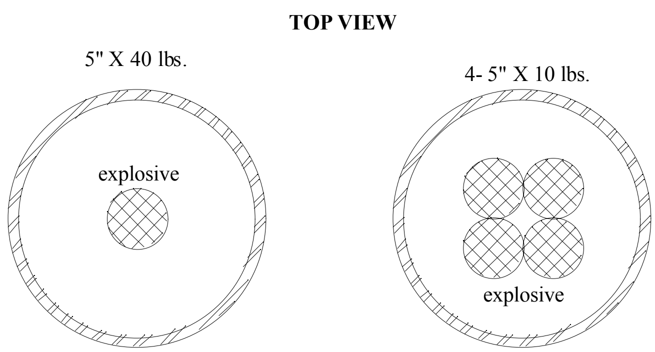


Figure 9.4 – Shaped Charge

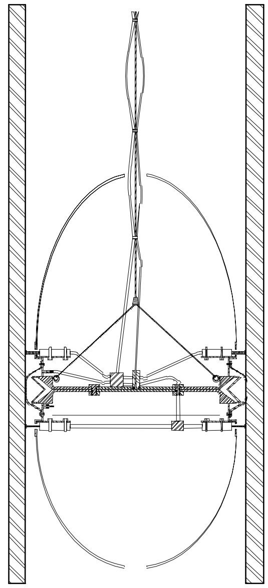


Figure 9.5 – 30"OD Diamond Wire Cutting Tool

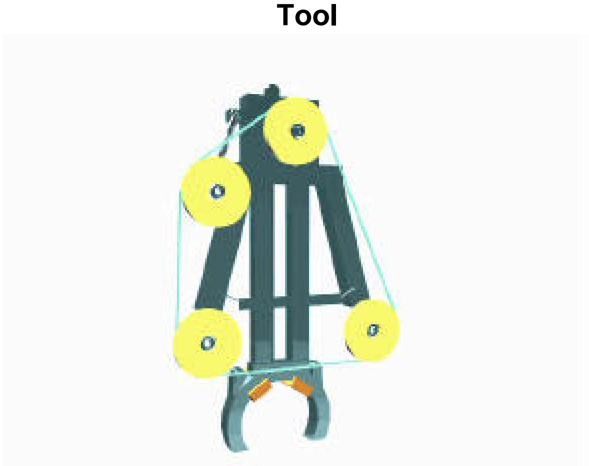


Figure 9.6 – 60" OD Diamond Wire Cutting Tool

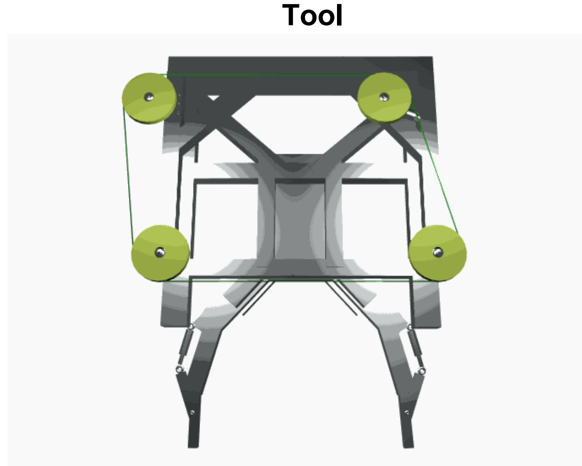
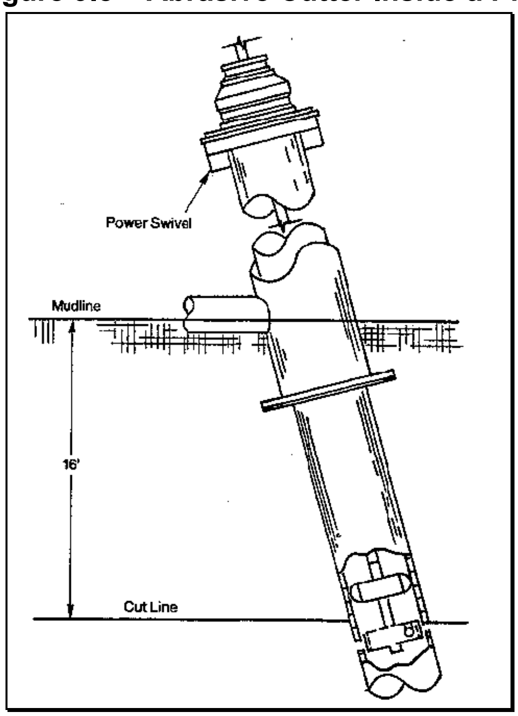


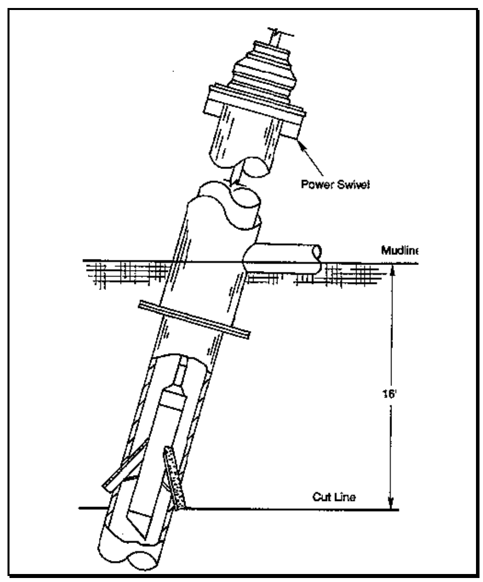
Figure 9.7 – DWCM Interfaced to ROV

Figure 9.8 – Abrasive Cutter Inside a Pile



Courtesy of HCS

Figure 9.9 – Mechanical Cutter Inside a Pile



Courtesy of HCS

Section 10 – Subsea Technology

Introduction

Due to the extreme water depths focused on in this study, several new subsea technologies have been reviewed to provide alternative methods for assisting in pile severing and jacket cutting. These include advanced remotely operated vehicles (ROVs), hard-shelled diving suits, and directly operated vehicles (i.e., single-person submarines).

This section includes a brief description of each of these technologies, and an assessment of the potential to apply them to the removal of deepwater platforms.

10.1 Remotely Operated Vehicles

Remotely operated vehicles (ROVs) are proven tools for safely operating in marine environments. The increasing need to be able to use these machines at deeper and deeper water depths is driving the development of advanced ROVs that can be utilized in deepwater platforms installations and removals.

The pile diameters associated with deepwater platforms is larger than standard platforms while pipelines are installed at greater depths; therefore, larger ROVs are necessary to handle equipment used to sever piles. Additionally, the pressure at these depths provides an additional challenge to ROV design.

Tasks needed to be performed at deeper water depths include:
- Valve operation
- Cutting steel and fiber cables or ropes
- Operation of disc grinders
- Attachment of external cutting tools
- Hot tapping
- High-pressure water jetting
- Removal of cuttings from well heads
- Make and break hydraulic connections
- Bathymetric surveys
- Trench profiles
- Sub-bottom pipe tracking
- Video observation and still photography
- Tool-skid carrying capabilities

An unit such as the Sealion MkII Heavy Work Class ROV (**Figure 10.1**), designed and manufactured by Techno Transfer Industries (TTI) and operated by Asiatic Racal Underwater

Contractors (ARUC), is an example of an ROV which can currently operate in deepwater environments.

10.1.1 Advantages

- Safer deepwater operations- replaces divers in extreme water depths
- Can be fitted with cutting tool to sever pipelines or jacket members.
- Aid in installing external cutting tools.
- Not depth dependent
- Not dependent of dive time

10.1.2 Disadvantages

- High fabrication, maintenance, and operations costs
- Larger umbilical and more power required
- Observations of working conditions are dependant on remote cameras
- Technical challenges
  - Operators must be highly skilled to operate these ROVs
  - Control systems are complex
  - Tether may create problems

10.2 Deepwater Diving Suits

In order to safely deploy divers at water depths exceeding 400 feet, diving suits used must meet the challenges of handling deepwater pressures while allowing divers to efficiently perform work in the deepwater environment.

Companies such as Oceaneering and Stolt Offshore, Inc. are currently using systems like the Hard Suit (**Figure 10.2**) to perform work in deep water. The Hard Suit is a proven tool for deploying divers at water depths exceeding 1,000 feet. The suit has been used in approximately 30 actual offshore operations in the Gulf of Mexico and in Brazil; the maximum water depth for these operations was 1033 fsw. These suits are rated for a maximum water depth of 1,200 fsw with a normal dive time of 6 hours.

In order to minimize downtime, the Hard Suit is operated in pairs to provide a "standby" diver in case one of the suits is in need of service or repair.

10.2.1 Advantages

- Ability to deploy divers in water depths up to 1,200 fsw
- Suited designed to kneel, lay down, and even work with the diver's head below his or her feet
- Has been used successfully in a number of deepwater operations

10.2.2 Disadvantages

- Extreme water depths still pose a threat to divers
- High fabrication, maintenance, and operations costs
- Highly skilled divers and above-water personnel needed to operate suit

10.3 Directly Operated Vehicles

As an alternative to ROVs or deploying divers in deepwater using hard-shelled diving suits, diving vessels (i.e., manned single-person controlled submarines) are currently being developed for deepwater operations. Also called directly operated vehicles (DOVs), these one-person submarines may someday prove to be extremely useful in deepwater decommissioning operations.

To meet the demand for vessels of this type, Nuytco, Inc. has developed the Newtsub Deepworker 2000 (**Figure 10.3**), a one atmosphere, single person, under-sea work vehicle. This vessel is designed to be completely tetherless in normal operations and can be fitted with a fiber optic cable (approximately the size of a lead pencil in diameter) to transmit data to the surface. Because of its autonomous design, the Deepworker 2000 has very high power availability at the vehicle, coupled with directly operated, high performance manipulator capabilities. Additionally, this system can be deployed to a maximum water depth of up to 2,000 feet.

10.3.1 Advantages

- Operator can observe situations first-hand
- Self-powered
- No tether required
- Powerful lifting system- lifts up to 150 lbs. at full extension
- Extreme water depths accessible to divers- up to 2,000 feet

10.3.2 Disadvantages

- Highly skilled divers and above-water personnel needed to operate vessel
- Use of manned system places personnel at risk
- High fabrication, operations, and maintenance costs

10.4 Conclusions

Remotely operated vehicles (ROVs) have been used successfully in a number of offshore operations for many years. Larger ROVs can provide the same key advantage of their shallow-water predecessors – decreasing the risk to human life. They can be fitted with a variety of cutting tools, assisting in external cuts at depths that are inaccessible to divers using conventional diving gear.

Hard-shelled diving suits and single-person diving vessels currently being developed and used can also be outfitted with these cutting tools and allow divers to access the depths defined as "deep water." While the major disadvantage of using these types of deepwater equipment is the fact that they still place human life at risk in deepwater environments, this fact is also their greatest advantage. They offer the ability to allow people to perform work first-hand at water depths exceeding 400 feet. An additional advantage of using the manned vessel is its ability to work without the constraints of a tether.

While these technologies are still young and relatively unproven, it is very likely that they will be used on deepwater platform installation, maintenance, and decommissioning operations in the near future.

Figure 10.1 - Deepwater Remote Operated Vehicles

Figure 10.2 Hard Shell Diving Suit

Figure 10.3 - Directly Operated Vehicles

List of Figures and Tables

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- Excalibur Engineering BV
- Global Maritime Heavy Industries
- John Gibson Projects Limited
- MPU Enterprise, AS
- Marine Shuttle Operations, Inc.
- Seaflex, Ltd.
- Versabar, Inc.

U.S. Minerals Management Service
Complete Removal
Decommissioning Summary - Hidalgo

Task	Days	Cost
Platform Hidalgo		
SSCV Mob/Demob	188	$7,520,000
CB, Crew and Equipment Mob/Demob	16	2,566,912
Well P&A	NA	NA
Platform Removal Prep	47	$2,032,884
Pipeline Decommissioning	20	$1,037,185
Conductor Removal	31	$1,005,000
Platform Removal	60	$17,931,105
Onshore Disposal	81	$8,028,156
Site Clearance	154	$1,593,807
Project Management and Engineering		$2,530,251
		$44,245,300

Point Arguello Platform Subtotal	**$44,245,300**
Permitting Cost	**$0**
Reef Donation	**$0**
Asset Area Total	***$44,245,300***

Cargo Barge/Crew and Equipment Summary - Hidalgo

Task	Total Hours	Total Days	Total Cost
Hidalgo			
Mob/Demob CB's			
Rig CB's	48	2	$654,064
Mob Cargo Barges	144	6	$1,212,192
Clean up Cargo Barges	48	2	$404,064
Demob Cargo Barges	24	1	$202,032
Mob/Demob CB's Subtotal	*216*		*$2,472,352*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	48	2	$8,250
Mob/Demob Crew	48	2	$44,310
Mob/Demob Equipment	72	3	$42,000
Mob/Demob Crew & Equipment Subtotal	*168*		*$94,560*
CB, Crew & Equipment Area Total	**384**		**$2,566,912**

U.S. Minerals Management Service
Complete Removal
Platform Task Information - Hidalgo

Task	Hours	Days	Cost
Well P&A	***0***	***0***	***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	384		$1,356,768
Prepare Cap Truss for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***752***	***47***	***$2,032,884***
Pipeline Decommissioning			
10" Gas Pipeline to Hermosa			
Pipeline Inspection	96		$176,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	8		$20,129
Insert Pigs	3		$7,549
Pig and Flush Pipeline	14		$35,226
Remove Launcher	8		$20,129
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	11		$28,307
Weather Provisions	11		$28,307
Dispose of Fluids	7		$4,780
16" Oil Pipeline to Hermosa			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	16		$40,259
Insert Pigs	3		$7,549
Pig and Flush Pipeline	34		$85,550
Remove Launcher	16		$40,259
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	17		$41,894
Weather Provisions	17		$41,894
Dispose of Fluids	17		$11,608
Pipeline Decommissioning Subtotal	***482***	***20***	***$1,037,185***
Conductor Removal	***744***	***31***	***$1,005,000***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize SSCV	24		$302,280
Setup SSCV	18		$226,710
Rig & Remove Modules	72		$968,400
Rig & Remove 8 Pile Deck in Two Sections	16		$212,848
Fabricate Explosives	0		$276,264
Install Explosives	24		$302,280

Task	Hours	Days	Cost
Pre/Post Detonation Survey	1		$16,345
Standby for Daylight Detonation	8		$100,760
Sever Main & Skirt Piles	8		$100,760
1st Cut			
Install Lifting Appurtenances (mechanical)	8		$100,760
Install Closures (mechanical)	4		$50,380
Deballast Legs	3		$37,785
Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move Jacket to 380' W.D.	1		$12,595
Set Jacket on Bottom	2		$25,190
Derig from Jacket	2		$25,190
Cut & Remove Bracing Between Rows 2 & 4	8		$100,760
Install Lifting Appurtenances Rows 1 & 5 (mechanical)	6		$75,570
Cut Rows 1 & 2 Above the (-) 45' Elevation	12		$151,140
Rig to Rows 1 & 2	3		$39,909
Remove Rows 1 & 2	24		$319,272
Derig from Rows 1 & 2	4		$53,212
Rig to Rows 4 & 5	4		$53,212
Cut Rows 4 & 5 Above the (-) 45' Elevation	12		$159,636
Remove Rows 4 & 5	24		$319,272
Derig from Rows 4 & 5	4		$53,212
2nd Cut			
Install Lifting Appurtenances (mechanical)	6		$75,570
Install Closures (mechanical)	4		$50,380
Deballast Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 310' W.D.	1		$12,595
Set Jacket on Bottom	2		$25,190
Derig from Jacket	2		$25,190
Cut & Remove Bracing Between Rows 2 & 4	8		$106,424
Install Lifting appurtenances on Rows 1 & 5 (mechanical)	6		$79,818
Rig to Rows 1 & 2	3		$39,909
Cut Rows 1 & 2 Above the (-) 115' Elevation	12		$159,636
Remove Rows 1 & 2	24		$319,272
Derig from Rows 1 & 2	4		$53,212
Rig to Rows 4 & 5	4		$53,212
Cut Rows 4 & 5 Above the (-) 115' Elevation	12		$159,636
Remove Rows 4 & 5	24		$319,272
Derig from Rows 4 & 5	4		$53,212
3rd Cut			
Install Lifting Appurtenances (mechanical)	6		$75,570
Install Closures (mechanical)	4		$50,380
Deballast Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 235' W.D.	1		$12,595
Set Jacket on Bottom	2		$25,190
Derig from Jacket	2		$25,190
Cut & Remove Bracing Between Rows 2 & 4	8		$100,760
Install Lifting appurtenances on Rows 1 & 5 (mechanical)	6		$75,570
Rig to Rows 1 & 2	3		$37,785
Cut Rows 1 & 2 Above the (-) 190' Elevation	12		$161,400
Remove Rows 1 & 2	24		$322,800
Derig from Rows 1 & 2 and Rig to Rows 4 & 5	8		$107,600
Cut Rows 4 & 5 Above the (-) 190' Elevation	12		$161,400

U.S. Minerals Management Service
Complete Removal
Platform Task Information - Hidalgo

Task	Hours	Days	Cost
Remove Rows 4 & 5	24		$322,800
Derig from Rows 4 & 5	4		$53,800
4th Cut			
Install Lifting Appurtenances (mechanical)	6		$75,570
Install Closures (mechanical)	4		$50,380
Deballast Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 155' W.D.	2		$25,190
Set Jacket on Bottom	2		$25,190
Derig from Jacket	2		$25,190
Cut & Remove Bracing Between Rows 2 & 4	8		$100,760
Install Lifting appurtenances on Rows 1 & 5 (mechanical)	6		$75,570
Rig to Rows 1 & 2	3		$37,785
Cut Rows 1 & 2 Above the (-) 270' Elevation	12		$161,400
Remove Rows 1 & 2	24		$322,800
Derig from Rows 1 & 2	4		$53,800
Rig to Rows 4 & 5	4		$53,800
Cut Rows 4 & 5 Above the (-) 270' Elevation	12		$161,400
Remove Rows 4 & 5	24		$322,800
Derig from Rows 4 & 5	4		$53,800
5th Cut			
Install Lifting Appurtenances (mechanical)	6		$75,570
Install Closures (mechanical)	4		$50,380
Deballast Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 75' W.D.	2		$25,190
Set Jacket on Bottom	2		$25,190
Derig from Jacket	2		$25,190
Cut & Remove Bracing Between Rows 2 & 4	8		$100,760
Install Lifting appurtenances on Rows 1 & 5 (mechanical)	6		$75,570
Rig to Rows 1 & 2	3		$40,350
Cut Rows 1 & 2 Above the (-) 350' Elevation	12		$161,400
Remove Rows 1 & 2	24		$322,800
Derig from Rows 1 & 2	4		$53,800
Rig to Rows 4 & 5	4		$53,800
Cut Rows 4 & 5 Above the (-) 350' Elevation	12		$161,400
Remove Rows 4 & 5	24		$322,800
Derig from Rows 4 & 5	4		$50,380
Install Lifting Appurtenances on Rows 1, 2, 4, & 5 (mechanical)	9		$113,355
Cut & Remove Horiz. Braces and Make Top Cuts on Diag. Braces at the (-) 350' Elevation	8		$107,600
Make U.W. Cuts & Remove the (-)350 to (-)434 Diagonal Braces	5		$67,250
Make U.W. Cuts & Remove the (-) 434 Horizontal Braces	24		$322,800
Remove Rows 1 & 2	24		$322,800
Derig from Rows 1 & 2	4		$53,800
Rig to Rows 4 & 5	4		$53,800
Remove Rows 4 & 5	24		$322,800
Derig from Rows 4 & 5	4		$53,800
Pick Up Anchors	18		$242,100
Demobilize SSCV	12		$151,140
Work Provisions	150		$2,011,595
Weather Provisions	150		$2,011,595
Platform Removal Subtotal	***1,447***	***60***	***$17,931,105***

Task	Hours	Days	Cost
Onshore Disposal			
Travel to Onshore Location	1512		$1,245,888
Offload Cargo Barge	432		$355,968
Dispose of Material			$6,426,300
Onshore Disposal Subtotal	***1,944***	***81***	***$8,028,156***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	384		$164,160
Inspect and Clean up	295		$691,875
Trawl	2,496		$389,376
Demob Vessels from Site	24		$70,254
Weather Provisions	483		$207,888
Site Clearance Subtotal	***3,707***	***154***	***$1,593,807***
Project Management and Engineering			***$2,530,251***
Platform Subtotal			**$34,158,387**
Total Hours SSCV On Site	990		

U.S. Minerals Management Service
Complete Removal
Equipment Spread Summary

Item	Rate	Unit		
Well P&A				
Topside Decommissioning/Platform Removal Prep				
Nitrogen Contractor	$ 5,000	day		
300 kW Generators (2)	$ 563	day		
750 CFM Air Compressor	$ 313	day		
550 gal. Diesel Tank	$ 25	day		
100 bbl. Potable Water Tank	$ 32	day		
150' Supply Vessel	$ 8,550	day		
Tug & Cargo Barge	$ 11,850	day		
Padeye Fabrication	$ 36,000	4 padeyes		
Brace Fabrication	$ 25,000	LS		
Labor	$ 30,300	day		
Structural Fitter (10)	$ 6,000	day		
Welder (8)	$ 7,160	day		
NDT	$ 3,750	day		
Flush and Clean Spread	$ 14,482	day		
Module Preparation Spread	$ 39,782	day		
Deck Preparation Spread	$ 39,782	day		
Jacket Removal Spread	$ 26,392	day		
Pipeline Decommissioning				
DSV	$ 40,000	day		
Consumables	$ 4,000	day		
P/L Decommissioning Crew	$ 16,388	day		
Platform Removal				
SSCV	$ 10,417	hour	$ 250,000	Per Day
Work Boat	$ 172	hour	$ 4,125	Per Day
Dive Basic Crew	$ 500	hour	$ 12,000	Per Day
Dive Supplemental Crew	$ 400	hour	$ 9,600	Per Day
Supplemental Welding Crew	$ 445	hour	$ 10,680	Per Day
Explosive Tech	$ 78	hour	$ 1,125	Per Day
Mechanical/Abrasive Cutter	$ 469	hour	$ 11,250	Per Day
Side Scan Sonar	$ 115	hour	$ 1,875	Per Day
ROV	$ -	hour	$ -	Per Day
Total Spread Rate	*$ 12,595*	*hour*	*$ 302,280*	Per Day
Platform Removal: Lump Sum Items				
Helicopter Trip	$ 3,750	round trip		
Mechanical Lifting Appurtenances	$ 2,500,000			
Site Clearance				
Side Scan Spread	$ 428	Per Hour	$ 10,260	Per Day
Inspect & Cleanup Spread	$ 2,344	Per Hour	$ 56,250	Per Day
Trawling Spread	$ 156	Per Hour	$ 3,744	Per Day
Cargo Barge Listing				
CB 300'x100' and Tug	$ 708	Per Hour	$ 16,992	Per Day
CB 400'x100' and Tug	$ 855	Per Hour	$ 20,520	Per Day
CB 450'x150' and Tug	$ 1,017	Per Hour	$ 24,408	Per Day
Weather Provision	15%			
Operating Efficiancy	87%			

U.S. Minerals Management Service
Remote Reefing
Decommissioning Summary - Hidalgo

Task	Days	Cost
Platform Hidalgo		
SSCV Mob/Demob	188	$4,042,752
CB, Crew and Equipment Mob/Demob	16	776,802
Well P&A	0	NA
Platform Removal Prep	47	$2,032,884
Pipeline Decommissioning	20	$1,037,185
Conductor Removal	31	1,005,000
Platform Removal	22	$3,877,113
Onshore Disposal	27	$3,063,588
Site Clearance	78	$973,769
Project Management and Engineering		$959,163
		$17,768,257

Permitting Cost	**$0**
Reef Donation	**$0**
Asset Area Total	***$17,768,257***

U.S. Minerals Management Service
Remote Reefing
Cargo Barge/Crew and Equipment Summary - Hidalgo

Task	Total Hours	Total Days	Total Cost
Hidalgo			
Mob/Demob CB's			
Rig CB's	48	2.0	$191,064
Mob CB's	144	6.0	$348,192
Clean up Cargo Barges	48	2.0	$116,064
Demob CB's	24	1.0	$58,032
Mob/Demob CB's Subtotal	*216*		*$713,352*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	48	2.0	$8,250
Mob/Demob Crew	48	2.0	$46,950
Mob/Demob Equipment	72	3.0	$8,250
Mob/Demob Crew & Equipment Subtotal	*168*		*$63,450*
CB, Crew & Equipment Area Total			**$776,802**

Task	Hours	Days	Cost
Well P&A	***0***	***0***	***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	384		$1,356,768
Prepare Cap Truss for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***752***	***47***	***$2,032,884***
Pipeline Decommissioning			
10" Gas Pipeline to Hermosa			
Pipeline Inspection	96		$176,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	8		$20,129
Insert Pigs	3		$7,549
Pig and Flush Pipeline	14		$35,226
Remove Launcher	8		$20,129
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	11		$28,307
Weather Provisions	11		$28,307
Dispose of Fluids	7		$4,780
16" Oil Pipeline to Hermosa			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	16		$40,259
Insert Pigs	3		$7,549
Pig and Flush Pipeline	34		$85,550
Remove Launcher	16		$40,259
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	17		$41,894
Weather Provisions	17		$41,894
Dispose of Fluids	17		$11,608
Pipeline Decommissioning Subtotal	***482***	***20***	***$1,037,185***
Conductor Removal	***744***	***31***	***$1,005,000***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize 2,000 ton capacity HLV	24		$164,750
Setup HLV	18		$123,563
Rig & Remove Modules	72		$555,810
Rig & Remove 8 Pile Deck in Two Sections	16		$121,161
Fabricate Explosives	0		$276,264
Install Explosives	24		$164,750

Pre/Post Detonation Survey	1		$6,865
Standby for Daylight Detonation	8		$54,917
Sever Main & Skirt Piles	8		$54,917
Install Lifting Appurtenances (welded - preinstalled)	8		$70,917
Install Closures (welded)	4		$35,458
Debballast Legs	8		$70,917
Lift & Secure Jacket for Tow	6		$53,188
Pick Up Anchors	18		$159,563
Tow to Disposal Site	72		$638,250
Transfer Rigging and Release Jacket from Barge, Deballast Jacket	24		$212,750
Demobilize HLV and Pull Tugs	12		$106,375
Work Provisions	45		$405,850
Weather Provisions	45		$405,850
Platform Removal Subtotal	***533***	***22***	***$3,877,113***
Onshore Disposal			
Travel to Onshore Location	504		$406,224
Offload Cargo Barge	144		$116,064
Dispose of Material			$2,541,300
Onshore Disposal Subtotal	***648***	***27***	***$3,063,588***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	144		$61,560
Inspect and Clean up	192		$450,000
Trawl	1,248		$194,688
Demob Vessels from Site	24		$70,254
Weather Provisions	245		$127,013
Site Clearance Subtotal	***1,877***	***78***	***$973,769***
Project Management and Engineering			***$959,163***
Platform Total			**$12,948,703**
Total Hours Derrick Barge On Site	287		

U.S. Minerals Management Service
Remote Reefing
Equipment Spread Summary

Item		Rate	Unit			
Well P&A						
Topside Decommissioning/Platform Removal Prep						
Nitrogen Contractor	$	5,000	day			
300 kW Generators (2)	$	563	day			
750 CFM Air Compressor	$	313	day			
550 gal. Diesel Tank	$	25	day			
100 bbl. Potable Water Tank	$	32	day			
150' Supply Vessel	$	8,550	day			
Tug & Cargo Barge	$	11,850	day			
Padeye Fabrication	$	36,000	4 padeyes			
Brace Fabrication	$	25,000	LS			
Labor	$	30,300	day			
Structural Fitter (10)	$	6,000	day			
Welder (8)	$	7,160	day			
NDT	$	3,750	day			
Flush and Clean Spread	$	14,482	day			
Module Preparation Spread	$	39,782	day			
Deck Preparation Spread	$	39,782	day			
Jacket Removal Spread	$	26,392	day			
Pipeline Decommissioning						
DSV	$	40,000	day			
Consumables	$	4,000	day			
P/L Decommissioning Crew	$	16,388	day			
Platform Removal						
2,000 ton HLV	$	5,600	hour	$	134,400	Per Day
Work Boat	$	172	hour	$	4,125	Per Day
Dive Basic Crew	$	500	hour	$	12,000	Per Day
Dive Supplemental Crew	$	400	hour	$	9,600	Per Day
Explosive Techs	$	78	hour	$	1,125	Per Day
Mechanical Cutter	$	-	hour	$	-	Per Day
Side Scan Sonar	$	115	hour	$	1,875	Per Day
ROV	$	-	hour	$	-	Per Day
Total Spread Rate	*$*	*6,865*	hour	*$*	*164,750*	Per Day
Pull tugs	$	1,000	hour	$	24,000	day
Platform Removal: Lump Sum Items						
Helicopter Trip	$	3,750	round trip			
Site Clearance						
Side Scan Spread	$	428	Per Hour	$	10,260	Per Day
Inspect & Cleanup Spread	$	2,344	Per Hour	$	56,250	Per Day
Trawling Spread	$	156	Per Hour	$	3,744	Per Day
Cargo Barge Listing						
CB 300’x100’ and Tug	$	708	Per Hour	$	16,992	Per Day
CB 400’x100’ and Tug	$	855	Per Hour	$	20,520	Per Day
Weather Provision		15%				
Operating Efficiency		87%				

U.S. Minerals Managment Service
Partial Removal
Decommissioning Summary - Hidalgo

Task	Days	Cost
Platform Hidalgo		
SSCV Mob/Demob	188	$4,042,752
CB, Crew and Equipment Mob/Demob	13	756,277
Well P&A	0	NA
Platform Removal Prep	47	$2,032,884
Pipeline Decommissioning	20	$1,037,185
Conductor Removal	14	435,000
Platform Removal	19	$1,902,110
Onshore Disposal	27	$2,994,000
Site Clearance	78	$973,769
Project Management and Engineering		$749,996
		$14,923,974

Permitting Cost	**$0**
Reef Donation	**$0**
Asset Area Total	***$14,923,974***

U.S. Minerals Management Service
Partial Removal
Cargo Barge/Crew and Equipment Summary - Hidalgo

Task	Total Hours	Total Days	Total Cost
Hidalgo			
Mob/Demob CB's			
Rig CB's	48	2	$191,064
Mob CB's	144	6	$348,192
Clean up Cargo Barges	48	2	$116,064
Demob CB's	24	1	$58,032
Mob/Demob CB's Subtotal	*216*		*$713,352*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	24	1	$4,125
Mob/Demob Crew	12	1	$10,800
Mob/Demob Equipment	48	2	$28,000
Mob/Demob Crew & Equipment Subtotal	*84*		*$42,925*
CB, Crew & Equipment Area Total			**$756,277**

U.S. Minerals Managment Serviec
Partial Removal
Platform Task Information - Hidalgo

Task	Hours	Days	Cost
Well P&A	***0***	***0***	***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	384		$1,356,768
Prepare Cap Truss for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***752***	***47***	***$2,032,884***
Pipeline Decommissioning			
10" Gas Pipeline to Hermosa			
Pipeline Inspection	96		$176,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	8		$20,129
Insert Pigs	3		$7,549
Pig and Flush Pipeline	14		$35,226
Remove Launcher	8		$20,129
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	11		$28,307
Weather Provisions	11		$28,307
Dispose of Fluids	7		$4,780
16" Oil Pipeline to Hermosa			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	16		$40,259
Insert Pigs	3		$7,549
Pig and Flush Pipeline	34		$85,550
Remove Launcher	16		$40,259
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	17		$41,894.18
Weather Provisions	17		$41,894.18
Dispose of Fluids	17		$11,608
Pipeline Decommissioning Subtotal	***482***	***20***	***$1,037,185***
Conductor Removal	***336***	***14***	***$435,000***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize 2,000 ton capacity HLV	24		$174,125
Setup HLV	18		$130,594
Rig & Remove Modules	72		$583,935
Rig & Remove 8 Pile Deck in Two Sections	16		$127,411
Demob HLV	12		$87,063
Mob Dive Spread	12		$22,000

U.S. Minerals Managment Serviec
Partial Removal
Platform Task Information - Hidalgo

Task	Hours	Days	Cost
Sever Diag. Braces Below the (-) 86' Elevation	30		$55,000
Sever Legs & Piles Rows 1 & 2 at the (-) 86' Elevation	12		$22,000
Sever Legs & Piles Rows 3 & 4 at the (-) 86' Elevation	12		$22,000
Mob Pull Tug	12		$12,000
Rig to Jacket	12		$34,000
Pull 1st 4-Leg Jacket Section	6		$17,000
Rig to Jacket	12		$34,000
Pull 2nd 4-Pile Jacket Section	6		$17,000
Inspect Platform Site	6		$17,000
Demobilize Dive Spread and Pull Tug	12		$34,000
Work Provisions	30		158,991
Weather Provisions	30		158,991
Platform Removal Subtotal	***455***	***19***	***$1,902,110***
Onshore Disposal			
Travel to Onshore Location	504		$406,224
Offload Cargo Barge	144		$116,064
Dispose of Material			$2,471,712
Onshore Disposal Subtotal	***648***	***27***	***$2,994,000***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	144		$61,560
Inspect and Clean up	192		$450,000
Trawl	1,248		$194,688
Demob Vessels from Site	24		$70,254
Weather Provisions	245		$127,013
Site Clearance Subtotal	***1,877***	***78***	***$973,769***
Project Management and Engineering			***$749,996***
Platform Total			**$10,124,945**
Total Hours SSCV On Site	238		

U.S. Mineral Management Service
Partial Removal
Equipment Spread Summary

Item		Rate	Unit			
Well P&A						
Topside Decommissioning/Platform Removal Prep						
Nitrogen Contractor	$	5,000	day			
300 kW Generators (2)	$	563	day			
750 CFM Air Compressor	$	313	day			
550 gal. Diesel Tank	$	25	day			
100 bbl. Potable Water Tank	$	32	day			
150' Supply Vessel	$	8,550	day			
Tug & Cargo Barge	$	11,850	day			
Padeye Fabrication	$	36,000	4 padeyes			
Brace Fabrication	$	25,000	LS			
Labor	$	30,300	day			
Structural Fitter (10)	$	6,000	day			
Welder (8)	$	7,160	day			
NDT	$	3,750	day			
Flush and Clean Spread	$	14,482	day			
Module Preparation Spread	$	39,782	day			
Deck Preparation Spread	$	39,782	day			
Jacket Removal Spread	$	26,392	day			
Pipeline Decommissioning						
DSV	$	40,000	day			
Consumables	$	4,000	day			
P/L Decommissioning Crew	$	16,388	day			
Platform Removal						
2,000 ton capacity HLV	$	5,600	hour	$	134,400	Per Day
Work Boat	$	172	hour	$	4,125	Per Day
Dive Basic Crew	$	500	hour	$	12,000	Per Day
Dive Supplemental Crew	$	400	hour	$	9,600	Per Day
Supplemental Welding Crew	$	-	hour	$	-	Per Day
Explosive Techs	$	-	hour	$	-	Per Day
Mechanical/Abrasive Cutter	$	469	hour	$	11,250	Per Day
Side Scan Sonar	$	115	hour	$	1,875	Per Day
ROV	$	-	hour	$	-	Per Day
Total Spread Rate	*$*	*7,255*	*hour*	*$*	*174,125*	Per Day
Pull Tug	$	1,000	hour		$24,000	Per Day
Platform Removal: Lump Sum Items						
Helicopter Trip	$	1,200	round trip			
Site Clearance						
Side Scan Spread	$	428	Per Hour		10,260.00	Per Day
Inspect & Cleanup Spread	$	2,344	Per Hour		56,250.00	Per Day
Trawling Spread	$	156	Per Hour		3,744.00	Per Day
Cargo Barge Listing						
CB 300'x100' and Tug	$	708	Per Hour	$	16,992	Per Day
CB 400'x100' and Tug	$	855	Per Hour	$	20,520	Per Day
Weather Provision		15%				
Operating Efficiency		87%				

U.S. Minerals Management Service
Complete Removal
Decommissioning Summary - Gail

Task	Days	Cost
Platform Gail		
SSCV Mob/Demob	188	$7,520,000
CB, Crew and Equipment Mob/Demob	19	$2,671,502
Well P&A	0	NA
Platform Removal Prep	43	$1,776,756
Pipeline Decommissioning	25	$1,266,942
Conductor Removal	105	$3,358,667
Platform Removal	77	$23,403,352
Onshore Disposal	90	$11,150,784
Site Clearance	227	$2,086,746
Project Management and Engineering		$3,443,460
		$56,678,210

Permitting Cost	**$0**
Reef Donation	**$0**
Grand Total	***$56,678,210***

U.S. Minerals Management Service
Complete Removal
Cargo Barge/Crew and Equipment Summary - Gail

Task	Total Hours	Total Days	Total Cost
Gail			
Mob/Demob CB's			
Rig up CB's	48	2	$639,952
Mobilize Cargo Barges to site	144	6	$1,169,856
Clean up cargo barges	72	3	$584,928
Demob Cargo Barges	24	1	$194,976
Mob/Demob CB's Subtotal	*288*		*$2,589,712*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	48	2	$8,250
Mob/Demob Crew	48	2	$45,540
Mob/Demob Equipment	72	3	$28,000
Mob/Demob Crew & Equipment Subtotal	*168*		*$81,790*
CB, Crew & Equipment Total	**456**		**$2,671,502**

Task	Hours	Days	Cost
Well P&A	***0***	***0***	***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	320		$1,100,640
Prepare Cap Truss for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***688***	***43***	***$1,776,756***
Pipeline Decommissioning			
8" Oil Pipeline to Grace			
Pipeline Inspection	96		$176,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline at Gail	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose Fluids	6		$3,756
8" Gas Pipeline to Grace			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose of Fluids	6		$3,756
8" Gas Pipeline to Grace			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	10		$25,665

Task	Hours	Days	Cost
Weather Provisions	10		$25,665
Dispose of Fluids	6		$3,756
Pipeline Decommissioning Subtotal	***594***	***25***	***1,266,942***
Conductor Removal	***2,520***	***105***	***$3,358,667***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize SSCV	24		$302,280
Setup SSCV	18		$226,710
Rig & Remove Modules	64		$851,392
Rig & Remove 8 Pile Deck in Two Sections	16		$212,848
Fabricate Explosives	0		$363,499
Install Explosives	30		$377,850
Pre/Post Detonation Survey	1		$16,345
Standby for Daylight Detonation	8		$100,760
Sever Main Pile & Skirt Piles	8		$100,760
1st Cut			
Install Lifting Appurtenances (mechanical)	8		$100,760
Install Closures In Legs (mechanical)	4		$50,380
Deballast Legs	4		$50,380
Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 625' Water Depth	2		$25,190
Set Jacket on Bottom	2		$25,190
Derig from Jacket	6		$75,570
Cut and Remove Bracing Between Rows 2 and 3	8		$107,600
Intsall Lifting Appurtenances (mechanical)	6		$80,700
Rig to Rows 1 and 2	3		$40,350
Cut Rows 1 and 2 Above the (-)118' Elevation	12		$161,400
Lift Rows 1 and 2, Set Upright on CB #1 and Seafasten	24		$322,800
Derig from Rows 1 and 2 and Rig to Rows 3 and 4	8		$107,600
Cut Rows 3 and 4 Above the (-)118' Elevation	12		$161,400
Lift Rows 3 and 4, Set 118' Upright on CB #1	24		$322,800
Derig from Rows 3 and 4	4		$53,800
2nd Cut			
Install Lifting Appurtenances (mechanical)	6		$80,700
Install Closures (mechanical)	2		$26,900
Deballast Legs	4		$53,800
Rig to, Lift and Secure Jacket for Move	6		$80,700
Shift Anchors	18		$242,100
Move to 495' Water Depth	2		$26,900
Set Jacket on Bottom	2		$26,900
Derig from Jacket	2		$26,900
Cut and Remove Bracing Between Rows 3 and 4	8		$107,600
Install Lifting Appurtenances on Rows 1 and 4 (mechanical)	6		$80,700
Rig to Rows 1 and 2	3		$40,350
Cut Rows 1 and 2 above the (-) 230' Elevation	12		$161,400
Lift Rows 1 and 2, Set the 130' Section Upright on CB #1 and Seafasten	24		$322,800
Derig from Rows 1 and 2 and Rig to Rows 3 and 4	8		$107,600
Cut Rows 3 and 4 above the (-) 230' Elevation	12		$161,400
Lift Rows 3 and 4, Set Upright on CB #1 and Seafasten	24		$322,800
Derig From Rows 3 and 4 and Release CB #1	4		$53,800
3rd Cut			

Task	Hours	Days	Cost
Install Lifting Appurtenances (mechanical)	6		$75,570
Install Closures (mechanical)	4		$50,380
Deballast Jacket Legs	3		$37,785
Rig to, Lift and Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move Jacket to 420' Water Depth	1		$12,595
Set Jacket on Bottom	2		$25,190
Cut and Remove brace between Rows 2 and 3	8		$106,424
Install Lifting Appurtenances on Rows 1 and 4 (mechanical)	6		$79,818
Rig to Rows 1 and 2	3		$39,909
Cut Rows 1 and 2 above the (-) 305' Elevation	12		$159,636
Lift Rows 1 and 2, Set the 75' Section Upright on CB #2 and Seafasten	24		$319,272
Derig from Rows 1 and 2 and Rig to Rows 3 and 4	8		$106,424
Cut Rows 3 and 4 above (-) 305' Elevation	12		$159,636
Lift Rows 3 and 4, Set Upright on CB #2 and Seafasten	24		$319,272
Derig from Rows 3 and 4 and Release CB #2	4		$53,212
4th Cut			
Install Lifting Appurtenances (mechanical)	4		$50,380
Install Closures (mechanical)	4		$50,380
Deballast Jacket Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 345' Water Depth	1		$12,595
Set Jacket on Bottom	2		$25,190
Derig from Jacket	4		$50,380
Cut and Remove Jacket Braces between Rows 2 and 3	8		$106,424
Install Lifting Appurtenances on Rows 1 and 4 (mechanical)	6		$79,818
Rig to Rows 1 and 2	3		$39,909
Cut Rows 1 and 2 above the (-) 380' Elevation	12		$159,636
Lift Rows 1 and 2, set the 75' Section Upright on CB #3 and Seafasten	24		$319,272
Derig from Rows 1 and 2 and Rig to Rows 3 and 4	8		$106,424
Cut Rows 3 and 4 above the (-) 380' Elevation	12		$159,636
Lift Rows 3 and 4 and Set Upright on CB #3 and Seafasten	24		$319,272
Derig from Rows 3 and 4 and Release CB #3	4		$53,212
5th Cut			
Install Lifting Appurtenances (mechanical)	4		$50,380
Install Closures (mechanical)	4		$50,380
Deballast Jacket Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 265' Water Depth	1		$12,595
Set Jacket on Bottom	2		$25,190
Derig From Jacket Section	2		$25,190
Cut and Remove Braces between Rows 3 and 4	8		$107,600
Install Lifting Appurtenances on Rows 1 and 4 (mechanical)	6		$80,700
Rig to Rows 1 and 2	3		$40,350
Cut Rows 1 and 2 above (-) 460' Elevation	12		$161,400
Lift Rows 1 and 2, Set the 80' Section Upright on CB #4 and Seafasten	24		$322,800
Derig from Rows 1 and 2 and Rig to Rows 3 and 4	8		$107,600
Cut Rows 3 and 4 above the (-) 460 Elevation	12		$161,400
Lift Rows 3 and 4 and Set Upright on CB #4 and Seafasten	24		$322,800
Derig from Rows 3 and 4 and Release CB #4	4		$53,800
6th Cut			
Install Lifting Appurtenances (mechanical)	6		$75,570

Task	Hours	Days	Cost
Install Closures (mechanical)	4		$50,380
Deballast Jacket Legs	3		$37,785
Rig to and Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move Jacket to 185' Water Depth	2		$25,190
Set Jacket on Bottom	2		$25,190
Derig from Jacket	2		$25,190
Cut and Remove Braces between Rows 2 and 3	8		$107,600
Install Lifting Appurtenances on Rows 1 and 4 (mechanical)	6		$80,700
Rig to Rows 1 and 2	3		$40,350
Cut Rows 1 and 2 above the (-) 545 Elevation	12		$161,400
Lift Rows 1 and 2, set the 85' Section Upright on CB #5 and Seafasten	24		$322,800
Derig from Rows 1 and 2 and Rig to Rows 3 and 4	8		$107,600
Cut Rows 3 and 4 above the (-) 545" Elevation	12		$161,400
Lift Rows 3 and 4, Set the 85' Section Upright on CB #5 and Seafasten	24		$322,800
Derig from Rows 3 and 4 and Release CB #5	4		$53,800
7th Cut			
Install Lifting Appurtenances (mechanical)	6		$75,570
Install Closures (mechanical)	4		$50,380
Deballast Jacket Legs	3		$37,785
Rig to, Lift & Secure Jacket for Move	6		$75,570
Shift Anchors	18		$226,710
Move to 95' Water Depth	2		$25,190
Set Jacket on Bottom	2		$25,190
Derig from Jacket	4		$50,380
Cut & Remove Horiz. & Diag. Braces Between Rows 2 & 3	16		$215,200
Install Lifting Appurtenances on Rows 1 & 4 (mechanical)	6		$80,700
Rig to Rows 1 & 2	3		$40,350
Cut Rows 1 & 2 Above the (-) 640' Elevation	12		$161,400
Remove Rows 1 & 2 and Set Upright on CB#6 and Seafasten	24		$322,800
Derig from Rows 1 & 2	4		$53,800
Rig to Rows 3 & 4	4		$53,800
Cut Rows 3 & 4 Above the (-) 640' Elevation	12		$161,400
Remove Rows 3 & 4 and Set Upright on CB#6 and Seafasten	24		$322,800
Derig from Rows 3 & 4 and Release CB#6	4		$53,800
Cut & Remove Horiz. Braces and Make Top Cuts on the Diag. Braces Between Rows 2 & 3 at the (-)640' Elevation	8		$108,896
Cut & Remove Diag. Braces at the -740 Level	10		$136,120
Cut & Remove Horiz. Braces at the -740 Level	24		$326,688
Install Lifting Appurtenances on Rows 1, 2, 3, & 4 (mechanical)	9		$122,508
Rig to Rows 1 & 2	4		$54,448
Remove Rows 1 & 2 and Set Upright on CB#7 and Seafasten	24		$326,688
Derig from Rows 1 & 2	4		$54,448
Rig to Rows 3 & 4	4		$54,448
Remove Rows 3 & 4 and Set Upright on CB#7 and Seafasten	24		$326,688
Derig from Rows 3 & 4 and Release CB#7	4		$54,448
Pickup Anchors	18		$226,710
Demobilize SSCV	12		$151,140
Work Provisions	196		$2,643,008
Weather Provisions	196		$2,643,008
Platform Removal Subtotal	***1,843***	***77***	***$23,403,352***
Onshore Disposal			
Travel to Onshore Location	1,680		$1,364,832

Task	Hours	Days	Cost
Offload Cargo Barges	480		$389,952
Dispose of Material			$9,396,000
Onshore Disposal Subtotal	***2,160***	***90***	***$11,150,784***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	576		$246,240
Inspect and Clean up	360		$843,750
Trawl	3,744		$584,064
Demob Vessels from Site	24		$70,254
Weather Provisions	709		$272,184
Site Clearance Subtotal	***5,437***	***227***	***$2,086,746***
Project Management and Engineering			***$3,443,460***
Platform Total			**$46,486,707**
Total Hours SSCV On Site	1,295		

U.S. Minerals Management Service
Complete Removal
Equipment Spread Summary

Item		Rate	Unit			
Well P&A						
Topside Decommissioning/Platform Removal Prep						
Nitrogen Contractor	$	5,000	day			
300 kW Generators (2)	$	563	day			
750 CFM Air Compressor	$	313	day			
550 gal. Diesel Tank	$	25	day			
100 bbl. Potable Water Tank	$	32	day			
150' Supply Vessel	$	8,550	day			
Tug & Cargo Barge	$	11,850	day			
Padeye Fabrication	$	36,000	4 padeyes			
Brace Fabrication	$	25,000	LS			
Labor	$	30,300	day			
Structural Fitter (10)	$	6,000	day			
Welder (8)	$	7,160	day			
NDT	$	3,750	day			
Flush and Clean Spread	$	14,482	day			
Module Preparation Spread	$	39,782	day			
Deck Preparation Spread	$	39,782	day			
Jacket Removal Spread	$	26,392	day			
Pipeline Decommissioning						
DSV	$	40,000	day			
Consumables	$	4,000	day			
P/L Decommissioning Crew	$	16,388	day			
Platform Removal						
SSCV	$	10,417	hour	$	250,000	Per Day
Work Boat	$	172	hour	$	4,125	Per Day
Dive Basic Crew	$	500	hour	$	12,000	Per Day
Dive Supplemental Crew	$	400	hour	$	9,600	Per Day
Supplemental Welding Crew	$	445	hour	$	10,680	Per Day
Explosive Tech	$	78	hour	$	1,125	Per Day
Mechanical/Abrasive Cutter	$	469	hour	$	11,250	Per Day
Side Scan Sonar	$	115	hour	$	1,875	Per Day
ROV	$	-	hour	$	-	Per Day
Total Spread Rate	*$*	*12,595*	*hour*	*$*	*302,280*	Per Day
Platform Removal: Lump Sum Items						
Helicopter Trip	$	3,750	round trip			
Mechanical Lifting Appurtenances	$	2,500,000				
Site Clearance						
Side Scan Spread	$	428	Per Hour	$	10,260	Per Day
Inspect & Cleanup Spread	$	2,344	Per Hour	$	56,250	Per Day
Trawling Spread	$	156	Per Hour	$	3,744	Per Day
Cargo Barge Listing						
CB 300'x100' and Tug	$	708	Per Hour	$	16,992	Per Day
CB 400'x100' and Tug	$	855	Per Hour	$	20,520	Per Day
CB 450'x150' and Tug	$	1,017	Per Hour	$	24,408	Per Day
Weather Provision		15%				
Operating Efficiency		87%				

U.S. Minerals Management Service
Remote Reefing
Decommissioning Summary - Gail

Task	Days	Cost
SSCV Mob/Demob	188	$4,042,752
CB, Crew and Equipment Mob/Demob	11	$774,098
Well P&A	0	NA
Platform Removal Prep	43	$1,776,756
Pipeline Decommissioning	25	$1,266,942
Conductor Removal	105	3,358,667
Platform Removal	22	$3,779,271
Onshore Disposal	27	$3,196,536
Site Clearance	78	$973,769
Project Management and Engineering		$1,148,155
		$20,316,947

Permitting Cost	**$0**
Reef Donation	**$0**
Grand Total	**$20,316,947**

U.S. Minerals Management Service
Remote Reefing
Cargo Barge/Crew and Equipment Summary - Gail

Task	Total Hours	Total Days	Total Cost
Gail			
Mob/Demob CB's			
Rig CB's	48	2.0	$184,008
Mobilize Cargo Barges to site	144	6.0	$327,024
Cleanup Cargo Barges	72	3.0	$163,512
Demob CB's	24	1.0	$54,504
Mob/Demob CB's Subtotal	*96*		*$729,048*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	48	2.0	$8,250
Mob/Demob Crew	48	2.0	$31,300
Mob/Demob Equipment	72	3.0	$5,500
Mob/Demob Crew & Equipment Subtotal	*168*		*$45,050*
CB, Crew & Equipment Area Total	**264**		**$774,098**

U.S. Minerals Management Service
Remote Reefing
Platform Task Information - Gail

Task	Hours	Days	Cost
Well P&A	***0***	***0***	***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	320		$1,100,640
Prepare Cap Truss for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***688***	***43***	***$1,776,756***
Pipeline Decommissioning			
8" Oil Pipeline			
Pipeline Inspection	96		$176,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline at Gail	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose Fluids	6		$3,756
8" Gas Pipeline			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose of Fluids	6		$3,756
8" Gas Pipeline			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129

U.S. Minerals Management Service
Remote Reefing
Platform Task Information - Gail

Task	Hours	Days	Cost
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose of Fluids	6		$3,756
Pipeline Decommissioning Subtotal	***594***	***25***	***1,266,942***
Conductor Removal	***2,520***	***105***	***$3,358,667***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize 2,000 ton capacity HLV	24		$164,750
Setup HLV	18		$123,563
Rig & Remove Modules	64		$484,646
Rig & Remove 8 Pile Deck in Two Sections	16		$121,161
Fabricate Explosives	0		$363,499
Install Explosives	30		$205,938
Pre/Post Detonation Survey	1		$10,615
Standby for Daylight Detonation	8		$54,917
Sever Main Pile & Skirt Pile	8		$62,917
Install Lifting Appurtenances (welded)	8		$54,917
Install Closures In Legs (welded)	4		$31,458
Deballast Legs	10		$78,646
Lift & Secure Jacket for Tow	6		$47,188
Pick Up Anchors	18		$141,563
Tow to Disposal Site	72		$566,250
Transfer Rigging and Release Jacket from Barge, Deballast Jacket	24		$188,750
Demobilize HLV and Pull Tugs	12		$94,375
Work Provisions	45		$394,560
Weather Provisions	45		$394,560
Platform Removal Subtotal	***533***	***22***	***$3,779,271***
Onshore Disposal			
Travel to Onshore Location	504		$381,528
Offload Cargo Barges	144		$109,008
Dispose of Material			$2,706,000
Onshore Disposal Subtotal	***648***	***27***	***$3,196,536***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	144		$61,560
Inspect and Clean up	192		$450,000
Trawl	1,248		$194,688
Demob Vessels from Site	24		$70,254
Weather Provisions	245		$127,013
Site Clearance Subtotal	***1,877***	***78***	***$973,769***
Project Management and Engineering			***$1,148,155***
Platform Total			**$15,500,097**
Total Hours SSCV On Site	287		

U.S. Minerals Management Service
Remote Reefing
Equipment Spread Summary

Item		Rate	Unit			
Well P&A						
Topside Decommissioning/Platform Removal Prep						
Nitrogen Contractor	$	5,000	day			
300 kW Generators (2)	$	563	day			
750 CFM Air Compressor	$	313	day			
550 gal. Diesel Tank	$	25	day			
100 bbl. Potable Water Tank	$	32	day			
150' Supply Vessel	$	8,550	day			
Tug & Cargo Barge	$	11,850	day			
Padeye Fabrication	$	36,000	4 padeyes			
Brace Fabrication	$	25,000	LS			
Labor	$	30,300	day			
Structural Fitter (10)	$	6,000	day			
Welder (8)	$	7,160	day			
NDT	$	3,750	day			
Flush and Clean Spread	$	14,482	day			
Module Preparation Spread	$	39,782	day			
Deck Preparation Spread	$	39,782	day			
Jacket Removal Spread	$	26,392	day			
Pipeline Decommissioning						
DSV	$	40,000	day			
Consumables	$	4,000	day			
P/L Decommissioning Crew	$	16,388	day			
Platform Removal						
2,000 ton HLV	$	5,600	hour	$	134,400	Per Day
Work Boat	$	172	hour	$	4,125	Per Day
Dive Basic Crew	$	500	hour	$	12,000	Per Day
Dive Supplemental Crew	$	400	hour	$	9,600	Per Day
Supplemental Welding Crew	$	-	hour	$	-	Per Day
Explosive Techs	$	78	hour	$	1,125	Per Day
Mechanical Cutter	$	-	hour	$	-	Per Day
Side Scan Sonar	$	115	hour	$	1,875	Per Day
ROV	$	-	hour	$	-	Per Day
Total Spread Rate	*$*	*6,865*	hour	*$*	*164,750*	Per Day
Pull tugs	$	1,000	hour	$	24,000	day
Platform Removal: Lump Sum Items						
Helicopter Trip	$	3,750	round trip			
Site Clearance						
Side Scan Spread	$	428	Per Hour	$	10,260	Per Day
Inspect & Cleanup Spread	$	2,344	Per Hour	$	56,250	Per Day
Trawling Spread	$	156	Per Hour	$	3,744	Per Day
Cargo Barge Listing						
CB 300'x100' and Tug	$	708	Per Hour	$	16,992	Per Day
CB 400'x100' and Tug	$	855	Per Hour	$	20,520	Per Day
Weather Provision		15%				
Operating Efficiency		87%				

U.S. Minerals Managment Service
Partial Removal
Decommissioning Summary - Gail

Task	Days	Cost
SSCV Mob/Demob	188	$4,042,752
CB, Crew and Equipment Mob/Demob	11	$794,098
Well P&A	0	NA
Platform Removal Prep	43	$1,776,756
Pipeline Decommissioning	25	$1,266,942
Conductor Removal	30	957,000
Platform Removal	19	$1,819,834
Onshore Disposal	27	$2,893,332
Site Clearance	78	$973,769
Project Management and Engineering		$775,011
		$15,299,494

Permitting Cost	**$0**
Reef Donation	**$0**
Asset Area Total	***$15,299,494***

U.S. Minerals Managment Service
Partial Removal
Cargo Barge/Crew and Equipment Summary - Gail

Task	Total Hours	Total Days	Total Cost
Gail			
Mob/Demob CB's			
Rig up CB's	48	2	$184,008
Mobilize Cargo Barges to site	144	6	$327,024
Clean up cargo barges	72	3	$163,512
Demob CB's	24	1	$54,504
Mob/Demob CB's Subtotal	*288*		*$729,048*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	48	2	$8,250
Mob/Demob Crew	48	2	$28,800
Mob/Demob Equipment	72	3	$28,000
Mob/Demob Crew & Equipment Subtotal	*168*		*$65,050*
CB, Crew & Equipment Area Total	**456**		**$794,098**

U.S. Minerals Managment Service
Partial Removal
Platform Task Information - Gail

Task	Hours	Days	Cost
Well P&A	***0***	***0***	***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	320		$1,100,640
Prepare Cap Truss for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***688***	***43***	***$1,776,756***
Pipeline Decommissioning			
8" Oil Pipeline to Grace			
Pipeline Inspection	96		$176,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline at Gail	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose Fluids	6		$3,756
8" Gas Pipeline to Grace			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose of Fluids	6		$3,756
8" Gas Pipeline to Grace			
Pipeline Inspection	96		$176,000
Connect Pig Launcher	6		$15,097
Insert Pigs	3		$7,549
Pig and Flush Pipeline	11		$27,678
Remove Launcher	6		$15,097
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129

U.S. Minerals Managment Service
Partial Removal
Platform Task Information - Gail

Task	Hours	Days	Cost
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	10		$25,665
Weather Provisions	10		$25,665
Dispose of Fluids	6		$3,756
Pipeline Decommissioning Subtotal	***594***	***25***	***$1,266,942***
Conductor Removal	***720***	***30***	***$957,000***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize 2,000 ton capacity HLV	24		$174,125
Setup HLV	18		$130,594
Rig & Remove Modules	64		$509,646
Rig & Remove 8 Pile Deck in Two Sections	16		$127,411
Demob HLV	12		$87,063
Mob Dive Spread	12		$22,000
Sever Diag. Braces Below the (-) 86' Elevation	36		$66,000
Sever Legs & Piles Rows 1 & 2 at the (-) 86' Elevation	12		$22,000
Sever Legs & Piles Rows 3 & 4	12		$22,000
Mob Pull Tug	12		$12,000
Rig to Jacket	12		$34,000
Pull 1st 4-Leg Jacket Section	6		$17,000
Rig to Jacket	12		$34,000
Pull 2nd 4-Pile Jacket Section	6		$17,000
Inspect Platform Site	6		$17,000
Demobilize Dive Spread and Pull Tug	12		$34,000
Work Provisions	30		149,498
Weather Provisions	30		149,498
Platform Removal Subtotal	***452***	***19***	***$1,819,834***
Onshore Disposal			
Travel to Onshore Location	504		$381,528
Offload Cargo Barges	144		$109,008
Dispose of Material			$2,402,796
Onshore Disposal Subtotal	***648***	***27***	***$2,893,332***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	144		$61,560
Inspect and Clean up	192		$450,000
Trawl	1,248		$194,688
Demob Vessels from Site	24		$70,254
Weather Provisions	245		$127,013
Site Clearance Subtotal	***1,877***	***78***	***$973,769***
Project Management and Engineering			***$775,011***
Platform Total			**$10,462,644**
Total Hours SSCV On Site	236		

U.S. Minerals Managment Service
Partial Removal
Equipment Spread Summary

Item	Rate	Unit		
Well P&A				
Topside Decommissioning/Platform Removal Prep				
Nitrogen Contractor	$ 5,000	day		
300 kW Generators (2)	$ 563	day		
750 CFM Air Compressor	$ 313	day		
550 gal. Diesel Tank	$ 25	day		
100 bbl. Potable Water Tank	$ 32	day		
150' Supply Vessel	$ 8,550	day		
Tug & Cargo Barge	$ 11,850	day		
Padeye Fabrication	$ 36,000	4 padeyes		
Brace Fabrication	$ 25,000	LS		
Labor	$ 30,300	day		
Structural Fitter (10)	$ 6,000	day		
Welder (8)	$ 7,160	day		
NDT	$ 3,750	day		
Flush and Clean Spread	$ 14,482	day		
Module Preparation Spread	$ 39,782	day		
Deck Preparation Spread	$ 39,782	day		
Jacket Removal Spread	$ 26,392	day		
Pipeline Decommissioning				
DSV	$ 40,000	day		
Consumables	$ 4,000	day		
P/L Decommissioning Crew	$ 16,388	day		
Platform Removal				
2,000 ton capacity HLV	$ 5,600	hour	$ 134,400	Per Day
Work Boat	$ 172	hour	$ 4,125	Per Day
Dive Basic Crew	$ 500	hour	$ 12,000	Per Day
Dive Supplemental Crew	$ 400	hour	$ 9,600	Per Day
Supplemental Welding Crew	$ -	hour	$ -	Per Day
Explosive Techs	$ -	hour	$ -	Per Day
Mechanical/Abrasive Cutter	$ 469	hour	$ 11,250	Per Day
Side Scan Sonar	$ 115	hour	$ 1,875	Per Day
ROV	$ -	hour	$ -	Per Day
Total Spread Rate	*$ 7,255*	*hour*	*$ 174,125*	Per Day
Pull Tug	$ 1,000	hour	$24,000	Per Day
Platform Removal: Lump Sum Items				
Helicopter Trip	$ 3,750	round trip		
Site Clearance				
Side Scan Spread	$ 428	Per Hour	$ 10,260	Per Day
Inspect & Cleanup Spread	$ 2,344	Per Hour	$ 56,250	Per Day
Trawling Spread	$ 156	Per Hour	$ 3,744	Per Day
Cargo Barge Listing				
CB 300'x100' and Tug	$ 708	Per Hour	$ 16,992	Per Day
CB 400'x100' and Tug	$ 855	Per Hour	$ 20,520	Per Day
Weather Provision	15%			
Operating Efficiency	87%			

U.S. Minerals Management Service
Complete Removal
Decommissioning Summary - Harmony

Task	Days	Cost
Platform Harmony		
SSCV Mob/Demob	188	$15,040,000
CB, Crew and Equipment Mob/Demob	14	$4,531,206
Well P&A	0	NA
Platform Removal Prep	59	$2,657,268
Pipeline Decommissioning	37	$1,862,445
Conductor Removal	365	$11,679,000
Platform Removal	96	$53,546,489
Onshore Disposal	90	$23,961,144
Site Clearance	289	$2,334,236
Project Management and Engineering		$7,683,246
		$123,295,033

Permitting Cost	**$0**
Reef Donation	**$0**
Grand Total	***$123,295,033***

U.S. Minerals Management Service
Complete Removal
Cargo Barge/Crew and Equipment Summary - Harmony

Task	Total Hours	Total Days	Total Cost
Harmony			
Mob/Demob CB's			
Rig up CB's	48	2	$920,032
Mobilize Cargo Barges to site	144	6	$2,185,834
Clean up Cargo Barges	72	3	$1,005,048
Demob Cargo Barges	24	1	$335,016
Mob/Demob CB's Subtotal	*240*		*$4,445,930*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	24	1	$4,700
Mob/Demob Crew	12	1	$23,312
Mob/Demob Equipment	48	2	$57,264
Mob/Demob Crew & Equipment Subtotal	*84*		*$85,276*
CB, Crew & Equipment Total	**324**		**$4,531,206**

Task	Hours	Days	Cost
Well P&A	***NA***		***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	576		$1,981,152
Prepare Module support frame for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***944***	***59***	***$2,657,268***
Pipeline Decommissioning			
14" Oil/Water line from Hondo	0		$0
12" Gas line from Heritage	0		$0
12" Water line from Las Flores Canyon	0		$0
12" Gas to Hondo			
Pipeline Inspection	168		$308,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	16		$40,259
Insert Pigs	3		$7,549
Pig and Flush Pipeline	14		$35,226
Remove Launcher	30		$75,485
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	16		39,630
Weather Provisions	16		39,630
Dispose of Fluids	7		$4,780
20" Oil/Water to Las Flores Canyon			
Pipeline Inspection	168		$308,000
Connect Pig Launcher	24		$60,388
Insert Pigs	6		$15,097
Pig and Flush Pipeline	145		$364,844
Remove Launcher	24		$60,388
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	36		$90,959.43
Weather Provisions	36		$90,959.43
Dispose of Fluids	73		$49,505
Pipeline Decommissioning Subtotal	***889***	***37***	***1,862,445***
Conductor Removal	***8,760***	***365***	***$11,679,000***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize SSCV	24		$552,280
Setup SSCV	18		$414,210

U.S. Minerals Management Service
Complete Removal
Platform Task Information - Harmony

Task	Hours	Days	Cost
Rig & Remove Modules	100		$2,386,667
Rig & Remove 8 Pile Deck in Two Sections	16		$381,867
Fabricate Explosives	0		$715,622
Install Explosives	56		$1,288,654
Pre/Post Detonation Survey	1		$26,762
Standby for Daylight Detonation	8		$184,093
Sever Main Pile & Skirt Piles	8		$184,093
1st Cut			
Install Lifting Appurtenance/closure (8)	12		$276,140
Install Lift Bags (if required)	0		$0
Rig to Jacket (2 cranes)	3		$69,035
Deballast Main Pile	18		$414,210
Lift Jacket & Secure for Move	8		$184,093
Move Jacket to 1063' Water Depth	3		$69,035
Set Jacket on Bottom & Reballast Main Pile	6		$147,223
Derig Cranes From Jacket	4		$98,149
Secure Support Derrick Barge to Jacket	2		$49,074
Remove Lifting Appurtenances From Rows 1&4	4		$98,149
Reorintate Lifting Appurtenances on Rows 2&3	6		$147,223
Scaffold Jacket Legs Above the (-) 15 Elevation	6		$147,223
Rig One SSCV Crane to the Center Four Legs (rows 2&3)	3		$73,612
Sever Jacket Horizontally Above the (-) 125' Elevation	12		$294,446
Lift Top 140' Section of Jacket	1		$24,537
Set Jacket Upright on CB#1	2		$49,074
Seafasten	15		$368,058
Derig From Jacket Section	6		$147,223
2nd Cut			
Install Lifting Appurtenances/Closures (4) (4 Installed Concurrent with Seafastening) Includes Rigging to Crane Blocks	6		$147,223
Deballast Jacket Legs	16		$392,595
Lift Jacket & Secure for Move	8		$196,297
Move to 908' Water Depth	3		$73,612
Set Jacket on Bottom & Reballast Main Pile	6		$147,223
Derig Cranes From Jacket	4		$98,149
Secure Support D B to Jacket	2		$49,074
Remove Lifting Appurtenances From Rows 1&4	4		$98,149
Reorintate Lifting Appurtenances on Rows 2&3	6		$147,223
Scaffold Jacket Legs Above the (-) 280' Elevation	6		$147,223
Rig 1 SSCV Crane to the Center Four Legs (rows 2&3)	3		$73,612
Sever Jacket Horizontally Above the (-) 280' Elevation	10		$245,372
Lift the 155' Jacket Section	1		$24,537
Set Jacket Section Upright on CB#1	2		$49,074
Seafasten	15		$368,058
Derig From Jacket Section	6		$147,223
3rd Cut			
Install Lifting Appurtenances/Closures (4) (4 Installed Concurrent with Seafastening)	6		$138,070
Deballast Jacket Legs	15		$345,175
Lift Jacket & Secure for Move	8		$184,093
Move to 813' Water Depth	8		$184,093
Set Jacket on Bottom & Reballast Main Pile	6		$143,200
Derig One SSCV Crane	3		$71,600
Secure Support DB to Jacket	2		$47,733
Sever & Remove Braces Between Rows 2&3	6		$143,200
Scaffold Jacket Legs Above the (-) 375 Elevation	6		$143,200

Task	Hours	Days	Cost
Sever Rows 1&2 Horizontally Above the (-) 375 Elevation	8		$190,933
Lift 95' Rows 1&2 Section	1		$23,867
Set Up Right on CB#2	1		$23,867
Seafasten	10		$238,667
Derig From Rows 1&2 Section	6		$143,200
Rig to Rows 3&4	2		$47,733
Sever Rows 3&4 Horizontally Above the (-) 375 Elevation	3		$71,600
Lift 95' Rows 3&4 Section	1		$23,867
Set Upright on CB#2	1		$23,867
Seafasten	10		$238,667
Derig From Rows 3&4 Section	6		$143,200
4th Cut			
Install Lifting Appurtenances/Closures (4) (4 installed concurrently with seafastening)	6		$138,070
Deballast Jacket Legs	14		$322,163
Lift Jacket & Secure for Move	8		$184,093
Move to 703' Water depth	3		$69,035
Set Jacket on Bottom & Reballast Jacket Legs	6		$143,200
Derig One SSCV Crane	3		$71,600
Secure Support DB to Jacket	2		$47,733
Sever & Remove Braces Between Rows 2&3	6		$143,200
Scaffold Jacket Legs Above the (-) 485' Elevation	6		$143,200
Sever Rows 1&2 Horizontally Above the (-) 485 Elevation	4		$95,467
Lift 110' Rows 1&2 Section	1		$23,867
Set Upright on CB#3	1		$23,867
Seafasten	10		$238,667
Derig From Rows 1&2 Section	6		$143,200
Rig to Rows 3&4	2		$47,733
Sever Rows 3&4 Horizontally Above the (-) 485 Elevation	4		$95,467
Lift 110' Rows 3&4 Section	1		$23,867
Set up Right on CB#3	1		$23,867
Seafasten	10		$238,667
Derig From Rows 3&4	6		$143,200
5th Cut			
Install Lifting Appurtenances/Closures (4) (4 installed concurrently with seafastening)	6		$138,070
Deballast Jacket Legs	12		$276,140
Lift & Secure Jacket for Move	8		$184,093
Move to 588' Water Depth	3		$69,035
Set Jacket on Bottom & Reballast Jacket Legs	6		$144,172
Derig One SSCV Crane	3		$72,086
Secure Support DB to Jacket	2		$48,057
Sever & Remove Braces Between Rows 2&3	6		$144,172
Scaffold Jacket Legs Above the (-) 600' Elevation	6		$144,172
Sever Rows 1&2 Horizontally Above the (-) 600' Elevation	4		$96,115
Lift 115' Row 1&2 Section	1		$24,029
Set Upright on CB#4	1		$24,029
Seafasten	10		$240,287
Derig From Rows 1&2	6		$144,172
Rig to Rows 3&4	2		$48,057
Sever Rows 3&4 Horizontally Above the (-)600' Elevation	4		$96,115
Lift 115' Row 3&4 Section	1		$24,029
Set Upright on CB#4	1		$24,029
Seafasten	10		$240,287
Derig From Rows 3&4	6		$144,172
6th Cut			

U.S. Minerals Management Service
Complete Removal
Platform Task Information - Harmony

Task	Hours	Days	Cost
Install Lifting Appurtenances/Closures (4) (4 installed concurrently with seafastening)	6		$138,070
Deballast Jacket Legs	11		$253,128
Lift & Secure Jacket for Move	8		$184,093
Move to 468' Water Depth	3		$69,035
Set Jacket on Bottom & Reballast Jacket Legs	6		$144,172
Derig One SSCV Crane	3		$72,086
Secure Support DB to Jacket	2		$48,057
Sever & Remove Braces Between Rows 1&2	6		$144,172
Scaffold Jacket Legs Above the (-) 720' Elevation	6		$144,172
Sever Rows 1&2 Horizontally Above the (-) 720' Elevation	4		$96,115
Lift 120' Row 1&2 Section	1		$24,029
Set Upright on CB#5	1		$24,029
Seafasten	10		$240,287
Derig From Rows 1&2	6		$144,172
Rig to Rows 3&4	2		$48,057
Sever Rows 3&4 Horizontally Above the (-) 720' Elevation	4		$96,115
Lift 120' Row 3&4 Section	1		$24,029
Set Upright on CB#5	1		$24,029
Seafasten	10		$240,287
Derig From Rows 3&4	6		$144,172
7th Cut			$0
Install Lifting Appurtenances/Closures (4) (4 installed concurrently with seafastening)	6		$138,070
Deballast Jacket Legs	8		$184,093
Lift Jacket & Secure for Move	8		$184,093
Move to 348' Water Depth	3		$69,035
Set Jacket on Bottom & Reballast Jacket Legs	6		$145,698
Derig Two SSCV Cranes	4		$97,132
Secure Support DB to Jacket	2		$48,566
Scaffold Jacket Legs Above the (-) 840' Elevation	6		$145,698
Sever & Remove Braces Between Rows 2&3	6		$145,698
Sever Braces Between Rows 'A'&'B'	4		$97,132
Rig to & Sever Legs A1&A2 Above the (-) 840' Elevation	5		$121,415
Lift 120' Section of Legs A1&A2	1		$24,283
Rig to Bottoms of Legs A1&A2	6		$145,698
Rotate Legs A1&A2 Horizontal	2		$48,566
Move CB#6 Under Cranes & Secure	3		$72,849
Lay Legs A1&A2 On CB#6	2		$48,566
Seafasten	6		$145,698
Derig Row Legs A1&A2	6		$145,698
Rig to & Sever Legs A3&A4 Above the (-) 840' Elevation	5		$121,415
Lift 120' Section of Legs A3&A4	1		$24,283
Rig to Bottoms of Legs A3&A4	6		$145,698
Rotate Legs A3&A4 Horizontal	2		$48,566
Move CB#6 Under Cranes & Secure	3		$72,849
Lay Legs A3&A4 On CB#6	2		$48,566
Seafasten	6		$145,698
Derig From Legs A3&A4	6		$145,698
Relocate SSCV to 'B' Row of Jacket	4		$97,132
Rig to & Sever Legs B1&B2 Above the (-) 840' Elevation	5		$121,415
Lift 120' Section of Legs B1&B2	1		$24,283
Rig to Bottoms of Legs B1&B2	6		$145,698
Rotate Legs B1&B2 horizontal	2		$48,566
Move CB#6 Under Cranes & Secure	3		$72,849
Lay Legs B1&B2 on CB#6	2		$48,566

U.S. Minerals Management Service
Complete Removal
Platform Task Information - Harmony

Task	Hours	Days	Cost
Seafasten	6		$145,698
Derig From B1&B2 Legs	6		$145,698
Rig to & Sever Legs B3&B4 Above the (-) 840' Elevation	5		$121,415
Lift 120' Section of Legs B3&B4	1		$24,283
Rig to Bottoms of Leg B3&B4	6		$145,698
Rotate Legs B3&B4 horizontal	2		$48,566
Move CB#6 Under Cranes & Secure	3		$72,849
Lay Legs B3&B4 on CB#6	2		$48,566
Seafasten	6		$145,698
Derig From Legs B3&B4	6		$145,698
8th Cut			
Install Lifting Appurtenances/Closures (4) (4 installed concurrent with 'B' row lift)	6		$138,070
Deballast Jacket Legs	6		$138,070
Lift Jacket & Secure for Move	8		$184,093
Move Jacket to 288' Water Depth	3		$69,035
Set Jacket on Bottom & Reballast Jacket Legs	6		$145,698
Derig Two SSCV Cranes	4		$97,132
Secure Support DB to Jacket	2		$48,566
Scaffold Jacket Legs Above the (-) 960' Elevation	6		$145,698
Sever & Remove Braces Between Rows 2&3	6		$145,698
Sever Braces Between Rows 'A'&'B'	4		$97,132
Rig to & Sever Legs B1&B2 Above the (-) 960' Elevation	5		$121,415
Lift 120' Section of Legs B1&B2	1		$24,283
Rig to Bottom of Legs B1&B2	6		$145,698
Rotate Legs B1&B2 horizontal	2		$48,566
Move CB#7 Under Cranes & Secure	3		$72,849
Lay Legs B1&B2 on CB#7	2		$48,566
Seafasten	6		$145,698
Derig From Legs B1&B2	6		$145,698
Rig to & Sever Leg B3&B4 Above the (-) 960' Elevation	5		$121,415
Lift 120' Section of Legs B3&B4	1		$24,283
Rig to Bottoms of Legs B3&B4	6		$145,698
Rotate Legs B3&B4 horizontal	2		$48,566
Move CB#7 Under Cranes & Secure	3		$72,849
Lay Legs B3&B4 on CB#7	2		$48,566
Seafasten	6		$145,698
Derig From Legs B3&B4	6		$145,698
Relocate SSCV to 'A' Row	4		$97,132
Rig to & Sever Legs A1&A2 Above the (-) 960' Elevation	5		$121,415
Lift 120' Section of Legs A1&A2	1		$24,283
Rig to Bottoms of Legs A1&A2	6		$145,698
Rotate Legs A1&A2 Horizontal	2		$48,566
Move CB#7 Under Cranes & Secure	3		$72,849
Lay on Legs A1&A2 on CB#7	2		$48,566
Seafasten	6		$145,698
Derig From Legs A1&A2	6		$145,698
Rig to & Sever Legs A3&A4 Above the (-) 960' Elevation	5		$121,415
Lift 120' Section of Legs A3&A4	1		$24,283
Rig to Bottoms of Legs A3&A4	6		$145,698
Rotate Legs A3&A4 Horizontal	2		$48,566
Move CB#8 Under Cranes & Secure	3		$72,849
Lay Legs A3&A4 On CB#8	2		$48,566
Seafasten	6		$145,698
Derig From Legs A3&A4	6		$145,698
9th Cut			

U.S. Minerals Management Service
Complete Removal
Platform Task Information - Harmony

Task	Hours	Days	Cost
Install Lifting Appurtenances/Closures (4) (4 installed concurrent with 'A' row lift)	6		$145,698
Deballast Jacket Legs	4		$97,132
Lift Jacket & Secure for Move	8		$194,263
Move Jacket to 108' Water Depth	3		$72,849
Set Jacket on Bottom & Reballast Jacket Legs	6		$145,698
Derig Two SSCV Cranes	4		$97,132
Secure Support DB to Jacket	2		$48,566
Scaffold Jacket Legs Above the (-) 1080 Elevation	6		$145,698
Sever & Remove Braces Between Rows 2&3	6		$145,698
Sever Braces Between Rows 'A'&'B'	4		$97,132
Rig to & Sever Legs A1&A2 Above the (-) 1080 Elevation	5		$121,415
Lift 120' Section of Legs A1&A2	1		$24,283
Rig to Bottoms of Legs A1&A2	6		$145,698
Rotate Legs A1&A2 Horizontal	2		$48,566
Move CB#8 Under Cranes & Secure	3		$72,849
Lay Legs A1&A2 On CB#8	2		$48,566
Seafasten	6		$145,698
Derig From Legs A1&A2	6		$145,698
Rig to & Sever Legs A3&A4 Above the (-)1080' Elevation	5		$121,415
Lift 120' Section of Legs A3&A4	1		$24,283
Rig to Bottoms of Legs A3&A4	6		$145,698
Rotate Legs A3&A4 Horizontal	2		$48,566
Move CB#8 Under Cranes & Secure	3		$72,849
Lay Legs A3&A4 on CB#8	2		$48,566
Seafasten	6		$145,698
Derig From Legs A3&A4	6		$145,698
Relocate SSCV to 'B' Row of Jacket	4		$95,467
Rig to & Sever Legs B1&B2 Above the (-) 1080' Elevation	5		$119,333
Lift 120' Section of B1&B2	1		$23,867
Rig to Bottoms of Legs B1&B2	6		$143,200
Rotate Legs B1&B2 horizontal	2		$47,733
Move CB#9 Under Cranes & Secure	3		$71,600
Lay Legs B1&B2 on CB#9	2		$47,733
Seafasten	6		$143,200
Derig From Legs B1&B2	6		$143,200
Rig to & Sever Legs B3&B4 Above the (-) 1080' Elevation	5		$119,333
Lift 120' Section of Legs B3&B4	1		$23,867
Rig to Bottoms of Legs B3&B4	6		$143,200
Rotate Legs B3&B4 horizontal	2		$47,733
Move CB#9 Under Cranes & Secure	3		$71,600
Lay Legs B3&B4 on CB#9	2		$47,733
Seafasten	6		$143,200
Derig From Legs B3&B4	6		$143,200
Sever & Remove Braces Between Rows 2&3 Above Water	6		$147,223
Sever & Remove Underwater Braces Between Rows 2&3	48		$1,177,784
Set Anchors on Support DB	6		$147,223
Secure Legs A1&A2 to Support DB	4		$98,149
Sever Underwater Braces Between A1&A2 and B1&B2	8		$196,297
Rig SSCV to Legs B1&B2	4		$98,149
Sever Above Water Braces Between Rows A1&A2 and B1&B2	4		$98,149
Lift Legs B1&B2 With Five Skirt Piles	2		$49,074
Rig to Bottoms of Legs B1&B2 Section	8		$196,297
Rotate Legs B1&B2 horizontal	4		$98,149
Move CB#10 Under Cranes	3		$73,612
Lay Legs B1&B2 on CB#10	3		$73,612

Task	Hours	Days	Cost
Seafasten	10		$245,372
Derig From Legs B1&B2	10		$245,372
Rig SSCV to Legs A1&A2	4		$98,149
Derig Support DB From Rows A1&A2	4		$98,149
Lift Legs A1&A2 With Five Skirt Piles	2		$49,074
Rig to Bottoms of Legs A1&A2	8		$196,297
Rotate Legs A1&A2 Section	4		$98,149
Move CB#10 Under Cranes	3		$73,612
Lay on CB#10	3		$73,612
Seafasten	10		$245,372
Derig From Legs A1&A2	10		$245,372
Secure Legs A3&A4 to Support DB	4		$98,149
Sever Underwater Braces Between A3&A4 and B3&B4	8		$196,297
Rig SSCV to Legs B3&B4	4		$98,149
Sever Underwater Braces Between A3&A4 and B3&B4	4		$98,149
Lift Leg B3&B4 Horizontal	2		$49,074
Rig to Bottoms Legs B3&B4 Horizontal	8		$196,297
Rotate Legs B3&B4 horizontal	4		$98,149
Move CB#10 Under Cranes	3		$73,612
Lay on CB#10	3		$73,612
Seafasten	10		$245,372
Derig From Legs B3&B4	10		$245,372
Rig SSCV Crane to Legs A3&A4	4		$98,149
Derig Support DB From Rows A3&A4	4		$98,149
Lift Legs A3&A4 with Five Skirt Piles	2		$49,074
Rig to Bottoms of Legs A3&A4 section	8		$196,297
Rotate Legs A3&A4 Horizontal	4		$98,149
Move CB#10 Under Cranes	3		$73,612
Lay on CB#10	3		$73,612
Seafasten	10		$245,372
Derig From Legs A3&A4	10		$245,372
Pickup Anchors	18		$414,210
Demobilize SSCV	12		$276,140
Work Provisions	249		$6,092,216
Weather Provisions	249		$6,092,216
Platform Removal Subtotal	***2,306***	***96***	***$53,546,489***
Onshore Disposal			
Travel to Onshore Location	1,680		$2,345,112
Offload Cargo Barges	480		$670,032
Dispose of Material			$20,946,000
Onshore Disposal Subtotal	***2,160***	***90***	***$23,961,144***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	624		$266,760
Inspect and Clean up	360		$843,750
Trawl	4,992		$778,752
Demob Vessels from Site	24		$70,254
Weather Provisions	904		$304,466
Site Clearance Subtotal	***6,928***	***289***	***$2,334,236***
Project Management and Engineering			***$7,683,246***
Platform Total			**$103,723,828**

Task		Hours	Days	Cost
	Total Hours SSCV On Site	1,651		

U.S. Minerals Management Service
Complete Removal
Equipment Spread Summary

Item	Rate	Unit		
Well P&A				
Topside Decommissioning/Platform Removal Prep				
Nitrogen Contractor	$ 5,000	day		
300 kW Generators (2)	$ 563	day		
750 CFM Air Compressor	$ 313	day		
550 gal. Diesel Tank	$ 25	day		
100 bbl. Potable Water Tank	$ 32	day		
150' Supply Vessel	$ 8,550	day		
Tug & Cargo Barge	$ 11,850	day		
Padeye Fabrication	$ 36,000	4 padeyes		
Brace Fabrication	$ 25,000	LS		
Labor	$ 30,300	day		
Structural Fitter (10)	$ 6,000	day		
Welder (8)	$ 7,160	day		
NDT	$ 3,750	day		
Flush and Clean Spread	$ 14,482	day		
Module Preparation Spread	$ 39,782	day		
Deck Preparation Spread	$ 39,782	day		
Jacket Removal Spread	$ 26,392	day		
Pipeline Decommissioning				
DSV	$ 40,000	day		
Consumables	$ 4,000	day		
P/L Decommissioning Crew	$ 16,388	day		
Platform Removal				
SSCV	$ 20,833	hour	$ 500,000	Per Day
Work Boat	$ 172	hour	$ 4,125	Per Day
Dive Basic Crew	$ 500	hour	$ 12,000	Per Day
Dive Supplemental Crew	$ 400	hour	$ 9,600	Per Day
Supplemental Welding Crew	$ 445	hour	$ 10,680	Per Day
Explosive Tech	$ 78	hour	$ 1,125	Per Day
Mechanical/Abrasive Cutter	$ 469	hour	$ 11,250	Per Day
Side Scan Sonar	$ 115	hour	$ 1,875	Per Day
Total Spread Rate	*$ 23,012*	*hour*	*$ 552,280*	Per Day
Platform Removal: Lump Sum Items				
Helicopter Trip	$ 3,750	round trip		
Mechanical Lifting Appurtenances	$ 2,500,000			
Site Clearance				
Side Scan Spread	$ 428	Per Hour	$ 10,260	Per Day
Inspect & Cleanup Spread	$ 2,344	Per Hour	$ 56,250	Per Day
Trawling Spread	$ 156	Per Hour	$ 3,744	Per Day
Cargo Barge Listing				
CB 400'x100' and Tug	$ 855	Per Hour	$ 20,520	Per Day
CB 450'x100' and Tug	$ 900	Per Hour	$ 21,600	Per Day
CB 450'x150' and Tug	$ 1,017	Per Hour	$ 24,408	Per Day
CB 524'x138' and Tug	$ 1,271	Per Hour	$ 30,510	Per Day
CB 580'x160' and Tug	$ 1,526	Per Hour	$ 36,612	Per Day
CB 650'x170' and Tug	$ 1,780	Per Hour	$ 42,714	Per Day
Weather Provision	15%			
Operating Efficiency	87%			

U.S. Minerals Management Service
Remote Reefing
Decommissioning Summary - Harmony

Task	Days	Cost
Platform Harmony		
SSCV Mob/Demob	188	$4,042,752
CB, Crew and Equipment Mob/Demob	14	$1,170,236
Well P&A	0	NA
Platform Removal Prep	59	$2,657,268
Pipeline Decommissioning	37	$1,862,445
Conductor Removal	365	$11,679,000
Platform Removal	27	$5,276,298
Onshore Disposal	90	$5,109,720
Site Clearance	78	$973,769
Project Management and Engineering		$2,204,680
		$34,976,168

Permitting Cost	**$0**
Reef Donation	**$0**
Grand Total	***$34,976,168***

U.S. Minerals Management Service
Remote Reefing
Cargo Barge/Crew and Equipment Summary - Harmony

Task	Total Hours	Total Days	Total Cost
Harmony			
Mob/Demob CB's			
Rig up CB's	48	2	$264,160
Mobilize Cargo Barges to site	144	6	$492,480
Clean up Cargo Barges	72	3	$246,240
Demob Cargo Barges	24	1	$82,080
Mob/Demob CB's Subtotal	*240*		*$1,084,960*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	24	1	$4,700
Mob/Demob Crew	12	1	$23,312
Mob/Demob Equipment	48	2	$57,264
Mob/Demob Crew & Equipment Subtotal	*84*		*$85,276*
CB, Crew & Equipment Total	**324**		**$1,170,236**

U.S. Minerals Management Service
Remote Reefing
Platform Task Information - Harmony

Task	Hours	Days	Cost
Well P&A	***NA***		***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	576		$1,981,152
Prepare Module support frame for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***944***	***59***	***$2,657,268***
Pipeline Decommissioning			
14" Oil/Water line from Hondo	0		$0
12" Gas line from Heritage	0		$0
12" Water line from Las Flores Canyon	0		$0
12" Gas to Hondo			
Pipeline Inspection	168		$308,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	16		$40,259
Insert Pigs	3		$7,549
Pig and Flush Pipeline	14		$35,226
Remove Launcher	30		$75,485
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	16		39,630
Weather Provisions	16		39,630
Dispose of Fluids	7		$4,780
20" Oil/Water to Las Flores Canyon			
Pipeline Inspection	168		$308,000
Connect Pig Launcher	24		$60,388
Insert Pigs	6		$15,097
Pig and Flush Pipeline	145		$364,844
Remove Launcher	24		$60,388
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	36		$90,959.43
Weather Provisions	36		$90,959.43
Dispose of Fluids	73		$49,505
Pipeline Decommissioning Subtotal	***889***	***37***	***1,862,445***
Conductor Removal	***8,760***	***365***	***$11,679,000***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize 2,000 ton capacity HLV	24		$164,750
Setup HLV	18		$123,563

Task	Hours	Days	Cost
Rig & Remove Modules	100		$771,959
Rig & Remove 8 Pile Deck in Two Sections	16		$123,513
Fabricate Explosives	0		$715,622
Install Explosives	56		$384,417
Pre/Post Detonation Survey	1		$10,615
Standby for Daylight Detonation	8		$54,917
Sever Main Pile & Skirt Piles	8		$54,917
Install Lifting Appurtenances (welded - preinstalled)	8		$70,917
Install Closures (welded)	4		$35,458
Deballast Main Pile	18		$159,563
Lift & Secure Jacket for Tow	6		$53,188
Pick Up Anchors	18		$159,563
Tow to Disposal Site	72		$638,250
Transfer Rigging and Release Jacket from Barge, Deballast Jacket	36		$319,125
Demobilize HLV and Pull Tugs	12		$106,375
Work Provisions	57		$567,294
Weather Provisions	57		$567,294
Platform Removal Subtotal	***639***	***27***	***$5,276,298***
Onshore Disposal			
Travel to Onshore Location	1,680		$574,560
Offload Cargo Barges	480		$164,160
Dispose of Material			$4,371,000
Onshore Disposal Subtotal	***2,160***	***90***	***$5,109,720***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	144		$61,560
Inspect and Clean up	192		$450,000
Trawl	1,248		$194,688
Demob Vessels from Site	24		$70,254
Weather Provisions	245		$127,013
Site Clearance Subtotal	***1,877***	***78***	***$973,769***
Project Management and Engineering			***$2,204,680***
Platform Total			**$29,763,180**
Total Hours SSCV On Site	369		

U.S. Minerals Management Service
Remote Reefing
Equipment Spread Summary

Item		Rate	Unit			
Well P&A						
Topside Decommissioning/Platform Removal Prep						
Nitrogen Contractor	$	5,000	day			
300 kW Generators (2)	$	563	day			
750 CFM Air Compressor	$	313	day			
550 gal. Diesel Tank	$	25	day			
100 bbl. Potable Water Tank	$	32	day			
150' Supply Vessel	$	8,550	day			
Tug & Cargo Barge	$	11,850	day			
Padeye Fabrication	$	36,000	4 padeyes			
Brace Fabrication	$	25,000	LS			
Labor	$	30,300	day			
Structural Fitter (10)	$	6,000	day			
Welder (8)	$	7,160	day			
NDT	$	3,750	day			
Flush and Clean Spread	$	14,482	day			
Module Preparation Spread	$	39,782	day			
Deck Preparation Spread	$	39,782	day			
Jacket Removal Spread	$	26,392	day			
Pipeline Decommissioning						
DSV	$	40,000	day			
Consumables	$	4,000	day			
P/L Decommissioning Crew	$	16,388	day			
Platform Removal						
2,000 ton HLV	$	5,600	hour	$	134,400	Per Day
Work Boat	$	172	hour	$	4,125	Per Day
Dive Basic Crew	$	500	hour	$	12,000	Per Day
Dive Supplemental Crew	$	400	hour	$	9,600	Per Day
Supplemental Welding Crew	$	-	hour	$	-	Per Day
Explosive Tech	$	78	hour	$	1,125	Per Day
Mechanical/Abrasive Cutter	$	-	hour	$	-	Per Day
Side Scan Sonar	$	115	hour	$	1,875	Per Day
ROV	$	-	hour	$	-	Per Day
Total Spread Rate	*$*	*6,865*	*hour*	*$*	*164,750*	Per Day
Pull Tugs	$	1,000	hour	$	24,000	per Day
Platform Removal: Lump Sum Items						
Helicopter Trip	$	3,750	round trip			
Mechanical Lifting Appurtenances	$	2,500,000				
Site Clearance						
Side Scan Spread	$	428	Per Hour	$	10,260	Per Day
Inspect & Cleanup Spread	$	2,344	Per Hour	$	56,250	Per Day
Trawling Spread	$	156	Per Hour	$	3,744	Per Day
Cargo Barge Listing						
CB 300'x100' and Tug	$	708	Per Hour	$	16,992	Per Day
CB 400'x100' and Tug	$	855	Per Hour	$	20,520	Per Day
Weather Provision		15%				
Operating Efficiency		87%				

U.S. Minerals Management Service
Partial Removal
Decommissioning Summary - Harmony

Task	Days	Cost
Platform Harmony		
SSCV Mob/Demob	188	$4,042,752
CB, Crew and Equipment Mob/Demob	14	$1,170,236
Well P&A	0	NA
Platform Removal Prep	59	$2,657,268
Pipeline Decommissioning	37	$1,862,445
Conductor Removal	69	$2,218,500
Platform Removal	21	$2,214,680
Onshore Disposal	90	$3,885,842
Site Clearance	78	$973,769
Project Management and Engineering		$1,105,000
		$20,130,493

Permitting Cost	**$0**
Reef Donation	**$0**
Grand Total	***$20,130,493***

U.S. Minerals Management Service
Partial Removal
Cargo Barge/Crew and Equipment Summary - Harmony

Task	Total Hours	Total Days	Total Cost
Harmony			
Mob/Demob CB's			
Rig up CB's	48	2	$264,160
Mobilize Cargo Barges to site	144	6	$492,480
Clean up Cargo Barges	72	3	$246,240
Demob Cargo Barges	24	1	$82,080
Mob/Demob CB's Subtotal	*240*		*$1,084,960*
Mob/Demob Crew & Equipment			
Mob/Demob Work Boat	24	1	$4,700
Mob/Demob Crew	12	1	$23,312
Mob/Demob Equipment	48	2	$57,264
Mob/Demob Crew & Equipment Subtotal	*84*		*$85,276*
CB, Crew & Equipment Total	**324**		**$1,170,236**

Task	Hours	Days	Cost
Well P&A	***NA***		***NA***
Platform Removal Prep			
Flush, Purge and Clean Facilities, Tanks and Vessels	224		$202,748
Prepare Modules for Removal	576		$1,981,152
Prepare Module support frame for Removal	96		$358,192
Prepare Jacket for Removal	48		$115,176
Platform Removal Prep Subtotal	***944***	***59***	***$2,657,268***
Pipeline Decommissioning			
14" Oil/Water line from Hondo	0		$0
12" Gas line from Heritage	0		$0
12" Water line from Las Flores Canyon	0		$0
12" Gas to Hondo			
Pipeline Inspection	168		$308,000
Mobilize DSV	12		$30,194
Connect Pig Launcher	16		$40,259
Insert Pigs	3		$7,549
Pig and Flush Pipeline	14		$35,226
Remove Launcher	30		$75,485
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Work Provisions	16		39,630
Weather Provisions	16		39,630
Dispose of Fluids	7		$4,780
20" Oil/Water to Las Flores Canyon			
Pipeline Inspection	168		$308,000
Connect Pig Launcher	24		$60,388
Insert Pigs	6		$15,097
Pig and Flush Pipeline	145		$364,844
Remove Launcher	24		$60,388
Expose Pipeline	8		$20,129
Cut, Plug and Bury Pipeline	10		$25,162
Cut Pipeline Riser	3		$7,549
Expose Pipeline (terminating end)	8		$20,129
Cut, Plug and Bury Pipeline (terminating end)	10		$25,162
Cut Pipeline Riser (terminating end)	3		$7,549
Demobilize DSV	12		$30,194
Work Provisions	36		$90,959.43
Weather Provisions	36		$90,959.43
Dispose of Fluids	73		$49,505
Pipeline Decommissioning Subtotal	***889***	***37***	***1,862,445***
Conductor Removal	***1,656***	***69***	***$2,218,500***
Platform Removal			
Platform Inspection	120		$195,000
Mobilize 2,000 ton capacity HLV	24		$174,125
Setup HLV	18		$130,594

U.S. Minerals Management Service
Partial Removal
Platform Task Information - Harmony

Task	Hours	Days	Cost
Rig & Remove Modules	100		$811,021
Rig & Remove 8 Pile Deck in Two Sections	16		$129,763
Demob HLV	12		$87,063
Mob Dive Spread	12		$22,000
Sever Diag. Braces Below the (-) 86' Elevation	36		$66,000
Sever Legs & Piles Rows 1 & 2 at the (-) 86' Elevation	12		$22,000
Sever Legs & Piles Rows 3 & 4	12		$22,000
Mob Pull Tug	12		$12,000
Rig to Jacket	12		$34,000
Pull 1st 4-Leg Jacket Section	6		$17,000
Rig to Jacket	12		$34,000
Pull 2nd 4-Pile Jacket Section	6		$17,000
Inspect Platform Site	6		$17,000
Demobilize Dive Spread and Pull Tug	12		$34,000
Work Provisions	35		195,057
Weather Provisions	35		195,057
Platform Removal Subtotal	***499***	***21***	***$2,214,680***
Onshore Disposal			
Travel to Onshore Location	1,680		$574,560
Offload Cargo Barges	480		$164,160
Dispose of Material			$3,147,122
Onshore Disposal Subtotal	***2,160***	***90***	***$3,885,842***
Site Clearance			
Mob Vessels to Site	24		$70,254
Side Scan at Platform Location	144		$61,560
Inspect and Clean up	192		$450,000
Trawl	1,248		$194,688
Demob Vessels from Site	24		$70,254
Weather Provisions	245		$127,013
Site Clearance Subtotal	***1,877***	***78***	***$973,769***
Project Management and Engineering			***$1,105,000***
Platform Total			**$14,917,505**
Total Hours SSCV On Site	284		

U.S. Minerals Management Service
Partial Removal
Equipment Spread Summary

Item		Rate	Unit			
Well P&A						
Topside Decommissioning/Platform Removal Prep						
Nitrogen Contractor	$	5,000	day			
300 kW Generators (2)	$	563	day			
750 CFM Air Compressor	$	313	day			
550 gal. Diesel Tank	$	25	day			
100 bbl. Potable Water Tank	$	32	day			
150' Supply Vessel	$	8,550	day			
Tug & Cargo Barge	$	11,850	day			
Padeye Fabrication	$	36,000	4 padeyes			
Brace Fabrication	$	25,000	LS			
Labor	$	30,300	day			
Structural Fitter (10)	$	6,000	day			
Welder (8)	$	7,160	day			
NDT	$	3,750	day			
Flush and Clean Spread	$	14,482	day			
Module Preparation Spread	$	39,782	day			
Deck Preparation Spread	$	39,782	day			
Jacket Removal Spread	$	26,392	day			
Pipeline Decommissioning						
DSV	$	40,000	day			
Consumables	$	4,000	day			
P/L Decommissioning Crew	$	16,388	day			
Platform Removal						
2,000 ton HLV	$	5,600	hour	$	134,400	Per Day
Work Boat	$	172	hour	$	4,125	Per Day
Dive Basic Crew	$	500	hour	$	12,000	Per Day
Dive Supplemental Crew	$	400	hour	$	9,600	Per Day
Supplemental Welding Crew	$	-	hour	$	-	Per Day
Explosive Tech	$	-	hour	$	1,125	Per Day
Mechanical/Abrasive Cutter	$	469	hour	$	11,250	Per Day
Side Scan Sonar	$	115	hour	$	1,875	Per Day
ROV	$	-	hour	$	-	Per Day
Total Spread Rate	*$*	*7,255*	*hour*	*$*	*174,125*	Per Day
Pull Tugs	$	1,000	hour	$	24,000	per Day
Platform Removal: Lump Sum Items						
Helicopter Trip	$	3,750	round trip			
Site Clearance						
Side Scan Spread	$	428	Per Hour	$	10,260	Per Day
Inspect & Cleanup Spread	$	2,344	Per Hour	$	56,250	Per Day
Trawling Spread	$	156	Per Hour	$	3,744	Per Day
Cargo Barge Listing						
CB 400'x100' and Tug	$	855	Per Hour	$	20,520	Per Day
Weather Provision		15%				
Operating Efficiancy		87%				

State of the Art
Of Removing Large Platforms
Located in Deep Water

Explosive Technology
Report

Submitted
By
DEMEX Division
TEI Construction Services, Inc.

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1. Introduction

Using explosives to remove large platforms in deep-water will certainly be a reality within the near future. In fact, the removal of deep-water sub sea structures has already begun. One such example is the removal of the Garden Banks 387 sub sea template this year. This Gulf of Mexico structure located in over 2,000 feet of water, incorporated several innovated approaches to using explosives in extreme water depths. These approaches involved the use of remotely operated vehicles (ROV's), dynamically positioned vessels, wire line units, and detonation of multiple charges with delays.

When we discuss the use of explosives relative to deep-water platforms a primary consideration will be the final disposition of the platform. Present options for the disposition of these deep-water platforms include total removal, reuse of the structure, and partial removal, which can involve leaving the lower portion of the jacket in place and/or toppling in place to establish a reef site. The equipment used to perform the removal will also dictate how explosives could be used for severance. Operational considerations should be established before a specific course of action involving explosives can be finalized. Governmental restrictions involving explosive usage offshore will need to be addressed before the final operating procedures are drawn up.

The Gulf of Mexico has been the proving ground for platform removals. During the years between 1986 and 1999, approximately 1,414 structures were removed. Of those structures, approximately 66% were removed by explosive methods. Explosives are widely used because they are safe, reliable, and cost effective. Governmental restrictions relative to explosive usage in the Gulf of Mexico have limited the options available for owners and contractors involved in the platform removal process. These governmental restrictions and associated generic guidelines have also placed additional costs that make alternative severance methods more fiscally sound.

It must be remembered that especially in deep water the severance method will be less than 1% of the total platform removal cost. Time is the major factor to consider. Delays in vessel spreads are the primary reason for cost over runs. A failure in the complete severance of a pile or conductor is usually charged to the owner of the platform. These costs can be enormous, as time and material rates for large crane vessels can exceed $500,000 dollars per day.

This paper will address many of the above concerns. Primarily, this report will be geared towards the deep-water platforms located in the Pacific Outer Continental Shelf Region. For our purposes deep-water will be considered 400' – 1,200'. Platforms today are being placed in much deeper waters and will require special attention when they reach the end of their useful life.

2. Literature Search

Our literature search was conducted through the use of various resources. These resources include an extensive Internet search, use of the library at Demex, and conversations with professionals within the industry. While the data available regarding the use of explosives in deep-water relative to platform removals is limited, there was data that could be applied to our overall objective. Much of the available data deals with environmental aspects. Unfortunately, there are some technical papers that are actually "sales" papers in disguise that must be viewed carefully.

2.1 Internet Search

A search of library holdings and journal records was conducted via the World Wide Web.

Keyword searches used were: *Underwater Cutting, Explosive Cutting, Platform Removal, Pile Severance, Platform Removals and Explosives, Pile Cutting, & Platform Abandonment.*

The search was conducted via the following databases:

1. Online Computer Library Center's (OCLC) search engines: Academic Search Elite, Master FILE Premier, Business Source Elite, and The Serials.
2. First Search OCLC's search engines: ArticleFirst, and WorldCat.
3. CARL UnCover
4. EBSCO Host and EBSCO Online.
5. Library of Congress Online Catalog
6. MIT's WebBarton
7. Cal Tech's CLAS

The following items of interest were found (Note: not all hits shown):

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2. The Use of Explosives for the Underwater Cutting of Steel, Sidney Alford, *International Underwater Systems Design 1990.*
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18. Removal of Offshore Platforms, *Institute of Marine Engineers by Marine Management Ltd.,* 1987.
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2.2 DEMEX Private Library

DEMEX was established in 1972. From that time we have built up an extensive library of over 1,000 technical papers, articles, books, and etc. relative to explosives. As we specialize in underwater explosive cutting relative to platforms we have built an excellent library towards this subject. The following are some of the literature directly related to explosives, underwater blasts, and platform removals. Further references are documented at the end of this report as they were used as cited literature.

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Jones, Royston Dr., *Response of a Jacket Structure to an Underwater Explosion,* Reverse Engineering Ltd., UMIST, Professor Salim T. S AL-Hassani BSc, MSC, PHD, F.Inst. Pet.

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Connor, Joseph G. Jr., *Underwater Blast Effects From Explosive Severance of Offshore Platforms Legs and Well Conductors,* Naval Surface Warfare Center, Dahlgren, Virginia and Silver Spring, Maryland, December 1990.

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Conference Documentation, *Decommissioning and Removal of Offshore Structures,* IBC Technical Services Limited, Café Royal, London, September 1993.

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3. Basic Explosive Review

Presently, in the Gulf of Mexico as well as other parts of the world a variety of explosives and charge types are used. The following sections will outline explosive characteristics and the varying degrees of charge types that are used.

3.1 Explosive Characteristics

(1) ***General -*** During the past 100 years many explosives have been studied for possible suitability for use, yet less than a score have been found acceptable for such use and some of these have certain characteristics that are considered to be serious disadvantages. Required characteristics are such that but few explosives can meet most of them and be acceptable for standardization.

(2) ***Availability and cost -*** In view of the enormous quantity demands, explosives must be produced from cheap raw materials that are non-strategic and available in great quantity. In addition, manufacturing operations must be reasonably simple, cheap, and safe.

(3) ***Sensitivity -*** All explosives are sensitive to some degree, but can be too sensitive for handling and use or too insensitive for use. It may be considered that the present standard explosives represent a range of sensitivity within which a new explosive must fall.

(4) ***Brisance and power -*** An explosive must have shattering effect (brisance) and potential energy that make it comparable with or superior to other high explosives used as bursting charges; or it must have the ability to initiate the detonation of other explosives and be sensitive enough itself to be initiated by practicable means such as percussion, friction, flame, or electric current.

(5) ***Stability -*** In view of the long periods of storage to which they are subjected to and because of the adverse conditions of storage to which they may be exposed, explosives must be as stable as possible.

(6) ***Velocity of Detonation -*** Explosives are classified as either high velocity or low velocity which is a measure of the speed in which the explosive changes through a chemical reaction from a solid state to a gaseous state. **Low Explosives** change from a solid to a gaseous state over a sustained period up to 400 meters/second (1,300 feet/second). **High Explosives** change to a gaseous state almost instantaneously at 1,000 meter/sec (3,800 feet/second) to 8,500 meters/second (27,888 feet/second), producing a shattering effect on the target.

(7) ***Density -*** Loading density is an important characteristic of explosives, a maximum density being desirable because of the fixed volume of the space available for explosives in a round of ammunition. The greater the loading density at which a fixed weight of a given explosive is pressed or cast, the greater is its effect when detonated. However, the standard explosives having the greatest density values, mercury fulminate and lead azide, are not the most powerful standard explosives; and the selection of an explosive for a specific use cannot be based primarily upon its density.

(8) ***Heat of Explosion -*** This value for an explosive can be determined by detonating a charge in a calorimetric bomb. The procedure is similar to that used for determining heat of combustion, except that no oxygen is used, and detonation instead of combustion is insured by means of a detonator. The heat of explosion, expressed as calories per gram, is considered to represent the useful work capacity of the explosive in fundamental terms.

(9) ***Hygroscopicity -*** Hygroscopicity, the property of absorbing moisture, can have an adverse effect on the sensitivity, stability, or reactivity of some explosives and must be negligible, if the explosive is to be

considered satisfactory for use. An exception is the very hygroscopic ammonium nitrate, which can be used in the manufacture of amatol, if kept under conditions that preclude the absorption of moisture.

(10) ***Volatility -*** Volatility of military explosives is an undesirable characteristic, and they must not be more than very slightly volatile at the temperature at which they are loaded or at their highest storage temperature. Loss by evaporation, the development of pressure in rounds of ammunition and separation of constituents of mixtures are sometimes the result of undue volatility.

(11) ***Reactivity and compatibility -*** Minimum reactivity and consequent maximum compatibility with other explosives and non-explosive materials are necessary properties of an explosive. As the explosive must be loaded in contact with metal or coated metal and may be mixed with another explosive or mixed with the other ingredients of a propellant, the explosive must be non-reactive therewith. Reaction, particularly in the presence of moisture, may produce sensitive metallic salts, cause deterioration and loss of power or sensitivity, or may result in the liberation of gaseous products of reaction. Compatibility is particularly important, if the explosive is mixed with liquid TNT to make an explosive mixture suitable for loading by casting.

(12) ***Toxicity -*** Many explosives, because of their chemical structures, are somewhat toxic. To be acceptable, an explosive must be of minimum toxicity. Careful attention must be paid to this feature, because the effects of toxicity may vary from a mild dermatitis or a headache to serious damage to internal organs (Kohler & Meyer, 1993).

3.2 Properties of Explosives

The following is a list of some commonly used explosives and their corresponding properties. In no way should this list be considered complete. There are hundreds of commercially available explosives as well as variations in chemical mixtures. This chart is only designed to give one an overview of some widely recognized explosives and their corresponding properties:

NAME	Principal Uses	Velocity (m/sec)	Velocity (ft/sec)	Density	Shattering Effect (TNT = 1.00)	Water Resistance	Specific Energy Watts/kg	Weight Strength %
Black Powder	5	400	1,320	1.6	0.1	Poor		
Initiating Explosives (Primary)								
Lead Azide	6	5,300	17,400	5	0.39	Fair	466K	39
Diazodinitrophenol (DDNP)	6	6,600	21,700	1.63	0.92	Fair	0	76
Lead Styphnate	6	5,200	17,000	2.9	0.4	Fair	470	40
High Explosives (Secondary)								
Pentaerythritol tetranitrate (PETN)	2,4,7,8	8,400	27,600	1.7	1.73	Good	675	96
Cyclonite (RDX)	1,2,4,7,8	8,750	28,700	1.76	1.57	Good	675	93
Homocyclonite (HMX)	1,2,7,8	9,100	29,800	1.91	1.45	Good	664	93
Trinitrotoluene (TNT)	1,2,3,4,7,8	6,900	22,600	1.65	1	Good	488	74
Ammonium Picrate (Explosive D)	1,2,7,8	7,150	23,500	1.6	1.25	Poor	321	70
Nitroglycerin (NG)	1,3,5,7,8	7,600	25,000	1.81	1.81	Fair	720	96
Nitroglycol (NGC)	1,3,5,7,8	7,300	24,000	1.48	2.06	Fair	780	105
Nitromethane (NM)	1,5,7,8	6,290	20,700	1.14	1.33	Fair	533	86
High Explosives (Tertiary)								
Ammonium Nitrate	3,8	2,800	9,200	1.13	0.6	Poor	280	52
High Explosive Compositions								
Composition B	1,2,7	7,840	25,700	1.68	1.3	Good		
Composition C-4	1,2,7	8,040	26,400	1.59	1.32	Good		

Cyclotol 70/30	1,2,7	8,060	26,450	1.73	1.31	Good		
Octol 75/25	1,2,7	8,643	28,350	1.81	1.16	Good	503	
Plastic Bonded (PBX9404)	1,2,7	8,800	28,900	1.86	1.37	Good		
Pentolite 50/50	1,2,7	7,465	24,500	1.66	1.22	Good	588	
Detasheet	1,7	7,300	24,000	1.62	1.12	Good	495	
Torpex (Aluminized Explosive)	1,2,7	7,500	24,600	1.81	1.64	Good	867	
Blasting Gelatin	1,2,7	7,300	24,000	1.5	1.91	Fair	740	100
HTA-3 Aluminized Explosive	1,2,7	7,870	25,800	1.9	1.19	Good	573	
Commercial Dynamites								
40% NG Dynamite	3					Fair		40
50% NG Dynamite	3					Fair		50
60% NG Dynamite	3					Fair		60

1. Demolition Charge
2. Shape Charge
3. Cratering & Rock Removal
4. Detonating Cord
5. Propellant
6. Detonator Primer
7. Metal Severance

Figure 1. Properties of Explosives

3.3 Physics of Underwater Explosives

The science and technology considerations relative to underwater explosions are a complex phenomenon. Volumes of papers and books have been written on this particular subject. The dynamics of the underwater explosion can be affected by a multitude of variables beginning with the explosive types, the variations in the targets, physical, environmental factors and even the salinity of the water. We will only give a brief description of the resultants from an underwater explosion.

***Shock wave*:** The compression wave that expands radially out from the detonation of an explosive or other source. It is supersonic in the media of transport. Shock waves are poor conductors of energy (due to energy conversion to heat through friction), and as such are soon reduced to normal acoustical waves. Shock wave velocities decrease drastically as they radiate out from the source, as do their ability to perform useful work.

***Peak Pressure*:** The maximum overpressure caused by the passage of a shockwave through a given media. Units given in lbf/in.^{2}.

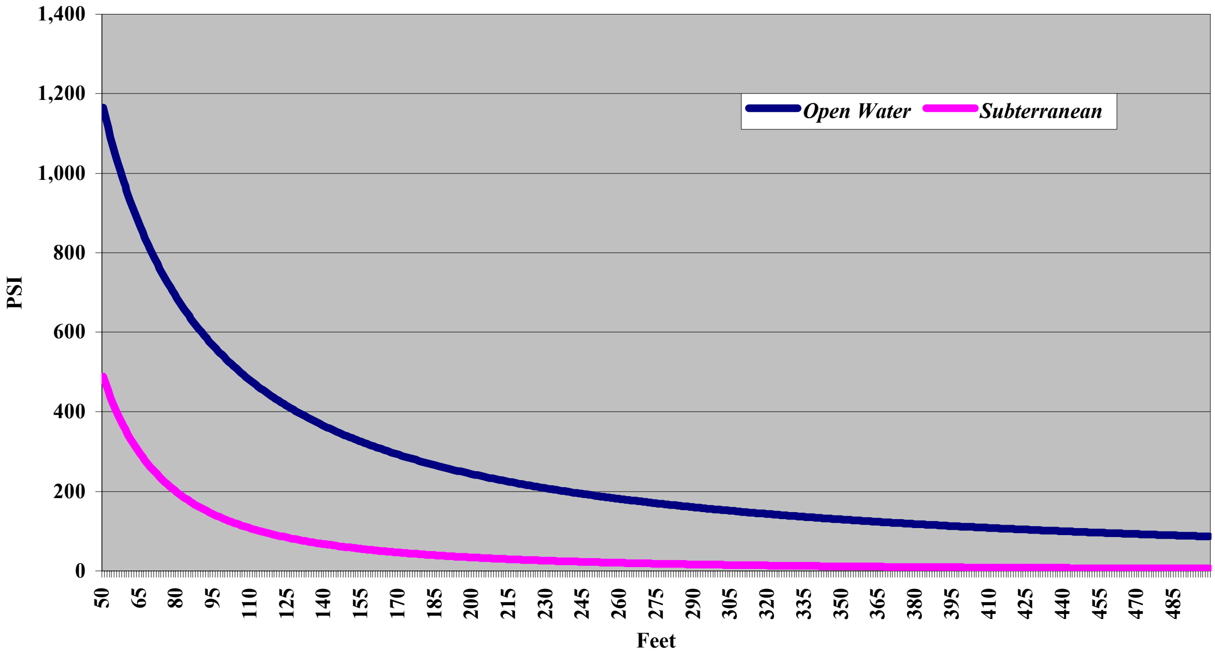


Figure 2. Peak Pressure Comparison of Open Water and Subterranean Blast from 50 pounds of Composition – B (Cole 1948, Connor 1990)

Impulse**:** The time dependent integral of the overpressure caused by the passage of a shock wave. The time interval escalates at greater distances from the explosion. Area of integration is an important consideration as the cumulative effect of the tail of the shock wave increases with distance. This can cause confusion as it increases the impulse without actually increasing the amount of true work being performed by the shock wave. Due to this nature, established time intervals must be used for integration at a given weight and distance, and commonly called delivered impulse in comparison to total impulse (Cole 1948, Connor 1990). See Time Interval.

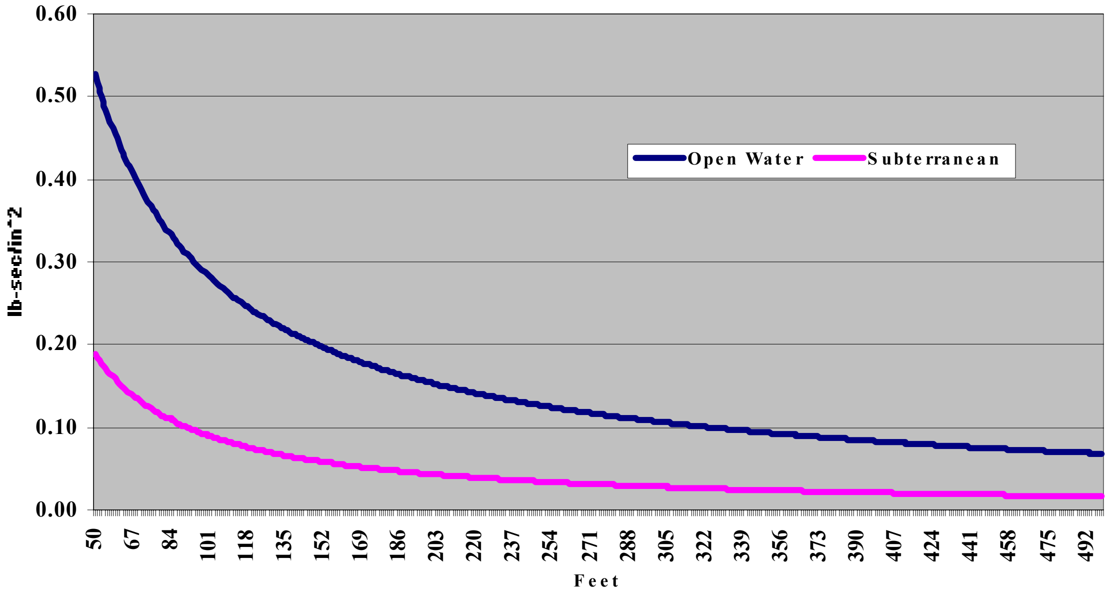


Figure 3. Impulse Comparison of Open Water to Subterranean Blast from 50 pounds of Composition – B (Cole 1948, Conner 1990)

Energy Flux: is considered the amount of work per given area normal to the point of detonation (in-lbf/in.^{2}). This measure is best used in dependence with impulse. If energy flux is held constant; then as the weight of the explosive and distance from explosion increase, peak pressure decreases and impulse increases. The often-misleading peak pressure would show a diminishing value, while the true escalation of damage would be revealed by the delivered impulse.

Example #1: 50 lbs. of Cyclotol 70/30 (range: 32 ft.) and Example #2: 5000 lbs. of Cyclotol 70/30 (range: 310 ft.):

#1-Energy Flux: 110 in-lbf/in.^{2}	Peak Pressure:	1966 lbf/in.^{2}	Delivered Impulse: 0.8 lbf-sec/in.^{2}
#2-Energy Flux: 110 in-lbf/in.^{2}	Peak Pressure:	840 lbf/in.^{2}	Delivered Impulse: 1.73 lbf-sec/in.^{2}

(Hayward & Ablard 1955)

Time Interval: This is the factor responsible for accurate representation of the delivered impulse of a shock wave. Normally given in milliseconds; it is the range required for integration. It effectively describes the shock wave's 'time on target'. As can be seen in the above example, the peak pressure for the 5000 lb. detonation at the given distance was not as great, but the time interval (to get area under pressure curve) was 5.5 times greater in duration.

Bubble Energy and Pulses: This is the product of the gas produced by an open water detonation. After the passage of the shockwave, pressure oscillations will occur due to over expanding and collapsing of the remaining gases as it rises toward the surface. These are known as bubble pulses. The cumulative effects of bubble pulses may be significant on fragile nearby structures. The extent of bubble energy in a subterranean blast is greatly diminished due to the bulk modulus of the surrounding media.

3.4 Mechanisms of a Shaped Charge

A shaped charge is an explosive charge with a hollow cavity facing the target material. To transfer the maximum amount of energy from the charge to the target, a soft metallic (i.e.- copper, lead, or aluminum) liner of a given thickness is placed in the cavity. Upon detonation of the explosive, the liner is collapsed into a central convergence under enormous pressure; it is this confluence of energy that forms the two main components of a shape charge. The “jet” is the forward moving product that performs the work on the target, and the “slug” is the backwards moving, non-working component. The formation process of the liner occurs under such great pressure that the metal reacts in a liquid (or more properly, hydrodynamic) like fashion. The jet maybe propelled at the target at speeds exceeding 10,000 m/sec (32,800 ft./sec.). It is this high-energy concentration that pierces the target (Kohler & Meyer 1993).

3.5 Types of Shaped Charges

Rotationally Symmetric (Conical): This type of charge produces the greatest penetration of all shape charges due to the 360 degrees of radial convergence forming the jet. Variation in the conical liner angle will result in varying properties of the jet. A small angle will produce a very small, deeply penetrating jet, while a large angle will produce a larger hole with shallower penetration.

Linear Charge: A *running* linear charge is a roof shaped liner of a given length used to cut plates or sheets of metals or other materials. The horizontal velocity of the detonation contributes to the effectiveness of the penetration. It normally comes sheathed in lead in a coil form. Its length is limitless. A simple cutting charge (or *non-running* linear charge) has a roof shaped liner two to three times the liner width and does not use horizontal velocity for establishing a jet.

Planar Symmetric Conical Charge: A regular rotationally symmetric shape charge may be modified to cut in a linear fashion with the addition of massive confinement. The two opposite sides parallel to the central axis have 90 degrees of heavy steel plating affixed to the outside of the charge. This results in uneven collapse of the liner and a fan shape jet toward the target. This produces a slit instead of a round hole for penetration.

Self-Forging Fragment Charge: This type of shape charge utilizes a high tensile liner and an extremely large cone angle. In this charge the angle is so great that there is no jet formation and the entire liner is turned into a projectile. These charges are more effective on soft targets (such as earth) and are not employed much in metal cutting operations (Kohler & Meyer, 1993).

Radial Shaped Charge: Unlike most linear formed shape charges, a radial shape charge can use the radial expansion of a tubular setting to develop the proper jet formation at inner diameter contact with the tubular. This is accomplished by providing an overly wide liner that reduces and accelerates toward target approach. A typical linear charge's capabilities diminish greatly as the jet approaches the tubular's inner periphery. This is due to the radial expansion of a charge geometry designed to impinge upon a flat surface; for instance, a sixty inch circumference charge attempting to cut an 82" O.D. tubular.

A radial shape charge is unique in radial cutting in several manners. This charge is designed to have linear flow as the liner expands in a radial manner. This flow is carefully designed to allow optimal development of the jet at the point of contact. A radial shape charge is not a normal shape charge in the sense that has no ‘slug’. This slug is the non-working remainder of a shape charge liner. Sting Ray uses massive steel confinement to provide accurate liner vectoring toward a central vertex on the target surface. Virtually 100 percent of the liner is used in cutting (slugless), compared to an average of about 20 percent (80% slug) for a typical shape charge. The combination of all these systems working together in synergy is what allows such a little amount of explosive to do so much useful work. Such highly efficient energy conversions in commercial shape charges have probably never been seen before in oil field applications (DEMEX Stingray Program 1997 – 2000).

3.6 Explosive Charge Types

Bulk Charges (Figure 4): One single mass of explosive material detonated at a single point. The energy release from this type of charge is not well directed. The field technician is relying on the "brute strength" of the explosive to overcome the target material by a shattering and tearing effect. Bulk charges are cylindrical in design. These charges vary in length and diameter to achieve the best fit with a wide range of typical offshore tubulars. These charge diameters range in size from 4" to 12".

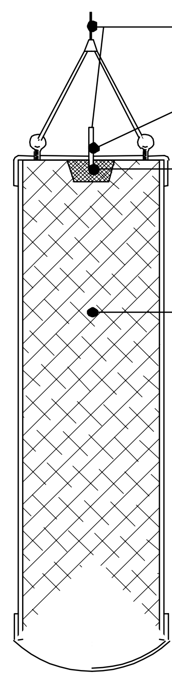


Figure 4. Bulk Charge

Smaller bulk charges can be arranged to create a larger diameter **(see Figure 5).** This technique allows the technician to configure the cast explosive material for whatever conditions may arise. For instance, in some cases it might be advisable to use smaller charges in a circular ring configuration to maximize the explosive concentration and proximity to the target material as shown.

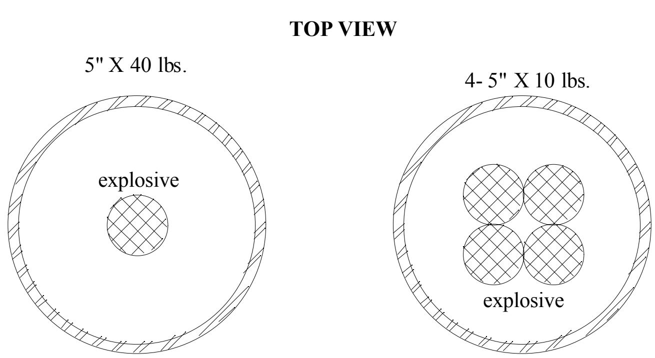


Figure 5. Bulk Charge arrangement for larger diameters

Double Detonation Bulk Charges (Figure 6): The use of a double detonation bulk charge creates more "cutting power", pound for pound, than an ordinary bulk charge. Double detonating the bulk charge is accomplished by using instant non-electric detonators at opposite ends of the charge. This detonation creates a confluence of energy at the center of the charge, which is dissipated, radially outward directly perpendicular into the target material. It is this directing of explosive energy that makes double detonating bulk charges more effective.

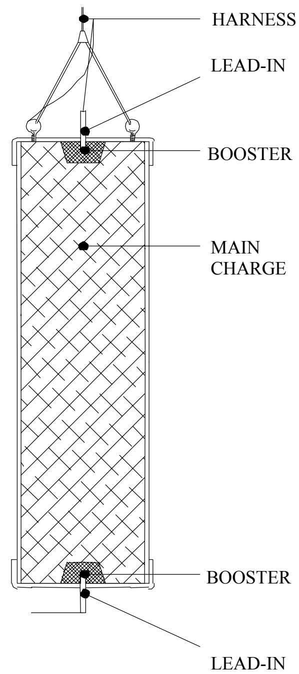


Figure 6. Double Detonation Bulk Charge

Configured Bulk Charges (Figure 7 & 8): For larger offshore tubulars, the configured charge uses explosive material in close proximity to the target material. Upon detonation, this results in a higher average pressure on the target material. Multiple points of detonation on this charge on the inner periphery can effectively direct the explosive energy to the target material.

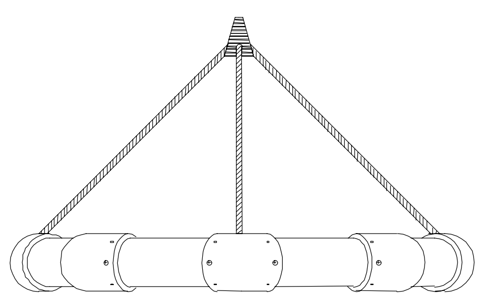


Figure 7. Configured Charge – Side View

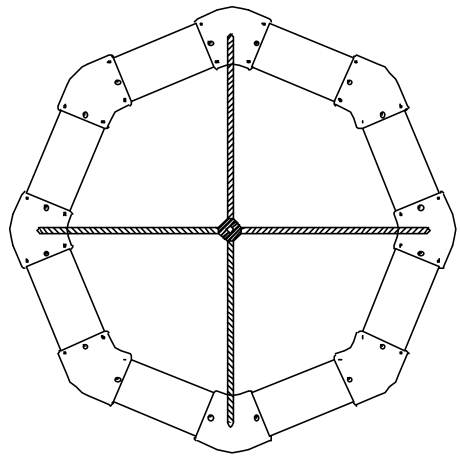


Figure 8. Configured Charge – Top View

Shockwave Enhancement/Focusing Devices (Figure 9): This is the ultimate combination of all the best features of the above charges with the added benefit of extreme confinement to concentrate all of the explosive energy on the target material. Using increased confinement, multiple point detonation, and the actual water inside of the tubular to direct energy; this device is the most reliable bulk explosive severance device available.

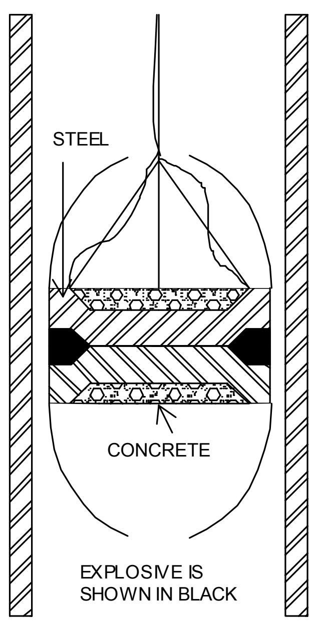


Figure 9. Shock Wave Enhancement/Focusing Device

Tamping (Figure 10): The energy released by a bulk charge can be enhanced by the use of tamping or confinement. A bulk charge is used with a metal and/or concrete plug above the charge. The addition of this tamping increases the duration of the impulse that is released by the explosive towards the target material.

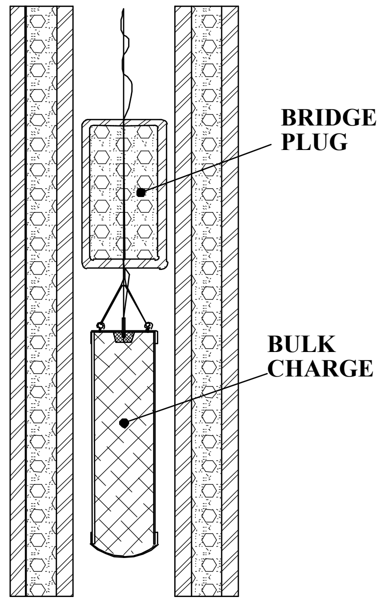
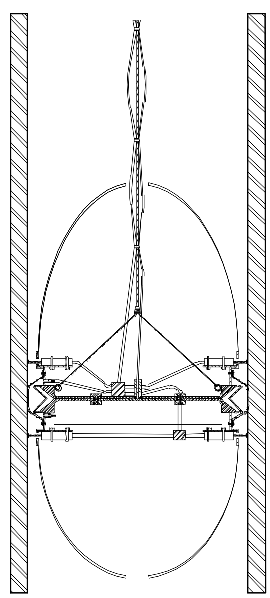


Figure 10. Bulk Charge with Tamping

Shaped Charges (Figure 11 & 12): The most effective use of explosives for severing is the shaped charge. The shaped charge uses the energy produced by the detonation to drive a liner at high velocity at the target. The liner striking it at this accelerated velocity then cuts the target.

While the quantity of explosives required to do the cutting can be reduced, shaped charges have myriad manufacturing and design criteria, which can drastically affect performance. The design criterion of shaped charges also requires that target specifications be known. Manufacturing of shaped charges can take weeks and can cost five times as much as conventional bulk charges.



For deep water use, divers and ROV's can be used to place external shape charges. This is accomplished by constructing the charge in the form of two 180 degree sections that are hinged together on one side and have a closing mechanism on the other side. They may be ballasted with rigid buoyancy tanks to provide neutral buoyancy for ROV placement.

Figure 11. Internal Shaped Charge

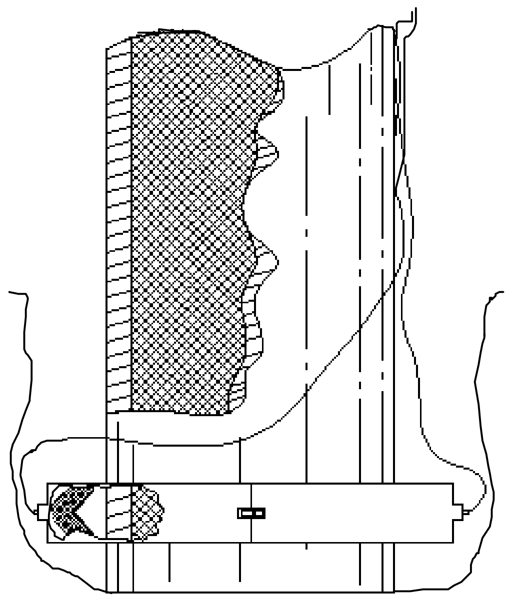
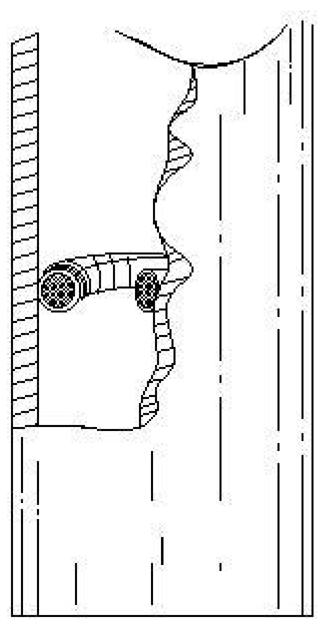


Figure 12. External Shaped Charge

Flexible Linear Bulk Charge (Figure 13): This is a highly effective form of a bulk charge. It is comprised of a plastic explosive encased in some form of a flexible tube. It is arranged in contact around the inner periphery of the target tubular. Severance of the tubular is very reliable due to the proximity of the explosive to the target material. Drawbacks of the charge are diver placement, access for a diver, and additional time required as such.



Flexible Linear Bulk Charge (Figure 13)

3.7 Charge Deployment Methods

One of the most critical aspects of using explosives for platform removals is having viable deployment or placement methods. Several methods may be employed.

Surface Placement by Hand: Charges that weight 50 pounds or so can be lowered inside a conductor or pile to the severance location on rope. This is generally, the quickest way to set a charge. A separate line from the charge to the surface could be detonating cord, nonel shock tube, or electric line to a detonator. This line is used to detonate the explosive device. The use of this method has the greatest control as the technician can control the descent of the device and "feel" problems such as tight fit or obstructions.

Surface Placement by Crane: A charge is attached to a predetermined length of wire rope and lowered down the jacket leg or well bore to the desired depth below mud line. This method is the most convenient type of deployment for devices with extreme weight. All that is required is a crane for picking up the charge and lowering it into the pile. This method requires that the bore of the pile be clear of major obstructions to the depth that the charge must be placed.

Diver Placement: A diver may be used to place a charge inside of the pile. Of course, the diameter of the pile must be large enough to accommodate the diver safely. The charge is lowered down with the diver to the desired depth and then affixed to the inside of the pile. Drawbacks to this method are the time required to set each charge and the safety issue of having a diver so far down in a confined space. Charge types for this method include bulk charges, flexible linear bulk charges, and shaped charges. Divers have also been used to "stab" charges inside sub sea piles (skirt piles) and conductors. Included with diver placement charges is also the use of Atmospheric Diving Suits (ADS), which are extremely helpful for deep-water applications.

ROV Placement: This is the best system to use for placing shaped charges on the outside of the jacket or conductor in deepwater. An articulated shape charge is placed with an ROV to the desired depth and can either be ROV attached or attached by a diver in an Atmospheric Diving Suit (ADS)(see figure XXX). In deepwater these methods are also used to "stab" charges inside sub sea piles and conductors.

Actuated Placement: Placing an explosive device in direct contact with the target can be the difference between success and failure. Most shaped charges and shock refracting charges require intimate contact with the device and the target. Presently, several approaches are used to place the charge against the target. They include mechanical, hydraulic, air driven, and explosive or propellant driven devices.

Wire Line Placement: The wire line units used for down hole tools in drilling operations can also be used to set charges. An advantage to using the wire line unit is that an electrical current can be sent down the wire to detonate the electric detonator. Wire line units are valuable in deepwater applications as the charge can be set and detonated off 1 line. This keeps the number of lines in the water down to the minimum, which can prevent "fouling" of multiple lines, and the speed of setting is increased.

4. Effectiveness of Charges

The effectiveness of explosive charges can be analyzed in several different ways. Primarily, contractors and oil companies consider effectiveness as 100% severance. This in itself can be a fallacy as other problems can be the cause of not being able to confirm that 100% severance has been achieved. These include piles grouted to the jacket and the inability of the lift vessel to pull the required load to free the pile from the mud. The following section will discuss variables affecting severance, performance, and a brief discussion on major variables that can affect severance of targets with explosives.

4.1 Variables

Effectively severing a pile with explosives seems simple enough but there are a multitude of variables, which can affect severance. The following table lists such variables:

Soil Types and Properties
Standard Variables

Conductor & Piles
Concentric
Eccentric
Diameter of internal string
Wall thickness
Yield strength
Tensile strength
Number of strings
Joint types (welded or screwed)
Height of each conductor string
Smoothness of pipe (RMS)

Cement
Diameter
Length
Strength
Curing time
Contaminated cement
Expansion of grout
Existing crack
Bonding
Vibration
Voids
Cement in annuli
Poured in wet or dry

Explosive
Type
Weight
Density
VOD
Shock wave energy
Impulse
Energy flux
Gas energy
Bubble effect
Height of burst
Detonation point (top/bottom)
Explosive canister
Confinement of explosive
Charge geometry

Other Variables
Water Depth
Hydrostatic head
Tension/compression on strings
Fluid between strings
Centralizers
Casing hangers
Temperature

Table 14. Variables Effect on Severance of A Pile

4.2 Performance Records

As discussed earlier the performance and/or effectiveness of an explosive charge depend on several variables. It must be remembered that governmental regulations in the OCS water of the Gulf of Mexico have limited explosive charge weight to 50 pounds. As such, different charge types are used for different targets. The following is an overall performance records from the past 3 years (DEMEX 1997-2000).

	CHARGE		1997			1998			1999			Overall
TARGET OD	TYPE	WT.	Severed	Shot	%	Severed	Shot	%	Severed	Shot	%	Percentage
Piles - 10"-20"	Bulk	20#	4	4	100%	0	0		0	0		100%
Piles - 10"-20"	Bulk	25#	12	12	100%	22	22	100%	2	2	100%	100%
Piles - 10"-20"	Bulk	30#	4	4	100%	0	0		0	0		100%
Piles - 10"-20"	Bulk	35#	114	121	94%	4	4	100%	0	0		94%
Piles - 10"-20"	Bulk	40"	4	4	100%	4	4	100%	0	0		100%
						0	0					
Piles - 20"-24"	Bulk	40#	114	114	100%	7	7	100%	10	10	100%	100%
Piles - 26"-30"	Bulk	40#	0	0		0	0		3	3	100%	100%
Piles - 26"-30"	Bulk	50#	73	73	100%	24	24	100%	29	31	94%	98%
Piles - 30"	SWEDe	50#	4	4	100%	0	0		0	0		100%
Piles - 36"	Bulk	50#	45	53	85%	2	2	100%	28	32	88%	86%
Piles - 36"	SWEDe	50#	14	16	88%	0	0		0	2	0%	78%
Piles - 42"	SWEDe	50#	10	10	100%	0	4	0%	1	3	33%	65%
Piles - 48"	SWEDe	50#	29	39	74%	7	7	100%	33	37	89%	83%
Piles - 52"	SWEDe	50#	0	0		0	0		4	4	100%	100%
Piles - 54"	SWEDe	50#	0	0		0	0		0	0		
Wells -16"-20"	Bulk	20#	1	1	100%	0	0		1	1	100%	100%
Wells -16"-20"	Bulk	25#	0	0		2	2	100%	0	0		100%
Wells -16"-20"	Bulk	30#	7	7	100%	0	0		0	0		100%
Wells -16"-20"	Bulk	45#	8	8	100%	0	0		0	0		100%
Wells -16"-20"	Bulk	40#	0	0		1	1	100%	10	10	100%	100%
Wells -16"-20"	Bulk	50#	9	9	100%	0	0		1	1	100%	100%
Wells -24"-26"	Bulk	20#	1	1	100%	0	0		0	0		100%
Wells -24"-26"	Bulk	40#	21	21	100%	2	3	67%	29	31	94%	95%
Wells -24"-26"	Bulk	50#	34	34	100%	0	0		19	20	95%	98%
Wells -30"	Bulk	50#	103	110	94%	26	28	93%	46	53	87%	92%
Wells -36	Bulk	50#	27	35	77%	5	6	83%	21	28	75%	77%
Caisson - 42" w/well	Bulk	50#	0	0		0	0		1	1	100%	100%
Caisson - 48" w/ well	Bulk	50#	5	11	45%	0	0		0	1	0%	42%
						0						
Caisson - 60"	FLBC	50#	0	0			0		1	1	100%	100%

Table 15. Performance Percentages

4.3 Major Factors affecting performance

It has been found that several variables can affect performance of an explosive charge. The following will discuss some of these main variables and their associated affect on performance.

Confinement of the explosive*:* the better the confinement of the explosive allows the pressure and associated energy to build up and be directed towards the target.

Explosive relative to target wall*:* It has been found that the closer the explosive is placed against the target the better the transfer of energy to perform the severance.

Explosive weight*:* the performance record of explosive charges could be greatly enhanced by a simple increase in explosive weight. It should be noted that by increasing explosive weight by 25% does not mean a corresponding increase of 25% of peak pressure produced. The weight of explosive is always applied to the 1/3 rd power for most explosive calculations in water. This cannot be considered applicable for all targets. We must think of this as an increase of explosive mass to the target in order to get a higher explosive mass to target ratio.

Target wall*:* it may not seem correct, but experience has shown that the thinner the wall of the target, the likely hood of an incomplete severance increases. Due to premature venting of the explosive products in a thin walled tubular, explosive energy is not as efficiently transferred. A target with a wall thickness of 1" will seem to stretch and expand whereas target with a 2.5" wall tends to act in a brittle manner and fracture cleanly.

Soils*:* The differences in soils can affect the way in which the target expands towards rupture. The expansion of the tubular target post detonation will be relative to the wall thickness and steel type, and the soil media backing it up. If the bulk modulus of elasticity of the soil is known, charge weights may be varied to compensate for it. Silts and sands provide less backing strength than dense clays. Clays also have a higher adhesive strength that hinders removal of a flared tubular and thus may require much more force to be pulled free.

Hydrostatic head*:* water depth alone cannot be considered a significant factor. What should be considered significant is the amount of confined water inside a pile during detonation. Such an example would be the amount of water above the water line in a confined pile.

4.4 Advantages & Disadvantages of Explosive Charge Types

Charge Type	Advantages	Disadvantages
Bulk Charges	easily designed & built relatively inexpensive excellent performance history	more environmental impact larger area of destruction on target
Double Detonation	good for conductors	depth sensitive (detonators) detonator timing is crucial
Bulk with Tamping	Increased efficiency	projectile in well more difficult to set
Configured Charges	explosive closer to target multiple detonation point	difficult to manufacture transportation issues
SWED/Focusing	excellent performance history explosive closer to target	longer lead-time to manufacture requires more time to load

	multiple detonation points	must be set with crane more expensive
Shaped Charges	less explosive weight clean cut outside charge/more effective	requires air stand off target specifics must be known inside charge/less effective long lead-time to manufacture poor performance history more expensive
FLBC	relatively inexpensive easily made	requires diver to set requires intimate contact to target

Figure 16. Advantages vs. Disadvantages

4.5 Shaped Charge Cut vs. Bulk Charge Cut

The use of shaped charges does not enjoy the performance history for platform removals that bulk explosives have obtained. The cut made by a properly designed and placed shaped charge is clean and looks somewhat like a torch cut. A bulk charge relies on the energy produced by the detonation to cause the pile to sever and rip circumferentially and horizontally. Below are photos showing the differences between the two cutting methods.

Photo 17. Inside Shaped Charge Cut on 26” x 1.25” wall pile

Photo 18. Bulk Charge Cut on 48" x 2" wall pile

4.6 Severance Verification

One of the best attributes of using bulk type charges for cutting piles and conductors is severance verification by the dropping of the target. Primarily, this verification can be seen with conductors that after detonation can drop from 3 feet to 7 feet. For this method of verification the target cannot be tied back to the jacket. In the case of piles, the entire jacket can drop 3 feet. This is only in the case of platforms not resting on the mud line or mud mats. Not all targets will drop; considerations include the soil type and the total length and weight of the target.

5. Deepwater Issues

Explosives have been used in deep-water in a variety of applications. Primarily, the work conducted relative to offshore structures has been for wells. Conductor wells have been successfully severed in water depths exceeding 2,850'. Explosive charges have been set using divers, Remotely Operated Vehicles (ROV), Atmospheric Diving Systems (ADS), and off the end of drill pipes from drilling vessels with the aid of underwater cameras.

5.1 Applicable Deep-water Projects

While it is true that no known platform removal projects have been conducted in our 400' – 1,200' range, there have been several platforms removed in water depths in excess of 200'. There have also been a multitude of projects where the knowledge and experienced gained could be applied to deep-water removals in the Pacific OCS Region. Examples are as follows (DeMarsh log books 1988-2000):

Location	Water Depth	Project Type	Comments
SS 364	450'	stub removal	outside 30" shaped charge set by WASP
HI 343A	237'	platform removal	8-pile with multiple conductors, reefed
SMI 190	359'	stub removal	diver set
Ver. 395	420'	stub removal	diver set
HI 492	195'	platform topple	1st rigs to reef in Texas waters
EI 392A	340'	platform removal	4-piles, 4-skirts, reefed
WC 624A	340'	platform removal	4-piles, 4-skirts, reefed
Brazos A-76	165'	platform removal	outside 42" 175# shaped charges, diver set
EB 947	783'	stub removal	from drill rig
HI 520A	235'	platform removal	8-pile, 4-skirts
WC 595	245'	platform removal	8-pile, 10-conductors, reefed
WC 616	294'	platform removal	8-pile, 8-skirts, topple for reef
EC347	280'	platform removal	4-pile, 6-conductor, 1 subsea conductor
WC 609	280'	platform removal	8-pile, 6-conductors
HI 567A	288'	platform removal	8-pile, 11-conductors, topple for reef
GB 387	2,081'	template removal	3-conductors, ROV set, multiple detonation

Figure 19. Deep-water Projects

5.2 Effect of Water Depth on Explosives & System Selection:

(1) The explosive selected for deepwater applications must be one that is not desensitized or degraded by water or pressure.

(2) It may become necessary to place the detonator underwater. Most common detonators are not designed for use in water depths over 400 feet. Seismic detonators will withstand depths of 5,000 feet or more. Things to be considered in detonator selection are:

- (a) Metal shell material, diameter, and wall thickness. Will the hydrostatic pressure to be encountered crush or disable the detonator?
- (b) Method of sealing around the wires going into the detonator. Will water be forced into the detonator housing, thereby desensitizing the initiating explosive?
- (c) In the case of non-electric detonators, the housing seal limits most nonel detonators to a maximum of 270 feet.
- (d) Only resistorized electrical detonators should be used. With unresistorized electrical detonators, galvanic force from anodic jacket protection could provide energy required for detonation.

(3) There are a number of initiation systems used, depending on the type detonator.

(a) Common electric detonators can be initiated at the surface by almost any electrical means. It does require that two-conductor wire be run from the detonator to the place of initiation.
(b) Both remote and acoustical firing systems are available for electric detonators. Here the limiting factors are the distance from the detonator to the receiver, and the distance between the receiver and the transmitter. System costs and deployment methods are problems with the acoustic system.
(c) Exploding Bridge Wire Systems require a firing module and a control unit. The maximum distance between the firing module and the EBW detonator is 300 feet. The maximum distance between the firing module and the control unit is 3.000 feet.

6. Safety

6.1 General - The following precautions should always be observed in shipping, storing, handling or delivering explosives, or when near explosives.

(1) High explosives (of which dynamite is the best known) are exploded by detonation, usually by blasting caps or electric blasting caps; they burn rapidly and while burning are liable to explode and will explode if heated to a temperature exceeding 360 degrees Fahrenheit or by the impact of a bullet fired into them.
(2) Blasting caps and electric blasting caps are devices having aluminum or copper shells which protect and contain a very sensitive explosive which will explode from sparks, shock, heat or by friction. Do not touch, pick or disturb the explosive contained herein.
(3) Whenever it becomes necessary to destroy damaged explosives, immediately communicate with the manufacturers for advice and instructions.
(4) Do not carry or allow others to carry matches or to smoke.
(5) Do not allow shooting or allow anyone to have cartridges or firearms.
(6) Do not allow unauthorized persons near explosives.
(7) Keep constant watch for broken, defective or leaky packages.
(8) Do not allow metal bale hooks or other metal tools to be used.
(9) Do not open or re-cooper packages of explosives with metal tools.
(10) Do not leave explosives unless they are stored in a locked magazine or under continuous observation of responsible persons.
(11) Do not carry blasting caps or electric blasting caps or any explosives in your pockets, or leave them around where children or others can meddle with them.
(12) Do not store, use or handle explosives in or near a residence.
(13) Do not allow explosive packaging to become wet or be exposed to the weather.
(14) Do not throw packages of explosives violently down or slide them along floors or over each other, or handle them roughly in any manner.
(15) Children or other unauthorized persons shall not be permitted to be present where explosives are being handled or used.
(16) It is prohibited to handle, use, or be near explosives during the approach or progress of an electric storm. All persons shall retire to a place of safety.
(17) Explosives or blasting equipment that are obviously deteriorated or damages shall not be used.
(18) Abandonment of any explosives, explosive devices or any other materials, which might be detonated, ignited or decomposed in such manner as to endanger persons or property shall be prohibited. The supplier shall be consulted regarding return, or destruction of explosives.
(19) All persons employed in operations where there may be exposure to falling objects shall be provided with, and shall wear protective hats or caps.
(20) It shall be prohibited to uncoil the wires or use electric blasting caps in the vicinity of operating, radio-frequency transmitters except at safe distances.
(21) No person shall be permitted to prepare or detonate explosive charges unless another person is present within calling distance, and able and ready to render assistance in the event of accident or injury.
(22) A test shall be made for presence of stray currents to any blasting operations in the vicinity of electric lines such as transmission lines, electrified railways and the like. Electric blasting caps shall not be used if stray currents are present.
(23) No blasting shall be done as to constitute a hazard or danger or do harm or damage to persons or property in the area of blasting.
(24) Blasts shall be fired only between sunrise and sunset unless a state of emergency requires otherwise.

6.2 Diver Safety

Explosive operations in water must make diver safety the primary concern. If divers are not involved with your specific project, be aware other divers could be in the area and be affected by an underwater explosion.

(1) The only safe distance for a diver during an underwater explosion is “out of the water”.
(2) Do not attempt to tie detonators into explosives while divers are still in the water.
(3) Divers required to set explosive charges should be trained. Briefing and communication with the explosive supervisor should be mandatory.
(4) No other underwater activities should be attempted when divers are placing explosives.
(5) Underwater burning gear and equipment should be removed from the water before lowering explosives to the diver.
(6) In saturation diving, or mixed gas diving, explosives shall not be transported in the dive bell.
(7) Divers must take care when returning to the bottom after an underwater explosion. The resultant components of an underwater detonation can turn a hard sand bottom to the consistency of quicksand.

6.3 Fires

The hazardous nature of explosives makes fire safety a major concern. When explosives are not in use they should be stored in an approved explosive magazine. If there is a fire aboard the vessel, try to isolate the fire away from the explosives. If fire comes into contact with explosives or loaded explosives magazine, “Do Not” continue to fight the fire. Remove all personnel to a safe distance or location. Secure the area against intrusion. Once explosives begin to burn a detonation is probable.

6.4 Exposure Time

Safety in the marine environment must be looked at relative to time. Oil companies, like insurance companies, view safety relative to the time on a project. It is a well-documented fact that the use of explosives is the quickest way in which to sever piles and conductors. Explosive devices set from the surface can be set with a minimal amount of personnel. In some instances, the explosive charges are set before the derrick barge arrives on location. Setting and detonation of the explosive charges on a four-pile platform with four conductors in 100 feet of water can be accomplished in 1 to 1½ hours. The water depth is a consideration for the time required for the charge to be lowered to severance depth. The work vessels must be moved to a safe distance, which can take from 15 –30 minutes.

7. Environmental

7.1 Historical Perspective

The owners, operators, or governmental agencies did not "formally" document the use of explosives for platform decommissioning before 1986. On April 15, 1986, the National Marine Fisheries Service (NMFS) sent a letter to Regional Director of the Mineral Management Service (MMS), Gulf of Mexico Outer Continental Shelf (OCS) Region. This letter expressed the concerns regarding stranding (to run ashore) events in 1985 & 1986. These strandings coincided with a number of explosive platform removals that were conducted in the State of Texas territorial waters. NMFS suggested that a correlation could exist between these strandings and the use of explosives for platform decommissioning. Consequently, MMS imposed an "unofficial moratorium" on platform removals. This was in an effort for industry to take the environmental issue seriously. Non-explosive removals were allowed to continue. Rules and regulations were then enacted upon the industry for using explosives for platform removals. NMFS started doing individual consultations for explosive removals. About thirty of these individual consultations were completed by the time the "generic consultation" was completed (DeMarsh 2000).

The platform removal market started to come back slowly. At the same time, various alternative methods for severing piles and conductors were applied and improved. Alternative methods include diver cut, abrasive cutting, diamond wire, chemical, and mechanical cutting methods. The industry also researched unusual methods such as pyronol torches and cryogenics without much success.

7.2 National Marine Fisheries Service Platform Removal Observer Program

The Observer Program conducted by NMFS at offshore platforms during detonation of explosives has yielded some interesting results. First and foremost is that the Observer Program has created a positive sense of awareness towards marine mammals and endangered species within the Gulf of Mexico. This awareness has been conveyed from the lease owners all the way down to the galley hands on the removal vessels. It has been commented more than once that before the program began hardly anyone ever saw sea turtles. Now sightings have become more frequent as the personnel that work on platforms and salvage vessels actually look for sea turtles and marine mammals without fear of consequences.

7.3 NMFS Field Observation Review

The NMFS Observers have logged a multitude of hours looking for turtles since the program got under way in 1986. The NMFS office in Galveston, Texas maintains an extensive database of all explosive removals since that time. Variables include the following: platform type, water depth, location, month of observation, day/night & aerial monitoring hours, and sightings. Sightings include number of individual sightings (by NMFS Observers and others), time of sighting, type of sighting (surface or aerial), distance to structure, and if possible, the species (unknown species are identified as such). The following table is derived from data collected from 1986-1998 by the NMFS observers (Gitschlag, personal communication, 2000).

Monitoring Hours		Structure Types		Individual Turtle Sightings	
Day	38,500	Platforms	758		
Night	23,392	Caissons	255		
Aerial	1,862	Casing Stub	57		
Total	***63,754***	***Total***	***1,070***	***Total***	***180***

Figure 20. Monitoring Time vs. Turtle Sightings

7.4 Surface vs. Aerial Monitoring

Review of data from the NMFS on monitoring efforts indicates that turtles were observed at 20% of the structures that were monitored. When comparing surface monitoring to the aerial surveys, the aerial surveys were found to be 30 times more effective in detecting the presence of sea turtles (Gitschlag & Herczag 1994). When discussing these sightings it must be remembered that the majority of these individual turtle sightings were turtles "in transit" and the majority of the time the turtles were just passing through the area. In some cases where multiple turtles are believed to be "resident" to the structure, either turtles are relocated or the structure is removed using some other means than explosives.

7.5 Turtle Injury due to Explosives

Since 1986 over 1,400 structures were removed from the Gulf of Mexico. During that time 3 incidents have been recorded relative to sea turtle injury.

1. October 1990 – one Loggerhead injured
2. November 1997 – one Loggerhead injured
3. July 1998 – one Loggerhead killed

In all cases, NMFS Observers had given permission to detonate explosives and all regulations were followed. The injured turtles were flown to the NMFS Laboratory in Galveston, Texas for rehabilitation and eventual release into the Gulf of Mexico (Thornton & Wiseman 2000).

7.6 Fisheries Impact

The use of explosives to remove offshore platforms does kill and injure fish. As the Gulf of Mexico does not have a great deal of coral reefs or hard bottom the 4,000 plus structures in the Gulf have become artificial reefs or habitat for millions of fish. The large numbers of sports fishermen who frequent the offshore platforms are evidences of this. The popularity of coastal states' artificial reef program has become enormous for the "reuse" of removed offshore structures. The NMFS Observers have also been documenting the fish mortality from explosive removals of offshore structures since 1987. Mortality of fish at offshore structures will depend on several variables such as age of the structure, fish density at the particular platform, water depth, range of the fish from the blast, and the types of fish. The NMFS assessed the fisheries impact at ten platforms removed from various locations in the Gulf of Mexico between August of 1993 and May of 1999. Total estimated mortality ranged from less than 2,000 to 6,000 fish per individual platform. (Gitschlag 1998) These impacts are considered small in comparison to other sources of fish mortality such as sports fishing and commercial trawling and the resulting bycatch.

7.7 Safe Distances for Various Marine Creatures from Blasting

The following chart shows the minimum safe distances for various marine creatures. This is for an open water blast and does not take into consideration the well-known damping effect of the subterranean blast that is being performed to sever piles (Young 1991).

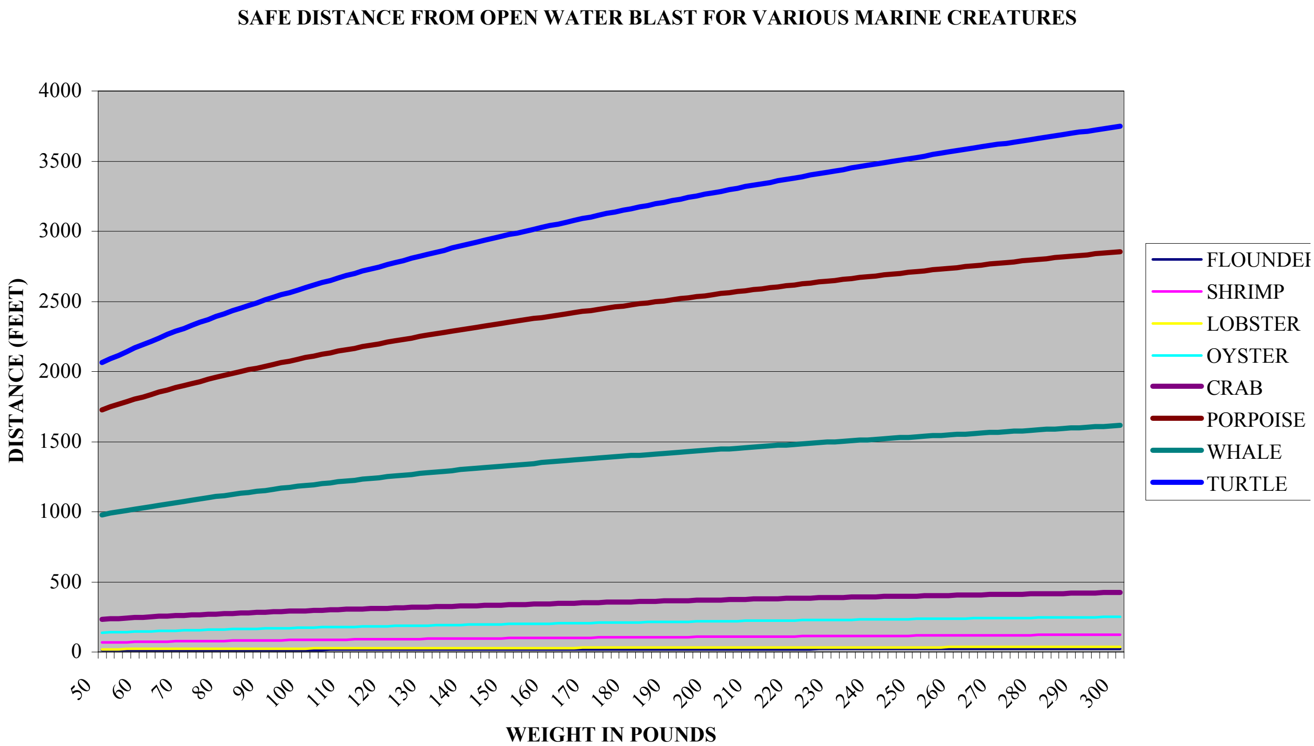


Figure 21. Safe Distances vs. Explosive Weight for various Marine Creatures

8. Regulatory

8.1 Federal Environmental Statutes

The use of explosives for platform removals and the corresponding regulations came about because of long established federal laws. The two major federal laws are the following.

Endangered Species Act (ESA): The ESA was passed by Congress in 1973 to "provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and to provide a program for the conservation of these species." This Act prohibits the "taking" of endangered species. "Taking is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" listed species. Offshore, in US waters, the National Marine Fisheries Service has responsibility for protection of threatened and endangered marine species ***(ESA The Basics 2000, Internet reference).***

Marine Mammals Protection Act (MMPA): The MMPA was enacted in 1972 and is the principal Federal legislation that guide's marine mammal protection and conservation policy. Enforcement of this Act is the responsibility of the NMFS ***(Marine Mammals Protection Act 2000, Internet Reference).***

8.2 Summary of "Generic" Incidental Take Statement

The following are general rules that must be followed when using explosives for platform removals in the Gulf of Mexico (Gitschlag & Herczag 1994).

1. Qualified observers monitor for sea turtles beginning 48 hours prior to detonations.
2. Thirty-minute aerial surveys within one hour prior to and after detonation.
3. If sea turtles are observed within 914 meters of the structure, detonations will be delayed and the aerial survey repeated.
4. No detonations will occur at night.
5. During salvage-related diving, divers must report sea turtle and dolphin sightings. If sea turtles are thought to be resident, pre- and post-detonation diver surveys must be conducted.
6. Detonation of sequential explosive charges must be staggered by at least 0.9 seconds to minimize cumulative effects of the explosions.
7. Avoid use of "scare" charges to frighten away sea turtles, which may actually be attracted to feed on dead marine life.
8. Removal Company must file a report summarizing the results.

Figure 22. Summary of Generic Incidental Take Statement

8.3 Responsible Agencies

The purchase, sale, storage, use, and transportation of explosives are regulated by a number of Federal, State and Local Agencies. These agencies and their areas of jurisdiction are as follows:

(1) ***Bureau of Alcohol, Tobacco & Firearms***, U. S. Treasury (BATF)
Regulates the manufacture, sale, purchase and storage of explosives. Anyone desiring to purchase and use explosives must obtain a User's permit from the Regional BATF Office having jurisdiction over the User's business location. The applicant must include evidence of adequate storage facilities (subject to BATF inspection prior to granting the permit). Specific requirements are outlined in Title 27, Code of Federal Regulations, Part 55, "Commerce in Explosives".

(2) ***U. S. Department of Transportation*** regulates the shipping of explosives and explosive devices are assigned a UN number and must be packaged and marked in accordance with the specified

requirements for that particular item. There are also specific requirements pertaining to shipping documents as well as carriage by highway, rail, aircraft, and vessel. Specific requirements are contained in Title 49 Code of Federal Regulations, Parts 171 through 180, "Hazardous Materials Regulations".

(3) ***U.S. Coast Guard*** has jurisdiction over the transportation of explosives by vessel. In addition to the requirements referred to in Para 11.2 above, the Marine Safety Office of the U. S. Coast Guard having jurisdiction over the port should be contacted well in advance of loading any explosive.

(4) ***U.S. Army Corps of Engineers*** has jurisdiction over all navigable inland waters. Prior to any explosive operations in any such waters, or in the vicinity of any levee, bridge, or tunnel, the nearest office of the Corps should be contacted regarding any necessary permits.

(5) ***Minerals Management Service***, U.S. Department of Interior has jurisdiction over any explosive operation carried out in connection with any oil, gas or other mineral lease in U.S. waters. The Regional Office having jurisdiction over the location should be contacted to obtain the necessary permit.

(6) ***National Marine Fisheries Service*** has the responsibility of enforcing the Endangered Species Act and the act prohibiting the harassment of marine mammals. Toward this end, the nearest NMFS office should be contacted to establish requirements for an NMFS Observer during explosive operations where an endangered species or marine mammal may be present.

(7) ***State & Local Authorities*** in many areas have requirements pertaining to the transport, use, and storage of explosives within their jurisdictions. The following is a suggested list of agencies to be contacted prior to undertaking any explosive operation:

a. State Police
b. State Fire Marshal
c. Sheriff's Office
d. County or City Fire Marshal
e. City Police

8.4 California Removal History

In July of 1996, Chevron's Hope, Heidi, and Hilda platforms were removed with the aid of explosives. The water depths were shallow; 99' to 132' and all the explosive shots were done in accordance with the following specification (DEMEX 1996).

- A licensed California blaster directed the use of explosives.
- Marine wildlife observers monitored the area prior to, during, and after detonation of charges. No detonations occurred without the approval of the marine wildlife observers.
- Detonations were delayed until no marine mammals were within 1,000 yards of the platform.
- A sonic warning device was provided to scare pinnipeds away from the vicinity of the blast site. The device was deployed per the direction of the marine wildlife observer.
- High velocity explosives were used.
- Detonations occurred during daylight hours only.
- Explosives were not used during the gray whale migration season from November to May.
- Personnel and equipment were provided to gather and dispose of all marine animals killed or injured as a result of the explosive detonations.

9. Cost Matrix

Deriving applicable cost matrix's for platform removals using explosives is easier said than done. The main problems extend from the high number of variables. These variables are especially relevant when obtaining cost figures for shaped charges. To obtain viable numbers we must identify the variables and identify the constants. The following graph will illustrate different costs for two different bulk charge types in around 250 feet of water.

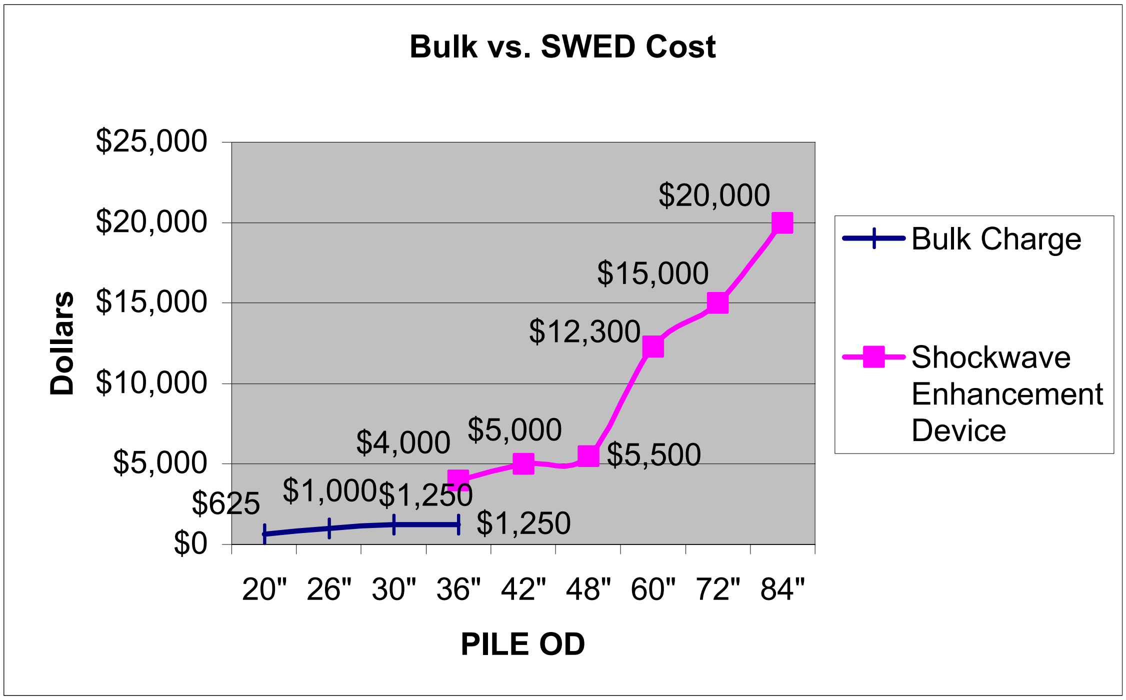


Figure 23. Bulk Charge vs. Shockwave Enhancement Device Cost

9.1 Effect of Water Depth on Cost

The effect of water depth for charges that weight under 100 pounds does not significantly change. These charges are lowered with rope, which has a minimal cost. The detonating cord is also minimal cost increase. Where we start to see significant cost increases are relative to charge size and weight. Setting a standard SWED type device weighing less than 600 pounds would only require ¼" wire cable. The larger the piles and the corresponding increase in charge weight would require larger cable. Increasing cable diameter to over 1" can have a significant affect on overall cost. This cost also includes handling and trucking. The Harmony platform case study in section 10 of this report requires 26 tons of cable to set the skirt pile charges alone.

9.2 Cost Increase due to Target & Charge Diameter

When using a SWED type device for large diameter piles, size and weight becomes relative. Bigger is not necessarily better. The SWED devices are constructed with large diameter plates in varying thickness. As the plate diameter and thickness increase, cost will escalate due to the difficulty in machining and handling. Plate diameters over 6 feet are considered special order and will require a long lead-time. The equipment just to handle these sizes and weights are expensive. Cost reductions could be achieved by forging these devices or certain components. Explosive cost was increased, as the weight required severing the target reliably was doubled and tripled from the standard 50 pounds presently used in the Gulf of Mexico.

9.3 Shaped Charge Cost

The variables that affect cost have just jumped up exponentially. Of all the uses of explosives, the shaped charge has developed the most scientific and practical applications. Shaped charges can be precision devices or what we refer to as "down and dirty" charges. As with most explosives, the military has done extensive testing and development. The factors that affect the cost of a shaped charge include depth of cut required, explosive type used, linear geometry, linear material (i.e. copper vs. steel), charge housing, and detonation method.

9.4 Off the Shelf vs. Custom Built Shaped Charges

As with most goods and services, explosives can be acquired "off the shelf". These mass produced explosive items can be relatively inexpensive as economies of scale are realized. Most of the explosive ancillary products that are used in platform removals such as detonating cord and detonators are used in a variety of blasting industries. Linear shaped charges can be purchased from explosive manufacturers in a variety of lengths and grain loadings. These linear shaped charges are used to cut relatively thin pieces of metal. Shaped charges of this sort have been used successfully in the severance of beams in buildings for "implosion" type demolition. The grain loadings refer to grains/foot of explosive. Generally, increased grain loading per foot corresponds to increased penetration of the shaped charge jet. The chart below shows various grain loadings, penetration, and approximate cost.

Grains/Foot	Optimum Penetration (inches)	Cost/Foot
250	0.40	$ 10.00
600	0.70	$ 10.50
900	0.85	$ 13.50
1,200	1.00	$ 15.50
2,000	1.50	$ 17.00
3,200	1.70	$ 23.00
10,500	3.50	not available

Chart 24. Shaped Charge Cost Comparisons (Accurate 1998)

As you can see, the linear shaped charges' penetration for the standard shelf items is not very deep. This penetration is also in mild steel, in an air environment. The penetration data was provided by the manufacturer and has not been independently verified. To use these charges offshore for platform severance would require bending the liners and inserting them into waterproof housings. As our water depth increases so does the thickness of the charge housing in order to overcome the hydrostatic pressure. This housing would first have to be penetrated by the shaped charge jet before even starting to sever the target material. Historically, the use of these "off the shelf" shaped charges for platform severance have not been successful.

To sever the large diameter and corresponding thick walled piles found in offshore structures would require special purpose shaped charges. These prototype charges would show an exponential increase in cost. Also, the charges would need to be manufactured whereby the explosives could be loaded on site, which would limit the types of explosives to be used. Pre packed or cast explosive shaped charges would require that EX numbers be assigned as well as approved shipping containers to meet Federal DOT regulations. Cost for such approval would be in excess of over $30,000 per charge design.

10. Case Studies

The removal of any type of offshore structure in any water depth has basic information that must be obtained to give a reasonable quote and outline proper operational procedures. For the following case studies: Hidalgo, Gail, and Harmony we will outline the requirements for an explosive removal. For these case studies we will not consider any limitations relative to explosive weight. At the end of the case studies, in Section 10.6, we will provide a synopsis of the EROS Project which could be considered applicable to these deep water removals.

10.1 Case Studies Assumptions

The following assumptions will be made in order to properly analyze these case studies as candidates for explosive severance of piles off the California coast.

- Governmental weight restrictions will not be a consideration for the explosive charges.
- Explosive charge weights will be given in a range, low to high.
- Cost will be for using shockwave enhancement type charges as they have the best history and greatest success percentages for large diameter piles.
- The cost of backup charges will not be included in this study.
- Pipelines in the vicinity will not be considered.
- Other NMFS procedures will be followed.
- All governmental permits will be obtained.
- All explosive charges will be set internally to the piles.
- For the main piles, the deck will have been removed or full access obtained.
- Damaged stabbing guides will not be considered.
- The explosive charges will not be set inside the stabbing guides.
- All piles will be jetted to at least 20' below the mud line.
- All piles will be gauged with a "dummy" charge of the same dimensions as the explosive charge.
- A crane or some other suitable means will be used to set the explosive charges.
- Explosive charge total weights will range between 6,000 and 12,000 pounds which will require wire rope diameter between ¾" and 1 1/8".
- Explosive charges will not be left in piles for over 1 week.
- Adequate time for manufacturing of charges and mobilization will not be considered.
- All cost will be in year 2000 dollars.
- SAFETY will be the number 1 priority!

10.2 Case Study #1: Hidalgo

10.2.1 Main Structure Details

Water depth: 435 feet
Main piles – 8 each with 4 on a double batter and 4 on a single batter
Skirt piles – 8 each with 8 on a double batter

10.2.2 Pile Details

Main piles: 60" x 2.25" wall (55.5" ID)
Stabbing Guides: minimum ID in stabbing guide is 52.75"
Skirt piles: 72" x 2.25" wall (64.75" ID)
Stabbing Guides: minimum ID in Stabbing guide is 64.75"

10.2.3 Explosive Charge Details

(a) The main piles (8) of this structure will require explosive devices whose outside diameter is 51". The explosive weight for these charges is estimated to be 67 to 99 pounds each. The total weight of each device will be approximately 5,700 pounds.
(b) The skirt piles (8) of this structure will require explosive devices whose outside diameter is 63". The explosive weight for these charges is estimated to be 83 to 123 pounds each. The total weight of each device will be approximately 8,400 pounds.

10.2.4 Operational Considerations

Severing piles with bulk charges:

- It is Demex's opinion that the most suitable charge for this type of operation would be a shockwave enhancement/focusing type device.
- Manufacturing lead-time for the explosive devices will be 6 months.
- Storage of charges and explosives must be considered, it could be possible to store the devices and explosives on the platform to be removed.
- A U.S. Coast Guard approved dock must be used for the load out of explosives offshore.
- It is estimated that 2 days will be required to prepare charges before loading in piles.
- As with any offshore operation, time is a major consideration. The time to set each charge in the main piles will be around 45 minutes each. This number is based on setting a similar device in 200 feet of water, which usually requires about 15 minutes.
- The skirt piles will require a little longer as the use of divers or an ROV will be required to stab the explosive device into the sub sea pile. We conservatively base these at 1 hour each.
- Total time to set main pile charges would be 6 hours and time for the skirt pile charges would be around 8 hours. ***Total time to set all charges is around 14 hours.***

Severing piles with shaped charges:

- Shaped charges for severing the piles would be an alternative to bulk explosive devices.
- The major cause of failures in shaped charges is water intrusion thereby causing the shaped charge jet not to adequately form. At these water depths shaped charge canisters must be designed to overcome these pressures.
- An option for the main piles is to detonate the shaped charge in a dry environment, which would entail evacuating the water out of the piles down to the severance location. This can only be accomplished if we have watertight integrity on the pile. Also, if the first charge is unsuccessful at a complete severance the pile will fill with water and another method would need to be employed.
- The skirt piles and/or the main piles could employ some sort of pack off system above and below the shaped charge to void the severance area of water. Time and operational considerations are unknown.

Detonating the explosive devices:

- Because of water depth and possible damage to detonating cord, 100-grain special cord with a thick plastic coating will be used.
- Detonating cord that would run from the charge all the way to the surface would detonate all explosive devices. Detonators would then be connected to the detonating cord at the jacket.

- Care must be taken that the detonating cord from each charge does not cross each other underwater. This could cause a shoot out and/or detonation of multiple charges at one time.
- As a safety measure, if divers are used, detonators will not be tied in until the divers are out of the water.
- Detonation of the 16 explosive charges will be with a 1 second delay between each to mitigate environmental impact.
- The initiation of the detonators will be accomplished through the use of a remote firing system. The removal vessel could conceivably be miles away from the detonations.

10.2.5 Cost

Mobilization of explosive charge canister: (New Orleans, LA. to Santa Barbara, CA.) (Requires 3 trailers)	$ 10,350
Mobilization of explosives: (New Orleans, LA. to Santa Barbara, CA.) (Requires 1 trailer)	$ 5,757
Mobilization of personnel: (New Orleans, LA. to Santa Barbara, CA.) (4 explosive personnel)	$ 3,450
Sub-Total	***$ 19,557***
Project Manager: 1 each	$ 700/day
Explosive Technicians: 3 each	$ 600/day/each
Sub-Total (based on 7 days)	***$ 17,500***
Explosives: (Includes 16 SWEDe's & ancillary equipment)	***$ 230,000***
Demobilization of explosives: (Santa Barbara, CA. to New Orleans, LA.)	$ 5,757
Demobilization of personnel: (Santa Barbara, CA. to New Orleans, LA.)	$ 3,450
Sub-Total	***$ 9,207***
TOTAL ESTIMATED COST:	**$ 276,264**

10.3 Case Study #2: Gail

10.3.1 Main Structure Details

Water depth: 740 feet
Main piles – 8 each with 4 on a double batter and 4 on a single batter
Skirt piles – 12 each with 8 on a double batter and 4 on a single batter

10.3.2 Pile Details

Main piles: 60" x 2.5" wall (55" ID)
Stabbing Guides: minimum ID in stabbing guide is 52.25"
Skirt piles: 72" x 2.5" wall (67" ID)
Stabbing Guides: minimum ID in stabbing guide is 64.25"

10.3.3 Explosive Charge Details

(a) The main piles (8) of this structure will require explosive devices whose outside diameter is 51". The explosive weight for these charges is estimated to be 67 to 99 pounds each. The total weight of each device will be approximately 5,700 pounds.
(b) The skirt piles (12) of this structure will require explosive devices whose outside diameter is 63". The explosive weight for these charges is estimated to be 83 to 123 pounds each. The total weight of each device will be approximately 8,400 pounds.

10.3.4 Operational Considerations

Severing piles with bulk charges:

- It is Demex's opinion that the most suitable charge for this type of operation would be a shockwave enhancement/focusing type device.
- Manufacturing lead-time for the explosive devices will be 6 months.
- Storage of charges and explosives must be considered, it could be possible to store the devices and explosives on the platform to be removed.
- A U.S. Coast Guard approved dock must be used for the load out of explosives offshore.
- It is estimated that 3 days will be required to prepare charges before loading in piles.
- As with any offshore operation, time is a major consideration. The time to set each charge in the main piles will be around 1 hour each. This number is based on setting a similar device in 200 feet of water, which usually requires about 15 minutes.
- The skirt piles will require a little longer as the use of divers or an ROV will be required to stab the explosive device into the sub sea pile. We conservatively base these at 1.5 hours each.
- Total time to set main pile charges would be 8 hours and time for the skirt pile charges would be around 18 hours. ***Total time to set all charges is around 26 hours.***

Severing piles with shaped charges:

- Shaped charges for severing the piles would be an alternative to bulk explosive devices.
- The major cause of failures in shaped charges is water intrusion thereby causing the shaped charge jet not to adequately form. At these water depths shaped charge canisters must be designed to overcome these pressures.
- An option for the main piles is to detonate the shaped charge in a dry environment, which would entail evacuating the water out of the piles down to the severance location. This can only be accomplished if we have watertight integrity on the pile. Also, if the first charge is unsuccessful at a complete severance the pile will fill with water and another method would need to be employed.
- The skirt piles and/or the main piles could employ some sort of pack off system above and below the shaped charge to void the severance area of water. Time and operational considerations are unknown.

Detonating the explosive devices:

- Because of water depth and possible damage to detonating cord, 100-grain special cord with a thick plastic coating will be used.
- Detonating cord that would run from the charge all the way to the surface would detonate all explosive devices. Detonators would then be connected to the detonating cord at the jacket.

- Care must be taken that the detonating cord from each charge does not cross each other underwater. This could cause a shoot out and/or detonation of multiple charges at one time.
- As a safety measure, if divers are used, detonators will not be tied in until the divers are out of the water.
- Detonation of the 20 explosive charges will be with a 1 second delay between each to mitigate environmental impact.
- The initiation of the detonators will be accomplished through the use of a remote firing system. The removal vessel could conceivably be miles away from the detonations.

10.3.5 Cost

Mobilization of explosive charge canister: (New Orleans, LA. to Santa Barbara, CA.) (Requires 4 trailers)	$ 13,800
Mobilization of explosives: (New Orleans, LA. to Santa Barbara, CA.) (Requires 1 trailer)	$ 5,872
Mobilization of personnel: (New Orleans, LA. to Santa Barbara, CA.)	$ 3,450
Sub-Total	***$ 23,122***
Project Manager: 1 each	$ 700/day
Explosive Technicians: 3 each	$ 600/day/each
Sub-Total (based on 8 days)	***$ 20,000***
Explosives: (Includes 20 SWEDe's & ancillary equipment)	***$ 311,170***
Demobilization of explosives: (Santa Barbara, CA. to New Orleans, LA.)	$ 5,757
Demobilization of personnel: (Santa Barbara, CA. to New Orleans, LA.)	$ 3,450
Sub-Total	***$ 9,207***
TOTAL ESTIMATED COST:	**$ 363,499**

10.4 Case Study #3: Harmony

10.4.1 Main Structure Details

Water depth: 1,200 feet
Main piles – 8 each
Skirt piles – 20 each

10.4.2 Pile Details

Main piles: 72" x 2" wall
Stabbing Guides: not available
Skirt piles: 84" x 2" wall
Stabbing Guides: not available

10.4.3 Explosive Charge Details

(a) The main piles (8) of this structure will require explosive devices whose outside diameter is 63". The explosive weight for these charges is estimated to be 83 to 123 pounds each. The total weight of each device will be approximately 8,400 pounds.
(b) The skirt piles (20) of this structure will require explosive devices whose outside diameter is 75". The explosive weight for these charges is estimated to be 99 to 147 pounds each. The total weight of each device will be approximately 12,000 pounds.

10.4.4 Operational Considerations

Severing piles with bulk charges:

- It is Demex's opinion that the most suitable charge for this type of operation would be a shockwave enhancement/focusing type device.
- Manufacturing lead-time for the explosive devices will be 6 months.
- Storage of charges and explosives must be considered, it could be possible to store the devices and explosives on the platform to be removed.
- A U.S. Coast Guard approved dock must be used for the load out of explosives offshore.
- It is estimated that 4 days will be required to prepare charges before loading in piles.
- As with any offshore operation, time is a major consideration. The time to set each charge in the main piles will be around 1.5 hours each. This number is based on setting a similar device in 200 feet of water, which usually requires about 15 minutes.
- The skirt piles will require a little longer as the use of divers or an ROV will be required to stab the explosive device into the sub sea pile. We conservatively base these at 2 hour each.
- Total time to set main pile charges would be 12 hours and time for the skirt pile charges would be around 40 hours. ***Total time to set all charges is around 52 hours.***

Severing piles with shaped charges:

- Shaped charges for severing the piles would be an alternative to bulk explosive devices.
- The major cause of failures in shaped charges is water intrusion thereby causing the shaped charge jet not to adequately form. At these water depths shaped charge canisters must be designed to overcome these pressures.
- An option for the main piles is to detonate the shaped charge in a dry environment, which would entail evacuating the water out of the piles down to the severance location. This can only be accomplished if we have watertight integrity on the pile. Also, if the first charge is unsuccessful at a complete severance the pile will fill with water and another method would need to be employed.
- The skirt piles and/or the main piles could employ some sort of pack off system above and below the shaped charge to void the severance area of water. Time and operational considerations are unknown.

Severing jacket and piles at each cross member elevation with shaped charges:

- Shaped charges for severing the jacket and piles at once would have to be used, bulk charges are not a consideration.
- Charges would be manufactured to be diver or ROV placed at the desired severance points on each individual elevation.

Detonating the explosive devices:

- Because of water depth and possible damage to detonating cord, 100-grain special cord with a thick plastic coating will be used.
- Detonating cord that would run from the charge all the way to the surface would detonate all explosive devices. Detonators would then be connected to the detonating cord at the jacket.
- Care must be taken that the detonating cord from each charge does not cross each other underwater. This could cause a shoot out and/or detonation of multiple charges at one time.
- As a safety measure, if divers are used, detonators will not be tied in until the divers are out of the water.
- Detonation of the 28 explosive charges will be with a 1 second delay between each to mitigate environmental impact.
- The initiation of the detonators will be accomplished through the use of a remote firing system. The removal vessel could conceivably be miles away from the detonations.

10.4.5 Cost

Mobilization of explosive charge canister:	$ 23,863
(New Orleans, LA. to Santa Barbara, CA.)	
(Requires 7 trailers)	
Mobilization of explosives:	$ 6,102
(New Orleans, LA. to Santa Barbara, CA.)	
(Requires 1 trailer)	
Mobilization of personnel:	$ 3,450
(New Orleans, LA. to Santa Barbara, CA.)	
Sub-Total	***$ 33,415***
Project Manager: 1 each	$ 700/day
Explosive Technicians: 3 each	$ 600/day
Sub-Total (based on 10 days)	***$ 25,000***
Explosives:	***$648,000***
(Includes 28 SWEDe's & ancillary equipment)	
Demobilization of explosives:	$ 5,757
(Santa Barbara, CA. to New Orleans, LA.)	
Demobilization of personnel:	$ 3,450
(Santa Barbara, CA. to New Orleans, LA.)	
Sub-Total	***$ 9,207***
TOTAL ESTIMATED COST:	**$ 715,622**

10.5 Various Operational (Cost Reduction) Considerations

When approaching platforms for explosive removals in these extreme water depths changes to standard operating procedures can be advantages. Below we will list some considerations that could help limit total exposure as well as reduce overall project cost.

- Jetting of skirt piles and drifting could be conducted before arrival of the removal vessel.
- Skirt pile charges could be set from the deck of the platform before the deck removal vessel arrives.
- The skirt piles could be severed before the arrival of the removal vessel.
- Much of the skirt pile work could be done with a dive vessel, with the aid of a supply vessel with ROV equipment on board or even deployed from the existing platform.
- The explosive charges could be pre-loaded in order to save time.
- The cost of the explosive charge housings could realize savings if all 3 platforms were awarded at once.
- Forging instead of manufacturing could significantly reduce charge housings cost.
- Reduction in the cable cost could be realized on the skirt piles, especially for the 1,200-foot Harmony platform, by using a single cable to lower each charge into the skirt piles. Of course these would need to be disconnected by the ROV.
- It is estimated that if all 3 platforms are done at one time, as much as $28,000 could be saved on trucking charges alone.
- The deployment of the explosive charges could incorporate some sort of reel system in order to make setting them quicker and safer. Air or some sort of other means could operate the reel type system.
- The deployment of the explosive charges could be done simultaneously in multiple piles if prior operational plans and equipment are available.
- Explosive charge canisters could be manufactured in California thereby saving some of the trucking cost. A suitable manufacturer would be required as well as a quality control person from the explosive service company to supervise manufacturing.

10.6 EROS (Explosive Response of Offshore Structures) Project

In 1994 and 1995 an extensive study was conducted in the United Kingdom relative to the use of explosives to sever and topple a deepwater jacket in the North Sea. The target jacket was the N. W. Hutton platform, owned and operated by Amoco. The project was awarded to UMIST (University of Manchester Institute of Science and Technology) who in turn sub-contracted Reverse Engineering Limited (REL) as the project management. The project was designed to study the effectiveness and reliability of using shaped charges to cut the steel jacket legs, modeling of the explosive event, the effects of the explosive load on the toppling behavior of the jacket, and validation of the empirical, theoretical and computational tools used to predict the effects of cutting the jacket underwater with explosives. To date, this has been the most comprehensive study conducted relative to using explosives on deepwater platforms. (UMIST, 1995)

It would be difficult to present all the results of this study within this report but we will summarize some of the important data and results in a condensed manner.

I. Trial tests: These 17 trial tests of the shape charge design were performed on two-foot squares of flat plate three inches thick. One successful test was performed on a foot and a half square plate, five and a half inches thick. These were preliminary tests to validate the design of the charge before the expense of full-scale charges was incurred. They also provided valuable insight into the repeatability of the shape charge process. The successful designs never failed to cut as expected in repeated tests.

II. Curvilinear tests: These 8 tests were performed on 120 or 90 degree sections of a 10 foot OD, three inch wall tubulars. They provided verification of the cutting ability of the charge when fired toward a target and the jet formation was concentrating. This also verified the correct physical standoff in relation to that indicated in the computer modeling of the severance charge.

III. Full scale tests: These 4 full-scale tests were performed on 10 foot OD (3 inch wall) tubulars. All test were successful. These charges utilized 325-340 lbs. of high explosive. The following photos illustrate the clean cutting ability of a well designed shape charge:

Photo 25. Charge assembled on 10 Foot OD Tubular

Photo 26. Charge awaiting incoming tide

Photo 27. Charge Detonated

Photo 28. Results of the Detonation at following low tide

Photo 29. Charge and Tubular awaiting incoming tide

Photo 30. Resultant cut of Tubular

Photo 31. Charge and Tubular and Cross Member awaiting incoming tide

Photo 32. Resultant Cut of Structure

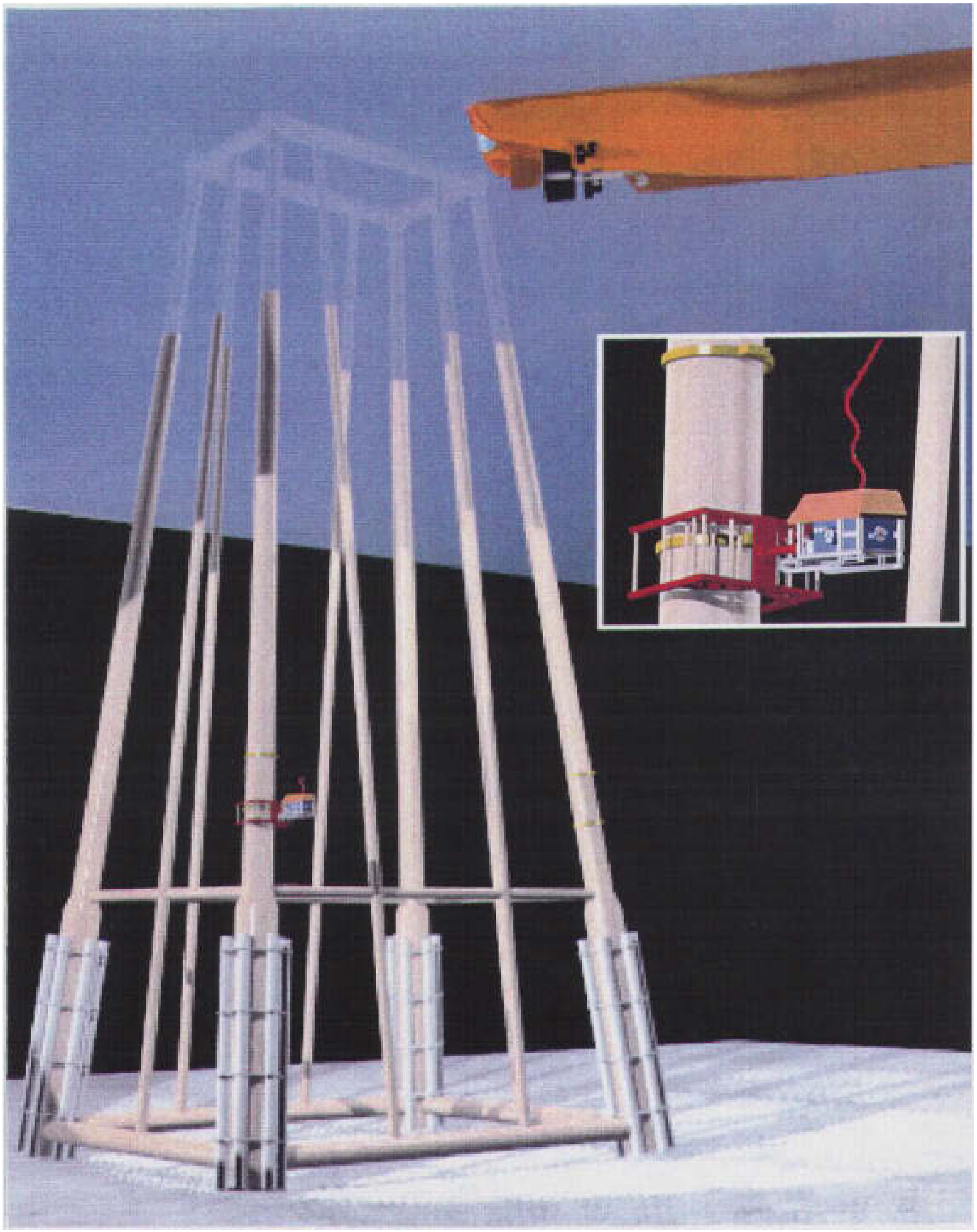


Figure 33. Sample Charge Placement on a Deepwater Structure

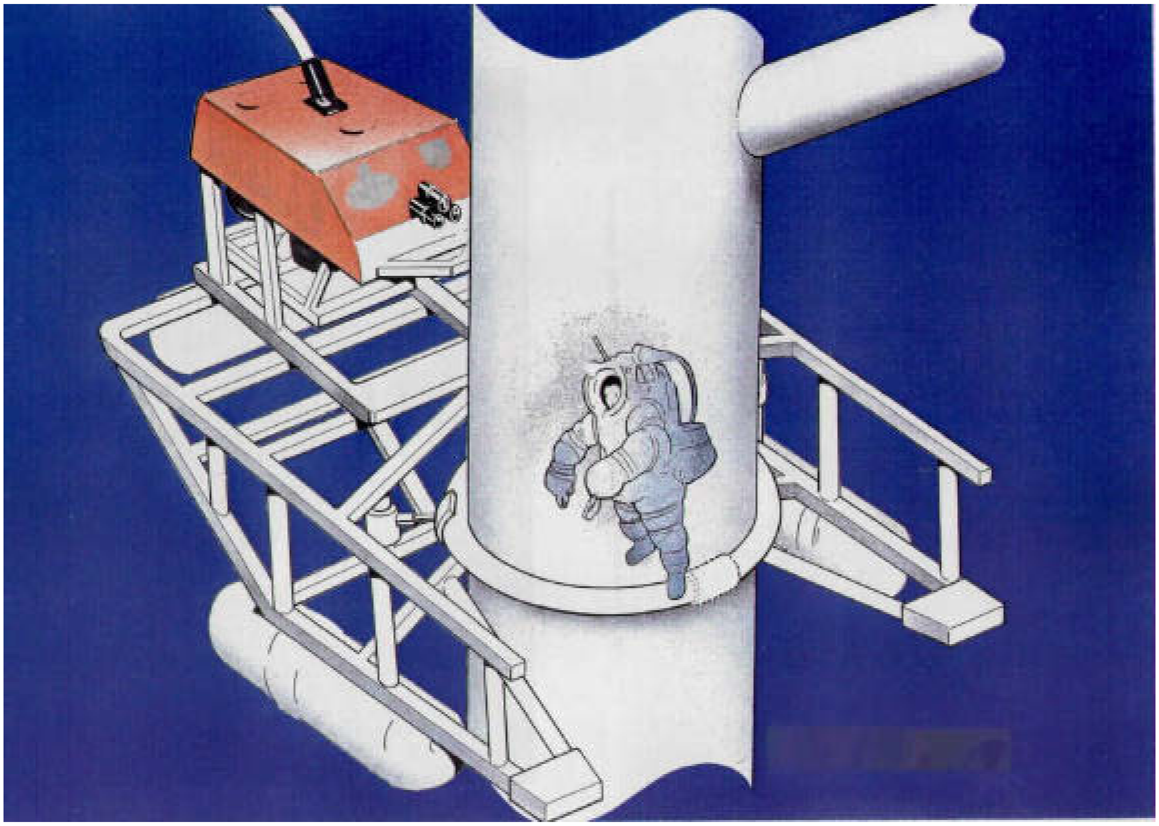


Figure 34. Sample Charge Placement on a Deepwater Structure (Close up)

10.7 Offshore Platform Removal Information Checklist

The following information is required in order to minimize problems in the effective execution of any explosive platform removal operation (DEMEX 1997).

1. Basic Information:
   - Owners
   - Customer
   - Location
2. Environmental Details:
   - Platform Installation Date
   - Water Depth
   - MMS Permit
   - Pipelines in Area
   - Soil Report
3. Jacket Details:
   - Piles Grouted
   - Batter
   - Top of Jacket
   - Bottom of Jacket
4. Main Piles Details

- Quantity
- OD
- Wall Thickness
- Material Properties (Steel Type, Welded, etc.)
- Stabbing Guide Makeup
- Pile Driving Records
- Internal Obstructions (Grout lines, etc.)
- Pile Cut Off (Top of Pile, Bottom of Pile)

5. Skirt Piles Details
    - Quantity
    - OD
    - Wall Thickness
    - Material Properties (Steel Type, Welded, etc.)
    - Stabbing Guide Makeup
    - Pile Driving Records
    - Internal Obstructions (Grout lines, etc.)
    - Pile Cut Off (Top of Pile, Bottom of Pile)
6. Conductors Details
    - Quantity
    - Top of Conductor
    - String Makeup
    - Material Properties (Steel Type, Welded, Etc.)
    - Grout Makeup
    - Stab Over
    - Template
    - Mud line Suspension Hanger
    - Sub-Sea Conductor
7. Operational Details
    - Work Platform Type
    - Diver Set Charges
    - ROV Set Charges
    - Pulling Conductors
    - Pulling Piles
    - Reuse of Jacket
8. Mob-Demob Details:
    - Mob Facility

- Demob Facility
    - M/V Information (see 11.2 U.S. Coast Guard Permit Information)

10.8 Typical Offshore Platform Removal Procedures

The following are typical procedures used in the removal of a platform involving explosives. These would be used as a guide for developing the standard operating procedures for each specific removal operation (DEMEX 1995-2000).

(1) The Explosive Technician will receive the explosives from the supplier, inventory the material, and confirm the date of manufacture as well as the shipping date.
(2) The Explosive Technician will survey the vessel prior to mobilization to the job site.
(3) The Explosive Technician will determine a safe location for the storage of the on-board magazine, said location to be decided upon after consultation with the Captain of the Vessel or Barge.
(4) The Explosive Technician will define and establish a safe perimeter for the restricted area that is to surround the Magazine(s) and Work Area. The Explosive Technician will utilize barriers and warning

signs that prohibit smoking, open flames, “hot work”, and unauthorized personnel to show the boundaries of the Restricted Area.
(5) The explosive materials (and detonators) must be the last items to be loaded onto the vessel.
(6) Electric detonators, delays and non-electric detonators will be stored in a separate magazine from the other explosives.
(7) The vessel departs for location.
(8) Upon arrival at the location, the Explosive Technician and Helper will begin to prepare the explosive devices (without actually arming the devices) in the aforementioned Restricted Area. Upon completion of the loading sequence, the magazines are re-locked.

Charges Set From Surface:

(9) For targets with internal access they will be sounded with a drifting template to verify the accessibility to the pre-determined depth and to assure that there are no residual hydrocarbons or natural gas.
(10) The Explosive Technician will then insert the explosive charges into the target and lower them to the pre-determined depth.
(11) The Explosive Technician will bring the shot line from the vessel to the work site.
(12) The Explosive Technician will verify the resistance to assure continuity of the line.
(13) All divers must be out of the water within a two thousand (2000) yard radius. Verification must be received prior to proceeding with the following stages.
(14) Radio silence is established and all personnel, with the exception of the Explosive Technician, will evacuate the work site.
(15) The Explosive Technician will verify delay sequences.
(16) The Explosive Technician will install the Detonators/Delay circuitry into the shot line. The Explosive Technician will again verify continuity.
(17) The Explosive Technician will perform the tie-in of the Detonators/Delay circuitry to the proper detonating cord to produce the desired delay between each successive detonation. The Explosive Technician will again verify continuity.
(18) The Explosive Technician will return to the vessel. The gangway is removed. The Explosive Technician will again verify continuity.
(19) Radio communications are re-established.
(20) The vessel is re-positioned a pre-determined distance from the work site. The Barge Captain will decide the actual positioning of barge and which direction from platform (North, South, East, or West) after consideration of wave activity, etc.
(21) The proper warning signals are executed and a visual search for vessels (including unauthorized crafts) is performed.
(22) At the prescribed time, after verifying continuity, the Explosive Technician will execute the initiation and detonation will begin.
(23) The Explosive Technician will observe the effects of the blasts, shock waves, and bubble energy.
(24) The vessel will not move back to position until the Explosive Technician gives the “all clear” signal. Upon receipt of this signal, the vessel may relocate to the platform.
(25) The vessel may begin the salvage operations as best determined by its Captain.
(26) This sequence is performed at each location.

Note: It is imperative that the Explosive Technician participates in all job safety and on-site (location) meetings.

Note: The Contractor’s crew will be permitted to assist Explosive Technician in the handling and movement of the explosives only under the direct supervision of the Explosive Technician. However, under no circumstances will the Contractor’s personnel load, arm, tie-in, or otherwise handle un-packaged explosives or detonators. The Explosive Technician will be the **ONLY** personnel to perform these tasks.

Diver or ROV Set Charges:

(27) A soft line with detonating cord attached will be connected to the bridle of the charge for the target.

(28) A cross bar is attached to the soft line and detonating cord at the proper distance to allow the diver to place the charge in the skirt pile and suspend the charge to proper cut depth.
(29) The diver jumps with the bulk load to the proper skirt pile, lower the charge to position and holding position with the crossbar.
(30) As the diver is descending, the attached soft line and detonating cord is played out to proper depth.
(31) While diver is returning to surface, shooting line is checked for continuity.
(32) When the diver is on deck, the tie in procedure starts.
(33) All radio and R.F. material is shut down and other vessels in the area notified and divers secured from the water.
(34) A detonator is taken from its magazine, placed in a place to protect the user in case of detonation, and is checked for continuity.
(35) With the shooting line shunted, the bitter end is un-shunted and the blasting cap attached.
(36) The shooting line and blasting cap assembly are checked for continuity.
(37) The detonator and detonating cord attached to the soft line are assembled.
(38) This assembly is attached to a float, which allows the cap to be above the surface of the water, and gives an indication of the position of the charge.
(39) The float and cap are placed overboard and the vessel moved off a minimum of 250 feet from location.
(40) The float position is observed to guarantee the charge is still in proper position.
(41) The shooting line assembly is again checked for continuity.
(42) The barge captain is checked for security of the barge, crew and divers. Upon his authorization, the shot is detonated.
(43) Each skirt pile is a repeat of the above.
(44) Should a shot misfire, the following procedure will be observed:
    a. Six potentials exist for a misfire:
        (1) Line shorts out.
        (2) Cap malfunctions.
        (3) Cap does not fire detonating cord.
        (4) Detonating cord shoots off.
        (5) Detonating cord does not detonate charge.
        (6) Detonator does not detonate charge.
(45) If any of the above exists, a time period of thirty minutes will be observed.
(46) (44) a. (1), (2), and (3) can be checked from the barge with the explosive galvanometer or visual.
    (44) a. (4) can be checked by the soft line.
    (44) a. (5) and (6) require the charge to be retrieved with soft line for observation.

11. Developing Technology

Improved shaped charges show the most promise for developing technology. Shaped charges have a long and established history. Cutting metal with shaped charges can be a very efficient use of explosives. Problems with the effectiveness of severing have usually come from the targets not being exactly what was planned. Such an example would be a pile that was out of round thereby causing the jet to loose energy in the water or not form properly. Several designs for improved shaped charges are in the testing phases by several explosive service companies. Many of the designs are incorporating a 5-pound limit in order to avoid NMFS observers and other regulatory requirements relative to offshore blasting. Unfortunately, this 5-pound limit will be limited to severing tubulars that are around 36" and smaller.

Charge deployment devices are the root of most problems with shaped charges and other explosive technology. The main problem is that most deployment devices are a one-time use. They are literally blown up when the explosive is detonated. Large investments into these deployment devices are rarely undertaken as the market is limited.

Computer modeling has advanced to a point, which has given better insight geared toward avoiding such failures. Little has been done to address the deliberate failure of tubulars. While modeling can give a better understanding of what it takes to fail structural members, the problem remains as to how explosives can be deployed to most effectively cause such a failure. There are several developments currently underway which are aimed at addressing this issue.

Explosive Cutting Tape is a form of linear shaped charge, which is extremely flexible, allowing the tape to be placed in direct contact with the tubular to be severed while maintaining the proper standoff. The flexibility of the tape may render it useless in deep water, as the hydrostatic pressure will very likely cause the liner to be distorted/collapsed.

Fracturing Charges in the form of "plaster" or contact charges can be placed in direct contact with the target. The explosion causes a shock wave to travel through the target thickness and spall some steel from the opposite side. Pressure from the expanding gas completes the severance. The effect of having a target backed by grout or by various types of soil has yet to be studied. Another form of fracturing charge is the Shock Refracting Charge. The same size as the plaster charge and similar in form to a shaped charge and the cutting tape, the shock refracting charge avoids the problem of compressibility due to water depth and does not require the precise standoff of a shaped charge. It would still require divers to secure the adhesive-backed charge to the pile.

Shock-Wave Focusing charges use two strips of explosive separated by a wave-guide wrapped around the target. This method produces very high compressive stresses on the target material and rapidly converts them into tensile stresses to cause controlled brittle fractures. Test in air show this technique could reduce the explosive weight by 90% compared to a comparable shaped charge. This technique poses little hope for deepwater applications because the side of the target opposite the charge must be backed by either air or water.

A technique using a series of ***radial hollow charges*** shows promise with respect to overcoming the low explosive-to-target area ratio experienced when using internal shaped charges. These radial charges consist of a several linear shaped charges bent into an arc so that each segment resembles a slice of pie. Because the point of initiation is at the edges of the explosive as opposed to the apex of the liner, the resulting diverging flow results in a long cut on a curved surface.

With all these avenues being explored, all of them are viable means of severing a tubular which is free of soil on one or both sides with unrestricted access at water depths under 300 feet or so. This situation does not exist when discussing the severance of tubulars of an offshore structure, knowing that such tubulars are going to be at least coated with mud if the majority of the surrounding seafloor has been jetted away. The most practical approach is in the development of a method of deploying an explosive system based on proven technology and involving a minimum of diver effort (Marine Board 1996).

12. Conclusions

The size and scope of removing platforms in deep water with explosives is a daunting task. While removing structures in shallow water is considered routine in the Gulf of Mexico, the larger and deeper structures that are located in the Pacific region OCS as well as other parts of the world will require detailed review. It is recommended that a full Engineering and/or Risk Assessment Study be performed. Computer modeling of the event would help assess the feasibility of the severance of a pile by several methods. Vulnerability studies would identify the variables and their corresponding affect on performance? The results of this study should answer the following questions:

- What type of explosive device will be most reliable to sever the pile?
- Is scaling of explosive devices for this type of work linear or exponential?
- Will explosives be able to sever the piles without a re-shoot?
- Should scale testing be performed?
- How is pile severance to be verified?
- What will be the contingency plan if pile is not severed on first shot?
- What preparations to the pile will be required to use explosives?
- How should the explosive devices be set?
- What are the risks, environmentally, financially, and to life?

Environmentally, the impact of using explosives for platform removals is considered minimal. Professionals within the governmental regulatory bodies agree that the impact of explosives is minute compared to other sources of mortality in the marine environment. This is not to say that we as an industry should be allowed to “do as we please” but continue to strive to perform our work in an environmentally sensitive manner.

Financially, explosives for severing piles are considered the most cost efficient procedure available. This cost even includes expenditures relative to environmental regulations such as observers and aerial surveys. It should be noted that the severance of piles is usually less than 1% of the total project cost for deep-water platform removals. The real cost is in barge time, so an unsuccessful severance can cause the cost to escalate at an exponential rate because of down time.

Historically, explosive methods have proven more reliable and more cost effective than alternative methods. The use of explosives is an exact science, so long as the associated variables are quantified. The degree of success in an explosive severance operation will be directly related to the precision with which these variables are defined.

In conclusion, given all of the financial, environmental, historical, and safety considerations, the use of explosives should be the preferred method for severing deep-water structures.

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