A SINGLE POINT MOORING FOR DIRECT PUMP-OUT OF HOPPER DREDGES

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ABSTRACT

The Corps of Engineers (CE) does not have the equipment required to perform open ocean direct pump-out (DPO) of material dredged by hopper dredge. The CE desires the to develop this capability to enable the use of hopper dredges for emergency beach fill or for beneficial uses of material dredged for channel maintenance.

As part of the Dredging Research Program (DRP), the CE contracted a study of commercially available mooring systems able to provide open ocean DPO for the CE hopper dredge fleet. This paper describes the adaptation of single point mooring (SPM) technology traditionally used in the offshore oil industry for export and import of oil for the DPO of hopper dredges.

INTRODUCTION

The Corps of Engineers (CE) owns four hopper dredges. In addition to their regular maintenance dredging duties in federal navigation channels, the CE desires these dredges to have the ability to place sand on beaches during national emergencies. For example, after a hurricane it may be necessary to quickly place additional sand on the beach to protect structures from subsequent storms. Also, in support of military activities, it can be desirable to place dredged material on the beach. At present, the CE does not have a system that allows their hopper dredges to direct pump-out (DPO) the contents of their hoppers when they are working in an open coastal environment.

The CE's Dredging Research Program (DRP) is a seven year, $35 million effort to lower the Corps 1/2 billion dollar annual dredging budget. The DRP included a work unit to investigate improved methods and equipment for near shore and onshore placement of dredged material. The major focus of this work unit was to investigate methods to allow the CE hopper dredges to have material directly pumped from the dredge to the beach when working on open coasts. The CE has a mooring barge that effectively allows DPO of material dredged in more sheltered environments.

The CE contracted with SOFEC, Inc. to: a) describe several DPO systems capable of meeting CE requirements; b) with CE input select a single system which best met CE requirements; and c) provide a detailed preliminary design of the entire DPO system including the buoy, swivel, floating and under buoy hoses, mooring hardware and suggested transportation and installation procedures. The intent of this effort was to allow a CE District Office with the need for such a system to use this design as a vehicle for developing final design drawings and fabrication of the DPO system.

This paper describes DPO concept, operating and design parameters for the DPO system, initial mooring systems capable of meeting these goals, and the final system selected. Short descriptions of how the system will be operated including transportation, assembly, and installation are provided.

DIRECT PUMP-OUT

Direct pump-out is a common method of removing dredge material from hopper dredges. A hopper dredge fills its hoppers as it dredges the sea floor. The dredge then moors to a structure, buoy or multiple buoy berth. Hoses connected to a pipeline running to shore are attached to the hopper dredge discharge manifold. The dredge mixes the dredge material with sea water to form a slurry and pumps the slurry from its discharge manifold through the hoses and pipeline to the designated discharge location.

DESIGN PARAMETERS

The mooring system was designed to be used by the following three CE hopper dredges.

USACE "Wheeler"	Length	408.0 ft
	Beam	78.0 ft
	Draft	29.5 ft
USACE "Essayons"	Length	350.0 ft
	Beam	68.0 ft
	Draft	28.5 ft
USACE "McFarland"	Length	300.0 ft
	Beam	68.0 ft
	Draft	26.0 ft

Operational weather conditions were chosen to fit the maximum operating environment for the dredges. The mooring was designed for the following operational conditions.

Significant Wave Height	6.0 ft
Wind Velocity	30.0 Kt
Current Velocity	2.0 Kt

Survival conditions for the mooring system design are:

Significant Wave Height	10.0 ft
Wind Velocity	30.0 Kt
Current Velocity	2.0 Kt

Direction of the environment was chosen to be consistent with near shore conditions. Current was chosen parallel to the shoreline and the wind and waves perpendicular to the shoreline.

The mooring system was designed for operation in a minimum water depth of 30 ft and a maximum water depth of 45 ft.

Location of the mooring system from shore is limited by the pumping capacity of the dredge. In many instances, the hopper dredges are required to operate in water depths very close to their maximum drafts due to the shallow slopes along parts of the inner continental shelf.

The following criteria was also required for the mooring design:

- Transportable by truck or rail
- Assembled rapidly
- Installed with a minimum of lift support
- Recoverable and reusable.

MOORING CONCEPTS

The following four concepts were considered for mooring the dredge.
- Guyed Tower
- Tension Leg Platform (TLP)
- Single Anchor Leg Mooring (SALM)
- Catenary Anchor Leg Mooring (CALM)

The CALM system was chosen for further study and preliminary design due to its ability to be transported in truck size packages, assembled quickly and proved to be the least costly to fabricate.

THE CALM SYSTEM

The CALM buoy in Figure 1 is a capsule shaped buoy which is 28'-0" long by 11'-6" wide by 7'-6" deep. Although not the conventional shape of a mooring buoy, the shape was chosen to facilitate towing the buoy and placement on truck flat beds. The buoy can be disassembled into the following four components.

- Buoy Hull
- Fluid Piping
- Fluid Swivel
- Mooring Table

The buoy hull serves as the foundation for the fluid piping. Slurry from the dredge enters the buoy through a floating hose connected to the fluid piping just above the water at the outer edge of the buoy. Piping is designed to contain a minimum amount of bends to reduce areas of high abrasion. Slurry travels through the piping to a fluid swivel. Slurry leaves the buoy through an under buoy hose which is connected to the fluid swivel and leads to a pipeline to the discharge area.

Near the fluid piping/floating connection, a mooring pad eye is provided for the connection of a mooring hawser. The hawser transfers the mooring forces from the dredge to the buoy.

The fluid swivel is an in-line swivel currently used by the dredge industry. It contains bronze bushings which reduce the need for seals or the extensive need for maintenance that roller bearings would require. The lower end of the fluid swivel contains a quick release flange to assist in connecting the underbuoy hose.

The buoy rotates about a shaft which runs through the centerwell of the buoy. The center shaft contains two permanently lubricated bronze bushings located at the top and bottom of the centerwell of the buoy. A 48" diameter flange is located at the bottom of the center shaft. The flange provides the mechanical connection between the buoy and the mooring table.

The mooring table extends below the buoy and provides locations for the connection of the mooring chains to the buoy. The mooring table also provides a bell fairing to reduce chafing of the under buoy hose.

Floating and under buoy hoses for this mooring system are standard commercially available hoses currently used in the dredging industry.

The mooring chains consist of four legs, each 600 ft 2 in. diameter ORQ (Oil Rig Quality) stud link chain.
Mooring anchors may either be 10,000 lb Navy Navmoor or 6,000 lb Bruce International FFTS anchor.

Figure 2 show the installed mooring system during the DPO process.

SYSTEM OPERATION

Transportation
The CALM system can be transported by truck, rail or barge to the assembly location. Figure 3 shows the CALM buoy packaged for transport by truck. Other components of the system can be consolidated and transported on standard flat bed tractor trailer rigs. The entire system can be transported by as few as six trucks.

The entire system can also be arranged on a standard 60 ft X 120 ft cargo barge for ocean transportation.

Assembly
The CALM system is assembled by attaching the mooring platform to the 48 in. diameter flange located at the bottom of the buoy (Figure 4). The fluid swivel is then attached to the buoy top deck followed by the attachment of the piping to the fluid swivel and to the buoy deck at the outer edge of the buoy. The buoy is then lifted into the water by a shore based crane. For short tows, the floating hose can be attached to the piping prior to leaving the dock.

Installation

Once the CALM buoy is assembled, a tow tug will connect to the towing pad eyes on the buoy deck opposite the piping. The capsule shape of the buoy will allow the buoy to be towed at greater speeds and should prove to be a more stabile tow than a conventional cylindrical buoy.

As the buoy is under tow to the installation location, an anchor handling tug will be installing the four mooring legs and the mooring anchors. The tug will tension the chains to set the anchors prior to buoy arrival. Chains will be laid closely to the pipeline under buoy hose connection. Pickup buoys will be attached to each leg.

As the chains are being installed, the pipeline will be assembled on the shore, floated into position and lowered to the seafloor. Any pipeline stabilization required will be undertaken while the buoy chains are being attached.

When the buoy arrives at the installation location, the chain legs are attached to the mooring platform and tensioned until the proper chain catenary is achieved.

The under buoy hoses are then pulled though the guide on the mooring platform and connected to the lower end of the fluid swivel. If the floating hoses were not installed at the shore, the connection is made between the floating hoses and the buoy piping.

The hawser is connected to the mooring pad eye to complete the system installation.

CONCLUSIONS

1. A detailed preliminary design for a DPO system for use with CE hopper dredges has been developed.

2. To meet operational requirements of use in shallow water (30 ft) and logistical requirements for rapid transport (light weight, easy assembly and truck transportable) a capsule shaped buoy using a CALM mooring system with a separate mooring system was designed. The buoy is 28'-0" long by 11'-6" wide by 7'-6" deep and weights approximately 30 short tons.

3. Subsequent detailed design and fabrication of this system will depend on CE District specific requirements.

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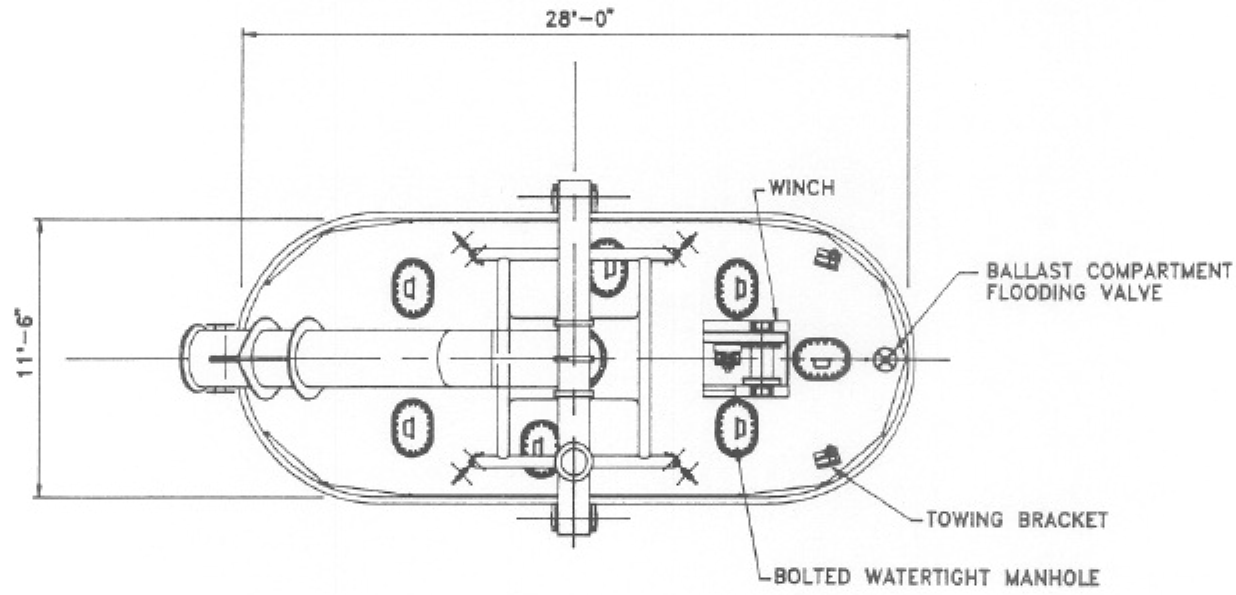

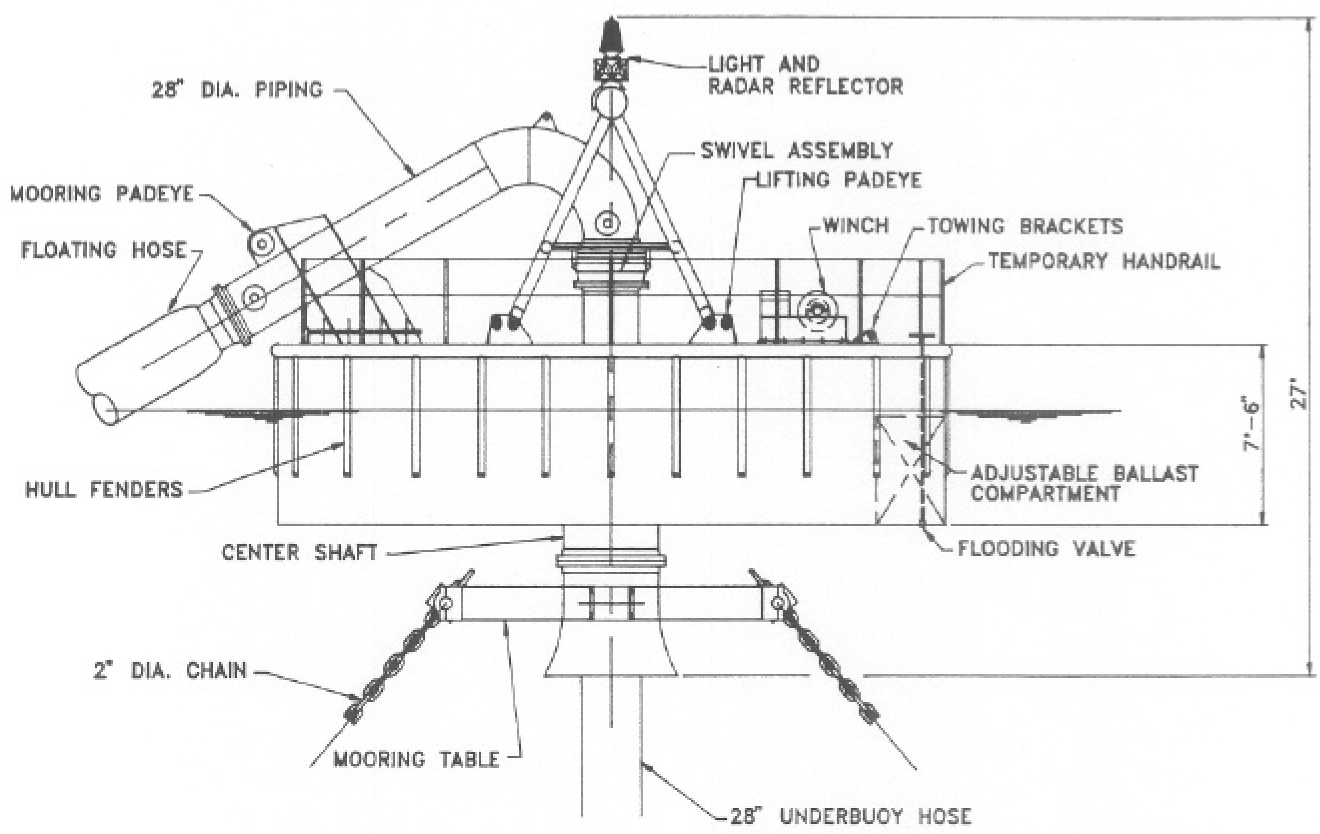

FIGURE 1.0 DREDGE MOORING PLAN AND ELEVATION

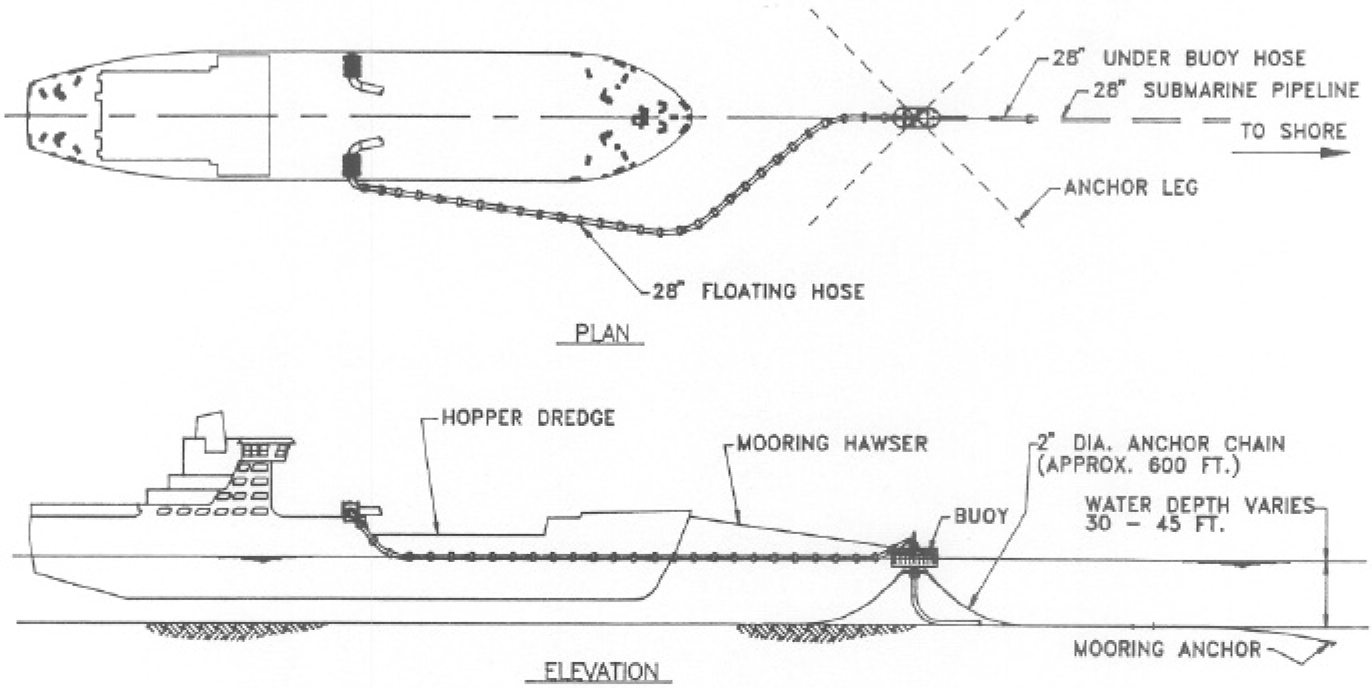

FIGURE 2.0 SYSTEM GENERAL ARRANGEMENT

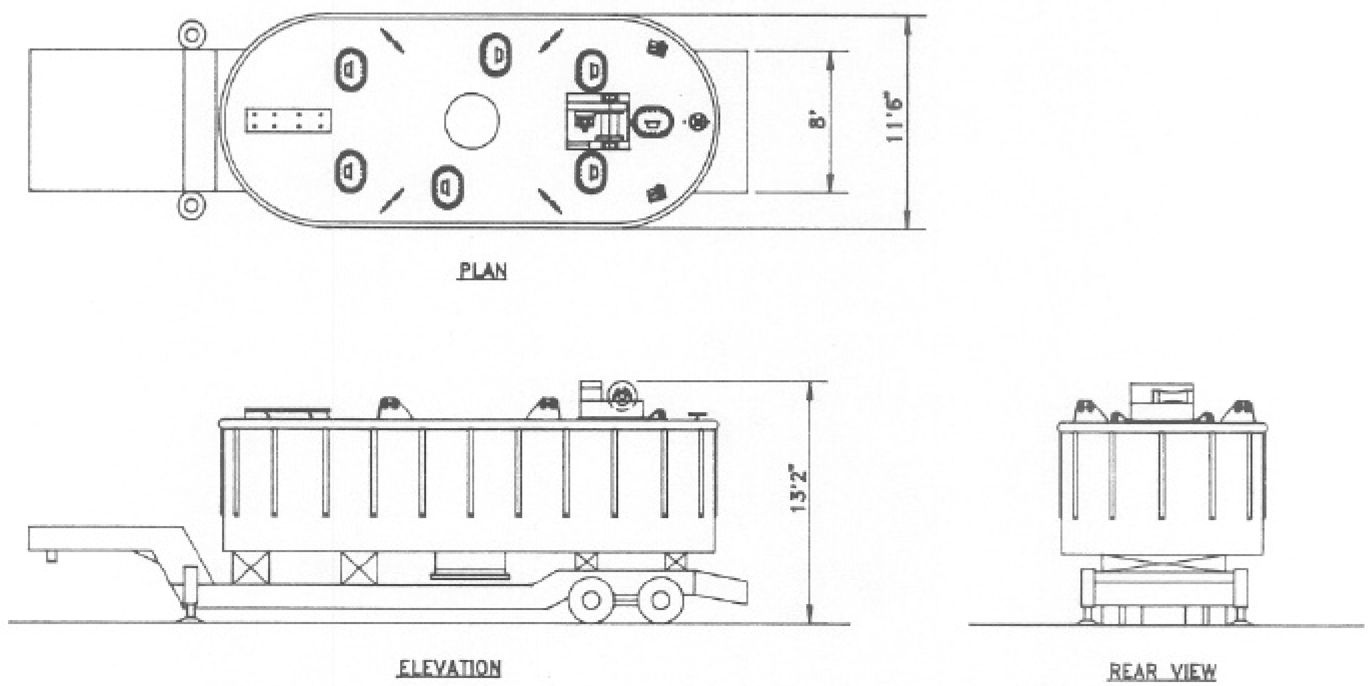

FIGURE 3.0 MOORING BUOY TRUCK TRANSPORT CONFIGURATION

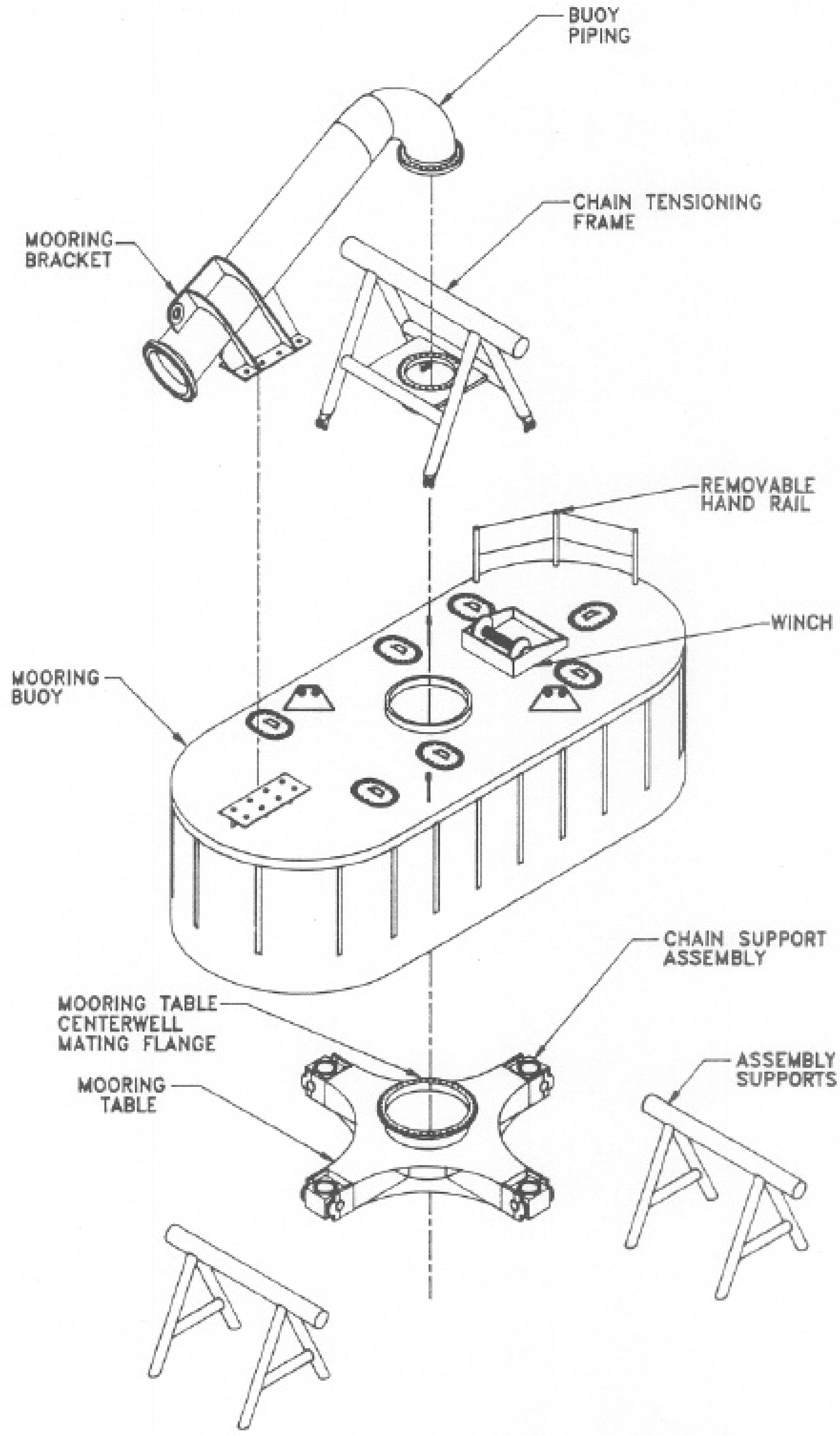

FIGURE 4.0 MOORING BUOY ASSEMBLY