



GUNDERBOOM

Engineered Aquatic Filter Barrier Systems

In Partnership with Seventy Percent of the Earth

**FULL-PLANT DEPLOYMENT OF AN AQUATIC FILTER
BARRIER SYSTEM AT A GENERATING STATION ON THE
HUDSON RIVER IN NEW YORK**

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Abstract

Substantial work has been done to develop intake technologies to mitigate environmental impacts associated with the withdrawal/use of surface waters. Recently, the Aquatic Filter Barrier (AFB) has been determined to be BTA for mitigating these environmental impacts at several cooling water intake structures. Gunderboom, Inc. has recently deployed a full-scale AFB at a coal-fired plant on the Hudson River in New York as required under a SPDES Permit. A filter fabric barrier system, originally designed by Gunderboom, Inc. as a sediment barrier and oil boom, was modified and developed for use at water intake structures. The AFB technology was developed over a six year period (1995-2000), largely through a project sponsored by Mirant New York, LLC. The AFB development program was carried out at a generating station on the Hudson River in New York, which has a once-through cooling water system with a capacity of 491 MGD. The AFB is designed to exclude entrainable fish eggs and larvae withdrawn at the water intake structure by filtering the total water volume required by the facility, while taking into consideration site water quality (sediment loading) and hydraulic conditions (tides, current velocities.) The deployment of a full-plant AFB requires the orchestration of multiple vendors and subcontractors. Prior to the deployment of the barrier itself, land-based construction activities include installation of dedicated electrical and air quality supply components, system control components, and the site specific anchoring system. To maximize efficiency multiple activities are undertaken concurrently including land based preparation of the barrier. Construction activities are timed such that the barrier can be placed in the water immediately following the completion of preparatory activities. This facility final design and installation, including a major waterfront construction component, was completed approximately six months after receiving the official notice to proceed.

Introduction

After eighteen years of aquatic filter barrier (AFB) technology projects and development, Gunderboom, Inc., designed, fabricated, installed and is operating a Gunderboom[®] Marine Life Exclusion System (MLES[™]) for Mirant Lovett, LLC at the Lovett Generating Station (Lovett), Tomkins Cove, NY, for spring, summer and fall operation during 2004. The diagrams, photos and depictions and their accompanying texts, presented as Figures 1 – 32 at the end of the text of this paper, provide an understanding of the design, fabrication, installation and operation of the Lovett MLES[™].

AFB and MLES[™] Technologies

An AFB is a full-water-depth, “fine-mesh” barrier that prevents the passage of particles, particulates, organisms and debris from passing through it while allowing the passage of water. Gunderboom has developed a number of different AFB applications for dredge material control, storm water control, and reservoir protection (see Attachment 1 for patent information). This particular application, the MLES[™], is designed to prevent aquatic biota, ranging in size as small as planktonic fish eggs and larvae, from entering or being drawn into water intake structures. With a fabric apparent opening size (AOS) on the order of 150 microns, fabric perforation size as low as 0.4 mm, and an approach velocity of 0.012 fps, the non-woven laser perforated fabric curtain allows the passage of water while preventing both impingement and entrainment of ichthyoplankton and juvenile aquatic life.

Most of Gunderboom’s applications, including the MLES[™] deployed at Lovett, utilize a permeable fabric, consisting of polyester fibers and constructed of two layers subdivided into vertical cells or pockets. A sufficient amount of filter fabric is designed into the boom to accommodate water level fluctuations (e.g. tides) up to the design high-water condition. For an “anchored, floating” system such as deployed at Lovett, a flotation hood along the top of the entire length of the boom keeps the system above the water surface and, together with a system for sealing with the bottom and ends of the AFB, maintains a complete filter through which all water must pass to reach the facility’s intake. The MLES[™] is fixed in position by a carefully engineered anchoring and mooring system. A heavy skirt constructed of durable, impermeable, rubberized material is attached to the bottom of the filter fabric to create a seal with the substrate and prevent aquatic organisms from passing underneath.

The MLES[™] is equipped with a computer-controlled AirBurst[™] cleaning system. Computer-controlled valves release compressed air between the two layers of fabric near the bottom of panels that segment the MLES[™] into ~7.5-foot cells. The released air expands up through the water column and out through the fabric, dislodging accumulated sediments by both the abrupt shaking and by the release of air through the fabric. Every facility, location and water body characteristics provides a different set of challenges and the Gunderboom MLES[™] can be designed to meet site-specific physical and biological constraints. An onsite fabric flow test is one of the techniques that has been developed to optimize design at any specific site. Ambient water

conditions are tested with a range of MLES™ materials and designs in order to achieve optimum flow rate for that site.

The Gunderboom® MLES™ is designed to filter the total cooling water volume required by a generating unit, while taking into consideration site water quality (sediment loading) and hydraulic conditions (tides, current velocities). Development program results over the past ten years have led to design improvements and modifications that increased the flow through capacity of the filtering fabric, strengthened the design, maintained fabric filtering capacity through the automated AirBurst™ cleaning system, and provided an anchor system that maintained the MLES™ under extreme flow and weather conditions.

What is unique about the Gunderboom® MLES™ as a 316(b) technology is that it is a physical barrier that can be designed to prevent the intake of even the smallest of fish eggs, larvae or other freshwater or marine life. Depending on the application, a properly designed and operated MLES™ may be able to achieve levels of entrainment reduction to make it equivalent to the capacity reduction characterized by use of wet cooling towers or even dry cooling. With the very large filter fabric surface area compared to a normal cooling water intake structure (CWIS), “through-fabric” velocities are very low.

The MLES™ has recently been specified as Best Technology Available (BTA) at two proposed new electrical generating facilities on the Hudson River. These new facilities will require relatively low flow rates (6-8,000 gpm) by incorporating hybrid wet cooling tower technology. The hybrid wet cooling tower technology in combination with the MLES™ is expected to achieve the equivalent of dry cooling tower impacts on aquatic life.

Plant and Site Parameters and Considerations

The Lovett Generating Station is located on the west bank of the Hudson River at River Mile (RM) 42, in Tomkins Cove, Rockland County, New York, about an hour's drive north of New York City. The station consists of three fossil-fueled, steam electric units (Units 3, 4 and 5), having net generating capacities ranging from 63 to 202 MWe for a total of 462 MWe for all units combined with once-through condenser cooling system requiring 391 MGD of non-contact cooling water at full capacity.

The cooling water required to operate Lovett is drawn from the Hudson River, a large coastal river that empties into New York Harbor. The Hudson River in the vicinity of Lovett experiences a 3-ft tidal range and has salinities ranging from 0-10 ppt depending on tides and freshwater flows. The river experiences periods of high total suspended solids (TSS) and flows 160,000 cfs as a result of seasonal rain events and snowmelt. The characteristic of the Hudson River that were considered in the development of the MLES™ at Lovett, including the water level fluctuations, currents, waves, waterborne sediments, substrate quality and potential fouling species (e.g. zebra mussels). Other site specific variables that were considered include the life history characteristics of the species targeted for protection and physical limitations of the site.

Development of MLES™ Technology at Lovett

Gunderboom MLES™-specific technologies were developed through a program at Lovett conducted over the period 1994 – 2000. The primary objective of the research development program was ultimately to maintain a permeable, physical barrier in front of the facility. Annual research goals focused on the flow-through capacity of the fabric, mooring and anchoring, cleaning the fabric, maintenance and the deployment process. Primary research targets and accomplishments by year, were:

- 1995 - Gunderboom System concept
- 1996 - Manual AirBurst™ cleaning system / spud-type anchors (3-unit deployment)
- 1997 - Manual AirBurst™ cleaning / dead-weight anchoring system
- 1998 - Automated AirBurst™ cleaning / 500-micron perforations / monitoring equipment
- 1999 - Automatic AirBurst™ cleaning / monitoring equipment
- 2000 - Improve field maintenance procedures, improve mooring hardware and test new zipper connections

The MLES™ forms a 1500-foot long ellipse encompassing the three intake structures. The system is designed with sufficient capacity to filter all of the water withdrawn by the three units at full flow conditions.

The MLES™ was designed based upon laboratory studies and developmental prototypes from 1994 through 2000 at the Lovett Generating Station. Ichthyoplankton monitoring was conducted during the developmental program to measure the system's effectiveness at reducing entrainment. Paired samples were collected during 1995, 1998, and 2000. Results from an Ichthyoplankton Monitoring Program indicate that the system's exclusion rate was greater than 80% effective at reducing entrainment. As a result of this development program, the Gunderboom MLES™ has been determined to be a BTA for mitigating environmental impacts associated with the use of surface waters at cooling water intake structures. Additional results of research demonstrate that, a seasonally deployed MLES™ can achieve BTA at the Lovett Generating Station at any water withdrawal rate, up to and including the maximum facility design rate, by filtering the cooling water. Limited research has also demonstrated that a flow velocity at the point of withdrawal from the Hudson River through the fabric of 0.01 to 0.02 fps can prevent damage to fish eggs, which contact the MLES™ and fish larvae exposed to these very low velocities.

Design of the Lovett Gunderboom® MLES™

The design of the Lovett Gunderboom® MLES™ had to take into account a significant list of operational, physical and biological parameters.

Plant operational parameters requiring attention by design engineers included:

- CWS flow at this facility can vary considerably as units come on and off and the AFB needs to function throughout the range of flow rates
- CWS discharges are located at both south and north ends of the facility. The AFB needed to achieve enough fabric area for the CWS flow

Site and waterbody design parameters that required specific attention included:

- Tidal range averaging 3 and up to ~5 ft; Higher during high river flows or with storm surge
- Bi-directional currents up to ~2 fps; Waves up to ~3 feet; Wakes from numerous pleasure craft up to large tankers and tugs
- Variable suspended sediment loading, up to ~50 mg/L
- Riverbottom along AFB alignment ranging from soft fine sediments to sand to shell-covered and steep and variable bottom slope. Riverbottom in anchoring area low shear strength, unconsolidated sediments
- Heavy debris loading that includes floating and submerged trees, leaves and aquatic vegetation

Gunderboom design engineers developed detailed analyses of:

- Development of site and application-specific design fabric flow rates and resultant filter fabric surface area requirements
- Loading on the AFB, mooring point connections, mooring lines and anchors (created by high hydraulic head differential) under conditions of high sediment loading, with maximum CWS flow, at extreme low water and rising tide
- Buoyancy requirements for the AFB that include consideration of CWS flow, water level and currents on maximum loading and on the ability to overtop to relieve pressure should excessive loading occur

The engineering analyses and design considerations led to a design that includes:

- Addition of sheet pile walls to extend the shoreline length of the AFB and extend the CWS discharges farther to the north and south
- Alignment of the AFB along approximately the 30-foot MLLW (mean lower low water) depth contour
- The AFB fabricated in sections that are connected after assembly on site, many of them of ~140 feet
- Provision of compressed air from each end of the AFB to provide a redundant system in case of any problems
- Water level sensors for determination of water level and tidal change and for continuous determination of head differential for ongoing monitoring, triggering AirBurst™ cycles and warning of any buildup above design levels
- Inclusion of strain gauges, or “load cells” on ten of the mooring lines to measure actual load on the boom, also for ongoing monitoring, triggering AirBurst™ cycles and warning of any buildup above design levels

- Numerous other features related to the strength of the AFB and operation of the system.

Final engineering design included all marine structures, the AFB itself, electrical, pneumatic and control system architecture and details.

Fabrication and Installation

Fabrication of the entire MLES™, including the AFB, was completed between August 2003 and March 2004. (AFB fabrication is shown in Figures 4 – 8). During the fall and winter of 2003-2004, sheet-pile walls were installed (see Figures 9 – 13); large rocks and boulders were removed from an area in the planned alignment for the AFB; anchor tests were conducted and anchors (Figure 12) fabricated and installed; and the pneumatic system components and electrical supply system were installed (see Figures 20 - 23).

Onsite assembly and installation of the AFB (Figures 14 – 20) and the air valve float boxes (Figures 24 – 26) were completed during February – April, 2004)

Operations and Maintenance of the Lovett Gunderboom® MLES™

System commissioning and O&M commenced with the “unreefing” of the curtain from the flotation collar on April 28, 2004. A substantial and important effort has been included in this first full year of system operation. These have included: “tuning” mooring lines; adjusting the vertical configuration of the AFB; optimizing the Supervisory Control and Data Acquisition (SCADA) system for monitoring and controls; optimizing AirBurst™ effectiveness, including tests and adjustments to pressure, burst duration and intervals between cycles; and learning about and adjusting to various unique site characteristics and their affect on AFB operations.

The system is monitored “24/7” by plant operators through an human machine interface (HMI) located in the Control Room for Unit 4. (See Figures 28 – 32 for representative Lovett Gunderboom MLES™ HMI screens and a description of their uses) MLES™ pneumatics and electrical systems are part of regular “rounding” inspections and are included in plant maintenance. Alerts and alarms setpoints for various system operational indicators and reporting procedures have all been refined.

Gunderboom will complete a review of the 2004 deployment soon after the AFB is removed for inspection, maintenance and modifications after its mandated deployment season is over (It is required to be in through October 31). Entrainment exclusion effectiveness sampling results, conducted independently of Gunderboom’s deployment activities, will also be analyzed and considered along with MLES™ operations information and monitoring data, after the deployment season has concluded.

Figures

Engineering Design

Figure 1. Preliminary plan view of the 1400-foot-long Gunderboom MLES™ at the Lovett Generating Station (Lovett). This diagram was prepared at the Conceptual Design phase of the project. It shows the location of the three bulkhead CWP intakes, approximate location of the top flotation collar of the boom (shaded line) and outer edge of the outer bottom skirt (thin line). The location of anchors and mooring lines (top and bottom at each location) are shown along with general bathymetric contours.

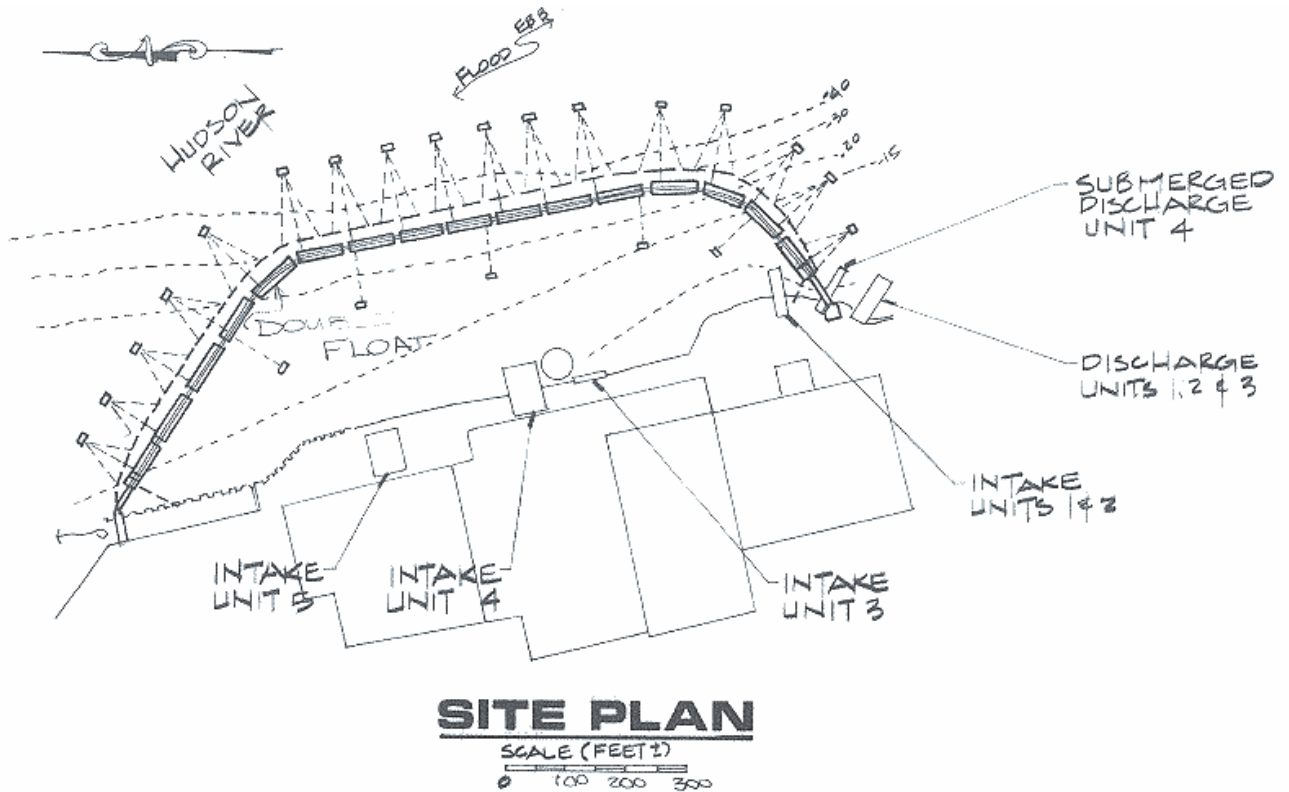


Figure 2. Detailed design drawing (plan view) of the 1400-foot-long Gunderboom MLES™ at the Lovett Generating Station (Lovett). Shows the final design location of the top flotation collar of the AFB (shaded line) and outer edge of the outer bottom skirt (thin line). The location of the 56, 66,000-pound outer anchors and the 24 inner anchors are shown on a bathymetric contour map developed from a Multi-beam survey completed as part of pre-design studies and data acquisition. Mooring lines attach to the AFB at the top and the bottom at each location.

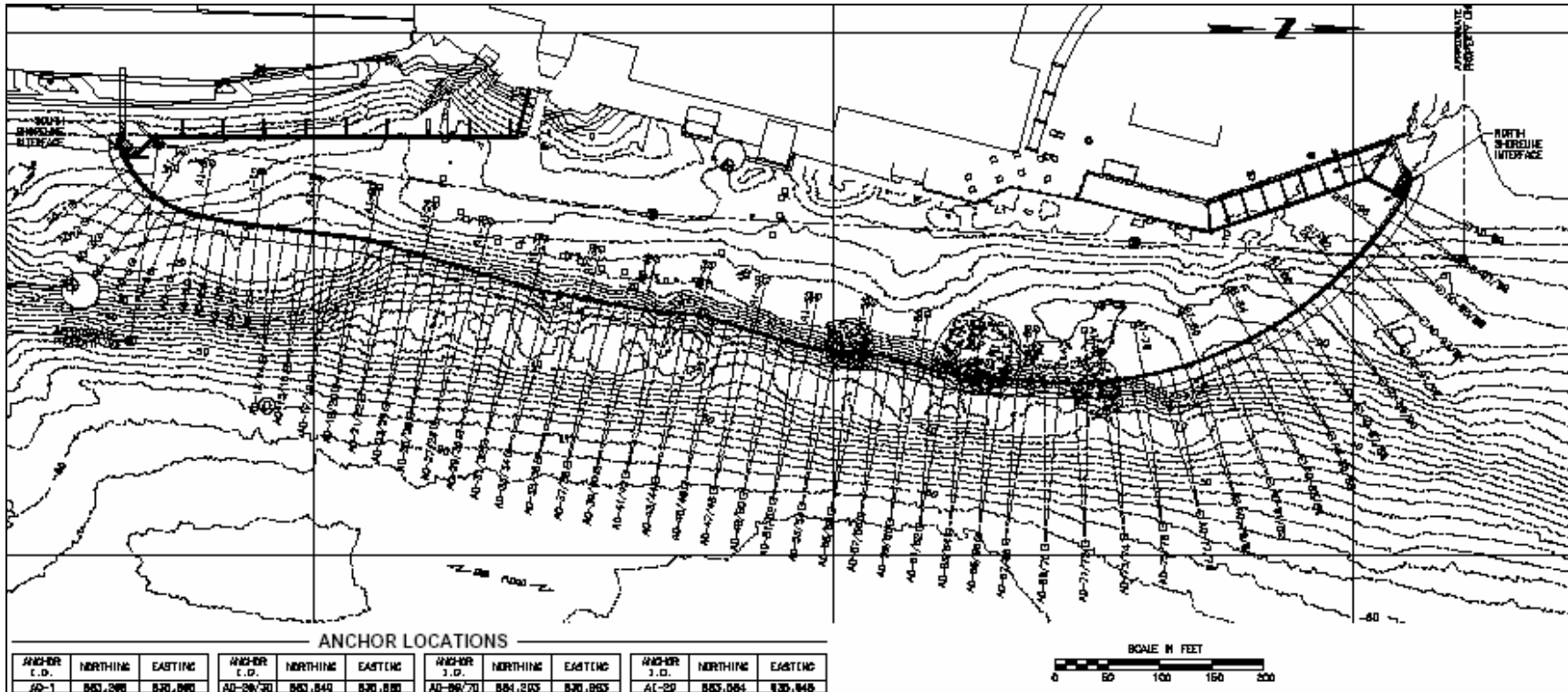


Figure 3. Photo looking northward along the Hudson River shoreline at Lovett, quickly relating the engineering drawings with a picture of the result. Here the top of the Gunderboom MLES™ can be seen as it appeared after onsite assembly and prior to attaching mooring lines from the anchors. The fabric is “reefed” to the flotation.



Fabrication Facility

Figure 4. At the Gunderboom manufacturing facility in Anchorage, Alaska, many specialized large-scale pieces of equipment are employed to make the AFB. Here a heat-seaming device is utilized in the attachment of the hood.



Figure 5. Long cutting/sewing/assembly tables with custom features provide optimum effectiveness for assembly in the manufacturing process.



Figure 6. Photo showing Gunderboom's Laser Perforating System penetrating the filter fabric for Lovett with 12,000 holes per square foot. The holes are required to be no greater than 0.5 mm as measured by Apparent Opening Size (AOS).



Figure 7. Gunderboom's custom-manufactured sewing machines are capable of sewing through thick layers of filter fabric, reinforced skirt fabric and 10,000-pound nylon support strapping.



Figure 8. After the manufacturing process is complete, sections, many on the order of 140-feet long and complete with hood, fabric, impermeable skirt, nylon webbing, structural netting, anchor attachment points, air hoses, bottom chain and more, are loaded onto pallets for shipping to the site.



Construction Activity

Figures 9 and 10: Gunderboom provides intake solutions that extend beyond the MLES™. In this section, figures are shown illustrating the construction activity provided by Gunderboom in support of the installation of the engineered MLES™. At the Lovett Generating Station, the MLES™ design solution included extending the discharge channels to achieve a greater length of AFB to provide the filter fabric area needed for the CWP flow. Both north and south sheet pile walls terminated in curved sheet pile cells to which the ends of the AFB attach and seal. These are depictions of the engineered drawings of the sheet pile walls.

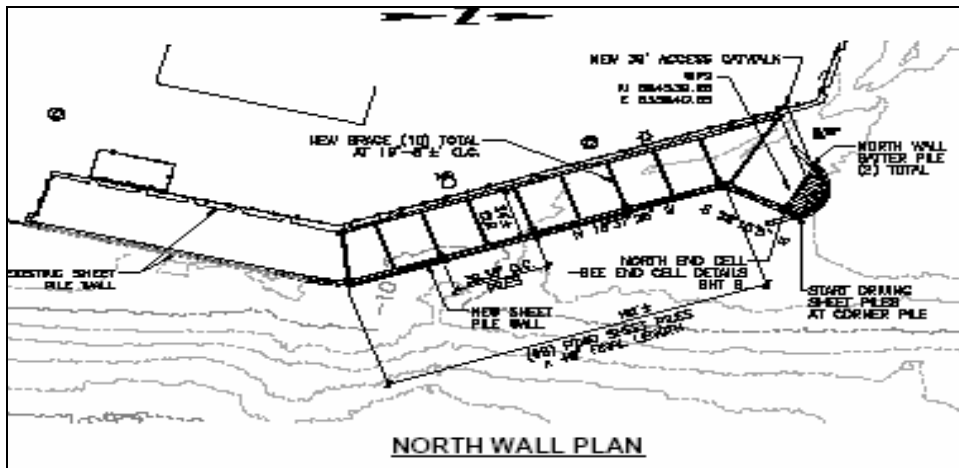
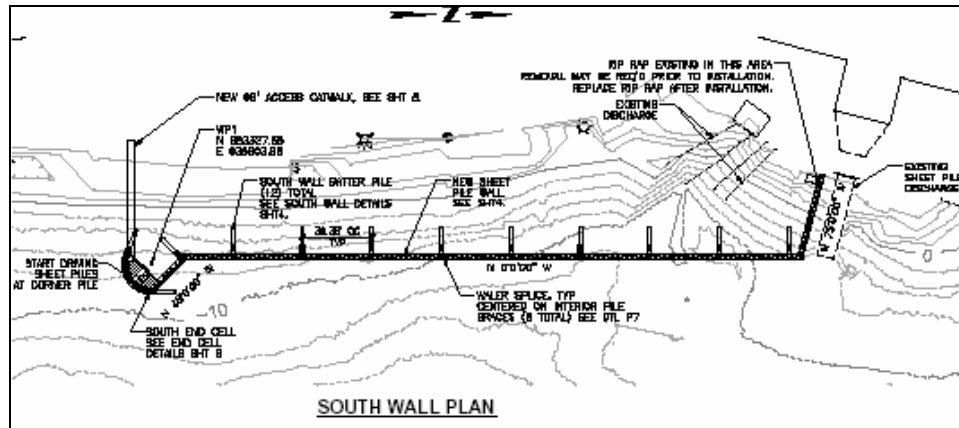


Figure 11. The South Mooring Cell is being installed at the extended Unit 3 and 4 discharge channel. Gunderboom, Inc, contracted and provided oversight for all marine work on this project.



Figure 12. The North Mooring Cell is being installed at the extended Unit 5 CWP discharge channel. The system's anchors can be seen on the barge.



Figure 13. The North End Cell, just before the AFB is attached. The mooring cell is wrapped with the impermeable material providing an end seal for the system, and equipped with a Gunderboom-designed and manufactured bridging arm to support the floating system, and air supply equipment that will provide the system with pressurized air for automatic cleaning.



Onsite AFB Assembly and Installation

Figure 14. A cross-sectional drawing of the installed AFB. The installation process requires that in addition to onsite assembly, towing the reefed AFB into position, making all attachments, unreefing, and making the bottom seal, fine-tune adjustments to the anchor lines for optimum length and load distribution is important to the shape, and therefore the function of the system.

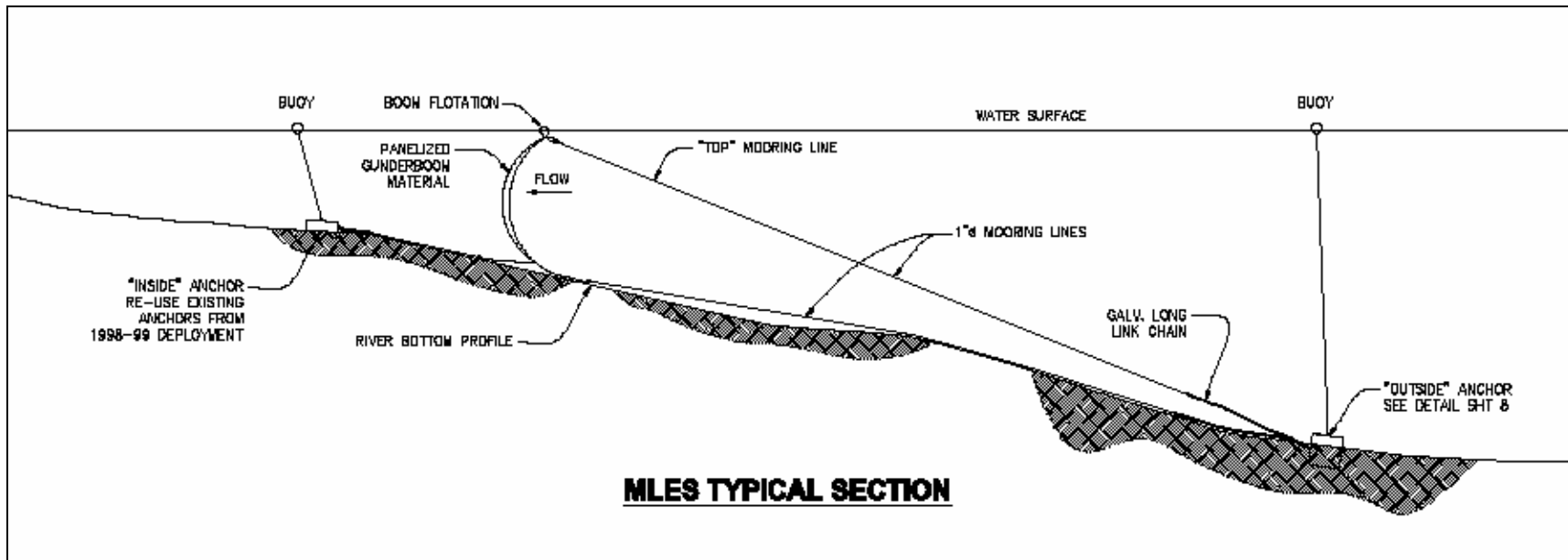


Figure 15. Onsite, the AFB is unfolded from the pallets shipped from the manufacturing facility in Anchorage, and laid out onto a geotextile-protected surface prepared for optimum mobility. Flotation billets (cylindrical polystyrene, 18-22 in diameter, 8-ft long) are inserted into the hood and after other preparation details, the curtain is reefed to the flotation in preparation for in-water deployment.



Figure 16. Installation team members secure the billet insertion pockets after the flotation billets for that section have been inserted. The individual cells, approximately 7.5 ft wide, are separated by sewn 10,000-lb nylon strapping. Each of the air hoses seen here provides air for cleaning a single cell.



Figure 17. A close-up of a multiple junction point. The chain weighs down the curtain from the bottom of the fabric. Galvanized D-rings connect two 140-foot curtain sections, here at the bottom of the fabric, along with zippers and other connection hardware. The impermeable material seen at the top and the bottom of the photo are the undersides of the inside and outside skirts, where they join vertically to the rest of the curtain.

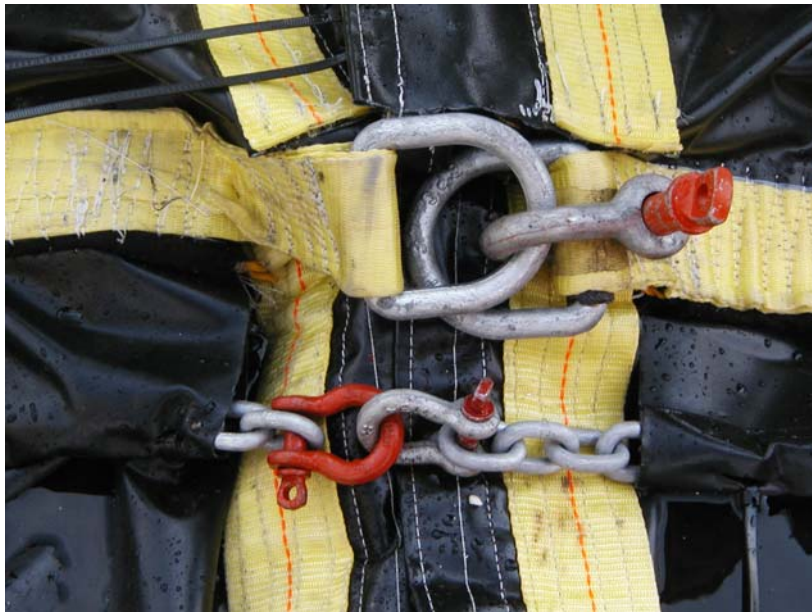


Figure 18. The reefed AFB as it is towed into the water. The flotation supports the entire curtain, as designed, allowing for a less difficult initial positioning.



Figure 19. The reefed AFB just after it has been attached to the north mooring cell. The cell has been prepared with the impermeable seal and the air supply and sensor equipment. Gunderboom used the FlexiFloat barge to support installation of the 56 sets of outer mooring lines (4 lines per set).



Figure 20. Divers prepare to attach anchor lines, distributing the loads by fine-tuning the lengths, and inspect the bottom seal after unreefing.



Air Delivery System

Figure 21. Diagram showing the locations of the air supply equipment and air piping lines installed for cleaning of the Gunderboom® MLES™. The automatic AirBurst™ System is programmable by operators to clean at specified time intervals, as well as cleaning automatically if sensors detect circumstances that require it.

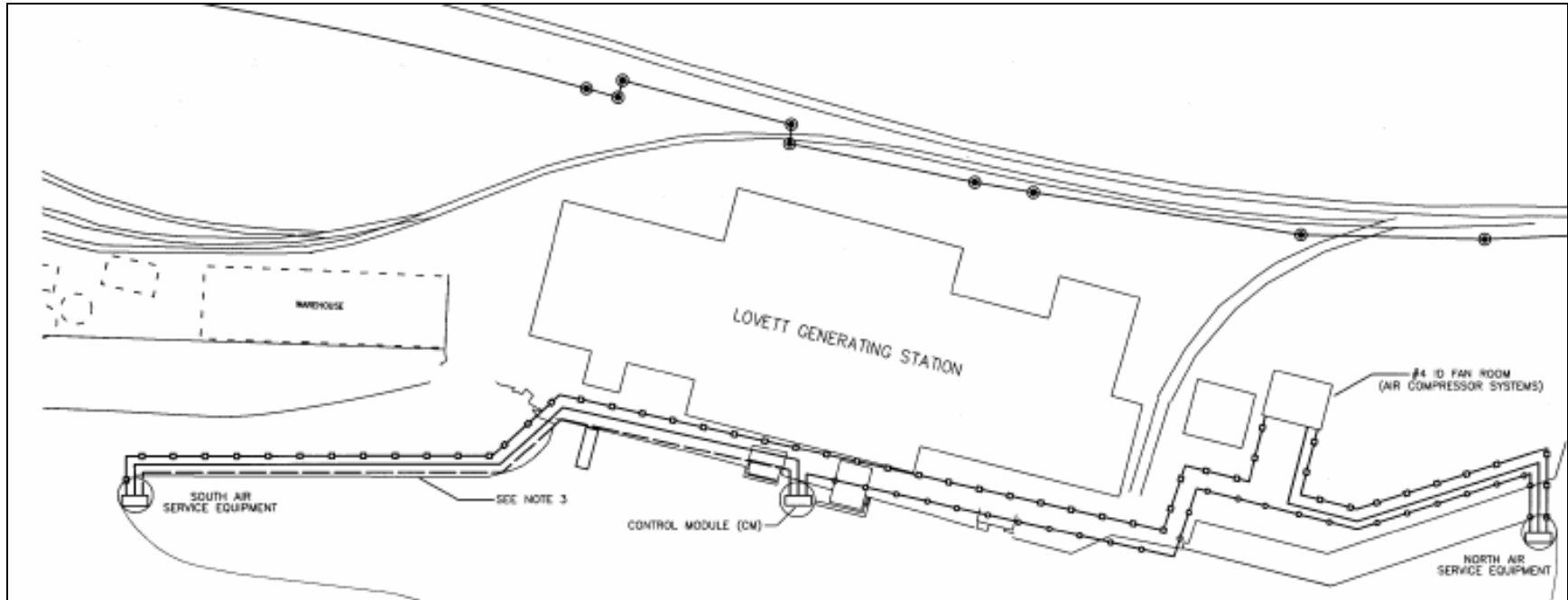


Figure 22. The air supply design for the AirBurst™ System includes a redundancy that optimizes functionality and provides cleaning even if there were a failure with a compressor, a set of air lines or other component. Valving allows a number of different configurations as compressed air is delivered from here to secondary air receivers, each on the South Cell and North Cell.



Figure 23. The compressed air travels from two oil-free compressors (one shown above) to the main receiver, then separate supply lines take it through the dryers and out to each end of the AFB. Shown below is the receiver at the north end, three regulated paths, and flow and pressure transmitters monitoring the function of the MLES™ cleaning.



Figure 24. Each cell of the AFB is cleaned with air supplied by a dedicated valve in the air line. Each of the control boxes below contains two valves, as well as power and computer network equipment. The automatic, complex and redundant cleaning system is protected by marine-grade enclosures, and is easily operated and monitored with operator control panels.



Figure 25. The interior components of a digital control box include a power converter, an InterBus module, and two valves.

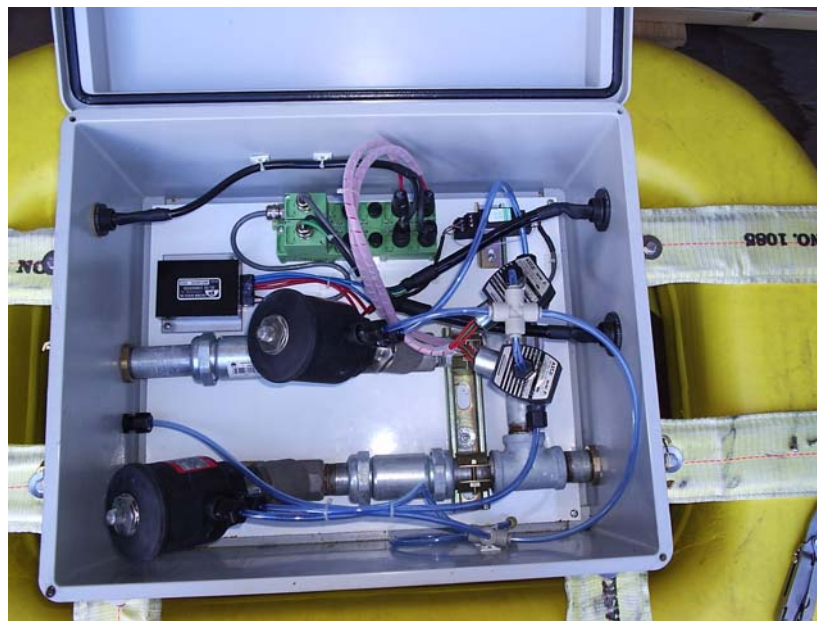


Figure 26a. The installation team members attaching the control boxes to the AFB and installing the air line hoses. Special attention must be paid to securing all of the cables and lines.



Figure 26b. Valve float box in place during AirBurst pulse.



Lovett Gunderboom MLES™ SCADA System

Figure 27. Diagram of the landside network components of the Lovett Supervisory Control and Data Acquisition System (SCADA). Network control is divided such that the AFB is serviced and cleaned by two separate, integrated systems. The South Cell Air Supply serves every other four consecutive cells and is controlled directly by the PLC (programmable logic controller) in the MLES™ Control Module on the Central Mooring Cell, adjacent to the bulkhead wall near the center location of the AFB. The other half of the system (alternate sets of four consecutive cells) is cleaned from the north air supply and is controlled through a PLC processor at the North Air Service Control Panel.

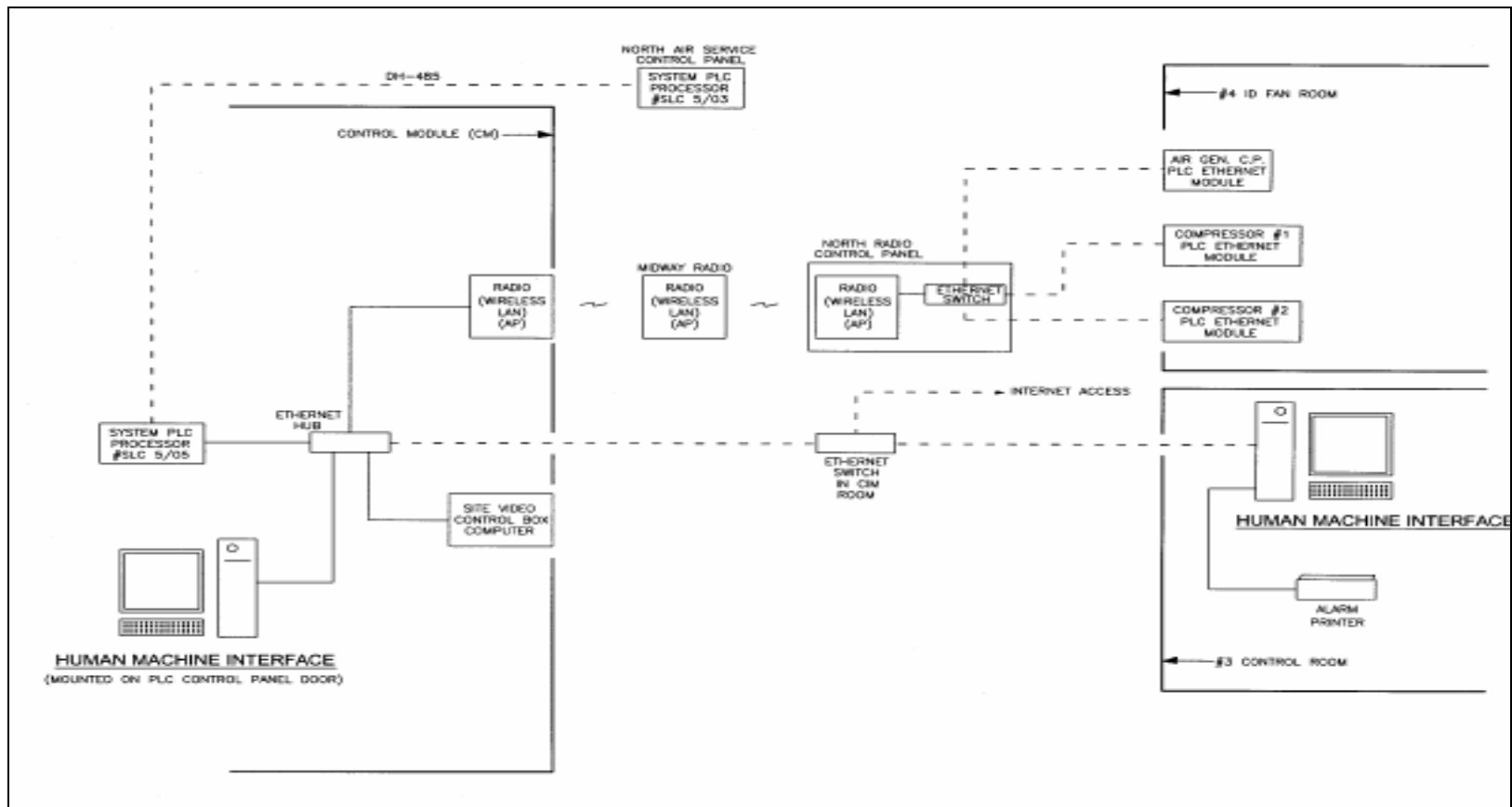


Figure 28. The Lovett Gunderboom MLES™ SCADA can be accessed from the Human Machine Interface (HMI) in the Control Module on the Central Mooring Cell, from an HMI in the Lovett Unit 4 Control Room and by remote access. The Overview Screen presents much of the current information on system status. The display is built around a generalized diagram depicting the AFB and the plant's shoreline. Current sensor readings are displayed for load cells deployed on AFB mooring lines, water level transmitters, as well as air flow and pressure at the end cells. At the top of the screen are real-time weather information, Airburst™ cycle status, and network status. At the bottom of the screen are compressor status, manual AirBurst™ controls, and a navigation bar allowing access to other pages in the program. User status and the most recent system alert are displayed here as well.

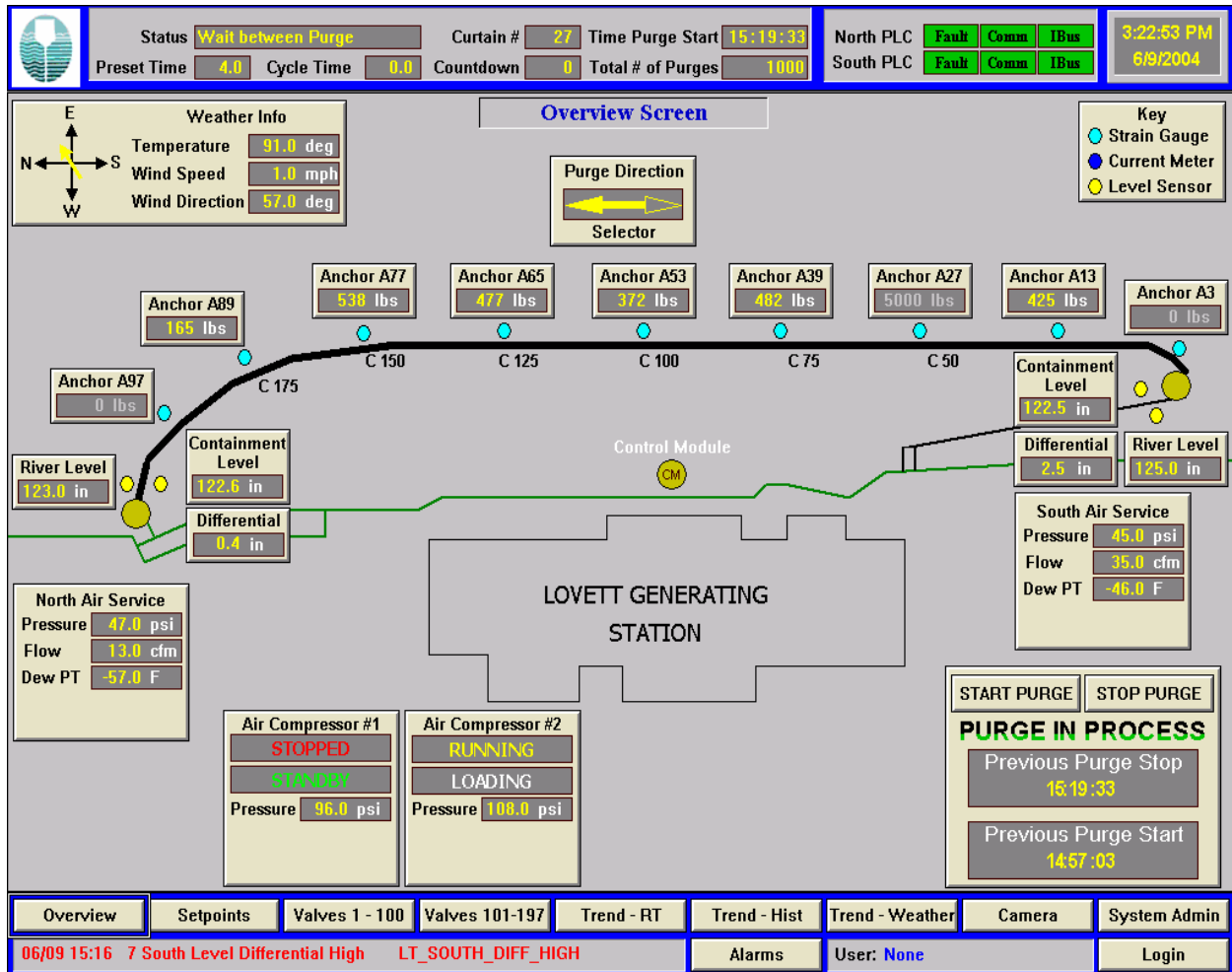


Figure 29. The System Setpoints Screen allows supervisors to control the levels at which automatic cleanings and alarms occur.

The screenshot displays the 'Setpoint Screen' interface. At the top, there is a status bar with the following information: Status: Not Active; Curtain #: 0; Time Purge Start: 0:00:00; Preset Time: 0.0; Cycle Time: 0.0; Countdown: 863; Total # of Purges: 757. On the right, there are indicators for North PLC (Fault, Comm, IBus) and South PLC (Fault, Comm, IBus), along with a timestamp of 2:32:35 PM on 5/22/2004.

The main area is divided into several sections:

- Purge Parameters:** A table with two columns: Parameter and Enable. Parameters include various Anchor - High Tension (A03, A13, A27, A39, A53, A65, A77, A89, A97) and Level Differential (North - Hi, South - Hi) settings. Enable buttons are either red (DISABLED) or green (ENABLED).
- Tension Alarm Setpoints:** A table with three columns: Parameter, Setpoint, and Units. All parameters are set to 800 lbs.
- Air Service Alarm Setpoints:** A table with three columns: Parameter, Setpoint, and Units. Parameters include North - Low Air Press SP (35 psi), South - Low Air Press SP (35 psi), North - High Dewpoint SP (-30 deg F), and South - High Dewpoint SP (-30 deg F).
- Level Alarm Setpoints:** A table with three columns: Parameter, Setpoint, and Units. Parameters include North - Level Differential SP (2.0 inches) and South - Level Differential SP (2.0 inches).
- General Setpoints:** A table with three columns: Parameter, Setpoint, and Units. Parameters include Purge Setpoint (3 secs) and Wait Setpoint (4 secs).

At the bottom, there are two buttons: 'STOP PURGE' and 'START PURGE', and an 'Execute' button.

Figure 30. The Gunderboom® MLES™ Valves Screens display real-time status of all system valves, indicating open or closed. For automatic operation, operators can choose enable or disable, valve purge time, and wait time between open valves for optimum cleaning and air pressure recovery. These screens also permit manual operation of individual valves.

Cell #/Valve # <input type="text" value="0"/>					Cell #/Valve # <input type="text" value="0"/>					Cell #/Valve # <input type="text" value="0"/>					Cell #/Valve # <input type="text" value="0"/>					2:04:50 PM 8/27/2004	
Status Not Active					Status Not Active					Status Not Active					Status Not Active						
Curtain Valves 1 - 100																					
Valve	Purge	Wait	Status	Enable	Valve	Purge	Wait	Status	Enable	Valve	Purge	Wait	Status	Enable	Valve	Purge	Wait	Status	Enable		
S 1/2	2	2	CLOSE	DIS	S 26	3	2	CLOSE	ENA	S 51	4	2	CLOSE	ENA	S 76	4	2	CLOSE	ENA		
S 3	2	2	CLOSE	ENA	S 27	3	2	CLOSE	ENA	S 52	4	2	CLOSE	ENA	S 77	4	2	CLOSE	ENA		
S 4	2	2	CLOSE	ENA	S 28	3	2	CLOSE	ENA	S 53	4	2	CLOSE	ENA	N 78	4	2	CLOSE	ENA		
S 5	2	2	CLOSE	ENA	S 29	3	6	CLOSE	ENA	N 54	4	2	CLOSE	ENA	N 79	4	2	CLOSE	ENA		
N 6	3	2	CLOSE	ENA	N 30	4	2	CLOSE	ENA	N 55	4	2	CLOSE	ENA	N 80	4	2	CLOSE	ENA		
N 7	4	3	CLOSE	ENA	N 31	4	2	CLOSE	ENA	N 56	4	2	CLOSE	ENA	N 81	4	2	CLOSE	ENA		
N 8	3	2	CLOSE	ENA	N 32	4	2	CLOSE	ENA	N 57	4	2	CLOSE	ENA	S 82	4	2	CLOSE	ENA		
N 9	3	2	CLOSE	ENA	N 33	4	2	CLOSE	ENA	S 58	4	2	CLOSE	ENA	S 83	4	2	CLOSE	ENA		
S 10	2	2	CLOSE	ENA	S 34	3	2	CLOSE	ENA	S 59	4	6	CLOSE	ENA	S 84	4	2	CLOSE	ENA		
S 11	2	2	CLOSE	ENA	S 35	3	2	CLOSE	ENA	S 60	4	2	CLOSE	ENA	S 85	4	2	CLOSE	ENA		
S 12	2	2	CLOSE	ENA	S 36	3	2	CLOSE	ENA	S 61	4	2	CLOSE	ENA	N 86	4	2	CLOSE	ENA		
S 13	2	2	CLOSE	ENA	S 37	3	2	CLOSE	ENA	N 62	4	2	CLOSE	ENA	N 87	4	2	CLOSE	ENA		
N 14	4	2	CLOSE	ENA	N 38	4	2	CLOSE	ENA	N 63	4	2	CLOSE	ENA	N 88	4	2	CLOSE	ENA		
N 15	4	2	CLOSE	ENA	N 39	4	2	CLOSE	ENA	N 64	4	2	CLOSE	ENA	N 89	4	6	CLOSE	ENA		
N 16	4	6	CLOSE	ENA	N 40	4	2	CLOSE	ENA	N 65	4	2	CLOSE	ENA	S 90	4	2	CLOSE	ENA		
N 17	4	2	CLOSE	ENA	N 41	4	2	CLOSE	ENA	S 66	4	2	CLOSE	ENA	S 91	4	2	CLOSE	ENA		
S 18	2	2	CLOSE	ENA	S 42	3	2	CLOSE	ENA	S 67	4	2	CLOSE	ENA	S 92	4	2	CLOSE	ENA		
S 19	2	2	CLOSE	ENA	S 43	3	2	CLOSE	ENA	S 68	4	2	CLOSE	ENA	S 93	4	2	CLOSE	ENA		
S 20	2	2	CLOSE	ENA	S 44	3	2	CLOSE	ENA	S 69	4	2	CLOSE	ENA	N 94	4	2	CLOSE	ENA		
S 21	2	2	CLOSE	ENA	S 45	4	2	CLOSE	ENA	N 70	4	2	CLOSE	ENA	N 95	4	2	CLOSE	ENA		
N 22	4	2	CLOSE	ENA	N 46	4	2	CLOSE	ENA	N 71	4	2	CLOSE	ENA	N 96	4	2	CLOSE	ENA		
N 23	4	2	CLOSE	ENA	N 47	4	4	CLOSE	ENA	N 72	4	2	CLOSE	ENA	N 97	4	2	CLOSE	ENA		
N 24	4	2	CLOSE	ENA	N 48	4	2	CLOSE	ENA	N 73	4	2	CLOSE	ENA	S 98	4	2	CLOSE	ENA		
N 25	4	2	CLOSE	ENA	N 49	4	2	CLOSE	ENA	S 74	4	2	CLOSE	ENA	S 99	4	2	CLOSE	ENA		
					S 50	4	2	CLOSE	ENA	S 75	4	2	CLOSE	ENA	S 100	4	2	CLOSE	ENA		

Overview	Setpoints	Valves 1 - 100	Valves 101-197	Trend - RT	Trend - Hist	Trend - Weather	Camera	System Admin
08/27 14:04 1 Compressor K-2 Warning Alarm			K2_ALARM_WARNING		Alarms	User: NONE	Login	

Figure 31. The Historical Trending Screens display sensor readings through time. The display can be easily manipulated by the Operator to present custom comparisons and any variety of sensors, time durations, and vertical scales. Air flow patterns below show the relationship between north-supplied and south-supplied air line activity and the regular pattern of valves opening and closing through AirBurst™ cycles. The ability to view any recorded time interval provides the Operator with the capability to look into patterns, deviations or occurrences in real time.

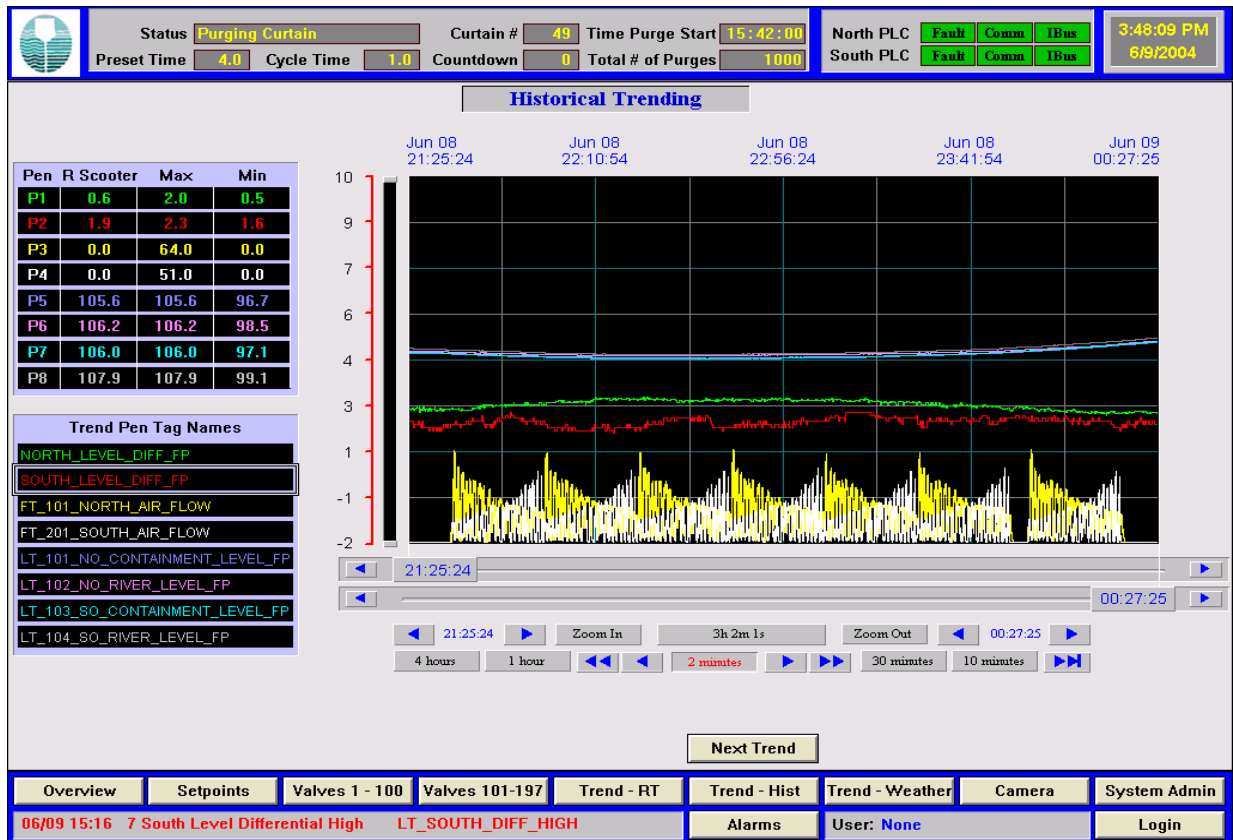
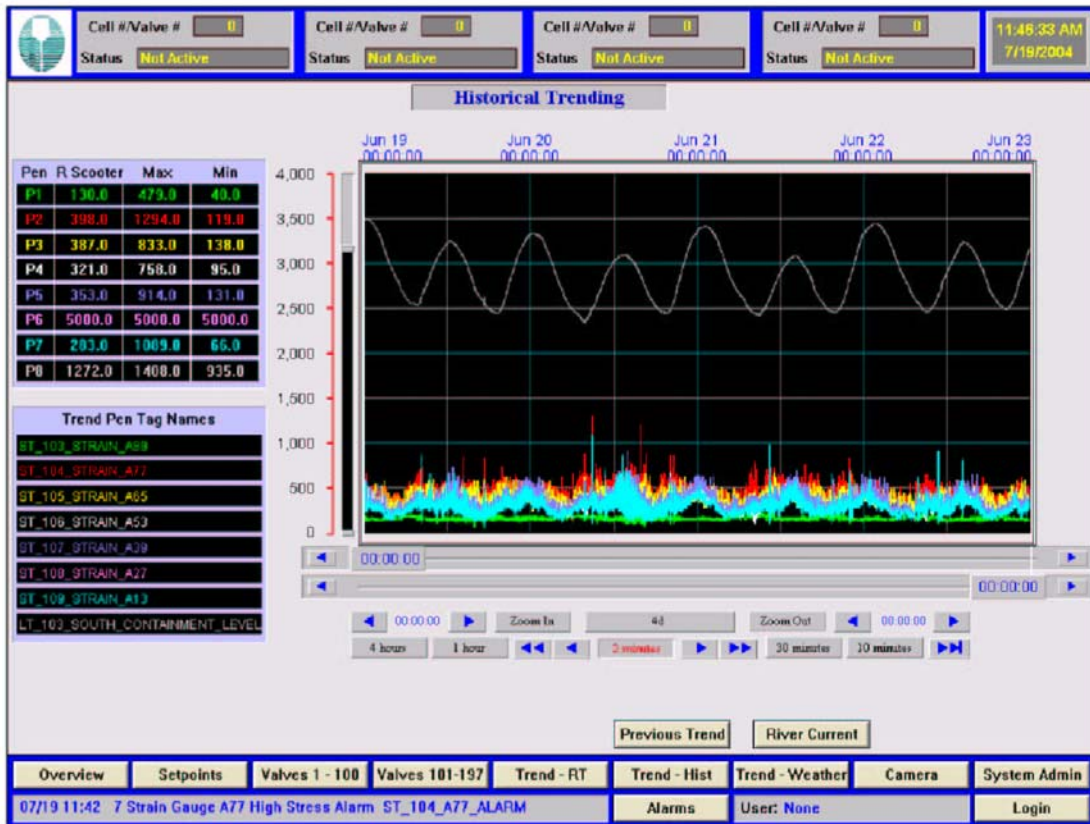


Figure 32. Patterns of varying and cyclical load on the AFB are observable with readings from the load cells (also referred to as strain gauges) on mooring lines. Displaying water level readings simultaneously with the load readings aids in understanding the relationship to tidal height and phase and identifies load changes with operating CWP's. Water level differential is another measure of the load on the AFB. Load and Differential readings are utilized to trigger automatic cleaning cycles if exceeding set system limits, causing an alert or alarm to appear on any screen that is being monitored. These on-screen data and trends are supplemented by the automatic recording of data files of all sensor readings for later data and trend analyses.



Attachment 1

PATENTS

April 7, 1992 U.S. Patent No. 5,102,261
Floating Containment Boom

November 26, 2002 U.S. Patent No. 6,485,229
Containment/Exclusion Boom and Methods of Using the Same (MLES)

February 4, 2003 U.S. Patent No. 6,514,010
Containment/Exclusion Boom with Bird Deterrent

May 20, 2003 U.S. Patent No. 6,567,341
Boom System and its use to Attenuate Underwater Sound or Shock Wave Transmission

December 9, 2003 U.S. Patent No. 6,660,170
Containment/Exclusion Barrier System with Infuser Adaptation to Water Intake System

May 25, 2004 U.S. Patent No. 6,739,801
Boom Curtain with Zipper Connections and Method of Assembling Boom

June 1, 2004 U.S. Patent No. 6,743,367
Boom Curtain with Expandable Pleated Panels, Containment Boom Containing the Same, and Use Thereof

All of the above have applications pending in Canada and Europe.

There are 13 other pending patent applications, most of these having applications also pending in Canada and Europe:

- Method of Controlling Contaminant Flow Into Water Reservoir
- Y-Panel Anchoring System For Boom Installation
- Boom Curtain with Expandable, Pleated Panels, Containment Boom Containing the same, and Use Thereof
- Removable Filter System Adapted for Fixed Water Intake Filtration System
- Filter Canister, System Containing Filter Canister, and Their Use
- Water Filtering Attachment for Scupper Hose of Spoil Barge
- Attachment for Use With Stockpiling Barge and Method of Filtering Runoff Water Therefrom
- Boom System for Water Filtration in Shallow Water
- Boom Support Arm and Use
- Water Filtration System Having Removable Filter Panels
- Boom System for Encircling Vessel
- Boom System for Supporting Deteriorating Ship Hull
- Submersible Boom Gate.