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United States Government Accountability Office  
Washington, DC 20548

May 23, 2007

The Honorable Mary L. Landrieu  
Chairman  
Ad Hoc Subcommittee on Disaster Recovery  
Committee on Homeland Security and Governmental Affairs  
United States Senate

Subject: *U.S. Army Corps of Engineers' Procurement of Pumping Systems for the New Orleans Drainage Canals*

Dear Madam Chairman:

To avoid flooding in New Orleans after a rain storm, the city's Sewerage and Water Board pumps rainwater from the city into three drainage canals at 17<sup>th</sup> Street, London Avenue, and Orleans Avenue, which then flows unrestricted into Lake Pontchartrain. The maximum amount of water that the Sewerage and Water Board can pump into these drainage canals is 10,500 cubic feet per second (cfs) at the 17th Street Canal, 7,980 cfs at the London Avenue Canal, and 2,690 cfs at the Orleans Avenue Canal. While critical to prevent flooding from rainfall, these canals are vulnerable to storm surge from Lake Pontchartrain during a hurricane, and consequently are lined with floodwalls along both sides to protect storm surge from overtopping the canals and flooding the city. However, during Hurricane Katrina, several breaches occurred in the canal floodwalls allowing significant amounts of water to enter New Orleans from Lake Pontchartrain.

In its efforts to restore pre-Katrina levels of hurricane protection to New Orleans by the June 1<sup>st</sup> start of the 2006 hurricane season, in late 2005, the U.S. Army Corps of Engineers (Corps) considered strengthening the drainage canal floodwalls but decided to postpone this effort due to cost and time constraints. Instead, the Corps decided to install three interim closure structures (gates) at the points where the canals meet the lake. These gates would be closed during major storm events to prevent storm surge from entering the canals and potentially breaching the canal floodwalls and flooding the city. With the gates closed, however, rainwater cannot flow from the drainage canals into Lake Pontchartrain and large capacity pumping systems are needed to pump water out of the canals and into the lake. Due to space constraints along the canals and the limited amount of time it had before the start of the 2006 hurricane season, the Corps

decided to procure 34 large-capacity hydraulic pumping systems<sup>1</sup> to provide the most pumping capacity possible by June 1, 2006. The Corps acknowledged that its decision to install the gates and provide pumping capacity that was less than what was needed to keep the city dry could result in some flooding by rainfall but believed that the risk from a hurricane-induced storm surge was far greater than the risk of flooding from heavy rainfall. In mid-2006, the Corps decided to procure six additional hydraulic pumping systems, thereby bringing the total number of pumping systems to be installed along the three drainage canals to 40.

During the process of acquiring, testing, and installing the pumping systems for the drainage canals, many concerns were raised by the media about potential problems with the operation of these pumping systems, and you asked us to examine the (1) specifications and requirements of the contract and the basis for selecting the supplier of the pumping systems; (2) concerns identified during factory testing and the Corps' rationale to install the pumping systems in light of the factory test failures; (3) actions the Corps has taken to address the known problems with the pumping systems; and (4) pumping capacity that existed on June 1, 2006, the capacity that currently exists, and the capacity that is planned for the 2007 hurricane season.

To address these objectives, we reviewed the Corps' plans for the three interim gates and temporary pumping systems for the three New Orleans drainage canals. (Unless otherwise noted, the pumping systems discussed in this report are the temporary ones installed at the three canals.) We reviewed documentation, including e-mails, correspondence, and other documents related to the solicitation process, contract specifications, factory test results, performance requirements, and the Corps' plans for increasing pumping capacity through 2007. We visited the 17th Street Canal and observed the pumping systems. We interviewed officials from (1) Corps Headquarters, New Orleans District, other Corps districts, and members of the Mississippi Valley Division's independent team reviewing issues related to the contract and pump performance; (2) Moving Water Industries Corporation and two other pump suppliers that bid on the solicitation; and (3) the architectural and engineering consulting firms under contract with the Corps. We conducted our work from late-March through mid-May 2007 in accordance with generally accepted government auditing standards.

On May 17, 2007, we provided a briefing to your staff on the results of this work. This report summarizes the information presented in that briefing and officially transmits the slides used during that briefing.

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<sup>1</sup> A hydraulic pumping system is one where pressurized fluid is used to transmit power from the engine to the pump motor and impeller. This allows for greater flexibility in the placement of the engine and the pumping system because they are connected by hydraulic lines.

## Summary

The Corps' decisions to acquire the 34 hydraulic pumping systems were focused on satisfying its commitment to have pumping capacity on the drainage canals in place by June 1, 2006—the start of the 2006 hurricane season. In order to increase the likelihood that pumping capacity would be in place when needed, the Corps utilized several tools to expedite and streamline the acquisition process. The Corps appears to have had a valid reason for each of the iterative decisions it made at each stage of the procurement process. The cumulative effect of these decisions resulted in one supplier—Moving Water Industries Corporation—being in the strongest competitive position to receive the contract for the pumping systems.

Factory testing of the pumps occurred from March through May 2006, and revealed several problems with specific components of the pumping systems. As a result of the concerns identified during factory testing, the Corps had no assurance that the pumping systems would operate to capacity when needed. Nevertheless, the pumping systems were installed as planned because the Corps believed that it was better to have some pumping capacity along the drainage canals during the 2006 hurricane season rather than none. The Corps also believed that many of the problems identified during factory testing could be resolved after installation.

Since June 1, 2006, the Corps has continued to take steps to correct known performance problems with the pumping systems, including uninstalling them to make some repairs. Specific problems that have been addressed include replacing some components that were undersized, such as springs and motors; rewelding of some critical structural welds; and revising certain start-up procedures.

On June 1, 2006, the Corps had installed 11 pumping systems, and by July 2006, it had installed 34, although it is uncertain how much of the theoretical capacity of these pumping systems would have worked and for how long. By June 1, 2007, the Corps plans to complete the reinstallation of all 40 pumping systems that have been repaired and each has been tested for between 45 minutes to 2 hours, thus providing greater assurance that they will perform as designed during the upcoming 2007 hurricane season. By mid-August 2007, the Corps plans to expand pumping capacity at the 17th Street and London Avenue canals by adding 19 additional pumps, acquired under another contract with a different supplier. However, the total planned pumping capacity will still not meet the Sewerage and Water Board's drainage needs to keep the city from flooding during a hurricane when the canal gates are closed. First, weaknesses in some canal floodwalls will continue to restrict the amount of water that can be pumped into the canals to about 69 percent of their maximum capacity. Second, even if these restrictions are lifted, the Corps' capacity to pump water out of the canals would only be about 82 percent of the maximum capacity that the Sewerage and Water Board can pump into the canals.

## Agency Comments

We obtained oral comments on our draft briefing slides at a meeting with the Director of Civil Works, U.S. Army Corps of Engineers and other senior Corps staff. In commenting on the slides, these Corps officials concurred with our findings and conclusions, and stated that they were very helpful in pointing out weaknesses in the Corps' approach and would help them develop procedures to prevent similar problems from occurring in the future. The Corps also provided us with technical comments that we have incorporated as appropriate.

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As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the Secretary of Defense, the Commanding General and Chief of Engineers of the U.S. Army Corps of Engineers, and appropriate congressional committees. We will also provide copies to others upon request. In addition, the report is available at no charge on GAO's Web site at <http://www.gao.gov>.

If you and your staff have any questions or need additional information, please contact me on (202) 512-3841 or [mittala@gao.gov](mailto:mittala@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Major contributors to this report were Edward Zadjura, Assistant Director; James Dishmon; Terry Dorn; Christine Frye; Moses Garcia; Bradley James; Richard Johnson; Stephanie May; Kenneth Patton; Alyssa Weir; and, William Woods.

Sincerely yours,

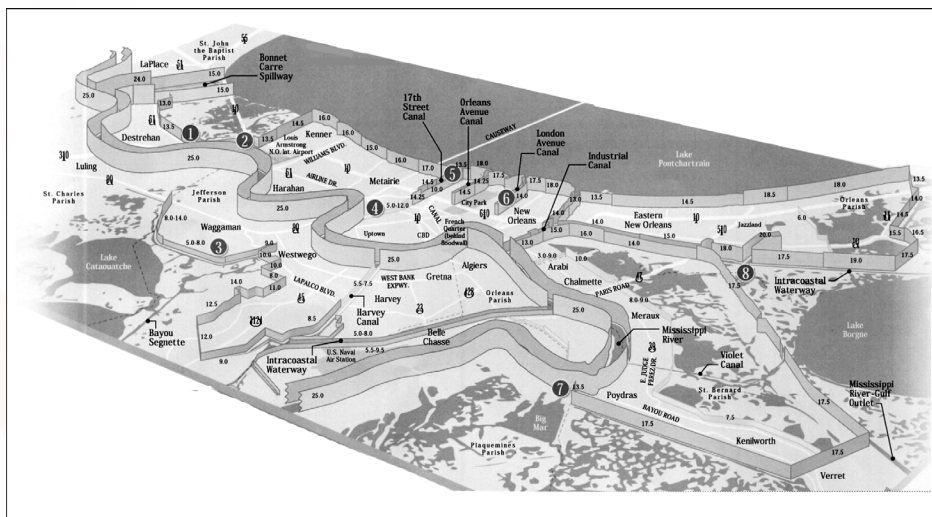


Anu K. Mittal  
Director, Natural Resources  
and Environment

Enclosure



# Lake Pontchartrain Hurricane Protection System



Source: Staff graphic by Emmett Mayer III/emayer@timespicayune.com.

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## Background

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- The New Orleans Sewerage and Water Board pumps rainwater from the city and into the three drainage canals, which flow into Lake Pontchartrain
- Maximum pumping capacity of the New Orleans Sewerage and Water Board into the drainage canals is 10,500 cfs for the 17<sup>th</sup> Street Canal,<sup>1</sup> 7,980 cfs for the London Avenue Canal, and 2,690 cfs for the Orleans Avenue Canal
- During Hurricane Katrina, several breaches occurred in the canal floodwalls which allowed storm surge to enter the city

<sup>1</sup> The Canal Street Pump Station, operated by Jefferson Parish, may pump up to 160 cfs of the 10,500 cfs maximum capacity into the 17<sup>th</sup> Street Canal.

## Background

- In late 2005, the Corps considered strengthening the drainage canal floodwalls but decided to postpone this effort due to cost and time constraints
- Instead, the Corps decided to install temporary gates and procure 34 large-capacity hydraulic pumps to obtain the most pumping capacity possible by the June 1<sup>st</sup> start of the 2006 hurricane season
- Because the Corps considers hurricane-induced storm surge from Lake Pontchartrain to be the greater risk, it intends to close the gates during major storm events to prevent storm surge from entering the drainage canals and potentially breaching the canal floodwalls and flooding the city



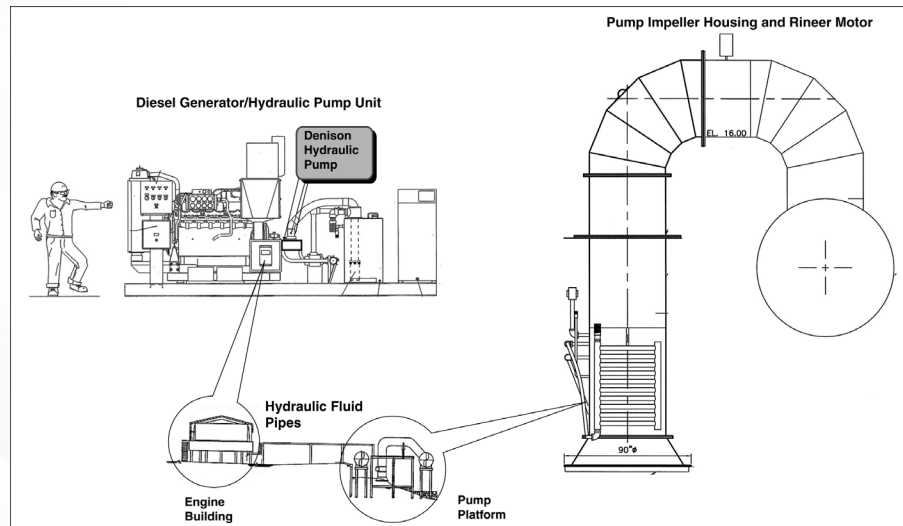
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## Background

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- With the gates closed, rainwater cannot flow into the lake and large capacity pumping systems are needed to pump water out of the drainage canals and into the lake
- The Corps acknowledged that its decision to install gates and provide limited pumping capacity could result in some flooding by rainfall but believed this risk was much lower than the risk posed by storm surge
- In mid-2006, the Corps decided to procure 6 additional hydraulic pumps to increase the pumping capacity at the 17<sup>th</sup> Street Canal

## Background



Source: U.S. Army Corps of Engineers.

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## Questions

- What were the specifications and requirements of the contract and what was the basis for the selection of the supplier for the pump systems?
- In light of the factory test failures known to the Corps, why did it install the pump systems?
- What pumping capacity existed on June 1, 2006, and what actions has the Corps taken to address the known problems with the pump systems?
- What is the current pumping capacity at the drainage canals and what are the Corps' plans to increase capacity during the 2007 hurricane season?

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## Scope and Methodology

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- We reviewed the Corps' plans for three interim closure structures (gates) and temporary pump systems on the three New Orleans drainage canals (unless otherwise noted, the pump systems discussed in this briefing are the temporary ones installed at the three canals)
- We reviewed documentation, including e-mails, correspondence, and other documents related to the solicitation process, contract specifications, factory test results, performance requirements, and the Corps' plans for increasing pumping capacity through 2007
- We visited the 17<sup>th</sup> Street Canal and observed the pump systems

## Scope and Methodology

- We interviewed officials from (1) the U.S. Army Corps of Engineers at Headquarters, the New Orleans District, other Corps districts, and members of the Mississippi Valley Division's independent team reviewing issues related to the contract and pump performance; (2) Moving Water Industries (MWI) Corporation and the other two pump suppliers that bid on the pump solicitation; and, (3) the architectural and engineering consulting firms contracted by the Corps
- We conducted our work from late-March through mid-May 2007 in accordance with generally accepted government auditing standards

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## Contract specifications and requirements

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### Process Used to Identify Pumping Options:

- The Corps contracted with two architectural and engineering consultant firms (consultants) to
  - determine available technical options that could meet the Corps' time, space, and pumping capacity needs,
  - conduct the associated market research, and
  - survey pump equipment suppliers

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## Contract specifications and requirements

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- On the basis of some technical analysis, the consultants concluded that the 60-inch hydraulic pump was the best alternative for the Corps because installation of
  - electric shaft pumps would require the use of auxiliary equipment and have greater space requirements, and
  - smaller sized hydraulic pumps would require more pumps to be installed to provide the same amount of pumping capacity
- The consultants' limited market research indicated that more than one supplier had specifications for a 60-inch hydraulic pump, but only MWI had actually built a pump of this type and size

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## Contract specifications and requirements

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- The consultants contacted both MWI and FPI (another pump manufacturer) regarding their pumps, and met with MWI
- Of these two suppliers, the consultants identified MWI as the only supplier who had actually manufactured the 60-inch hydraulic pump with a 60-inch impeller; FPI's design for a 60-inch pump included only a 54-inch impeller
- The consultants believed that MWI could deliver the 34 60-inch pumps that the Corps needed on schedule
- The consultants had conferred with MWI as they were developing the design for the gates and pump stations along the drainage canals

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## Contract specifications and requirements

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- Process used to develop the specifications included in the Corps' Request for Proposal (RFP)
  - The Corps did not have an existing technical specification for a 60-inch hydraulic pump
  - The consultants drafted a specification for the RFP based on technical specifications and descriptions of the pump contained in catalogs published by MWI and FPI
  - The consultants told us that they had provided the Corps with a generic specification because any reference to a specific supplier had been removed

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## Contract specifications and requirements

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- Our analysis of the RFP equipment specifications indicate that they more closely matched MWI's than FPI's catalog descriptions
- The testing specifications used for the RFP were identical to those published by MWI, which included an open sump test requirement
  - After another supplier complained that the open sump test requirement was restrictive because only MWI had an open sump, the Corps amended the RFP to delete this requirement
  - This more stringent test requirement was incorporated into the contract at the time of award because it was offered by MWI as part of its proposal and accepted by the Government

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## Contract specifications and requirements

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- Given the limited period of time before the start of the 2006 hurricane season, the Corps contracted for the pumps under statutory authority allowing for use of other than full and open competition procedures when the agency's needs are of an unusual and compelling urgency
- Using this authority, the Corps streamlined parts of the acquisition process:
  - RFP was issued on Jan. 13, 2006; contractors' proposals were due on Jan. 18, 2006; and contract was awarded on Jan. 27, 2006
  - Limited market analysis was conducted to identify potential products and suppliers

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## Contract specifications and requirements

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- RFP prescribed the method and mechanism by which the pumping capacity would be provided, rather than using a performance specification approach in which the offerors propose the method or mechanism they would use to meet requirements for pumping capacity
- The Corps expected these steps to reduce the delivery time for the pumps by at least 25 days

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## Basis for vendor selection

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- The Corps received 3 proposals in response to its RFP
- Suppliers submitted pricing information and technical proposals, and made oral presentations to the Corps
- Corps officials told us their preference was to award one contract to one vendor for ease of administration and perceived economies of scale; however, to encourage competition the RFP allowed for multiple contracts
- The Corps evaluated proposals on a best value basis making cost-technical tradeoffs between price and technical merit/quality

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## Basis for vendor selection

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- The Corps' five-member Source Selection Evaluation Board evaluated offers using the following factors in order of descending importance:
  - Technical Approach
  - Project Management
  - Past Performance
  - Small/Small Disadvantaged Business (SDB) Participation
  - Price
- The Source Selection Evaluation Board rated MWI's proposal significantly higher than the other two proposals received

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## Basis for vendor selection

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- MWI's proposal included commitments from suppliers and subcontractors to deliver the necessary pump components
- MWI was believed to represent the best chance of meeting the Corps' critical schedule of June 1, 2006

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## Basis for vendor selection

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- MWI offered a firm fixed price of \$26.6 million (based on the government estimate of \$25.6 million, MWI's price was within 2.8% of the government estimate)
- The Contracting Officer determined that MWI's price was fair and reasonable so no discussions were conducted
- Based on the evaluation results, a firm fixed price contract was awarded on Jan. 27, 2006 to MWI
- The total price of the contract was increased by about \$5 million for delivery incentives and subsequently by about \$4 million for acquiring 6 additional pumping systems
- As of May 4, 2007 the Corps has paid MWI \$28,583,950

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## Additional Pumps Acquired Under Another Contract

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- Subsequent to awarding the contract for the 34 pumps, the Corps in June 2006 released another RFP for additional hydraulic pumps with the same specifications as the original RFP for the MWI contract
- This procurement was protested to GAO because the requirement was restrictive to one supplier and it called for an extremely short proposal turn around and equipment delivery time
- The protest was withdrawn when the Corps agreed to cancel the RFP and write one with broader specifications
- This RFP also included government inspection and rejection of unsatisfactory equipment, field tests for reliability, and inspection and X-ray examination of welds, if needed, and that resulted in a different vendor supplying different types of pumps that met the Corps' needs

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## Factory test concerns

- We identified the following concerns with the testing conducted on the hydraulic pumps acquired under the contract with MWI
  - The Corps and MWI lacked a comprehensive testing plan designed to identify and resolve problems before shipment
  - Because of schedule and performance concerns, factory testing parameters changed several times, for example the Corps discontinued some tests and added others
  - Limited provisions for field testing were included in the contract—with no criteria for desired end result or success of test

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## Factory test concerns

- Some of the factory test requirements in the contract
  - were inconsistent with the Corps' guidance, for example the requirement for open sump testing was contrary to the Corps' guidance, which limits testing for pumps 24-inch and larger to model testing
  - lacked specificity, for example the requirement to obtain pump performance curves did not outline how curves were to be obtained, and
  - did not always identify what results constituted acceptable performance or what was needed to ensure performance

## Factory test concerns

- Factory testing was conducted from March through May 2006
  - Hydrostatic tests for leaks: Performed and passed
  - Performance tests:
    - About mid-April, due to concerns about the time required to perform these types of tests and the mechanical problems observed with the hydraulic motor assembly the Corps stopped performance testing and added endurance testing to help isolate the cause of the problems with the hydraulic motor assembly
    - As a result, only ¼ of Rineer motor/pump impeller systems were performance tested before shipment, some of which were later found to have problems

## Factory test concerns

- Endurance tests:
  - The Corps requested a 5-hour endurance test, which was later changed to a 3-hour test due to schedule concerns
  - Endurance tests were conducted and passed on hydraulic drive parts of the pump systems (including spares), although some required several test attempts after correcting non-hydraulic component failures
  - MWI conducted one 24-hour endurance test as requested by the Corps but only at 1/3 of the full operating pressure due to testing limitations at the factory

## The Corps rationale for installing the pumps

- Despite the incomplete and/or unsatisfactory results of the initial factory tests, due primarily to problems with the hydraulic drive parts of the pump systems, the Corps installed the pump systems because it believed that the hydraulic drive parts of the pump systems had satisfactorily completed the endurance tests and that
  - Any amount of pumping capacity that would help mitigate rainfall-related flooding would be beneficial in the event that the gates had to be closed due to a hurricane or storm, and
  - Any performance problems with the pump systems could be resolved after they were installed on the canals

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## Pumping capacity for the 2006 hurricane season

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- As of June 1, 2006, the Corps had installed
  - 5 temporary pump systems on the Orleans Avenue Canal with a theoretical capacity of 915 cfs
  - 0 temporary pump systems on the 17<sup>th</sup> Street Canal
  - 0 pumping capacity on the London Avenue Canal (there were 6 temporary pumps installed on the London Avenue Canal but the gates were not functioning so pumping capacity was not an issue)

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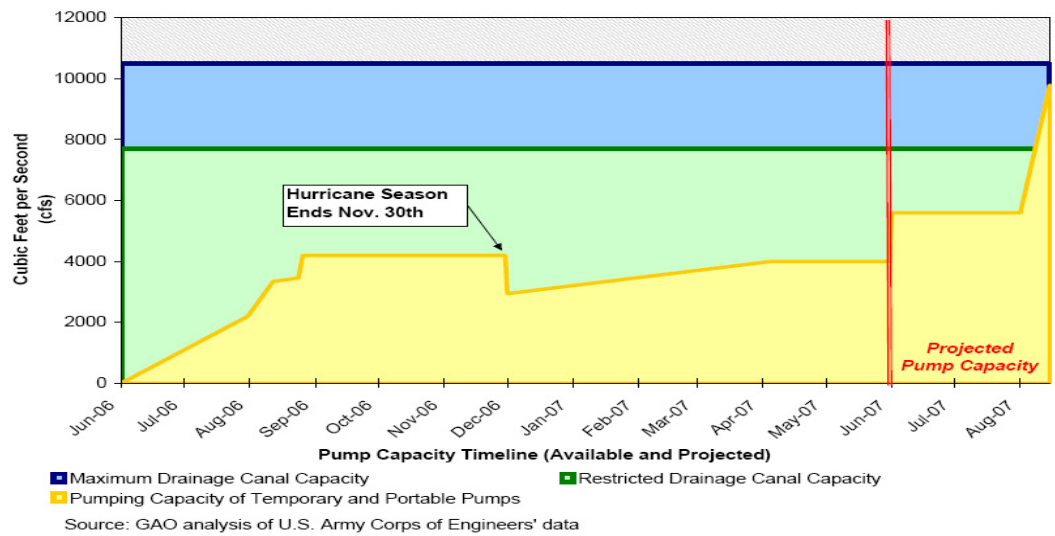
## Pumping capacity for the 2006 hurricane season

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- Shortly after the beginning of the 2006 hurricane season, the Corps added capacity at the three canals (including portable pumps) as shown on the following three charts
- Although by July 2006 all 34 pumps had been installed, due to pump performance problems during factory tests, it is uncertain how much of this theoretical pumping capacity would have worked and for how long



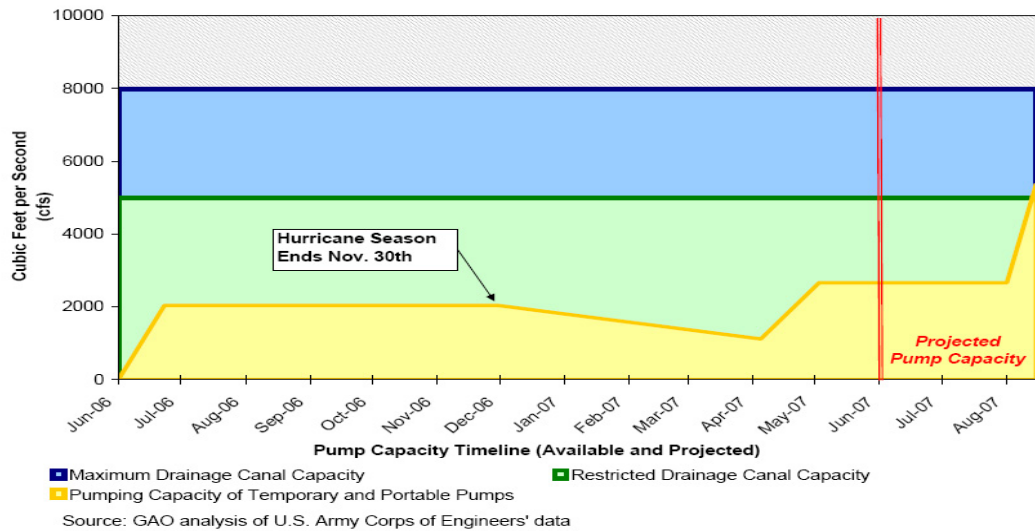
## Pumping Capacity Trend for the 17<sup>th</sup> Street Canal (June 1, 2006 – August 15, 2007)



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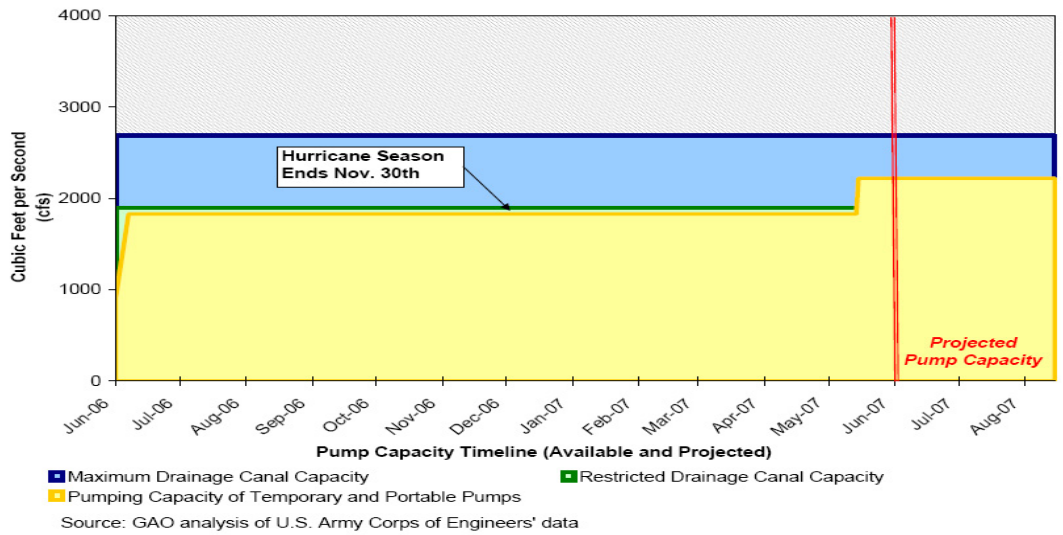
## Pumping Capacity Trend for the London Avenue Canal (June 1, 2006 – August 15, 2007)



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## Pumping Capacity Trend for the Orleans Avenue Canal (June 1, 2006 – August 15, 2007)



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## **Actions taken to address problems with certain components of pump systems**

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- Known component problems and fixes
  - Gear oil circulation pumps—undersized motors caused overheating
    - Replaced with larger motors
  - Denison hydraulic pumps—air pockets in hydraulic lines, caused hydraulic pumps to run dry and become damaged
    - As an interim fix, the Corps revised its start-up procedures
    - The Corps also added a priming valve to 34 pumps to keep hydraulic lines primed and will retrofit these pumps with a permanent fix but a schedule has not yet been determined

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## **Actions taken to address problems with certain components of pump systems**

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- Welds—suspected weak welds on pump housing which could cause pump failure, and on hydraulic piping which could cause leaks
  - Rewelded some critical structural welds and pressure-tested hydraulic piping
- Rineer motor—undersized springs, caused pulsation in hydraulic lines
  - Upgraded to stronger springs in Rineer motor

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## Pumping capacity for 2007 hurricane season and plans for additional capacity

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- On June 1, 2007, Corps plans to have 40 pump systems installed with the following capacity
  - 17<sup>th</sup> Street - 18 temporary pump systems with 4,000 cfs and portable pumps with 1,600 cfs will provide a total of 5,600 cfs or 73% of restricted canal capacity and 53% of maximum canal capacity
  - London Avenue - 12 temporary pump systems with 2,665 cfs or 53% of restricted canal capacity and 33% of maximum canal capacity
  - Orleans Avenue - 10 temporary pump systems with 2,220 cfs or 117% of restricted canal capacity and 83% of maximum canal capacity

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## Pumping capacity for 2007 hurricane season and plans for additional capacity

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- Within practical testing parameters, as the Corps has reinstalled the pump systems at the drainage canals, it has tested each one from between 45 minutes to 2 hours, and believes that the known problems are being fixed and that each pump system should operate as designed
  - As of May 15, 2007, the Corps has reinstalled and tested 35 pumps and plans to reinstall and retest the remaining 5 pumps by May 24, 2007
- According to the Corps, it is not possible to test each pump system for an extended period of time or to test the entire system due to limitations in simulating the amount of water that would be present in the canals and the lake during an actual storm event

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## Pumping capacity for 2007 hurricane season and plans for additional capacity

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- Additional plans for the 2007 Hurricane Season
  - Installation and testing of 19 vertical direct-drive pump systems (11 on the 17<sup>th</sup> Street Canal will provide 4,180 cfs and 8 on the London Avenue Canal will provide 2,700 cfs)
  - 14 portable pumps will provide 1,600 cfs at the 17<sup>th</sup> Street Canal



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## Pumping capacity for 2007 hurricane season and plans for additional capacity

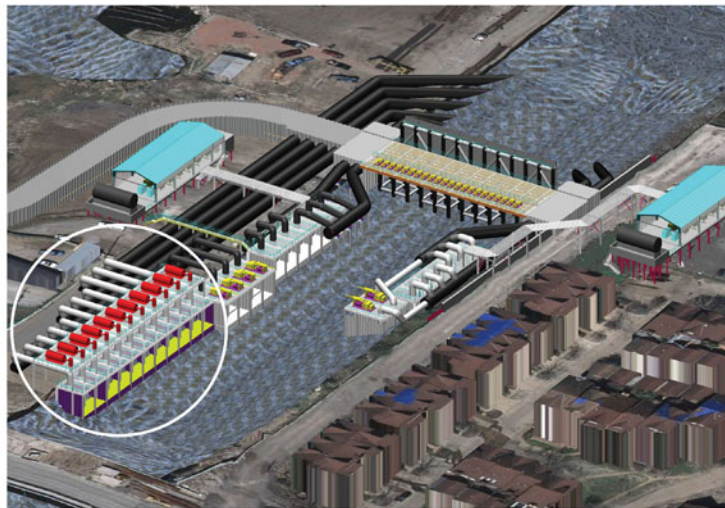
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- The total planned pumping capacity provided by all temporary and portable pumps to be installed by August 2007 will meet the restricted level of water that the Sewerage and Water Board can pump into the canals, given the current status of the canal floodwalls
  - As a result of the restricted water levels allowed in the drainage canals, there still may be some flooding in parts of the city in the event that the canal gates are closed due to a hurricane or storm
  - Furthermore, some questions remain regarding the actual capacity of the pump systems due to the differences in the specifications (a larger clearance between the impeller and housing)
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## Illustration of the 17<sup>th</sup> Street Canal with the additional vertical flow pumps (in circle)



Source: U.S. Army Corps of Engineers.

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## Conclusions

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- The Corps' decisions were focused on satisfying the primary requirement to have pumping capacity in place by the start of the 2006 hurricane season
- In order to increase the likelihood that pumping capacity would be in place when needed, the Corps utilized several tools to expedite and streamline the acquisition process
- The Corps appears to have had a valid reason for each of the iterative decisions it made at each stage of the procurement process; the cumulative effect of these decisions resulted in MWI being in the strongest competitive position to receive the contract

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## Conclusions

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- Although factory testing revealed problems with the pumps, and the Corps had no assurance that the pump systems would operate to capacity when needed, the Corps installed these pump systems to provide some pumping capacity during the 2006 hurricane season
- Since June 1, 2006, Corps has continued to take steps to correct known performance problems

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## Conclusions

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- By June 1, 2007, the Corps plans to complete reinstallation of the 40 pump systems that have each been tested for 45 minutes to 2 hours thus providing greater assurance that they will perform as designed
- By mid-August 2007, the Corps plans to expand temporary pumping capacity at the 17<sup>th</sup> Street and London Avenue canals by adding 19 additional pumps of a different design

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## Conclusions

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- However, total planned temporary and portable pumping capacity will not meet the Sewerage and Water Board's drainage needs to keep the city from flooding during a hurricane when the canal gates are closed for 2 reasons:
  - Weaknesses in some canal walls will continue to restrict the amount of water that can be pumped into the canals from the city to about 69% of their maximum capacity
  - Even if these restrictions were eased or lifted, the Corps would have pumping capacity equal to about 82% of the maximum canal capacity

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