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United States Government Accountability Office
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May 13, 2010

The Honorable Patty Murray
Chairman
The Honorable Christopher Bond
Ranking Member
Subcommittee on Transportation, Housing and Urban Development, and Related Agencies
Committee on Appropriations
United States Senate

The Honorable John W. Olver
Chairman
The Honorable Tom Latham
Ranking Member
Subcommittee on Transportation, Housing and Urban Development, and Related Agencies
Committee on Appropriations
House of Representatives

Subject: *St. Lawrence Seaway: Estimates for the Asset Renewal Program Will Change, and Implementing Best Practices May Improve the Estimates' Reliability*

The St. Lawrence Seaway (the Seaway) is a 50-year-old binational transportation asset serving substantial manufacturing and service industries in both the United States and Canada. Jointly operated by the United States and Canada, the 15-lock Seaway has been used to move more than 2.5 billion metric tons of cargo, which includes iron ore, grain, and coal, valued at more than $375 billion, between the United States, Canada, and international markets since opening in 1959. A single ship on the Seaway can carry about 25,000 tons of cargo, which is the equivalent amount of cargo that 870 large trucks or 225 railcars can carry. The Saint Lawrence Seaway Development Corporation (SLSDC), a wholly owned government corporation within the U.S. Department of Transportation (DOT), operates and maintains the two locks owned by the United States and the navigation channels in U.S. waters between Massena, New York, and Lake Ontario.[1] In 2009, SLSDC initiated a 10-year U.S. Seaway Asset Renewal Program (ARP) for its navigation infrastructure and

[1]A government corporation is an entity for a public purpose established by the U.S. government in a corporate form by a federal charter, and subject to chapter 91 of Title 31 of the U.S. Code, commonly referred to as the Government Corporation Control Act. However, for the purposes of this report, we sometimes refer to SLSDC as an agency.

facilities. The ARP marks the first time in SLSDC's history that a dedicated effort to repair and modernize the U.S. Seaway infrastructure has taken place. The projects included in the ARP focus on improving aging Seaway infrastructure, conducting maintenance dredging, investing in new technologies, purchasing new equipment, and refurbishing old facilities. None of these investments will result in increases to the authorized depth or width of the navigation channel or to the size of the two existing U.S. locks.

In 2009, Congress instructed us to examine the ARP.[2] As discussed with the committees of jurisdiction, we examined (1) how the cost estimates in the ARP have changed from February 2009 to February 2010, (2) the extent to which the ARP covers all asset renewal needs, and (3) the steps U.S. and Canadian authorities have taken to coordinate their asset renewal programs.

Among other things, we found that SLSDC's estimating process for the projects we reviewed did not fully meet the four characteristics—comprehensive, well documented, accurate, and credible—for producing a high-quality cost estimate. We are therefore making a recommendation to SLSDC to improve its cost-estimating process. The results of our work are contained in enclosure I.

Agency Comments and Our Evaluation

We provided a draft of this report to the U.S. Department of Transportation for its review and comment. SLSDC officials commented that they were pleased that the report's findings showed that the total estimated cost of the ARP had not changed significantly after the first year of the program. They also agreed to consider our recommendation by carefully reviewing the *GAO Cost Estimating and Assessment Guide* to identify those concepts and practices that offer potential utility to the development of future ARP project cost estimates. SLSDC officials noted that while they recognize the potential utility of the best practices identified in the *GAO Cost Estimating and Assessment Guide* for large multiyear projects, they believe the cost guide's applicability is less apparent with regard to a number of small-scale projects in SLSDC's ARP. We are encouraged that SLSDC is committed to considering our recommendation and, as stated in our report, agree that the extent to which each of the cost guide's best practices can be implemented by SLSDC may vary depending on each project's scope and complexity.

SLSDC officials also provided technical comments to our report, which we incorporated as appropriate.

Scope and Methodology

To perform our work, we interviewed SLSDC officials; reviewed agency documents related to the ARP, asset renewal needs, and its program to assess the condition of its assets; and

[2] Explanatory Statement in the 2009 Committee Print of the House Committee on Appropriations on H.R. 1105, at 2109, accompanying the Omnibus Appropriations Act for FY 2009, Pub. L. No. 111-8, Div. I, Title I, 123 Stat. 524, 943 (2009). In addition, S. Rep. No. 111-69, at 94 (2009), which accompanied the Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill for FY 2010 stated that the GAO report should be submitted to the House and Senate Committees on Appropriations no later than May 31, 2010. The Conference Report, H.R. Rep. No. 111-366, at 379 (2009), accompanying the Consolidated Appropriations Act for FY 2010, Pub. No. 111-117, 123 Stat. 3034 (2009), stated the language in Senate Report No. 111-69 should be complied with unless specifically addressed to the contrary in the conference report and the statement of the managers. There was no statement to the contrary relating to the date for the submission of this report.

analyzed agency data on the estimated costs of ARP projects and fiscal year 2009 contracts. We also assessed the extent to which 2 of the 52 ARP projects met the best practices guidelines for cost estimating contained in the *GAO Cost Estimating and Assessment Guide.* We selected these projects because they started in fiscal year 2009 or 2010, are expected to cost more than $1 million when completed, are complex, and are critical to the operation of the locks. We reviewed industry information and prior GAO reports to determine the expected variability between estimated and actual costs as well as the reasonableness of SLSDC's assessment program. We also interviewed U.S. and Canadian officials to understand the steps taken to coordinate their asset renewal programs and reviewed applicable laws and treaties. We conducted this performance audit from July 2009 to May 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. Additional information about our scope and methodology is provided in enclosure II.

We are sending copies of this report to interested congressional committees and the Secretary of Transportation. In addition, the report is available at no charge on the GAO Web site at http://www.gao.gov. If you or your staff have any questions about this report, please contact Terrell Dorn at (202) 512-6923 or dornt@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors are listed in enclosure II.

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Director, Physical Infrastructure Issues

Enclosures

Committees on Appropriations 05/13/2010

St. Lawrence Seaway

Estimates for the Asset Renewal Program Will Change, and Implementing Best Practices May Improve the Estimates' Reliability

Why GAO Did This Study

The St. Lawrence Seaway is a 50-year-old binational transportation asset jointly operated by the United States and Canada that is used to move cargo between North America and international markets. In 2009, the U.S. Saint Lawrence Seaway Development Corporation (SLSDC), which is responsible for operating and maintaining the two locks and navigation channels in the U.S. portion of the Seaway, initiated a 10-year Asset Renewal Program (ARP) to address long-term needs of the locks, navigation channels, and related facilities and equipment.

In 2009, Congress instructed GAO to examine the ARP. Accordingly, GAO examined (1) how the cost estimates have changed from February 2009 to February 2010, (2) the extent to which the ARP covers all asset renewal needs, and (3) the steps U.S. and Canadian authorities have taken to coordinate their asset renewal programs. To conduct this work, GAO reviewed agency program documents, interviewed SLSDC officials, and analyzed ARP estimates and fiscal year 2009 contract data.

What GAO Recommends

To improve estimates of the cost of the ARP projects, GAO recommends that SLSDC develop a cost-estimating process that follows best practices to better ensure that its estimates are comprehensive, well documented, accurate, and credible. SLSDC agreed to consider the report's recommendation.

For more information, contact Terrell G. Dorn at (202) 512-6923 or dornt@gao.gov.

Summary of Results

The total ARP estimate, which increased from $177 million to $186 million from February 2009 to February 2010, will continue to change as its 52 component projects are developed. Generally, as projects mature and requirements are refined, the accuracy of estimates increases and the variability decreases. For the ARP contracts that SLSDC awarded in fiscal year 2009, GAO found significant variability between the estimated costs and the amounts of some awarded contracts. This variability is attributable to, among other things, general economic conditions, project-specific factors, and incomplete requirements definitions. Though some factors that affect the variability between estimated and actual costs may be out of the control of SLSDC, reliable estimates should consider potential uncertainties. GAO used the *GAO Cost Estimating and Assessment Guide* to evaluate SLSDC's cost-estimating process on two of the complex ARP projects that began in fiscal year 2009, are expected to cost more than $1 million when completed, and are critical to the operation of the locks. GAO found that SLSDC's estimating process for these two projects did not fully meet any of the four characteristics—comprehensive, well documented, accurate, and credible—for producing a high-quality cost estimate, and partly as a result, the estimates were unreliable and underestimated the actual cost. Because of the variability between estimated costs and actual awards, SLSDC adjusted the ARP spending plan by reallocating project funding and deferring or accelerating projects to meet the targeted spending amount of approximately $17.6 million for fiscal year 2009.

The ARP addresses most asset renewal needs identified through prior inspections of its assets. The remaining needs are generally addressed through routine maintenance. However, SLSDC could use its program flexibility to add or modify ARP projects if the needs cannot be adequately addressed through routine maintenance. For example, because routine maintenance funding is not adequate for the second phase of an emergency communications system in the underground areas of the locks, SLSDC plans to add a project to the ARP for this work. Furthermore, SLSDC's continual condition assessment of its assets may result in reprioritizing existing ARP projects or adding new projects if the cost to address newly identified needs exceed its routine maintenance budget.

The steps the United States and Canada have taken to coordinate the ARP generally involve setting the annual opening and closing dates of the Seaway and exchanging technical project information. Coordination of the opening and closing dates, while routine, is important for the ARP because it determines the work schedule for a number of critical projects that can be completed only during the winter shutdown period. SLSDC and the Canadian Seaway share technical information about similarly scoped projects both countries are doing and on projects that would affect vessel-operating procedures at the locks.

Background

Great Lakes St. Lawrence Seaway Study

As joint custodians of the Great Lakes St. Lawrence Seaway System, the governments of the United States and Canada signed a memorandum of cooperation in 2003. It formed the framework for a binational study to assess the current condition of the waterway and determine how to best use and maintain it now and in the future.

A final report resulting from the study was made public on November 26, 2007. The report addresses future investments needed to keep the existing infrastructure reliable and ensure the system is a safe, efficient, and sustainable component of North America's transportation infrastructure for years to come. The report also addresses both the expected economic benefits arising from the continued operation of the system and the potential environmental impact associated with commercial navigation.

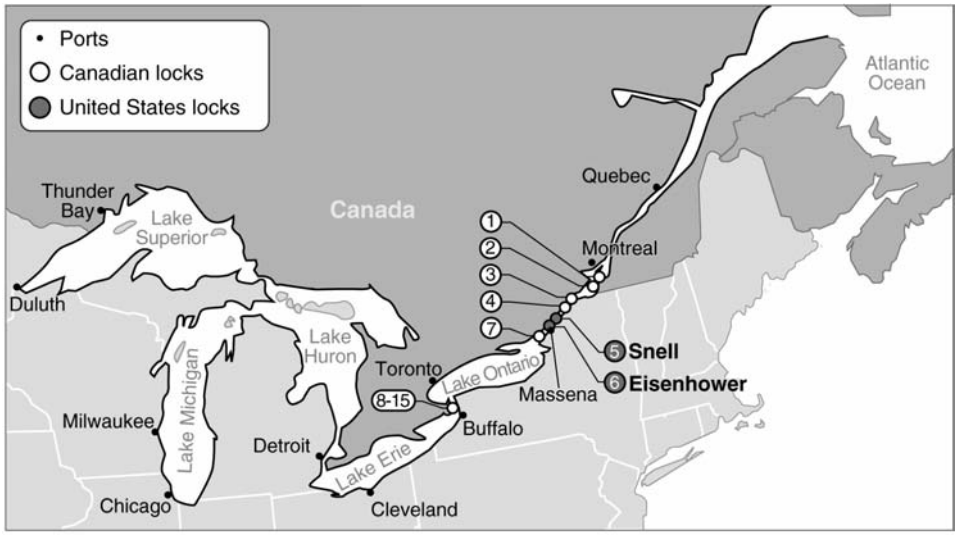
The following seven U.S. and Canadian departments and agencies were involved in the multiyear study:

- U.S. Department of Transportation
- Saint Lawrence Seaway Development Corporation
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- Transport Canada
- St. Lawrence Seaway Management Corporation (the Canadian Seaway)
- Environment Canada

Great Lakes St. Lawrence Seaway System

As shown below, the St. Lawrence Seaway, which extends from Montreal to Lake Erie, is part of the larger Great Lakes St. Lawrence Seaway System that moves cargo between North America and international markets. The Seaway is operated jointly by the U.S. Saint Lawrence Seaway Development Corporation—which operates 2 locks---and the Canadian Seaway—which operates 13 locks.[1] The unique binational nature of the Seaway requires 24-hour, year-round coordination between SLSDC and the Canadian Seaway, particularly regarding rules and regulations, overall day-to-day operations, traffic management, navigation aids, safety, environmental programs, and operating dates. In addition, SLSDC and the Canadian Seaway work on trade development activities designed to increase use of the Great Lakes St. Lawrence Seaway System.

Figure 1: Map of the Great Lakes St. Lawrence Seaway System, with the 15 locks on the St. Lawrence Seaway portion identified



Sources: Map Resources and GAO.

The Seaway operates a little more than 9 months a year, closing for winter from late December through late March. While the Seaway is closed, U.S. and Canadian officials perform detailed inspections and routine maintenance of infrastructure. These efforts are key to the operational sustainability of the Seaway because they allow officials to identify and schedule repairs before conditions reach a critical stage.

Unlike most other lock-based transportation systems that have twinned locks to ensure continued operation in the event of a lock failure, the Seaway is a single lock system. As a result, closures or delays at one of the locks would disrupt the entire Seaway's operation and could result in Seaway customers seeking alternative transportation modes in the future. For example, a number of customers stopped using the Seaway after a lock failure at one of the Canadian locks in 1985 trapped 53 commercial vessels in the Seaway for 24 days and cost shippers more than $24 million.

[1]See enclosure III for a visual presentation of how locks operate.

Great Lakes St. Lawrence Seaway Study (cont.)

As part of the study, engineers from the United States and Canada performed inspections and developed recommendations for repairs and/or improvements to critical infrastructure in the Great Lakes St. Lawrence Seaway System. In describing the condition of the system, the study states that it has held up reasonably well; however, a number of components need repair, rehabilitation, or replacement. According to the study, Seaway infrastructure—which has worn as a result of operational and weather-related stress—has reached or exceeded its original design life. Because each year the likelihood increases that any one of the Seaway's hundreds of different components will fail, the study states that a considerable amount of effort is needed to maintain the system at its current operational level.

Design life: When properly maintained, navigation projects, such as locks, traditionally have a 50-year design life, which is the minimal time the project is expected to provide reliable performance without major infrastructure investments to keep it safe and efficient.

Operational stress: Day-to-day passage of vessels contributes to operational stress that is typically either a result of wear/damage from vessel movement or wear from the cyclical operation of the various mechanical components, such as gates and valves.

Weather-related stress: The geographic location of the Seaway subjects it to severe weather conditions that cause wear as a result of freeze-thaw cycles and ice buildup on components.

Saint Lawrence Seaway Development Corporation

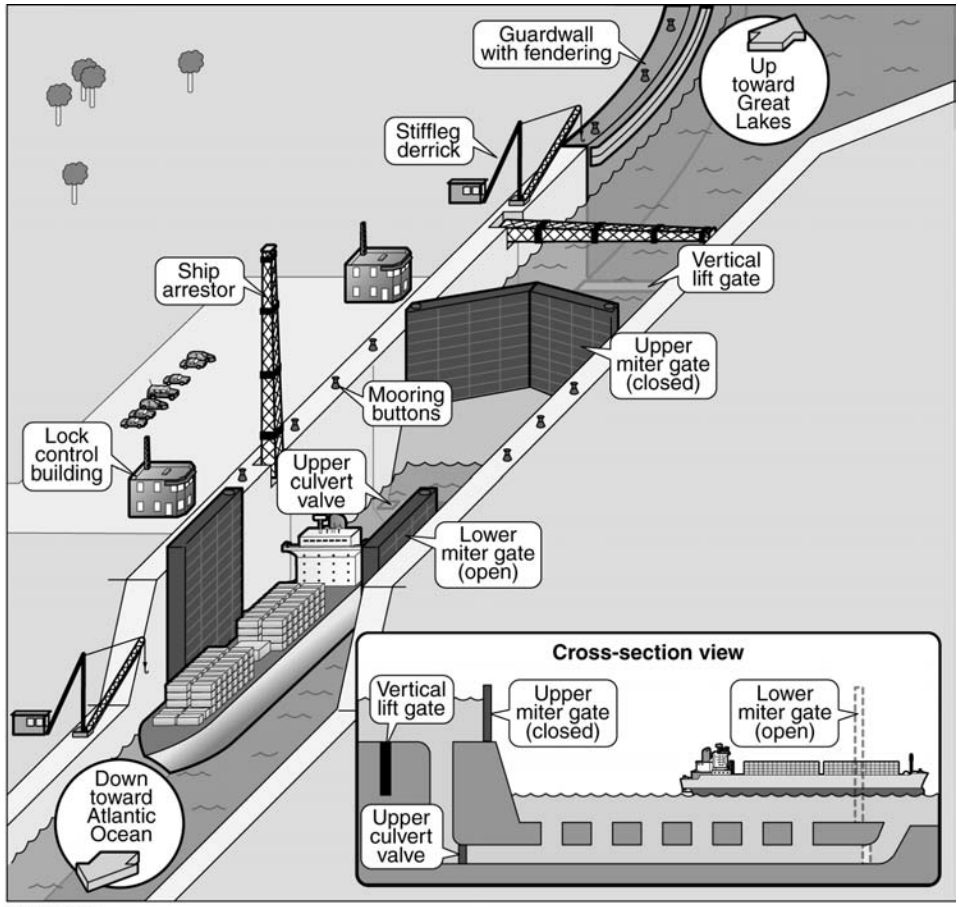
SLSDC operates and maintains the U.S. portion of the St. Lawrence Seaway, to include portions of the navigation channels and the Bertrand Snell and Dwight D. Eisenhower Locks. Over its history, these locks and the U.S. portion of the Seaway have been available to vessels about 99 percent of the time during the 24-hours-a-day, 7-days-a-week shipping season.[2] However, as indicated by recent component failures at similarly-aged locks on the Ohio River, continued reliable operation of SLSDC's locks is uncertain considering that the infrastructure is approaching the end of its 50-year design life.[3] As shown in figure 2, the locks have a number of mechanical components. SLSDC also owns and maintains other assets—such as roads, a bridge jointly owned with Canada, a highway tunnel, a Visitors' Center, various buildings, vessels, and vehicles—and ensures that its portion of the waterway is deep enough for vessels to transit.

In fiscal year 2009, SLSDC initiated a 10-year Asset Renewal Program, informed by the results of the Great Lakes St. Lawrence Seaway Study to address the long-term asset renewal needs of the U.S. lock infrastructure, navigation channels, and related facilities and equipment. The current 52 projects in the ARP cover a number of agency assets and focus on, among other things, improving lock structure and operating equipment, conducting maintenance dredging, investing in new technologies, purchasing new vehicles and equipment, and refurbishing old facilities. To ensure that the ARP is executed properly and to identify any concerns, SLSDC formed an internal working group, made up of senior managers in engineering, procurement, financial management, budget, legal affairs, and policy that meets every 2 weeks to review the status of ongoing projects and discuss ways to improve the overall management, execution, and reporting of the program.

SLSDC receives funding for the ARP through the annual appropriations process.[4] As part of this process, SLSDC submits an annual spending plan identifying estimated amounts for each project it expects to work on in that year. These project estimates are typically "project feasibility" estimates developed during the planning stage of project development. SLSDC has flexibility to adjust the annual spending plan and may reallocate funding among ARP projects based on bids received, updated estimates, and project reprioritization that occurs after the spending plan has been submitted.

[2]The Seaway's shipping season is typically from late March through late December. In measuring time when the locks are not available to vessels, SLSDC considers, among other things, delays caused by weather, vessel incidents, insufficient water levels, and lock equipment malfunction.
[3]See Tom Sawyer, "Metal Fatigue Suspected in Second Lock-Gate Failure," *Engineering News-Record* (Feb. 15, 2010), 15.
[4]Fiscal year 2009 was the first year SLSDC was appropriated funds for the ARP. See Pub. No. 111-8, Div. I, Title I, 123 Stat 524, 943 (2009).

Figure 2: Illustration of a Lock and Its Various Components



Source: GAO.

ARP Cost Estimates Will Change over Time, but SLSDC Does Not Use Best Practices to Estimate Costs

Cost Estimating

According to the *GAO Cost Estimating and Assessment Guide*, cost estimating requires both science and judgment. Since, by definition, answers are seldom—if ever—precise, the goal is to find a reasonable "answer."[5] Cost estimates are based on many assumptions and are expected to change as project requirements are clarified. Once a cost estimate has been accepted and approved, it should be updated periodically as the program matures and as schedules and requirements change. Updated estimates help give management control over a project's resources when new requirements are called for under tight budget conditions.

ARP Cost Estimates Have Changed

From February 2009 to February 2010, the ARP program estimate, which is the sum of cost estimates of the individual projects, increased from $177 million to $186 million.[6] Over $3 million (39 percent) of this increase is due to updates reflecting the continual refinement of project requirements, actual awards made in the first year of the program, and inflation adjustments. The remaining increase of over $5 million is due to the 2 ARP projects added as part of the agency's continual efforts to evaluate and reprioritize agency needs.

Specifically, SLSDC revised its baseline estimate for 30 ARP projects—increasing the estimate for 14 projects and decreasing the estimate for 16 projects.[7] For example, SLSDC increased the project estimate for its miter gate rehabilitation project by 23 percent based on the results of the first phase of the project.[8] In another case, on the basis of a consultant's evaluation of the current system, SLSDC decreased by 49 percent its estimate for upgrading the compressed air systems that are used to control the buildup of ice in and around the locks. Even though SLSDC has adjusted the estimated cost of some projects, officials stated that they expect to satisfy all requirements originally identified in the ARP.

[5]GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009).

[6] The February 2009 ARP estimate of $177 million was based on 50 projects. SLSDC added 2 projects to the ARP, and therefore the February 2010 program estimate of $186 million was based on 52 projects. The 2 projects added will replace the Visitors' Center and upgrade physical security. For more information on all 52 projects, see enclosure IV.

[7]Of the 30 projects where the estimate was revised, 8 estimates changed by less than 5 percent, 4 changed from 5 to 10 percent, and the remaining 18 changed by more than 10 percent.

[8]Many of the ARP projects have multiple phases that may span a number of years, and SLSDC may award multiple contracts to complete each project or project phase. In addition, each phase may go through the project development process, and therefore a project with multiple phases may have phases in different stages of project development.

Project Development Stages

Planning stage: Planning activities generally occur 3 to 5 years prior to construction. During this stage, project officials set functional requirements. General design criteria, significant features and components, methods of accomplishment, and a proposed schedule are defined. Cost estimates at this stage may be based on past cost experience with similar projects or on an order-of-magnitude basis and may be expected to vary by plus or minus 40 percent from the actual cost.

Design stage: Detailed criteria and parameters of a project are developed to define, as applicable, significant features and components. Design work generally begins 1 to 2 years prior to construction. Working drawings and specifications for construction activities are produced in this stage. The cost estimates are refined as the design matures and may be expected to vary by plus or minus 30 percent from actual costs.

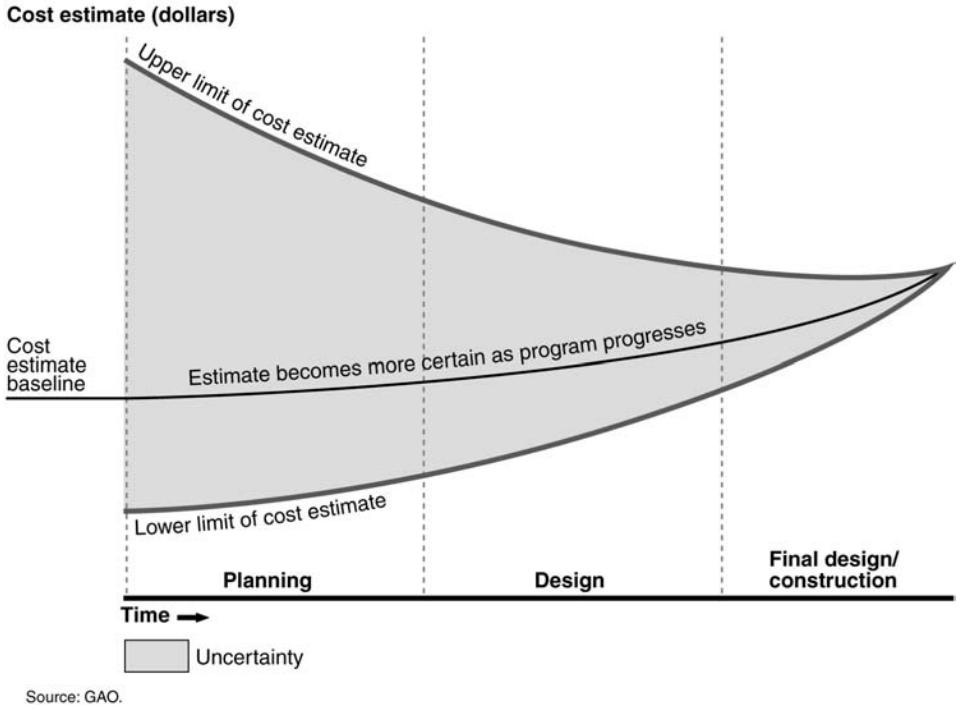
Final design: Final plans and detailed specifications for the performance of construction work are developed. The cost estimates developed at this stage are the most accurate estimates possible prior to competitive bidding and construction and are expected to be plus or minus 10 percent of actual costs.

Construction stage: Contractor services are procured through a solicitation process, and contracts are awarded in accordance with acquisition protocols. Work detailed in the design drawings and specifications is executed. Changes may occur after contract award, and because of any such changes, project costs may be expected to vary up to 10 percent.

ARP Project Estimates Will Continue to Change

Because the majority of project estimates were developed in the planning stage, they will continue to change as part of the project development process. Generally, the more information that is known about a project and is used to develop the estimate, the more accurate and less variable the estimate is expected to be. While all estimates will have some degree of variability from actual costs, cost uncertainty is greatest in the initial project development stages. As shown in figure 3, as projects mature and requirements are refined, the accuracy of the estimate increases and the variability decreases to reflect these updates.

Figure 3: Cone of Uncertainty in Cost Estimating



Source: GAO.

Fiscal Year 2009 Projects

For the 19 projects funded in fiscal year 2009, SLSDC awarded 41 contracts for a wide variety of equipment and services:

- Commercial items, such as a crane and a snowplow;
- Engineering consulting services for surveying and design work; and
- Construction services to repair/upgrade lock structures and operating components.

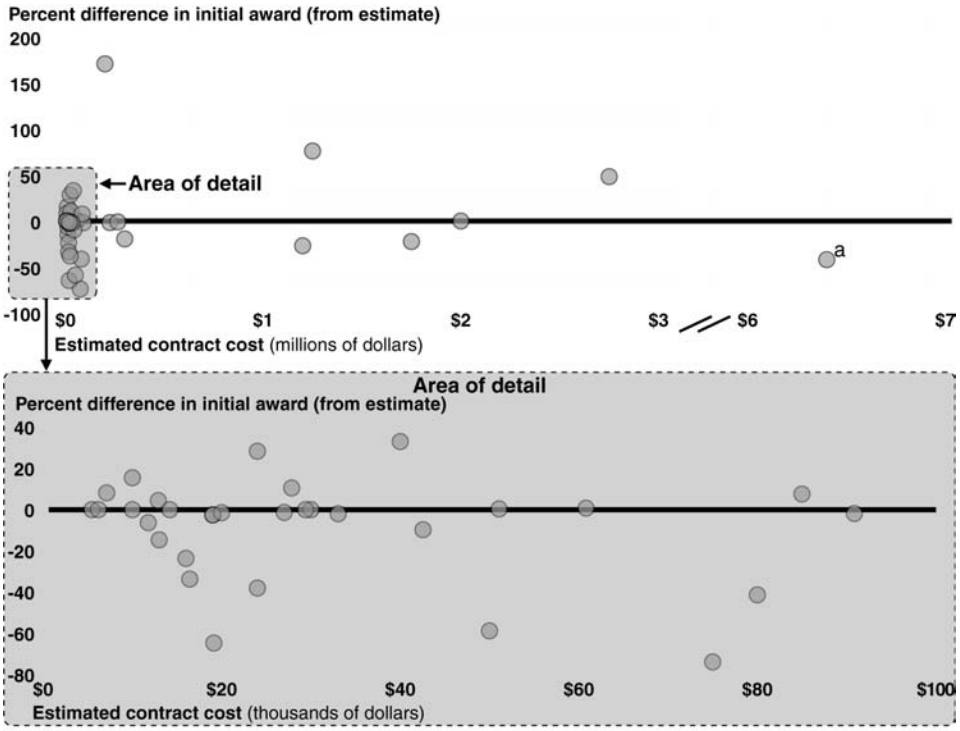
The 19 projects were

1. *Snell Lock Guidewall Fendering:* Replace protective fendering on downstream guidewall.
2. *Guidewall Rehabilitation:* Repair concrete and mooring buttons on approach walls at both locks.
3. *Paving and Drainage Infrastructure:* Repair pavement and improve drainage on roads, work areas, and parking lots.
4. *Valve Operating Equipment:* Replace electric motors with hydraulic machinery at north side culvert valves at both locks.
5. *Lock Covers:* Refurbish and insulate steel modules used to cover locks for winter maintenance.
6. *Seaway International Bridge:* Repair, blast clean, and coat structural components on south span.
7. *Navigational Aids:* Replace buoys, flashers, and markers.

Fiscal Year 2009 Contract Awards Varied Widely from Estimates

For the 41 ARP contracts awarded in fiscal year 2009, covering 19 ARP projects, we found significant variability between the estimated costs and the amounts of the initial awarded contracts. (See fig. 4.) Industry definitions indicate that contract award amounts should generally be plus or minus 10 percent of the estimate used as part of the contract solicitation process. Of the 41 contracts awarded for ARP projects in fiscal year 2009, 22 contract awards were within 10 percent of the estimate used as part of the contract solicitation process. These contract awards totaled more than $3 million of the approximately $17.6 million obligated for fiscal year 2009. The remaining 19 contract awards varied by more than 10 percent from estimates used as part of the contract solicitation process and totaled nearly $13.3 million.[9] We found that the initial award amounts of these ARP contracts ranged from 74 percent less to 171 percent greater than estimates. (See enc. V for details).

Figure 4: Differences between Fiscal Year 2009 ARP Estimate and Initial Contract Award Price



Source: GAO presentation of SLDSC data.

[a]For this contract the estimate included combined costs of dredging at two separate locations. Because there was a delay in obtaining required permits at one of the locations, SLSDC awarded the contract in two parts. Therefore, we used both awards in our analysis.

[9]SLSDC also obligated approximately $85,000 for small purchase orders and $1.2 million for modifications to existing contracts, primarily for additional work on the Seaway International Bridge.

Fiscal Year 2009 projects (cont):

8. *Vehicles and Equipment:* Replace a crane and other mobile equipment.
9. *Electric Power Utility:* Upgrade power supply infrastructure to locks and facilities.
10. *Floating Plant:* Repair or replace vessels used to support operations.
11. *Roof Replacement:* Replace roofs on SLSDC buildings.
12. *Eisenhower Lock Tunnel:* Seal leaking joints in tunnel.
13. *Navigation Support Systems:* Install systems to support automated traffic management and monitor weather conditions.
14. *Dredging:* Conduct maintenance dredging.
15. *Miter Gates:* Repair upstream gate at Eisenhower Lock.
16. *Lock Controls:* Upgrade and expand computer system used to monitor and control lock functions.
17. *Compressed Air Systems:* Replace air compressors and piping in systems used for maintenance and ice control in and around the locks.
18. *Lock Structural Repairs:* Repair/grout cracks and joints in concrete at both locks.
19. *Fire Alarm Systems:* Replace fire alarm systems at SLSDC facilities.

Contract Awards Varied for a Number of Reasons

Several factors, including economic conditions, project-specific conditions, and requirements definition, contributed to the substantial differences between estimated costs and award amounts of some of the fiscal year 2009 contracts. In some cases, a combination of these factors may have contributed to these differences.

- ***Economic conditions:*** As we reported in December 2009, weak economic conditions have contributed to many federally funded contracts being awarded for less than the estimated cost.[10] Similarly, SLSDC officials indicated that these economic conditions likely increased competition for some of its contracts and created a bidding environment favorable to the agency. For example, four contractors bid on a contract to repair paving and drainage structures, and SLSDC awarded the contract at a cost 27 percent less than estimated. However, the level of competition was not consistently strong across all of SLSDC's contract solicitations. For example, SLSDC received only one bid on a contract to supply a container trailer and made an award at an amount 16 percent greater than the estimated cost. In another example, SLSDC canceled its procurement action to award a contract in fiscal year 2009 for replacement culvert valves when it received a single bid that was 52 percent higher than estimated.[11]
- ***Project-specific conditions:*** Some contract costs varied from estimates because of unique circumstances that could not have been anticipated. For example, SLSDC awarded a contract for replacement of rubber fenders at an amount 19 percent less than estimated because the winning contractor possessed a mold for fabricating the fenders that matched SLSDC's specifications.
- ***Requirements definition:*** Incomplete definition of requirements resulted in some contract awards at higher-than-estimated amounts. For example, after developing the estimate for the purchase of a boat to use as a maintenance vessel, SLSDC modified its specification to add items to the boat without updating its estimate. As a result, SLSDC awarded the contract at an amount 11 percent higher than estimated.

SLSDC can correct incomplete project requirements definitions, but factors such as project-specific and general economic conditions and their effect on estimates are difficult to control. Though some factors may be out of SLSDC's control, we have found that reliable estimates should account for uncertainties. Because uncertainty cannot be avoided, it is preferable to identify the elements that represent the most uncertainty as part of the overall project development process. Incorporating uncertainties into a cost estimate, as part of the overall cost-estimating and project development process, allows decision makers to determine a range of potential costs and assess and communicate the variability in an estimate. For example, uncertainties such as undefined or unknown technical information, uncertain economic conditions, and requirements growth may negatively or positively affect a program's cost.

[10]GAO, *Recovery Act: Status of States' and Localities' Use of Funds and Efforts to Ensure Accountability*, GAO-10-231, (Washington, D.C.: Dec. 10, 2009).
[11]SLSDC resolicited for contract bids in fiscal year 2010 and awarded a contract for culvert valve replacement at an amount 51 percent less than estimated.

Characteristics of High-Quality Cost Estimates[12]

Comprehensive: The cost estimates should include costs of the program over its full life cycle, provide a level of detail appropriate to ensure that cost elements are neither omitted nor double-counted, and document all cost-influencing ground rules and assumptions.

Well documented: The cost estimates should be supported by detailed documentation that describes the purpose of the estimate, the program background and system description, the scope of the estimate, the ground rules and assumptions, all data sources, estimating methodology and rationale, and the results of the risk analysis. Moreover, this information should be captured in such a way that the data used to derive the estimate can be traced back to, and verified against, their sources.

Accurate: The cost estimates should be based on an assessment of most likely costs (adjusted for inflation), documented assumptions, and historical cost estimates and actual experiences on other comparable programs. Estimates should be cross-checked against an independent cost estimate for accuracy, double counting, and omissions. In addition, the estimates should be updated to reflect any changes.

Credible: The cost estimates should discuss any limitations of the analysis because of uncertainty, or biases surrounding data or assumptions. Risk and uncertainty analysis should be performed to determine the level of risk associated with the estimate. Further, the estimate's results should be cross-checked against an independent cost estimate.[13]

SLSDC Does Not Use Formal Cost-Estimating Guidance, Increasing the Risk of Unreliable Estimates

A senior SLSDC official stated that because of the small size of the engineering office and the staff's familiarity with lock infrastructure, the agency does not use formal estimating guidance; rather engineers and management communicate routinely about project requirements and cost estimates. SLSDC's engineering and maintenance staff, who are responsible for maintaining the lock infrastructure, generally develop the ARP project cost estimates. In estimating project costs, SLSDC staff obtain cost information from various sources, depending on the specifics of the project. The information sources are commercially available cost-estimating guides, such as RSMeans, and historical data from past SLSDC work and comparable Canadian or U.S. Army Corps of Engineers projects.[14] In addition, SLSDC uses expert consultants when it determines that it cannot develop project requirements and cost estimates in-house.

We have previously reported that the lack of cost-estimating guidance at other agencies has led to cost estimates of poor quality.[15] Such guidance serves as a mechanism for providing a standard cost-estimating process to agency officials and contractors. Cost-estimating guidance also establishes roles and responsibilities for those preparing, reviewing, and updating all types of cost estimates.

According to the *GAO Cost Estimating and Assessment Guide*, a reliable cost-estimating process is necessary to ensure that cost estimates—particularly for large, complex projects—are comprehensive, well documented, accurate, and credible.[16] The cost guide identifies best practices that, followed correctly, should result in reliable cost estimates that management can use for making informed decisions. (See enc. VI for details).

We used the *GAO Cost Estimating and Assessment Guide* to provide criteria for evaluating SLSDC's cost-estimating process on two of the complex ARP projects that began in fiscal year 2009, are expected to cost more than $1 million when completed, and are critical to the operation of the locks, and, as shown in tables 1 and 2, found that its estimating process for both projects was lacking. In particular, we found that SLSDC's process did not fully meet any of the four characteristics for producing a high-quality cost estimate, and partly as a result, the estimates produced by this process were unreliable and underestimated the actual cost of each project by more than 45 percent. See enclosure VII for our more detailed assessments.

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[12]GAO-09-3SP.

[13]An independent cost estimate is another estimate based on the same technical information that is used to validate and cross-check the baseline estimate but is prepared by a person or organization that has no stake in the approval of the project.

[14]The U.S. Army Corps of Engineers operates over 200 locks throughout the United States.

[15]GAO, *Department of Energy: Actions Needed to Develop High-Quality Cost Estimates for Construction and Environmental Cleanup Projects*, GAO-10-199 (Washington, D.C.: Jan. 14, 2010); *Telecommunications: GSA Has Accumulated Adequate Funding for Transition to New Contracts but Needs Cost Estimation Policy*, GAO-07-268 (Washington, D.C.: Feb. 23, 2007).

[16]The definition of a "large, complex project" varies by agency depending on the size and value of the assets it manages.

Table 1: Assessment of ARP Project # 4: Culvert Valve Operating Equipment, Phase I

Project description: This is a two-phase project to replace the operating machinery for the Eisenhower and Snell Lock culvert valves, which are used for filling and emptying the locks. The upgrade will replace motors and gears—which have been maintained but not replaced or upgraded since their installation in the 1950s—with new hydraulic operating machinery to match the upgrades made at the Canadian Seaway locks and other similar locks in the United States.

The first phase of this project began in fiscal year 2009 when SLSDC awarded a contract to upgrade the operating machinery on the north sides of both locks. Because of the long lead time needed to acquire the equipment, the actual work will be performed over the 3-month period of January to March 2011.

Final estimate (phase I): $2.8 million **Actual award (phase I):** $4.1 million

Characteristic	Overall assessment (fully met/substantially met/partially met/minimally met/not met)[a]	Reason for assessment
Comprehensive	Partially met	The cost estimate defined the work in detail and, for each cost category, clearly described how most of the various cost elements are summed. The cost estimate also included basic assumptions, such as inflation. However, because the cost estimate does not specifically break out common costs, such as training and testing, we were unable to determine whether the estimate included all of the relevant costs of the project. In addition, key assumptions on time frame and risk, including their effect on costs, were not accounted for in the estimate.
Well documented	Substantially met	The documentation of the cost estimate included the purpose and basic cost-influencing ground rules and assumptions. In addition, the cost estimate incorporated local labor rates and vendor quotes, and was based on a technical baseline that included final drawings and specifications. However, while the documentation for the most part provided details on the cost of the estimate, the estimate provided to management did not clearly convey whether all costs were properly captured, all risks were properly considered, and underlying assumptions were valid. For example, key assumptions on time frame and risk were not reflected in the estimate.
Accurate	Substantially met	The cost estimate is based on a detailed buildup of estimated labor and material prices, and SLSDC updated both the current and future phases of the project cost estimate with fiscal year 2009 award data. However, the estimate for this project was not cross-checked against an independent cost estimate to ensure accuracy and minimize the risk of omissions and double counting in the estimate.[b]
Credible	Minimally met	The cost estimate is based on a detailed buildup of estimated labor and material prices. However, the estimate was not cross-checked against an independent cost estimate to ensure that different estimating approaches would produce similar results. In addition, SLSDC did not conduct sensitivity and risk analyses; therefore, the estimate did not reflect the degree of uncertainty, and decision makers had no insight into the level of confidence associated with it.

Source: GAO analysis of SLSDC data.

[a]Notes: The ratings we used in this analysis are as follows: "Fully met" means that the agency provided complete evidence that satisfies the entire criterion; "Substantially met" means that the agency provided evidence that satisfies a large portion of the criterion; "Partially met" means that the agency provided evidence that satisfies about half of the criterion; "Minimally met" means that the agency provided evidence that satisfies a small portion of the criterion; and "Not met" means that the agency provided no evidence that satisfies any part of the criterion.

[b]An independent cost estimate is another estimate based on the same technical information that is used to validate and cross-check the baseline estimate but is prepared by a person or organization that has no stake in the approval of the project.

Table 2: Assessment of ARP Project #31: Rehabilitate Upstream Miter Gates, Phase I

Project description: This is a two-phase project to rehabilitate the miter gates at the upstream end of both Eisenhower and Snell Locks. The project will replace worn and/or damaged components to ensure proper functioning of the miter gates.

The first phase of this project began in fiscal year 2009 when SLSDC awarded a contract to rehabilitate the upstream gate at Eisenhower Lock. Because of the long lead time needed to acquire gate components, the actual work will be performed over the 3-month period of January to March 2011.

Final estimate (phase 1): $1.3 million **Award amount (phase 1):** $2.2 million

Characteristic	Overall assessment (fully met/substantially met/partially met/minimally met/not met)[a]	Reason for assessment
Comprehensive	Minimally met	The estimate included basic cost-influencing ground rules and assumptions, such as labor and inflation rates. However, key assumptions on time frame and risk, including their effect on costs, were not accounted for in the estimate. In addition, the cost estimate does not define the work in detail nor does it provide a framework for planning and assigning the work down to an appropriate level of detail.
Well documented	Partially met	The documentation of the cost estimate included the purpose and basic cost-influencing ground rules and assumptions. However, the estimate did not provide enough detail to easily defend the estimate. For example, a technical baseline description with all of the project requirements was only 35 percent complete, and key assumptions on time frame and risk were not included in the documentation. In addition, the cost estimation documentation did not provide detailed material and labor cost information that would allow someone unfamiliar with the project to re-create them.
Accurate	Partially met	SLSDC updated both the current and future phases of the project cost estimate with fiscal year 2009 award data. While the cost estimate for this project is based on a similar project, adjusted with a rule-of-thumb factor, the cost estimate was not based on a detailed buildup of individual cost elements. In addition, the estimate for this project was not cross-checked against an independent cost estimate to ensure accuracy and minimize the risk of omissions and double counting in the estimate.[b]
Credible	Minimally met	The cost estimate is based on a similar project as well as the knowledge of SLSDC engineers. However, the estimate was not cross-checked against an independent cost estimate to ensure that different estimating approaches would produce similar results. In addition, SLSDC did not conduct sensitivity and risk analyses; therefore, the estimate did not reflect the degree of uncertainty, and decision makers had no insight into the level of confidence associated with it.

Source: GAO analysis of SLSDC data.

[a] The ratings we used in this analysis are as follows: "Fully met" means that the agency provided complete evidence that satisfies the entire criterion; "Substantially met" means that the agency provided evidence that satisfies a large portion of the criterion; "Partially met" means that the agency provided evidence that satisfies about half of the criterion; "Minimally met" means that the agency provided evidence that satisfies a small portion of the criterion; and "Not met" means that the agency provided no evidence that satisfies any part of the criterion.

[b] An independent cost estimate is another estimate based on the same technical information that is used to validate and cross-check the baseline estimate but is prepared by a person or organization that has no stake in the approval of the project.

SLSDC Adjusted the Fiscal Year 2009 Spending Plan

Because of the variability in cost estimates and reprioritization of ARP projects, SLSDC adjusted its fiscal year 2009 spending plan by reallocating funding, and deferring and accelerating projects to meet the targeted spending amount of approximately $17.6 million.

- **Reallocating project funding:** SLSDC reallocated funding gained from contracts with lower-than-expected costs to pay for contracts with higher-than-expected costs. For example, the cost of the contract to dredge the navigation channel was significantly lower than estimated because the estimate included an allowance for hauling and disposing of hazardous sediments. Because no hazardous material was found, SLSDC was able to complete the work for 42 percent less than expected. Unused funds were then applied to other projects, such as the miter gate rehabilitation, in which actual awards were greater than estimates.
- **Deferring projects:** As a result of the increased costs of higher-priority projects, such as the miter gate rehabilitation and replacement of the culvert valve operating equipment, SLSDC deferred plans to purchase a new emergency response boat and a barge. Similarly, SLSDC deferred the purchase of materials to refurbish the lock covers used during the winter maintenance season because of the increased costs of the higher-priority projects.
- **Accelerating projects:** SLSDC accelerated projects that increased in priority as a result of its continual monitoring of lock conditions. For example, SLSDC accelerated repair work in one of the lock machinery recesses to reduce leaking, which had increased significantly in 2009.

While SLSDC has flexibility to adjust its annual spending plans, such flexibility does not eliminate the need to produce reliable and valid cost estimates. Office of Management and Budget guidance points out that estimating inaccuracy—both overestimating and underestimating—can adversely affect other projects. With overestimating, an agency may request and be provided with more resources than it will actually need for the project, thereby resulting in fewer resources available for other projects or programs. Underestimating projects can lead an agency to request fewer resources than it will actually need to complete the project, potentially leading to a reduction in the project scope, termination of the project, or the shifting of funds from other projects. Furthermore, inaccurate estimates may also reduce confidence in the accuracy of future estimates provided by an agency.

Great Lakes St. Lawrence Seaway Study Inspections

As part of the Great Lakes St. Lawrence Seaway Study, engineers from the United States and Canada, including engineers from SLSDC and the Canadian Seaway, conducted on-site assessments of the current condition of all locks in the Great Lakes St. Lawrence Seaway System to obtain a general picture of issues such as wear, material fatigue, redundancy, and problems with concrete, as well as to categorize outstanding maintenance issues. Individual lock components were evaluated in terms of importance to operation, likelihood of failure, consequences of failure, and costs of keeping them operational. At the two U.S. locks, the engineers determined that the most critical areas are associated with concrete quality at the Eisenhower Lock, the condition of the lower miter gates at both locks, the south span of the Seaway International Bridge, and the Eisenhower Lock highway tunnel.

SLSDC Capital Plans

Each year, SLSDC engineering and maintenance teams update plans for capital projects and equipment based on lock inspections and anticipated life cycles of parts and machinery. Projects deemed necessary to ensure reliability and availability of the existing lock structures are included in the agency's annual budget request. Project work may span a number of years because of the need to maintain the agency's capital budget at consistent levels and because of the limited 3-month winter shutdown period to complete the work.

ARP Addresses Most Previously Identified Asset Renewal Needs, and SLSDC Will Continue to Assess Condition of Assets

ARP Addresses Most Asset Renewal Needs, and Remaining Needs Are Generally Addressed through Routine Maintenance

The ARP addresses the vast majority of the asset renewal needs identified through inspections performed as part of the Great Lakes St. Lawrence Seaway study and the development of agency capital plans submitted with annual budget requests for fiscal years 2003-2008. The remaining needs are generally addressed through routine maintenance, but SLSDC could use its flexibility to add new or modify existing ARP projects if maintenance funding cannot adequately address the needs. For example, SLSDC plans to add a project to the ARP to install the second phase of an emergency communications system in the underground areas of the locks and modify or add a project to construct a washing facility to help reduce corrosion on and extend the service life of agency vehicles, because routine maintenance funding is not adequate to address these needs.

SLSDC's Ongoing Assessment Program Could Affect the ARP

While the ARP addresses most known asset renewal needs, SLSDC's ongoing asset condition assessment program may identify new requirements and cause the agency to add new or reprioritize current ARP projects. Periodic condition assessment—in which assets are inspected to determine if they are sound and functional and to identify maintenance and repair needs—is an essential step in effective facilities management. SLSDC has followed a reasonable approach for condition assessment. SLSDC's operating, maintenance, and engineering staff who are involved with the assets on a daily basis perform the assessments. As shown in table 3, assets are assessed at varying frequencies and levels of detail, depending on their significance to sustaining operations. For example, SLSDC staff inspect critical lock-operating equipment and systems three times a week during the shipping season and perform a more detailed inspection during the winter shutdown period. In contrast, equipment and vehicles that are less critical to operations are inspected less frequently. This approach is consistent with National Research Council guidance that states the importance of prioritizing assets so that assessments concentrate on the critical elements that affect the ability of the agency to operate effectively.[17] SLSDC uses a preventive maintenance database to record inspection results, create repair work orders, and schedule maintenance activities.

To address new requirements that may be identified through its condition assessment program, SLSDC officials stated that the agency will first attempt to use routine maintenance funding. If these requirements cannot be met using this funding, SLSDC officials said that they would then revise the ARP to account for the work. In addition, SLSDC's assessment program may cause it to modify the scheduling of ARP projects if assets currently slotted to have work performed in future years begin to experience problems that require more immediate attention.

[17]National Research Council, *Stewardship of Federal Facilities: A Proactive Strategy for Managing the Nation's Public Assets* (Washington, D.C.: 1998).

Condition Assessments

Condition assessments are conducted to understand an asset's overall state and to identify renewal or replacement needs that will preserve its ability to support the mission or activities it was designed to serve. During a condition assessment, trained personnel inspect the physical condition and functional performance of facilities, systems, and materials for signs of deterioration, failure, or more subtle symptoms that conditions are not normal. Condition assessments can range from staff walking through a facility and visually inspecting conditions to more comprehensive studies, using a variety of technical diagnostic techniques.

Table 3: SLSDC's Condition Assessment Program for Infrastructure Assets

Asset	Description of assessment
Electrical equipment	• Lock-operating machinery is inspected three times per week during the navigation season. • Emergency generators are inspected and tested biweekly. • Transformers, automatic transfer switches, switchgear, and limit switches are inspected and preventive maintenance is performed annually.
Concrete structures	• Approach walls and lock walls are inspected for damage on all shifts each day during the navigation season. • All concrete is inspected annually when the locks are dewatered. Damaged or deteriorated concrete is further assessed by taking core samples to determine extent of damage/deterioration.
Vertical lift gate	• Vertical lift gate is tested monthly to ensure it would operate in an emergency.
Lock-operating equipment and systems (including gates, valves, ship arrestors, walls, compressors, and pumps)	• Lock-operating equipment and systems are inspected three times a week during the navigation season. Checklists are used for these inspections. • Lock-operating equipment and systems, and all underwater structures, are inspected in greater detail during the winter shutdown period. As part of this inspection, equipment is operated and/or disassembled.
Fleet of vessels (tugs, buoy barge, and gatelifter vessel)	• Major pieces of the fleet are taken out of the water for assessment, and underwater components are repaired on a 5- to 10-year cycle. • The 300-ton gatelifter vessel is assessed through a training exercise annually or biannually. • All vessels are inspected before each use. • The large tug has oil samples taken from multiple systems twice a year, and the oil is changed based on the results of the samples. • For all other vessels, the oil is changed after operating for a predetermined number of hours.
Fixed and floating aids to navigation	• Fixed and floating aids are inspected annually, more frequently if maintenance is required. • All floating aids are repaired, cleaned, and painted on a 5-year cycle.
Vehicles	• Vehicles are checked and serviced every 3,000 miles, at a minimum.
Mobile equipment (cranes, grader, backhoe, loader, forklifts, snowplows, mowing equipment, generators, air compressors, and so forth)	• Cranes are inspected monthly. • Equipment utilized during winter maintenance periods (e.g., snowplow) is inspected and serviced before and after each winter season. • All other equipment is inspected and serviced annually, at a minimum.
Buildings	• Buildings are continuously assessed as part of routine use.

Source: SLSDC data.

U.S. and Canadian Officials Coordinate as Needed on ARP Issues

The Canadian Seaway's ARP

The Canadian Seaway began an asset renewal program for its 13 locks in 1997, and because it considers asset renewal work an ongoing effort, there is no targeted end date. The Canadian ARP is funded in 5-year increments from the Canadian government, and the Canadian Seaway currently expects to spend about C$570 million through 2013.

ARP Projects Affecting Vessel Operating Procedures

Vessel self-spotting system: This technology uses laser scanning and image recognition techniques to detect and track the position of a vessel as it enters the lock. The system will provide vessel captains with visual and audio indication of their vessel's position relative to its mooring position. According to the Canadian Seaway, the technology will reduce the time vessels are in the lock. All Canadian locks are expected to be equipped with this technology by 2010. SLSDC's project to install this system is currently expected to begin in 2014.

Vessel vacuum mooring system: This technology uses vacuum pads to secure vessels while they are in the lock. The system has been proposed as an alternative to manually securing vessels using casting lines from the ship to the lock wall. Use of this system could allow ships to transit the system without Seaway-specific equipment they currently carry. According to the Canadian Seaway, testing of this technology is under way. SLSDC's project to install this system is currently expected to begin in 2016.

While the two Seaway entities collaborated on the binational study and coordinate on day-to-day operations, U.S. and Canadian officials stated that coordination specific to the ARP generally involves opening and closing of the Seaway and the exchange of technical project information. Although both countries currently have programs to renew assets, officials stated that more detailed coordination of their programs is not warranted because of differences in the programs.

Coordination of the opening and closing dates, while routine, is important for the ARP because it determines the work schedule for a number of critical projects that can be completed only during the winter shutdown period. Because of this limited winter maintenance time frame, SLSDC's ARP contracts contain penalty clauses to ensure that contractors complete work in time to allow the two U.S. locks to open on the agreed-upon date.

SLSDC and the Canadian Seaway share technical information about projects both countries are doing. For example, the Canadian Seaway shared with SLSDC specifications and drawings from its miter gate project, which were used to assist SLSDC in designing its miter gate rehabilitation project. In addition, as part of the common goal to ensure that vessel operators transiting the Seaway have the same experience at each of the 15 locks, the two entities are coordinating on projects that would affect vessel operating procedures at the locks. For example, the Canadian Seaway is researching, testing, and implementing technologies to track and secure vessels as they enter the locks, and is sharing the results with the United States. SLSDC officials told us that work on two ARP projects to incorporate this technology will begin after they are successfully implemented at the Canadian locks. In the meantime, SLSDC uses updates from Canada's testing and implementing efforts to refine the scope and estimates of its projects. For example, SLSDC updated the scope and estimate of its vacuum mooring system project after Canadian testing of the system indicated that four vacuum units per lock may be required as opposed to the original plan of two per lock.

Conclusions and Recommendation for Executive Action

Conclusions

The Asset Renewal Program represents a significant investment in SLSDC's infrastructure as part of the agency's effort to maintain the functionality of the St. Lawrence Seaway. Because many of the individual ARP projects are still in the early stages of project definition, it is reasonable to expect that cost estimates will continue to change. Estimates for asset renewal projects, like any estimate of a future activity, can never be exact. On the basis of the variability between estimated and actual costs experienced during the first year of the ARP, SLSDC was able to adjust its spending plans by reallocating funding and reprioritizing projects. Nevertheless, there is no guarantee that such favorable adjustments can be repeated in future years. As the ARP nears completion, SLSDC may have limited opportunities to reallocate funding and reprioritize projects. As a result, SLSDC may need to reduce the scope of work in the ARP or extend the length of the program beyond the current 10-year plan in order to complete all planned projects.

SLSDC's need to adjust its annual spending plans could be reduced through increasing the reliability of project cost estimates. While we acknowledge that the considerable knowledge and experience of SLSDC's personnel is a valuable input to the cost-estimating process, it is only one part of a reliable cost-estimating process. We have identified a number of cost-estimating best practices in our cost assessment guide that, when applied, should result in reliable and valid cost estimates. We recognize that application of all of these best practices takes both time and financial resources. Therefore, SLSDC may choose to apply each best practice to varying degrees, depending on the scope and complexity of the individual projects. However, the overall effect of applying these best practices is to enable SLSDC to better identify and address issues contributing to cost variability and allow the agency to provide congressional decision makers, and other stakeholders, with more precise information about the ARP's estimated cost and increased confidence in SLSDC's annual spending plans.

Recommendation for Executive Action

To improve the reliability of cost estimates of the ARP projects, we recommend that the Secretary of Transportation direct the SLSDC Administrator to develop a cost-estimating process that follows best practices to better ensure that its estimates are comprehensive, well documented, accurate, and credible.

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Staff Acknowledgments

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Enclosure II: Scope and Methodology

The objectives of this study were to determine (1) how the cost estimates in the Asset Renewal Program (ARP) have changed from February 2009 to February 2010, (2) the extent to which the ARP covers all asset renewal needs, and (3) the steps the U.S. and Canadian authorities have taken to coordinate their asset renewal programs.

We employed several methods to determine how the cost estimate for the ARP has changed from February 2009 to February 2010. For example, we interviewed Saint Lawrence Seaway Development Corporation (SLSDC) officials and compared the February 2009 project feasibility estimates of the original 50 projects with the February 2010 estimates updated after the end of the first year of the 10-year program to quantify differences and determine the reasons for changes in the estimates.[18] We obtained information from SLSDC on the project development stage at which each of the February 2010 project estimates was developed and used industry information and prior GAO reports to determine the expected variability between estimated and actual costs, and how this variability may change as the projects, and their corresponding estimates, mature through the project development process. We then compared the estimates used as part of the contract solicitation process with the initial award amount for 40 of the 41 ARP contracts awarded in fiscal year 2009 to determine the extent of variability between estimates and initial awards. For the remaining fiscal year 2009 contract, the estimate included combined costs of dredging at two separate locations. Because there was a delay in obtaining all required permits, SLSDC awarded the contract in two parts; therefore, we compared the total of the two award amounts to the estimate used as part of the contract solicitation process. We interviewed SLSDC officials and analyzed data to determine the reasons for the variability between estimates and awards, and how the agency's fiscal year 2009 spending plan was modified in response to this variability as well as changes in project priorities, including the addition of two ARP projects. Our analysis of fiscal year 2009 contract data cannot be generalized to ARP contracts awarded after fiscal year 2009. We interviewed an SLSDC official and reviewed audited financial statements to ensure the reliability of the contract data and determined that the data were sufficiently reliable for the purposes of this report.

To evaluate the process SLSDC used to estimate the costs of projects in the ARP, we interviewed SLSDC officials and reviewed documents related to the agency's estimating process. We used the *GAO Cost Estimating and Assessment Guide* to evaluate the extent to which the estimates SLSDC prepared for two projects reflected the four key characteristics of high-quality estimates—credible, well documented, accurate, and

[18]The estimates for six of the projects changed by $3,000 or less because of minor rounding of future SLSDC budget estimates. Because these changes were small, due only to rounding, and not a result of a material change in the project, we did not consider the adjustments in these projects to reflect a change in the total project estimate.

comprehensive. We selected projects to review in detail based on the following criteria: (1) projects starting in fiscal year 2009 or 2010, (2) projects expected to cost more than $1 million when completed, (3) projects that were complex, and (4) projects that were critical to the operation of the locks. While 5 of the 52 projects met all of the criteria, we selected 3 projects because of the time and level of effort required to evaluate the estimating process for these projects. The 3 projects we initially selected were Project 4: Both Locks: Culvert Valve Machinery–Upgrade to Hydraulic Operations; Project 12: Corporation Equipment: Upgrade/Replace Floating Plant; and Project 31: Both Locks: Rehabilitate Upstream Miter Gates. However, Project 12 was dropped from our analysis after additional information obtained from officials and project documents revealed that the project did not fully meet our selection criteria.[19] For Projects 4 and 31, we analyzed supporting technical and design documents related to the estimates, and interviewed SLSDC officials and the contractor involved in Project 4 about the processes used to prepare the estimates. GAO cost-estimating experts then compared the approaches for preparing the estimates for these two projects with the best practices contained in our guide and determined the extent to which the process complied with our cost guide. The information obtained from our review of SLSDC's estimating process for these two projects cannot be generalized to all ARP estimates.

To determine the extent to which the ARP covers asset renewal needs, we interviewed SLSDC officials, and reviewed (1) ARP documents that described the projects, (2) agency capital plans and annual reports from 2003-2008, and (3) the Great Lakes St. Lawrence Seaway Study to identify SLSDC asset renewal needs. We compared the needs identified in the agency capital plans and the Great Lakes St. Lawrence Seaway Study with the current 52 ARP projects to determine the extent to which the ARP addressed all asset renewal needs. For any asset renewal need not identified in the ARP, we obtained additional information and interviewed SLSDC officials to determine why these needs were not included in the ARP, the extent to which these needs were addressed prior to implementing the ARP, and how SLSDC plans to address any needs in the future. We also reviewed documents and interviewed SLSDC officials to understand SLSDC's program to assess the condition of its infrastructure, facilities, and equipment, and how SLSDC anticipates addressing any future needs identified as a result of its assessment program, including how the results of the program could affect the ARP. We used industry information on condition assessment for facilities to determine the reasonableness of SLSDC's condition assessment program.

To determine the steps taken by SLSDC and Canadian authorities to coordinate their asset renewal programs, we interviewed officials from SLSDC and their counterparts at the Canadian St. Lawrence Seaway Management Corporation and reviewed relevant laws and treaties and agreements between the United States and Canada. In addition, we reviewed annual reports from SLSDC and the Canadian Seaway describing asset renewal efforts.

[19]In fiscal year 2009, SLSDC awarded a number of small contracts (each less than $1 million) for commercial-off-the-shelf items with fairly well-established market prices, and as such, these contracts were not for complex projects critical to the operation of the locks. Future work planned as part of this project is expected to be more complex and cost more than $1 million, but this work is still in the planning stage and lacked enough information to evaluate using our cost-estimating criteria.

We conducted this performance audit from July 2009 to May 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Enclosure III: How a Lock Works

The primary purpose of a lock is to raise and lower ships to bypass rapids in a river and/or overcome changes in water surface levels. Generally, a lock does not require pumps to operate, as water is moved by gravity from the high water side to the lower water side. The basic feature of a lock structure is an enclosed area called the chamber. The chamber of concrete walls has watertight gates at each end (called miter gates) and valves to fill and empty water from the chamber. The process of raising or lowering a ship in the chamber is called a lockage and is shown below in figure 5.

Lock Operation

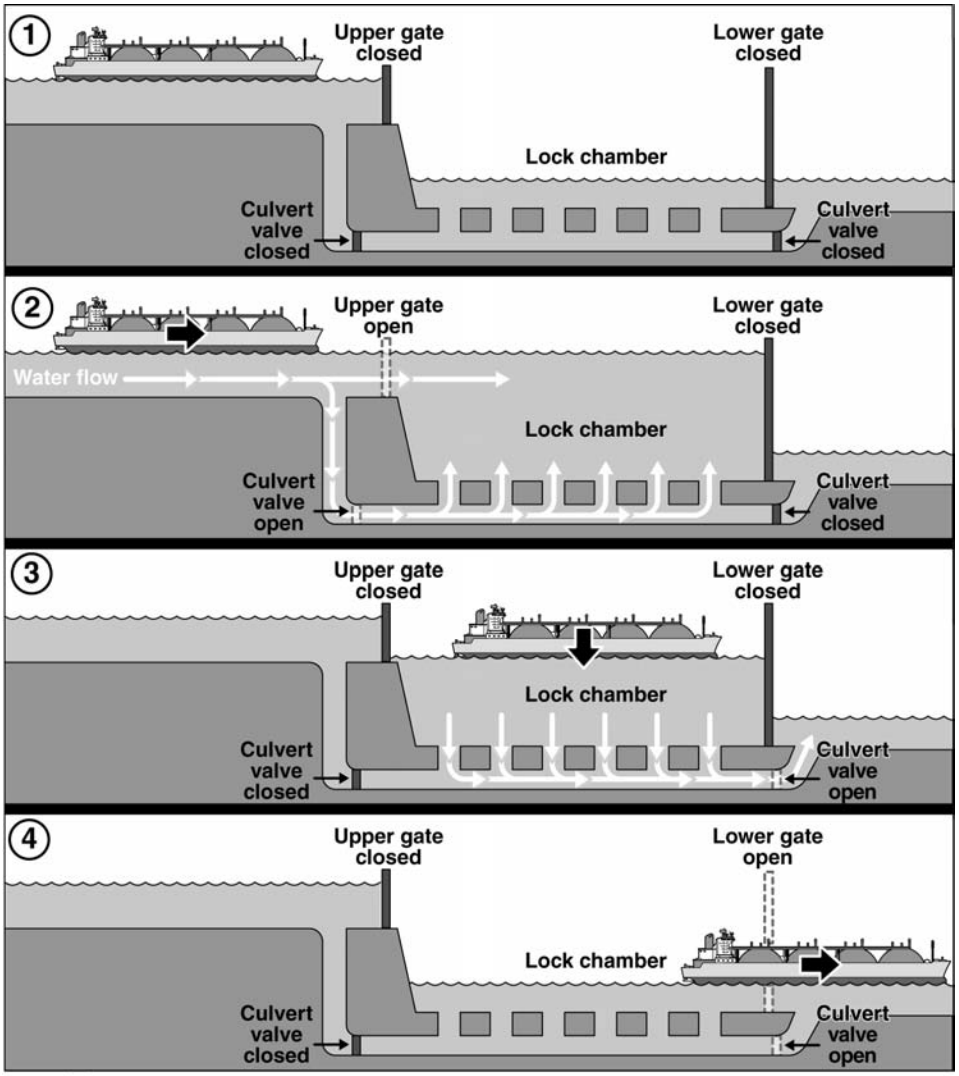
(1) In this example, a ship approaches the lock chamber from the west, or upstream, end. The lock gates are closed, and the water level in the lock chamber is the same as the water level downstream of the lock chamber.

(2) With both the lower and upper gates closed and the emptying culvert valves closed, the chamber is brought to the upper level by opening the filling culvert valves. This allows the water to flow from the intakes into the chamber. Once the chamber is filled, the upper gates are opened and the ship enters.

(3) After the ship is in the chamber, the upper gates and the filling culvert valves are closed. The emptying culvert valves are then opened to allow water to flow out of the lock chamber to the lower level. As the water leaves the chamber, the ship is lowered.

(4) When the water in the chamber reaches the lower level, the ship is fully lowered. The lower gates are opened, and the ship leaves.

Figure 5: Operation of a lock



Source: GAO.

Enclosure IV: 52 ARP Projects

Table 4: Projects in the ARP

Project	Description	Total project estimate (as of February 2010)
1. Snell Lock: Replace Fendering Downstream Guidewall Extension	This project is to replace the 20-year-old composite fendering on the downstream guidewall at Snell Lock.	$251,600
2. Eisenhower and Snell Locks: Rehabilitate Downstream Miter Gates	This project is to completely rehabilitate the miter gates at the downstream ends of both locks. It includes replacing worn and/or damaged components to ensure proper functioning of the miter gates.	8,630,000
3. Eisenhower and Snell Locks: Rehabilitate Mooring Buttons and Pin and Rehabilitate Concrete along Guidewalls and Guardwalls	This project is to rehabilitate the upstream and downstream concrete approach walls at both locks and the mooring buttons located behind these walls for transiting vessels to tie to. The rehabilitation work will include pinning dislodged lifts, repairing damaged concrete, and raising mooring buttons that have settled.	251,000
4. Eisenhower and Snell Locks: Culvert Valve Machinery—Upgrade to Hydraulic Operation	This project is for replacing the 50-year-old operating machinery for culvert valves at both locks with new hydraulic operating machinery to match the upgrades made at the Canadian Seaway locks and other similar locks in the United States.	8,617,050
5. Eisenhower and Snell Locks: Rehabilitate and Insulate Winter Maintenance Lock Covers	This project is for rehabilitating and insulating the 40-year-old steel modules utilized to cover both locks when major winter maintenance projects are planned.	304,698
6. Seaway International Bridge: Perform Structural Rehabilitation and Corrosion Prevention	This project is for rehabilitation of the structural components of the south span of the Seaway International Bridge, which crosses the Seaway navigation channel and is jointly owned with Canada. SLSDC owns 68 percent of the south span of the bridge, and the budget request reflects the U.S. prorated amount for the project. Canada owns the remaining 32 percent of the south span.	12,341,878
7. Eisenhower and Snell Locks: Culvert Valves—Replace with Single Skin Valves	This project is for replacing the 50-year-old double skin culvert valves utilized for filling and emptying both locks with single skin valves, which will provide better access to the structural members for inspection and maintenance.	1,514,000
8. Floating Navigational Aids: Replace	This is an ongoing program to replace approximately 100 buoys and 50 winter markers on an as-required basis.	615,254
9. SLSDC Equipment: Replace Heavy and Light Equipment, Maintenance Vehicles, and Shop Equipment	This is an ongoing program to replace heavy and light equipment, vehicles, and shop equipment as they become worn out and unserviceable. Heavy and light equipment includes such items as a crane, dump truck, snowplow, backhoe, grader, and front end loader, and shop equipment includes such items as a lathe, a milling machine, and a drill press.	3,728,504
10. Eisenhower and Snell Locks: Upgrade Power Supply Infrastructure from Moses-Saunders Dam to Both Locks and Adjacent Facilities	This project is for upgrading the 50-year-old infrastructure that supplies power to both locks and to SLSDC's maintenance facility.	289,594
11. Fixed Navigational Aids: Rehabilitate	This project is for rehabilitating 50-year-old fixed navigational aids in the Seaway, including the concrete bases of some of these structures, which are eroding and cracking.	1,743,000

Project	Description	Total project estimate (as of February 2010)
12. SLSDC Equipment: Upgrade/Replace Floating Plant	This is an ongoing program to rehabilitate and/or replace SLSDC's floating plant, which is utilized for maintaining the locks and navigation channels. This multiyear project also includes replacing the tug; upgrading the buoy tender barge; purchasing a smaller tug and a small barge and scow for maintaining fixed navigation aids and for emergency/spot dredging; and for rehabilitating the crane barge/gate-lifter, which would have to be utilized if a miter gate was damaged and had to be replaced.	32,020,745
13. SLSDC Facilities: Replace Roofs	This project is for replacing the roofs on SLSDC's various buildings and facilities in Massena, New York, as required.	1,887,949
14. SLSDC Facilities: Replace Paving and Drainage Infrastructure	This project is for improving the pavement and drainage along lock approach walls, agency roadways, and parking and work areas at all SLSDC facilities.	6,255,837
15. Eisenhower Lock: Highway Tunnel—Rehabilitate	This is an ongoing project to maintain the highway tunnel that goes under the Eisenhower Lock, including grouting to limit the water leaking into the tunnel, replacing damaged or missing tiles from the walls and ceiling, replacing deteriorated/ damaged gratings and railings, stabilizing or repairing wingwalls at the tunnel approaches, clearing tunnel drains that are becoming plugged with concrete leachate products, and upgrading the lighting to meet current standards.	1,449,636
16. Seaway System: Upgrade GPS/AIS/TMS Technologies	This project is to expand the use of the Seaway's Global Positioning System (GPS)/Automatic Identification System (AIS) navigation technologies, which are incorporated into the Seaway's binational Traffic Management System (TMS). Future upgrades will further improve the safety for vessels transiting the Seaway. Plans are to use these technologies to enable vessels to better identify hazards at times of limited visibility.	459,997
17. Navigation Channels: Dredge U.S. Sectors to Maintain Design Grade and Dispose of Sediments	This project is for dredging of the navigation channel to remove sediments to maintain the channel at its authorized depth.	14,636,556
18. Eisenhower Lock: Vertical Lift Gate—Replace Wire Ropes	This project is for replacing the 30-year-old wire rope cables that serve to raise and lower the vertical lift gate at Eisenhower Lock. The vertical lift gate is an emergency closure designed to hold back water if a miter gate is compromised.	503,000
19. SLSDC Facilities: Upgrade Electrical Distribution Equipment	This project is for upgrading 50-year-old electrical distribution equipment at both locks and at the Maintenance Facility.	801,000
20. Eisenhower and Snell Locks: Upgrade Lock Status/Controls	This project is for upgrading the lock/equipment status systems and the lock operating controls at both locks.	234,558
21. Eisenhower and Snell Locks: Compressed Air Systems—Upgrade/Replace	This project is for replacing the compressors and corroded piping that provide compressed air for various systems at both locks for maintenance work and for ice control in and around the locks during the opening and closing of the Seaway.	1,527,878
22. Eisenhower and Snell Locks: Install Vessel Self Spotting Equipment	This project is for installing technology at both locks so that vessel captains transiting the locks can more easily locate their vessel’s position in the lock. The Canadian Seaway agency has been testing this new technology at its locks and will have it installed at all of its locks during the 2010 shipping season.	579,000
23. Eisenhower and Snell Locks: Install Vessel Vacuum Mooring Systems	This project is for installing vessel vacuum mooring equipment at both locks to hold vessels in place while they are in the lock. The Canadian Seaway agency commenced testing this new technology at the beginning of the 2007 navigation season and continues to refine equipment specifications.	9,971,000
24. Eisenhower and Snell Locks: Structural Repair—Grout Leaks in Galleries and Recesses	This project is for grouting cracks/joints in the concrete in the galleries and recesses at both locks to reduce the infiltration of water into these areas.	441,561
25. SLSDC Facilities: Upgrade/Replace Fire Alarm/Protection Systems	This project is for replacing antiquated fire alarm and fire protection systems at SLSDC facilities. Prior to the start of the ARP, SLSDC began work on this project because problems with the current system required more immediate attention. Therefore, the scope of the project under the ARP has been reduced.	105,148
26. SLSDC Facilities: Upgrade Storage for Lock Spare Parts	This project is for constructing buildings for storage of lock spare parts to prevent them from corroding prior to their use.	609,000

Project	Description	Total project estimate (as of February 2010)
27. SLSDC Facilities: Replace Windows and Doors and Repair Building Facades	This project is for replacing corroded/worn windows and doors and for repairing the brick and stone facades.	1,025,000
28. Snell Lock: Walls, Sills and Culverts: Rehabilitate Concrete	This project is to replace deteriorated/damaged concrete at Snell Lock along the lock walls, filling and emptying culverts, and the gate sills.	6,207,000
29. Eisenhower Lock: Walls, Sills and Culverts—Rehabilitate Concrete	This project is to replace deteriorated/damaged concrete at Eisenhower Lock along the lock walls, filling and emptying culverts, and the gate sills.	8,182,000
30. Eisenhower Lock: Ice Flushing System—Upgrade	This project was for making improvements to the Eisenhower Lock ice flushing system used to remove ice from the lock chamber. However, SLSDC addressed this need through improved preventive maintenance procedures and minor improvements to the current system, which eliminated the need for major upgrades. Therefore, the scope of the project under the ARP has been reduced.	0
31. Eisenhower and Snell Locks: Rehabilitate Upstream Miter Gates	This project is to completely rehabilitate the miter gates at the upstream ends of both locks. It includes replacing worn and/or damaged components to ensure proper functioning of the miter gates.	3,709,585
32. SLSDC Facilities: —Rehabilitate Spare Gate Storage and Assembly Area	This project is for rehabilitating the spare miter gate storage and assembly area. The work will include repair of the spare gate assembly pads and their supporting piles and blast cleaning and painting of the spare miter gates and gate assembly towers.	762,000
33. Eisenhower and Snell Locks: Upgrade Drainage Infrastructure in Galleries and Recesses	This project is to open existing drains or to drill new ones in the galleries and machinery recesses at both locks.	614,000
34. Eisenhower and Snell Locks: Improve Ice Control	This project is to improve the methods and equipment used to control ice in and around both locks during the opening and closing of each shipping season.	1,021,000
35. Vessel Mooring Cells: Rehabilitate and Extend	This project is for rehabilitating and extending the vessel mooring cells upstream of Eisenhower Lock and in the Intermediate Pool between the locks. These mooring cells are used by vessels to tie the ship to a fixed point while awaiting repairs or inspections.	3,186,000
36. Eisenhower Lock: Diffusers— Replace	This project is to replace deteriorated and damaged concrete in the diffusers at Eisenhower Lock. The diffusers are the outlet structures used to slow the flow of water when the lock is emptied.	3,045,000
37. Eisenhower Lock: Construct Drydock for Vessel Maintenance	This project is for constructing a drydock in Eisenhower Lock so that repairs to SLSDC's floating plant can be made on-site.	800,000
38. Eisenhower and Snell Locks: Upgrade/Replace Emergency Generators	This project is for replacing the 20-year-old emergency generators at both locks. The project will also transfer and install one of the generators removed from the locks at the Maintenance Facility.	1,018,000
39. Eisenhower and Snell Locks: Dewatering Pumps—Upgrade Outdated Equipment	This project is for replacing the 50-year-old pumps used for dewatering both locks.	407,000
40. Eisenhower and Snell Locks: Extend Guidewalls in Pool	This project is for extending the downstream guidewall at Eisenhower Lock and the upstream guidewall at Snell Lock.	3,076,000
41. Snell Lock: Install Ice Flushing System Technologies	This project is for installation of an ice flushing system at Snell Lock similar to the one at Eisenhower.	10,178,000
42. Eisenhower and Snell Locks: Miter Gates—Structural Rehabilitation	This project is to blast-clean and coat the upstream and downstream miter gates at both locks.	2,554,000
43. Eisenhower and Snell Locks: Miter Gate Machinery—Upgrade/Replace	This project is for replacing the 50-year-old operating machinery for the miter gates at both locks. The upgrade will include new hydraulic operating equipment to match the upgrades made at the Canadian Seaway locks and the other locks in the United States.	3,281,000

Project	Description	Total project estimate (as of February 2010)
44. Eisenhower and Snell Locks: Ship Arrestor Machinery—Upgrade/Replace	This project is for replacing the 50-year-old operating machinery for the ship arrestors at both locks. The ship arrestors protect the miter gates from damage that would be caused by a vessel that was unable to stop.	825,000
45. Flow Control Dikes—Rehabilitate	This project is for placing additional stone on the dikes downstream of Snell Lock to return them to their original design.	515,000
46. Eisenhower and Snell Locks: Guidewall Extensions—Rehabilitate	This project is to repair damage to the guidewall extensions located at the upstream end of Eisenhower Lock and at the downstream end of Snell Lock.	1,033,000
47. Eisenhower Lock: Vertical Lift Gate—Structural Rehabilitation	This project is for blast-cleaning and treating the vertical lift gate at Eisenhower Lock to prevent corrosion. The vertical lift gate is an emergency closure designed to be raised in the event a miter gate is compromised.	725,000
48. Eisenhower and Snell Locks: Stiffleg Derricks—Replace	This project is for replacing the structural components of the stiffleg derricks at both locks. The stiffleg derricks, located at each end of each lock, are hoisting devices used to place the temporary closure structures required for dewatering a lock for inspection and/or repair of the underwater components.	834,000
49. Seaway International Bridge—Replace Deck	This project is for rehabilitation of the deck of the south span of the Seaway International Bridge, which crosses the Seaway navigation channel and is jointly owned with Canada. SLSDC owns 68 percent of the south span of the bridge, and the budget request reflects the U.S. prorated amount for the project. Canada owns the remaining 32 percent of the south span.	14,225,000
50. Snell Lock: Diffusers—Replace	This project is to replace the deteriorated and damaged concrete in the diffusers at Snell Lock. The diffusers are the outlet structures used to slow the flow of water when the lock is emptied.	3,140,000
51. SLSDC Facilities: Upgrade Physical Security to Meet Homeland Security Presidential Directive 12 (HSPD-12) Requirements	This project is for procuring the Personal Identity Verification cards issued by the Department of Transportation and for acquiring and installing the required infrastructure to meet HSPD-12, which establishes a federal standard for secure and reliable forms of identification for access to federal facilities.	200,000
52. Eisenhower Lock: Visitors' Center—Replace	This project will replace the existing 50-year-old Visitors' Center at Eisenhower Lock with a new facility that will meet federal physical security and accessibility standards.	5,000,000
Engineering Design, Construction Inspection, Contracting Support, and Project Management	To accomplish all of the ARP projects, SLSDC will require additional engineering design support, construction inspectors to monitor and insure the quality of the work, and contracting specialists to handle the increase in contract work. This estimate is for fiscal year 2010 only. Similar costs for fiscal year 2009 (actual) and fiscal year 2011 and beyond (estimates) are included directly in the individual project estimates.	306,000
TOTAL		**$185,638,028**

Source: GAO analysis of SLSDC data.

Enclosure V: ARP Fiscal Year 2009 Contract Estimates and Awards

Table 5: ARP Fiscal Year 2009 Contracts Estimates Compared with Awards

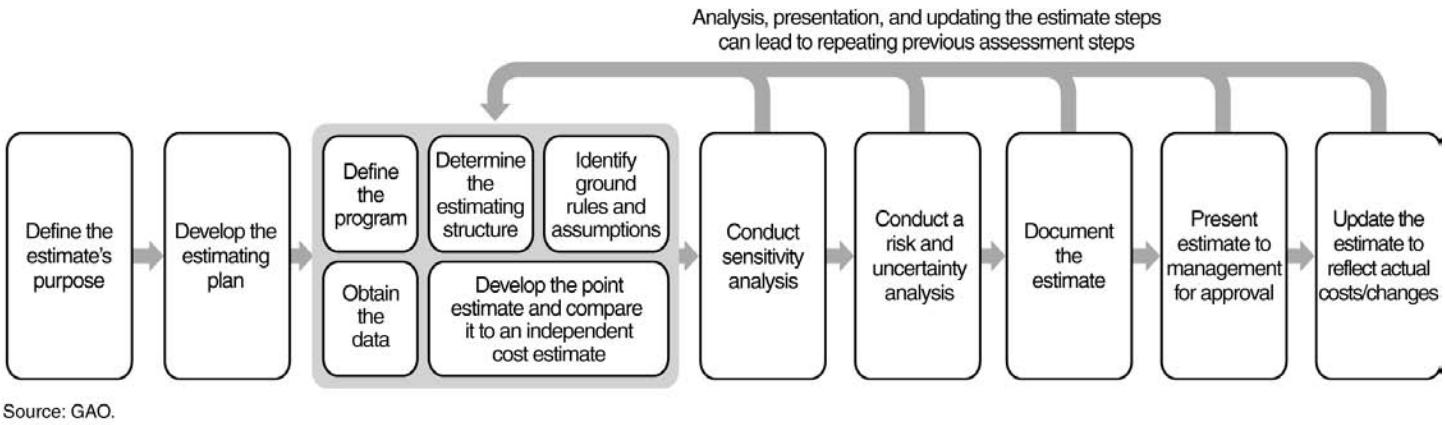
Fiscal year 2009 awarded contracts	Estimate used during contract solicitation	Initial contract award	Percent difference between estimate and award	ARP project number
1. Power supply infrastructure upgrade	$75,000	$19,594	-74%	10
2. Software for viewing and plotting hydrographic survey results	19,123	6,750	-65	12
3. Paving and drainage repairs at both locks—design	50,000	20,600	-59	3 & 14
4. Navigation channel dredging	6,400,000	3,690,700	-42	17
5. River bottom sediment sampling	80,000	46,918	-41	17
6. Paving at Visitors' Center parking lot	24,000	14,873	-38	3 & 14
7. Hydrographic survey equipment	16,421	10,890	-34	12
8. Pavement, mooring buttons, and drainage repairs and improvement at both locks	1,200,000	877,350	-27	3 & 14
9. Mower	16,000	12,216	-24	9
10. All-terrain crane	1,750,000	1,358,888	-22	9
11. Rubber fenders	300,000	241,600	-19	1
12. Rotary cutter	13,000	11,096	-15	9
13. Hydrographic survey equipment	42,550	38,396	-10	12
14. Hydrographic survey software	11,775	11,030	-6	12
15. Weather and visibility monitoring equipment	19,000	18,499	-3	16
16. Snowplow	90,869	89,162	-2	9
17. Dry dock buoy barge	225,000	221,182	-2	12
18. Beacon marking a known critical point to be picked up by a ship's radar for use during periods of limited visibility	33,050	32,389	-2	16
19. Weather and visibility monitoring equipment	19,000	18,531	-2	16
20. 27-foot hydrographic survey vessel (boat)	265,000	262,355	-1	12

Fiscal year 2009 awarded contracts	Estimate used during contract solicitation	Initial contract award	Percent difference between estimate and award	ARP project number
21. Grouting and lighting of highway tunnel—study	27,000	26,636	-1	15
22. Compressed air systems—study	20,000	19,704	-1	21
23. Culvert valve machinery—design	30,000	30,000	0	4
24. Culvert valve machinery—design	10,000	10,000	0	4
25. Lock roof cover upgrade/rehabilitation	29,400	29,400	0	5
26. Rehabilitation work on U.S. portion of the bridge	2,000,000	2,000,000	0	6
27. Snowplow	51,069	51,250	0	9
28. Weather- and visibility-monitoring equipment	14,190	14,190	0	16
29. Weatherproof enclosure for wind-monitoring equipment	5,460	5,460	0	16
30. Differential gauges	6,196	6,198	0	20
31. Marine lanterns for navigational aids	60,815	61,254	1	8
32. Steel and materials for lock roof cover upgrade/rehabiliation	12,900	13,467	4	5
33. Hydrographic survey equipment	7,120	7,700	8	12
34. Roofs on control houses at Snell Lock	85,000	91,419	8	13
35. Boston whaler (boat)	27,838	30,766	11	12
36. Container trailer	10,000	11,550	16	9
37. Tractor	24,000	30,808	28	9
38. Grouting at Snell Lock	40,000	53,215	33	24
39. Upgrade culvert valve operating machinery control for the north side valves at both locks	2,750,000	4,077,050	48	4
40. Rehabilitation of upstream miter gate at Eisenhower Lock	1,250,000	2,201,585	76	31
41. Inspection and pre- and postdredge surveys	200,000	541,829	171%	17
Total	**$17,310,776**	**16,316,500**		
Small purchase orders and modifications to contracts after initial award		**1,270,528**		
Final total fiscal year 2009 obligations		**$17,587,028**		

Source: GAO analysis of SLSDC data.

Enclosure VI: Cost-Estimating Best Practices

Figure 6: 12 Key Cost-Estimating Steps



Source: GAO.

Table 6: Four Characteristics of a High-Quality Cost Estimate with Their Corresponding 12 Key Cost-Estimating Steps

Characteristic	Step
Comprehensive	• Develop the estimating plan • Identify ground rules and assumptions[a] • Determine the estimating structure
Well-documented	• Define the estimate's purpose, scope, and schedule • Define the program • Identify ground rules and assumptions[a] • Obtain the data • Document the estimate • Present the estimate to management
Accurate	• Develop the point estimate and compare it with an independent cost estimate[b] • Update the estimate to reflect actual costs and changes
Credible	• Develop the point estimate and compare it with an independent cost estimate[b] • Conduct a sensitivity analysis • Conduct risk and uncertainty analysis

Source: GAO

[a]This step applies to two of the characteristics—comprehensive and well documented.

[b]This step applies to two of the characteristics—accuracy and credibility.

Enclosure VII: Assessment of Two Project Cost Estimates Reviewed

This enclosure provides the assessments of two SLSDC project cost estimates we reviewed in detail. Each assessment provides our analysis of the extent to which the project's cost-estimating processes and methodologies included the 12 key steps necessary for preparing high-quality estimates (see fig. 6), and some key examples of the rationale behind our analysis.

Assessment of ARP Project #4: Culvert Valve Operating Equipment, Phase 1

Project description: This is a two-phase project to replace the operating machinery for the Eisenhower and Snell Lock culvert valves, which are used for filling and emptying the locks. The upgrade will replace motors and gears—which have been maintained but not replaced or upgraded since their installation in the 1950s—with new hydraulic operating machinery to match the upgrades made at the Canadian Seaway locks and other similar locks in the United States. SLSDC contracted with the U.S. Army Corps of Engineers to develop the project's design and cost estimate.

The first phase of this project began in fiscal year 2009 when SLSDC awarded a contract to upgrade the operating machinery on the north side of both locks. Because of the long lead time needed to acquire the equipment, the actual work will be performed over the 3-month period of January to March 2011.

Final estimate (phase 1): $2.8 million

Actual award (phase 1): $4.1 million

Four characteristics of high-quality cost estimates and 12 key steps	Explanation	Overall assessment (fully met/substantially met/partially met/minimally met/not met)[a]	Key examples of rationale for assessment
Comprehensive		**Partially met**	
• Develop the estimating plan	The cost-estimating team should develop a written study plan that (1) determines the estimating team's composition and whether the team is from a centralized office, (2) identifies which subject matter experts the team will rely on for information, (3) outlines the estimating approach, and (4) identifies a master schedule for completing the estimate that provides adequate time to do the work.	Minimally met	The contractor responsible for creating the estimate has a centralized cost-estimating department that specializes in marine equipment. However, SLSDC did not specify details or requirements for the cost estimate or identify any necessary guidance or policy to be followed. In addition, a written study plan and schedule of specific tasks were not developed, and therefore, responsibilities were not clearly defined and due dates were not established.

• Determine the estimating structure	There should be a defined work breakdown structure (WBS) and/or a cost element structure. The WBS should be product-oriented, traceable to the statement of work, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted. A WBS dictionary should be developed that defines what is included in each element and how it relates to other elements in the hierarchy.	Partially met	The cost estimate defined the work in detail and for each cost category, the estimate clearly describes how most of the various cost elements are summed, thereby ensuring that no costs are double-counted. However, because the estimate does not specifically break out costs common for most projects, such as testing, training, or government equipment costs, we cannot verify that the estimate includes all relevant costs of the project. In addition, the estimate was task-oriented, rather than product-oriented. A product-oriented work breakdown structure allows a program manager to more precisely identify which components are causing cost or schedule overruns and to more effectively mitigate the root causes of overruns.
• Identify ground rules and assumptions	Ground rules and assumptions should document the rationale and any historical data to back up any claims. Risks that are associated with any assumptions should be identified and traced to specific WBS elements. Budget constraints, as well as the effect of delaying program content, should be defined. Inflation indexes and their source should be identified, and if items are excluded from the estimate, they should be documented and explained.	Partially met	The cost estimate documentation provides for basic assumptions underlying the estimate; however, some assumptions are not fully documented. Key global assumptions about the project were not taken into account because they were not discussed between SLSDC and its contractor. For example, several risks, including confined working spaces, ice, and freezing conditions, which could cause a delay in the schedule, were not accounted for in the cost estimate.
Well documented		**Substantially met**	
• Define the estimate's purpose	The purpose and scope of the cost estimate should be defined and documented. The level of detail in the cost estimate should be consistent with the level of detail available for the program, and all applicable costs should be estimated, including life cycle costs.	Fully met	The purpose and scope of the cost estimate is documented and clearly defined in the statement of work at a level that would enable SLSDC to submit a quality cost estimate.
• Define the program characteristics	There should be a documented technical baseline description that is contained in a single document. The technical baseline description should include requirements, purpose, technical characteristics, development plan, acquisition strategy, operational plan, and risk.	Fully met	A technical baseline has been documented that includes, among other things, requirements, purpose, and design features. The cost estimate is based upon the final drawings and specifications.
• Identify ground rules and assumptions	Ground rules and assumptions should document the rationale and any historical data to back up any claims. Risks that are associated with any assumptions should be identified and traced to specific WBS elements. Budget constraints, as well as the effect of delaying program content, should be defined. Inflation indexes and their source should be identified, and if items are excluded from the estimate, they should be documented and explained.	Partially met	The cost estimate documentation provides for basic assumptions underlying the estimate, such as inflation; however, some assumptions are not fully documented. Key global assumptions about the project were not taken into account because they were not discussed between SLSDC and its contractor. For example, several risks, including confined working spaces, ice, and freezing conditions, which could cause a delay in the schedule, were not accounted for in the cost estimate.
• Obtain the data	The data should be gathered from valid historical actual cost, schedule, and program and technical sources. The data should apply to the program being estimated and should be analyzed for cost drivers. Data should be collected from primary sources and adequately documented. Analysts should meet with the data sources to better understand the program, and data should be reviewed and benchmarked against historical data for reasonableness.	Substantially met	The final cost estimate is based partially on the preliminary cost estimate from 2002, adjusted to current year dollars. The 2002 estimate incorporated data on similar historical projects, local labor rates, vendor quotes, and estimator experience to develop the estimate. However, estimators did not adjust the historical data to reflect the increased labor costs required to complete the project during the compressed timeline of the winter shutdown period, which limited the usefulness of these data.

• Document the estimate	Documentation should describe the cost-estimating process, data sources, and methods step by step so that a cost analyst unfamiliar with the program can understand what was done and replicate it. The documentation should include ground rules and assumptions, descriptions of methodologies, and sensitivity and risk and uncertainty analysis results broken out by cost element. Management approval and updates that reflect actual costs or changes should be included.	Substantially met	The documentation of the final cost estimate includes detailed materials for estimated labor, equipment, contingency, and bond requirements, which allows management to clearly see how the total cost of the project is calculated. However, the cost estimate documentation does not trace all estimates to raw or normalized data. For example, the documentation does not provide a basis or supporting data for included quantities, equipment, or contingency that would allow an analyst unfamiliar with the project to recreate them.
• Present the estimate to management	Management should be presented with a clear explanation of the cost estimate so as to convey its level of competence. The presentation should illustrate the largest cost drivers, an overview of the program's technical foundation and objectives, a discussion of ground rules and assumptions, cost-estimating methodologies for each cost element, and the results from the sensitivity and risk and uncertainty analyses. Feedback from the briefing, including management's acceptance of the estimate, should be acted upon and recorded in the cost estimate documentation.	Minimally met	While the estimate was approved by SLSDC management, it was not presented to SLSDC management in a clear and concise way. For example, while SLSDC officials stated that the estimate was reviewed for completeness and reasonableness of assumptions, the estimate provided did not clearly convey whether or not all costs were properly captured, all risks were properly considered, and underlying assumptions were valid.
Accurate		**Substantially met**	
• Develop the point estimate and compare with an independent cost estimate	The cost estimator should consider various cost-estimating methods, like analogy, engineering buildup, parametric, and extrapolating from actual costs. The point estimate should be developed by aggregating the WBS cost estimates, and results should be checked for accuracy, double counting, and omissions. The point estimate results should be validated with cross-checks and an independent cost estimate.	Substantially met	The cost estimate is based on a detailed buildup of estimated labor and material prices, but was not cross-checked against an independent cost estimate to ensure accuracy and minimize double counting and omissions.
• Update the estimate to reflect actual costs and changes	There should be a process for the estimating team to update the estimate with actual costs as they become available. The estimate should reflect changes in technical or program assumptions. Finally, the estimate should discuss lessons learned for elements whose actual costs or schedules differed from those of the estimate.	Substantially met	SLSDC updated both the current and future phases of the project cost estimate with fiscal year 2009 award data; however, because the project is not yet complete, SLSDC cannot update the estimate with actual incurred costs or lessons learned.
Credible		**Minimally met**	
• Develop the point estimate and compare to an independent cost estimate	The cost estimator should consider various cost-estimating methods like analogy, engineering buildup, parametric, and extrapolating from actual costs. The point estimate should be developed by aggregating the WBS cost estimates. The point estimate results should be cross-checked against an independent cost estimate to ensure that different estimating approaches would produce similar results.	Substantially met	The cost estimate is based on a detailed buildup of estimated labor and material prices, but was not cross-checked against an independent cost estimate to ensure that different estimating approaches would produce similar results. Comparing the cost estimate against an independent cost estimate would allow SLSDC to examine where and why there are differences in key cost drivers.
• Conduct a sensitivity analysis	The cost estimate should include a sensitivity analysis that identifies a range of possible costs from changing key cost driver assumptions or factors.	Not met	A sensitivity analysis was not performed on the estimate, and therefore, decision makers were not fully aware of how changes to assumptions or key cost drivers (such as labor or equipment) could affect the estimate. For example, a sensitivity analysis could have provided decision makers with information on how premium pay rates would affect the estimate.

•	Conduct risk and uncertainty analysis	A risk and uncertainty analysis should be conducted that quantifies the risks and identifies the effects of changing key cost driver assumptions and factors. The probability associated with the point estimate should be identified, and contingency reserves should be recommended for achieving the desired confidence level. Finally, a risk management plan should be implemented jointly with the contractor to identify and analyze risk, plan for risk mitigation, and continually track risk.	Not met	A risk and uncertainty analysis was not performed on the estimate and therefore the estimate did not reflect the degree of uncertainty, and decision makers had no insight into the level of confidence associated with it. SLSDC officials stated that they did not request that their contractor perform an uncertainty analysis, despite the project risk involved in completing the project under a compressed schedule.

Source: GAO analysis of SLSDC data.

[a]The ratings we used in this analysis are as follows: "Fully met" means that the agency provided complete evidence that satisfies the entire criterion; "Substantially met" means that the agency provided evidence that satisfies a large portion of the criterion; "Partially met" means that the agency provided evidence that satisfies about half of the criterion; "Minimally met" means that the agency provided evidence that satisfies a small portion of the criterion; and "Not met" means that the agency provided no evidence that satisfies any part of the criterion.

Assessment of ARP Project #31: Rehabilitate Upstream Miter Gates, Phase 1

Project description: This is a two-phase project to rehabilitate the miter gates at the upstream ends of both Eisenhower and Snell Locks. The project will replace worn and/or damaged components to ensure proper functioning of the miter gates.

The first phase of this project began in fiscal year 2009 when SLSDC awarded a contract to rehabilitate the upstream gate at Eisenhower Lock. Because of the long lead time needed to acquire gate components, the actual work will be performed over the 3-month period of January to March 2011.

Final estimate (phase 1): $1.3 million

Award amount (phase 1): $2.2 million

Four characteristics of high-quality cost estimates and 12 key steps	Explanation	Overall assessment (Fully met/Substantially met/Partially met/Minimally met/Not met)[a]	Key examples of rationale for assessment
Comprehensive		**Minimally met**	
• Develop the estimating plan	The cost-estimating team should develop a written study plan that (1) determines the estimating team's composition and whether the team is from a centralized office, (2) identifies which subject matter experts the team will rely on for information, (3) outlines the estimating approach, and (4) identifies a master schedule for completing the estimate that provides adequate time to do the work.	Minimally met	While the cost estimators were from a centralized team that specializes in marine equipment, SLSDC did not develop a written study plan or a schedule of specific tasks, clearly define responsibilities, or identify due dates for key tasks.
• Determine the estimating structure	There should be a defined work breakdown structure (WBS) and/or a cost element structure. The WBS should be product-oriented, traceable to the statement of work, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted. A WBS dictionary should be developed that defines what is included in each element and how it relates to other elements in the hierarchy.	Not met	The cost estimate does not define the work in detail nor does it provide a framework for planning and assigning the work down to an appropriate level of detail. A product-oriented structure allows a program manager to more precisely identify which components are causing cost or schedule overruns and to more effectively mitigate the root cause of overruns.
• Identify ground rules and assumptions	Ground rules and assumptions should document the rationale and any historical data to back up any claims. Risks that are associated with any assumptions should be identified and traced to specific WBS elements. Budget constraints, as well as the effect of delaying program content, should be defined. Inflation indexes and their source should be identified, and if items are excluded from the estimate, they should be documented and explained.	Partially met	Basic cost-influencing ground rules and assumptions, such as labor rates, and inflation rates, were documented. However, the cost estimate did not reflect (1) the compressed time frame required to complete the work during the winter shutdown and penalties for not completing the work on time and (2) the risks associated with performing the effort in the winter (ice and freezing conditions).
Well documented		**Partially met**	
• Define the estimate's purpose	The purpose and scope of the cost estimate should be defined and documented. The level of detail in the cost estimate should be consistent with the level of detail available for the program, and all applicable costs should be estimated, including life cycle costs.	Fully met	The purpose of the cost estimate is documented at a level that would enable SLSDC to submit a high-quality cost estimate.

Four characteristics of high-quality cost estimates and 12 key steps	Explanation	Overall assessment (Fully met/Substantially met/Partially met/Minimally met/Not met)[a]	Key examples of rationale for assessment
• Define the program characteristics	There should be a documented technical baseline description that is contained in a single document. The technical baseline description should include requirements, purpose, technical characteristics, development plan, acquisition strategy, operational plan, and risk.	Partially met	The cost estimate and the technical design are based on a similar Canadian project, and adjusted based on SLSDC's requirements. However, when the cost estimate was prepared, the technical baseline description was only 35 percent complete. The accuracy of a cost estimate depends on a well-defined program. In the absence of fully defined requirements, more assumptions must be made, increasing the risk associated with the estimate.
• Identify ground rules and assumptions	Ground rules and assumptions should document the rationale and any historical data to back up any claims. Risks that are associated with any assumptions should be identified and traced to specific WBS elements. Budget constraints, as well as the effect of delaying program content, should be defined. Inflation indexes and their source should be identified, and if items are excluded from the estimate, they should be documented and explained.	Partially met	Basic cost-influencing ground rules and assumptions, such as labor rates, and inflation rates, were documented. However, the cost estimate did not reflect (1) the compressed time frame required to complete the work during the winter shutdown and penalties for not completing the work on time and (2) the risks associated with performing the effort in the winter (ice and freezing conditions).
• Obtain the data	The data should be gathered from valid historical actual cost, schedule, and program and technical sources. The data should apply to the program being estimated and should be analyzed for cost drivers. Data should be collected from primary sources and adequately documented. Analysts should meet with the data sources to better understand the program, and data should be reviewed and benchmarked against historical data for reasonableness.	Partially met	The cost estimate was based on a 2005 Canadian project, as well as expert knowledge from SLSDC in-house engineers. However, the Canadian project information was from a contractor's bid and not from actual costs of the completed project. In addition, SLSDC had equipment requirements that differed from those of the Canadian project and that SLSDC did not account for in its estimate.
• Document the estimate	Documentation should describe the cost-estimating process, data sources, and methods step by step so that a cost analyst unfamiliar with the program can understand what was done and replicate it. The documentation should include ground rules and assumptions, descriptions of methodologies, and sensitivity and risk and uncertainty analysis results broken out by WBS cost element. Management approval and updates that reflect actual costs or changes should be included.	Minimally met	The cost estimate documentation did not provide detailed material and labor cost information that would allow someone unfamiliar with the project to recreate it. Without thorough documentation, a cost estimate cannot be properly validated or defended. Well-documented estimates may also contribute to the collection of cost and technical data that could be used to support the cost estimates of future Seaway projects.
• Present the estimate to management	Management should be presented with a clear explanation of the cost estimate so as to convey its level of competence. The presentation should illustrate the largest cost drivers, an overview of the program's technical foundation and objectives, a discussion of ground rules and assumptions, cost-estimating methodologies for each WBS, and the results from the sensitivity and risk and uncertainty analyses. Feedback from the briefing, including management's acceptance of the estimate, should be acted upon and recorded in the cost estimate documentation.	Minimally met	While the estimate was approved by SLSDC management, the estimate did not provide enough detail to easily defend the estimate by showing how it is accurate, complete, and high in quality. SLSDC officials stated that the estimate was not reviewed in detail because the majority of the effort was used to review technical specifications for the miter gates. Without a thorough management review, SLSDC cannot ensure that the cost estimate properly captures all of the costs and risks associated with the project.

Four characteristics of high-quality cost estimates and 12 key steps	Explanation	Overall assessment (Fully met/Substantially met/Partially met/Minimally met/Not met)[a]	Key examples of rationale for assessment
Accurate		**Partially met**	
• Develop the point estimate and compare with an independent cost estimate	The cost estimator should consider various cost-estimating methods like analogy, engineering buildup, parametric, and extrapolating from actual costs. The point estimate should be developed by aggregating the WBS cost estimates and results should be cross-checked for accuracy, double counting, and omissions. The point estimate results should be validated with cross-checks and an independent cost estimate.	Partially met	The cost estimate is based on a similar Canadian project, and SLSDC engineers applied professional judgment and experience to adjust the estimate to reflect the requirements of the project. However, the estimate was based on a project bid, adjusted with a rule-of-thumb factor, rather than actual costs, and the estimate was not based on a detailed buildup of individual cost elements. In addition, the estimate was not cross-checked against an independent cost estimate to ensure accuracy and minimize double counting and omissions.
• Update the estimate to reflect actual costs and changes	There should be a process for the estimating team to update the estimate with actual costs as they become available. The estimate should reflect changes in technical or program assumptions. Finally, the estimate should discuss lessons learned for elements whose actual costs or schedules differed from those of the estimate.	Substantially met	SLSDC updated both the current and future phases of the project cost estimate with 2009 award data. However, because the project is not yet complete, SLSDC cannot update the estimate with actual incurred costs or lessons learned.
Credible		**Minimally met**	
• Develop the point estimate and compare to an independent cost estimate	The cost estimator should consider various cost-estimating methods like analogy, engineering buildup, parametric, and extrapolating from actual costs. The point estimate should be developed by aggregating the WBS cost estimates. The point estimate results should be cross-checked against an independent cost estimate to ensure that different estimating approaches would produce similar results.	Partially met	The cost estimate is based on a similar Canadian project, and SLSDC engineers applied professional judgment and experience to adjust the estimate to reflect the requirements of the project. However, the estimate was based on a project bid, adjusted with a rule-of-thumb factor, rather than actual costs, and the estimate was not based on a detailed buildup of individual cost elements. In addition, the project estimate was not cross-checked against an independent cost estimate to ensure that different estimating approaches would produce similar results. Comparing the cost estimate against an independent cost estimate would allow SLSDC to examine where and why there are differences in key cost drivers.
• Conduct a sensitivity analysis	The cost estimate should include a sensitivity analysis that identifies a range of possible costs from changing key cost driver assumptions or factors.	Not met	A sensitivity analysis was not performed on the estimate, and therefore, decision makers were not fully aware of how changes to assumptions or key cost drivers (such as labor or equipment) could affect the estimate. For example, a sensitivity analysis could have provided decision makers with information on how premium pay rates would affect the estimate.

Four characteristics of high-quality cost estimates and 12 key steps	Explanation	Overall assessment (Fully met/Substantially met/Partially met/Minimally met/Not met)[a]	Key examples of rationale for assessment
• Conduct risk and uncertainty analysis	A risk and uncertainty analysis should be conducted that quantifies the risks and identifies the effects of changing key cost driver assumptions and factors. The probability associated with the point estimate should be identified, and contingency reserves should be recommended for achieving the desired confidence level. Finally, a risk management plan should be implemented jointly with the contractor to identify and analyze risk, plan for risk mitigation, and continually track risk.	Not met	A risk and uncertainty analysis was not performed on the estimate, and therefore the estimate did not reflect the degree of uncertainty and decision makers had no insight into the level of confidence associated with it. SLSDC officials stated that despite the project risk involved in completing the project under a compressed schedule, they did not conduct a risk and uncertainty analysis because such an analysis is not a part of their estimating process.

Source: GAO analysis of SLSDC data.

[a]The ratings we used in this analysis are as follows: "Fully met" means that the agency provided complete evidence that satisfies the entire criterion; "Substantially met" means that the agency provided evidence that satisfies a large portion of the criterion; "Partially met" means that the agency provided evidence that satisfies about half of the criterion; "Minimally met" means that the agency provided evidence that satisfies a small portion of the criterion; and "Not met" means that the agency provided no evidence that satisfies any part of the criterion.