Gate Hoist Replacement Study

Findley Ryther Dam

Report prepared for

Macon-Bibb County

Report prepared by

Mead & Hunt

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List of Contributors

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Executive Summary

The existing electrically-driven hoists at the Findley Ryther Dam (Project) are undersized and can no longer reliably operate the Project's tainter gates. Furthermore, the existing hoist gear boxes are more than 50 years old and their already inadequate lifting capacity will continue to diminish as they age. As such, the existing hoists will need to be replaced to provide for safe, reliable operation of the Project's tainter gates.

Macon-Bibb County (MBC) retained Mead & Hunt, Inc. (Mead & Hunt) to evaluate alternatives for replacing the Project's existing gate hoists. The following alternatives were considered:

- **Alternative No. 1** – Replacement of the existing hoists with new electric hoists in the same location. The current gate hoist configuration, including the balance arm system, would be maintained.

- **Alternative No. 2** – Retirement of the balance arm system and replacement of the existing hoists with new, larger electric hoists at the same location.

- **Alternative No. 3** – Retirement of the balance arm system and replacement of the existing hoists with new, larger electric hoists that lift the gates from the point where the balance arms are currently connected to the gate arm assemblies.

It is our opinion that Alternative No. 2 presents the best overall solution for addressing the Project's gate operational issues primarily because it is substantially less expensive than Alternative No. 3, it reduces MCB's risk exposure significantly more than Alternative No. 1 by replacing the historically unpredictable and unreliable balance arm system with a more conventional hoist system, and it is not prohibitively more expensive than Alternative No. 1.

We recommend that MBC move forward with final design of Alternative No. 2, which would involve retirement of the existing balance arm system and replacement of the existing 20-ton hoists with larger, electrically-driven hoists at the same location.

1. Introduction

A. Project description

The Project is located approximately 10 miles west of the city of Macon in Bibb County, Georgia. The Project lies along Tobesofkee Creek and impounds Lake Tobesofkee, which is used for recreational purposes. The Project's water-retaining structures consist of two earth embankments and a reinforced concrete gated spillway structure with two 43-foot-high by 40-foot-wide steel tainter gates. The Project, which is under the jurisdiction of the Natural Resources Conservation Service (NRCS) and is classified as a high hazard dam, is owned and operated by MBC.

B. Purpose of study

The existing gate configuration includes balance arms and an integral counterweight (hereafter referred to as the balance arm system) that was originally intended to be used in combination with a second counterweight and associated buoyancy chamber system to limit the required hoist capacity for gate operation. It is our understanding that operations become unpredictable and the buoyancy chambers were retired. Gates started to open unexpectedly and would not close until a significant amount of the reservoir had been drained. MBC attempted to address these issues by welding steel plates to the bottom girder of the skin plate assemblies to increase the gate weight. MBC also modified the original gate hoists to increase their lifting capacity such that they could reliably operate the heavier gates, something that proved to be difficult.

While the modifications discussed above improved the predictability of gate operations, we understand that a gate has opened unexpectedly on at least one occasion since the ballast plates were added to the bottom of the gates. This prompted MBC to weld additional steel plates to the bottom girder of both gates. Our preliminary calculations indicate that the current lifting load is approximately equal to the rated capacity of the existing 20-ton hoist system (see Appendix A). It is common industry practice to oversize the rated capacity of gate hoists by 15 to 20 percent to ensure reliable gate operation. By this measure, the existing electrically-driven hoists are undersized and can no longer reliably operate the gates because of the weight added. The existing hoist gear boxes are more than 50 years old and their already inadequate lifting capacity will continue to diminish as they age. As such, the existing hoists will need to be replaced to provide for safe, reliable operation of the Project's tainter gates.

MBC retained Mead & Hunt to evaluate alternatives for replacing the Project's existing gate hoists and provide budgetary estimates for engineering and construction for each alternative. The following alternatives were considered:

- **Alternative No. 1** – Replacement of the existing hoists with new electric hoists in the same location. The current gate hoist configuration, including the balance arm system, would be maintained.
- **Alternative No. 2** – Retirement of the balance arm system and replacement of the existing hoists with new, larger electric hoists at the same location.
- **Alternative No. 3** – Retirement of the balance arm system and replacement of the existing hoists with new, larger electric hoists that lift the gates from the point where the balance arms are currently connected to the gate arm assemblies.

2. Alternatives Analysis

A. Alternative No. 1

(1) Description

The existing hoists would be replaced with new electrically-driven hoists in the same location. The new hoists would have a greater lifting capacity than the existing hoists to allow them to reliably lift the gates, which are heavier than originally designed due to the ballast weight that has been added. The current gate hoist configuration, including the balance arm system, would be maintained. The steel ballast plates welded to the bottom girders of the skin plate assemblies would also be left in place.

(2) Work required

The following is a summary of the work that may be required if this alternative were to be selected:

- The new hoists would need to be designed to have a greater lifting capacity than the existing 20-ton hoists. Based on our preliminary calculations (see Appendix A), we anticipate that the rated capacity required for the new hoists would be 25 tons. As a result of the increased hoist capacity, new lifting cables and structural modifications to the lifting cable connections, bottom horizontal girder, skin plate, vertical skin plate ribs, and the bottom of the gate may be required. While less likely, it is possible that structural modifications to the remaining horizontal girders, vertical girders, and gate arm assemblies may also be required. The required gate modifications are likely to be less substantial than those for Alternative No. 2 because lifting cable loads will be lower for Alternative No. 1.

- The existing concrete hoist supports at the left/right abutments and center pier would need to be modified to provide full bearing support for the new hoists. However, it is unlikely that structural modifications would be necessary for the abutments and center pier themselves.

- We understand that a stress analysis has not been performed for the Project's tainter gates. A stress analysis of these types of hydraulic steel structures is widely considered to be a best practice within the dam safety industry. It is our opinion that a stress analysis should be performed to evaluate the structural adequacy of the gates for this alternative because the increased lifting capacity of the new gate hoist configuration would result in increased stresses in the gate that were not accounted for in the original design.

- As discussed in Section 1.B, a gate has opened unexpectedly on at least one occasion since the first set of steel ballast plates was installed. This prompted MBC to weld additional ballast plates to the bottom girder of both gates. We understand that a gate has not opened unexpectedly since the second set of ballast plates was installed. However, there is no way to know how close the gates currently are to opening unexpectedly or what combination of conditions may cause them to open unexpectedly. As a result, it is our opinion that an extensive on-site instrumentation and testing program, as well as a detailed structural analysis of the gates under a wide range of operating conditions, would be required for both gates to reduce these uncertainties. This would be required at the start of final design to determine static and operating loads and after construction to confirm that the design intent has been achieved.

(3) Cost

Of the three alternatives evaluated, Alternative No. 1 had lowest total estimated cost ($1,860,000) and is approximately 12 percent cheaper than Alternative No. 2 ($2,090,000). However, the costs associated with engineering of this alternative are significantly higher than for the other two alternatives because it maintains use of the existing balance arm system, which has historically proven to be unreliable. For this reason, MBC may find it difficult to obtain NRCS approval of Alternative No. 1. Furthermore, our budgetary cost estimate does not include ongoing costs for maintenance of the balance arm system, which would be required for continued reliable operation. Budgetary cost estimates for each alternative are provided in Appendix B.

B. Alternative No. 2

(1) Description

The existing hoists would be replaced with new electrically-driven hoists in the same location. The new hoists would have a greater lifting capacity than those associated with Alternative No. 1. The current gate hoist configuration, including the balance arm system, would be retired. The steel ballast plates welded to the bottom girders of the skin plate assemblies would be removed.

(2) Work required

The following is a summary of the work that may be required if this alternative were to be selected:

- The new hoists would need to be designed to have a greater lifting capacity than the existing 20-ton hoists. Based on our preliminary calculations (see Appendix A), we anticipate that the rated capacity required for the new hoists would be 70 tons. As a result, new lifting cables and structural modifications to the lifting cable connections, bottom horizontal girder, skin plate, vertical skin plate ribs, and the bottom of the gate may be required. While less likely, it is possible that structural modifications to the remaining horizontal girders, vertical girders, and gate arm assemblies may also be required. The required gate modifications are likely to be more substantial than those for Alternative No. 1 because the lifting cable loads will be greater for Alternative No. 2.

- The existing concrete hoist supports at the left/right abutments and center pier would need to be modified to provide full bearing support for the new hoists. It is unlikely that structural modifications would be necessary for the abutments and center pier themselves. The civil modifications for Alternative No. 2 are likely to be more extensive than for Alternative No. 1 because of the increased hoist size.

- We understand that a stress analysis has not been performed for the Project's tainter gates. A stress analysis of these types of hydraulic steel structures is widely considered to be a best practice within the dam safety industry. It is our opinion that a stress analysis should be performed to evaluate the structural adequacy of the gates for this alternative because the gate hoist configuration would be significantly different than the original design intent.

- The existing balance arm system would need to be retired. It may be possible to accomplish this by dewatering the gate and using the existing hoist to lower the downstream end of the balance arm until the counterweight is within approximately 10 feet of the abutments and center pier, at which point it could be stabilized in place. Alternatively, the balance arm systems could be removed from the Project in their entirety. Final design of Alternative No. 2 would need to consider cost, structural stability, maintenance requirements, and whether the counterweight would be an impediment during passage of flood flows if the balance arm system were to be retired in place.

- The steel ballast plates welded to the bottom girder of the skin plate assemblies would be removed to limit the required lifting capacity of the new hoists to the extent possible. Portions of the bottom girder's protective paint coating would need to be repaired after removal of the ballast plates.

- It is our opinion that an extensive on-site instrumentation and testing program would not be required for Alternative No. 2 because the historically unpredictable and unreliable balance arm system would be retired. The less complex gate hoist configuration associated with Alternative No. 2 would allow it to be adequately modeled without the benefit of on-site testing data.

(3) Cost

Of the three alternatives evaluated, Alternative No. 2 had second lowest total estimated cost ($2,090,000). It is approximately 12 percent more expensive than Alternative No. 1 ($1,860,000) and significantly cheaper than Alternative No. 3 ($2,990,000). The costs associated with engineering of this alternative are significantly lower than Alternative No. 1 because the existing unreliable balance arm system would be retired. This alternative utilizes a conventional tainter gate hoist system. For this reason, MBC will likely experience significantly less difficulty in obtaining NRCS approval of Alternative No. 2. Furthermore, ongoing maintenance costs, which were not included in our budgetary cost estimates, would be less for Alternative No. 2 than for Alternative No. 1 due to retirement of the balance arm system. Budgetary cost estimates for each alternative are provided in Appendix B.

C. Alternative No. 3

(1) Description

The existing hoists would be replaced with new, larger electric hoists that lift the gates from the point where the balance arms are currently connected to the gate arm assemblies. The new hoists would have a greater lifting capacity than those associated with Alternative Nos. 1 and 2. The current gate hoist configuration, including the balance arm system, would be retired. The steel ballast plates welded to the bottom girders of the skin plate assemblies would be removed.

(2) Work required

The following is a summary of the work that may be required if this alternative were to be selected:

- The hoist configuration associated with this alternative would result in the skin plate assemblies, which account for most of the gate weight, cantilevering out from the new gate-lifting point on the gate arm assemblies. As a result, the new hoists and lifting cables would need to be designed to have a greater lifting capacity than Alternative Nos. 1 and 2. Based on our preliminary calculations (see Appendix A), we anticipate that the rated capacity required for the new hoists would be 120 tons. The existing lifting points on the gate arm assemblies would need to be modified to allow the new lifting cables to be attached to the gate at these locations. Furthermore, this hoist configuration would result in increased stresses in the gate arm assemblies at and upstream of the new lifting points. Structural modifications to the gate arm assemblies may be required to accommodate the increased stresses associated with the new gate hoist configuration. While less likely, it is possible that structural modifications to the horizontal and vertical girders may also be required. The required gate modifications for this alternative are likely to be more substantial than those for Alternative Nos. 1 and 2.

- The center of the new lifting point on the gate arm assemblies would be approximately 4.75 feet from the face of the abutments and center pier. This is significantly further than the lifting points for the existing hoists, which are approximately one foot from the wall face. As a result, considerable structural modifications would be necessary to support the new hoists on the existing civil structures. Furthermore, the projection of the new hoists into the gate bay may interfere with the gate arm assemblies and/or retired balance arms, which could prevent the gates from being opened as far as they can be currently.

- We understand that a stress analysis has not been performed for the Project’s tainter gates. A stress analysis of these types of hydraulic steel structures is widely considered to be a best practice within the dam safety industry. It is our opinion that a stress analysis should be performed to evaluate the structural adequacy of the gates for this alternative because the gate hoist configuration would be significantly different than the original design intent.

- The existing balance arm system would need to be retired. It may be possible to accomplish this by dewatering the gate and using the existing hoist to lower the downstream end of the balance arm until the counterweight is within approximately 10 feet of the abutments and center pier, at which point it could be stabilized in place. Alternatively, the balance arm systems could be removed from the Project in their entirety. Final design of Alternative No. 3 would need to consider cost, structural stability, maintenance requirements, and whether the counterweight would be an impediment during gate operation and/or passage of flood flows if the balance arm system were to be retired in place.

- The steel ballast plates welded to the bottom girder of the skin plate assemblies would be removed to limit the required lifting capacity of the new hoists to the extent possible. Portions of the bottom girder's protective paint coating would need to be repaired after removal of the ballast plates.

- It is our opinion that an extensive on-site instrumentation and testing program would not be required for Alternative No. 3 because the historically unpredictable and unreliable balance arm system would be retired. The less complex gate hoist configuration associated with Alternative No. 3 would allow it to be adequately modeled without the benefit of on-site testing data.

(3) Cost

Of the three alternatives evaluated, Alternative No. 3 had highest total estimated cost ($2,990,000) by a wide margin. This alternative utilizes an unconventional tainter gate hoist configuration. For this reason, MBC may find it difficult to obtain NRCS approval of Alternative No. 3. Budgetary cost estimates for each alternative are provided in Appendix B.

D. Comparison of alternatives

A tabular side-by-side comparison of all three gate hoist replacement alternatives evaluated with respect to various considerations is presented in Appendix C. This table includes separate columns for evaluation of the following considerations:

- Extent of gate and civil structure modifications
- Operations
- Maintenance
- Dam safety/NRCS approval
- Risk
- Cost

3. Conclusions and Recommendations

Alternative No. 3 is clearly not the most favorable approach because it is substantially more expensive that the other two alternatives evaluated, does not eliminate MBC's exposure to the risks associated with unconventional gate operating configurations, and is likely to be more difficult to obtain NRCS approval of than Alternative No. 2.

Alternative No. 1 has the lowest total estimated cost. However, a significant drawback of this alternative is that it maintains the existing balance arm system. This system has historically resulted in unpredictable and unreliable gate operation, which presents a major risk to MBC. Furthermore, the up-front engineering costs associated with Alternative No. 1 are substantially greater than the other two alternatives and the NRCS may be reluctant to approve a design that utilizes the existing balance arm system. This exposes MBC to additional risk because there would be no way to know whether Alternative No. 1 is likely to be acceptable to the NRCS until a significant investment in engineering has been made.

Alternative No. 2 reduces MCB's risk exposure more than the other two alternatives evaluated by replacing the historically unpredictable and unreliable balance arm system with a proven, conventional gate hoist system. The design of this alternative is much more straight-forward that Alternative No. 1 and the NRCS is likely to look favorably on this solution because it is consistent with the types of gate hoist systems they are familiar with. While it is more expensive than Alternative No. 1, the additional cost associated with Alternative No. 2 is not prohibitive when considering risk mitigation and future maintenance.

It is our opinion that Alternative No. 2 presents the best overall solution for addressing the Project's gate operational issues. We recommend that MBC move forward with final design of this alternative, which would involve retirement of the existing balance arm system and replacement of the existing 20-ton hoists with larger, electrically-driven hoists at the same location.

Appendix A. Preliminary Hoist Load Computations

Determination of Hoist Lifting Loads

Cases Evaluated:

1) *Maintain Current Configuration* - Replace hoist maintaining current configuration and include 15 weights, which were added June 2015 (see email dated 9/12/17).

2) *Counterweight Retirement w/ Hoist in current location* - Retirement of current hoist configuration (counterweight & balance arm) and replacement of the exising electric hoists at the same location.

3) *Counterweight retirement w/ Hoist in new location* - Retirement of the current hoist configuration (counterweight and balance arm) and replacement of the exsting hoists with new, larger hoists that lift the gates from the point where the balance arms are currently connected to the gate.

References:

Determination of approximate hoist load calculations for existing conditions, Mead & Hunt Report prepared for Bibb County, November 2006

Assumptions:

1) Downstream balance weight = 230k (extra weight added inside 6' dia tube) (see existing plan sheet 54 of 58)
2) Gate weight acting at sill = 130 kip based on 2006 M&H Study
3) Assumed friction resistance from pin, gate seal & pulleys:
   20% Assumed with balance arm and counterweight system.
   15% Assumed without balance arm and counterweight system.
4) Hydrostatic pressure along curved skin plate neglected.
5) Counterweight chamber completely evacuated of water.
6) Gate lifting load = 13,485 lbs without side seals or added weight or water pressure, as determined from Alpha in 2001 (email from Bibb County 11/22/17).
7) Plates added (email from Bibb County 9/12/17):
   * Prior to 2006 study - 20 plates 2'x5' x 1" thick (2'x5'x1"*(1/12") * 490 pcf = 409 lb ea).
   * After 2006 study (June 2015) - 15 plates 2'x5'x2" (817 lb ea).

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Job No. 02334(00-171740.01 Sheet 2 of 8
Job Name FINDLEY RYTHER DAM
Task DETERMINATION OF LIFTING LOADS
Calculated by GAR Date 1/18/18
Checked by JAR Date 1/18/18

CASE 1 MAINTAIN CURRENT CONFIGURATION

(SEE SHEET 4)

DETERMINATION OF COUNTERWEIGHT T1

$V = \pi/4 (8')^2 (10.5') = 527.8 \text{ FT}^3 \sim 528 \text{ FT}^3$

UNIT WT ASPHALT

$(110 \text{ LB/IN/SY})(1.0 \text{ SF})(12 \text{ IN})(1/9) = 146.6 \#/\text{FT}^3$

USE 147 LB/FT^3

$T_1 = (528 \text{ FT}^3)(0.147^k/\text{FT}^3)(2 \text{ WTS})$

$T_1 = 155.2^k \sim 155^k$

DETERMINATION OF T2

$W_1 L_1 = T_1 L_2 + T_2 L_3$

$(230^k)(33.5') = (155^k)(19') + (T_2)(33')$

$T_2 = \dfrac{(230)(33.5) - (155^k)(19')}{33'}$

$T_2 = 144.2^k \sim 144^k$

DETERMINATION OF T3

$W_2 L_4 = T_2 L_3 + T_3 L_5$

BASE GATE WT; R's JUNE 2015 → 12.26^k

$W_2 = 130^k + (20)(0.409) + (15)(0.817^k) = 150.4^k \sim 150^k$

R's BEFORE 2006 → 8.18^k

$T_3 = \dfrac{(150^k)(43') - (144)(33)}{55'} = 30.9^k$

$T_3 = (30.9^k)(1.20)$ ← ASSUME 20% FOR PIN, SEAL & PULLEY FRICTION

$T_3 = 37.1^k \sim 20^T$ REQ'D LIFTING LOAD

CASE 1: MAINTAIN CURRENT CONFIG. - CONT'D

COMPARE CAL'D LIFTING LOAD. TO GATE LIFTING LOAD DETERMINED FROM ALPHA IN 2001

GATE LIFTING WEIGHT = 13,485 LB (W/O SEALS OR ADDED WT) ← ASSUMED PER GATE

ADDED WT. =
- PRIOR 2006 → 8.18^k
- JUNE 2015 → 12.26^k

20.44^k

ASSUME 15% INC. FOR PIN & SEAL FRICTION

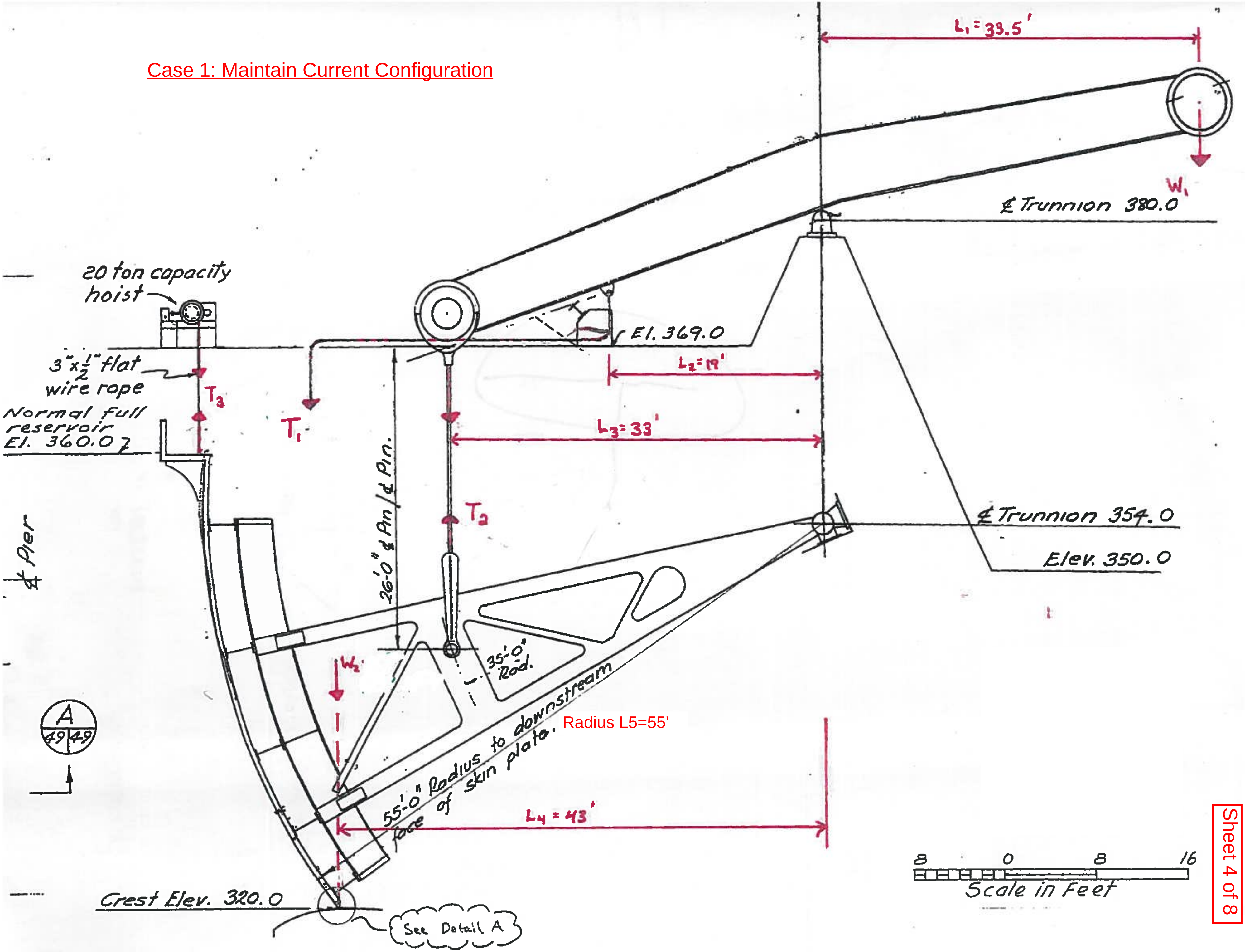
TOTAL LIFTING LOAD = (1.15)[(13.5) + 20.4] ← ASSUMED 15% FOR PIN & SEAL FRICTION *

* IT IS ASSUMED THAT THE FRICTION RESISTANCE FROM BALANCE WEIGHT IS ALREADY INCLUDED IN THE 2001 LIFTING WEIGHT DATA FROM ALPHA. THEREFORE, 15% PIN & SEAL FRICTION WAS APPLIED WITHOUT THE BALANCE WEIGHT PULLEY FRICTION.

LIFTING LOAD = 39.0^k, 20^T REQ'D LIFTING LOAD, WHICH COMPARES WELL WITH THE T3 CALCULATION FROM PAGE 2

It is common practice to specify a rated hoist capacity of 15-20% greater than the required lifting load to ensure the hoist is of sufficient capacity. Following this practice, it is anticipated that a 25-ton hoist would be required for Alternative No. 1.

Case 1: Maintain Current Configuration



CASE 2: COUNTER WT. RETIREMENT W/ HOIST @ SAME LOCATION

DETERMINATION OF T_3 (T_2 & W_2 ELIMINATED)

$W_2 L_4 = T_3 L_5$

$W_2 = 130^k$ (ASSUME ℞'S ADDED BEFORE 2006 & JUNE 2015 REMOVED)

$(130^k)(43') = (T_3)(55') \Rightarrow T_3 = 101.6^k$

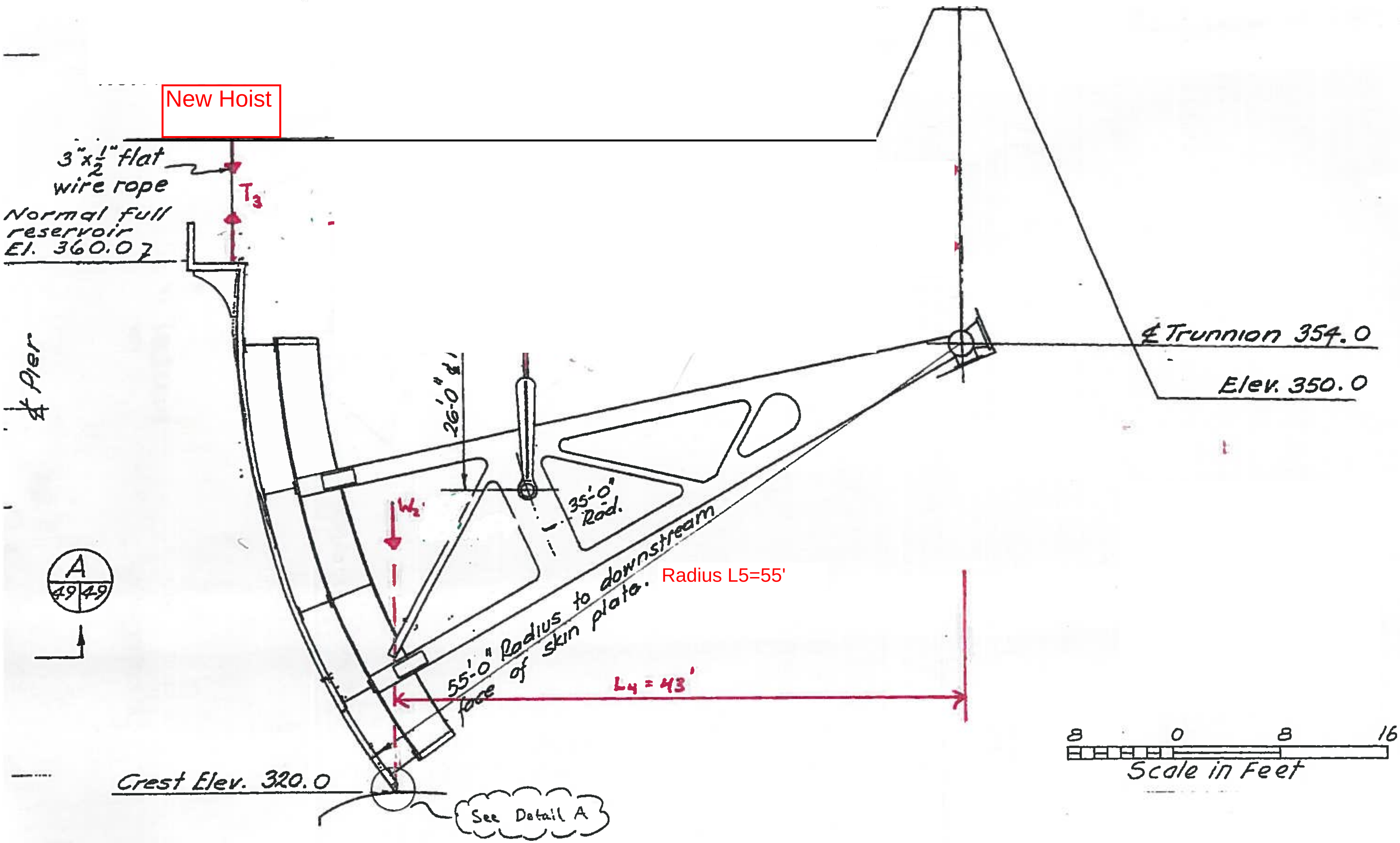
ASSUMED PIN & SEAL FRICTION

$T_3 = (101.6^k)(1.15) =$

$T_3 = 116.8^k \approx 60^T$ REQ'D LIFTING LOAD

It is common practice to specify a rated hoist capacity of 15-20% greater than the required lifting load to ensure the hoist is of sufficient capacity. Following this practice, it is anticipated that a 70-ton hoist would be required for Alternative No. 2.

Case 2: Counterweight Retirment with Hoist in Current Location



CASE 3: COUNTER WT. RETIREMENT W/ HOIST @ SAME LOCATION

DETERMINATION OF T_2

$W_2 L_4 = T_2 L_3$

$W_2 = 130^k$ (SAME AS CASE 2)

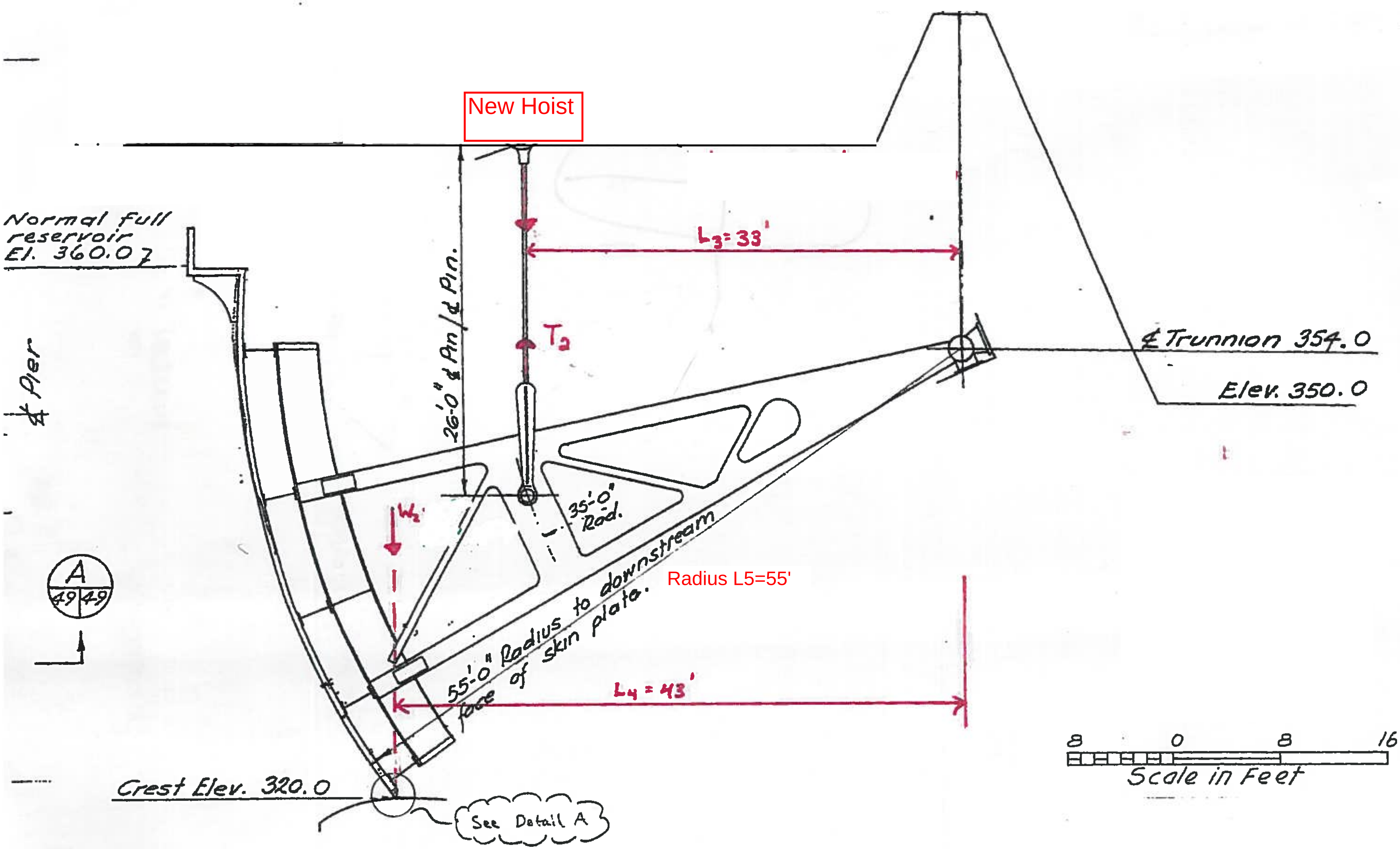
$(130^k)(43') = (T_2)(33') \Rightarrow T_2 = 169^k$

$T_3 = (169^k)(1.15)$ ← ASSUMED PIN & SEAL FRICTION

$T_3 = 194.4^k \sim 100^T$ REQ'D LIFTING LOAD

It is common practice to specify a rated hoist capacity of 15-20% greater than the required lifting load to ensure the hoist is of sufficient capacity. Following this practice, it is anticipated that a 120-ton hoist would be required for Alternative No. 3.

Case 3: Counterweight Retirement with Hoist in T2



Appendix B. Budgetary Cost Estimates

Budgetary Cost Estimate - Findley Ryther Dam

Alternative No. 1 - Maintain Balance Arm System and Replace Existing Hoist

Maintain Current Hoist Location

Quantity	Unit	Item Description	Unit Price	Total
		Construction		
1	LS	Mobilization	$65,000	$65,000
2	EA	Remove and dispose of existing hoists	$50,000	$100,000
2	EA	New 25-ton hoists	$210,000	$420,000
2	EA	Civil modifications (hoist support)	$5,000	$10,000
2	EA	Installation and commissioning of new hoists	$105,000	$210,000
2	EA	Structural modifications to gates	$20,000	$40,000
2	EA	Remove and dispose of existing ballast plates	$0	$0
2	EA	Retire existing balance arm system (in place)	$0	$0
		Engineering		
1	LS	Design engineering	$175,000	$175,000
1	LS	Instrumentation and testing of gates	$190,000	$190,000
1	LS	Construction engineering	$80,000	$80,000
		Total Construction Cost		$845,000
		Total Engineering Cost		$445,000
		Contingency (Construction)	40%	$338,000
		Contingency (Engineering)	50%	$222,500
		Total Estimated Cost (Engineering & Construction)		**$1,860,000**

Budgetary Cost Estimate- Findley Ryther Dam

Alterantive No. 2 - Retire Balance Arm System & Replace Existing Hoist

Maintain Current Hoist Location

Quantity	Unit	Item Description	Unit Price	Total
		Construction		
1	LS	Mobilization	$100,000	$100,000
2	EA	Remove and dispose of existing hoists	$50,000	$100,000
2	EA	New 70-ton hoists	$325,000	$650,000
2	EA	Civil modifications (hoist support)	$10,000	$20,000
2	EA	Installation and commissioning of new hoists	$160,000	$320,000
2	EA	Structural modifications to gates	$45,000	$90,000
2	EA	Remove and dispose of existing ballast plates	$20,000	$40,000
2	EA	Retire existing balance arm system (in place)	$30,000	$60,000
		Engineering		
1	LS	Design engineering	$85,000	$85,000
1	LS	Instrumentation and testing of gates	$0	$0
1	LS	Construction engineering	$30,000	$30,000
		Total Construction Cost		$1,380,000
		Total Engineering Cost		$115,000
		Contingency (Construction)	40%	$552,000
		Contingency (Engineering)	30%	$34,500
		Total Estimated Cost (Engineering & Construction)		**$2,090,000**

Budgetary Cost Estimate- Findley Ryther Dam

Alterantive No. 3 - Retire Balance Arm System & Replace Existing Hoist

New Hoist Location (Above Existing Connection Between Arm Assembly and Balance Arm)

Quantity	Unit	Item Description	Unit Price	Total
		Construction		
1	LS	Mobilization	$145,000	$145,000
2	EA	Remove and dispose of existing hoists	$50,000	$100,000
2	EA	New 120-ton hoists	$415,000	$830,000
2	EA	Civil modifications (hoist support)	$100,000	$200,000
2	EA	Installation and commissioning of new hoists	$205,000	$410,000
2	EA	Structural modifications to gates	$100,000	$200,000
2	EA	Remove and dispose of existing ballast plates	$20,000	$40,000
2	EA	Retire existing balance arm system (in place)	$30,000	$60,000
		Engineering		
1	LS	Design engineering	$110,000	$110,000
1	LS	Instrumentation and testing of gates	$0	$0
1	LS	Construction engineering	$45,000	$45,000
		Total Construction Cost		$1,985,000
		Total Engineering Cost		$155,000
		Contingency (Construction)	40%	$794,000
		Contingency (Engineering)	30%	$46,500
		Total Estimated Cost (Engineering & Construction)		**$2,990,000**

Appendix C. Gate Hoist Replacement Alternative Comparison

Table C-1. Comparison of Gate Hoist Replacement Alternatives

Considerations	Alternative No. 1	Alternative No. 2	Alternative No. 3
Extent of Gate and Civil Structure Modifications	May require new lifting cables and structural modifications to several gate elements. Required gate modifications are likely to be less substantial than those for Alternative Nos. 2 and 3. Would require modifications to existing concrete hoist supports. Unlikely to require structural modifications to abutments and center pier.	May require new lifting cables and structural modifications to several gate elements. Required gate modifications are likely to be more substantial than those for Alternative No. 1 and less substantial than those for Alternative No. 3. Would require modifications to existing concrete hoist supports. Unlikely to require structural modifications to abutments and center pier.	May require new lifting cables and structural modifications to gate arm assemblies. Would require modifications to existing lifting points on gate arms assemblies. Required gate modifications are likely to be more substantial than those for Alternative Nos. 1 and 2. Would require considerable structural modifications to abutments and center pier to support new hoists.
Operations	Limits changes to current gate operation. However, gate operation would remain somewhat unpredictable.	Gate operation would be predictable.	Gate operation would generally be predictable. However, projection of new hoists into gate bay may interfere with gate arm assemblies at higher gate openings.
Maintenance	Requires continued inspection and maintenance of balance arm system.	Inspection and maintenance of balance arm system no longer required.	With the exception of connection between lifting cables and lift point on gate arm assemblies, inspection and maintenance of balance arm system no longer required.
Dam Safety / NRCS Approval	A tainter gate stress analysis will be required. The NRCS is unlikely to look favorably on a design that relies in part on the balance arm system, which has historically resulted in unpredictable and unreliable gate operation. Extensive on-site instrumentation and testing and a significantly greater amount of engineering effort would be required for this alternative. Even with this investment, there is no guarantee of consistent and reliable gate operation as the balance arm system ages.	A tainter gate stress analysis will be required. This alternative does not rely on the balance arm system, which has historically resulted in unpredictable and unreliable gate operation. Furthermore, the gate-lifting configuration associated with this alternative is consistent with what the NRCS is used to seeing for other tainter gates. As a result, the NRCS is likely to look much more favorably on this design than Alternative No. 1.	A tainter gate stress analysis will be required. This alternative does not rely on the balance arm system, which has historically resulted in unpredictable and unreliable gate operation. As a result, the NRCS is likely to look upon this design more favorably than Alternative No. 1. The NRCS is likely to look upon this design less favorably than Alternative No. 2 because very few if any tainter gates that they are familiar with lift the gate from a point located on the arm assemblies. Additionally, projection of the new gate hoists into gate bay may interfere with full opening of gates.
Risk	The risk associated with this alternative is significantly higher than Alternative Nos. 2 and 3 because operation relies in part on the balance arm system, which has historically been unpredictable and unreliable.	The risk associated with this alternative is significantly lower than Alternative No. 1 and comparable to Alternative No. 3 because gate operation does not rely on the balance arm system, which has historically been unpredictable and unreliable.	The risk associated with this alternative is significantly lower than Alternative No. 1 and comparable to Alternative No. 2 because gate operation does not rely on the balance arm system, which has historically been unpredictable and unreliable.
Cost	Lowest total cost of the alternatives evaluated ($1,860,000). Approximately 12 percent cheaper than Alternative No. 2 and considerably cheaper than Alternative No. 3. Up-front engineering costs significantly higher than Alternative Nos. 2 and 3.	Total project cost ($2,090,000) approximately 12 percent greater than Alternative No. 1 and considerably lower than Alternative No. 3. Up-front engineering costs significantly lower than Alternative No. 1 and likely to be lower than Alternative No. 3.	Total project cost ($2,990,000) considerably greater than Alternative Nos. 1 and 2. Up-front engineering costs significantly lower than Alternative No. 1 but likely to be higher than Alternative No. 2.