Rio Grande Reservoir Multi-Use Study

Phase 3 Report

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DiNatale Water Consultants, Inc.

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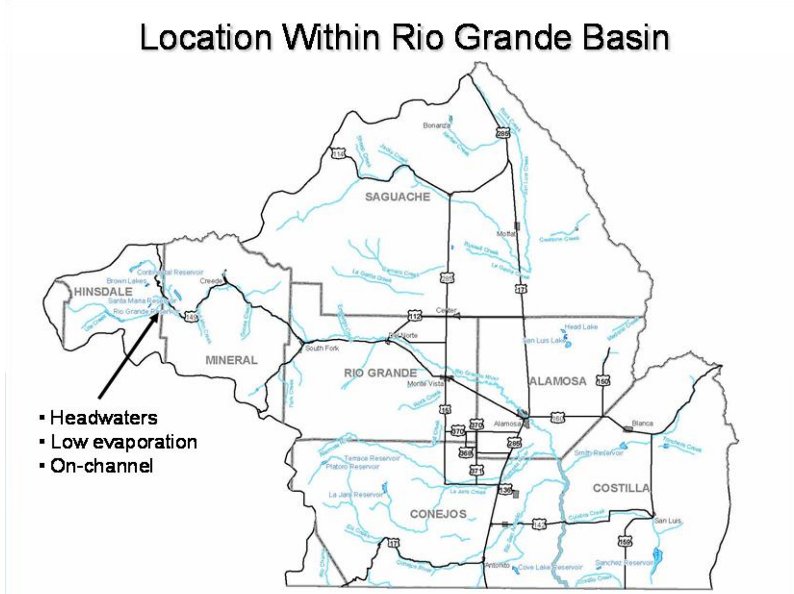
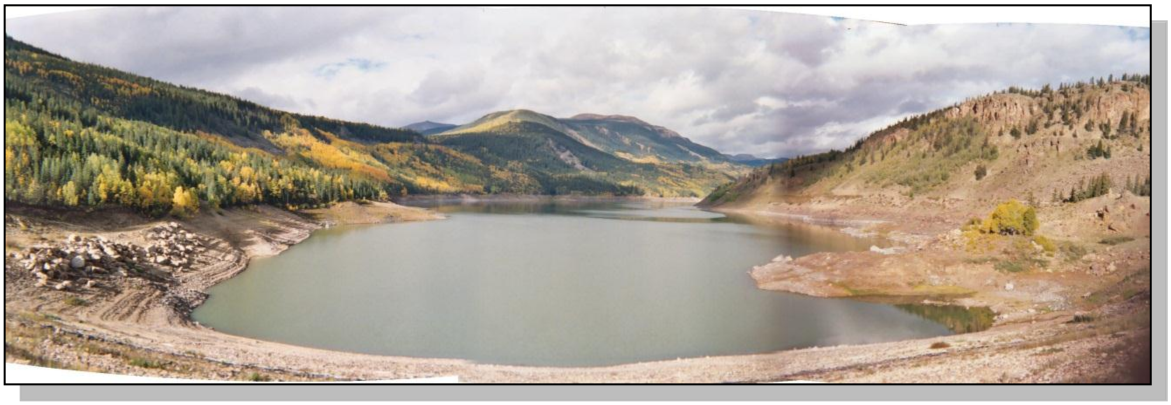
I. Background

Rio Grande Reservoir (Reservoir) is located on the headwaters of the Rio Grande in Hinsdale County, Colorado with a storage capacity of approximately 54,000 acre-feet (AF). The Reservoir is owned and operated by the San Luis Valley Irrigation District (District). The District, with funding assistance from the Colorado Water Conservation Board (CWCB), has studied the potential for a multi-use rehabilitation of the Reservoir. Currently, several entities store water in the Reservoir under temporary storage space lease agreements. Colorado Parks and Wildlife (CPW), previously known as the Division of Wildlife, stores water for a conservation pool and to meet its extensive needs throughout the Basin. The Colorado Division of Water Resources (DWR) stores compact water to assist in the management and delivery of its obligations under the Rio Grande Compact. The San Luis Valley Water Conservancy District (SLVWCD) is the primary agency for augmentation of domestic and commercial uses in the Basin and stores a portion of its augmentation supply in the Reservoir. Also, the Navajo Development Co. stores water for residential development. However, aging infrastructure and operational constraints threaten the District's ability to continue store water for these and other purposes over the long-term. Therefore, the District initiated a study and analysis of the infrastructure improvements required to provide a multi-use facility that would meet the permanent storage needs of many entities throughout the Rio Grande Basin in addition to the District's own needs for storage for irrigation.



Low flows downstream of the dam

The studies concluded that an enlargement or rehabilitation of the Reservoir could provide the facility and infrastructure necessary for to provide long-term lease and space available storage to meet the multiple use water demands throughout the Basin. Those uses could include the storage of Rio Grande Compact water, CPW transmountain rights and augmentation supplies for municipal, industrial, domestic and agricultural uses. In addition, once rehabilitated the Reservoir could provide storage for the Groundwater Management Subdistricts to time and replace pumping depletions to the Rio Grande caused by irrigation well pumping. Once rehabilitated, releases and deliveries from the multiple Reservoir storage pools could, at times, be re-operated and coordinated without affecting yield, to provide additional benefits, including enhancements of streamflow for environmental and recreational purposes and hydropower generation. In addition, the Reservoir could provide safe flood routing by attenuating very high peak inflows that could potentially result in downstream property damage.



Panoramic photo looking west from the top of the dam; ordinary high water for the Reservoir is marked by the vegetation line on the bank..

II. Phase 1 and 2 Reports

Phases 1 and 2 of the study evaluated storage enlargements, rehabilitation needs, permitting issues and potential fatal flaws associated with these activities. In addition, multi-use opportunities for the Reservoir were explored and detailed. The study concluded that 10,000 AF was the maximum potential enlargement, but permitting issues and limited legally available water supplies were significant concerns. With or without an enlargement, the Reservoir's outlet works and spillway, and amelioration of seepage primarily along the left (northern) abutment were necessary to properly rehabilitate the Reservoir.

The Phase 1 and 2 reports identified several potential storage pools including a pool for Compact water to provide the State of Colorado with a tool to better manage, retain, and utilize the State's share of Rio Grande water while assuring that it meets its water delivery obligations under the Compact at the Colorado-New Mexico border. Storing and re-regulating the delivery of Compact water to the state border could also enhance in stream flows for fish and riparian habitat particularly at low flow periods late in the irrigation season and during the winter. It will also provide the State Engineer with a tool to help reduce the wide fluctuation in curtailments – the percentage reduction in the flow available at the Del Norte gage for diversion -- to assure Colorado meets its water delivery obligations to the New Mexico border. This will provide irrigators with a more consistent water supply during the irrigation season while assuring that Colorado has stored a sufficient amount of water that, if needed, can be released to meet any remaining Compact obligation after the irrigation season ends.

Phase 2 also addressed the following tasks:

- Preliminary Design of enlargement and rehabilitation
- Geological/Geotechnical Investigation of dam and upstream landslide areas
- Refinement of flood hydrology using EPAT
- Development of Re-operations Model
- Wetlands Delineation

- Biological Assessment
- Draft Participation Agreements
- Stakeholder Meetings

The Phase 2 preliminary design of dam rehabilitation included seepage reduction, outlet works and spillway improvements. The outlet gates have been a recurring problem since the initial construction of the Reservoir. The existing outlet gates restrict the flexibility of releases from the Reservoir. The spillway concrete needs repair and the spillway cannot safely pass the design flood. Rehabilitation costs were estimated at approximately $22-$26 million with the higher cost if hydropower is included.

The Reservoir will need to be rehabilitated to address the diverse needs identified in the studies. In particular, new outlet works will allow for more controlled releases, seepage control measures will allow for higher levels of carryover storage and spillway improvements will improve dam safety and allow continued use of the full storage capacity.

A monthly timestep Reservoir reoperations model was developed in Phase 2 to illustrate the potential benefits of a rehabilitated Reservoir. Storage for the SLVID, CPW, Compact Storage, SLVWCD, Groundwater Management Subdistricts and others can be modeled. The model uses historical data from 1985-2005 and calculates storage and releases from the Reservoir on a monthly time-step.

After review of the preliminary design plans and permitting issues, the District Board determined not to pursue an enlargement at this time.

III. Phase 3 Basin Roundtable funding and scope

The CWCB, under the Rio Grande Basin Water Supply Reserve Account ("BRT") provided a $100,000 grant to support Phase 3 of the study, and the Water Resources and Power Development Authority provided a $15,000 Small Hydropower Loan Program Grant. A daily re-operations model was also developed that allows potential storage lessees and stakeholders to evaluate the benefits of storage in the reservoir for firming yields, meeting compact deliveries, providing for augmentation of domestic, commercial, municipal and groundwater management sub district's needs, generating hydropower and providing environmental and recreational benefits. A hydropower analysis and associated cost estimate was also completed and incorporated into the operations model.

The project team included:

- DiNatale Water Consultants (project management, stakeholder meetings, modeling and hydropower analysis)
- Helton & Williamsen (modeling)
- URS (hydropower evaluation and cost estimates)
- Law Office of Tod Smith (legal)

In addition, Deere & Ault updated the estimated rehabilitation costs for incorporating hydropower and the associated land requirements.

The scope of work for Phase 3 included three tasks:

- Task 1 - Refine Inputs and Modeling Needs for the Reservoir Reoperation and Optimization Model. This task included workshops and discussions with various stakeholder groups including the Division Engineer and water users, potential storage pool holders, the Forest Service and other groups interested in environmental and recreational flows.

- Task 2 - Implement Model Enhancements. Refine the monthly timestep model developed in Phase 2 based on feedback received from the modeling workshops with various interests and participants. As a result of meetings with water users in the early part of the Phase 3 study, it was recommended to convert the model to a daily timestep that would allow more refined analysis of inflows and releases, impacts on streamflows, and the ability to store direct flow rights under existing direct flow storage decrees.

- Task 3 - Hydropower Analysis. This task addressed other issues pertaining to hydropower usage including legal issues, permitting, existing power infrastructure evaluation, investigation into available hydropower technical options, land ownership requirements and associated dam improvements required to implement hydropower.

IV. Stakeholder Involvement

Workshops, meetings and on-site visits were held with many of the basin stakeholders. The meetings included discussions and review of the Reservoir daily operations model, briefings on the hydropower studies and results and exploration of hydropower operations, and discussions on potential agreements for storage in the Reservoir. In addition, the workshops and meetings included review of the challenges with implementing any reoperations, storage pool leases or hydropower operations until the Reservoir rehabilitation is completed. The stakeholder meetings included:

- Modeling workshops with Division Engineer and representatives of water users, including the Rio Grande Water Users, Rio Grande Water Conservation District and SLVWCD, were held to refine water use data and beneficial model enhancements including: water rights data, compact deliveries and flow projections, curtailments, stream gains and losses, direct flow storage utilization, and potential demands and operational criteria from the existing Groundwater Management Subdistrict #1 and the proposed groundwater management sub districts (GMS) #3 and 4.

- Workshops with potential storage pool lessees, including Division Engineer (Compact Storage), Colorado Parks and Wildlife, and Rio Grande Water Conservation District and San Luis Valley Water Conservancy District to refine long-term storage needs and water delivery scenarios to best address water use needs while potentially meeting stream flow and riparian demands

- Meetings were held with the U.S. Forest Service to review the proposed rehabilitation and hydropower addition, review the Forest Service reserved water rights and seek a Forest Service position on the existing 1891 Act right of way held by the District for Rio Grande Reservoir

- Interim results were presented at a May, 2010 Rio Grande Basin Roundtable meeting and several SLVID Board of Directors meetings

Table 1 shows the modeling and stakeholder meetings and the subject of the meetings.

Table 1. Stakeholder Meetings

	Subjects Covered in Stakeholder Meetings		
Stakeholder	Hydropower	Storage Agreements	Reservoir Operations Modeling
Rio Grande Basin Round Table	✓	✓	
Division Engineer and Division of Water Resources (DWR)		✓	✓
Rio Grande Water Users			✓
Rio Grande Water Conservation District and Groundwater Management Subdistricts		✓	✓
San Luis Valley Wetlands Focus Group			✓
U.S. Forest Service	✓		✓
Division of Parks and Wildlife (CPW)		✓	✓
Governor's Energy Office	✓		
San Luis Valley Water Conservancy District (SLVWCD)		✓	✓
San Luis Valley Rural Electrical Electric Cooperative (SLVREC)	✓		✓
Town of Monte Vista		✓	

Photo courtesy of Rio de la Vista

Stakeholder Reservoir site visit

The meetings indicated general stakeholder understanding of the need and support for rehabilitating of the Reservoir. Many of the stakeholders realize the potential benefit of rehabilitating and creating leased storage pools in the Reservoir. Concerns were expressed over the ability of the District and/or potential new users to pay for the significant cost of the rehabilitation. Discussions are continuing on how water stored for consumptive use purposes may be released at times to enhance flows for environmental and recreational purposes without impacting water yields. To date, none of the parties that might store water in the Reservoir have fully analyzed how the release of their stored water might be retimed to provide enhanced environmental or recreational benefits. They also expressed concern over potential impacts to water rights and compact obligations as a result of retiming. Draft storage agreements were developed for the DWR for the storage of compact water, CPW for storage of transbasin supplies, the SLVWCD and the Town of Monte Vista for augmentation for municipal, domestic and commercial purposes. As a direct result of this project, a 30 year storage lease was signed with the Town of Monte Vista. The Town has leased 240 AF of storage at a capital cost of $3,500 per acre-foot. The CWCB provided a loan to Monte Vista for the lease of storage space in the Reservoir and the acquisition of water rights that will be stored in the leased storage pool. A copy of the long-term storage lease agreement with the Town of Monte Vista is attached as Appendix A.

Phase 3 included ongoing discussions on long-term storage agreements with CPW, DWR and SLVWCD, analyzing the potential need for storage for the Groundwater Management Subdistricts, and modeling potential storage accounts using the daily operations model developed in Phase 3. As noted, stakeholders identified the cost of rehabilitation and the resulting costs for leasing storage space as an impediment to the development of long-term storage agreements. However, it was generally recognized that long-term storage agreements are contingent upon rehabilitation of the Reservoir, which can only proceed with long-term storage lease payments and/or grant funds to defray a portion of the cost.

Meetings were held with CPW and environmental interests to discuss how to best optimize available flows to better meet fish, riparian and other environmental needs and quantify the benefits of the modeled changes. Conclusions on potential reoperation scenarios for aquatic and riparian needs were not reached in Phase 3, but will be the subject of future discussions.

V. Model Enhancements

The Rio Grande Reservoir Reoperations model, developed in Excel, utilizes the 1980 through 2005 historical period to evaluate changes in Reservoir operations that result from storage for multiple users and purposes. Lessees can evaluate how the use of Reservoir storage can better manage their portfolio of water rights and preserve supplies, the impacts on carryover storage and the ability to meet demands in average and drought years. The model tables and figures show the effects of potential changes in water stored and releases on Reservoir levels, hydropower generation and stream flows at key gages from the Reservoir to the state line. Based on stakeholder feedback at preliminary modeling meetings in Phase 3, the existing monthly timestep model was modified to provide for daily operations as part of the Phase 3 effort. This daily re-operations model provides a more refined dataset for evaluating impacts on daily needs, timing of storing direct flow rights under existing direct flow storage decrees, peak hydropower generation, and daily streamflows for providing environmental and recreational benefits.

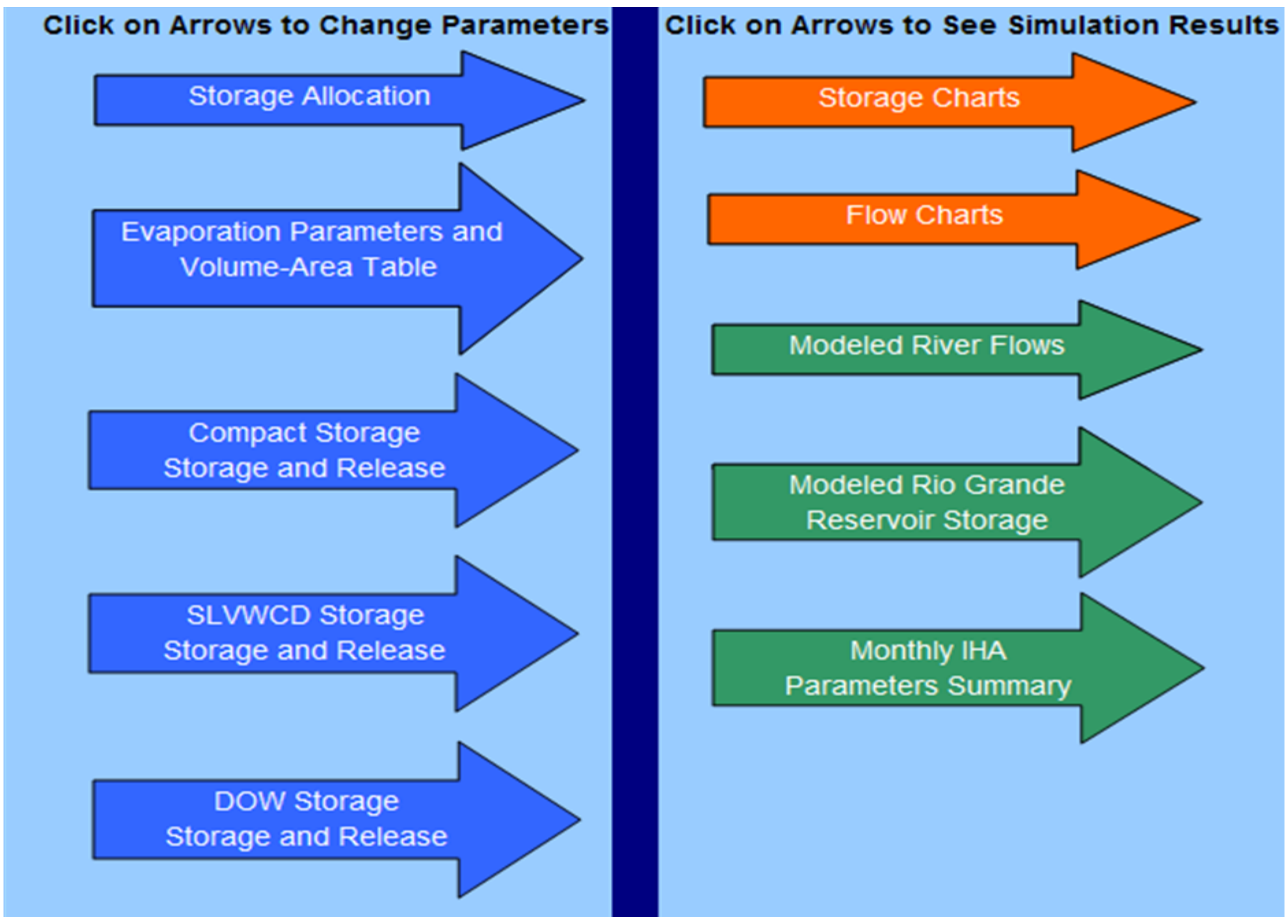
As a result of feedback from the stakeholder meetings, the Phase 3 work added the following model enhancements

- Daily timestep
- Additional storage accounts for the Town of Monte Vista and three groundwater management subdistricts (#1, 3 and 4)
- Historical stream gains and loss data
- Historical NRCS stream flow forecasts for April, May and June and a comparison of the actual flow to the forecasted flows
- Simplified representation of water rights and deliveries

- Estimate of historical river calls based on Del Norte gage flows
- Dynamic modeling of hydropower production based on modeled Reservoir level and releases and a comparison of the change in hydropower generation potential compared to historical operations

The conversion of the model to a daily operations timestep was completes and is available for use by stakeholders. Current storage accounts that can be modeled are:

- San Luis Valley Irrigation District (owner)
- Colorado Parks and Wildlife (CPW)
- Compact Water (DWR)
- San Luis Valley Water Conservancy District (SLVWCD)
- Direct Flow Storage accounts
- Groundwater Management Subdistricts (#1, 2 and 4)
- Town of Monte Vista



Example of Model Options Selection

Figure 1 Model Options Selection

Other accounts can be added as may be needed in the future.

A technical memorandum summarizing the modeling enhancements was prepared by Helton & Williamsen and is attached as Appendix B.

Meetings were held with potential lessees to further evaluate their storage needs and to discuss the possibility of re-timing and reoperating releases and deliveries to enhance flows for environmental and recreational benefits. As part of the future effort, CPW will provide additional information for input into the model to evaluate the benefits to CPW, potential cooperative operations with Beaver Park Reservoir, a CPW facility located in the South Fork drainage on Beaver Creek and for other ancillary benefits such as streamflow enhancements when its water is delivered to downstream CPW uses.

VI. Hydropower Evaluation

The hydropower study examined two alternatives. A 500 kW option would supply power to a local area in the vicinity of the reservoir. The generated power would be transmitted via the existing single phase 11 mile transmission line. A 2 MW option would also supply power to the local area and export additional generated power via the local electrical provider. This alternative would require the construction of a three phase 11 mile transmission line. The hydropower analysis was conducted by URS and is attached as Appendix C. This analysis assumed that the dam rehabilitation was completed and a pressurized outlet tunnel was available for the hydropower plant.

The initial cost estimates were refined subsequent to the development of the URS memo to reflect updated permitting costs and additional improvements required to incorporate hydropower. The estimated cost for the hydropower facilities is $6 - $8 million. In addition to the cost of the hydropower facilities, facilities that would be required for hydropower generation include:

- Pressurized outlet tunnel
- Stilling basin
- Upgrade of 11 mile transmission line for 2 MW option
- Small tracts exchange with the Forest Service

As noted, a pressurized outlet tunnel is required for a hydropower operation. The tunnel outlet and hydropower plant would utilize land at the base of the Reservoir that is currently held by the U.S. Forest Service. The conveyance of that land could be accomplished by a small tracts exchange initially proposed by the Forest Service several years ago to address its encroachment onto District land for the Thirty Mile Campground. Under this proposal, the District would exchange the land it owns that is presently encumbered by the Forest Service's Campground for Forest Service land lying immediately below the Reservoir. The Forest Service and District initiated preliminary discussions of a potential land swap as part of Phase 3.

The addition of hydropower at the Reservoir is subject to Federal Energy Regulatory Commission (FERC) regulations for hydropower facilities under 5 MW. The cost for the FERC "under 5 MW exemption" permitting process is estimated at $500,000 to $750,000. Under this permitting "exemption" process the Reservoir would be subject to additional federal regulations including environmental and dam safety review. Absent an agreement between the FERC dam safety group and the Colorado State Engineer's Office (SEO), the addition of hydropower would subject the Reservoir to future jurisdiction and inspection of the dam by FERC's dam safety group in addition to SEO dam safety regulations.

As noted, meetings were held with the staff of the Governor's Energy Office. The State of Colorado signed a Memorandum of Understanding (MOU) with FERC for streamlining the small hydro permitting process. SRI International, a consulting firm, has been retained by the Governor's Energy Office to assist permittees through the under 5 MW exemption process. The MOU and the assistance of the State should reduce the time for the FERC permitting process from two years to less than one year. However, the District will still be required to fulfill federal environmental permitting requirements, and subject the Reservoir to conflicting federal and state dam safety regulations.

A major constraint on the hydropower potential at the Reservoir is the need for a storage pool greater than gage height 50 (approximately 15,000 acre-feet) throughout the summer months to provide the head required to generate power sufficient to pay for the capital and O&M cost of adding hydropower facilities. Table 2 illustrates the relationship between kilowatts generated for various release rates and Reservoir gage heights for a 300 cfs powerplant. For a release rate of 300 cfs, the power generated at a gage height of 40 feet is 870 kilowatts. For the same release rate of 300 cfs, a Reservoir gage height of 90 feet (full Reservoir) would generate 2,150 kilowatts.

Rio Grande Reservoir Hydropower Evaluation						
Kilowatts Generated At Various Flow Rates and Gage Heights						
	Reservoir gage height (head)					
CFS Release Rate	90	80	70	60	50	40
70	500	440	380	320	260	200
150	1,080	940	810	680	560	440
300	2,150	1,880	1,620	1,360	1,110	870

Table 2. Hydropower Potential

The daily operations model linked hydropower generation with the Reservoir reoperations. As various operations scenarios are modeled for the various stakeholder storage accounts, the hydropower generated under that specific operational scenario will be calculated and can be compared to other scenarios. The model was used to estimate average monthly hydropower generation under historical and various modeled scenarios. Figure 2 shows the comparison of additional hydropower that could be generated with modified Reservoir operations. As noted, the addition of hydropower will require a Reservoir rehabilitation that both allows increased storage volumes for longer time periods and includes a pressurized outlet works. Under no circumstance would hydropower revenues pay for the rehabilitated or new outlet works, but could provide a revenue stream to pay for the installation and operation and maintenance of the hydropower facilities, providing an average of 1,700,000 kilowatt hours of renewable, green energy annually.

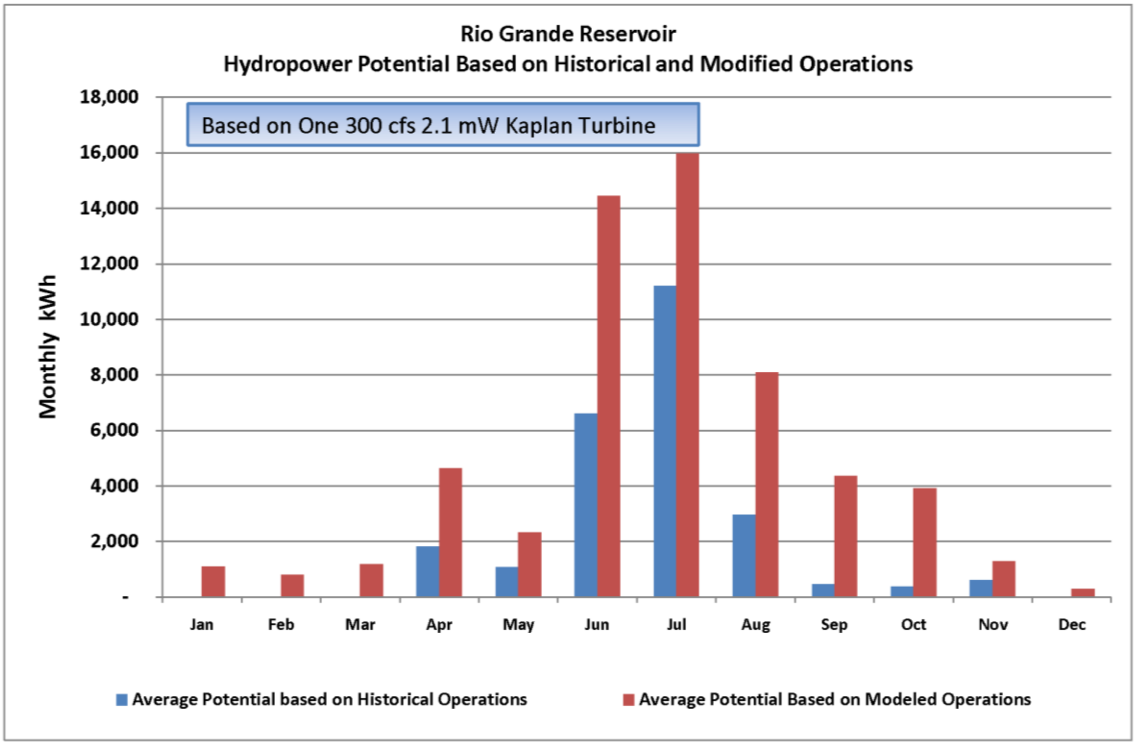


Figure 2. Comparison of Monthly Hydropower Potential Under Historical and Modeled Operations

Several meetings were held with the San Luis Valley Rural Electrical Cooperative (SLVREC). Colorado utilities must meet state mandated renewable energy targets. The SLVREC outlined two potential Power Purchase Agreement options:

- $0.08 - $0.09 per kWh generated
- $0.02 -$0.03 per kWh generated + $18-$20/kW of power generated during peak hours (7 am – 10 pm)

Annual revenues under basic reoperations are projected in the range of $80,000 - $145,000 if the Reservoir is reoperated to provide for increased storage levels during peak flow months.

VII. Conclusions

The following are the conclusions of the Phase 3 study:

1. Storage has historically been made available by the District under temporary storage agreements at very low annual lease rates

2. The District cannot fund the rehabilitation at current lease rates

3. The District landowners must determine if revenues and other benefits from long-term leases of storage outweigh the loss of storage

4. There are benefits to numerous parties, including the State, from the long-term lease of storage space

5. The daily timestep model can be used by potential storage lessees to evaluate the benefits of better managing water supplies, increased yield, carryover and meeting dry year demands. The model can also be used to illustrate to water users and other stakeholders the potential benefits of reoperations on streamflows and other recreational and environmental benefits.

6. Hydropower is feasible and cost-effective, but only if a Reservoir rehabilitation is funded from other sources

7. There are impediments to the addition of hydropower. These include:

    a. Potential changes to the existing 1891 Act Right of Way

    b. FERC permitting and the addition of federal dam safety jurisdiction in addition to the State Engineer

    c. The need for a land swap with the Forest Service

8. Without funding assistance, it is unlikely that the Reservoir can be rehabilitated to provide for the multi-purpose benefits identified in the reports and through stakeholder discussions.

APPENDICES

A. Town of Monte Vista Storage Lease Agreement, September 2010

B. Modeling Enhancements Technical Memo, October, 2011

C. URS Rio Grande Reservoir Hydropower Evaluation, July, 2009

APPENDIX A

STORAGE LEASE AGREEMENT
BETWEEN THE SAN LUIS VALLEY IRRIGATION DISTRICT
AND
THE CITY OF MONTE VISTA, COLORADO

THIS LEASE AGREEMENT, entered into on this 8th day of September, 2010 between the CITY OF MONTE VISTA, COLORADO, whose address is 4 Chico Camino, Monte Vista, Colorado 81144, hereinafter referred to as "Monte Vista," and the SAN LUIS VALLEY IRRIGATION DISTRICT, whose address is P.O. Box 637, Center. Colorado 81125, hereinafter referred to as the "Irrigation District" (collectively referred to herein as the "Parties").

RECITALS

A. The Irrigation District is a Colorado Irrigation District organized and existing under and pursuant to the Irrigation District Law of 1905, Article 41 of Title 37 C.R.S.

B. Monte Vista is a Home Rule City of the State of Colorado organized and existing under and pursuant to Article XX of the Colorado Constitution.

C. Monte Vista is developing an augmentation plan to provide augmentation water necessary to assure its ability to provide municipal water to its residents and others.

D. Monte Vista may use various water rights in its augmentation plan ("Subject Water Rights"), including, but not limited to:

1. Anderson Ditch;
2. Ben Ogle Ditch;
3. McDonald Ditch;
4. Lariat Ditch; and
5. Williams Creek Squaw Pass Ditch.

E. The parties wish to facilitate implementation of Monte Vista's augmentation plan by providing storage space in Rio Grande Reservoir for the Subject Water Rights. The parties acknowledge that some of the Subject Water Rights can be stored in Rio Grande Reservoir only by exchange.

F. The Irrigation District owns Rio Grande Reservoir located on the headwaters of the Rio Grande in Hinsdale County, Colorado, and owns water right priorities to store water therein.

G. This Lease will provide Monte Vista with firm storage space to facilitate operation of its augmentation plan, and provides the Irrigation District with funds to operate, maintain, repair and rehabilitate Rio Grande Reservoir to assure that it remains a safe and fully functioning dam and outlet works.

H. The Irrigation District is authorized to enter this Lease pursuant to C.R.S. § 37-41-156.

I. Monte Vista is authorized to enter this Lease pursuant to Article I, Section 2 of its Home Rule Charter.

DEFINITION OF TERMS

"Operation And Maintenance Costs" shall mean those costs incurred to operate and maintain Rio Grande Reservoir, including any administrative, overhead, or general expenses incurred by the Irrigation District, either directly or indirectly, in the operation and maintenance of Rio Grande Reservoir and in the administration of this contract.

"Rehabilitation Project" means the Rehabilitation Project or any portion of that Project, as described in the "Rio Grande Reservoir Multi-Use Rehabilitation and Enlargement Study – Phase II," prepared by CDM (the "Rehabilitation Study").

"Lease Execution Date" means the date this Lease Agreement is entered as set forth above.

"Firm Storage" means water stored in Rio Grande Reservoir that cannot be spilled or evacuated from the Reservoir, except as provided for in this Lease. Water stored by the Irrigation District pursuant to its water rights is considered "firm storage."

"Pro-rata Share" means Monte Vista's acre-feet of leased storage capacity divided by 51,113 acre-feet, the actual storage capacity of the Rio Grande Reservoir, or the restricted storage capacity of the Reservoir, whichever is less.

AGREEMENT

NOW THEREFORE, for and in consideration of the following covenants, terms and conditions, and in full consideration of other conditions as hereinafter set forth, it is hereby agreed by and between Monte Vista and the Irrigation District as follows:

1. <u>Leased Capacity</u>: The Irrigation District agrees to lease to Monte Vista up to a total of two hundred and forty (240) acre-feet of firm storage capacity in Rio Grande Reservoir. Monte Vista may use its firm storage capacity to store the Subject Water Rights for any decreed purpose or as approved by the State or Division Engineer. Monte Vista may carryover any water stored to subsequent water years, if legally permitted to do so, provided such carryover storage shall be counted against Monte Vista's leased firm storage capacity.

2. <u>Lease Period</u>: This Lease shall be for thirty (30) years, which period shall commence on the Lease Execution Date.

3. Payment: Monte Vista shall pay the Irrigation District for the Leased Capacity as follows:

a. One hundred thousand dollars ($100,000) payable within 10 days following receipt of funds from the Colorado Water Conservation Board Construction Fund Loan.

b. Five hundred and thirty thousand dollars ($530,000) for one hundred and eighty (180) acre-feet of firm storage capacity payable within 10 days following receipt of funds from the Colorado Water Conservation Board Loan Fund and the earlier of:

i. The effective date of the proposed "Rules Governing the Withdrawal of Ground Water in Water Division No. 3;"
ii. Four (4) years from the effective date of the contract between Monte Vista and the CWCB; or
iii. Sixty (60) days following receipt of written notice from the Irrigation District of its needs for such funds to pay for the Rehabilitation Project, or some portion thereof.

c, The payment required under subparagraph 3.b (i) - (iii) above, shall be paid by Monte Vista to the Irrigation District in full regardless of whether Monte Vista's estimate of the firm storage capacity it requires is reduced between the Lease Execution Date and the date it is required to purchase its firm storage capacity pursuant to that subparagraph.

d. At the option of Monte Vista, thirty-five hundred dollars ($35,000) per acre foot for up to an additional sixty (60) acre-feet of firm storage capacity. This option shall expire three (3) years after payment by Monte Vista to the Irrigation District under subparagraph 3.b. immediately above.

4. Operation. Maintenance and Repair:

a. The Lease Payment shall include Monte Vista's share of all Rio Grande Reservoir annual Operation and Maintenance Costs for five (5) years following the payment described in paragraph 3.b above. Thereafter, Monte Vista shall pay the Irrigation District its pro-rata share of all annual Operation and Maintenance Costs necessary to maintain Rio Grande Reservoir for the preceding twelve months.

b. The Irrigation District shall provide Monte Vista an invoice for its pro-rata share of the annual Operation and Maintenance Costs no later than the 31st day of October of each year, which amount shall be paid by Monte Vista within 30 days of the date of the invoice.

c. The Irrigation District shall be responsible for and furnish all personnel necessary for the annual operation and maintenance of Rio Grande Reservoir, including, but not limited to, reading and operating gauges, valves, and gates, maintenance of District property including the caretaker's house, and normal preventative maintenance.

5. Storage and Release of Subject Water Rights: The Irrigation District shall be responsible for all aspects of the operation of Rio Grande Reservoir. Monte Vista shall provide the Irrigation District a proposed monthly release schedule on or before April 1st of each year. The Irrigation District will attempt to store and release the Subject Water Rights as directed by Monte Vista, provided however, that storage, release, and spill of the Subject Water Rights is subject to the terms and conditions of this Lease and the direction of the Division Engineer. The Irrigation District cannot guarantee, but shall make its best efforts to assure that storage or release of the Subject Water Rights is accomplished at the rates of flow requested. Monte Vista shall have a right proportionate to its share of the firm storage capacity to use the Reservoir's inflow and outlet facilities and capacities. The Irrigation District maintains and reserves the right to operate the Reservoir, store, release, or spill water therefrom at such times and in such manner as is required by the State or Division Engineer or as reasonably determined by the District for safe reservoir operation.

6. Augmentation Plan.

a. Monte Vista agrees to keep the Irrigation District fully advised in the adjudication of Monte Vista's augmentation plan and changes of water rights which involve Monte Vista's storage of water in Rio Grande Reservoir, including providing the District with all engineering reports provided to any party, and proposed decrees and stipulations prior to filing with the court.

b. The Irrigation District agrees that it will cooperate with Monte Vista to address any concerns or issues raised by objectors regarding the use of Rio Grande Reservoir in the water court, administrative or other proceedings for approval of the modifications to the Subject Water Rights necessary to obtain Monte Vista's augmentation plan, which may include appropriative rights of exchange, or any applications for substitute water supply plans, interruptible water supply agreements, or other water court or administrative applications involving the Subject Water Rights prior to obtaining an augmentation plan. The Irrigation District further agrees that it will not oppose Monte Vista's applications in water court, administrative or other proceedings pertaining to Monte Vista's augmentation plan unless it has first consulted in good faith with Monte Vista for the purpose of determining whether there are means by which the filing of any such opposition can be avoided. Monte Vista agrees that it will not oppose and will consent to the Irrigation District's intervention in any water court, administrative or other proceeding relating to Monte Vista's augmentation plan following good faith consultation between the District and Monte Vista.

c. The Irrigation District is a member of the Rio Grande Water Users Association (the "Association"). Nothing in this Lease, including this paragraph 6, shall restrict in any manner or circumstance any opposition, objections or other actions taken by the Association with respect to any proceeding initiated by Monte Vista.

7. Hold Order or Other Storage Capacity Restriction: If Rio Grande Reservoir's storage capacity is subject to a lawful hold order or is otherwise limited to less than 51,113 acre-feet, the Irrigation District shall stop storing all non-firm water. Monte Vista shall be entitled to use its pro-rata share of the total reduced storage capacity in the Reservoir. The provisions of paragraph 5 of this Lease shall apply to the reduced storage capacity during the period the storage capacity is limited. When all or a portion of the Reservoir's storage capacity is restored, Monte Vista's pro-rata share shall also be restored. Under no circumstances shall Monte Vista be entitled to any refund of any Lease Payment previously paid to the Irrigation District.

8. Emergency Release: If the Irrigation District is required to release water from Rio Grande Reservoir because of an emergency or order of the State or Division Engineer, it will cooperate with Monte Vista and the Division Engineer to plan the release of Monte Vista's stored water in a manner that the Division Engineer agrees will meet Monte Vista's augmentation requirements or other decreed purposes, and then take the following steps:

First: It will release all non-Irrigation District spillable water;

Second: It will release all Irrigation District water that it can legally divert at the Farmers Union Canal headgate or some other location agreed to by the State or Division Engineer;

Third: It will endeavor to exchange stored water to Santa Maria and/or Continental Reservoirs. Any stored water so exchanged will be divided pro-rata between the Irrigation District, Monte Vista, and any other entity with firm storage in Rio Grande Reservoir; and,

Fourth: It will release pro-rata the water stored by the Irrigation District, Monte Vista, and any other entity with water in firm storage in Rio Grande Reservoir.

9. Enlargement: If Rio Grande Reservoir is enlarged and its current storage capacity of 51,113 acre-feet is increased, Monte Vista's pro-rata share used to calculate its share of Reservoir costs and expenses as set forth in this Lease shall be recalculated. Monte Vista shall have the option to obtain additional storage capacity in an enlargement subject to agreement with the Irrigation District.

10. Potential Reservoir Rehabilitation: The Irrigation District is seeking funding for rehabilitating the dam, outlet works, and spillway at Rio Grande Reservoir. To the extent the Rehabilitation Project or a portion of that Project as described in the Rehabilitation Study is funded and is constructed during the Lease term, Monte Vista shall not be charged or assessed any costs or expenses related to the construction of that Project.

11. Seepage and Evaporation: Monte Vista agrees to a proportionate allocation of the loss of water for seepage and evaporation of water stored in Rio Grande Reservoir. Evaporation loses shall be assessed as determined by the Division Engineer, if such evaporation losses are assessed to Rio Grande Reservoir. If the seepage can be measured, subject to the agreement of the Division Engineer and, if required by the Water Court, Monte Vista may account for the seepage to meet its augmentation requirements and the amount of seepage accounted for in this manner will be deducted from Monte Vista's stored water.

12. Assignment: The right to use storage capacity in Rio Grande Reservoir as provided for in this Lease shall not be separately assigned or sublet by Monte Vista to any other person, firm, or organization unless agreed to in writing by the Irrigation District, which agreement shall not be unreasonably withheld.

13. Accounting: The Irrigation District, after consultation with Monte Vista, shall implement and utilize such reservoir accounting procedures to effectuate this Lease as may reasonably be required by the Division Engineer.

14. No Abandonment: By entering this Lease and storing the Subject Water Rights, the Irrigation District does not and does not intend to abandon, relinquish, or forfeit any amount of water associated with its water rights decreed for storage in Rio Grande Reservoir.

15. Legal Right to Store: Monte Vista is solely responsible for assuring that the Subject Water Rights may be legally stored in Rio Grande Reservoir and can be used for the purposes designated by Monte Vista upon release from the Reservoir.

16. Delivery: Monte Vista shall take delivery of any Subject Water Rights stored in Rio Grande Reservoir at the point the Reservoir outlet works discharge into the Rio Grande. The Irrigation District shall have no obligation or responsibility for delivery of the Subject Water Rights stored in Rio Grande Reservoir downstream of the Reservoir's outlet works.

17. Water Quality: The Irrigation District provides no warranty but shall make reasonable efforts to operate Rio Grande Reservoir in a manner that does not impair the quality of the water stored in the Reservoir, including water stored by Monte Vista.

18. Waiver: Monte Vista waives any loss or claim of loss against the Irrigation District, its employees and agents, for the Irrigation District's operation of Rio Grande Reservoir.

19. Indemnification: To the extent authorized by law, Monte Vista shall indemnify, save, and hold harmless the Irrigation District, its employees and agents, against any and all claims, damages (including, but not limited to, state owned natural resources), liability and court awards including costs, expenses, and attorney fees

incurred as a result of any act or omission by the Irrigation District, or its employees, agents, subcontractors, or assignees in the operation of Rio Grande Reservoir pursuant to the terms of this Lease.

20. Use of the Reservoir for Recreational Purposes: Notwithstanding any other provision of this Lease to the contrary, none of the Lease's terms or condition shall be construed or interpreted as a waiver, either expressed or implied, of the limitations on the Irrigation District's potential liability that may arise from use of its property by members of the public for public recreational purposes under the provisions of Article 41 of Title 33, C.R.S., as amended or as it may be amended.

21. TABOR. This agreement is subject to annual appropriation of funds for each and every year of the Lease, and nothing herein contained shall be construed in a manner to violate Article 10, Section 20 (TABOR) of the Colorado Constitution.

22. Governmental Immunity: Notwithstanding any other provision of this Lease to the contrary, none of the Lease's terms or conditions shall be construed or interpreted as a waiver, either expressed or implied, of any of the immunities, rights, benefits, or protections provided to Monte Vista or the Irrigation District under the Colorado Governmental Immunities Act, 24-10-101, *et seq*. C.R.S., as amended or as it may be amended (including, without limitation, any amendments to such statute, or under any similar statute which is subsequently enacted).

23. Option to Renew: Monte Vista shall have the right to renew this Lease for additional terms of thirty (30) years for thirty-five hundred dollars ($3,500) per acre-foot, adjusted by the change in Bureau of Labor Statistics' Consumer Price Index (CPI) CPI-U (CPI for all urban consumers, U.S. city average, all items) from the date of this Storage Lease Agreement to the effective date of such renewal.

24. Termination: Monte Vista may terminate this Lease on sixty (60) days written notice at any time after it has paid the Irrigation District for up to one hundred eighty (180) acre-feet of firm storage capacity pursuant to paragraph 3.b. above. If Monte Vista exercises its right to terminate under this paragraph, the Irrigation District shall have no obligation to return any funds previously paid by Monte Vista to the District.

25. Default: If Monte Vista defaults in the performance of any of its obligations under this Lease, then (a) the Irrigation District will give Monte Vista written notice of the default; and (b) Monte Vista will have thirty (30) days thereafter to cure the default unless cure of the default will reasonably require more than thirty (30) days, in which case Monte Vista will have thirty (30) days to undertake substantial action to cure the default and thereafter diligently complete the curative actions. If Monte Vista fails to cure the default, then the Irrigation District, in addition to any other remedies that may be available at law or in equity, will have the right to terminate this Lease by written notice to Monte Vista.

26. Dispute Resolution: The parties agree that should any dispute arise under this Lease, they will submit such dispute to non-binding mediation prior to seeking to enforce such Agreement in court. If the Parties litigate any provision of this Agreement for a breach or default under this Lease, the non-prevailing Party will pay to the prevailing Party all reasonable costs and expenses, including but not limited to, reasonable attorneys' fees and court costs incurred by the prevailing Party in preparation for and at trial, and on any appeal.

27. Force Majeure: If at any time, the Irrigation District is unable to provide storage or release of water at Rio Grande Reservoir pursuant to this Lease, by reason of an act of God or other forces beyond the District's control, state law, rule or order, then for the period of time storage cannot be provided, this Lease shall be held in abeyance and be of no force or effect.

28. Reservoir not a Public Water System: The Parties agree that by providing Monte Vista firm storage capacity in Rio Grande Reservoir, the Irrigation District is neither operating nor including the Reservoir in a "public water system," a community water system," or a "non-community water system" as those terms are defined in the Safe Drinking Water Act, 42 U.S.C. §§ 300f – 300j-26, that the District is not a provider of drinking water within the meaning of the Safe Water Drinking Act, and that the District has no responsibilities to Monte Vista or its citizens under the Safe Water Drinking Act. The Parties further agree that the Irrigation District has no obligation to Monte Vista or its citizens under the Colorado Drinking Water Quality statute, C.R.S. § 25-1-107(x), or under the Colorado Primary Drinking Water Regulations, 5 CCR 1003-1.

29. Authority: Each Party hereby warrants and represents that it has the full right and lawful authority to enter into this Lease and has taken all actions required to make this Lease binding on the Party.

30. Notices: Any notice, demand, or election under this Lease must be in writing and must be given in person or mailed by registered or certified mail, addressed as follows:

If to the Irrigation District:

San Luis Valley Irrigation District
Attention: Superintendent
296 Miles Street
PO Box 637
Center, Colorado 81125

If to Monte Vista:

City of Monte Vista
Attention: City Manager
4 Chico Camino
Monte Vista, Colorado 81144-1016

31. Recording: This Lease shall be recorded by Monte Vista in the real property records of Rio Grande and Hinsdale Counties.

32. Modification: This Lease may be modified as necessary by mutual consent of both parties as set forth in a signed and dated written amendment. Each party assumes all risks, liabilities, and consequences of performing work outside the specified scope of this Lease without a prior approved amendment. This Agreement represents the entire agreement between the Parties and supersedes all prior agreements and understandings, written or oral, with respect to the subject matter of this Lease. No representations, warranties, or agreements have been made by the Irrigation District or Monte Vista to one another with respect to this Lease except those contained herein.

33. No Third Party Beneficiaries: It is expressly understood and agreed that enforcement of the terms and conditions of this Lease, and all rights of action relating to such enforcement, shall be strictly reserved to the Parties and nothing contained in this Lease shall give or allow any such claim or right of action by any other third party on such Lease. It is the express intention of the Parties that any person other than Parties receiving services or benefits under this Lease shall be deemed to be an incidental beneficiary only.

34. Assignment: No Party may assign this Lease, parts hereof, nor its rights hereunder without the express written consent of the other Party.

35. Strict Observation of Terms: The failure of a Party to insist in one or more cases upon the strict observation of any of the terms of this Lease shall not be considered as a waiver or relinquishment in any future case of any of the terms of this Lease.

36. Binding Effect: This Lease shall inure to and be binding on the heirs, executors, administrators, successors and assigns of the Parties hereto.

37. Unenforceable Provisions: If any provision of this Lease is determined to be unenforceable or invalid, then such provision of the Agreement shall be unenforceable and invalid, and the remainder of this Lease shall remain in full force and effect to the extent practicable unless both Parties agree otherwise.

38. Captions: The captions of this Lease are for convenience of reference only, are not part of this Lease, and do not define or limit any of the terms of this Lease.

Unless the context clearly requires otherwise, the singular includes the plural, and vice versa.

39. Legal Counsel: Each Party to this Lease has engaged legal counsel to negotiate, draft, and/or review this Lease. Therefore, in the construction and interpretation of this Lease, the Parties agree that it will not be construed against either Party on the basis of authorship.

40. Governing Law: This Lease is governed by the laws of the State of Colorado in all respects including matters of validity, construction, performance, and enforcement. Venue for any action arising out of this Lease is proper only in the District Court of Saguache County, State of Colorado.

[The rest of this page intentionally blank.]

The Parties have signed this Lease effective on the date stated at the beginning of this Lease.

SAN LUIS VALLEY IRRIGATION DISTRICT	THE CITY OF MONTE VISTA
By: ______________________	By: [signature]
Randall Palmgren, President	Jose "Art" Medina, Mayor

STATE OF COLORADO)
) ss
COUNTY OF __________)

The foregoing instrument was subscribed and sworn before me this _____ day of July, 2010, by Randall Palmgren as President of the Board of Directors of the San Luis Valley Irrigation District.

Witness my hand and official seal.

My commission expires: ________

____
Notary

STATE OF COLORADO)
) ss
COUNTY OF Rio Grande)

The foregoing instrument was subscribed and sworn before me this 8th day of July, 2010, by Jose "Art" Medina Mayor of the City of Monte Vista.

Witness my hand and official seal.

My commission expires: 4-27-11

RHONDA VALDEZ NOTARY PUBLIC STATE OF COLORADO

Rhonda Valdez
Notary

The Parties have signed this Lease effective on the date stated at the beginning of this Lease.

SAN LUIS VALLEY IRRIGATION DISTRICT

By: Randall Palmgren
Randall Palmgren, President

THE CITY OF MONTE VISTA

By: ______________________
____

STATE OF COLORADO)
) ss
COUNTY OF Saguache)

The foregoing instrument was subscribed and sworn before me this 8th day of ~~July,~~ September 2010, by Randall Palmgren as President of the Board of Directors of the San Luis Valley Irrigation District.

Witness my hand and official seal.

My commission expires: 6/30/2012

____
Notary

STATE OF COLORADO)
) ss
COUNTY OF ___________)

The foregoing instrument was subscribed and sworn before me this ______ day of July, 2010, by ________________ as ________________ of the City of Monte Vista.

Witness my hand and official seal.

My commission expires: _________

____
Notary

Appendix B

HELTON & WILLIAMSEN, P.C.
CONSULTING ENGINEERS IN WATER RESOURCES
384 INVERNESS PARKWAY, SUITE 144
ENGLEWOOD, COLORADO 80112-5822
PHONE: (303) 792-2161
FAX: (303) 792-2165

RIO GRANDE RESERVOIR DAILY MODEL - TECHNICAL MEMORANDUM

October 12, 2011

I. INTRODUCTION

A water use and storage model was initially developed by CDM, Inc. utilizing a monthly time step to investigate changes to Rio Grande Reservoir storage levels and stream flows that would occur by operating the Reservoir with increased storage capability and capacity associated with the rehabilitation and enlargement options. The monthly model description was identified in Section 8 of the report entitled *Rio Grande Reservoir - Multi-Use Rehabilitation and Enlargement Study Phase II,* dated October 10, 2008. The daily model described herein has been modified from the monthly time step model. The basic principles in the monthly model were maintained in the daily model, and certain aspects of the documentation in the previous report will be included in the following documentation. As in the monthly model, storage accounts for multiple entities are modeled. The available flows for daily storage, daily release demands, and quantity and type of storage (e.g., firm/spill-proof or space available storage) can be specified. Differing storage and release patterns can be specified for each month based on characterization of each year as dry, average, or wet. The model calculates the volume of water each entity has in storage, the volume spilled, and the effects of differing storage and release patterns on stream flow downstream of the dam.

II. MODEL SUMMARY

Several entities have expressed interest in acquiring or maintaining storage space in the Rio Grande Reservoir. The model evaluates the impact to the San Luis Valley Irrigation District's storage space for its reservoir water rights and direct flow storage water right associated with the Farmers Union Canal. Entities included in the daily model that already have storage accounts in the reservoir are the Division of Water Resources (Compact), Colorado Parks and Wildlife (CPW), the San Luis Valley Water Conservancy District (SLVWCD), Rio Grande Canal Direct Flow Storage (RGC DFS), Commonwealth Irrigation Company Direct Flow Storage (Empire DFS), and "Other Entities", which include parties who have agreements with the District to store smaller amounts of water at the Reservoir.

The model also includes additional accounts for the proposed sub-districts in the Rio Grande basin. These sub-district accounts could utilize a portion of the available current storage capacity in the reservoir. The sub-districts have not historically had any storage accounts; thus, the impact of storing water for sub-districts could affect reservoir storage levels, releases, and stream flows. The model is designed to evaluate these potential impacts. A base assumption in the model is that those entities interested in storing water at the Reservoir have, or will have, their water rights decreed for such storage. No restrictive terms and conditions have been placed in the model. Any terms and conditions from such decrees can be added to the model upon entry of the decrees.

The daily model is a spreadsheet-based model that expanded the original monthly model developed by CDM, Inc. The model allows for instantaneous results when changes are made to any of the several model parameters, including storage pool volumes for each entity, storage and release patterns, and evaporation and loss charges. The model uses historical flows and storage patterns from 1980 to 2008 on a daily time step as its input basis. This period of record was selected based on the period of record used in the monthly model and the daily curtailment data obtained from the Division 3 Engineer's Office. Modeled storage and releases are superimposed over the historical regime, and changes in flow patterns are calculated. Firm storage (non-spillable) and space-available storage capacity can be specified for each entity, and the demands for each entity can be specified as either a set volumetric demand, or as a percentage of the current pool. Storable flows for each entity were developed and are explained in further detail below. Modeled storage shows end-of-day contents at the Reservoir for each entity and for the Reservoir as a whole. Changes in stream flows to the Rio Grande as a result of the modeled storage patterns at the Reservoir are calculated at the Thirty Mile, Del Norte, Monte Vista, Alamosa, and Lobatos gages. These gaging stations have complete records of daily data for the selected period of record. Other gaging stations on the Rio Grande were evaluated for inclusion in the daily model but were not included due to lack of a complete daily data record.

Changes in river flow due to proposed changes in Reservoir operations are also analyzed by changes to the "last priority served". Helton & Williamsen, P.C. compiled a list of the Division 3 Engineer's Last Priority Served and the associated non-curtailment flow at the Del Norte gage. For example, it takes 788.16 cfs for the Rio Grande Canal right (Priority 216A) to be fully satisfied. Any flow above this amount partially satisfies the next priority (#217), the Rio Grande & Lariat Ditch, until it is fully satisfied when the Del Norte flow is 841.18 cfs. This list is incorporated into the RGR model, referencing the Del Norte non-curtailment flows on the "**Streamflows**" sheet. The "**WR Served**" (Water Right Served) sheet compares the historical theoretical calls with those that would potentially take place under the scenario being modeled, based on changes in flow at the Del Norte gage. This sheet is described in further detail in Section IV below. This comparison method does not consider whether a water right's apparent injury is due to the same water right being stored in the Reservoir when it historically was run down the river, and it also does not attempt to predict the Division 3 Engineer's administrative practice or the impacts of changes in return flow patterns.

Another component to the model calculates the potential hydropower output from the reservoir. The model will evaluate the amount of potential power generated from modeled releases from the Reservoir for three different sets of turbines. The power generation calculation utilizes the amount of flow released from the reservoir and its corresponding efficiency at that flow rate. Included in modeled potential releases are any spill amounts; the releases and spills are routed through the turbines rather than being allowed to discharge over the spillway. The flow through the turbine, and thus the amount of power produced, is limited to the maximum flow rate for the specified turbine. Any excess flow above the maximum flow rate is allowed to flow past the turbines to the river, and the maximum flow of the turbine is used for power generation. The power generation potential of the modeled Reservoir operation is reported in a few tables within the model and also in a separate spreadsheet containing summary tables of the power generation output. These are discussed in Section IV below. During model development, power could be produced nearly every year in April through October by adjusting the parameters for the SLVID so that a minimum flow is released regardless of the other Reservoir operations.

As an aid to comparing wet, average, and dry years and their overall effect on the Reservoir operations, a separate spreadsheet containing NRCS stream flow forecast data has been developed. The data were collected from the NRCS from online reports and through personal communications with NRCS staff. This spreadsheet is also discussed in greater detail in Section IV, and the data are described in the next section.

The CDM report introduced the method of considering environmental releases from the Reservoir through the application of Indicators of Hydraulic Alteration (IHA). IHA is a statistical tool developed by The Nature Conservancy which compares statistics on natural and modeled flows. The model computes several statistics on both naturalized and modeled flows. Modeled flow statistics that are within one standard deviation of the naturalized flow are considered successes, while those lying outside of this range are considered failures. The model divides the number of successes by the total number of occurrences to compute the attainment percentage. The higher the attainment percentage, the closer the flow regime is to the naturalized flow regime (i.e., to the flow regime before the impacts of man). The model's reports of the attainment percentages of several IHA parameters are introduced in Section IV.B below.

III. INPUT DEVELOPMENT

There are several inputs to the model, including historical flow and storage data and user specified inputs.

Historical gage data for the Thirty Mile, Del Norte, Monte Vista, Alamosa, and Lobatos gages were obtained from the Colorado Decision Support System (CDSS) Hydrobase and summarized in units of acre-feet per day. Monthly climate data were also obtained from the CDSS Hydrobase. The climate data are not direct inputs to the model calculations but rather provide additional information in analyzing the effects on Reservoir operations and river flows during specific years or wet, average, and dry years in general.

Historical Reservoir storage levels were taken from multiple sources. RGDSS model input and Rio Grande Daily Reports were used for 1980 through October 1994 and 2006 through 2008. Data provided by the District in the form of Reservoir Storage and Release books and monthly Superintendent reports were used for November 1994 through December 2005. When the Reservoir Storage and Release books or Superintendent reports were available, that data superseded RGDSS input and Rio Grande Daily Reports as the District data are considered an original source. Where values were not available from the District-provided data, RGDSS and Daily Report values were used. Any daily reservoir data that could not be filled from these sources were interpolated. For example, only beginning-of-month values were available from September 1, 1986 to May 1, 1988, so the daily values between these dates were interpolated.

Forecasted and actual stream flows were obtained online and from NRCS through NRCS personnel. The most complete and usable forecast data sets are the April, May, and June 50 percent confidence interval forecasts for total April-September flow for the Del Norte and 30-Mile gages. Data for most of the period were obtained from the NRCS office in Denver. These forecasts were missing for 1996-97 and 2007-08; the missing forecasts were filled from reports available at the NRCS website. The actual observed April through September flows were obtained from the Snow Survey Supervisor at the NRCS office in

Lakewood, CO. RG Forecasted & Actual Stream flow 1982-2008 is a separate spreadsheet, described in Section IV.D. below, that contains tabular and graphical summaries of this data.

The model user can specify the amount and type of storage accounts for each entity in the model. There are two types of storage: firm and space-available. Firm storage is guaranteed to not spill and is higher priority water than any water the District has in storage. Space-available storage is allocated only if there is remaining capacity after the District has stored its water and all firm storage pools have been quantified. If an entity has both firm and space-available storage, water is stored first in firm storage, then in the space-available pool. Water is released first from the space-available pool, then from firm storage. The entire Reservoir capacity of approximately 54,000 AF is used in the model, but the District is limited to its decreed amount of 51,113 AF for storage of its native Rio Grande storage decrees.

Storable flows are calculated for each entity based on each entity's existing or projected water supplies that could potentially be stored in the Reservoir. The source of storable flows for each entity is summarized in Table III.1. The user can specify the portion of the storable flow to store by either a percentage of the storable flow or as a volumetric demand, and different storage patterns can be specified for dry, average, and wet years. For example, San Luis Valley Water Conservancy District (SLVWCD) is modeled as having available for potential storage 50 percent of the Pine River Weminuche Ditch that brings trans-basin water into the Reservoir and 121 AF of the Anaconda Ditch. The maximum SLVWCD 's storable flows are specified as 50 percent of the Pine River Weminuche ditch flows plus the 121 AF of the Anaconda Ditch. In addition, volumetric storage demands are always supply-limited by the source of storable flows (e.g., if there is a specified storage demand of 100 AF, and only 80 AF is physically available, only 80 AF goes into storage). Release patterns are also specified for each entity in the tables. Similar to Storable Flows, Releases can be specified as either a percentage of the current pool or a volumetric release, and are also supply limited.

Table III.1: Source of Potential Storable Flows

Entity	Source of Storable Flows
Compact Water	Historical curtailment water at the Del Norte gage, limited by physical availability of inflows at the Reservoir.
SLVWCD	50 percent of Pine River Weminuche Ditch and 121 AF of the Anaconda Ditch (assumed to yield 60 AF in May, 40 AF in June and 21 AF in July, and assumed exchanged to the Reservoir).
CPW	Tabor Ditch. Stored water assumed exchanged to the Reservoir.
DFS	The minimum of Big 6 diversions without SLVID diversions. Flow at Del Norte less 2150cfs or inflows to the Reservoir. DFS available flow is limited by the USFS instream flow decree.
Other Entities	Historical storage average based on wet, average, and dry years.

IV. MODEL USE PROCEDURE

The basic operation of the Rio Grande Reservoir daily operations model was introduced above. This section describes the operation in more detail. The model is operated by adjusting storage and release volume limits or triggers in various parameter sheets as described below. The model automatically recalculates each time a parameter is changed, so the effect of the change can be seen immediately. Figure B.IV.1 is a flow chart of the model and displays the interrelation of the model sheets. The colors of the sheet icons for input or output in Figure B.IV.1 correspond with the colors of the navigation arrows on the Menu sheet.

IV.A. Model Input

1. **Menu Sheet:** The Menu sheet is used for navigation purposes. The navigation arrows on the left take the model user to the parameter sheets that adjust the amounts the various entities that may store water in the Reservoir, and the arrows on the right hand column navigate to the sheets that display various outputs of the model (Figure B.IV.2). Descriptions of these sheets follow:

2. **Storage Pools Sheet:** The “Storage Allocation” arrow on the **Menu** sheet takes the user to the Storage_Pools sheet (Figure B.IV.3) where default spill-proof and space-available storage amounts for all entities can be adjusted. In addition, the total storage of the reservoir may be changed to model the expansion option.

3. **Parameter Sheets:** The “Parameter” arrows on the left-hand column of the **Menu** sheet (blue arrows below the “Storage Allocation” arrow) navigate to the parameter sheets for each entity, wherein monthly storage and release amounts are assigned. For example, clicking on the “SLVID DFS” arrow would take the user to the **Parameter Farmers DFS** sheet where the user may 1) set the monthly storage and release requirements to percentages or volumes, 2) adjust the monthly percentages and volumes, and 3) adjust the evaporation charge on releases.

IV.B. Model Output

1. **Chart Sheets:** The right-hand portion of the **Menu** sheet contains arrows that navigate the user to the output results. The top three orange arrows take the user to graphical output:

a. **Storage Charts:** The “Storage Charts” arrow allows the user to see daily and monthly storage for a particular entity and year, in addition to the potential hydro power produced that year (Figure B.IV.4).

b. **Flow Charts:** The “Flow Charts” arrow links to the sheet that displays daily and monthly total flows at the user’s choice of stream gage and year along with a climate station specified by the user (Figure B.IV.5).

c. **Hydropower annual chart Sheet:** The “Hydropower Chart” arrow takes the user to charts displaying the annual and monthly average historical and modeled power production potential (Figures B.IV.6 and B.IV.7).

2. **Flow & Storage Sheets:** The next three green arrows navigate the user to the sheets where stream flows and hydropower production potential are calculated, in addition to IHA parameters.

a. **Streamflows Sheet:** The “Modeled River Flow” arrow navigates to the **Streamflows** sheet where the historical river flows (recorded stream gage data) are adjusted by the model based on the user-entered parameters. This sheet also calculates the “last priority served” comparison described in Section II above.

b. **sim2 Sheet**: The "Modeled Rio Grande Reservoir Storage" arrow displays the **sim2** sheet. This sheet is where the bulk of the reservoir modeling is calculated. The daily calculations displayed on this sheet are summarized in the chart sheets described above.

c. **IHA Summary Sheet:** The "Monthly IHA Parameters Summary" arrow displays the sheet containing the monthly percent of attainment for each of the Nature Conservancy's IHA (Indicators of Hydraulic Alteration) parameters at each stream gage. These calculations are based on monthly streamflows.

3. **Loss Percentages Sheet:** The "Evap/Loss Percentages" arrow (first blue arrow on the right hand side of the **Menu** sheet) navigates to this sheet that displays the evaporation and loss percentages charged by the Division 3 Engineer and used in the model to calculate the adjusted flow due to the modeled scenario.

4. **Parameters Sheet:** The "Evaporation Parameters and Volume-Area Table" arrow displays the Parameters sheet, which houses temporary storage amounts as changed from the original parameters specified in the Storage Allocation step ("Storage Allocation" arrow, IV.A.2).

5. **WR Served Sheet:** The "Calling Water Right" arrow navigates the user to the **WR Served** sheet which contains a comparison of the potential calling water right from historical to modeled reservoir operations. This sheet contains two tables showing daily potential water right calls during the irrigation season (April–October). The top table displays the call based on historical conditions, and the bottom table shows the modeled condition. Changes in call regime are highlighted by 1) green cells if the flow increases and the call becomes more junior, and 2) bold red text if the flow decreases and the call becomes more senior. The year is changed by spinner buttons at the top left of the sheet. Figure B.IV.8 is an example of the **WR Served** sheet. The data and basis for this comparison were described in Section II above.

IV.C. Hydropower reports

The "**Hydro_Reports**" spreadsheet contains several monthly summary tables of data pertaining to hydropower production. These are Average Monthly Modeled Power, Maximum Monthly Modeled Power, Minimum Monthly Modeled Power, Average Monthly Reservoir Stage, Average Monthly Reservoir Release, and Average Monthly Modeled Turbine Flow. Figures B.IV.9 and B.IV.10 are examples of the Average Reservoir Release and Average Modeled Power summary tables.

The **Hydro** sheet in this spreadsheet is a copy of the **Hydro** sheet in the Rio Grande Reservoir model spreadsheet. The data values in the model's **Hydro** sheet may simply be copied into the **"Hydro_Reports'" Hydro** sheet. The report tables listed above update automatically with this new data.

The **Hydro** sheet is updated by the following steps:

1. Select the data in Columns A through V in the model spreadsheet's **Hydro** sheet;

2. Copy the data;

3. Right-click in Cell A3 of the **"Hydro_Reports'" Hydro** sheet;

4. Choose Paste Special;

5. Choose Values.

IV.D. Stream flow Forecast Charts

"RG Forecasted & Actual Stream flow 1982-2008" is a stand-alone spreadsheet that contains the stream flow forecasts discussed in Section II above. This separate spreadsheet contains summaries of this data and a chart that displays the 50 percent Confidence Interval April through June forecasted and actual annual total streamflows at the 30-Mile and Del Norte gages. The user may change the year displayed by a dropdown menu on the chart. Figure B.IV.11 is an example of this chart.

The user may desire to update this spreadsheet periodically in future years. This involves the following steps:

1. Obtain the data from the NRCS;

2. Insert the data into the bottom of the **DN** and **30Mile** sheets;

3. Copy and paste the formulas in Columns AA through AD of the **DN** and **30Mile** sheets down for the years of data just inserted;

4. Insert rows and copy formulas at the bottom of the **Chart** sheet (below the chart, just above the "Chart Data" row) for the years just updated in the **DN** and **30Mile** sheets; and

5. Update the "Source Data" ranges in the chart.

V. REFERENCES

CDM report, *Rio Grande Reservoir - Multi-Use Rehabilitation and Enlargement Study Phase II,* October 10, 2008.

Colorado Decision Support System (CDSS) – Hydrobase. http://cdss.state.co.us/.

NRCS website for snow surveys: www.co.nrcs.usda.gov/snow.

Pacheco, Chris (NRCS Snow Survey Supervisor). Personal Communication, March 2010. Visited his website, http://www.cpachecojr.com/cgi-bin/work/fcst/hist_fcst.cgi, March 2010.

Rio Grande daily reports.

SLVID reported data.

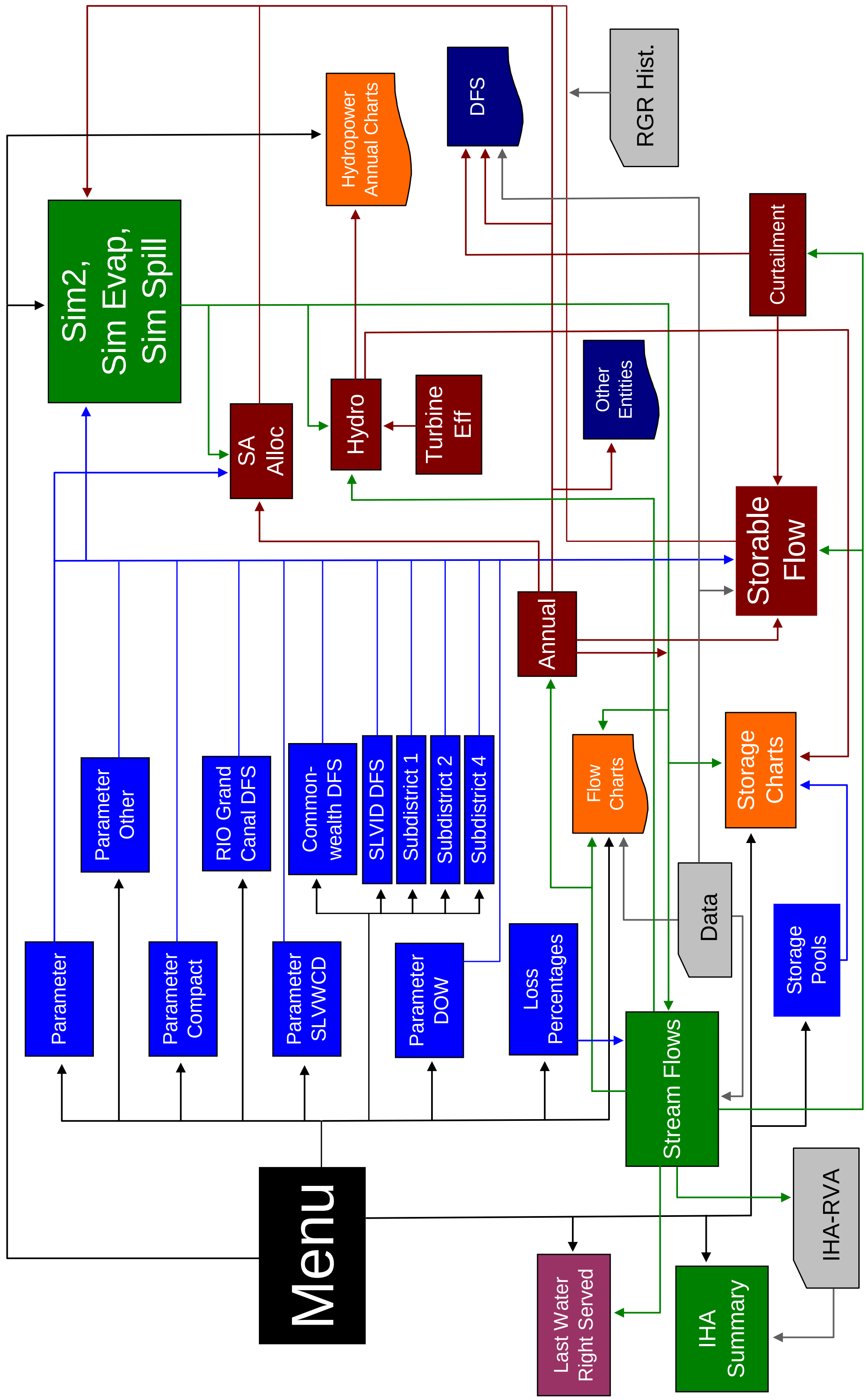

Sim2,
Sim Evap,
Sim Spill
Hydropower
Annual Charts
DFS
RGR Hist.
Curtailment
SA
Alloc
Hydro
Turbine
Eff
Other
Entities
Storable
Flow
Annual
Parameter
Other
RIO Grand
Canal DFS
Common-
wealth DFS
SLVID DFS
Subdistrict 1
Subdistrict 2
Subdistrict 4
Flow
Charts
Storage
Charts
Data
Storage
Pools
Parameter
Parameter
Compact
Parameter
SLVWCD
Parameter
DOW
Loss
Percentages
Stream Flows
Menu
IHA-RVA
Last Water
Right Served
IHA
Summary

Figure B.IV.1: Rio Grande River Daily Model Flowchart

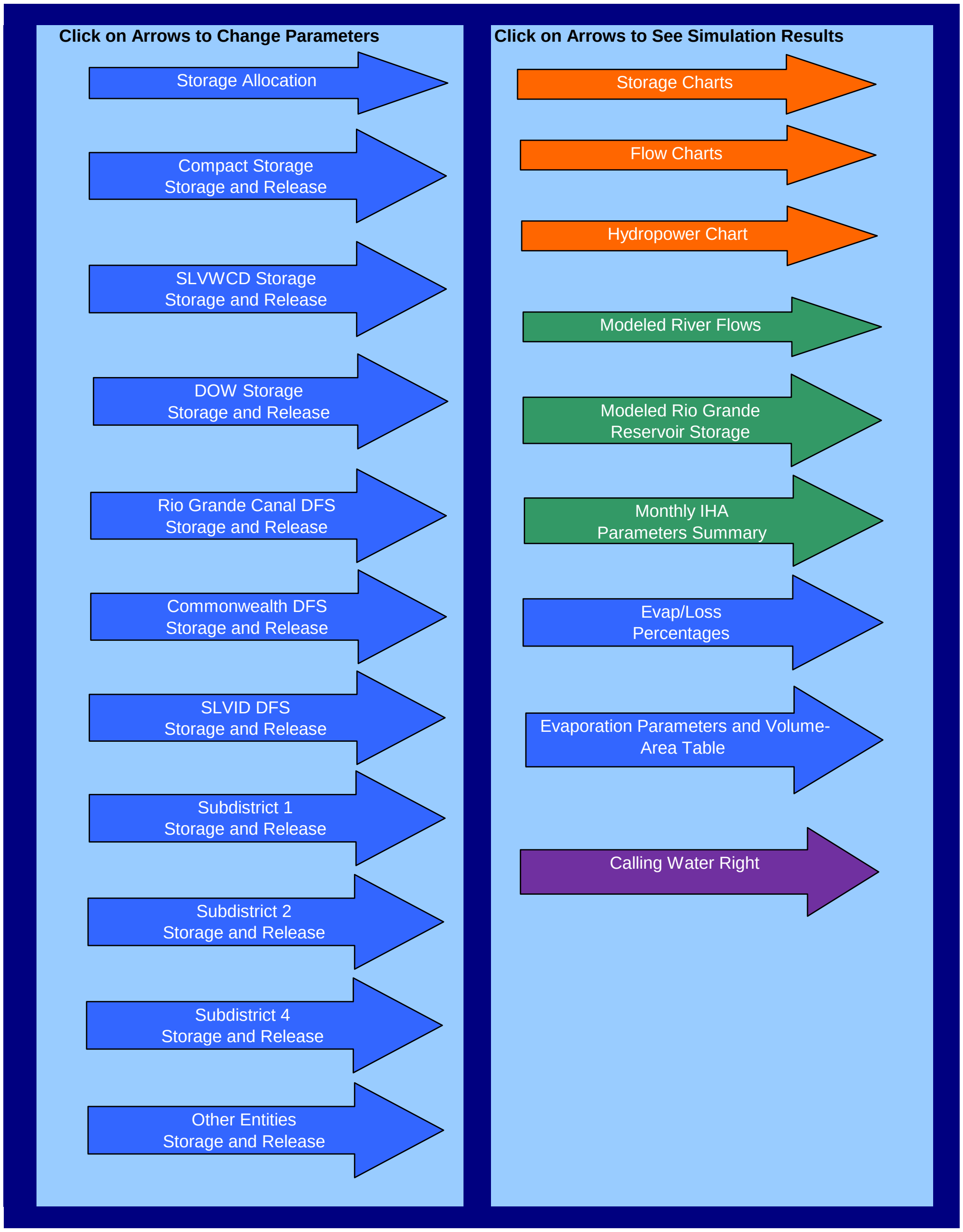
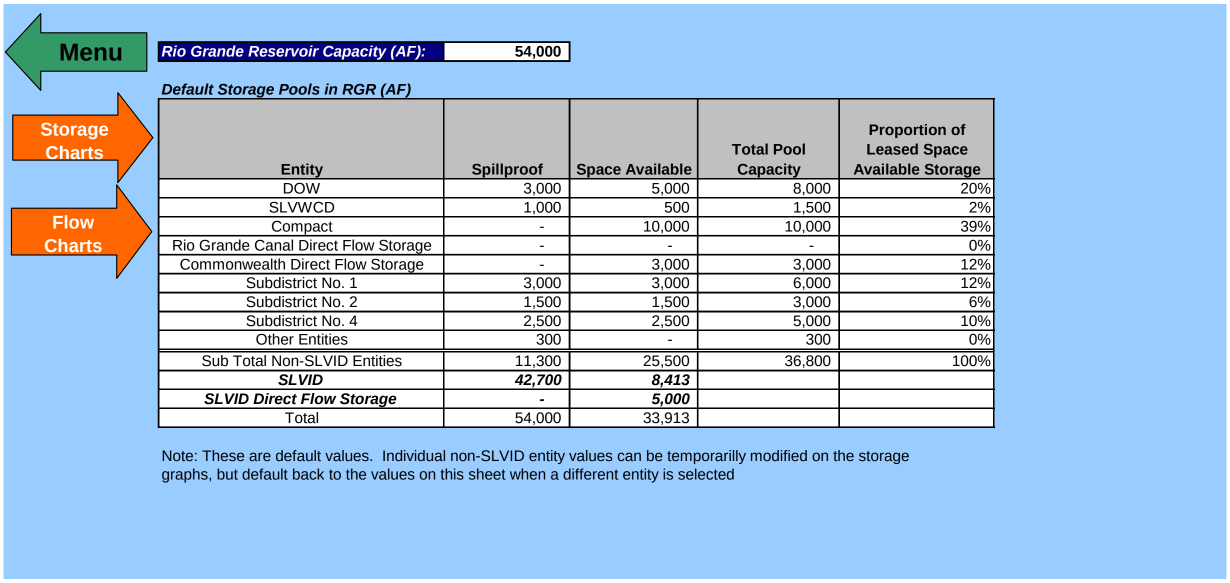


Figure B.IV.2: Menu Sheet



Entity	Spillproof	Space Available	Total Pool Capacity	Proportion of Leased Space Available Storage
DOW	3,000	5,000	8,000	20%
SLVWCD	1,000	500	1,500	2%
Compact	-	10,000	10,000	39%
Rio Grande Canal Direct Flow Storage	-	-	-	0%
Commonwealth Direct Flow Storage	-	3,000	3,000	12%
Subdistrict No. 1	3,000	3,000	6,000	12%
Subdistrict No. 2	1,500	1,500	3,000	6%
Subdistrict No. 4	2,500	2,500	5,000	10%
Other Entities	300	-	300	0%
Sub Total Non-SLVID Entities	11,300	25,500	36,800	100%
SLVID	***42,700***	***8,413***		
SLVID Direct Flow Storage	***-***	***5,000***		
Total	54,000	33,913		

Figure B.IV.3: Storage Pools

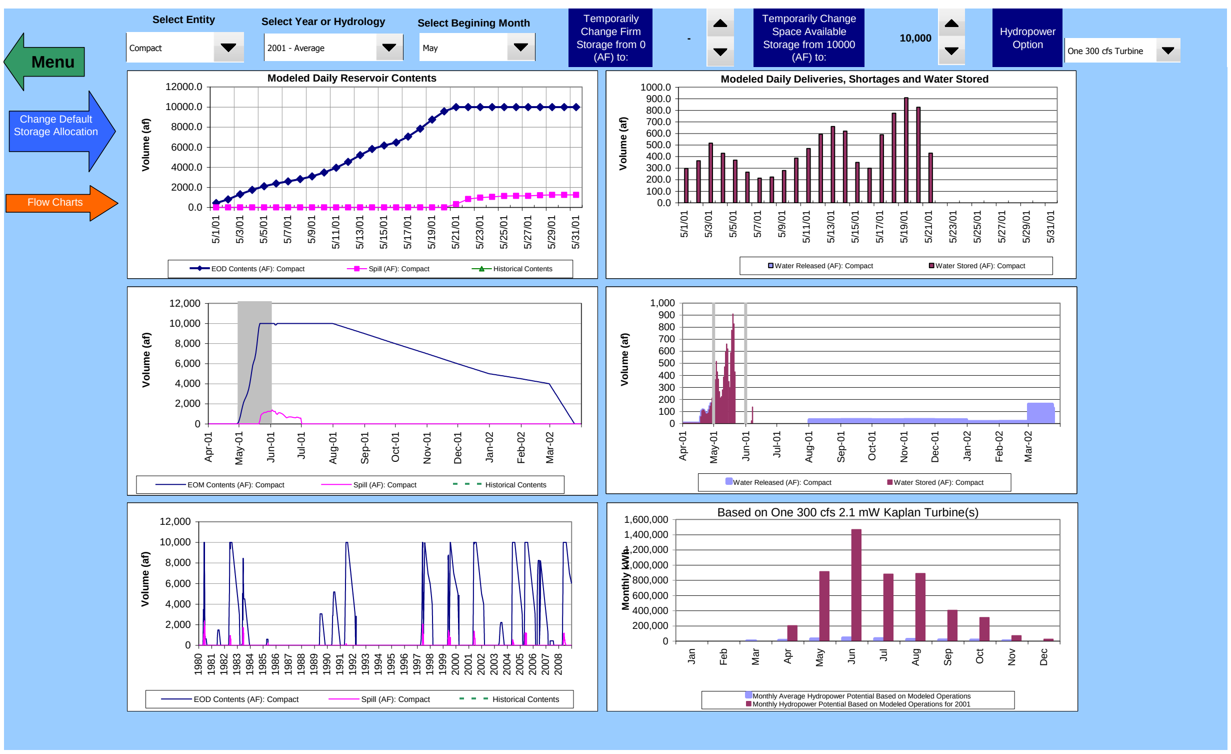


Figure B.IV.4: Storage Charts

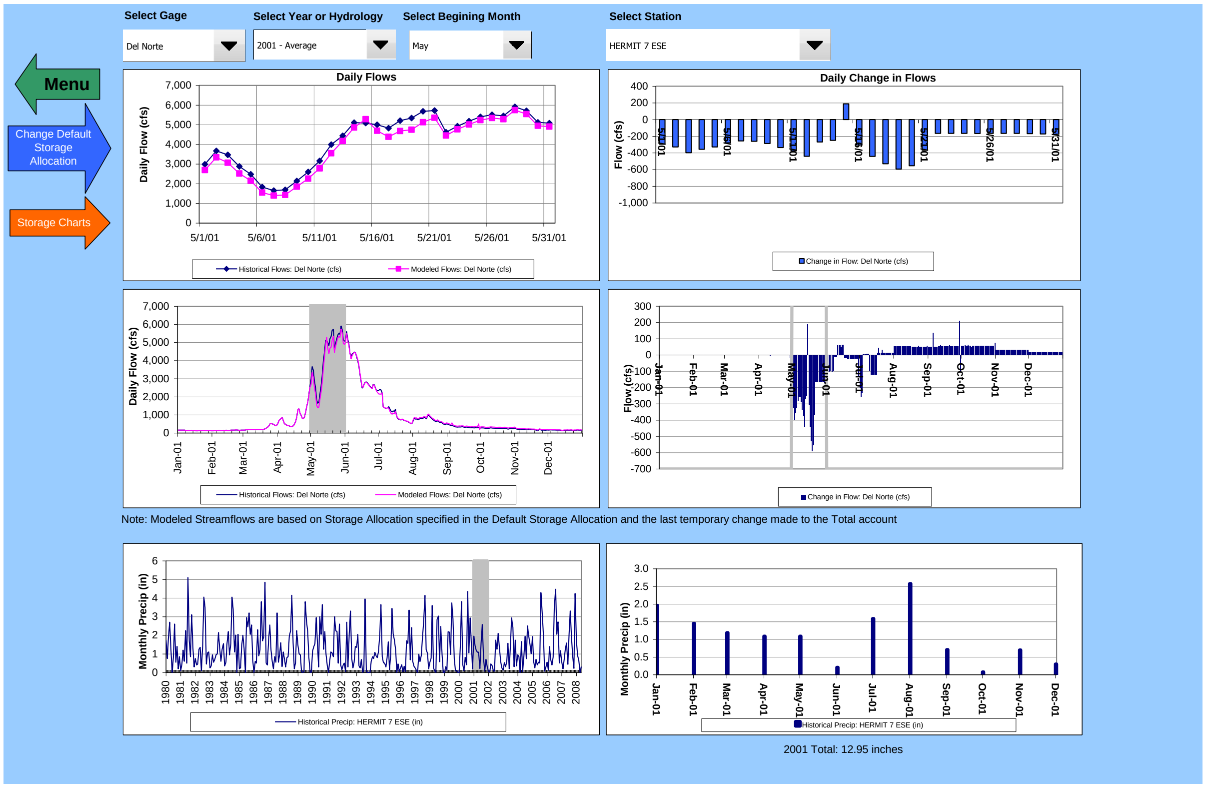


Figure B.IV.5: Flow Charts

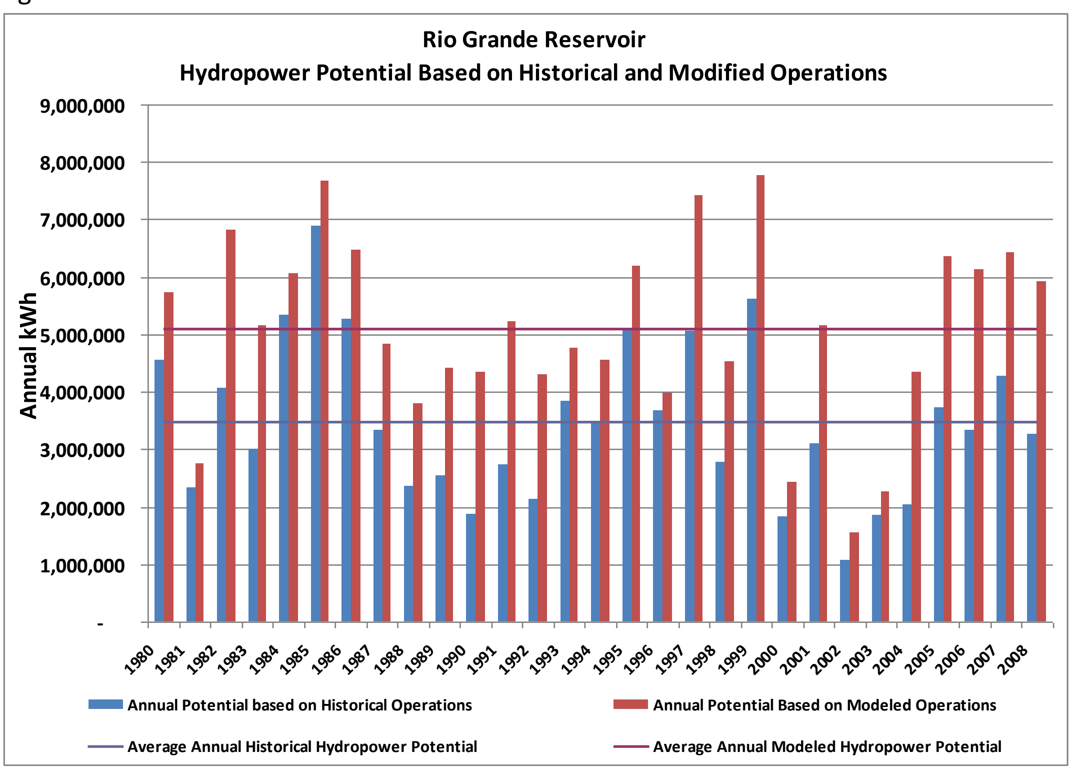


Figure B.IV.6: Annual Total Hydropower Production, Historical vs. Modeled Reservoir Operations

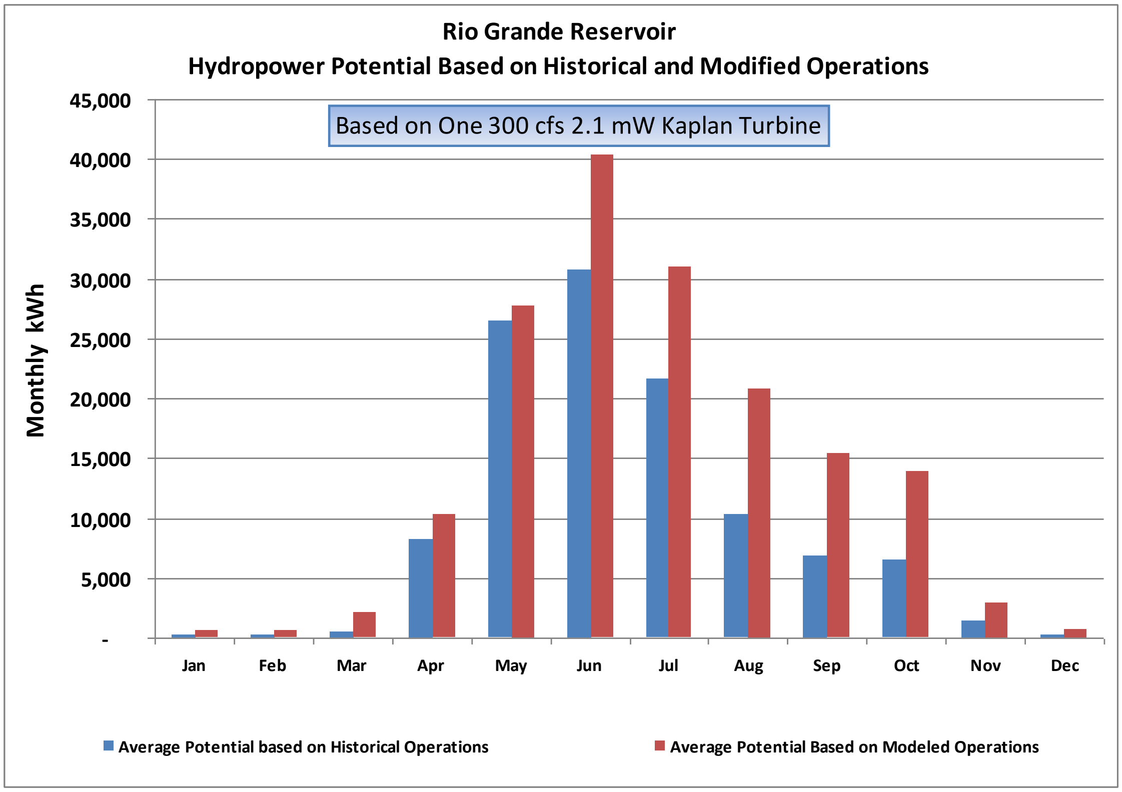


Figure B.IV.7: Monthly Average Hydropower Production, Historical vs. Modeled Reservoir Operations

Last Priority Served and Calling Ditch
From Modeled RGR Operations

Year: 2005

	---------April----------		----------May-----------		----------June----------		----------July----------		---------August----------		-------September--------		---------October--------	
Day	Priority Number	Ditch	Priority Number	Ditch	Priority Number	Ditch	Priority Number	Ditch	Priority Number	Ditch	Priority Number	Ditch	Priority Number	Ditch
1	8	RGrnd #1	216-A	RGC	1903-34-C	RGC	358	MntVsta	199	Park&Green	173	Centnnl	224	MntVsta
2	8	RGrnd #1	216-A	RGC	1903-34-G	FarmersU	322	WestSide	198	RGC	173	Centnnl	216-A	RGC
3	8	RGrnd #1	217	RG&L	1903-34-G	FarmersU	314	FarmersU	198	RGC	174	Chicago	216-A	RGC
4	173	Centnnl	217	RG&L	1903-24-G	SanLuis	314	FarmersU	216-A	RGC	192	Nichol	216-A	RGC
5	173	Centnnl	224	MntVsta	1903-24-C	RGC	308	Prairie	216-A	RGC	197	RGC	236-A	Empire
6	174	Chicago	224	MntVsta	1903-22-E	FarmersU	297	Prairie	216-A	RGC	197	RGC	224	MntVsta
7	203	RGC	236-A	Empire	1903-24-C	RGC	297	Prairie	216-A	RGC	197	RGC	236-A	Empire
8	216-A	RGC	236-A	Empire	1903-22-C	Prairie	290	Kane&Calln	216-A	RGC	197	RGC	217	RG&L
9	216-A	RGC	236-A	Empire	1903-22-C	Prairie	288-A	RGC	216-A	RGC	198	RGC	224	MntVsta
10	200	RGrnd #2	293	Costilla	1903-22-A	RG&L	262	Excelsior	216-A	RGC	211	Empire	224	MntVsta
11	197	RGC	344	RGC	365	RGC	236-A	Empire	216-A	RGC	216-A	RGC	224	MntVsta
12	192	Nichol	314	FarmersU	365	RGC	231	Marajo	216-A	RGC	198	RGC	218	Butler
13	198	RGC	293	Costilla	363-B	RGC	224	MntVsta	216-A	RGC	197	RGC	217	RG&L
14	216-A	RGC	288-A	RGC	363-A	RGC	217	RG&L	216-A	RGC	178	RGC	216-A	RGC
15	216-A	RGC	293	Costilla	365	RGC	216-A	RGC	216-A	RGC	178	RGC	216-A	RGC
16	216-A	RGC	314	FarmersU	365	RGC	216-A	RGC	216-A	RGC	176	RGC	216-A	RGC
17	224	MntVsta	365	RGC	1903-22-B	SanLuis	216-A	RGC	216-A	RGC	173	Centnnl	216-A	RGC
18	224	MntVsta	1903-22-B	SanLuis	365	RGC	216-A	RGC	216-A	RGC	166	Indpndnt	216-A	RGC
19	236-A	Empire	1903-24-D	SanLuis	1903-17	RG&L	216-A	RGC	216-A	RGC	166	Indpndnt	217	RG&L
20	236-A	Empire	1903-30-C	RGC	365	RGC	216-A	RGC	216-A	RGC	163	Excelsior	224	MntVsta
21	236-A	Empire	1903-45-A	MntVsta	365	RGC	216-A	RGC	209	Billings	163	Excelsior	224	MntVsta
22	236-A	Empire	1903-57-A	RGC	365	RGC	216-A	RGC	204	RG&SL	166	Indpndnt	216-A	RGC
23	236-A	Empire	1903-49-D	RGC	365	RGC	216-A	RGC	203	RGC	174	Chicago	216-A	RGC
24	270	SanLuis	1903-46-C	RGC	363-B	RGC	216-A	RGC	202	RGC	193	JAnderson	216-A	RGC
25	259	WestSide	1903-45-C	RGC	363	WestSide	216-A	RGC	200	RGrnd #2	178	RGC	216-A	RGC
26	236-A	Empire	1903-45-G	SanLuis	363-B	RGC	216-A	RGC	216-A	RGC	173	Centnnl	216-A	RGC
27	236-A	Empire	1903-49-D	RGC	361-B	Empire	216-A	RGC	216-A	RGC	173	Centnnl	216-A	RGC
28	236-A	Empire	1903-45-C	RGC	361-A	Empire	216-A	RGC	216-A	RGC	216-A	RGC	216-A	RGC
29	224	MntVsta	1903-34-G	FarmersU	358	MntVsta	216-A	RGC	203	RGC	216-A	RGC	216-A	RGC
30	217	RG&L	1903-34-D	SanLuis	358	MntVsta	216-A	RGC	197	RGC	216-A	RGC	216-A	RGC
31			1903-30-F	RG&SL			204	RGC	174	Indpndnt			216-A	RGC

Figure B.IV.8: Excerpt of WR Served sheet, Comparison of Modeled to Historical River Conditions due to Reservoir Operations

AVERAGE RESERVOIR RELEASE, CFS													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann Ave
1980	1	0	0	3	226	112	367	96	72	63	19	3	80
1981	19	21	11	20	173	178	27	23	14	39	0	0	44
1982	1	0	0	64	83	162	204	220	58	99	24	7	77
1983	6	5	4	38	9	183	312	131	73	75	25	8	72
1984	9	8	7	40	31	16	270	85	54	54	17	1	49
1985	0	0	0	41	92	20	67	126	40	80	160	5	53
1986	0	0	0	46	101	9	212	380	88	39	17	0	74
1987	0	0	0	42	0	1	325	282	53	37	17	0	63
1988	4	3	3	41	48	184	30	76	64	50	21	3	44
1989	4	3	3	43	47	347	216	86	51	45	22	6	73
1990	6	6	5	43	10	260	147	64	62	52	25	9	57
1991	10	9	8	44	30	249	208	71	74	53	24	7	66
1992	8	7	6	36	33	176	107	53	51	44	17	1	45
1993	1	0	0	42	39	2	323	91	49	49	17	1	51
1994	1	0	0	39	8	236	295	46	41	46	17	1	61
1995	1	0	0	55	200	11	17	107	46	54	19	3	43
1996	24	21	13	38	156	381	26	12	8	5	0	8	58
1997	0	0	3	38	67	88	476	164	77	45	25	10	83
1998	10	15	8	48	32	120	25	48	44	46	18	2	35
1999	0	0	0	36	0	23	373	119	170	174	46	8	79
2000	41	33	25	20	85	157	37	8	4	1	0	0	34
2001	1	0	0	1	7	358	70	58	56	50	21	4	52
2002	19	21	19	28	19	15	18	10	10	10	28	22	18
2003	7	6	8	18	98	169	73	17	17	11	1	0	35
2004	1	7	0	5	133	73	25	48	64	61	17	1	36
2005	117	0	0	52	187	173	240	69	61	71	17	16	83
2006	1	0	20	82	121	184	21	58	47	93	17	1	54
2007	1	0	0	67	3	121	162	56	53	61	18	1	45
2008	1	1	1	163	158	144	53	51	52	45	36	0	59
Monthly Average	10	6	5	43	76	143	163	92	54	54	24	4	56

Figure B.IV.9: Average Reservoir Release table

AVERAGE MONTHLY MODELED POWER, KW													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1980	0	0	0	11	843	406	1,496	321	290	208	35	0	3,610
1981	37	41	6	57	623	515	50	46	16	103	0	0	1,495
1982	0	0	0	287	416	873	1,095	821	199	361	36	0	4,090
1983	0	0	0	112	34	513	1,739	560	313	312	48	0	3,632
1984	0	1	0	132	192	43	994	413	216	220	37	0	2,249
1985	0	0	0	165	592	60	408	702	166	449	922	25	3,488
1986	0	0	0	206	711	20	794	1,417	293	82	21	0	3,544
1987	0	0	0	83	0	0	1,368	1,311	136	82	24	0	3,004
1988	0	0	0	110	220	892	89	302	232	153	36	0	2,035
1989	0	0	0	148	249	1,698	503	221	162	103	30	0	3,113
1990	0	0	0	108	22	941	690	229	204	157	38	0	2,389
1991	0	0	0	151	140	1,169	915	279	273	170	36	0	3,133
1992	0	1	0	104	138	872	375	156	145	108	24	0	1,923
1993	0	0	0	129	149	0	1,133	313	188	175	35	0	2,122
1994	0	0	0	144	21	856	789	146	120	135	29	0	2,240
1995	0	0	0	219	903	44	50	425	218	267	59	10	2,196
1996	88	59	20	186	798	1,322	47	19	14	9	0	32	2,595
1997	0	0	11	142	331	233	1,694	596	257	99	32	7	3,402
1998	0	20	0	125	126	528	77	154	133	140	34	7	1,344
1999	0	0	0	124	0	71	1,700	563	674	578	93	0	3,802
2000	50	54	41	27	266	334	62	0	2	0	0	0	836
2001	0	0	0	0	27	1,337	187	229	209	138	35	0	2,163
2002	34	37	34	59	33	33	31	16	16	16	41	40	389
2003	31	24	29	54	381	381	63	21	25	7	0	0	1,016
2004	0	22	0	7	517	284	67	152	209	199	29	0	1,485
2005	48	0	0	205	763	949	652	268	215	241	29	45	3,413
2006	0	0	118	413	643	755	87	227	164	365	38	0	2,810
2007	0	0	0	355	0	773	1,004	270	254	287	42	0	2,984
2008	0	0	0	767	870	724	240	197	202	155	132	0	3,288
Monthly Average	10	9	9	160	345	573	635	358	191	183	66	6	2,545

Figure B.IV.10: Average Modeled Power Table

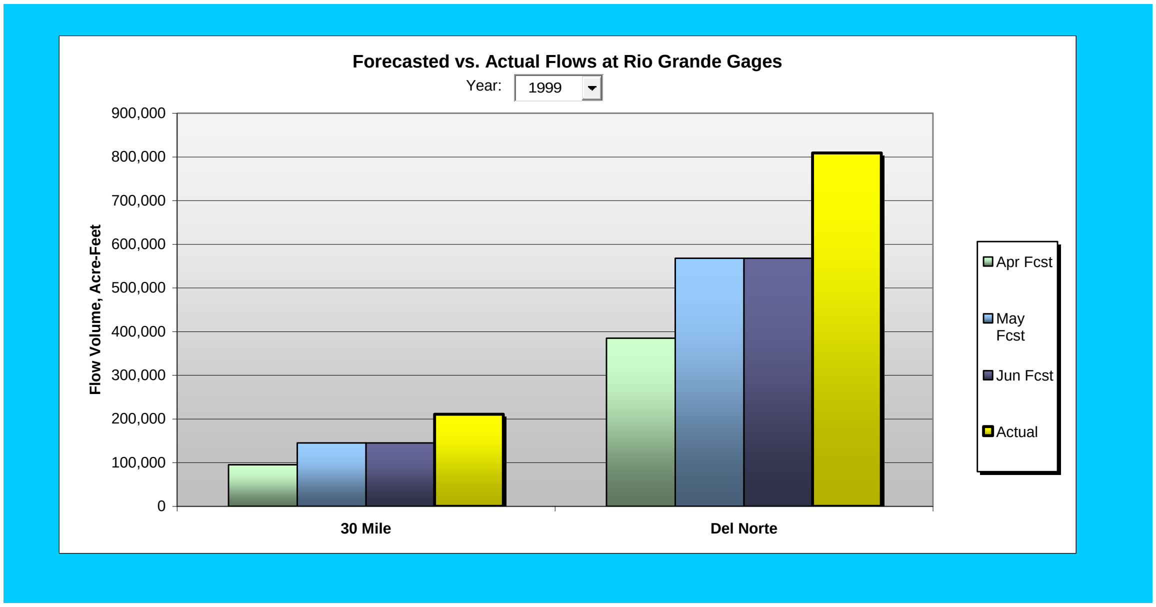


Figure B.IV.11: "RG Forecasted and Actual Streamflow 1982-2008.xls" Chart Page

URS

July 7, 2009

Mr. Travis Smith
General Manager
296 Miles Street
Center, Colorado 81125

Subject: Rio Grande Reservoir Hydropower Evaluation

Dear Mr. Smith:

URS Corporation (URS) is pleased to provide the San Luis Valley Irrigation District (SLVID) with this reconnaissance-level investigation into the potential addition of hydropower generation to the existing facilities at Rio Grande Reservoir. This investigation provides an assessment of the projected power and energy potential at Rio Grande Reservoir, conceptual layout of the turbines and other machinery, and a preliminary economic assessment. This assessment will serve as the technical foundation for inclusion of hydropower generation facilities within the proposed dam rehabilitation and in consideration within an overarching reoperation and optimization investigation for the reservoir.

EXECUTIVE SUMMARY

The addition of hydropower generation capacity at Rio Grande Reservoir is feasible from a technical and economic perspective. No fatal flaws were identified in this reconnaissance-level investigation that precludes the installation and operation of a hydropower plant at the reservoir. The preferred conceptual layouts include two configurations of Kaplan turbines with operational capacities of 0.5 MW and 2.12 MW respectively, which are based upon historic hydrologic conditions at the reservoir, existing electrical distribution line capacity, power generation potential, and costs. The economic analysis includes powerhouse costs, potential revenue from the sale of electricity, and debt finance options to determine the annual rate of return for the following two alternatives:

0.5 MW hydropower plant	14.75% rate of return
2.12 MW hydropower plant	13.17% rate of return

URS respectfully recommends the SLVID proceed to the next level by performing a comprehensive feasibility investigation to refine the technical and economic analyses that may be used in seeking an exemption from required federal regulatory licensing (less than 5 MW FERC permit). We further recommend the next work product be supplemented with detailed engineering and preliminary design to incorporate hydropower generation within the outlet works at Rio Grande Reservoir.

URS Corporation
8181 E. Tufts Ave.
Denver, CO 80237
Tel: 303.694.2770 and 303.740.2600
Fax: 303.694.3946

TASK 1 - DEFINE THE POWER POTENTIAL AND ESTIMATE POWER OUTPUT

The two dominant parameters that define the potential for electricity generation at hydropower facilities and the type of necessary machinery to produce power are hydraulic head and flow rates through the turbines.

Hydraulic Head

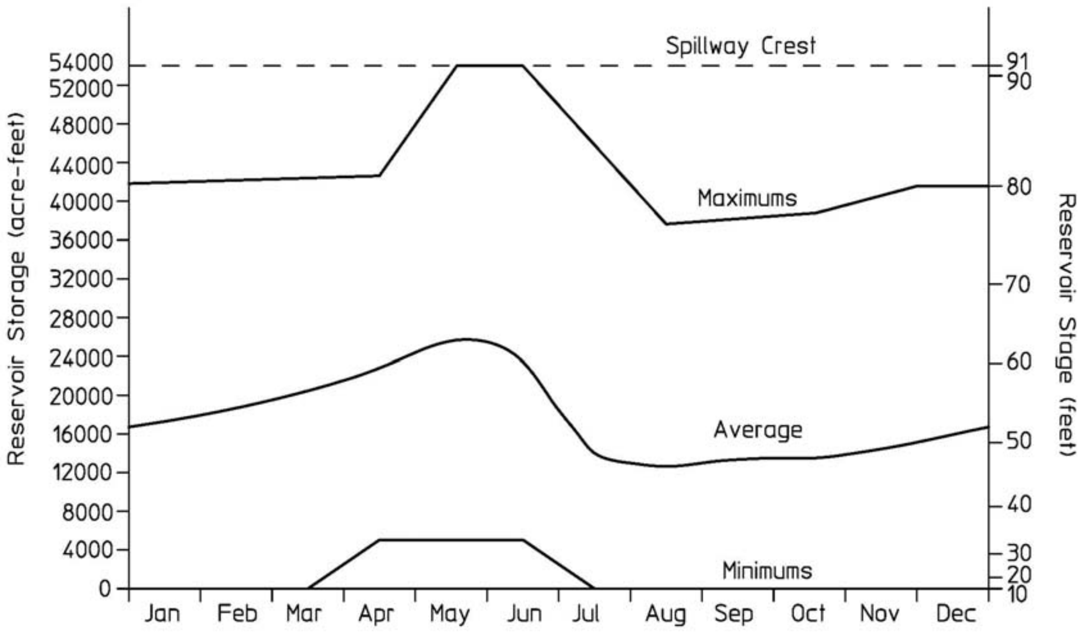
The gage height of the spillway at Rio Grande Reservoir is 91 feet according to the elevation-capacity curve[1] for the reservoir, which corresponds to an elevation of 9,449 feet above mean sea level. This elevation was used as the maximum water level for hydropower calculations. Review of the structural drawings for Rio Grande Reservoir indicates the elevation of outlet to the river is approximately 9,353 feet, which is also applied as the as the normal tailwater elevation. The difference between these elevations provides a gross hydraulic head of approximately 96 feet. There will be losses through the intake and in the conduit that were estimated to be less than 5%. These losses are deducted from the total potential head to establish a rough maximum net head of 91 feet for the turbines as an acceptable value for determining the types of turbines used for hydropower generation.

The end-of-month reservoir elevations for the period of 1980 through 2007 were used to simulate historic operations.[2] The historic elevation record reflects the wide range of storage levels within Rio Grande Reservoir on an annual basis in performance of its typical operational protocol to capture spring runoff from snowmelt for subsequent release and application to beneficial irrigation use during the summer months and gradually filling through the end of the year, as portrayed in Figure 1. The historic records indicate the reservoir has been at or above a gage height of 40 feet for over 75% of the time since 1980. The reservoir has operated at a gage height of 50 feet or greater for approximately 50% of the historic period since 1980. These levels were addressed in context of turbine type selection since a Kaplan turbine with a maximum head of 91 feet in service at an elevation greater than 9,000 feet above mean sea level can operate effectively down to a minimum head of approximately 40 feet. A Francis turbine can efficiently operate down to hydraulic head of approximately 50 feet.

---

[1] Rio Grande Reservoir Elevation-Capacity Curve, October 1981.
[2] Source: SLVID records and Rio Grande Reservoir Multi-Use Rehabilitation and Enlargement Study, Phase II by CDM (October 2008).

Figure 1. Annual Rio Grande Reservoir Storage Elevations



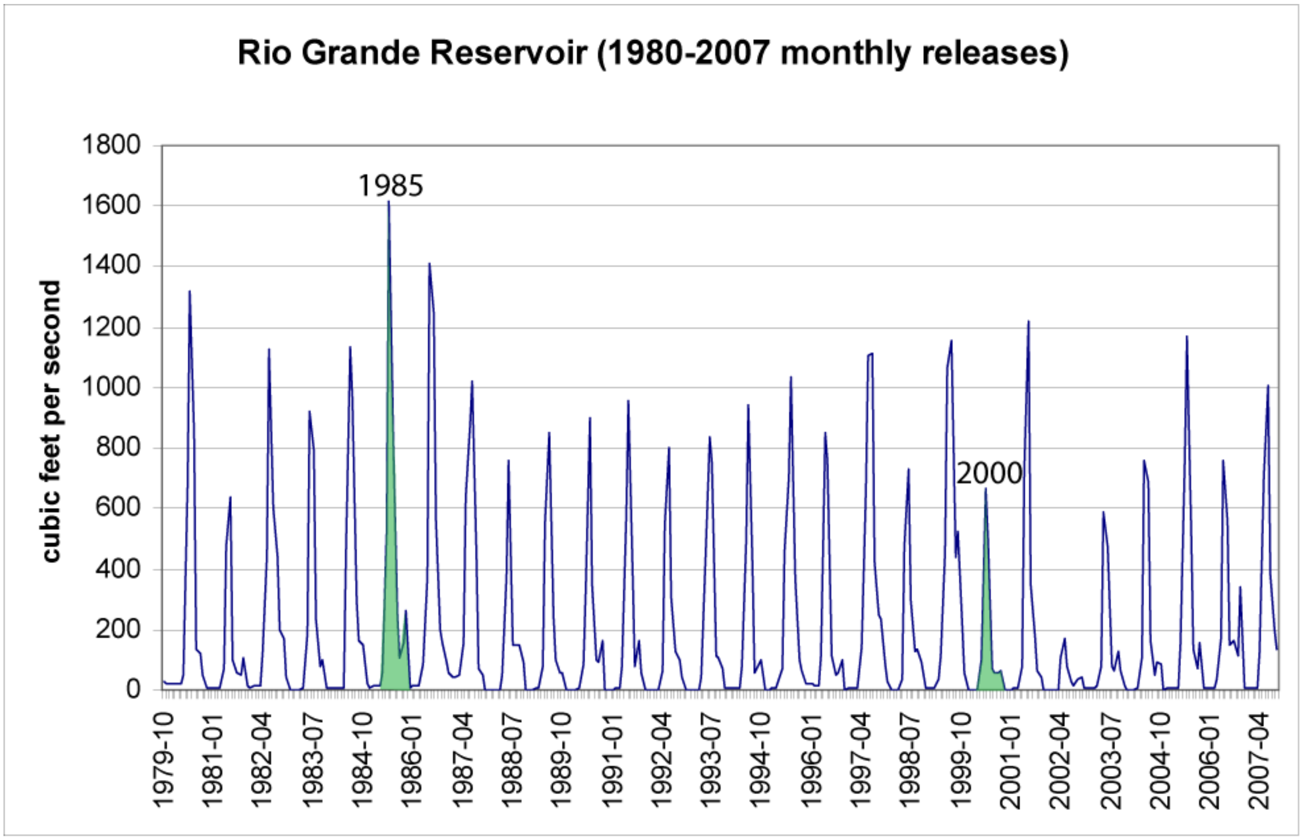
Average Annual Reservoir Storage / Stage Curve

Flow Rates

The source of flow rate or reservoir discharge information is the streamflow records available from the river gaging station located approximately 0.8 miles below the reservoir outlet known as the Rio Grande River at Thirty Mile Bridge near Creede, Colorado (station number 08213500). The period of record at this station extends from June 1910 to the present. For this analysis, we focused upon the period of record for Water Years 1980 through 2007.[3] This period of record is considered reliable and reflects varying hydrologic conditions through representation of dry, average, and wet years.

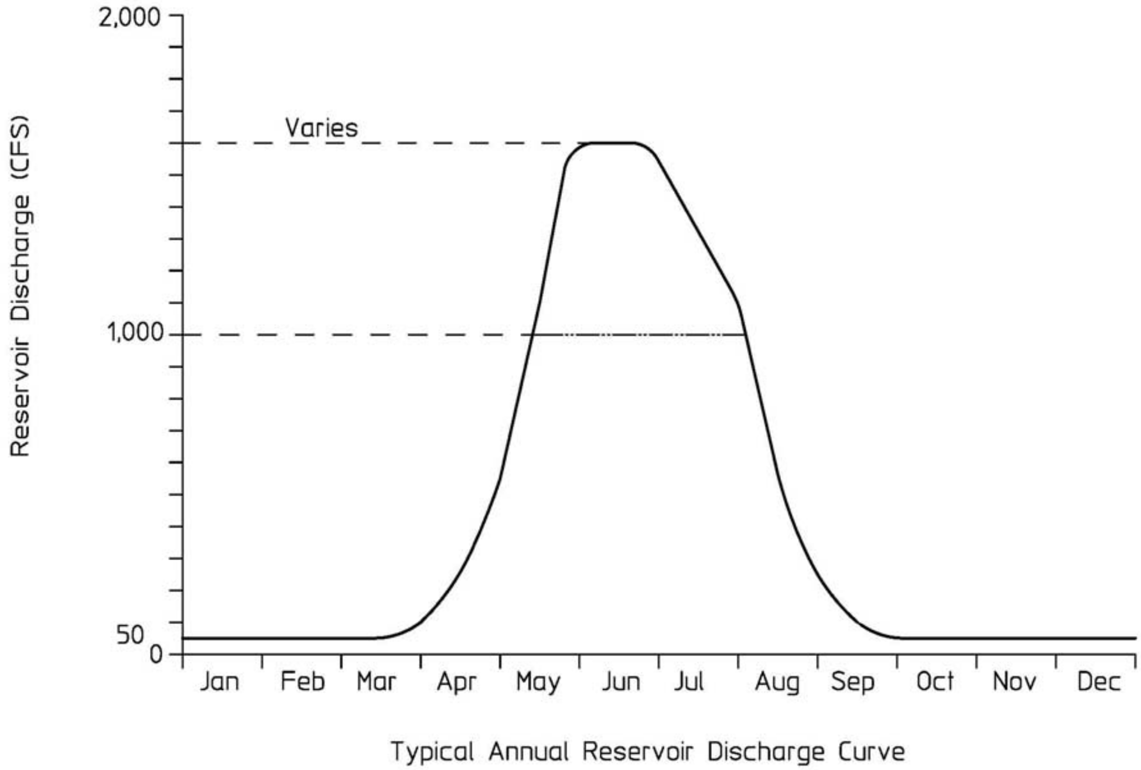
[3] Source: Colorado Division of Water Resources historic streamflow record database.

Figure 2. Historic Discharge from Rio Grande Reservoir



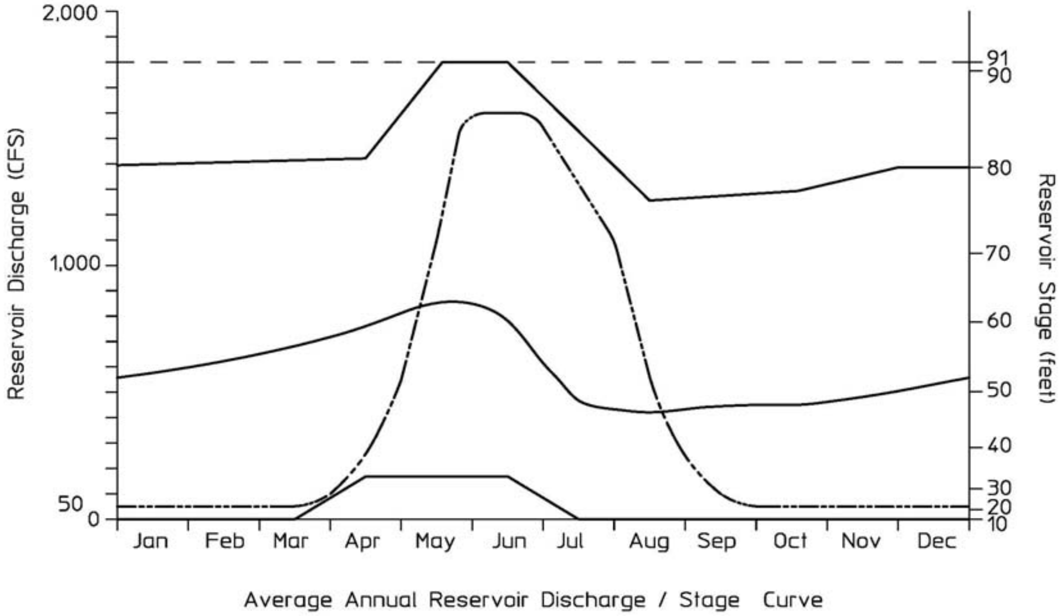
Review of the daily records indicate the reservoir discharge measured at the streamflow gaging station Rio Grande at Thirty Mile Bridge varied between less than 1.0 cfs to 2,530 cfs during the subject period of analysis. The hydrograph for Rio Grande Reservoir releases that portrays the variance of flows over the period of record on an annual timeframe is depicted in Figure 3.

Figure 3. Rio Grande Reservoir Discharge Hydrograph



Combining the reservoir elevation or stage data with and flow rate or discharge curves as represented in Figure 4, it is readily evident the minimum and maximum head and flow conditions tend to follow each other throughout the year, which is expected.

Figure 4. Rio Grande Reservoir Discharge



For the purposes of defining the power potential and estimated power input, we applied the monthly reservoir elevation and discharge data from two indicative years to represent dry (2000) and wet (1985) hydrologic conditions. These two water years represent the range of operational parameters for adding hydropower generation to Rio Grande Reservoir based upon historic conditions.[4] The average monthly elevation and discharge for the period of record 1980 through 2007 was also analyzed for comparative purposes.

- In the dry year of 2000: the average monthly reservoir gage level (estimated hydraulic head) ranged from 27 to 49 feet. The average flow rate throughout the year was 140 cfs.

- During the wet year of 1985: the average monthly gage level behind the dam ranged from 63 feet to 89 feet (peaked at spillway elevation of 91 feet). The average flow rate throughout the year was 323 cfs.[5]

[4] Water Year 2002 was not selected to represent the dry-year hydrologic conditions because of its extreme and statistically rare occurrence.

[5] In both the dry (2000) and wet-year (1985) streamflow records, the daily discharge from the dam during the year ranged from near zero to over 1000 cfs.

- For the period of record 1980 through 2007: the average monthly reservoir gage level ranged from 46 to 62 feet, the range is narrower as anticipated to reflect the influence of applying the average statistical function. The average flow rate throughout the year was 210 cfs.

It is not economically feasible to size turbine capacity to capture the infrequent peak discharge and operate at the full range of reservoir elevations (less than 30 feet to 91 feet at the spillway crest) to capture all potential hydropower generation capacity. Historical records and cost-effective design principles indicate the powerhouse should be equipped with a turbine design that is capable of operating at lower heads to increase the term of hydropower generation throughout the year. Based upon the historic reservoir elevation and discharge regime, two different generation capacities (50 cfs and 300 cfs) were analyzed in context of the monthly distribution and the results are fully presented in Appendix A. The annual amount of power generated for the two different powerplant designs analyzed under the three hydrologic classifications is tabulated below:

Table 1. Annual Power Generation in megawatt-hours (MWh)

Hydrology classification	Generation at 70 cfs limit	Generation at 300 cfs limit
Dry-year (2000)	330	989
Wet-year (1985)	2,172	6,988
Average (1980 – 2007)	1,370	3,901

TASK 2 – IDENTIFY PHYSICAL WORKS

As previously indicated, one of the challenges in the selection of turbine equipment and powerhouse design for the Rio Grande Reservoir project is the range of head (less than 30 feet to the spillway crest elevation at 91 feet). Under ideal operations to maximize hydropower generation, the reservoir would be operated to maintain the highest pool possible and the powerhouse would be designed with turbines rated at the higher head, based on the water surface elevation at the spillway crest height as the maximum head value. This operational protocol was not selected in the analysis in recognition that the reservoir is drawn down in the summer and used to provide late-season irrigation water to its beneficiaries.

Turbine Selection

The type and size of turbine selection for Rio Grande Reservoir is predicated upon the need to efficiently capture the potential energy at the powerplant throughout the year. Based on historical Rio Grande Reservoir operations as an irrigation and flood control vessel, augmented with a minimum 50 cfs discharge, there are two distinct operating regimes for the powerplant: (1) operation at a minimum flow of 50 cfs, and (2) operation at flows up to 1,000 cfs. Traditional reservoir operations minimized releases during the winter season. This analysis considers augmenting the releases to reach the lower bound of 50 cfs and is considered reasonable in perspective of the value of minimum reservoir discharges that (1) extend the tenure of hydropower generation through the year; and (2) integrate the hydropower operational regime into the proposed reoperation and optimization investigations being conducted by the SLVID that complement existing beneficial uses with enhancement of the ecological benefits of flow releases into the Rio Grande and assistance toward meeting Rio Grande Compact (1938) obligations.

Although the upper bound of flows is 1,000 cfs, a 300 cfs flow regime was used in the conceptual turbine selection. The 300 cfs is considered reasonable in context of the average daily flow for the period of record of 1980 to 2007 that was 210 cfs and the average daily flow in the wet year 1985 was 323 cfs. The intermediate 300 cfs flow rate is designed to reflect the balance between the capturing the most hydropower generation capacity in context with cost-effective turbine selection. Design and selection of a turbine to meet maximum head and flow rates, if only available for limited and infrequent periods of time such as those historically experienced at Rio Grande Reservoir, is cost-prohibitive.

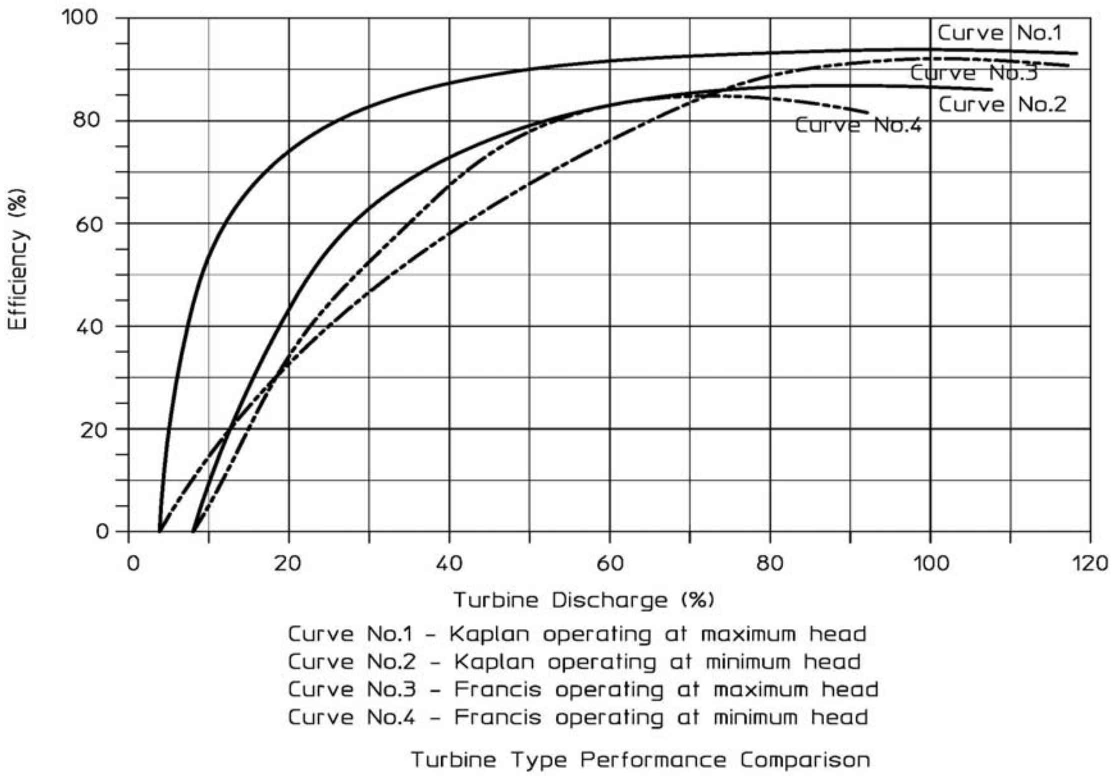
The two recommended turbines for this project are the Kaplan or Francis types.

- Kaplan turbines will provide better performance for a low head project with wide variation in operating conditions. This turbine technology is well developed and uses a combination of adjustable inlet vanes and adjustable runner blades to provide highly efficient operations over a wide range of flows and heads. The technology is more expensive and more complicated than that used in the Francis turbine. The Kaplan units will be vertical axis machines and the powerhouse height will be greater, but the total area footprint is smaller. The requirement of a powerhouse crane can be deleted if the powerhouse roof is designed with roof hatches to provide access to the turbine generator and inlet valves using a mobile crane.

- Francis turbines will provide good performance for this project. However, they operate efficiently in a narrower range of conditions. They are less complicated than a Kaplan turbine and will be less expensive to install and maintain. Francis units for this project would be horizontal axis this will reduce the overall height of the powerhouse, but will increase the footprint and will require the installation of a powerhouse hoist to access and maintain all components.

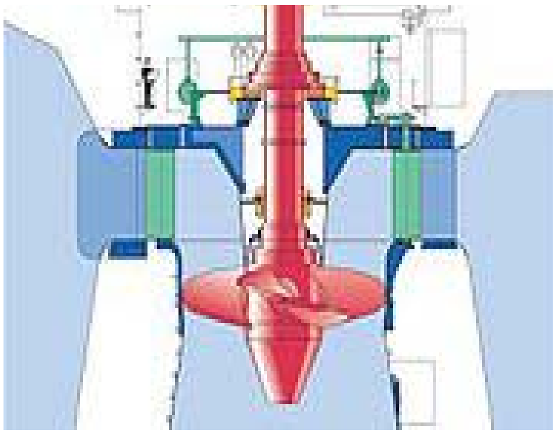
The curves below in Figure 5 portray the relative performance of Kaplan and Francis turbines and it is evident the Kaplan turbines will operate at higher efficiencies over a greater range of flow.

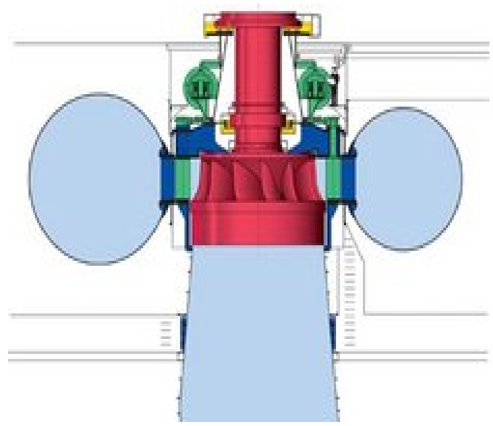
Figure 5. Kaplan and Francis Turbine Efficiency Curves



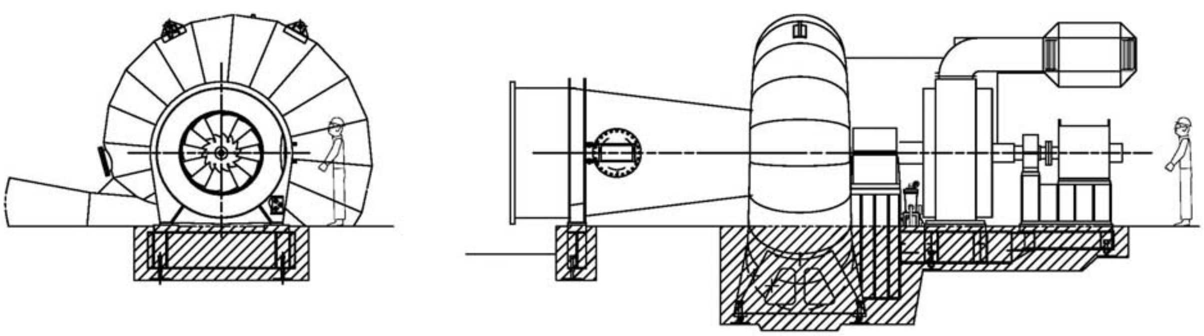
The drawings below show cross sections through conventional Kaplan and Francis turbines. At the Rio Grande powerhouse, both types of turbines would likely be manufactured with spiral cases. The Kaplan turbines would be vertical axis units, while the Francis turbines could be either vertical axis or horizontal (horizontal axis units will be less expensive the vertical units and the powerhouse height will be less which reduces its cost per square foot).

Figure 6. Drawings of Kaplan and Francis Turbines





Typical Kaplan Turbine, Vertical Axis **Typical Francis Turbine, Vertical Axis**



Horizontal Axis Turbine **(Drawings courtesy Voith-Siemens)**

The table below list comparative advantages and disadvantages of turbines considered for Rio Grande Reservoir.

Table 2. Comparative advantages and disadvantages for turbine types

Turbine Type	Advantages	Disadvantages
Kaplan, double regulated	Higher efficiency over greater range of flow Higher speed for lower cost generator Lower cost tubular housing Can operate at lower heads	Lower turbine setting requires deeper powerhouse excavation
Propeller, single regulated	Higher speed for lower cost generator Lower cost tubular housing Can operate at lower heads	Fixed blades reduce overall efficiency Lower turbine setting requires deeper powerhouse excavation
Francis	Higher turbine setting reduces depth of powerhouse excavation	Lower overall efficiency Lower speed will increase generator cost More expensive spiral case housing Cannot operate at lower heads

Turbine Criteria

The following turbine equipment recommendations are based on operating the reservoir with the maximum head at spillway crest height and with the highest specific speed for settings no lower than 33 feet below tailwater. Solutions to calculate annual hydropower generation are based upon historical elevation and flow data and were evaluated for Kaplan and Francis turbines. The alternative turbine configurations are demonstrated below in Options 1, 2 and 3 for both the Kaplan and Francis types. Please note: Option 3 was developed to satisfy the requirement for a 500 kW powerhouse that does not require installation of a new distribution line to the reservoir.

Rio Grande Reservoir physical parameters used in the conceptual turbine selection:

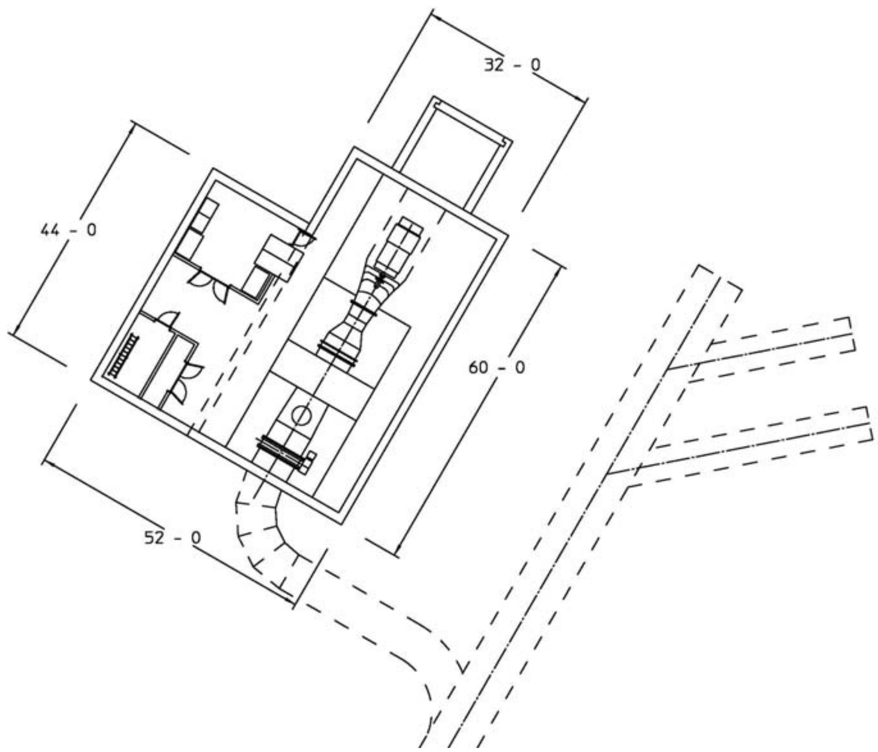
- Maximum forebay elevation: 9,449 feet
- Inlet elevation [invert]: 9,358 feet
- Minimum forebay elevation: 9,386 feet
- Minimum tailwater elevation: 9,354 feet
- Powerhouse elevation: 9,350 feet
- Head:
  - Maximum: 96 feet
  - Minimum: 33 feet
  - Losses: 5% [inlet and penstock]
  - Net, maximum: 91 feet
- Penstock length: 1,000 feet (300m)
- Flow:
  - Maximum: 300 cfs
  - Minimum: 50 cfs
- Generator:
  - Synchronous
  - Voltage: 4,160 volts
  - Phase: 3

- Frequency: 60 Hz

Turbine Configurations

Kaplan Option 1- Single Unit, Horizontal Tubular, Double Regulated

- Flow:
  - Rated/maximum: 300 cfs
  - Minimum: 75 cfs
- Head:
  - Rated/maximum: 90 feet
  - Minimum: 40 feet
- Setting: 22 feet below tailwater
  - Runner centerline elevation: 9,332 feet
  - Tailrace floor elevation: 9,323 feet
- Speed: 600 rpm
- Turbine Output:
  - Rated head x rated flow: 2,130 kW
  - Min. head x rated flow: 770 kW
  - Min. head x min. flow: 180 kW [low efficiency]



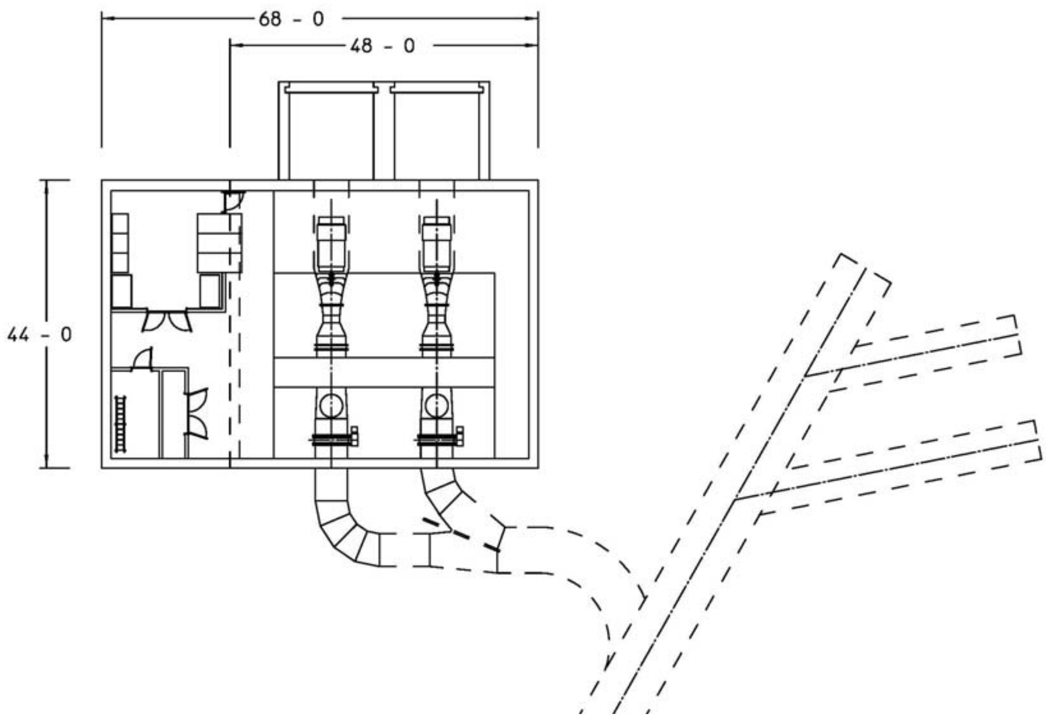
Control equipment installed on mezzanine level

Kaplan Option 2- Two Equal Units, Horizontal Tubular, Double Regulated

Higher plant factor, greater reliability, wider flow range, better performance at low flows

- Flow:
  - Rated/maximum: 150 cfs
  - Minimum: 40 cfs
- Head:
  - Rated/maximum: 90 feet
  - Minimum: 40 feet

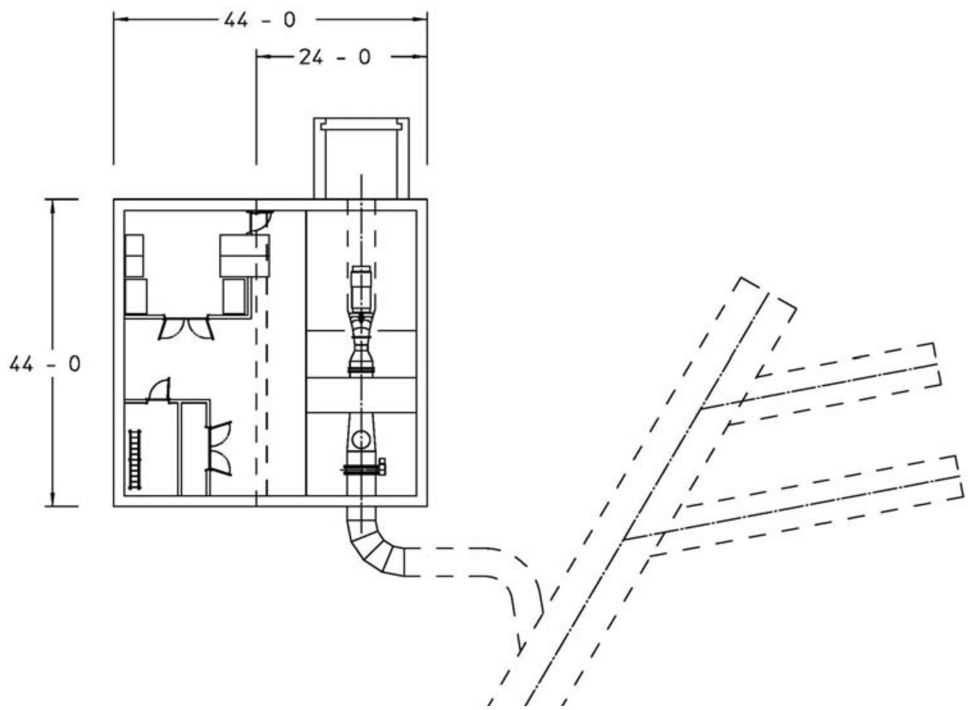
- Setting: 28 feet below tailwater
  - Runner centerline elevation: 9,326 feet
  - Tailrace floor elevation: 9,320 feet
- Speed: 900 rpm
- Turbine Output:
  - Rated head x rated flow: 1,060 kW
  - Min. head x rated flow: 380 kW
  - Min. head x min. flow: 90 kW [low efficiency]



Control equipment installed on mezzanine level

Kaplan Option 3 - Single Unit, Horizontal Tubular, Double Regulated

- Flow:
  - Rated/maximum: 70 cfs
  - Minimum: 20 cfs
- Head:
  - Rated/maximum: 90 feet
  - Minimum: 40 feet
- Setting: 18 feet below tailwater
  - Runner centerline elevation: 9,336 feet
  - Tailrace floor elevation: 9,331 feet
- Speed: 1,200 rpm
- Turbine Output:
  - Rated head x rated flow: 500 kW
  - Min. head x rated flow: 180 kW
  - Min. head x min. flow: 50 kW [low efficiency]

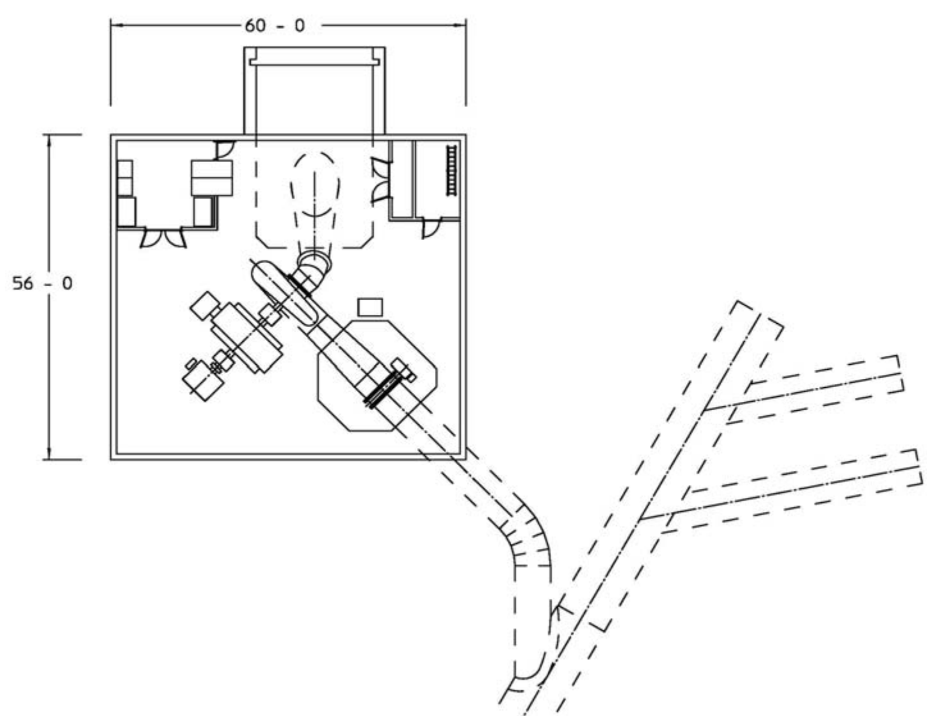


Control equipment installed on mezzanine level

Francis Option 1- Single Unit, Horizontal, Spiral Case, Inclined Elbow Conical Draft Tube

- Flow:
  - Rated: 300 cfs
  - Maximum: 360 cfs
  - Minimum: 75 cfs [very low efficiency]
- Head:
  - Rated: 72 feet
  - Maximum: 90 feet
  - Minimum: 40 feet

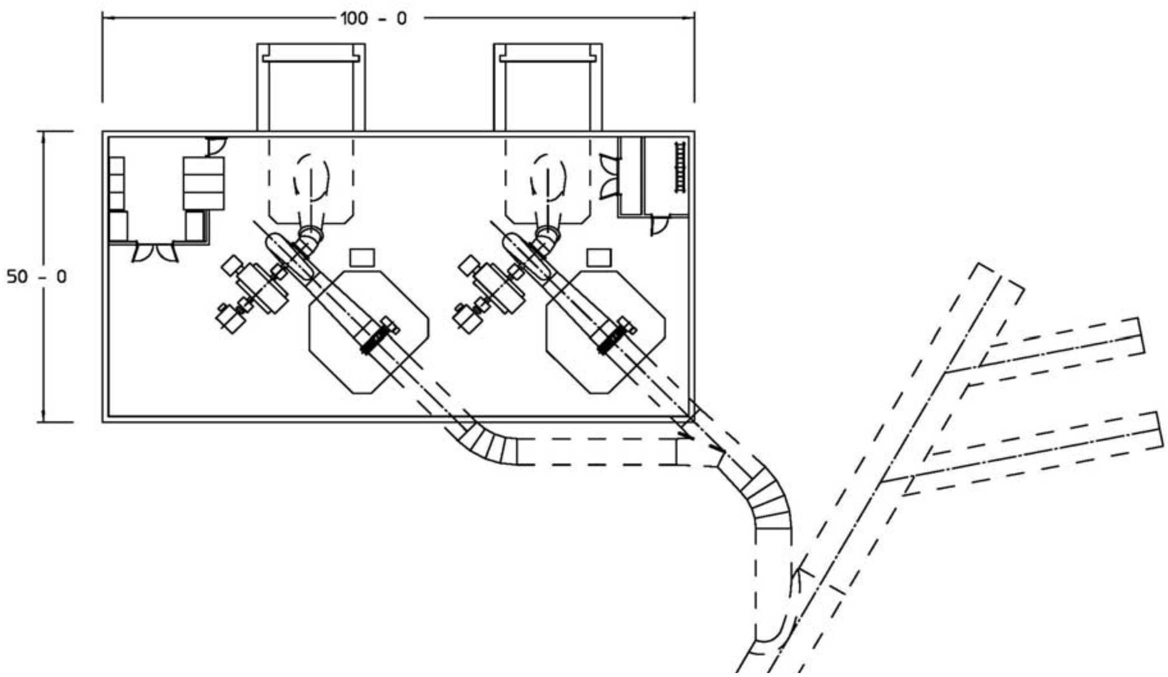
- Setting: 7 feet below tailwater
    - Runner centerline elevation: 9,347 feet
    - Tailrace floor elevation: 9,327 feet
- Speed: 327.3 rpm
- Turbine Output:
    - Rated head x rated flow: 1,700 kW
    - Rated head x max. flow: 1,970 kW
    - Min. head x rated flow: 700 kW [very low efficiency]
    - Min. head x min. flow: 100 kW [very low efficiency]



Francis Option 2 - Two Equal Units, Horizontal, Spiral Case, Inclined Elbow Conical Draft Tube

Higher plant factor, greater reliability, wider flow range, better performance at lower flows:

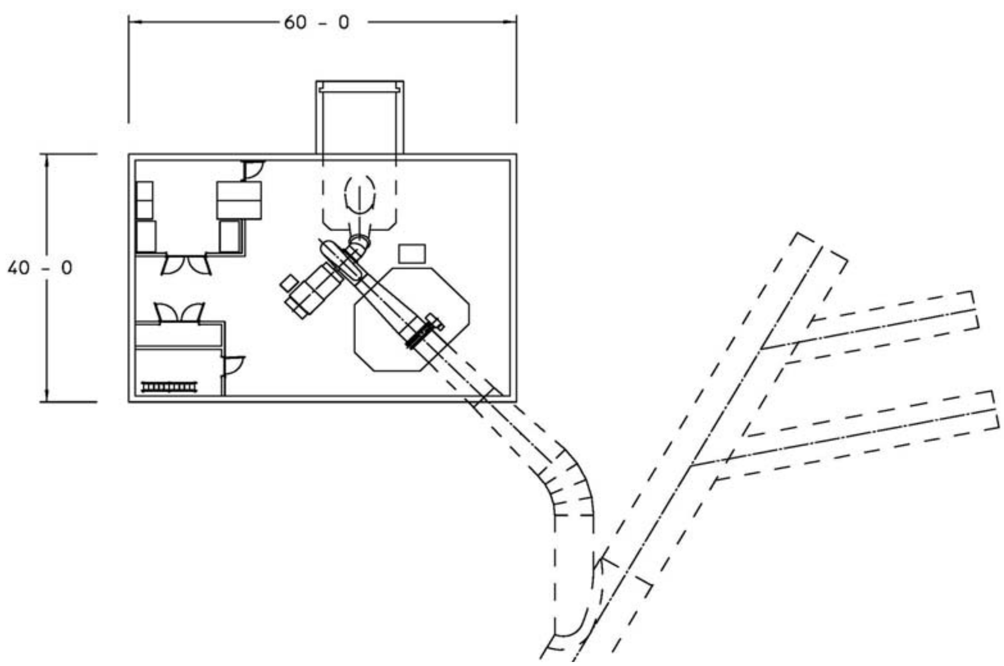
- Flow:
  - Rated: 150 cfs
  - Maximum: 180 cfs
  - Minimum: 40 cfs [very low efficiency]
- Head:
  - Rated: 72 feet
  - Maximum: 90 feet
  - Minimum: 40 feet
- Setting: 7 feet below tailwater
  - Runner centerline elevation: 9,347 feet
  - Tailrace floor elevation: 9,332 feet
- Speed: 450 rpm
- Turbine Output:
  - Rated head x rated flow: 850 kW
  - Rated head x max. flow: 980 kW
  - Min. head x rated flow: 360 kW [very low efficiency]
  - Min. head x min. flow: 60 kW [very low efficiency]



Francis Option 3- Single Unit, Horizontal, Spiral Case, Inclined Elbow Conical Draft Tube

- Flow:
  - Rated: 90 cfs
  - Maximum: 110 cfs
  - Minimum: 25 cfs [very low efficiency]
- Head:
  - Rated: 72 feet
  - Maximum: 90 feet
  - Minimum: 40 feet

- Setting: 3 feet above tailwater
  - Runner centerline elevation: 9,347 feet
  - Tailrace floor elevation: 9,335 feet
- Speed: 600 rpm
- Turbine Output:
  - Rated head x rated flow: 500 kW
  - Rated head x max. flow: 590 kW
  - Min. head x rated flow: 200 kW [very low efficiency]
  - Min. head x min. flow: 30 kW [very low efficiency]



Powerhouse Design

The powerhouse at the Rio Grande reservoir is intended to be integrated into the outlet valve structure. There are two primary hydropower generation considerations used in the conceptual powerhouse design for Rio Grande Reservoir:

- Building a 500 kW powerhouse to supply power to the local community through transmission over an existing 11-mile single-phase distribution line. The hydropower plant at Rio Grande Reservoir could provide sufficient flow through the year to meet the local load [500 kW max].

- Building a larger powerhouse up to approximately 2 MW to supply the community and export power under a commercial contract with the local electrical utility. Included in this project cost would be the construction of a three-phase transmission line from the powerhouse to the closest utility node [11 miles]. The owner of the powerhouse will operate the reservoir to optimize/maximize return on the value of the water from generation and/or supplemental irrigation deliveries.

There are several methods to construct a hydroelectric powerhouse and for a project the contemplated size of Rio Grande Reservoir, the powerhouse will typically consist of an anchored reinforced concrete foundation with a concrete, metal or combination superstructure. It is anticipated the top of the foundation will be the floor of the powerhouse and all elements suspended above this elevation will be supported on fabricated steel structures. In the case of a powerhouse with vertical axis turbines, there will be galleries below the floor to access the bottom of the turbine through the draft tubes.

Review of the aerial photographs and constructed diagrams of the reservoir and dam indicates there is potential to construct the powerhouse with a load-bearing roof. This roof alternative would include a large hatch for access to lift equipment from the powerhouse floor. The powerhouse would be equipped with electrical generation equipment and other features described in Appendix B.

Powerhouse Cost Estimate

The estimated costs for construction of the powerhouse, including the machinery necessary to generate hydropower, for the alternative turbine configurations is presented in Table 3 below. In general, the footprint for a Kaplan powerhouse can be more compact than that designed for Francis turbines. Each of the powerhouse designs will have common similarities such as the main transformers and substation equipment, AC/DC station service systems, etc.

Table 3. Estimated costs to construct and equip the Rio Grande Reservoir powerhouse

Item	Cost x $1000					
	Kaplan			Francis		
	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
Powerhouse excavation[6]	369	390	150	411	509	166
Powerhouse concrete[7]	743	855	446	528	644	200
Powerhouse superstructure[8]	234	224	145	252	375	180
Inlet pipe	100	150	80	100	150	70
Turbine(s)	298	406	152	361	488	182
Valve(s)	80	120	50	80	120	40
HPU(s)	50	100	50	50	100	50
Generator/exciter(s)	215	222	67	295	392	138
Oil cooling unit(s)	30	60	30	0	0	0
Switchgear	80	120	80	80	120	80
Switchboard/governor/SCADA	75	100	75	75	100	75
DC station service	25	25	25	25	25	25
AC station service	20	20	20	20	20	20
Bridge crane	150	150	100	150	150	100
Stop logs/hoist	20	25	15	20	25	15
Step-up transformer	90	90	40	90	90	40
Substation/equipment	40	40	30	40	40	30
Construction/installation/commissioning	150	200	120	150	200	120
Total	2,768	3,298	1,675	2,727	3,548	1,531

[6] Powerhouse excavation was based on cost of $100/cuyd
[7] Powerhouse concrete was based on $800/cuyd.
[8] Powerhouse superstructure is based on $70/sqft and includes a 25 foot high metal building constructed from the top of the concrete wall at El 9361.

TASK 3 – ASSESS MARKET POTENTIAL

The local utility serving Rio Grande Reservoir is the San Luis Valley Rural Electric Cooperative (SLVREC). The SLVREC owns the distribution line that is currently connected to the dam providing electricity for the SCADA system and remote operation of the gates and valves. The SLVREC is one of 44 cooperatives served with electrical power from Tri-State Generation and Transmission Association (Tri-State). SLVREC will be the buyer of the electricity produced from the potential Rio Grande Reservoir hydropower facility via a Power Purchase Agreement (PPA). The PPA is an agreement between SLVREC and the SLVID for the local electrical cooperative to buy all of the energy produced from the project over a 20-year term, with contractual provisions on the price to be paid for the energy, delivery location, metering provisions, interconnection to the electrical grid, and payment method.

Colorado Renewable Portfolio Standard

Colorado passed the nation's first voter-mandated Renewable Portfolio Standard (RPS) in 2004 that required utilities to obtain 10% of its overall energy sales from renewable energy by 2020 (Amendment 37). The Colorado General Assembly doubled the state's renewable energy portfolio standard to 20% by 2020 for large utilities such as Xcel Energy and amended the RPS to include municipalities and electric cooperatives (including Tri-State) to obtain 10% of their overall energy sales from renewable energy by 2020 (House Bill 2007-1281). Therefore, an expanded market for hydropower generation and sales to Tri-State was created through the RPS. The renewable energy credits (RECs) created by the hydropower generation facility at Rio Grande Reservoir may be counted toward meeting the RPS mandate for Tri-State. RECs are the "green" attribute of generating energy from renewable resources versus the energy generated from fossil fuels that have a larger environmental impact.

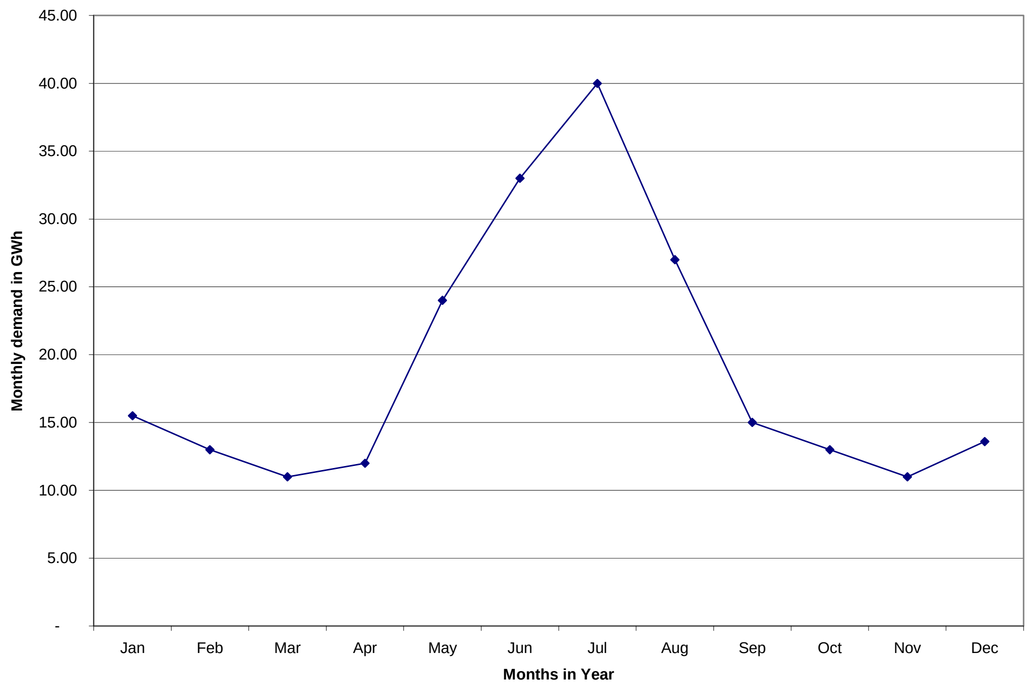
Energy Pricing

Tri-State currently provides all of the energy that SLVREC needs to satisfy its customer demand through a long-term, all-power contract. It is important to note that SLVREC is able to purchase power for its needs from a third party (example: SLVID and the Rio Grande Reservoir hydropower project) for up to 5% of its annual energy demand. Tri-State sells energy to its 44 cooperatives with two components within its pricing model. The first component is the energy cost in $ per MWh for the actual energy used, as measured by a utility meter. The second component is a demand charge in $ per peak megawatt (MW) of demand as measured in any 15-minute period during the entire month of billing. A high demand in this peak 15-minute period of the month sets the demand charge for that sale to SLVREC for the entire month, regardless of demand in prior or subsequent hours in the month. A demand charge is much like a reservation charge paid by SLVREC to Tri-State for the right to receive the peak demand of energy at any 15-minute period during each month. Each month in the calendar can and will experience a different demand in MW consumption, and consequently a different demand charge in $ for that month.

Energy pricing also varies significantly throughout each day and throughout the different seasons of the year. To satisfy peak demand in the summer during the Peak Power Periods, Tri-State must operate high-cost peaking units that may only run a small number of hours each year. This "needlepoint" demand satisfaction comes at a higher cost since Tri-State must pay for the peaking unit installation and operating expenses, but they operate at a lower utilization rate.

SLVREC operations reflect a significant seasonal increase in its energy demand in the summer season versus the winter season. This is primarily due to the increased electricity demand from irrigation pumping placed on its system during the April through September time frame and is referred to as the Peak Power Period. The demand for pumping ground water for irrigation load on their electric system comprises approximately 65% of overall energy sales each year. The peak monthly summer energy demand is approximately 40 gigawatt-hour (GWh) per month (July) in comparison with the winter monthly demand of approximately 14 GWh (December) as reflected in Figure 7. This period of high energy demand by SLVREC also coincides with Rio Grande Reservoir's ability to supplement the peaking power demands through increased reservoir discharge to meet downstream surface water irrigation demands.

Figure 7. SLVREC Monthly Electricity Demand in Gigawatt-hours (GWh)



The SLVREC pricing structure is also variable within a 24-hour day. Due to the high demand for energy during the 7:00 AM to 10:00 PM period each day from April through September, SLVREC incurs a higher cost for the energy it provides to its constituents. This higher rate comes in two segments: (1) an energy charge of approximately $32 per MWh; and (2.) a demand charge of approximately $21.50 per kW per month. An attractive facet of the Rio Grande Reservoir hydropower project to the SLVREC is the increased value it achieves through provision of reliable power supplies during these Peak Power Periods, both during the peak demand hours within a 24-hour period as well as during the peak months of the year. Purchase of power from the Rio Grande Reservoir project is attractive to SLVREC through savings in the energy charge and demand charge. Official representatives of the SLVREC indicated they need at least 2 MW of capacity to reduce their high cost of energy during the Peak Power Periods.

Market Potential for Sale of Hydropower Electricity from Rio Grande Reservoir

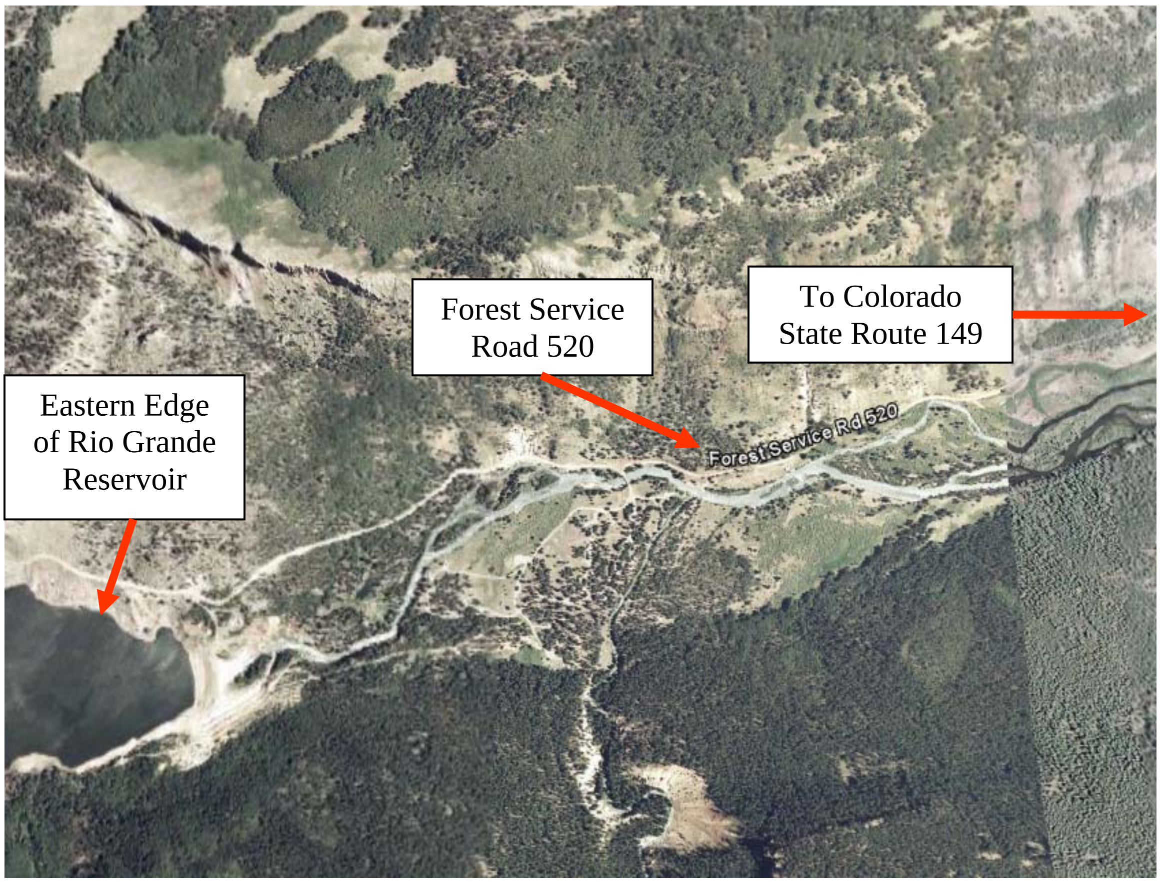
The market for generation and sale of hydropower as a source of renewable energy is favorable. The SLVREC representative indicated Tri-State was encouraging the acquisition of renewable energy by its 44-member cooperatives, and in particular hydropower generation to position the company to be compliant with the RPS by 2020. The representative indicated that Tri-State preferred hydropower over solar and wind renewable energy sources due to its relatively-high capacity factor (the percentage of the year that the renewable resource can produce energy) and its reliability.

TASK 4 – DETERMINE ECONOMIC FEASIBILITY

Connection to the Electrical Grid

To assess the potential cost of updating the distribution line that may be necessary to sell electrical power from the hydropower facility, URS determined the current electrical service to the dam at Rio Grande Reservoir is a single-phase distribution line that originates approximately 11 miles west from the three-phase service at the intersection of Colorado Route 149 and Forest Service Road #520 as shown in Figure 8. The distribution line follows Forest Service Road #520 from Rio Grande Reservoir to Colorado Route 149. The single-phase electric distribution service is capable of handling a hydropower generation unit at Rio Grande Reservoir of approximately 500 kilowatts (kW), or 0.5 megawatts (MW) without upgrade. For hydropower generation capacities above 0.5 MW, the distribution line to Colorado Route 149 will require an upgrade estimated to cost $1.375 million.

Figure 8 Aerial View of Rio Grande Reservoir and Forest Service Road #520



Economic Feasibility to Add Hydropower Generation at Rio Grande Reservoir

URS performed an economic analysis based upon a range of hydrologic conditions to provide a comparative analysis of costs, revenues, and potential risk to SLVID in the installation of a hydropower facility at Rio Grande Reservoir. As previously mentioned, the amount of hydropower generated (and potential sales) is directly related to the hydraulic head and flow rates released from the reservoir. The dry year (2000) and wet year (1985) hydrology provide the sideboards for the economic analysis and are used in context with the average revenue stream based upon the period of record 1980 through 2007 at current market prices for energy.

The economic feasibility analysis was further segmented to address two potential operational capacities for the hydropower generation plant: (1) for a 0.5 MW plant (Kaplan turbine option 3); and (2) for a 2.12 MW plant (Kaplan turbine option 2).[9] We also performed the analysis in context of several equity positions and document the results in Table 4 below that illustrates the rate of return with a potential financing schedule of 20% equity/80% loan.

Table 4 Economic Rate of Return for Hydropower Generation at Rio Grande Reservoir

		Energy Generated (MWh)			Project Year 1 Revenue $ Thousands			Rate of Return % 20% Equity / 80% Loan		
Turbine Capacity (MW)	Capital Cost ($ million)	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet	Average
0.50	1.88	330	2,172	1,370	30	195	123	N/A*	31.79	14.75
2.12	4.87	989	6,988	3,901	89	629	351	N/A*	37.56	13.17

* The rate of return for the dry year hydrology is not applicable since the MWh energy production available at reduced reservoir elevations and discharge is insufficient to support the debt payments.

The following criteria and/or assumptions were used in the economic analysis:

1. The capital cost for the 0.5 MW hydropower facility includes $1.68 million estimated cost of the powerhouse and equipment and $200,000 for anticipated environmental and regulatory permitting.

2. The capital cost for the 2.12 MW hydropower facility includes $3.298 million estimated cost of the powerhouse and equipment, $1.375 million for the upgrade of the 11-mile distribution line, and $200,000 for anticipated environmental and regulatory permitting.

3. The purchase price offered by SLVREC for "anytime" energy production is $90/MWh.

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[9] The Kaplan turbine options were selected in perspective of their superior generation capacity, operational flexibility, and cost estimate.

4. URS used the estimate of $1.375 million from the SLVREC for the potential upgrade of the 11-mile distribution system from single-phase to three-phase service.

5. Annual operation and maintenance costs were included in this preliminary economic evaluation. The estimated cost is $10,000 per year for the 0.5 MW turbine capacity, and $27,000 per year for the 2.12 MW turbine capacity.

6. The San Luis Valley Irrigation District, owner of the Rio Grande Reservoir, is not a state or federal tax-paying entity, and plans to own and operate the project.

7. The San Luis Valley Irrigation District may be liable for property tax for the new hydropower generation unit and will incur incremental operating and insurance expenses for the project.

8. The San Luis Valley Irrigation District is able to obtain debt financing up to $2 million for a 30-year term at a 2.0% annual interest from the Colorado Water Resources & Power Development Authority. Additional debt financing may be obtained from the Colorado Water Conservation Board for a 20-year term at a 2.5% annual interest rate.

9. The cash flow analysis selects the lowest available debt financing cost for the amount of capital required in each case.

10. The Hinsdale County Tax Assessors office was consulted on the appropriate property tax rate for a hypothetical hydropower project, and a 29% assessment was used at a rate of $0.047469 per $ of the appraised value. The Colorado Division of Property Taxation was consulted and renewable energy facilities installed are assessed property taxes as though their installed costs were comparable to those of non-renewable energy facilities. For 2009, the non-renewable facility value was determined to be $1,128 per kilowatt (kW) for renewable energy projects up to 2 megawatts (MW). This valuation methodology applies to renewable generators that are connected to the transmission system.

11. The IMA Financial Group, Inc. in Denver was consulted to determine the range in insurance expense for a generic hydropower project similar to that contemplated herein and their estimates are included in the cash flow analysis. Their estimate is 0.25%-0.4% of the property value per year for the project.

12. The hydropower generation unit will have a useful life of 25 years for depreciation purposes for property tax calculations.

13. Annual inflation rate of 4% for revenue and operating expenses.

TASK 5 – ASSESS SITE ISSUES AND FACILITY INTEGRITY

The site assessment was performed in context of professional inspection of the reservoir and embankment structures by URS personnel (former Dam Safety Engineer Dennis Miller) and review of structural drawings provided by the Colorado Division of Water Resources and the proposed outlet alignment tendered by Deere & Ault (Rio Grande Reservoir Multi-Use Rehabilitation and Enlargement Study, Phase II, October 10, 2008).

The steep, narrow canyon provides limited working and staging space at the existing tunnel portal. However, the existing tunnel is constructed through competent volcanic rocks (Fish Canyon Tuff) of the right abutment, and has performed well structurally throughout its life. Rockfalls have not been noted, and the need for rockbolting has not existed. The downstream tunnel portal is constructed of concrete and is approximately 12 feet in width between sidewalls at that point. The current tunnel discharges along the toe of the dam downstream slope, and there is inadequate area at that location to construct a powerplant.

It is feasible to extend the penstock downstream to a location between the tunnel portal and the spillway discharge from the right abutment. The canyon is narrow throughout this reach, and working conditions will be limited. Foundation conditions for the powerplant are more desirable on the rock right abutment (the left side slope of the river channel is composed of a landslide mass of unknown age and movement potential). Ideally, the powerplant should be located far enough away from the toe of the existing dam to allow for potential dam enlargement (10 feet proposed, by downstream construction method), if desired.

In conducting our investigation, it became evident that rehabilitation of the existing outlet tunnel for placement of the power penstock/outlet conduit, rather than boring a new downstream tunnel segment, which ties into the existing tunnel upstream of the existing gate chamber as proposed by Deere & Ault, has potential that may result in significant cost savings to the SLVID. However, use of the existing tunnel presents some serious technical challenges as well. Our primary concern is the need to pass river flows, anticipated throughout a sustained period of time in a season, through the existing tunnel while performing modifications to it. This has consistently proven to be a challenge during past repairs within the outlet gate chamber on this structure.

URS respectfully asserts the placement of a power penstock within the existing tunnel with a new 9-foot diameter conduit is an attractive alternative to the proposed new tunnel and outlet structure described by Deere & Ault. The new conduit would be placed upon pedestals with a walkway beside it to offer better access for maintenance and inspection of the gate chamber. This alternative will include modern gates and valves that will resolve the historic cavitation problems and will safely discharge the 2,500 cfs flow rate required by the Colorado Division of Water Resources. The URS proposed design is a recognized standard that is applied by the United States Bureau of

Reclamation, U.S. Army Corps of Engineers and other dam design and operation agencies. Modifications to the existing outlet tunnel to accept a power penstock and new gates will require demolition of significant concrete features and structural steel works within the existing gate chamber and shaft, and their removal from the tunnel, which will impact the start of construction of the new features. We suggest implementing a phased construction schedule that will facilitate critical working time within the tunnel during the period of approximately November 1 through the first of April when river flows are minimal to minimize adverse impacts to reservoir storage deliveries to downstream irrigation.

The proposed outlet alignment requires less steel and other materials to meet the operational discharge requirements and offers an attractive and cost-effective alternative to the SLVID. A conceptual design of the URS alternate outlet alignment is provided for your consideration in Appendix C.

RECOMMENDATION

URS respectfully recommends the Rio Grande Reservoir hydropower project proceed to the next level, which is a comprehensive and detailed feasibility investigation. Our recommendation is based upon the attractive economic rates of return from the installation of a hydropower generation unit and no identification of fatal flaws. Assuming an average year of precipitation, the project yields a rate of return for 20% equity and 80% loan at low cost financing to be 14.75% for the 0.5 MW plant capacity and 13.17% for the 2.12 MW plant per year over a 20-year period.

Conducting a feasibility study will assist the SLVID in preparing for environmental and regulatory compliance. In particular, the investigation should develop a "project plan" that may be used in petitioning the Federal Energy Regulatory Commission to issue an exemption from licensing requirements for this facility since it is less than the 5 MW capacity threshold (Handbook for 5MW Exemptions from Licensing, 2004). If the SLVID decides to proceed with a comprehensive feasibility study, which is the next step in the project planning and development process, URS suggests performance of the following actions:

1. Integrate and model the potential hydropower operations with the traditional irrigation supply and other demands upon the reservoir to optimize power revenues with minimal adverse impacts to current operations.

2. Investigate the potential to schedule reservoir discharge and power generation within a 24-hour day to meet peak load demands by the SLVREC to capture incremental increased revenues (example: peak daily discharge from 7 am to 10 pm during the summer season).

3. Refine the turbine capacity and conceptual layout upon evaluation of the potential hydropower generation capacity based on daily reservoir elevation and discharge data.

4. Develop additional information and analyses to support the technical design and economic evaluation of the project. This information may include mapping of the site, review of existing geologic data and/or foundation drilling to determine the adequacy of the site conditions, and evaluation of environmental data/permitting requirements necessary to refine the alternative hydropower plant configuration and size as a preferred alternative for design and construction.

5. Perform detailed engineering and preliminary design to incorporate hydropower generation within the outlet works (using either the rehabilitated outlet conduit through the existing structure or the proposed new tunnel) at Rio Grande Reservoir.

Thank you for the opportunity to conduct this reconnaissance-level investigation of hydropower development at Rio Grande Reservoir If you have any questions or wish to discuss the report further, please contact me at your convenience.

Sincerely,

Ken Knox, Ph.D., P.E.
Principal Water Resources Engineer

Appendix A

Annual Power Generation for Rio Grande Reservoir

Appendix A

1985	323	Estimated Allowable Flow, cfs				WET YEAR							
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Month	Annual Totals
													Power
													MWH
31234	32143	33714	39758	51113	51113	33063	29450	34454	33993	25188	27711	EOM Reservoir Storage, acre-feet	
70	71	72	78	89	89	72	68	73	72	63	66	Estimated Head, feet	
0	0	0	0.88	0.93	0.93	0.92	0.92	0.91	0.92	0.91	0	Estimated turbine efficiency 300cfs plant *	
0	0	0	0.92	0.93	0.93	0.92	0.92	0.92	0.92	0.91	0	Estimated turbine efficiency 70cfs plant **	
31	28	31	30	31	30	31	31	30	31	30	31	Days/Month	
40	15	26	98	185	0	-294	-59	81	-7	-143	41	Rate of Change Reservoir Storage, cfs	
12	13	14	55	522	1619	868	255	107	159	259	10	Rate of Reservoir Discharge, cfs	
52	28	40	154	707	1619	574	196	188	151	116	51	Sum of above Rates, cfs	
0	0	0	298	1942	1942	1554	1247	554	821	1163	0	Output, 300cfs kW	
0	0	0	214	1445	1398	1156	928	399	611	837	0	Generation 300cfs limit, MWH	6988
0	0	0	311	453	453	363	342	368	363	314	0	Output, 70cfs kW	
0	0	0	224	337	326	270	255	265	270	226	0	Generation 70cfs limit, MWH	2172
2000	140	Estimated Allowable Flow, cfs				DRY YEAR							
2736	2950	5479	11290	14371	5509	5519	5431	5418	5483	8661	10756	EOM Reservoir Storage, acre-feet	
27	27	34	45	49	34	34	34	34	34	40	44	Estimated Head, feet	
0	0	0	0.88	0.89	0	0	0	0	0	0	0	Estimated turbine efficiency 300cfs plant *	
0	0	0	0.87	0.88	0	0	0	0	0	0	0	Estimated turbine efficiency 70cfs plant **	
31	29	31	30	31	30	31	31	30	31	30	31	Days/Month	
7	3	41	95	50	-144	0	-1	0	1	52	34	Rate of Change Reservoir Storage, cfs	
2	2	3	102	663	512	74	55	57	64	2	3	Rate of Reservoir Discharge, cfs	
9	6	44	197	713	368	74	54	57	65	54	37	Sum of above Rates, cfs	
0	0	0	316	1023	0	0	0	0	0	0	0	Output, 300cfs kW	
0	0	0	228	761	0	0	0	0	0	0	0	Generation 300cfs limit, MWH	989
0	0	0	214	236	0	0	0	0	0	0	0	Output, 70cfs kW	
0	0	0	154	176	0	0	0	0	0	0	0	Generation 70cfs limit, MWH	330
AVG	210	Estimated Allowable Flow, cfs				Averaged Data 1980 - 2006							
16662	17937	19674	21912	24713	23255	13189	12292	12756	12798	14907	17265	EOM Reservoir Storage, acre-feet	
52	54	56	59	62	60	47	46	47	47	50	53	Estimated Head, feet	
0	0	0	0.88	0.91	0.91	0.9	0.87	0.88	0.88	0	0	Estimated turbine efficiency 300cfs plant *	
0	0	0	0.91	0.91	0.91	0.88	0.88	0.88	0.88	0.7	0	Estimated turbine efficiency 70cfs plant **	
31	28	31	30	31	30	31	31	30	31	30	31	Days/Month	
-10	21	28	36	46	-24	-164	-15	8	1	34	38	Rate of Change Reservoir Storage, cfs	
7	8	12	85	532	894	523	193	125	112	25	8	Rate of Reservoir Discharge, cfs	
-3	29	40	121	578	870	359	178	132	112	59	46	Sum of above Rates, cfs	
0	0	0	344	1324	1281	992	604	403	361	0	0	Output, 300cfs kW	
0	0	0	248	985	922	738	449	290	268	0	0	Generation 300cfs limit, MWH	3901
0	0	0	294	309	299	226	222	226	226	68	0	Output, 70cfs kW	
0	0	0	212	230	215	168	165	163	168	49	0	Generation 70cfs limit, MWH	1370

Notes:
1. (*) The generation values for the 300cfs option were calculated using the performance parameters of a two unit Kaplan powerhouse [Option 2]
2. (**) The generation values for the 70cfs option [500kW] were calculated using the performance parameters of a one unit Kaplan powerhouse [Option3]
3. Output is calculated setting flow equal to 'Rate of Reservoir Discharge', and generator efficiency at 92%
4. Months with 'zero' output have heads and/or flows that are below minimum operating requirements of the turbine equipment

Appendix B

Powerhouse Equipment and Features

Appendix B

Powerhouse Equipment and Features

Automation & SCADA: Modern powerhouses are equipped with control systems that can provide fully automatic operation of all systems in all conditions. Systems are equipped with manual control devices and through mode select switches local or automatic control is selected. When in automatic mode, the control system (utilizing industrial quality Programmable Logic Control hardware and hardened field devices) can monitor and control the powerhouse equipment efficiently and safely. SCADA [Supervisory Control and Data Acquisition] systems provide convenient and easy to use local and remote monitoring and control for powerplant systems through an HMI [Human Machine Interface], typically a desktop or laptop computer. The programming for these systems is project specific but uses off-the-shelf applications and proven programming algorithms.

AC/DC Station Service: The powerhouse will be equipped with both AC and DC station service systems. The AC system will typically be supplied off of the low side of the step-up transformer where a smaller 3-phase transformer sized for station loads will be connected. The load side of this station service transformer will be connected to a 3-phase distribution panel equipped with molded case circuit breakers that will feed the stations 3-phase loads [pump motors, fan motors, etc.]. A single phase transformer fed by the 3-phase panel board will be installed to provide circuits to the stations single phase loads [lighting, receptacles, etc.].

The station will also include a DC station service system. Typically a 120V system with amp-hour capacity sized to provide the power requirements for all of the station DC systems. DC is used to power station inverter(s), pump motors, etc. and provides the energy for the station systems to operate if the plant should suffer a loss of grid connection. The DC system will include a battery charger, inverter, and distribution panel board.

In addition to the above systems there may be reason to consider the installation of a standby diesel engine powered generator. An emergency generator is normally not a requirement unless there may be periods when long outages [loss of grid connection] may occur. These units are normally sized to provide power to the essential powerhouse systems [battery charger, lighting, etc].

Generator: Horizontal generators may be supplied with either pedestal or bracket mounted bearings, lower speed units more typically are equipped with the former. Preferably, the horizontal generator can be designed with a shaft/bearing arrangement capable of carrying the overhung load of the turbine runner. One of the bearings in the horizontal arrangement will need to be designed for the thrust loading of the turbine runner.

Generator selection will impact the powerhouse footprint. A generator with bracket mounted bearings and shaft coupled directly to the turbine runner will be several feet shorter in length than a unit with pedestal bearings and a separate turbine shaft and bearing. A vertical axis unit will have the smallest footprint. If a vertical generator is used, it will be designed with a housing that integrates and supports the stator and the upper and lower bearings. Typically the upper bearing is designed with the thrust surfaces to bear the generator and turbine axial loads.

For Kaplan units the generator shaft is typically bored to allow hydraulic lines to pass to the control surface actuator connections in the turbine runner. Modern 3 phase synchronous generators that would be typically be used for this project will have brushless excitation and will be equipped with an exciter. The exciter will typically receive 125VDC power from the regulation system and powerhouse DC station service system. The generators for this project will have a nominal output voltage of 5 kV. The generator will be equipped with a terminal cabinet that is either free standing or mounted to the generator frame.

The generator may need to have additional inertia depending on the requirements of the utility. Additional inertia can be built into the rotor or increased by adding a flywheel. The units at this project will have relatively low rotating speed and it is unlikely that flywheels will be required.

Governor: Each turbine will be controlled by its own electronic governor. The governor may be stand-alone or integrated into the unit control equipment. Today’s governors are compact and can usually be mounted into the switchboard. The governor will monitor and control the dynamic surfaces of the turbine by providing signals to the control valves of the hydraulic power unit.

Hoist: Regular maintenance will require an overhead lift device. For a powerhouse the size and complexity of that required for this project a bridge crane is recommended. The hoist trolley would travel across the width of the powerhouse and the bridge would travel the length of the powerhouse. The main hoist will be rated for the highest maintenance lift required, typically the generator stator. Larger capacity cranes may be required for construction and heavy lifts would be performed prior to the completion of the powerhouse roof. If vertical axis units are installed, an alternative to a powerhouse crane would be to use mobile hydraulic cranes or a powerhouse structure gantry crane that would access the turbine stack and TIV through openings in the roof.

HVAC: The heating, ventilation and air conditioning system maintains the air temperature and humidity in the powerhouse. This system will need to be designed to accommodate the heating and cooling loads the building will be exposed to. These loads include the heat lost from electrical windings, bearings, heat exchangers, etc.

Hydraulic Power Unit [HPU]: A stand-alone system includes an oil reservoir, station service powered pumps and control devices for powering the turbine equipment servomotors. If the TIV is equipped with a hydraulic actuator, the turbine HPU will normally be used to provide power. Hydraulic connections from the HPU to the actuators will be constructed of stainless steel tubing and hydraulic hose. Normal system operating pressure will be between 1,500 – 2,000 psi [100-130 bar]. It may be practical to use a single HPU for multiple turbines.

Lubricating Oil Cooling Unit: It may be necessary to install an oil cooling system for the bearing lubricating oil. The cooling unit will be equipped with pumps to circulate oil through the heat exchangers. It may be practical to use a single cooling system for more than one unit.

Neutral Grounding Equipment: The generator neutral will be connected to ground through a low voltage high resistance network. This grounding equipment will typically be mounted in a free standing cabinet located near the generator in order to keep the length of the neutral conductors as short as possible, in some cases this equipment will be integrated into the generator terminal cabinet.

Penstock/Inlet Pipe: The power conduit [penstock] inlet into the powerhouse will need to be coordinated with the reservoir outlet pipe works. To insure adequate discharge release, the outlet must continue to be equipped with a sufficient number of discharge valves to accommodate the required reservoir discharge during periods when the turbines are out of service. The current fixed cone valves may be used for this application and their control would be integrated into the powerplant control system. The conduit must be designed to accommodate stresses encountered during operations under the maximum head/transient conditions that can be generated by the turbines; all hydraulic components must be selected based on these maximum conditions. The proposed outlet entails a 9 foot diameter steel pipe for the new outlet works. This pipe diameter is more than adequate to carry the 1,000 cfs for hydropower generation [water velocity approx 16 feet/second].

Step-up Transformer: This transformer increases the generation voltage to the transmission voltage. The transformer is connected to the grid through a circuit interrupter.

Substation Equipment: Normally included at the powerhouse substation will be the step-up transformer, and all equipment that operates at transmission voltage.

Switchboard: Normally located in a control room in the powerhouse where the room air can be filtered and temperature controlled. The switchboard is a multi-section metal cabinet equipped with metering and control switches that provides monitoring and control of all powerhouse systems and equipment. Interconnecting control and metering wiring and cables will be routed from the powerhouse equipment into the cabinet and terminated on terminal blocks.

Switchgear: Each generator will have a protective circuit interrupter typically this will be a medium voltage circuit breaker or contactor. This device can be unit installed in an individual free standing cabinet at the generator or more commonly installed in a station switchgear cabinet that will contain interrupters for each generator and all of the other medium voltage equipment. Medium voltage cable is routed from the generator terminal cabinet to the switchgear. The ‘line’ side of the switchgear is connected by medium voltage cable to the station step-up transformer located in the substation.

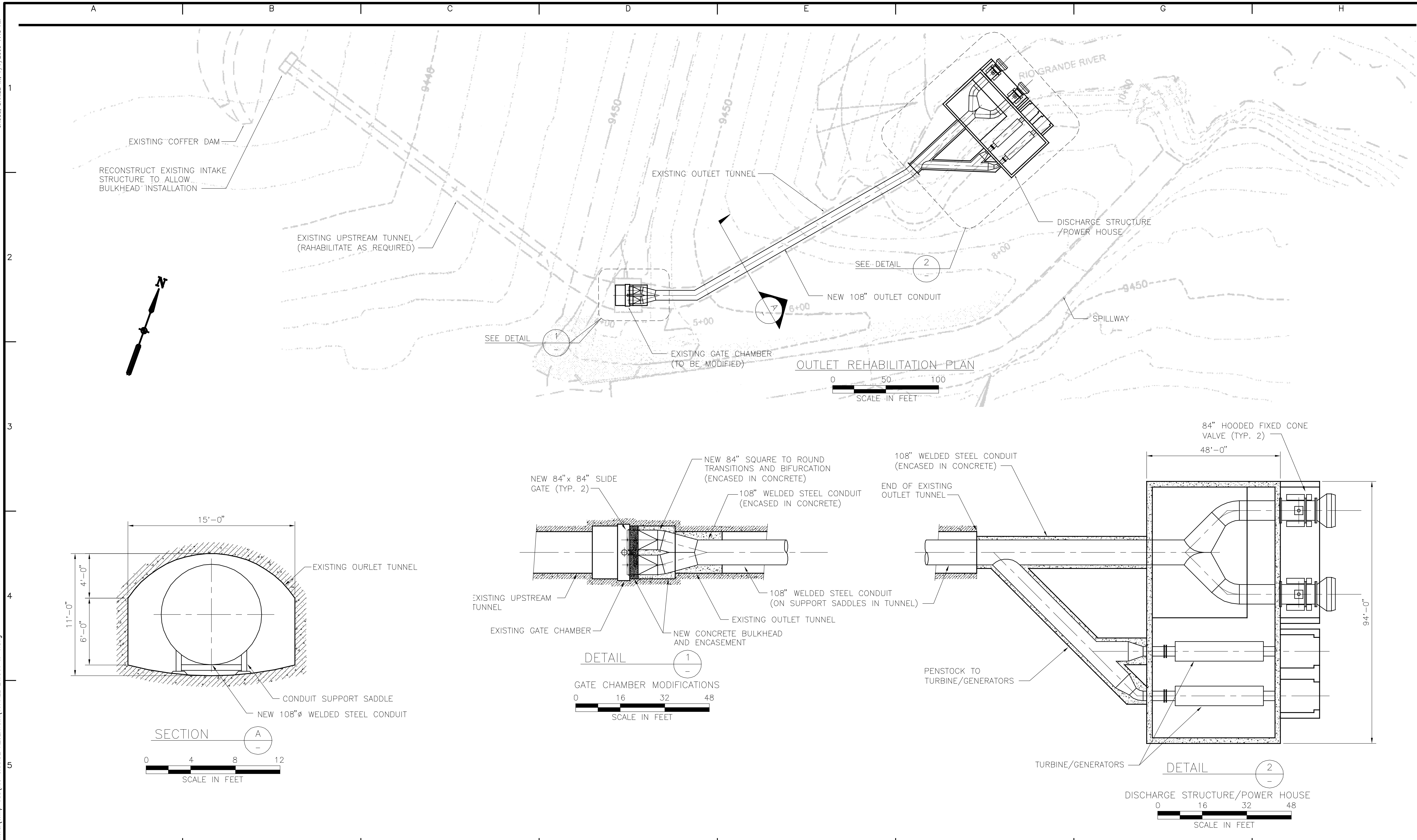
Tailrace and Stop Logs: The discharge from the turbine will pass through a draft tube and empty into the unit tailrace below the turbine. The concrete tailrace will be formed during the construction of the powerhouse foundation. Each tailrace will have provisions for stop logs in order to isolate and dewater the structure for routine maintenance activities. Means for hoisting and moving the stop logs should be included in the design. One set of stop logs can be used if the tailraces are the same size.

Turbine: The reaction turbines will be supplied with an inlet, spiral case, and elbow draft tube. The turbine selection will determine a horizontal or vertical axis. Horizontal axis units may or may not be equipped with a turbine guide bearing. Vertical units will have a turbine guide bearing. Dynamic turbine hydraulic surfaces will be actuated by hydraulically powered servomotor(s) controlled by the turbine governor.

Turbine Inlet Valve [TIV]: A conventional rated-for-duty butterfly valve will typically be specified for this service. Each turbine will have a properly sized valve that is typically equipped with a powered actuator [hydraulic or electric] operated by the powerplant control system.

Appendix C

URS Conceptual Layout of the Rio Grande Reservoir Outlet Works Using the Existing Tunnel



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RIO GRANDE RESERVOIR

OUTLET WORKS REHABILITATION USING EXISTING TUNNEL "APPENDIX C"

SHEET NUMBER

M-1

SHEET 1 OF 1