MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Operations RCG Meeting

June 27, 2013

Final KDM 07-16-13

ATTENDEES:

Vivianne Vejdani (SCDNR)
Dick Christie (SCDNR)
Scott Harder (SCDNR)
Malcolm Leaphart (Congaree Riverkeeper)
Gerrit Jobsis (American Rivers)
Prescott Brownell (NOAA)
Joseph Wojcicki (By-PAS)
Erich Miarka (Gills Creek Watershed Association)
J. Hagood Hamilton, Jr. (SCANA)
Bill Stangler (Congaree Riverkeeper)
Bill Argentieri (SCE&G)
Ray Ammarell (SCE&G)
Kelly Miller (Kleinschmidt)
Alan Stuart (Kleinschmidt)
Bill Marshall (SCDNR)
Jon Quebbeman (Kleinschmidt) via Conf. Call
Randy Mahan (SCANA)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Alan opens the meeting with introductions, and then turns the floor over to Gerrit. Gerrit begins with showing information collected from the USGS gages at Carlisle and Alston. The gage at Carlisle is located upstream of the Project, while the Alston gage is located downstream of the Parr Dam. The first slide Gerrit presents is of flow data collected at each gage over the previous week. He then shows a slide that includes flow data from each gage over the past thirty days, making the point that the Project does have an effect on flows. He says that American Rivers has been interested in the phenomenon of how the Project changes the flows of the Broad River, and so they asked Erich to study this effect as part of his graduate work with the University of South Carolina.

The result of this study was Erich's thesis paper entitled "Flows Effects of the Parr Hydroelectric Project," which was distributed to members of the Operations RCG in advance of the meeting. Erich then presented his findings, allowing for questions during and after the presentation. One issue that was raised was the selection of the Indicators of Hydrologic Alteration (IHA) software that Erich used to analyze the flows. As Erich indicates in his paper, the standard method of using IHA did not apply in this particular situation, however, the nature of the data and location of the gages did fit the intended use of the software. Also, IHA is designed to use daily data versus the 15 minute discharge data that Erich substituted. Erich explains to the group that this replacement in effect did not make a difference to the overall results, as long as one keeps in mind that this substitution was done. Erich also admits that some of the numbers may be larger than expected, and larger than actual, due to him not accounting for flow attenuation when determining inflow. He also points out that the number of reversals indicated in the study may not be realistic, since there was no threshold limit in determining a reversal. Keeping these considerations in mind, Erich asks the group for any questions.

Ray and Bill A. ask Erich why he decided to use hourly data instead of daily data, which was also available. Erich says he felt like the hourly variability would have been lost if he used a daily average, and that hourly variability is what he wanted to capture through this study. He reiterates that if it is noted that the units were changed from daily to hourly in the IHA software, it doesn't matter which data is used. Gerrit agrees, stating that American Rivers was interested in seeing the changes in flows in regards to how they affect the river. It is important to examine how the hourly fluctuations affect the aquatic environment. Ray points out that although it may seem like a simple substitution, the model may have been built with constraints that could skew the hourly data. Since the software was designed to handle only daily data, using hourly may not just be a simple substitution, as this type of software is often very complex.

Jon then adds his comments on the study. He says that he doesn't agree with the surrogate river used as part of the study to determine the pro-rating ratio. He also mentions he would like to see a more robust modeling system used. He says that selection of specific periods in time is not representative of an entire year or decade. Jon believes that it should be easy to run this same analysis on a continual basis to gain a greater understanding of what's typical for this stretch of the Broad River. He adds that straight line proration is not appropriate to use here. Erich responds by saying that 83% of the study areas is covered by gages, so only 17% of the data was prorate, which he believes is fairly insignificant. Erich adds that he thinks it is important to show what Project operations are capable of doing. Gerrit agrees with Jon and says that the Project can and should be studied more robustly, but that Erich's study contains some important results and can be used as a starting point for future study. Jon says that he just doesn't want the results of the study to be misinterpreted as what the Project is definitely doing. He thinks this is an example of what the Project can do, but not what is actually happening. He points out that any dam is going to alter the flow regime of a river. However, determining the actual effects that the Project is having is what's important, and since Jon doesn't believe the study is taking into account typical operations (since periods of time were chosen to study versus a continuous time period that stretched back one or several years) the actual effects are not accurately represented.

After discussion on Erich's paper concluded, Ray presents the group with information on Parr Hydro project regulation effects, the Project's license compliance summary, and an overview of the Parr and Fairfield plants. These presentations are attached at the end of these notes. Several questions arose during these presentations and are discussed below.

Scott asks Ray if the evaporation numbers included as part of the inflow/outflow values take into account the evaporation from the nuclear plant. Ray answers yes the evaporation is calculated over the entire Monticello reservoir.

Gerrit asks how low the gates can operate at the Parr Dam and how low the units can operate. Malcolm then asks if they have any water quality issues regarding nitrogen due to aeration. Ray says he doesn't have the answers to these questions, but that he will find out and get back with the group.

After lunch, Alan leads the group in a discussion on identifying any information needs and how the group would like to address these needs. Bill A. brings up a list of information needs that were identified early on by the agencies and NGOs to use as a starting point.

The group first tackles the issue of determining what effects Project operations have on the Congaree River. Bill S. adds that we need to look at how operations impact fisheries and aquatic resources, along with flood inundation at the Congaree National Park (CNP). Alan asks the group what specific information is needed, and how do we go about getting that information? He also asks if we want to use a long term record, or just a snap shot. Gerrit says a snap shot can be used to simulate how the flows would be without the Project. Ray adds that we would then have to develop a hydrologic model. We can then determine how the Project affects flows, river levels and ultimately the national park.

Jon suggests the use of a model known as HEC-EFM, which can use any timescale, and can be tied directly to GIS information. Gerrit mentions that the CNP already collects data over many transects across the park and it would be great if this HEC-EFM model could interact with the one already used. Jon says that if the model already used at the CNP is HEC-RAS, the information can easily be transferred into the HEC-EFM. Ray points out that if you have HEC-RAS model information you can then use the HEC-EFM model to produce the GIS data that can potentially be used with any GIS application available. Bill S. mentions a model known as TUFLOW has been used at CNP. Jon says that this model is very different from the HEC-EFM, which is much more user friendly. Scott asks if the models take into account the downstream attenuation. Jon says he knows that the HEC-EFM does, but he isn't sure about the TUFLOW.

Jon and Ray agree that routing can be done using a one dimensional approach, as a 2-D model might give more information than is actually needed. Gerrit agrees.

Jon tells the group that metrics need to be determined to develop an effective HEC-EFM model. Gerrit says that species of importance have already been determined as part of the IFIM study.

The group agrees that it will be important to examine the Broad River and the Saluda River, since both have an effect on the Congaree River. The group then discusses how this will be possible, through the use of historical data to create a baseline model. Jon points out that developing the various models will not be difficult instead the hard part of the process will be to develop the metrics. The group tells him that some of the metrics will be determined based on the IFIM study, while the others have already been established for the CNP.

The group decides to use the existing USGS data to establish a baseline, and then create an operations model utilizing this baseline and the already determined metrics. Scott wants to know if a reasonable model can be built that will accurately capture the complexity of the Project. Jon says that it can, but it will be difficult and the resulting model will be very complex. He adds that as with any model, everyone needs to keep in mind that the results will be greatly simplified.

The group then discusses the creation of a water budget, or allocation model. Gerrit mentions there is a possibility that a statewide basin model might be created in the near future, and that could be utilized here. However, he states that we won't know until August if this project will be funded. A water allocation budget will be part of the operations model that was discussed earlier. It will be used as a constraint within the model.

The possibility of a sediment management plan is mentioned. The group is reminded that the Water Quality TWC is working through this issue and will report back to the Operations RCG on what they determine. Currently the Water Quality TWC is considering whether a sediment management plan is needed or not, and if not, addressing the need for a plan to be in place to handle future sediment management considerations.

As the meeting wraps up, Ray and Jon plan to get together to begin initial development of the operations model, with plans to get Scott involved further in the process. Gerrit asks if the group wants to evaluate Erich's study any further. Jon says that more information along the lines of his study will be coming out of the operations model.

The group will plan to reconvene in the late September/early October timeframe to discuss a study plan for the operations model. Action items stemming from this meeting are listed below.

ACTION ITEMS:

- Ray and Bill A. will follow up with answers to some of the operations questions that were asked during Ray's presentation.
- Jon Quebbeman will prepare an outline of development of the Operations Model for distribution to RCG.

- What effects do dam operations have on the Congaree River? It is noted that operations appear to affect the minimum (lower) and maximum (higher) outflows relative to corresponding inflows and that flow pulses increase with flow. Are these measureable at Congaree? The Jobsis (Erich Miarka) study is referenced. (Operations)
    - Effects on aquatic resources
    - Effects at Columbia USGS gauge
    - Effects on the Congaree National Park
    - Magnitude and frequency of flows at CNP gauge
    - What are we trying to compare?
    - Inflow vs what is seen at Columbia USGS gauge and CNP
    - HEC- EFM (ecosystem function model)
    - First cut – one dimensional, unsteady state conditions model
    - Possibly build HEC-RAS model of Congaree River reach
    - What is happening now?
    - What changes could be made to improve flow conditions?
    - Use USGS data that already exists
    - Might need to develop an operations model in addition to our flow routing model
    - Time step to be used – hourly???

- Description of current operations and proposed future operations at the project and related effects on instream flows. (Operations)
    - Related to Broad River
    - Not proposing any change in future operations at this time
    - Evaluating current operations and potential operations that may benefit IFIM results and CNP needs
    - Effects of Parr Project on downstream flow – similar to IHA analysis

- Water budget/allocation model– (Operations)
    - Project effects on downstream water budget – (Operations)
    - What are the projected long term water demands on the Broad River? This will require coordination with the City of Columbia and analysis of their plans for projected population growth and water supply demands. It will also have to consider future demand from facilities like VC Summer and other water users. (Operation)
    - daily operations, low flows, drought, & flood
    - operational constraints
        - Water allocation assessment/budget
        - Inflow patterns/data set – potential changes in future inflow patterns and water demands (constraints in flow model from above)
        - Potential to use statewide model to address this issue
        - Develop future inflow series
        - This will be in a checklist format

- Information sheet: A comprehensive explanation of the hydro operations at the Parr Shoals Project. Including: daily operations, low flows, drought, flood and status on existing units (working condition) (Operation)
    - Addressed in today's presentation
    - Additional group information needs will be addressed as they arise

- Information sheet: A comprehensive explanation of the operations at the Fairfield Pump Storage station. Including: daily operations, low flows, drought, & flood. (Operation)
    - Addressed in today's presentation
    - Additional group information needs will be addressed as they arise

- Future operational plans
    - TBD

- Instream flow compliance records
    - Will be provided after this meeting

- Sediment management plan
    - Is there a sediment management plan needed
    - If not, is there a plan to address this concern if it is determined to be needed at a later date
    - Let WQ TWC address this and what information is needed to look into a management plan

- Low Flow Protocol – LFP
    - To be determined during relicensing

- Develop inflow determination protocol – streamflow gauging process, determine inflow to project at a given time, look into scaling of gauges

Flow Effects of the Parr Hydroelectric Project

Erich Miarka
University of South Carolina

MEERM 2012

Outline

- Brief Description and Background
- Advisors and Internship Site
- Study Area
- Objective of Study
- Methods & IHA
- Results & Implications

Overview

- The Parr Hydroelectric Project is owned and operated by South Carolina Electric and Gas Company (SCE&G)
- License with the Federal Energy Regulatory Commission expires in June 2020
  - SCE&G will likely begin relicensing procedure within next year
- Stakeholders will have a chance to intervene in relicensing process

Internship Site & Advisors

- American Rivers
  - Gerrit Jöbsis: Southeast Regional Director
  - Rebecca Haynes: Associate Director, Southeast Conservation
- University of South Carolina
  - Dr. Allan James: Professor, Department of Geography
  - Dr. John Grego: Associate Professor, Department of Statistics

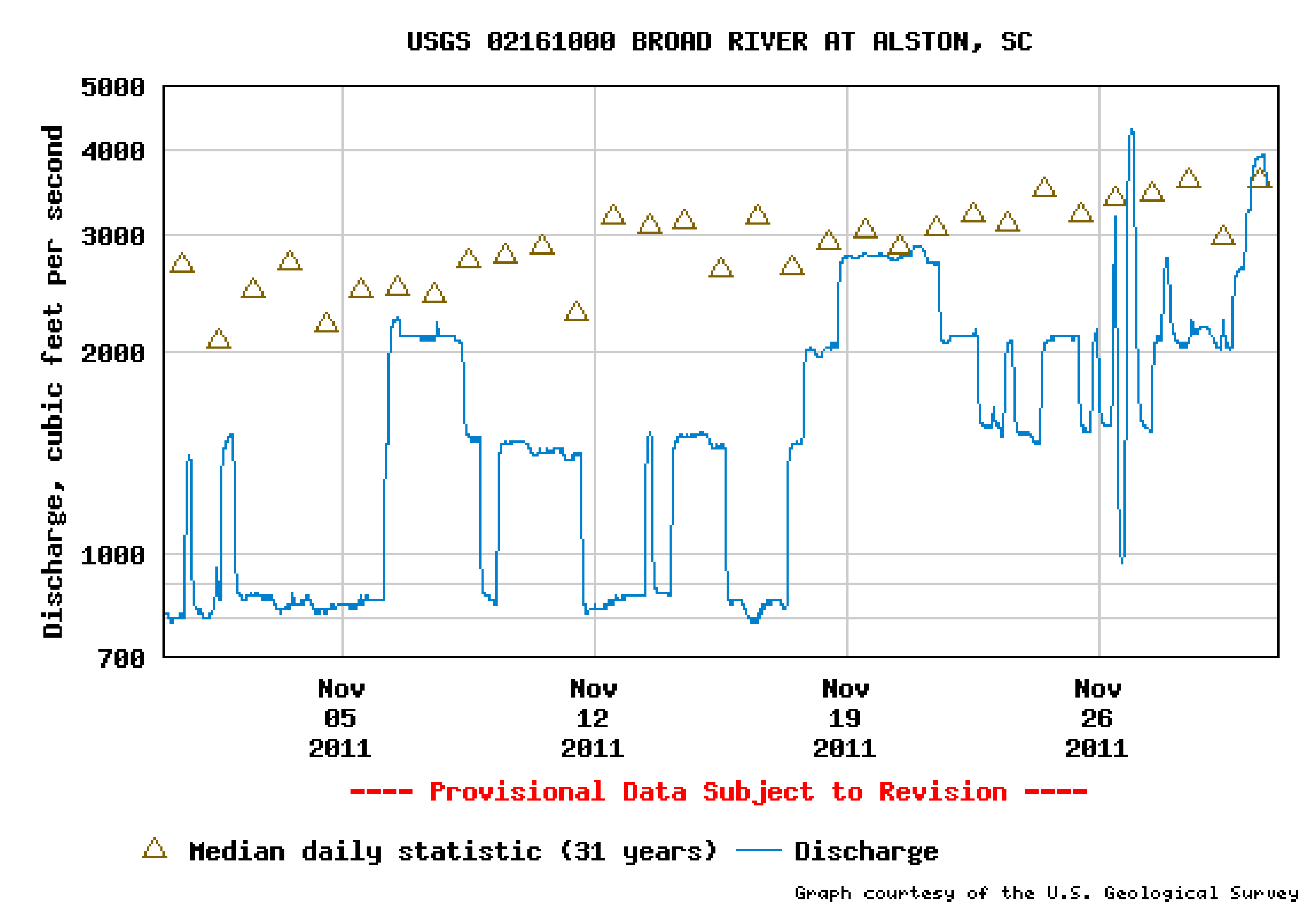
Blair Gage
N
Monticello
Parr Shoals Reservoir
Fairfield Facility
V.C. Summer Nuclear Complex
Parr Shoals Dam
4.05 mi
Alston Gage
Google earth
Imagery Date: 1/29/2012
34°19'11.94" N 81°19'17.22" W elev 425 ft
Eye alt 17.63 mi

Research Question

- What effect is the Parr Hydroelectric Project having on flow?
  - What ability does it have to alter the flow regime it receives?

Critical Steps

- Calculate inflow to the Project
- Analyze flow data below the Parr Shoals Dam
- Determine frequency and severity of flow alteration
  - Pulses in water release
- Results to be used in FERC relicensing procedures for Parr Hydroelectric Project by American Rivers


USGS 02161000 BROAD RIVER AT ALSTON, SC
Discharge, cubic feet per second
5000
4000
3000
2000
1000
700
Nov 05 2011
Nov 12 2011
Nov 19 2011
Nov 26 2011
---- Provisional Data Subject to Revision ----
Median daily statistic (31 years)
Discharge
Graph courtesy of the U.S. Geological Survey

The River System

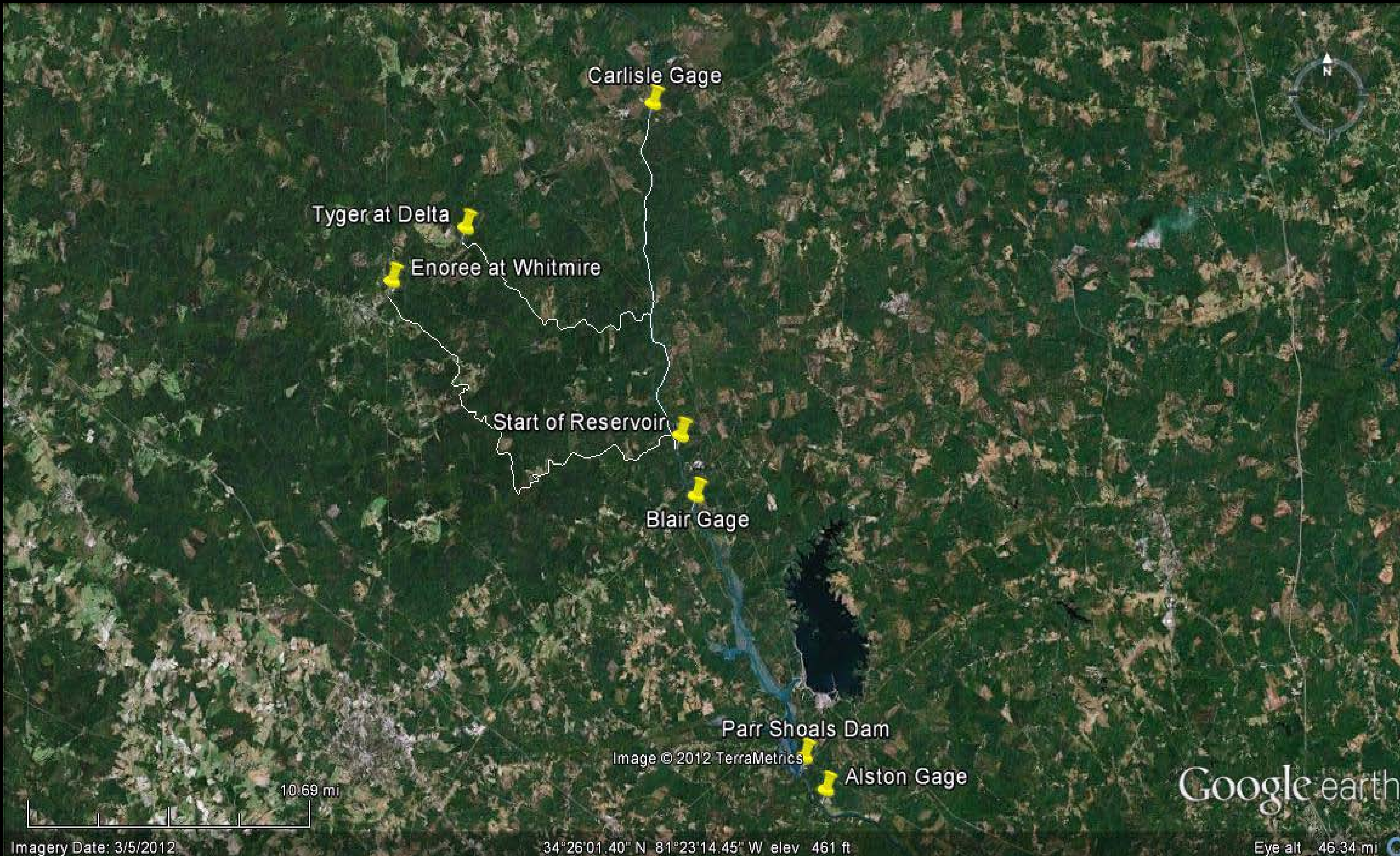
- Source of human recreation
- Home to many species
  - Shortnose sturgeon, Carolina darter
- Nourishes Congaree National Park
  - River flooding sustains the park's ecosystem
  - Largest continuous tract of old growth bottomland hardwood forest in the U.S.

Methods

- Calculate inflow to the Parr Hydroelectric Project
  - Project begins at the start of the Parr Reservoir
- Allot for flow travel time into Project
- Compare to outflow of Project
  - Indicators of Hydrologic Alteration

Inflow

- Three gages above Parr Hydro Project
  - Carlisle on the Broad, Tyger at Delta, and Enoree at Whitmire
  - Hourly flow data available from each site
- Each river shares similar characteristics
  - Piedmont style river
  - Different flow regimes
- Characterize each river's low, medium, and high flows
  - 25^{th}, 50^{th}, and 75^{th} percentiles


Carlisle Gage
Tyger at Delta
Enoree at Whitmire
Start of Reservoir
Blair Gage
Parr Shoals Dam
Image © 2012 TerraMetrics
Alston Gage
10.69 mi
Google earth
Imagery Date: 3/5/2012
34°26'01.40" N 81°23'14.45" W elev 461 ft
Eye alt 46.34 mi

Proration Method

- Gages for tributaries not at mouth of river
- 460 mi^2 along Broad River unaccounted for by gages
  - Need to account for flows into the Broad above project but below gages
- Proration method used to extrapolate flow values to mouth of river (at Broad River)

Proration Method Example

- Enoree gage drains 444 mi^2, entire river drains 731.3 mi^2

(Discharge/444) * 731.3 = Prorated Discharge

- Also done for Tyger River and the 460 mi^2 of area along Broad River (prorated off Carlisle)

Travel Times - Surrogate

- Need to account for flow travel times
  - Each gage above Project is different distance away
- Surrogate river used to calculate a per mile travel time
  - Lower Saluda River
- Different flow periods timed
  - Low, medium, and high flows

River	Flow Level, Per Mile Rate	Distance to Reservoir (miles)	Total Travel Time (hours)
Broad, Carlisle	Low, .300	12.73	3.819
Broad, Carlisle	Medium, .286	12.73	3.646
Broad, Carlisle	High, .232	12.73	2.955
Tyger	Low, .300	15.88	4.764
Tyger	Medium, .286	15.88	5.548
Tyger	High, .232	15.88	3.686
Enoree	Low, .300	20.55	6.165
Enoree	Medium, .286	20.55	5.886
Enoree	High, .232	20.55	4.770

Indicators of Hydrologic Alteration

- Software developed by The Nature Conservancy
- Analyzes daily streamflow data
  - 33 statistical parameters
- Need to “lie” to software
  - Change timestamp from hourly to daily
- 2 parameter groups wanted
  - Pulse characteristics
  - Rate and frequency of water condition changes

Results: Min & Max

- Outflows amplified
  - Maximum flows higher in outflow
  - Minimum flows lower in outflow
- Range of flows increases with flow category
  - Average increase of low flow range: 716 cfs
  - Average increase of medium flow range: 3,454 cfs
  - Average increase of high flow range: 6,005 cfs

Results: Number of Pulses

- Pulses increase with flow
- Low Flow Periods:
  - No noticeable change in pulses
- Medium Flow Periods:
  - 6 low pulses
  - 4 high pulses
- High Flow Periods:
  - 6 low pulses
  - 10 high pulses

Results: Duration of Pulses

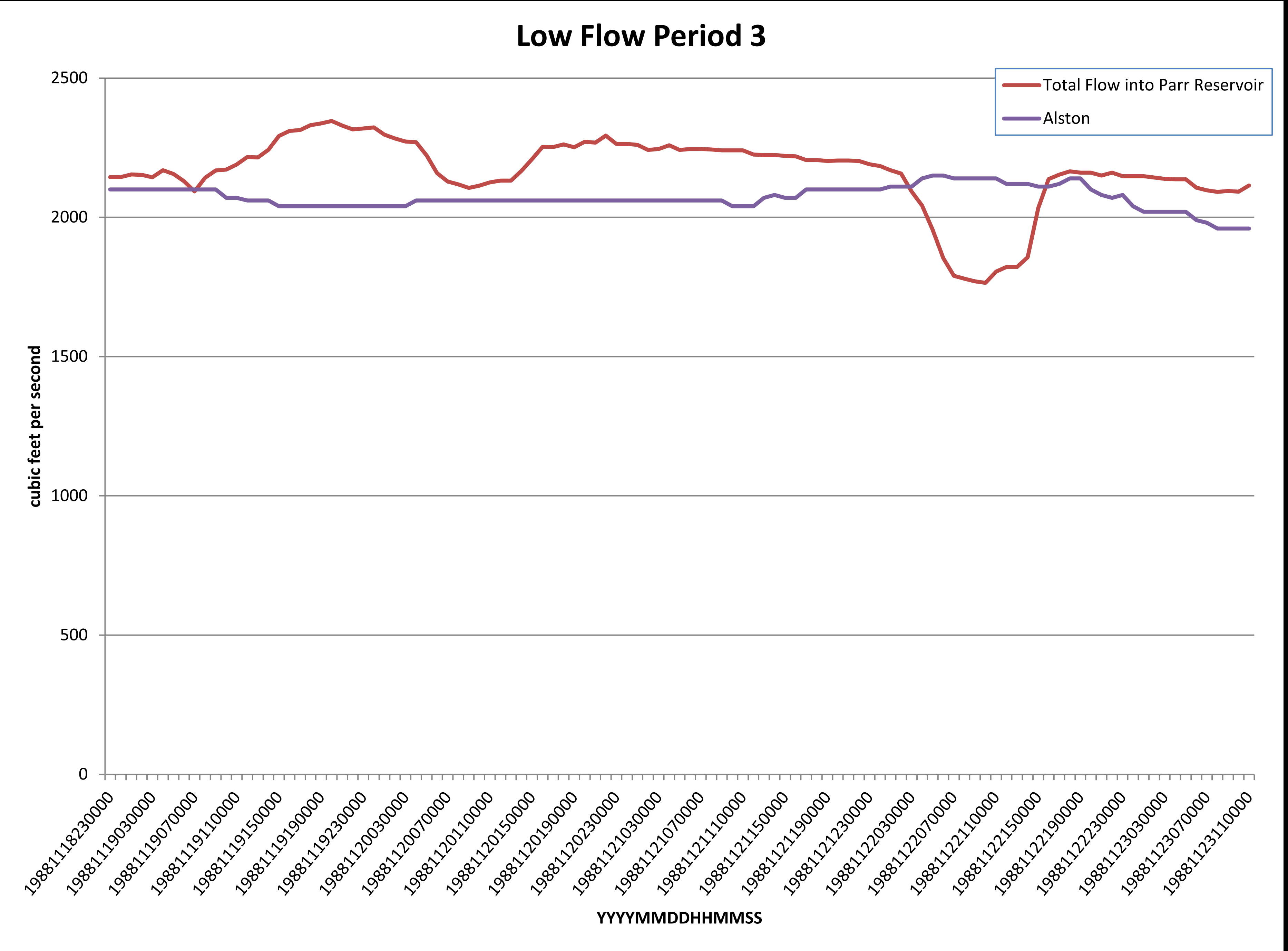
- Pulse duration decreases as flow increases
- Low Flow Periods:
  - No noticeable change in pulses
- Medium Flow Periods:
  - Low pulses: 12.67 hours
  - High pulses: 20.5 hours
- High Flow Periods:
  - Low pulses: 3.67 hours
  - High pulses: 12.83 hours

Results: Flow Reversals

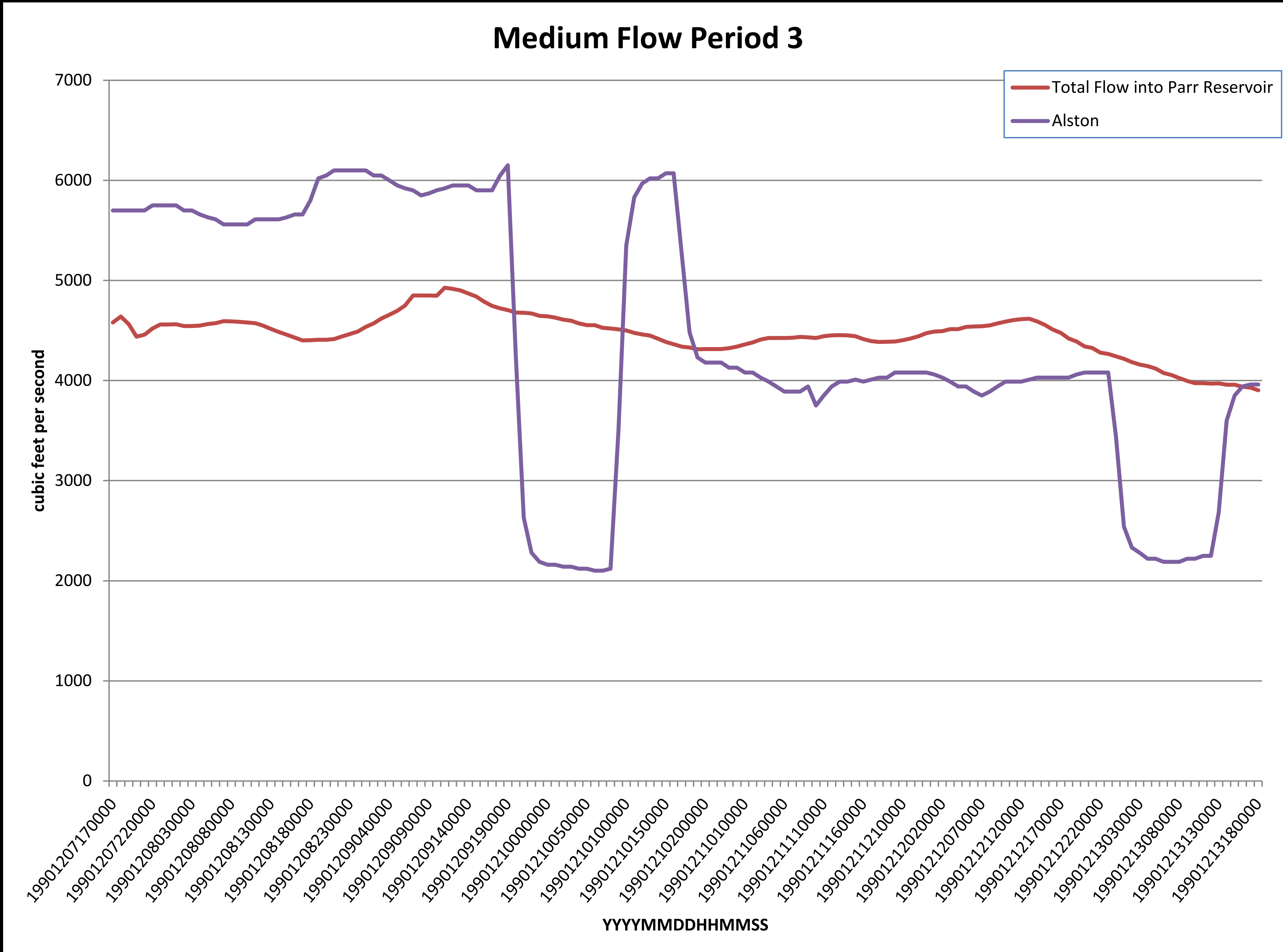
- Low flow periods:
  - Reversals decreased from 25.67 to 12
- Medium flow periods:
  - Reversals decreased from 26.67 to 19.33
- High flow periods:
  - Reversals increased from 18.33 to 23.67
  - Only these three periods increased in reversals

Results: Rise and Fall Rates

- Low flow periods:
  - Slight increase in rise and fall rates
- Medium flow periods:
  - Rise rate increased from 11.32 to 55
  - Fall rate increased from -14.39 to -65
- High flow periods:
  - Rise rate increased from 29.53 to 250
  - Fall rate increased from -27.95 to -210



Low Flow Period 3
Total Flow into Parr Reservoir
Alston
cubic feet per second
2500
2000
1500
1000
500
0
19881118230000
19881119030000
19881119070000
19881119110000
19881119150000
19881119190000
19881119230000
19881120030000
19881120070000
19881120110000
19881120150000
19881120190000
19881120230000
19881121030000
19881121070000
19881121110000
19881121150000
19881121190000
19881121230000
19881122030000
19881122070000
19881122110000
19881122150000
19881122190000
19881122230000
19881123030000
19881123070000
19881123110000
YYYYMMDDHHMMSS


Medium Flow Period 3
Total Flow into Parr Reservoir
Alston
cubic feet per second
7000
6000
5000
4000
3000
2000
1000
0
19901207170000
19901207220000
19901208030000
19901208080000
19901208130000
19901208180000
19901208230000
19901209040000
19901209090000
19901209140000
19901209190000
19901210000000
19901210050000
19901210100000
19901210150000
19901210200000
19901211010000
19901211060000
19901211110000
19901211160000
19901211210000
19901212020000
19901212070000
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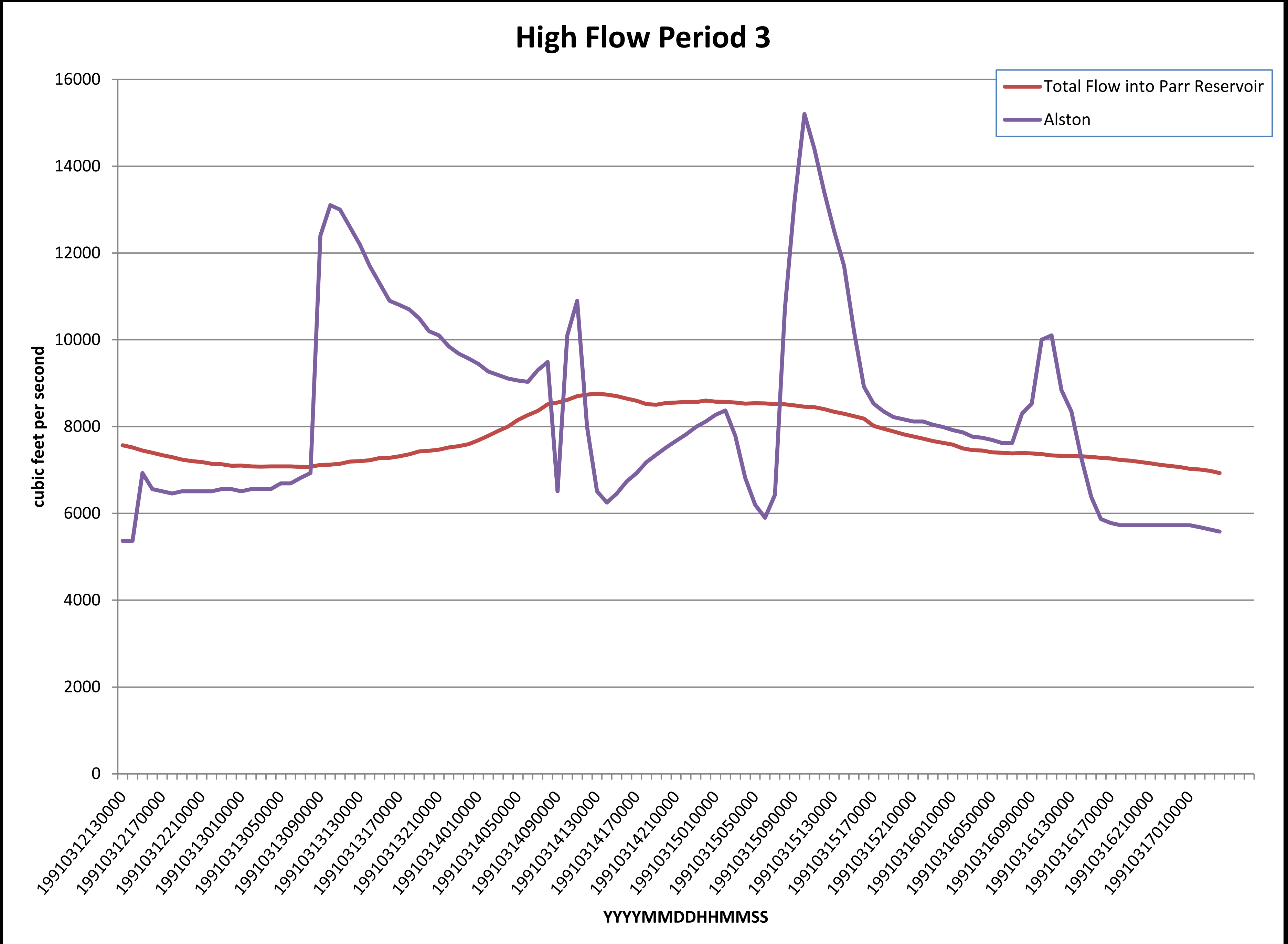
19901213180000
YYYYMMDDHHMMSS


High Flow Period 3
Total Flow into Parr Reservoir
Alston
cubic feet per second
16000
14000
12000
10000
8000
6000
4000
2000
0
19910312130000
19910312170000
19910312210000
19910313010000
19910313050000
19910313090000
19910313130000
19910313170000
19910313210000
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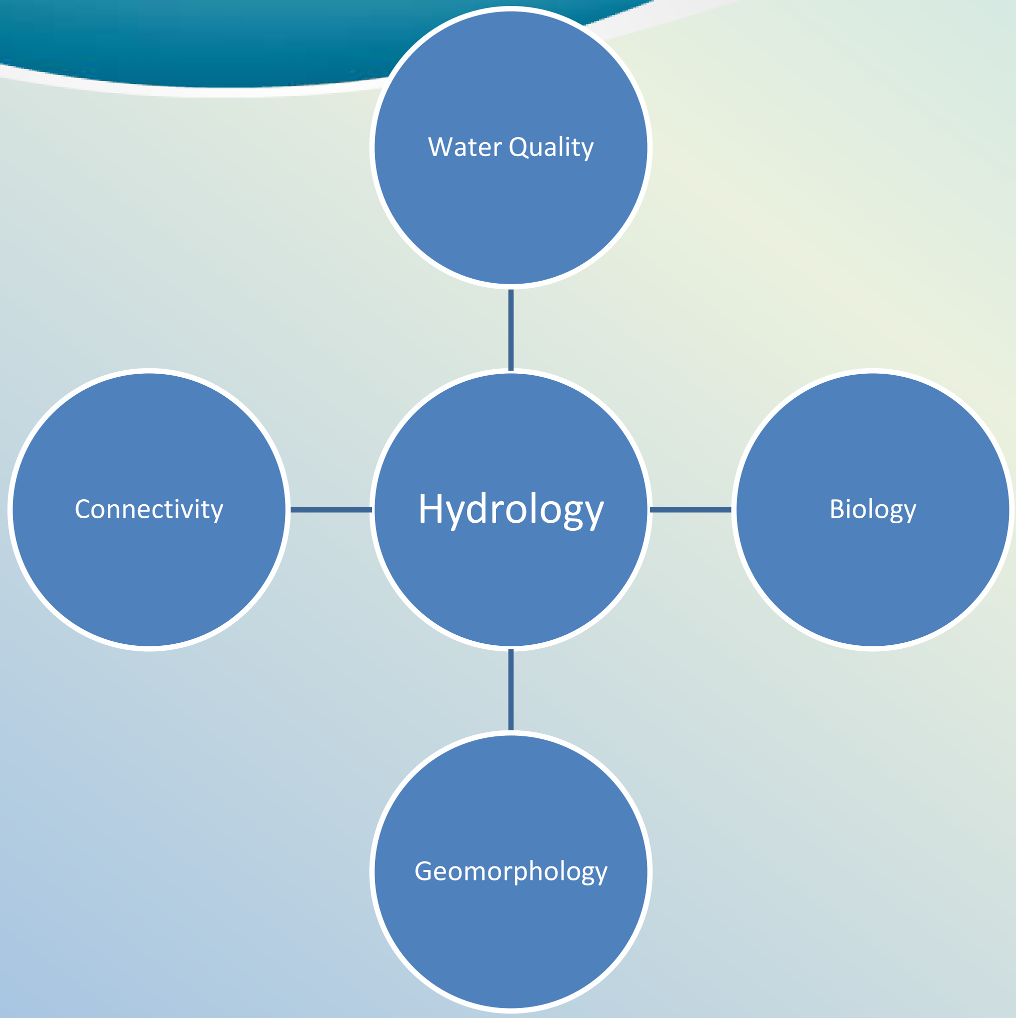
YYYYMMDDHHMMSS

Implications: Riverine Ecology



Annear, Thomas C. *Instream Flows for Riverine Resource Stewardship.* Cheyenne, WY: Instream Flow Council, 2004. Print.

Implications

- Fast rise rates serve as spawning cues to some fish
  - Artificial high pulses may cause inappropriate spawning
- Flashiness can leave natives susceptible to nonnative takeover
- Increased maximum and minimum flows can leave soil too moist or too dry

Further Questions

- How does altered hydrology affect the biological, connectivity, geomorphological, and water quality on the Lower Broad?
- How can the Project be better managed to mimic the natural hydrograph or incoming flows?

Considerations

- Reversals should have a threshold limit before considered a reversal (e.g. ±10%)
  - Too many reversals on inflow, too sensitive
  - Incorporating attenuation could help
- Inflow should account for attenuation of flow from gage sites
  - Reversals and rise/fall rates would be reduced for inflow

- “the natural flow regime of virtually all rivers is inherently variable and that this variability is critical to ecosystem function and native biodiversity.”
  - Poff et al. 1997

Acknowledgements

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- Dr. Allan James
- Dr. John Grego
- Sarah Ellisor
- Scott Harder
- Bill Argentieri

Questions?

References

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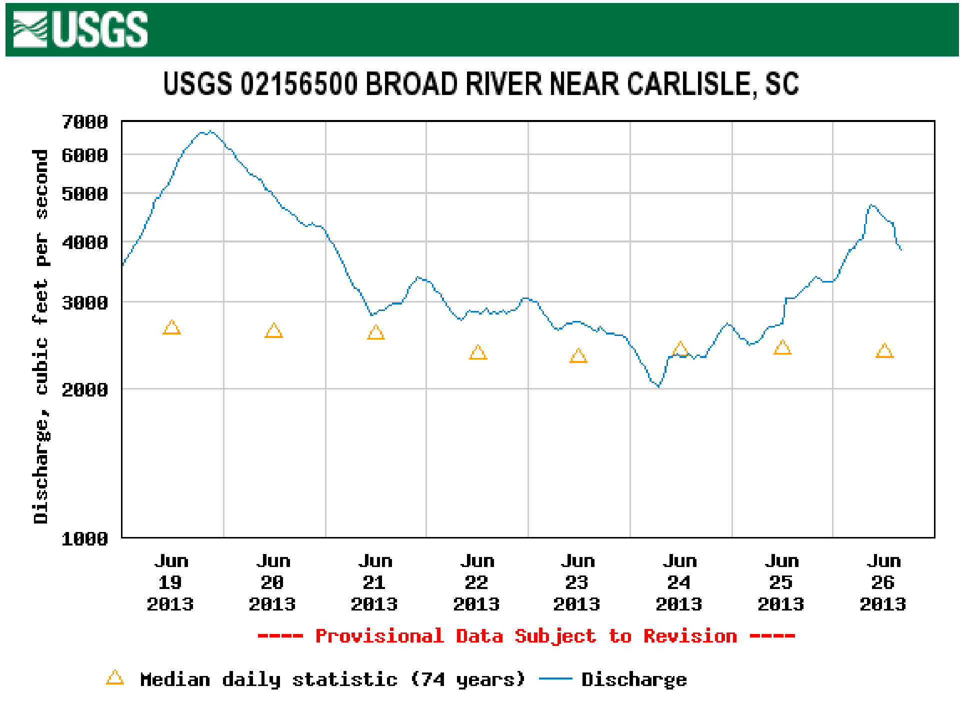
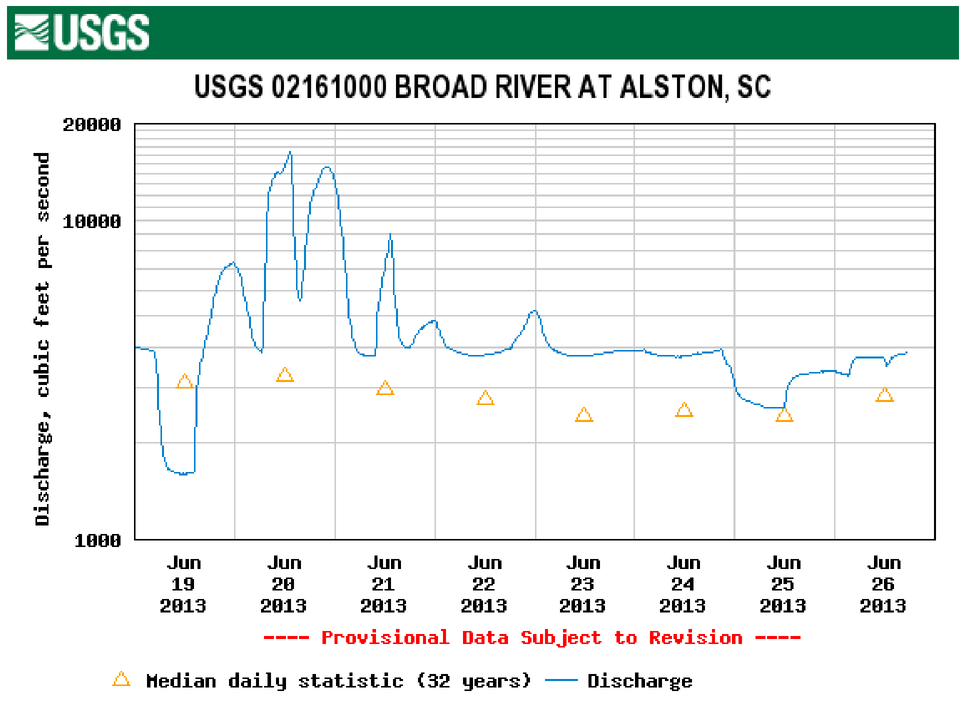
Past 7 days

Carlisle

vs.

Alston



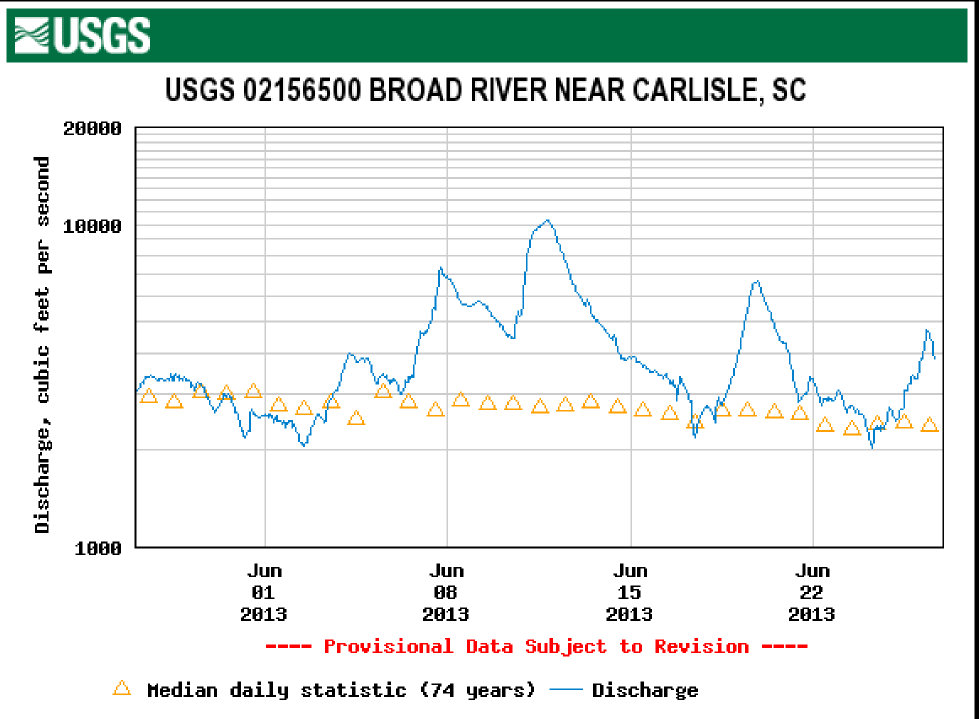


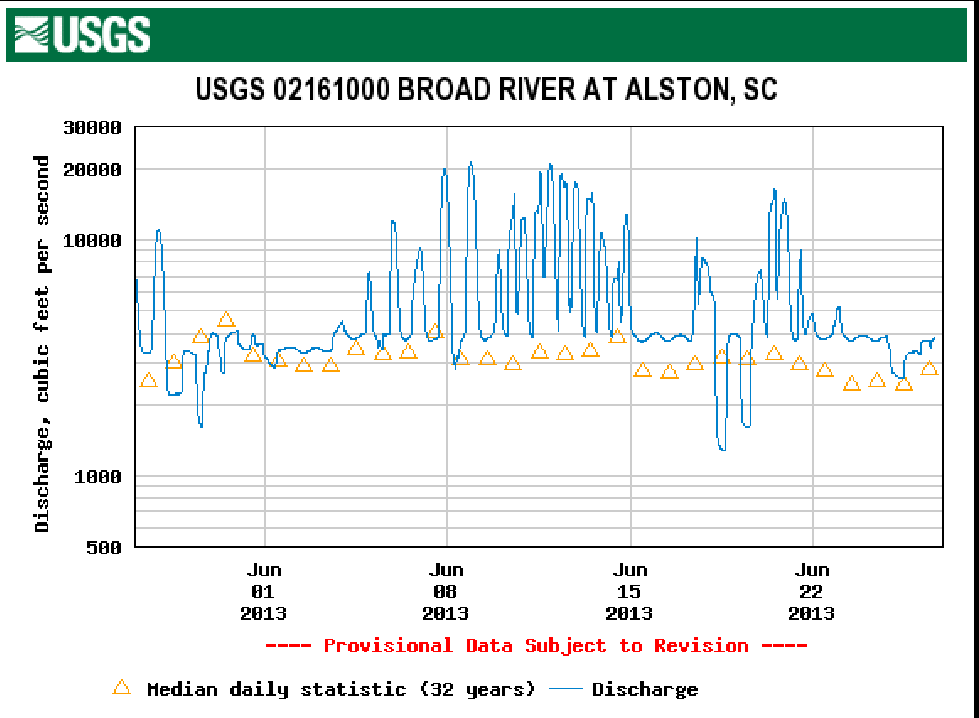
Past 30 days

Carlisle

vs.

Alston





PARR HYDROELECTRIC PROJECT
PARR & FFPS PLANT OVERVIEW
FERC PROJECT No. 1894 - SC

JUNE 27, 2013

SCE&G®
A SCANA COMPANY

PARR
Relicensing Project

TOPICS

- Table of Standard Project Numbers
- Parr Hydro:
  - Plant Overview & Basic Data
  - Drag Rake Description & Operation
  - Spillway and Crest Gates
- Fairfield Pumped Storage:
  - Plant Overview & Basic Data
  - Intake and Tailrace
- Project Operation Overview

Parr Hydroelectric Project P-1894

Table of Standard Project Numbers

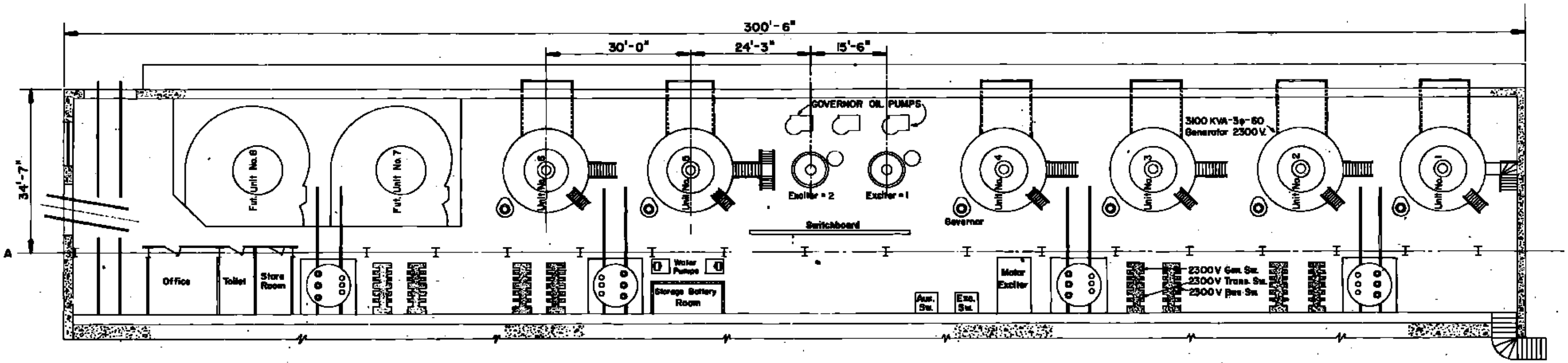
DESCRIPTION	NUMBER OR FACT (PARR SHOALS DEVELOPMENT)	NUMBER OR FACT (FAIRFIELD PUMPED STORAGE DEVELOPMENT)
Project Location	25 mi northwest of City of Columbia; Fairfield and Newberry Counties	27 mi northwest of City of Columbia; Fairfield County
GENERAL		
Project drainage area	4,750 sq. miles	4,750 sq. miles (lower res.) 9,400 acres (upper res.)
Station rated generating capacity	14,880 kW	511,200 kW
Estimated reliable capability	7,000 kW	511,200 kW
Annual gross generation	54,086 MWh (2000 thru 2010)	708,636 MWh (2000 thru 2010)
Discharge at rated capacity	6,000 CFS	50,400 CFS (Generating); 41,800 CFS (Pumping)
Minimum recorded daily average flow	800 CFS (at USGS Alston Gage Site)	0 CFS (into Parr Reservoir)
DAM & RESERVOIR		
Dam Type & Dimensions	Concrete gravity spillway, 37 ft. high, 2000 ft. long, crest el. 257.0 ft. NGVD29	(4) Primary earth embankments, all with crest el. 434.0 ft. NGVD29: Dam A: 85 ft. high, 3,130 ft long Dam B: 160 ft. high, 4,700 ft. long Dam C: 60 ft. high, 2,000 ft. long Dam D: 30 ft. high, 1,300 ft. long (2) Perimeter freeboard embankments on east side of reservoir
Max. Res. Oper. Level (Full Pool) & Area	El. 266.0 ft. NGVD29; 4,400 ac.	El. 425.0 ft. NGVD29; 6,800 ac.
Min. Res. Oper. Level	El. 256.0 ft. NGVD29	El. 420.5 ft. NGVD29
Total storage at full pool	32,000 ac-ft	400,000 ac-ft
Active storage	29,000 ac-ft in 10 ft. operating range	29,000 ac-ft in 4.5 ft. operating range
SPILLWAY		
Spillway Gates Number and Type	(10) Bottom hinged bascule crest gates, each 200 ft. long and 9 ft. high.	None
Discharge Capacity	230,000 CFS (Inflow Design Flood) 427,000 CFS (Probable Maximum Flood)	N/A
POWERHOUSE		
Construction type	Steel framed brick masonry	Reinforced concrete
Dimensions	300 ft. long, 60 ft. wide, 50 ft. high	520 ft. long, 150 ft. wide, 108 ft. high (below grade)
INTAKE STRUCTURE		
Type and Dimensions	Integral with powerhouse	Reinforced concrete, 300 ft. long, 260 ft. wide, 50 ft. high
Head Gates Number and Type	(6) Bottom hinged steel	(4) Vertical lift steel had gates; (8) vertical lift steel tail gates

Parr Hydroelectric Project P-1894

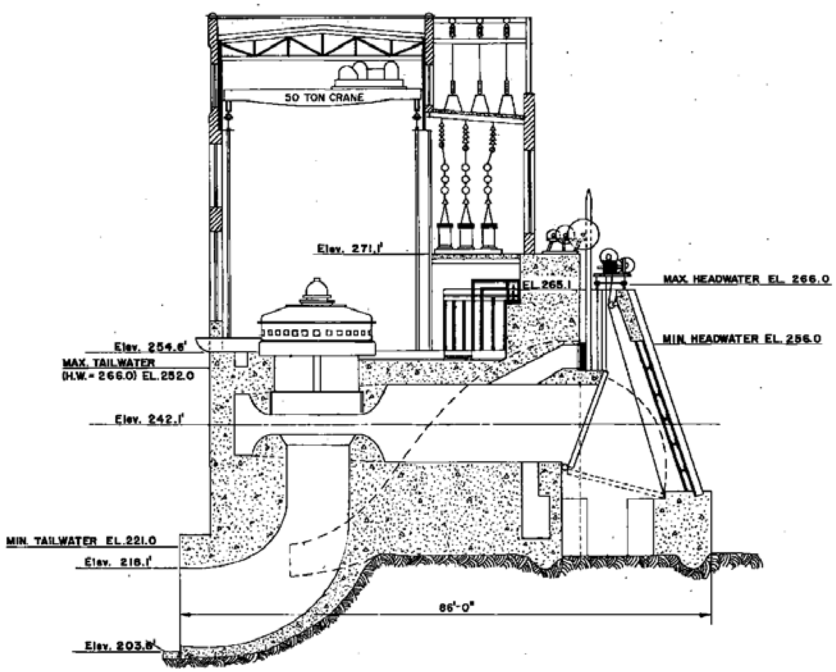
Table of Standard Project Numbers

DESCRIPTION	NUMBER OR FACT (PARR SHOALS DEVELOPMENT)	NUMBER OR FACT (FAIRFIELD PUMPED STORAGE DEVELOPMENT)
PENSTOCKS		
Number, Type and Dimensions	(6) Concrete, integral with powerhouse	(4) Steel, 800 ft. long, 26 ft. diameter (each serves 2 units)
TURBINES		
Number & Manufacturer	(6) Allis Chalmers	(8) Allis Chalmers
Type	Vertical Francis	Vertical Francis Reversible Pump-Turbines
Rated net head/TDH	35 ft.	150 to 167 ft. (Turbine mode); TDH 158 to 173 ft. (Pump mode)
Approximate min. discharge capacity	150 CFS	2,500 CFS
Rated maximum discharge capacity	1,000 CFS	6,300 CFS (generating); 5,225 CFS (avg. pumping)
Draft tube invert elevation	El. 203.6 ft. NGVD29	El. 189.0 ft. NGVD29
HP rating at rated head	3,600	95,375 to 108,570
Synchronous speed (rpm)	100	150
GENERATORS		
Manufacturer	Allis Chalmers	Westinghouse
Type	AC	AC Motor-Generators
Phases	3	3
Voltage	2,300	13,800/13,200 V @ 60° C/80° C
Frequency	60 Hz	60 Hz
KVA rating	3,100	71,000 (generating); 74,570 (pumping, 100,000 HP equiv.)
Power factor	0.8	0.9 (generator); 1.0 (pump)
KW output	2,480	63,900
TRANSFORMERS		
Number & Type	(3) OA/FA	(4) FOA (each serves 2 units)
Voltage (Primary/Secondary)	2.4/13.8-kV	13.8/230-kV
Phases	3	3
KVA Rating @ Temp. Rise	6,000/6,720 KVA (OA), @ 55 °C/65° C rise 7,500/8,400 KVA (FA), @ 55 °C/65° C rise	160/80/80 MVA @ 55° C rise (160 MVA 230 kV primary wye connected, 2-80 MVA 13.8 kV secondaries each connected to 1 motor-generator); 179.2/89.6/89.6 MVA @ 65° C rise

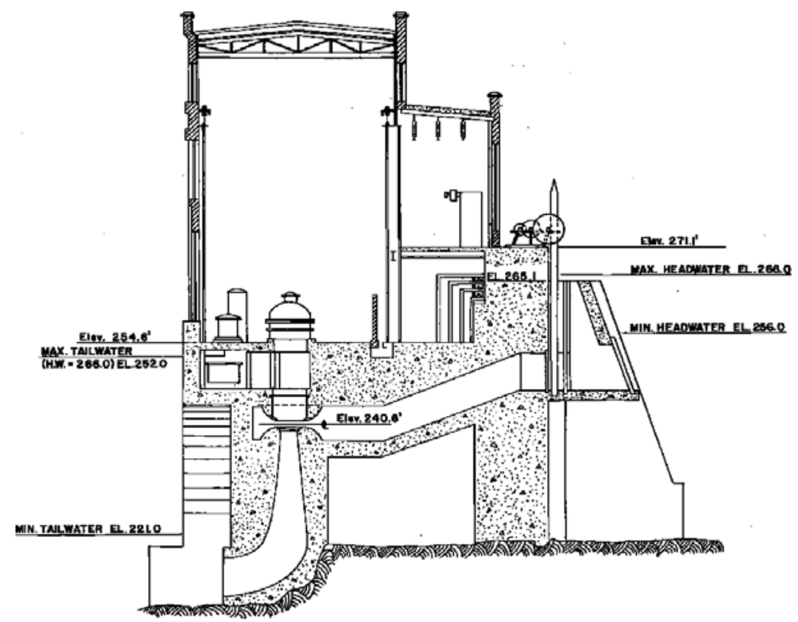
Parr Hydro Plant Overview and Basic Information



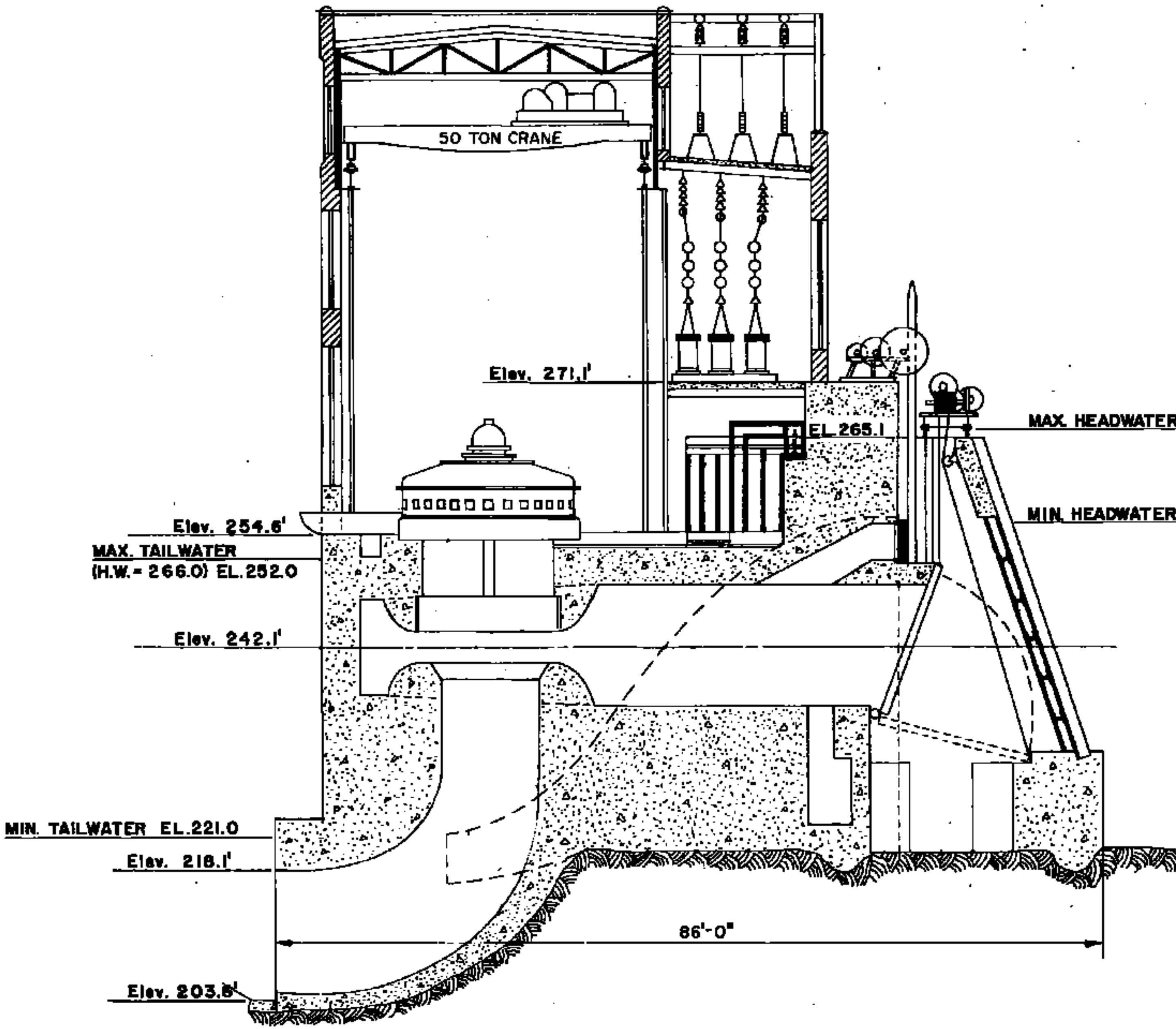
PLAN OF GENERATOR FLOOR



SECTION THRU MAIN UNIT



SECTION THRU EXCITER UNIT



SECTION THRU MAIN UNIT


EXIT
02/02/2011 14:49


EXIT
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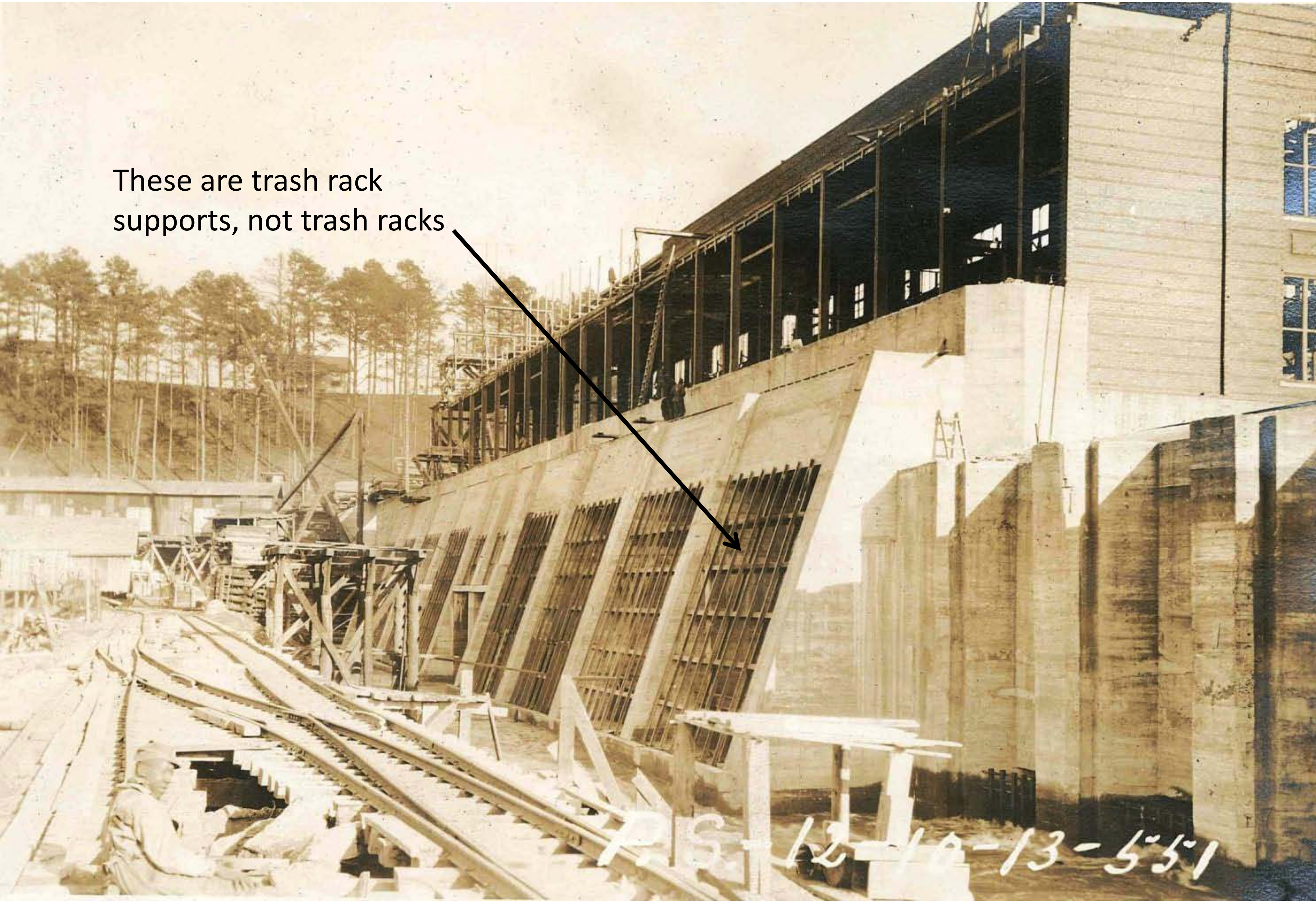
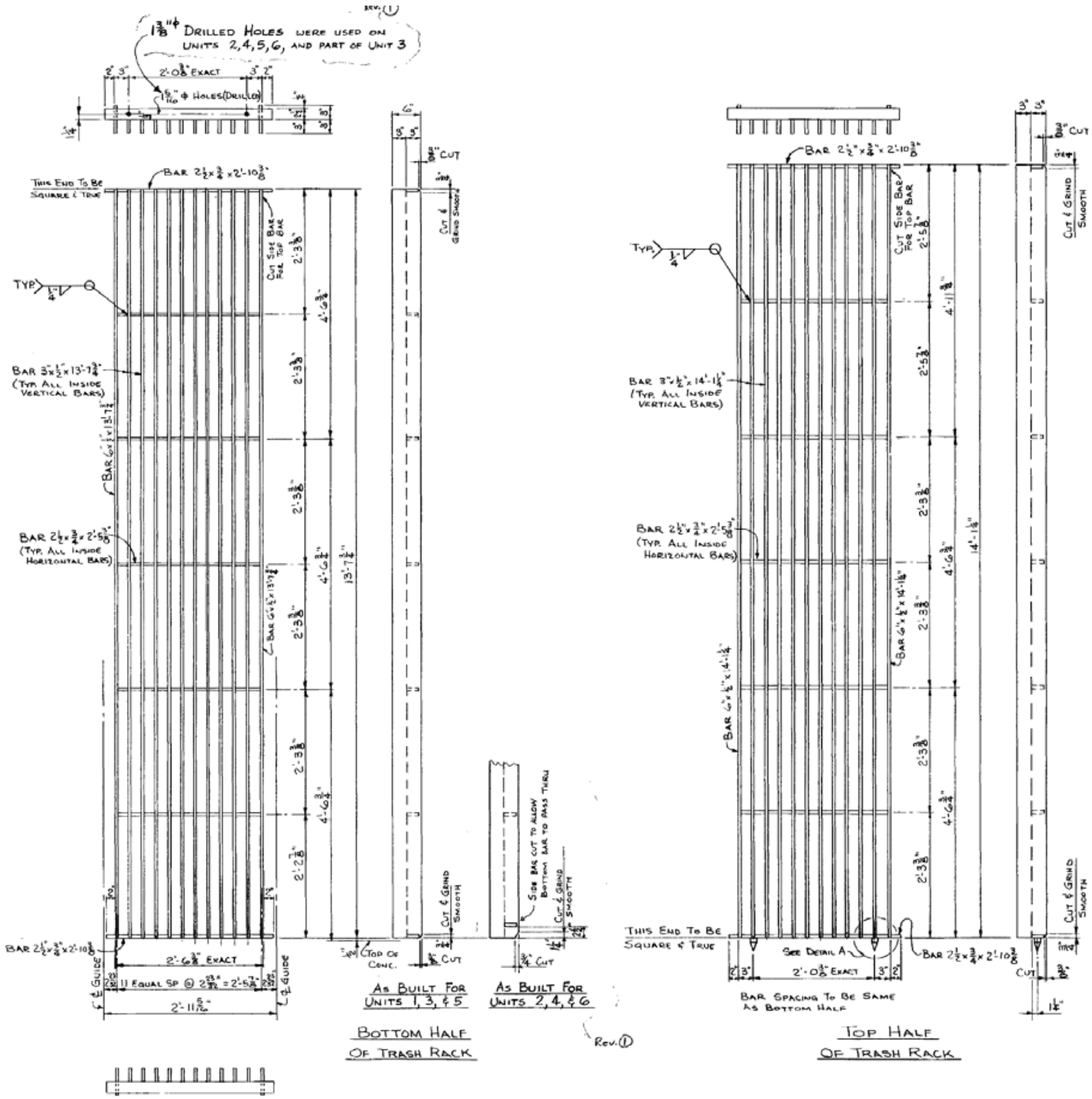
Parr Hydro
Intake and Drag Rake System



1913 Photo of Parr Hydro Intakes

Parr Hydro Trash Racks

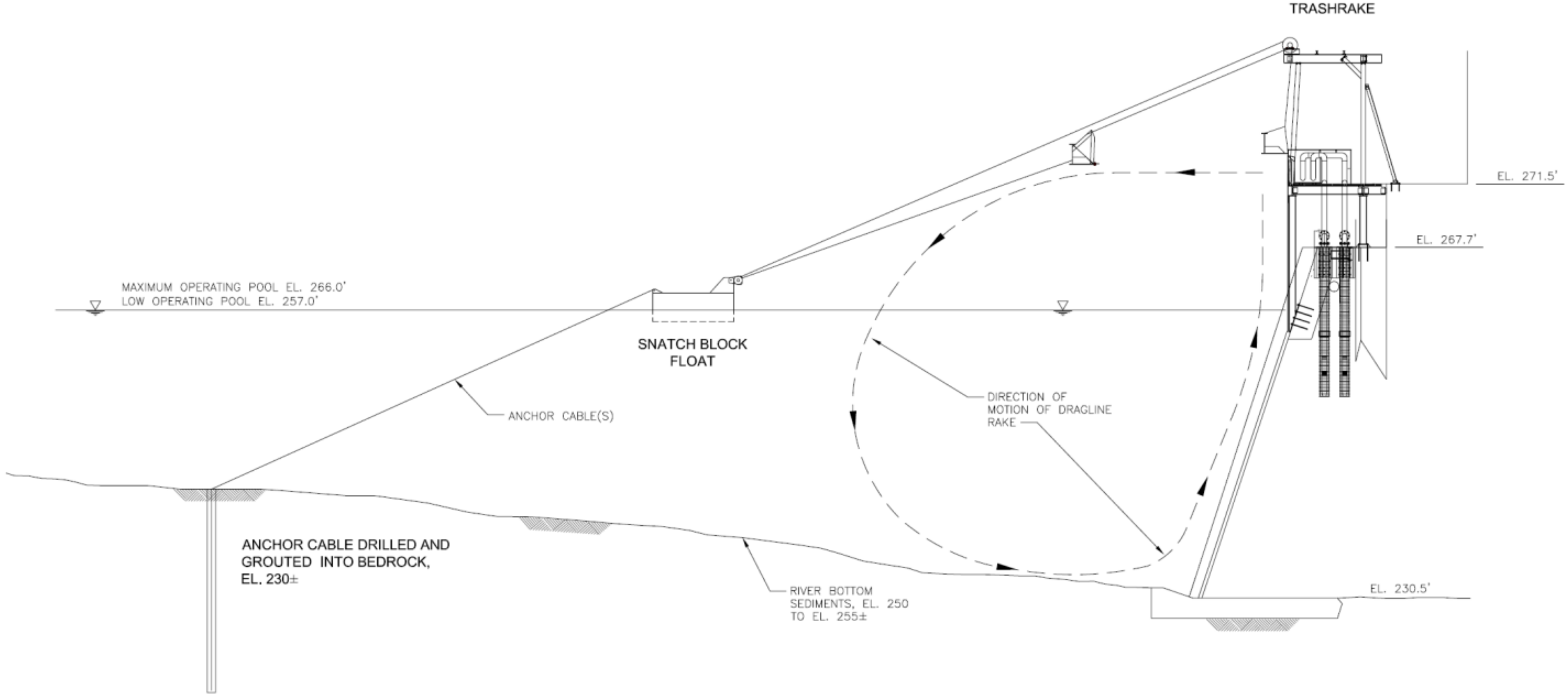
- 8 trash racks, 1 per turbine.
- Each trash rack is 27 ft. wide, 28 ft. tall.
- Vertical bars are ½ in. thick with 2-¼ in. clear between bars.
- Racks are made in 3 ft. wide panels, 9 panels per rack.



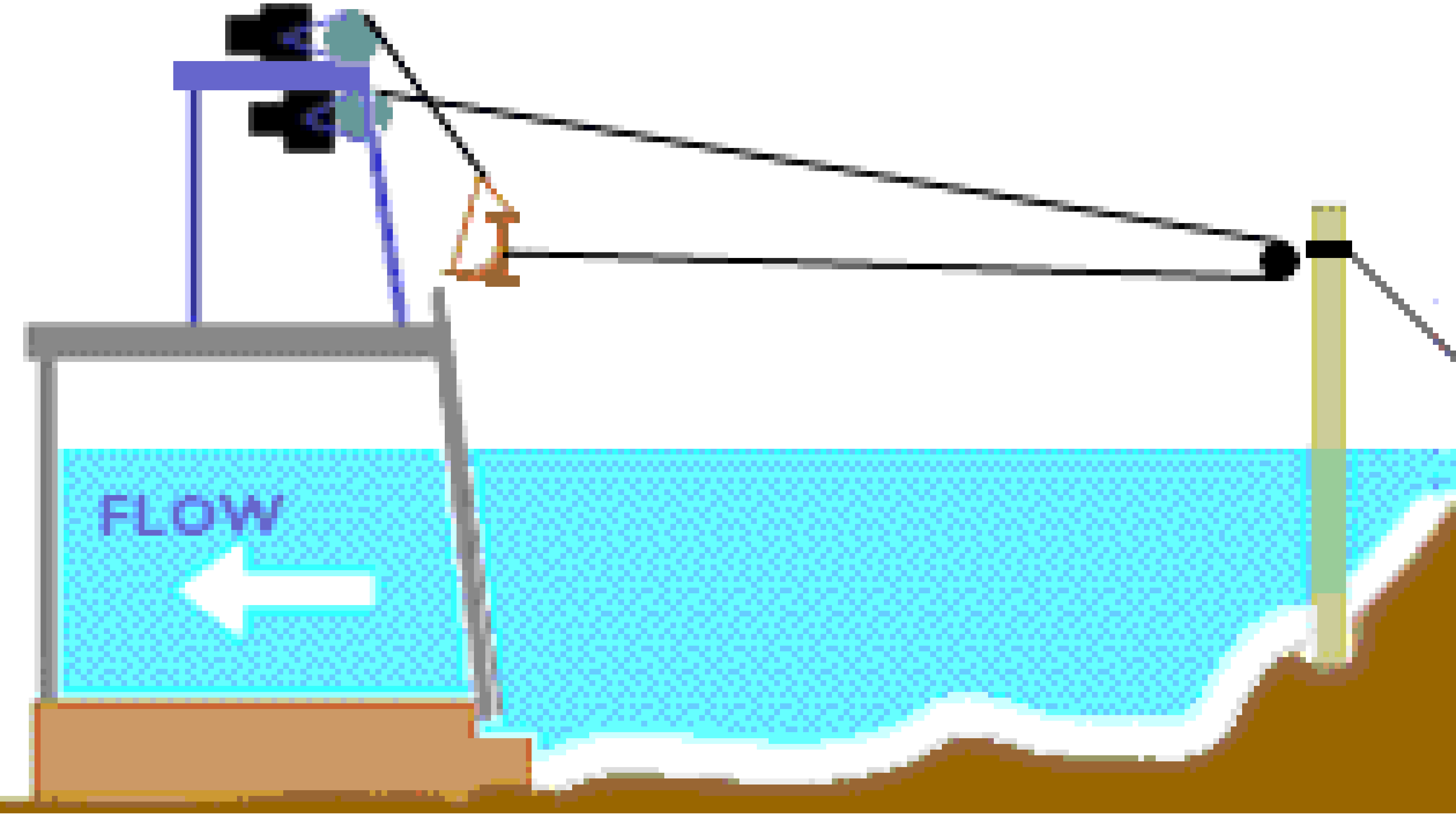
Parr Hydro Trash Rack Panel (9 panels per rack)

Trash Handling Crane (prior to Drag Rake Installation)

Drag Rake System Installed



Parr Hydro Drag Rake System

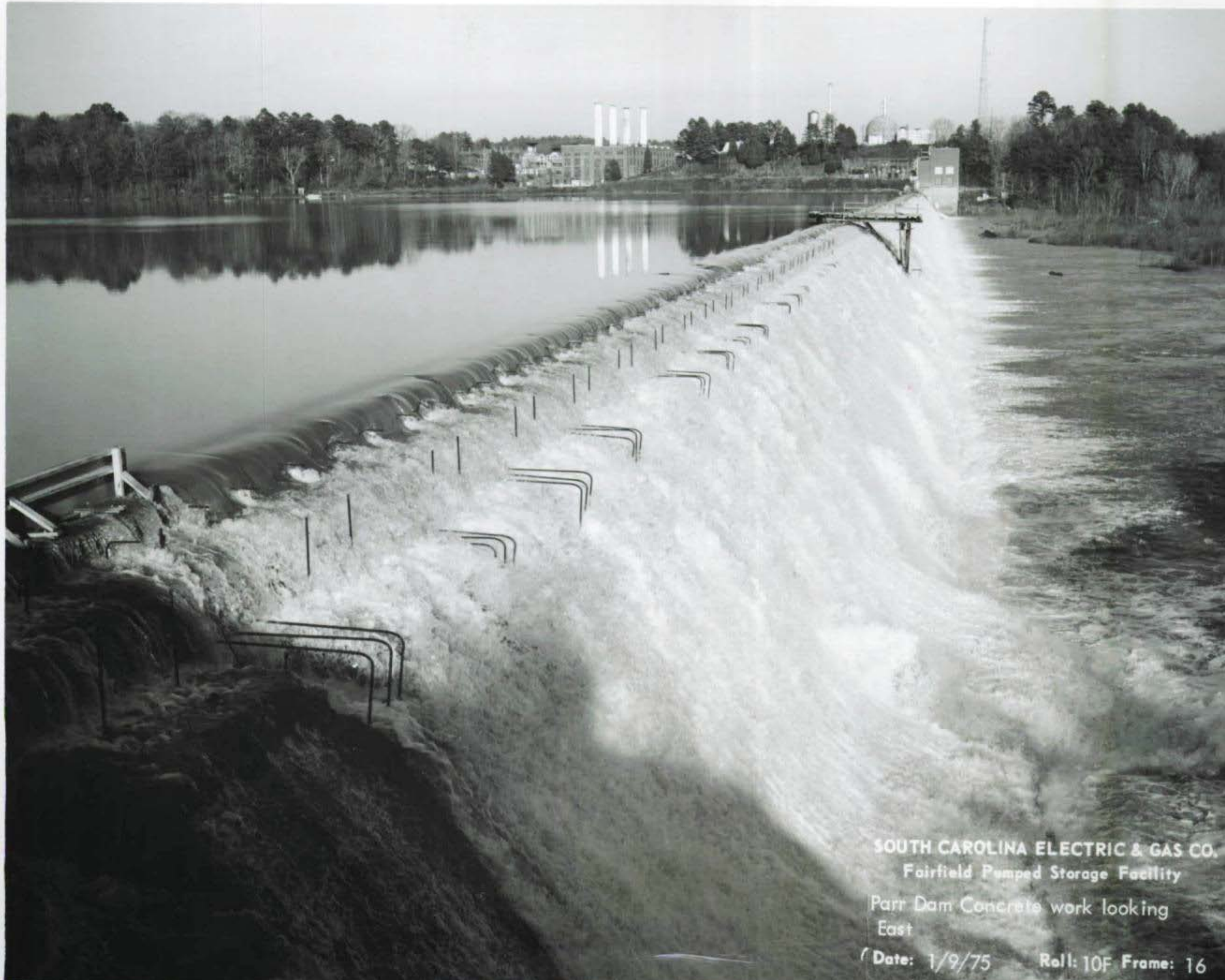


Drag Rake Operation Animation
(Courtesy North Fork Electric Co.)

Intake Deck showing debris and sluice trough

Parr Spillway and Crest Gates

Parr Dam Under Construction - 1913

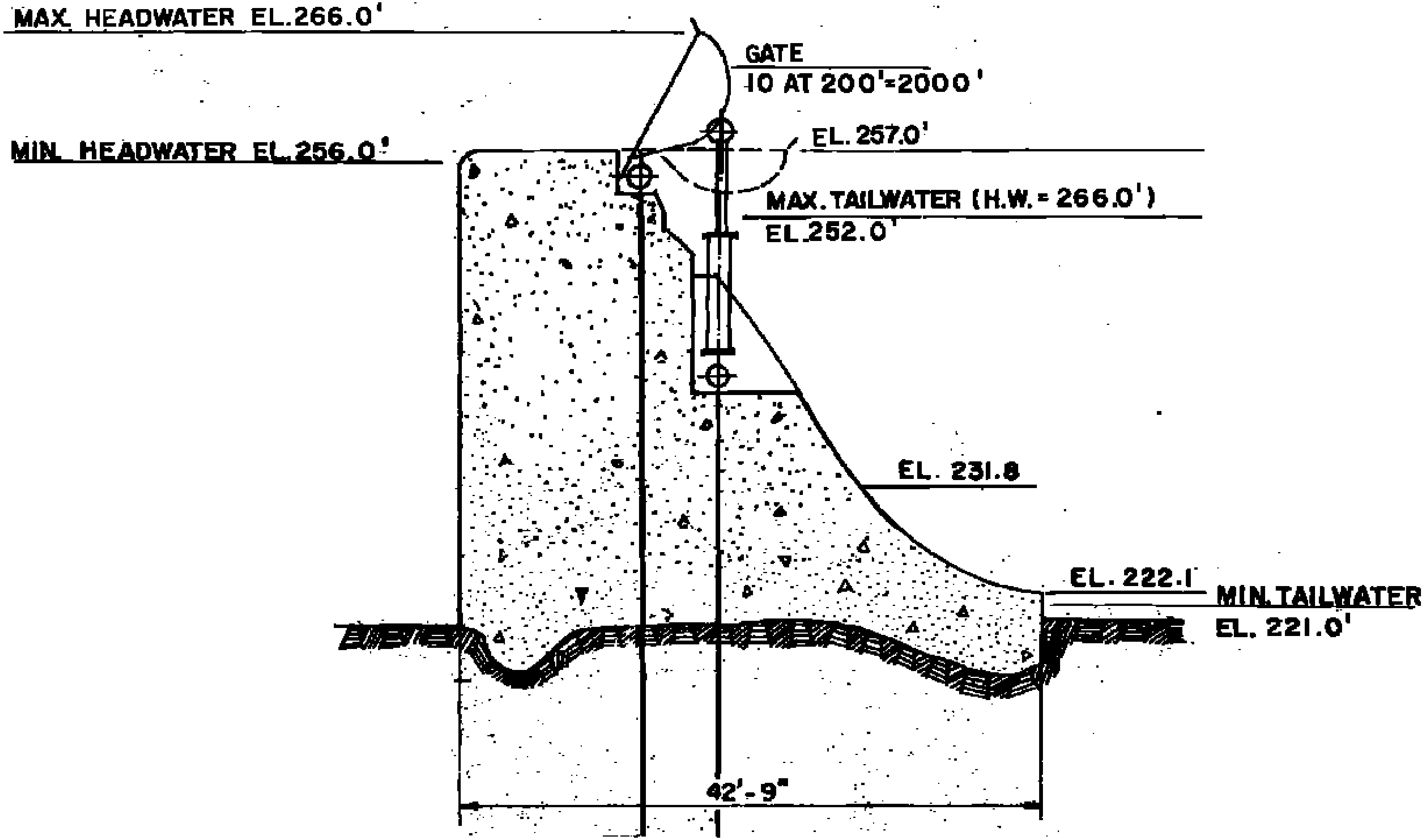


SOUTH CAROLINA ELECTRIC & GAS CO.
Fairfield Pumped Storage Facility

Parr Dam Concrete work looking East

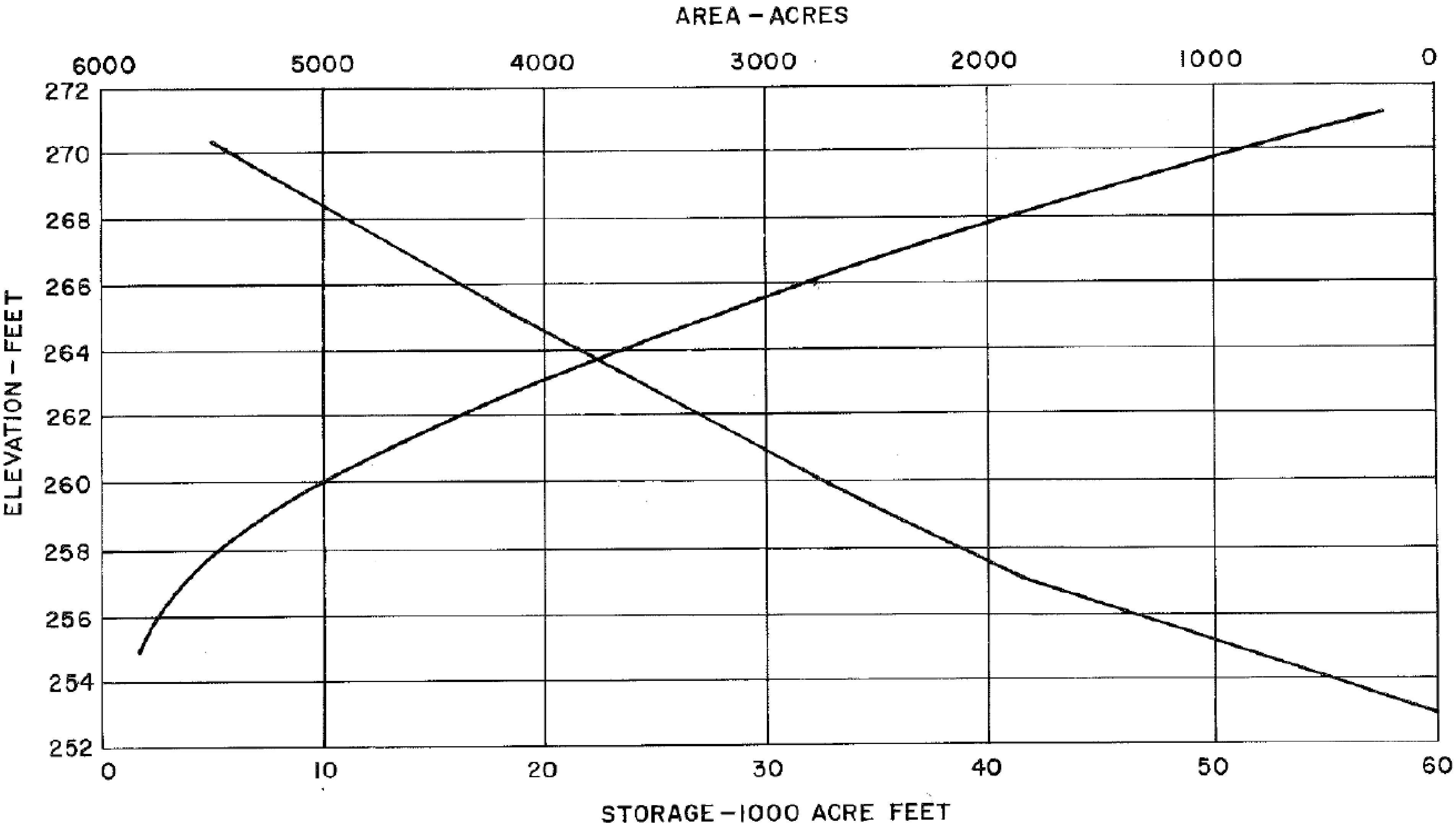
Date: 1/9/75 Roll: 10F Frame: 16

Parr Dam and Crest Gates


MAX. HEADWATER EL.266.0'
GATE
10 AT 200'=2000'
EL. 257.0'
MIN. HEADWATER EL.256.0'
MAX. TAILWATER (H.W.= 266.0')
EL.252.0'
EL. 231.8
EL. 222.1
MIN. TAILWATER
EL. 221.0'
42'-9"

Parr Spillway Information

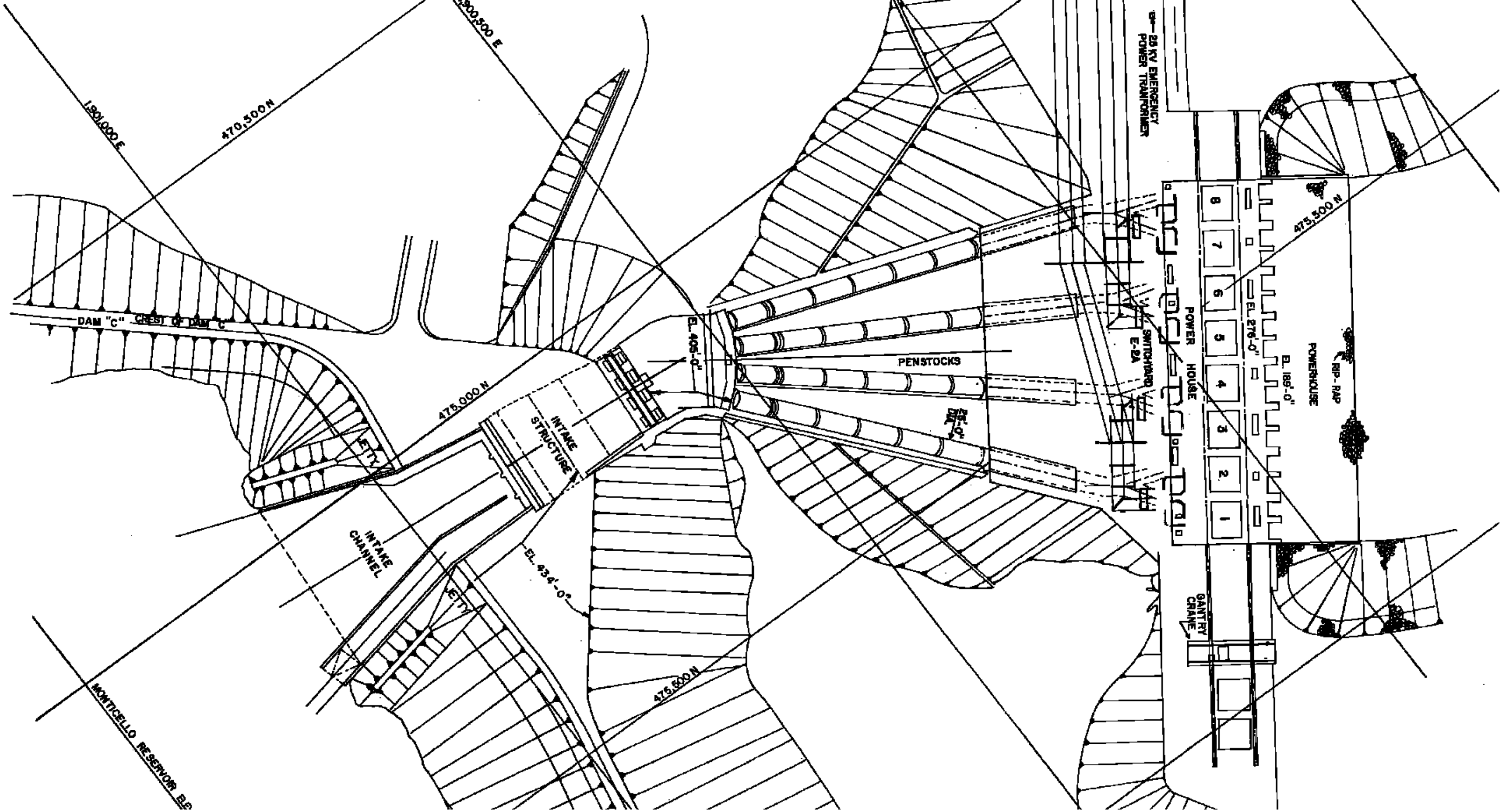
- Crest length = 2,000 feet
- 10 gates at 200 ft. each
- Gates operate in pairs
- Crest elevation = 257.0 ft. NGVD
- Spillway capacity at reservoir el. 266.0 ft. NGVD = 161,500 CFS (all gates down)
- Maximum rated capacity 229,113 CFS at reservoir el. 268.5 ft. NGVD.



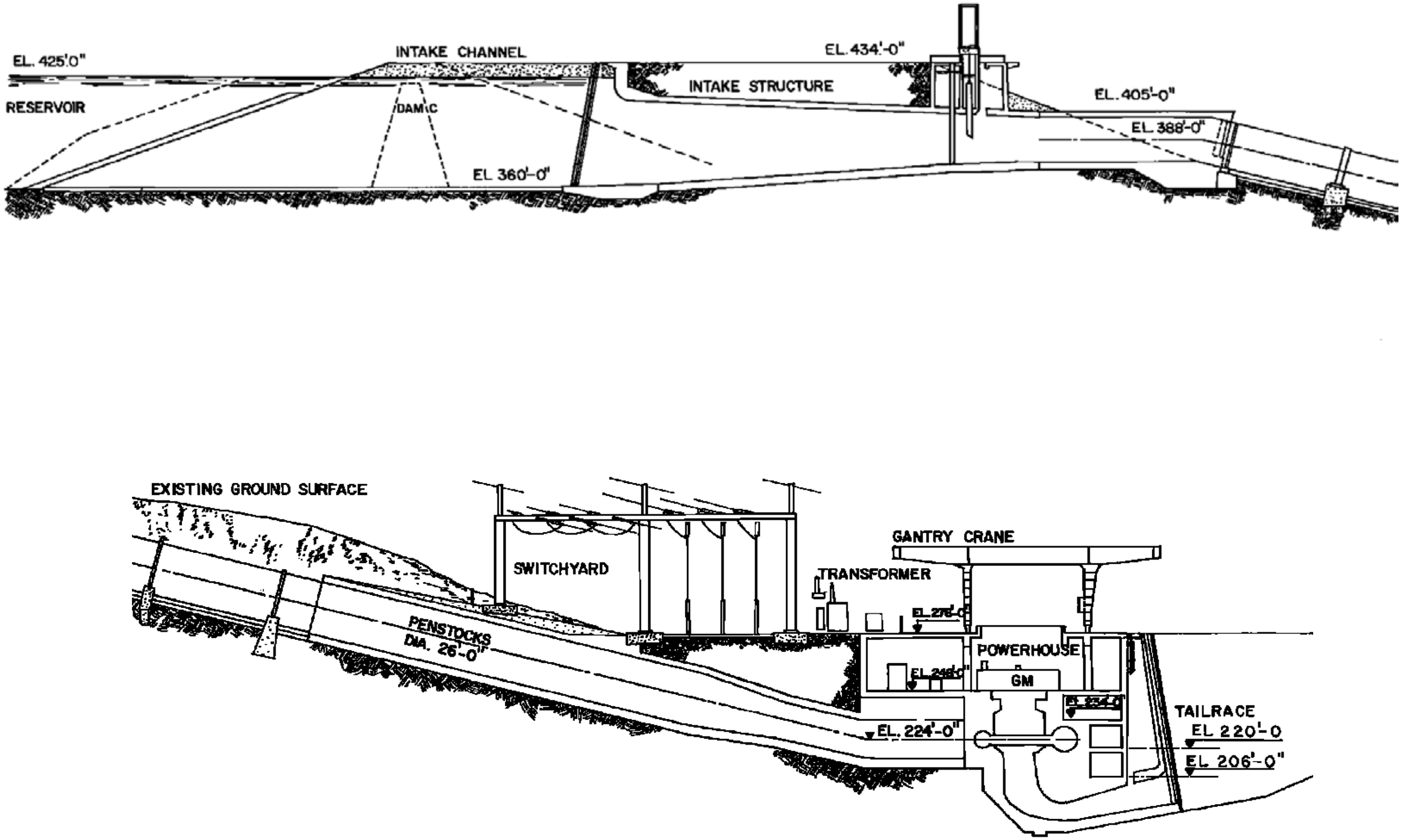
Parr Reservoir Area Capacity Curves

Fairfield Pumped Storage Plant Overview


02/02/2011 16:28



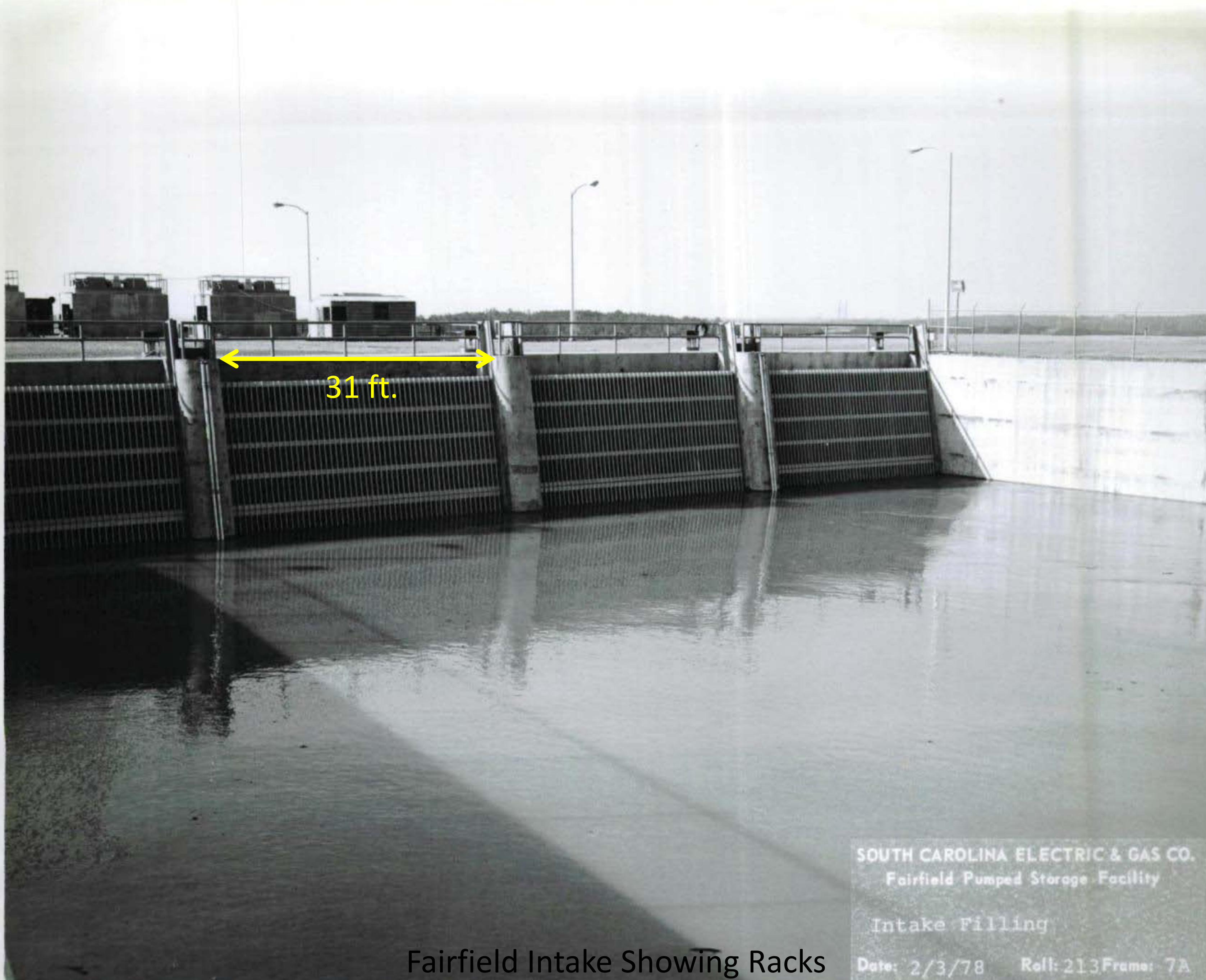
Fairfield Plan View



Fairfield Cross Sections at Intake and Powerhouse

Basic Information

- Intake Structure:
  - 265 ft. long, 132 ft. wide, 74 ft. tall.
  - Intake channel is 300 ft. long, tapers from 260 ft. wide to 132 ft. wide at intake racks.
  - Four trash racks, each 31 ft. wide, 73 ft. tall.
  - Each rack bay serves 2 units (one penstock).
  - Vertical bars are 1 in. wide on 7 in. centers = 6 in. clear spacing (horizontal).

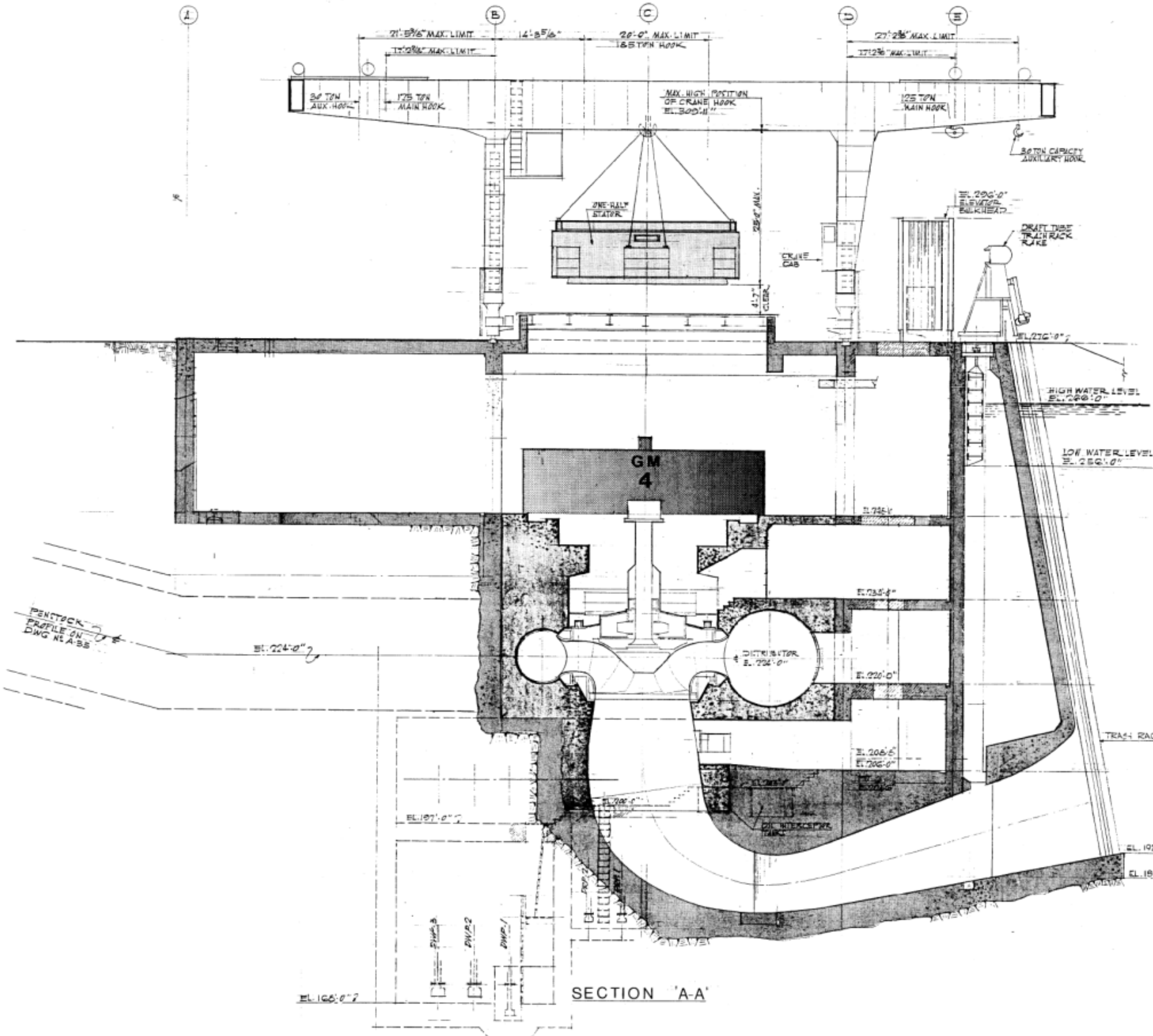


Fairfield Intake Showing Racks


SOUTH CAROLINA ELECTRIC & GAS CO.
Fairfield Pumped Storage Facility
Intake Structure
Date: 9-1-76 Roll: 177 Frame: 20A

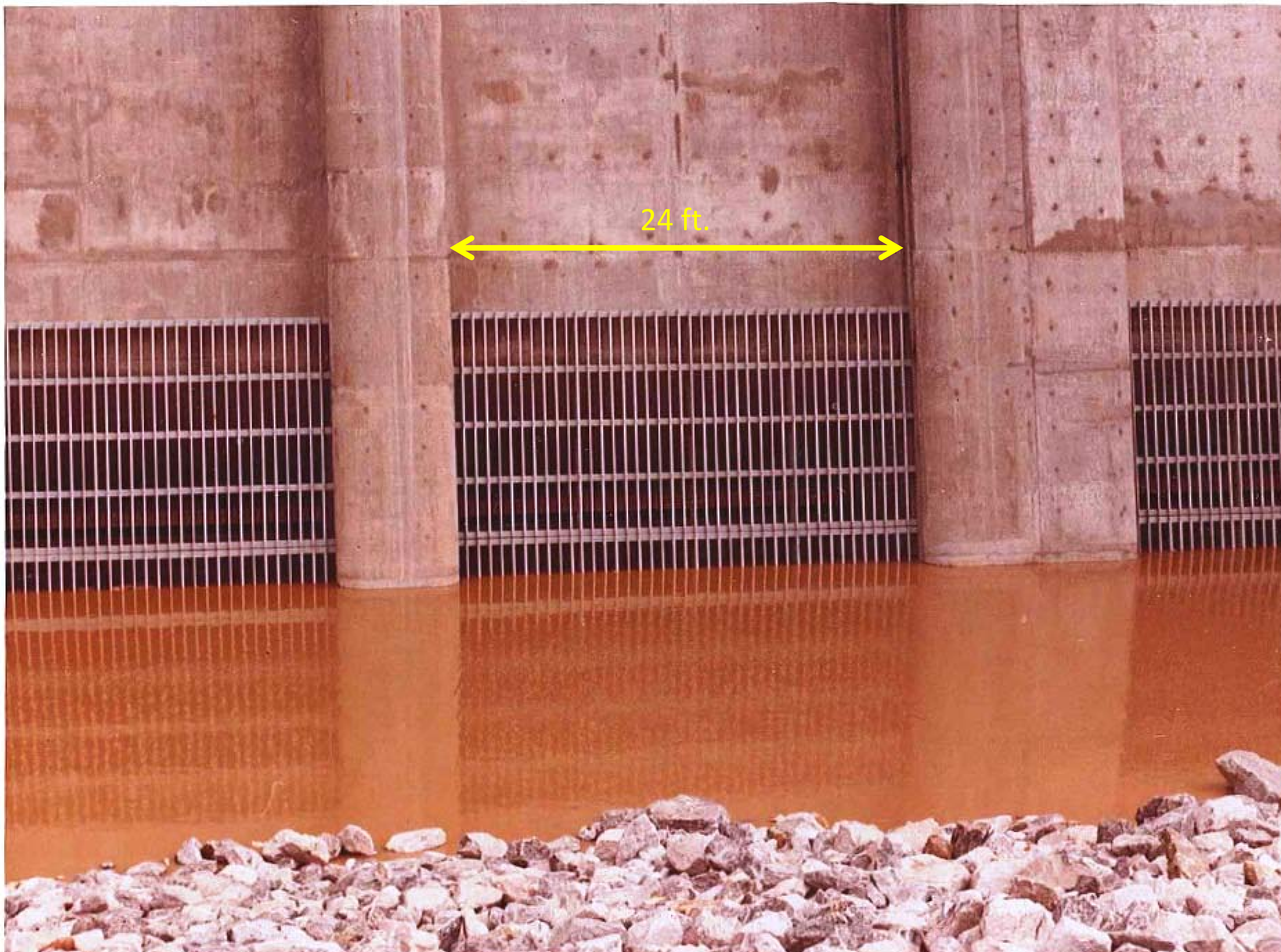
Basic Information

- FFPS Powerhouse:
  - 520 ft. long, 150 ft. wide, 108 ft. tall.
  - Eight 65 ft. wide bays, each with one pump-turbine-motor-generator unit.
  - 16 draft tube racks at tailrace, each rack is 24.5 ft. wide, 23 ft. tall.
  - Vertical bars are 1 in. wide on 7 in. centers = 6 in. clear spacing (horizontal).



Fairfield Cross Section Through Powerhouse

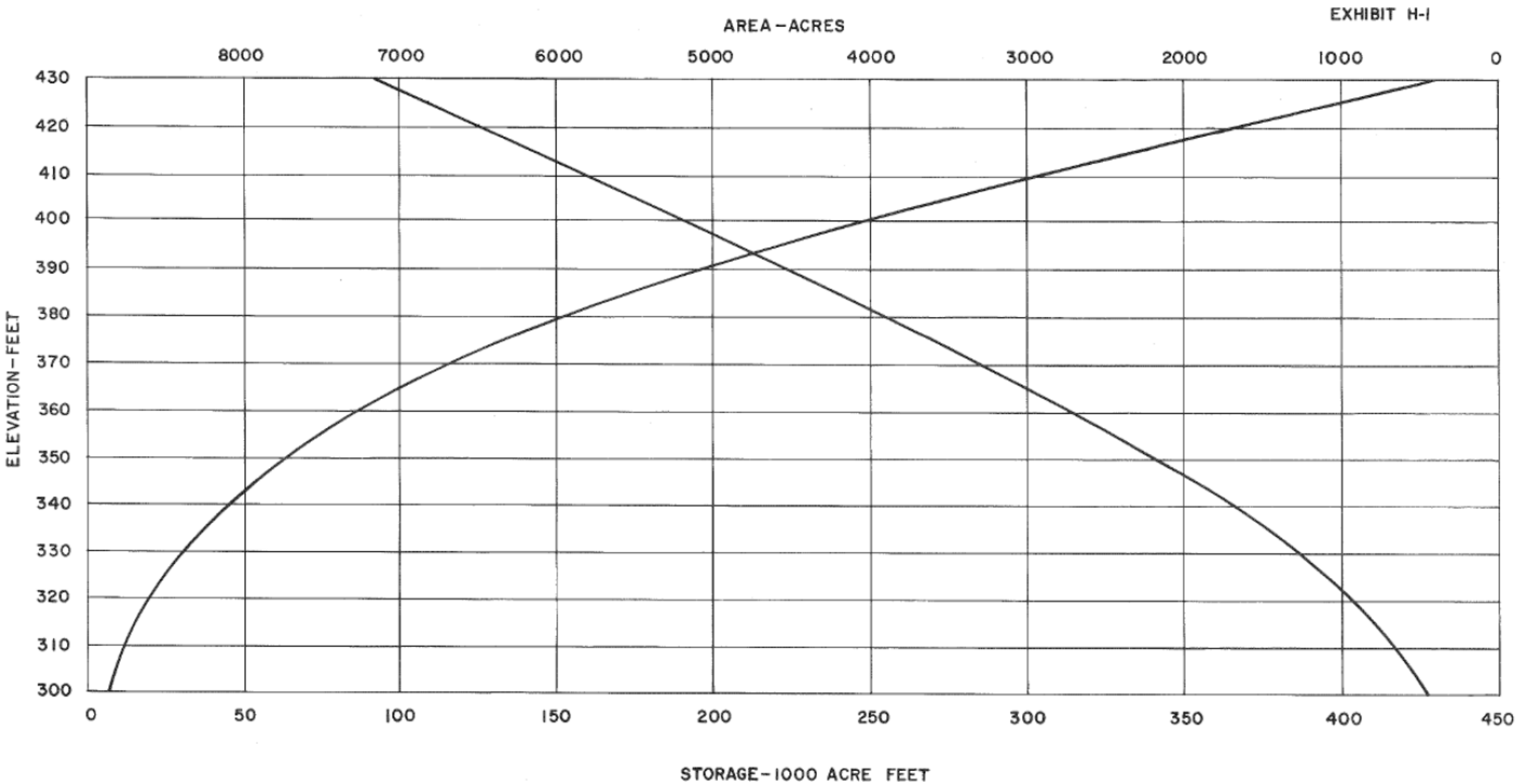

SOUTH CAROLINA ELECTRIC & GAS CO.
Fairfield Pumped Storage Facility
Powerhouse - Facing Northeast
Date: 6-1-76 Roll: 172 Frame: 1A


24 ft.

Initial Filling of Monticello Reservoir

Plant Upgrades Since Construction

- 2000: New stainless steel water wheels, generators rewedged, turbine runners and partial rotor poles replaced on Units 7 and 8.
- 2001: New stainless steel water wheels, generators rewedged, turbine runners and partial rotor poles replaced on Units 3 and 4. Exciters replaced on Units 5 and 6.
- 2002 – 2003: Generators rewedged, turbine runners replaced, and tailrace trash racks replaced on Units 1 and 2. Partial rotor pole replaced on Unit 1. Exciters replaced on Units 3 and 4.
- 2004 – 2005: Exciters replaced on Units 1 and 2. Generators rewedged, turbine runners replaced, partial rotor pole replaced, controls and governors upgraded, and individual servo replaced with a slip ring mechanism on Units 5 and 6.
- Tailrace trash racks and exciters replaced on Units 7 and 8.



Monticello Reservoir Area-Capacity Curves

Operation Overview

Project Operation at Various Flow Ranges

- Inflow ≤ 6,000 CFS:
  - No need for natural flow regulation since Parr Reservoir is capable of storing the entire upper reservoir active storage, and Parr Hydro is capable of discharging the natural river flow.
  - Parr crest gates maintained in fully raised position, no spill occurs.
  - FFPS generation not limited.

Project Operation at Various Flow Ranges

- Inflow Between 6,000 and 40,000 CFS:
  - Some natural flow regulation will occur as crest gates are lowered to maintain Parr Reservoir at allowable elevations.
  - Spill plus Parr generation may exceed natural inflow.
  - Some upper reservoir water will be spilled when FFPS is generating, and will be recaptured from natural river flow during subsequent pump cycle.
  - FFPS generation limited as necessary to maintain total discharge from project ≤ 40,000 CFS.

Project Operation at Various Flow Ranges

- Inflow > 40,000 CFS:
  - No natural flow regulation will occur as all crest gates are lowered fully and FFPS generation is ceased.
  - Parr Hydro will generate with all available units.
  - Parr generation plus spill equals natural inflow.
  - No water released from Monticello Reservoir.

Questions?

Parr Hydroelectric Project Regulation Effects

Raymond R. Ammarell, P.E.

Operations RCG Meeting

June 27, 2013

SCE&G A SCANA COMPANY

PARR Relicensing Project

Topics

- Review of existing USGS flow data
- Comparison of inflow vs. outflow correlations
- Broad River flow-duration comparison for inflow and outflow
- Downstream effects – normal and high flows
- License compliance summary

USGS Flow Data

- Four gauges are used to operate Parr Hydro Project:
  - Broad River near Carlisle (02156500)
  - Tyger River near Delta (02160105)
  - Enoree River near Whitmire (02160700)
  - Broad River at Alston (02161000)
- Continuous daily flow record for all 4 gauges from 10/1/1980 to present (approved data to 9/30/2012, 32 years).

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PARR Relicensing Project

USGS Flow Data

- Daily flow statistics (for 10/1/1980 to 9/30/2012):

	Mean (CFS)	Median (CFS)
Inflow	4,573	3,256
Outflow	5,163	3,440

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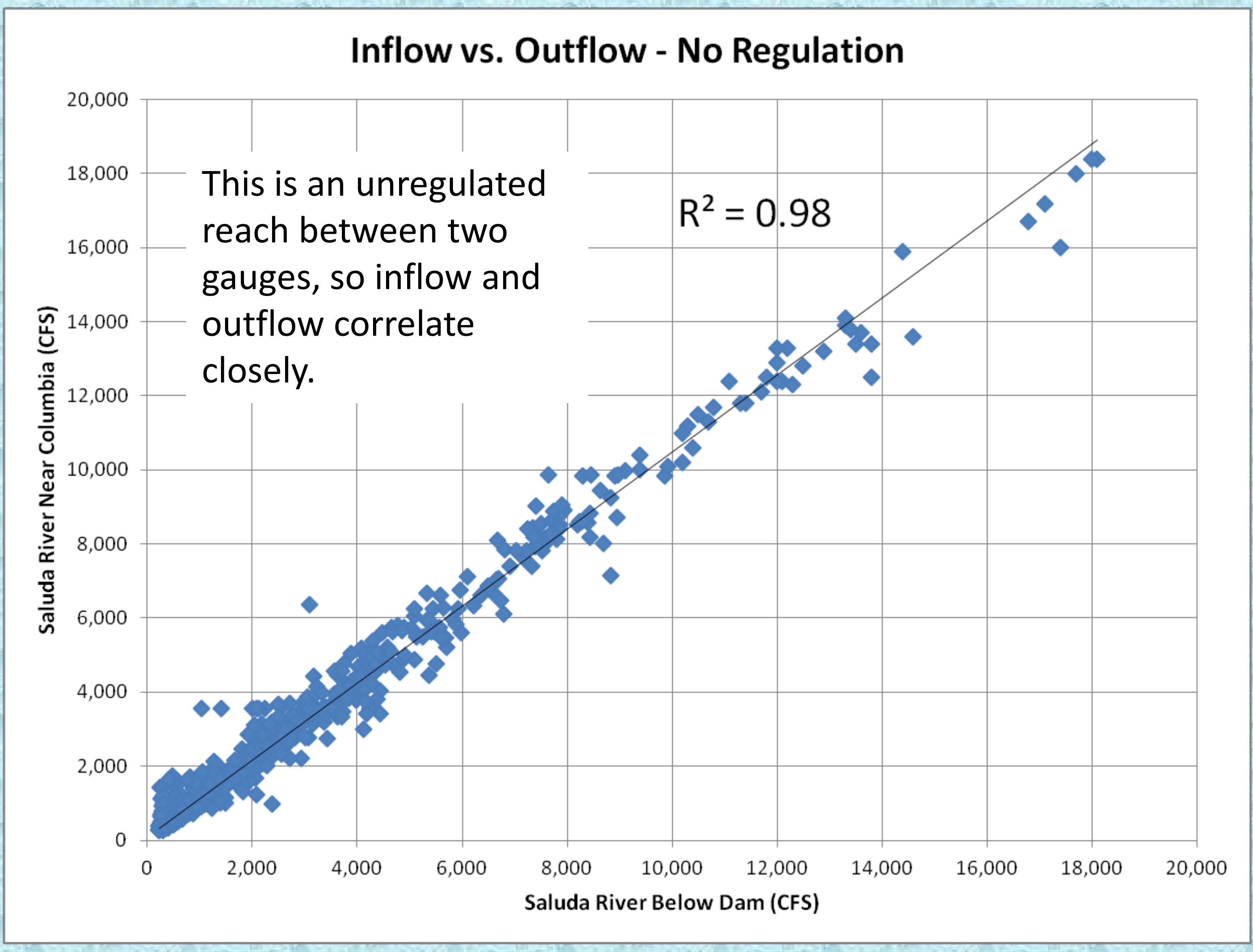
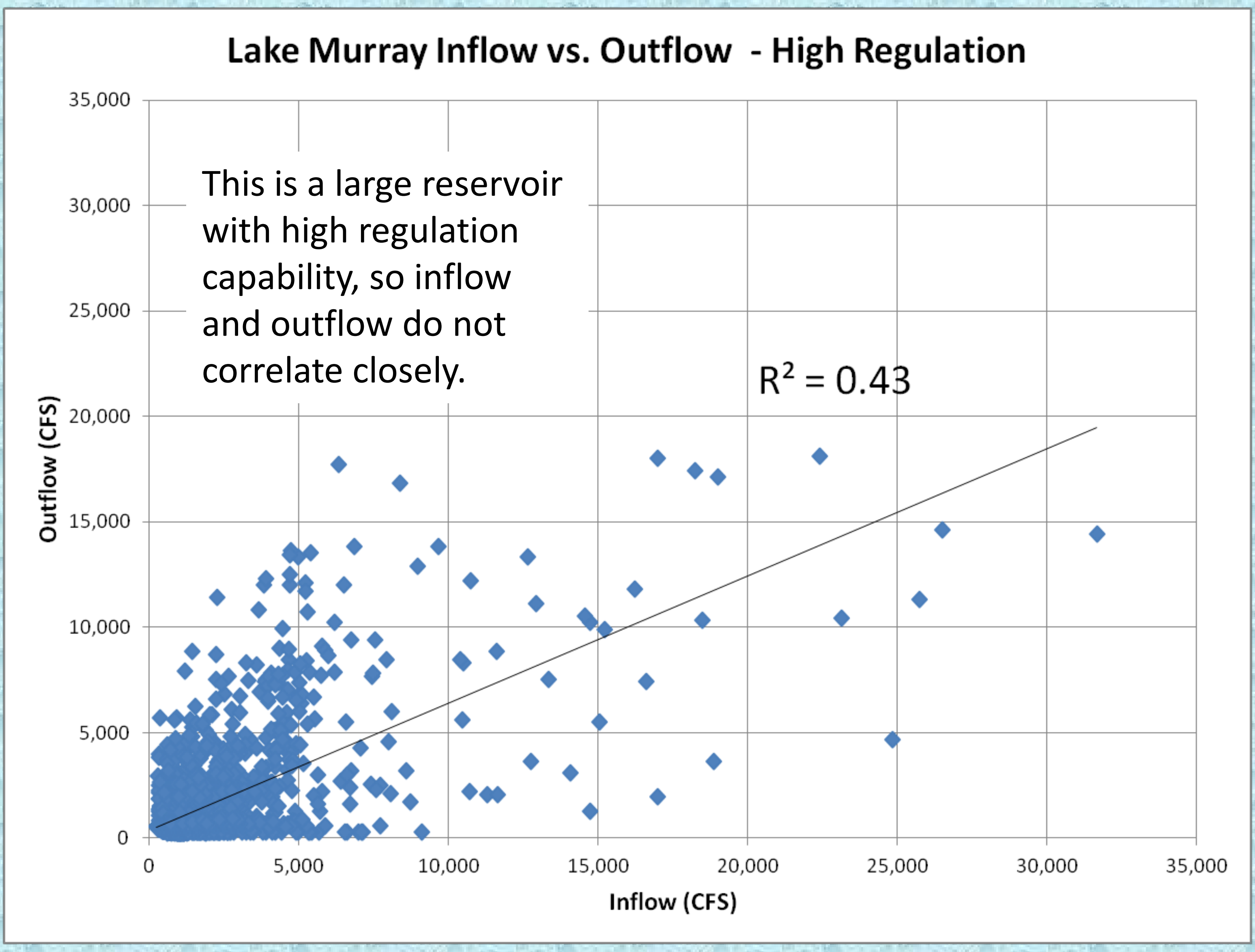
PARR Relicensing Project

Inflow-Outflow Correlation

- Plotting inflow vs. outflow provides an indication of the degree of regulation a reservoir provides.
- No regulation = good correlation (r^2 close to 1)
- Much regulation = poor correlation ($r^2 << 1$)
- Example: look at lower Saluda River and Lake Murray.


Inflow vs. Outflow - No Regulation
This is an unregulated reach between two gauges, so inflow and outflow correlate closely.
R² = 0.98
Saluda River Near Columbia (CFS)
Saluda River Below Dam (CFS)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000



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PARR Relicensing Project

Inflow-Outflow Correlation

- Now look at Parr Project inflow vs. outflow
- Inflow is sum of three upstream gauges
- Outflow is Alston gauge

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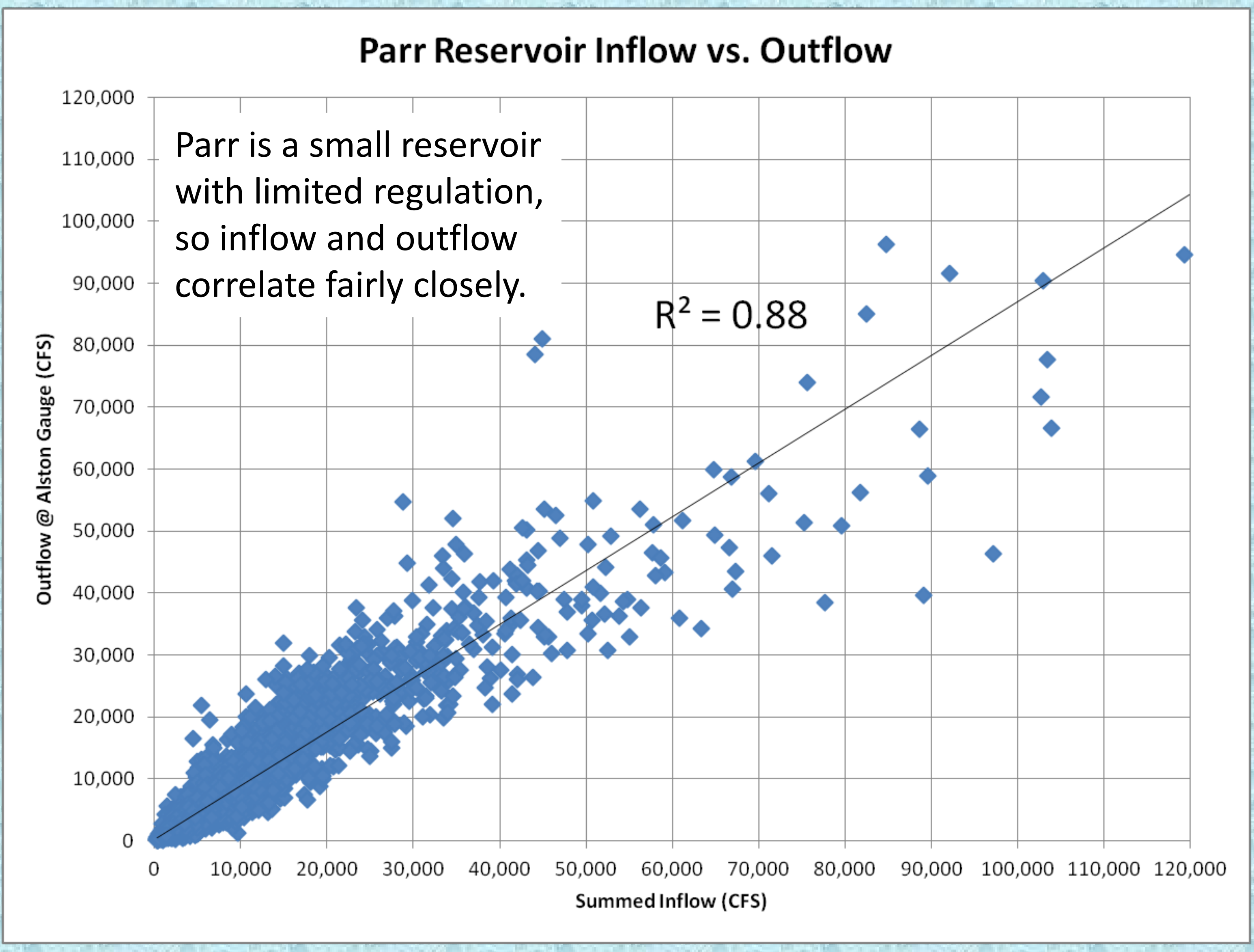
PARR Relicensing Project


Parr Reservoir Inflow vs. Outflow
Parr is a small reservoir with limited regulation, so inflow and outflow correlate fairly closely.
R² = 0.88
Outflow @ Alston Gauge (CFS)
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
Summed Inflow (CFS)

Parr Inflow-Outflow Correlation

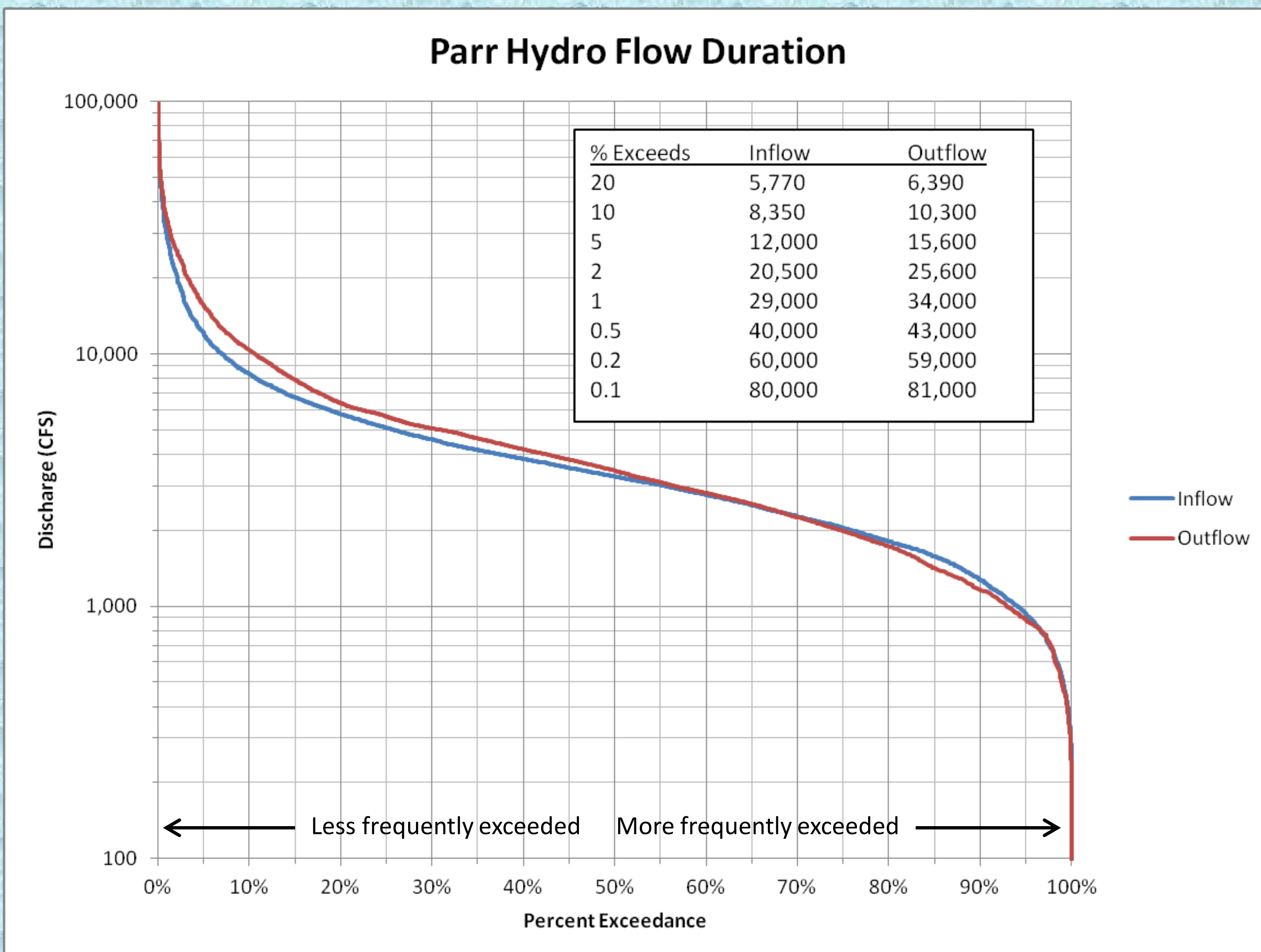
- Parr project provides a fairly low degree of regulation.
- Daily inflow correlates fairly closely with daily outflow.
- Scatter at higher flows may be due to timing effects as the hydrographs move down the basin.

Broad River Flow Frequency

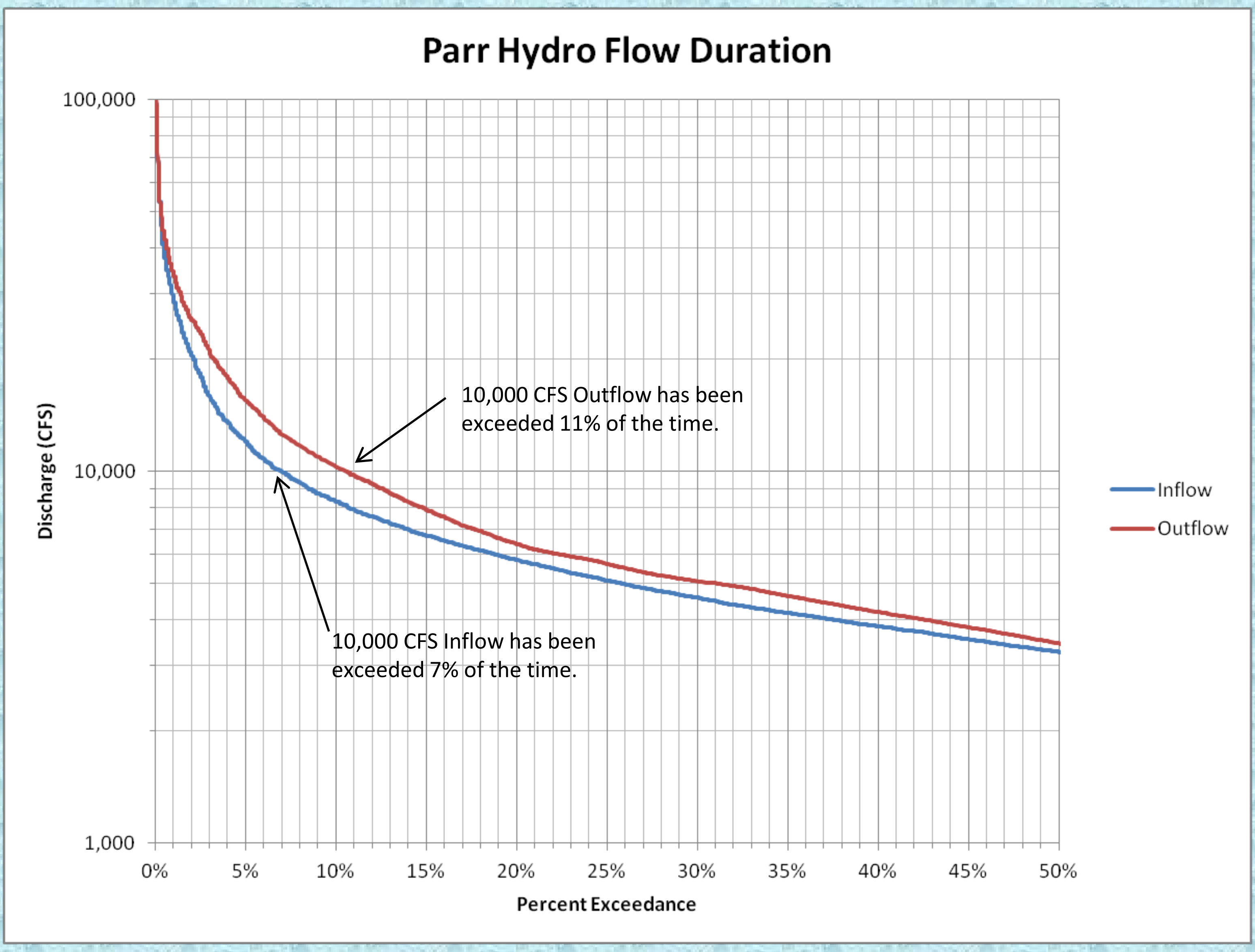
- Compare flow duration curves for inflow and outflow for Parr Project.
- Curve shows how often a given flow has been exceeded during the period of interest.
- Can show effect of regulation if project is increasing or decreasing the frequency of certain ranges of flow.
- Also shows effect of license conditions.

Broad River Flow Frequency

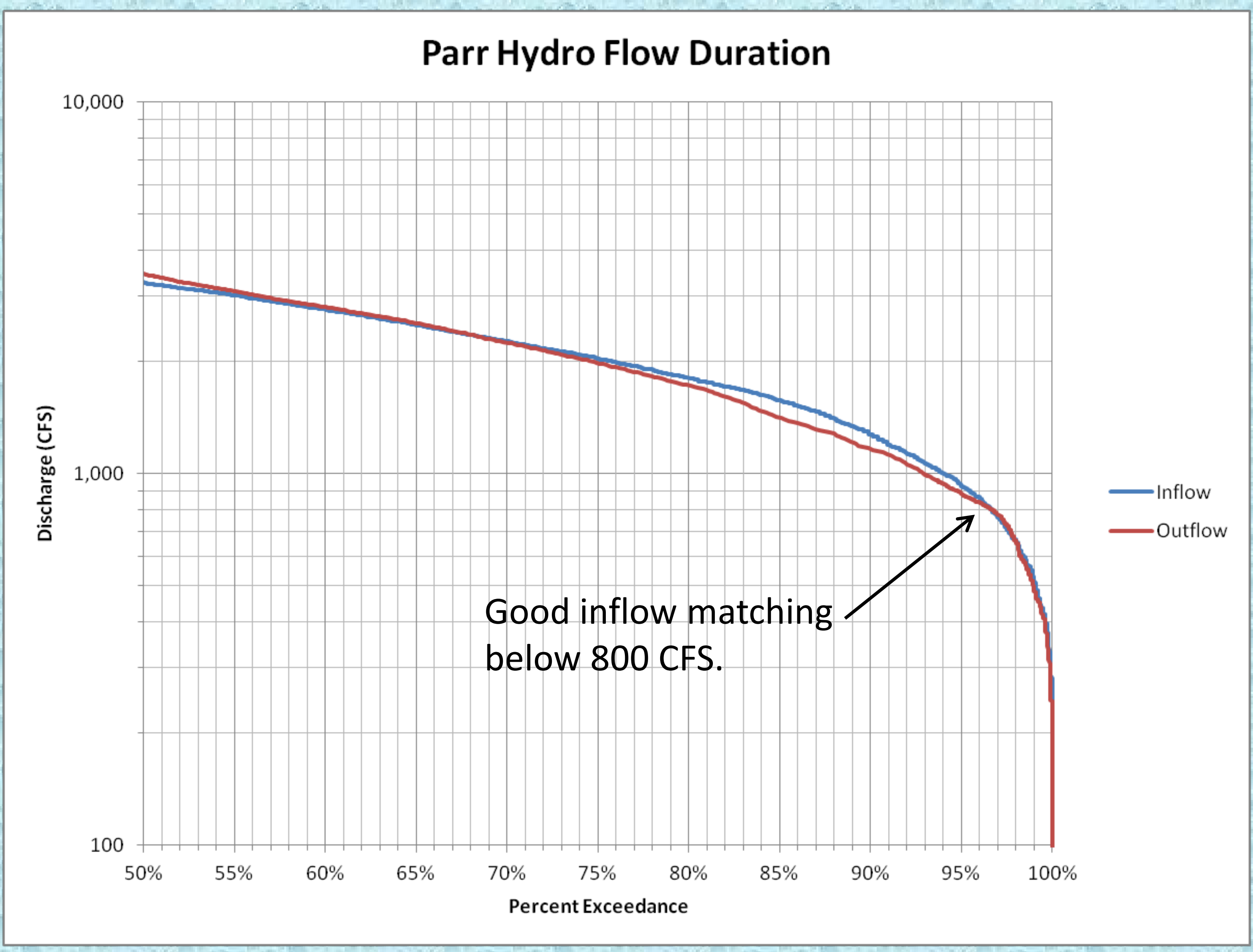
- Current operating constraints:
  - Must pass inflow (minus evaporation) for inflows < 800 CFS (1,000 CFS spring).
  - Plant hydraulic capacity is 6,000 CFS – above this flow some spill will occur.
  - When Fairfield is generating and gates are down, upper reservoir water will be spilled (adds to natural river flow at Alston).
  - Cannot exceed 40,000 CFS downstream with Fairfield operating.



Parr Hydro Flow Duration
% Exceeds | Inflow | Outflow
20 | 5,770 | 6,390
10 | 8,350 | 10,300
5 | 12,000 | 15,600
2 | 20,500 | 25,600
1 | 29,000 | 34,000
0.5 | 40,000 | 43,000
0.2 | 60,000 | 59,000
0.1 | 80,000 | 81,000
Discharge (CFS)
100,000
10,000
1,000
100
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Exceedance
Less frequently exceeded
More frequently exceeded
Inflow
Outflow



Parr Hydro Flow Duration
100,000
10,000
1,000
Discharge (CFS)
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
Percent Exceedance
10,000 CFS Outflow has been exceeded 11% of the time.
10,000 CFS Inflow has been exceeded 7% of the time.
Inflow
Outflow

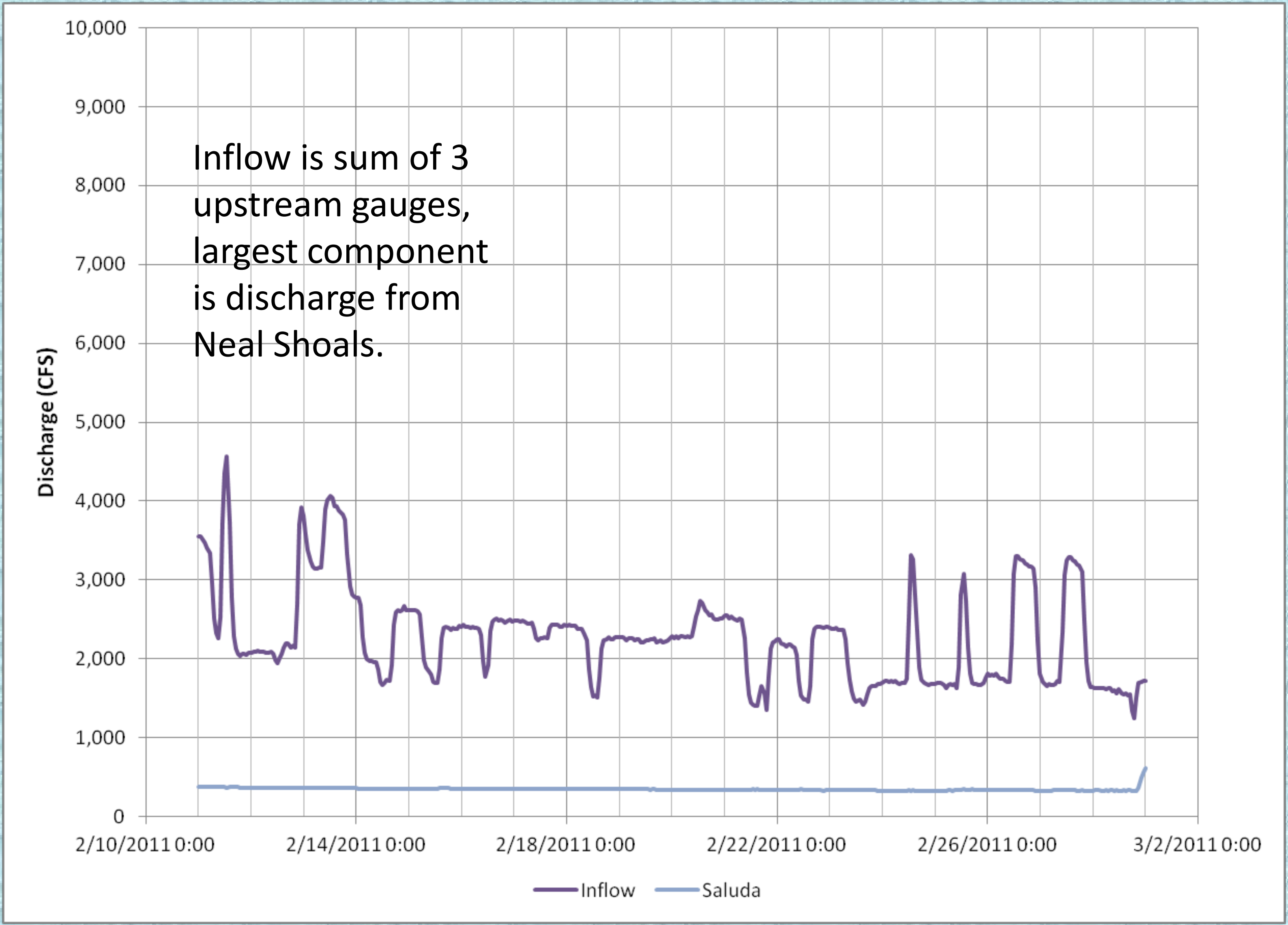

Parr Hydro Flow Duration
10,000
1,000
100
Discharge (CFS)
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Percent Exceedance
Inflow
Outflow
Good inflow matching
below 800 CFS.

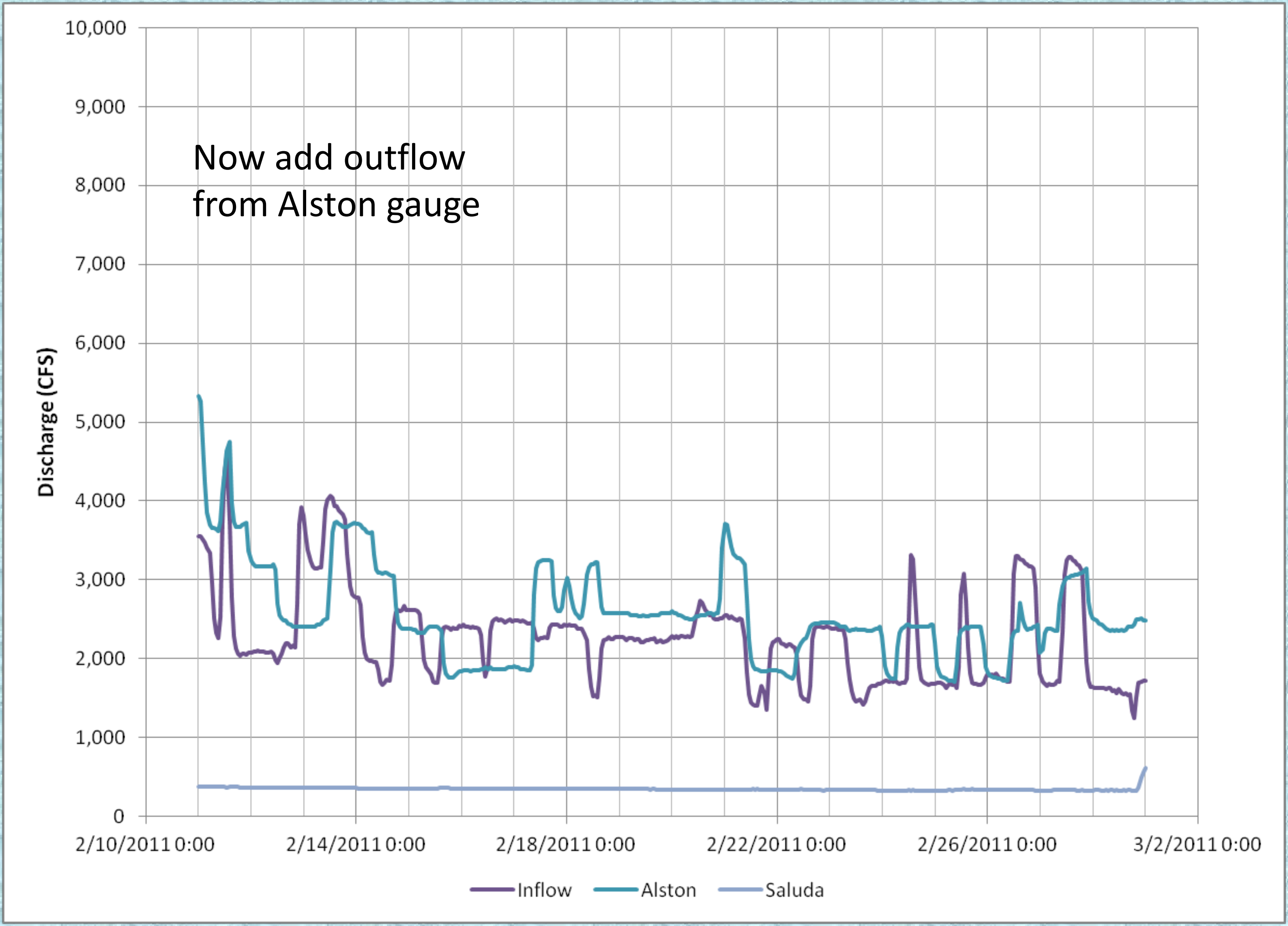
Broad River Flow Frequency

- Conclusions:
  - Good flow frequency matching on a daily basis below 800 CFS.
  - Between 800 and 1,500 CFS, daily outflow appears to be slightly less than daily inflow due to regulation.
  - Between 1,500 and 40,000 CFS, daily outflow appears to be greater than daily inflow.
  - Good flow frequency matching on a daily basis over 40,000 CFS.

Parr Operation Flow Effects During "Normal" Flow Periods

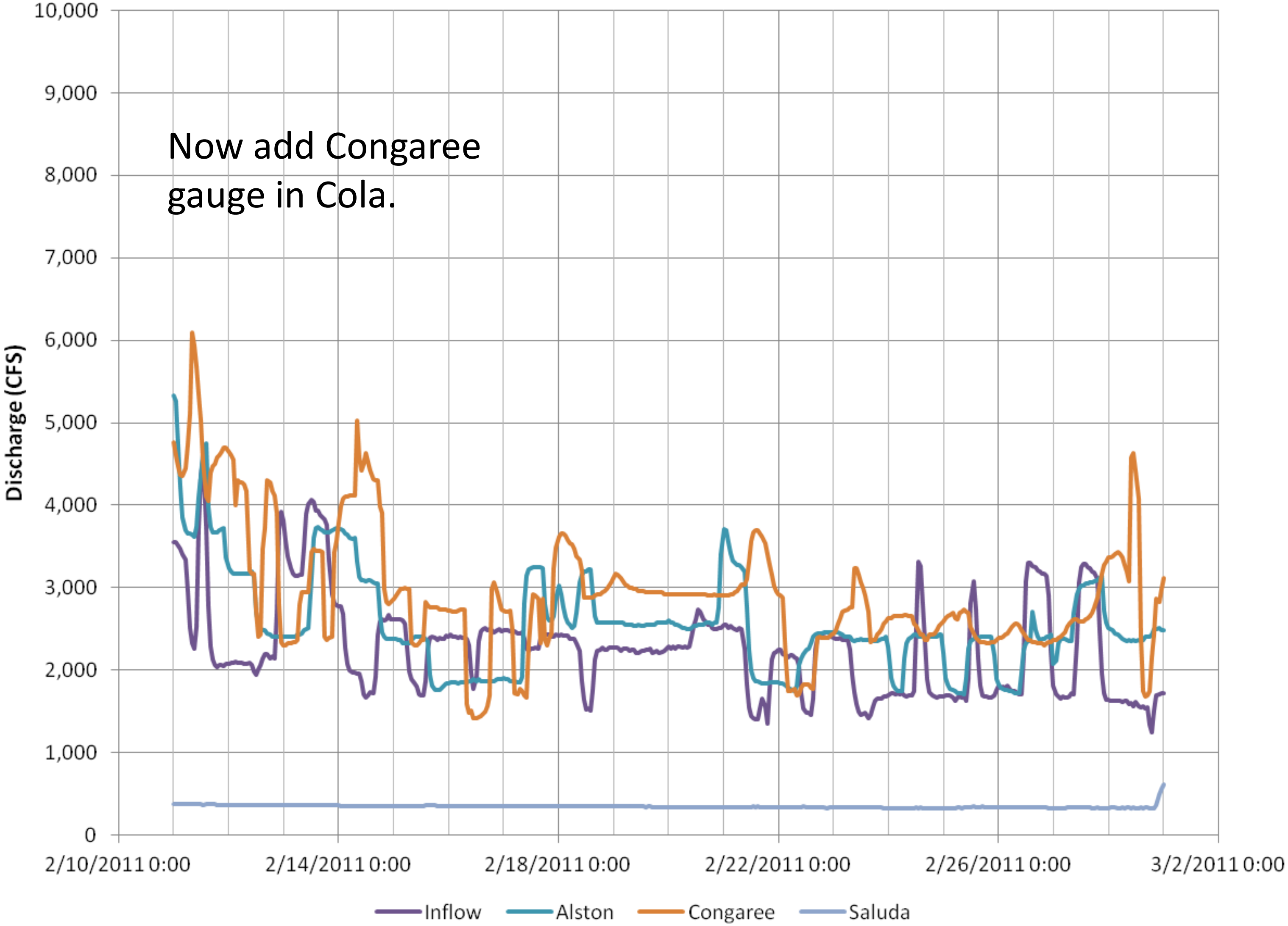
- Look at typical period with inflow < 6,000 CFS.
- Normal Parr Hydro operation with all gates up.
- Compare inflow hydrograph with Alston and Congaree gauges.
- No Saluda Hydro Operation during this period.


Inflow is sum of 3 upstream gauges, largest component is discharge from Neal Shoals.
Discharge (CFS)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2/10/2011 0:00
2/14/2011 0:00
2/18/2011 0:00
2/22/2011 0:00
2/26/2011 0:00
3/2/2011 0:00
Inflow
Saluda



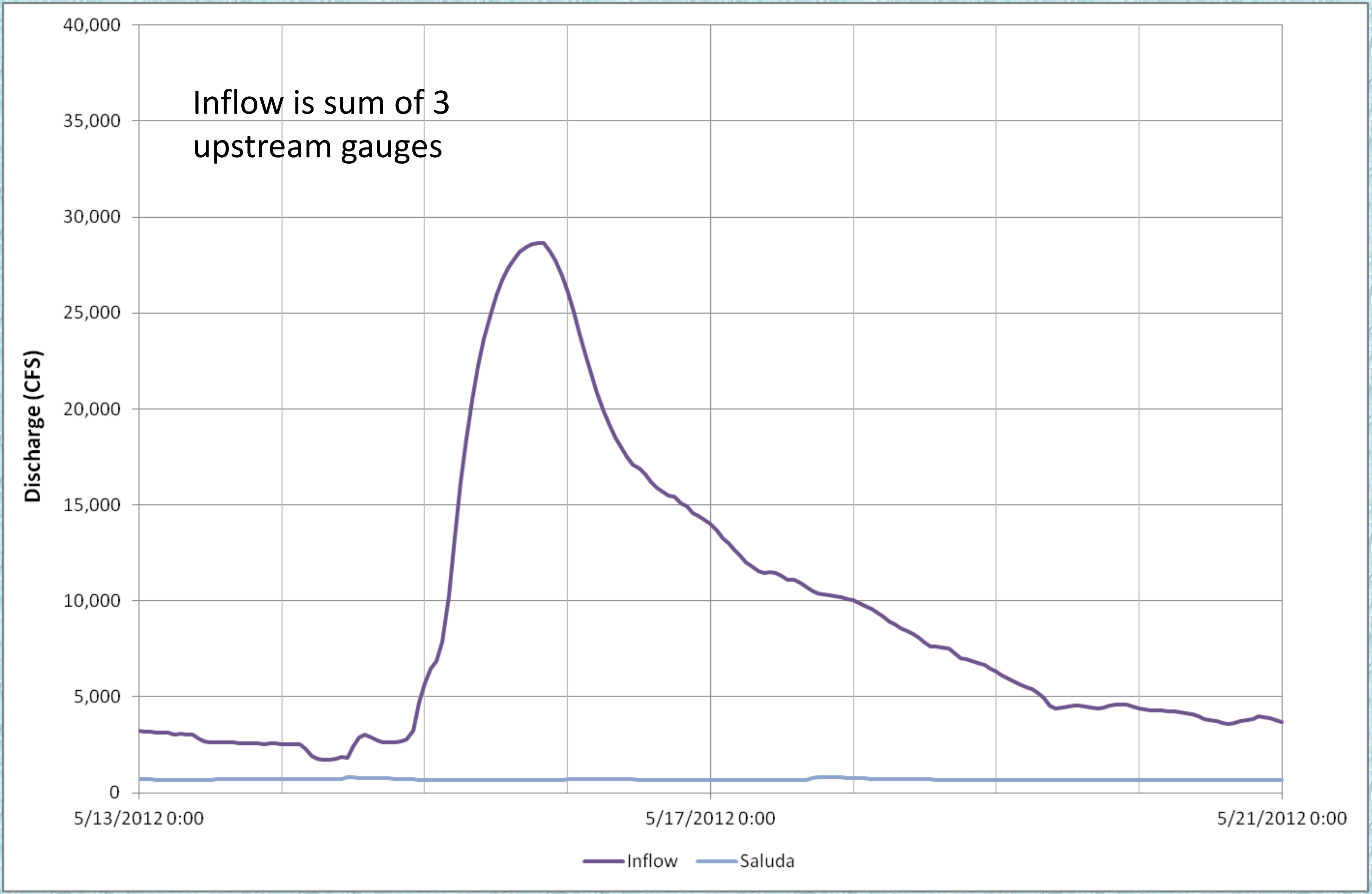
Now add outflow
from Alston gauge
Discharge (CFS)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2/10/2011 0:00
2/14/2011 0:00
2/18/2011 0:00
2/22/2011 0:00
2/26/2011 0:00
3/2/2011 0:00
Inflow
Alston
Saluda

Now add Congaree gauge in Cola.

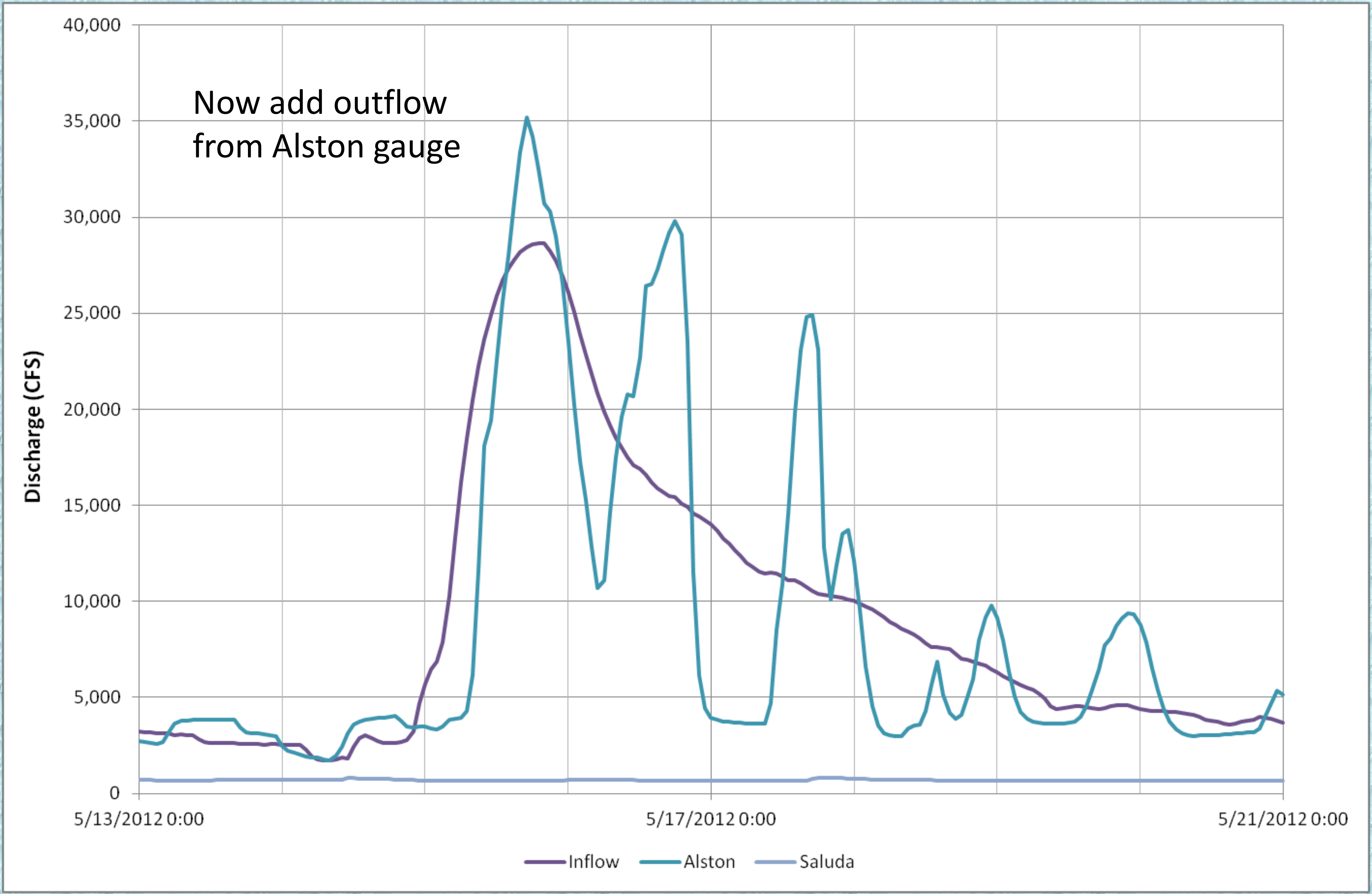


Downstream Effects of FFPS Operations During High Flows

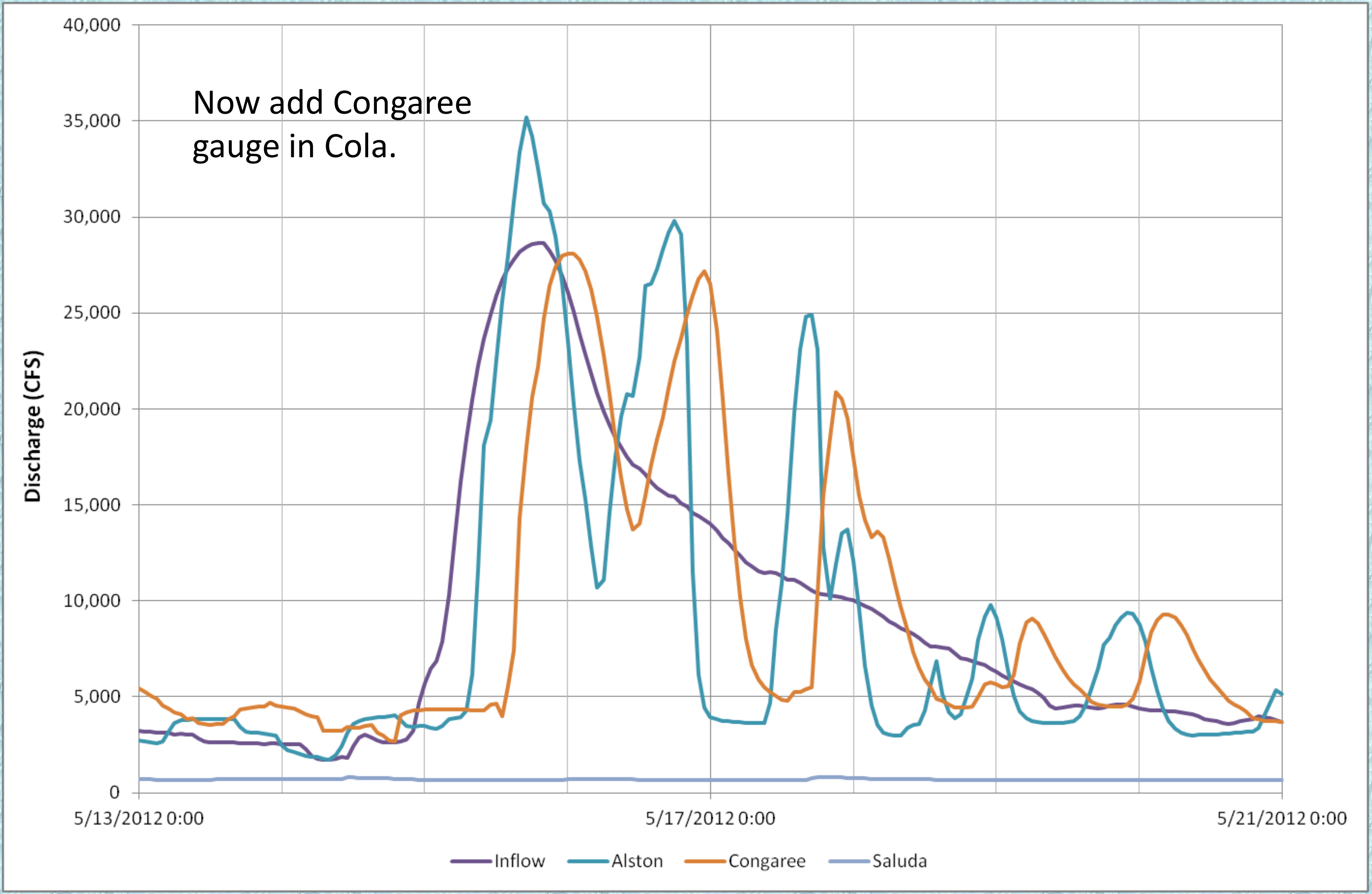
- Look at a typical hydrograph from minor flood event – May 2012.
- Peak Inflow of 28,000 CFS
- Peak Outflow of 35,000 CFS
- Illustrates effect of FFPS operation when Parr gates are down.
- Discharge increased during generation and reduced during pumping.
- No Saluda Hydro operation during this event.



Inflow is sum of 3 upstream gauges
Discharge (CFS)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
5/13/2012 0:00
5/17/2012 0:00
5/21/2012 0:00
Inflow
Saluda



Now add outflow
from Alston gauge
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Discharge (CFS)
5/13/2012 0:00
5/17/2012 0:00
5/21/2012 0:00
Inflow
Alston
Saluda


Now add Congaree
gauge in Cola.
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Discharge (CFS)
5/13/2012 0:00
5/17/2012 0:00
5/21/2012 0:00
Inflow
Alston
Congaree
Saluda

License Compliance Summary

Parr Hydro Minimum Flow Compliance Summary

Year	Lowest Hourly Project Discharge During Year @ Alston Gauge (CFS)	Number of Days Daily Average Discharge < (Inflow minus Evaporation)	Minimum Recorded Daily Inflow During Year (CFS)
2000	122	18	641
2001	122	17	564
2002	26	43	266
2003	301	1	2401
2004	301	0	1412
2005	437	0	1267
2006	106	8	906
2007	163	14	298
2008	170	2	153
2009	246	0	709
2010	340	0	486
2011	270	6	290
2012	444	0	860

Parr Reservoir Elevation Summary

Year	Minimum Recorded Reservoir Elevation (ft. NGVD)	Maximum Recorded Reservoir Elevation (ft. NGVD)
2000	255.9	266.2
2001	255.6	266.2
2002	255.9	266.4
2003	256.0	266.5
2004	255.9	266.5
2005	256.1	266.5
2006	254.9	266.1
2007	255.7	266.2
2008	256.0	266.6
2009	256.9	266.3
2010	256.1	266.3
2011	256.1	266.2
2012	256.5	266.4

Monticello Reservoir Elevation Summary

Year	Minimum Recorded Reservoir Elevation (ft. NGVD)	Maximum Recorded Reservoir Elevation (ft. NGVD)
2000	420.5	425.0
2001	420.5	425.0
2002	420.0	425.0
2003	420.5	425.0
2004	420.0	425.0
2005	420.5	425.0
2006	420.6	425.0
2007	420.5	425.0
2008	420.5	425.0
2009	420.6	425.0
2010	420.0	425.0
2011	420.5	425.0
2012	420.6	425.0

Questions?