Altoona Water Supply Reservoirs and By-Pass Channel System

Horseshoe Curve Area

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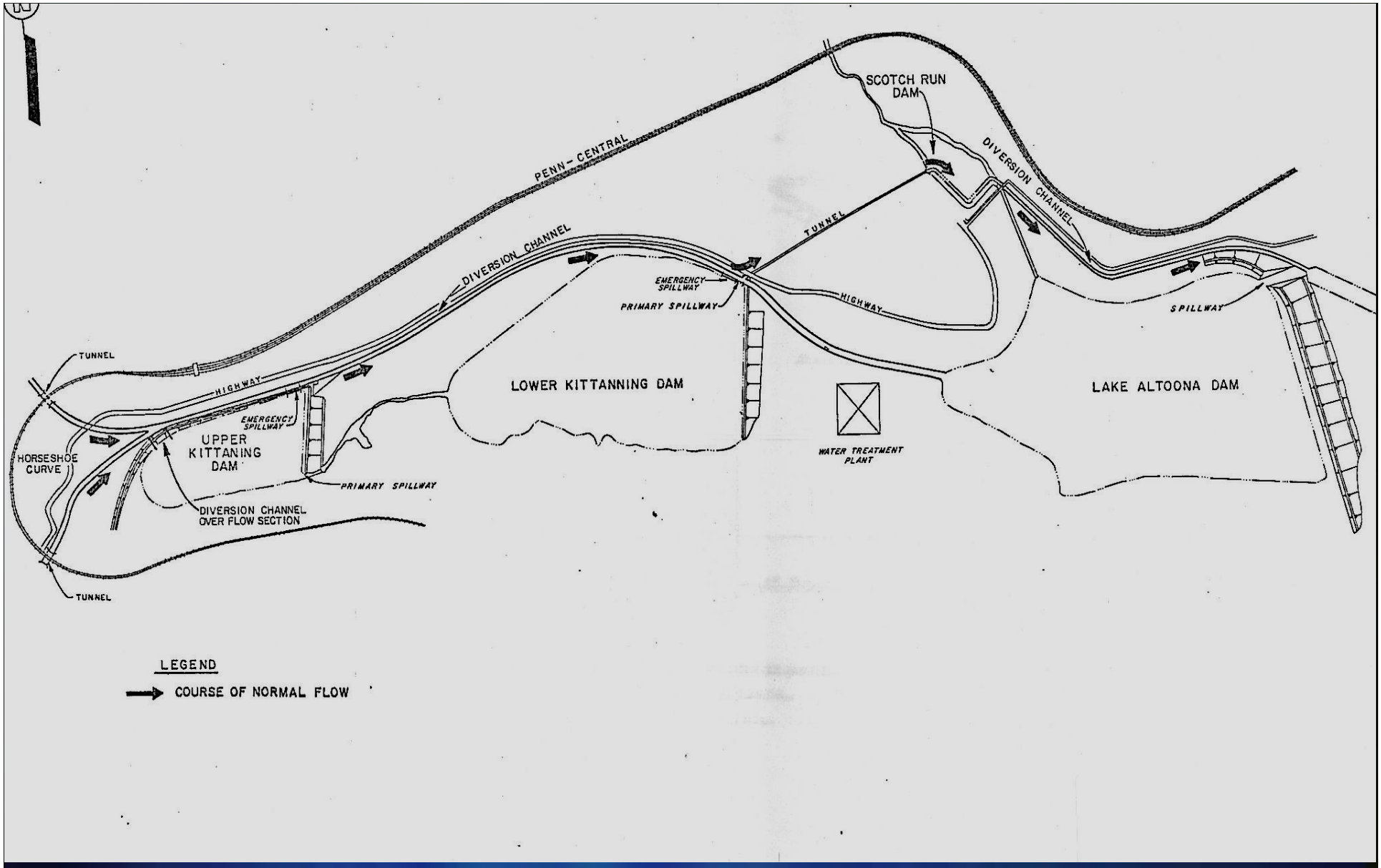
Altoona Horseshoe Curve Reservoir System

System Owner

- Owner – Altoona City Authority
- Purpose – Public Water Supply
- Service Area – Central Blair County
- Customers – 30,000
- Connected Population – 75,000
- Average Daily Demand – 11.5 MGD
- Safe Yield – 14.5 MGD
- Total Storage – 2.8 Billion Gallons
- Number of Reservoirs – 12
- Horseshoe Curve Reservoirs – 40% of Total

Project Setting

- 3 Water Supply Reservoirs in Series (1.2 Billion Gal)
- Burgoon Run Watershed (12.4 sq. mi.)
- Located at Horseshoe Curve Railroad Embankment
- Forested, Mountain Watershed with Prior Coal Mining
- Streams Polluted by Acid Mine Drainage
- Bypass Channel Diverts Low Flow Around Reservoirs
- Original Construction – 1886 to 1913
- Water Treatment Plant – 7.5 MGD Capacity (1968)



Plan of Reservoir System

Hydraulic Features

- 3 Earth Dams in Series
- Primary & Emergency Spillways
- Chute and Side Channel Spillways
- Bypass Channels and Diversion Tunnel
- Small Dam Built to Economically Connect Tunnel Outlet to a Bypass Channel (to Avoid an Aqueduct)
- Broad-Crested, Sharp-Crested and Ogee Weirs
- Reservoir Intake Towers
- One of the Most Complex PA Water Supply Systems

Hydraulic Design

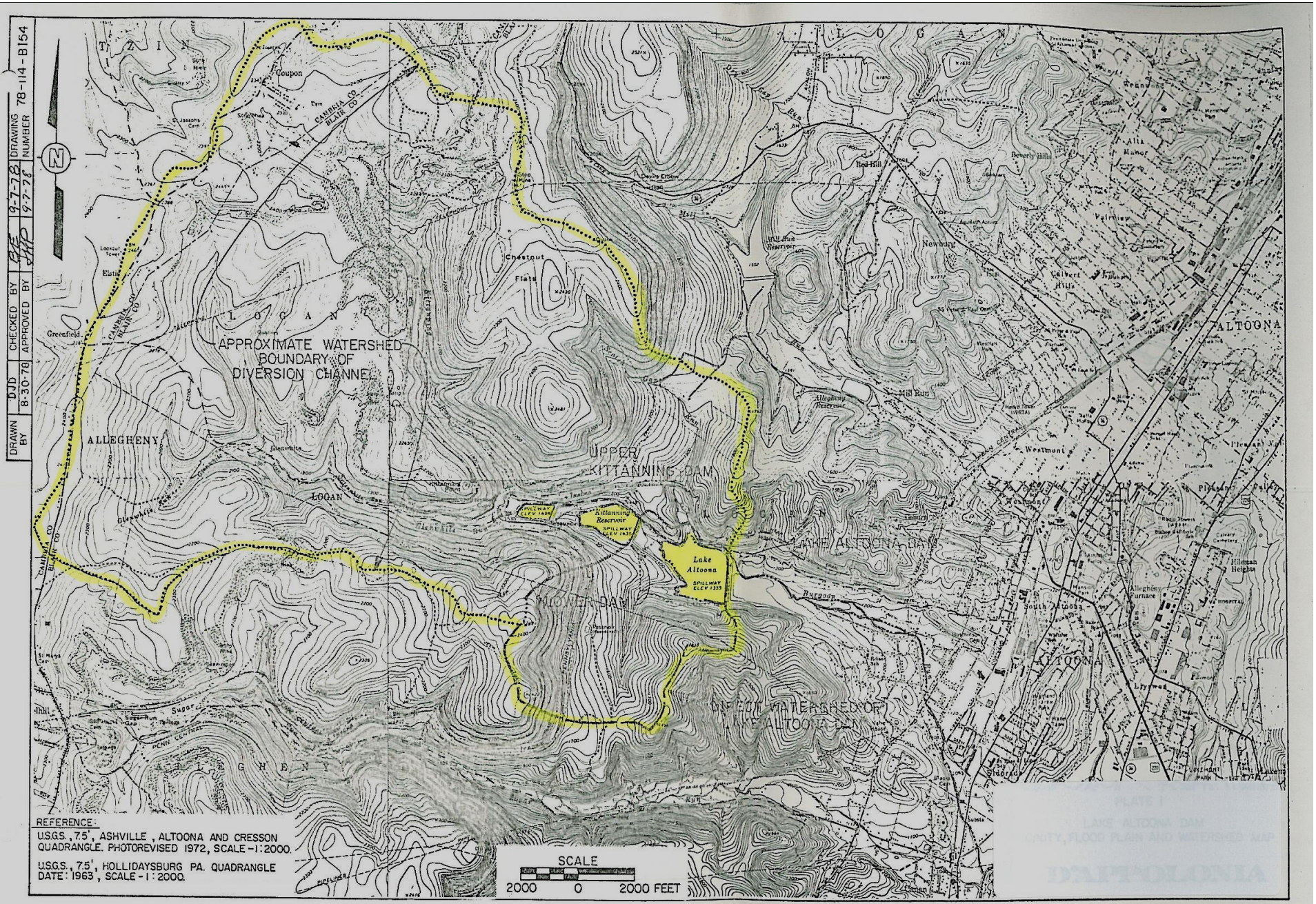
- Culverts/Bridge Openings – Orifice Formula
- Tunnel Hydraulics – Inlet/Outlet Control
- Channel Design – Steady Uniform Flow/Mannings Eqn
- Spillway Overflows – Weir Formula/Velocity Vectors
- Water Surface Profiles – Standard Step Method
- Chutes – Unsteady/Rapidly Varied Flow (Energy Eqn)
- Dam Break Analysis – Unsteady Flow (Rapidly Varied)
- Spatially Varied Flow/Critical Depth – Side Channel Spillways & Overflow Structures
- Terminal Structure Hydraulics

System Deficiencies

- Corps of Engineers Classification - High Hazard
- Spillways Pass 28% of PMF, Seriously Inadequate
- Hydraulic Capacity Must Be Upgraded
- Project Must Protect Bypass Channel System That Diverts Low Flow AMD/Sediment Around Reservoirs
- Portions of System Badly Deteriorated (Concrete)
- Solution Cannot Compromise Reservoir Storage
- Partial Fix Not Possible – Failure of Kittanning Point Dam Overtops Impounding & Lake Altoona Dams

Hydrology

- Project Design Flood – Probable Maximum Flood (Based on Hazard & Size Classification)
- "…*Most Severe Combination of Critical Meterological & Hydrologic Conditions that are Reasonably Possible in a Region*…"
- Hydrometerological Report for Susquehanna River Basin – Probable Maximum Precipitation
- 72-Hour Storm Duration
- Total Precipitation – 33.6 In.,
- Max 6-hr Rainfall - 28.9 In.



Reservoir Watershed Boundary (12.42 sq. mi.)

Hydrology (Cont.)

- PMF Runoff Hydrograph - Corps of Engineers "*Flood Hydrograph Analysis & Computations*"
- Snyder's Synthetic Unit Hydrograph Method
- Applicable for Small, Appalachian Watersheds
- Basin Geometry Important
- Reservoir Surcharge Storage Negligible (5%)
- Also Surcharge Storage Will Not Contain Upstream Dam Breach

Hydrology (Cont.)

- Summary of Cumulative PMF Peak Discharges
  1. Kittanning Point Dam – 21,325 CFS
  2. Impounding Dam – 22,760 CFS
  3. Lake Altoona Dam – 31,880 CFS

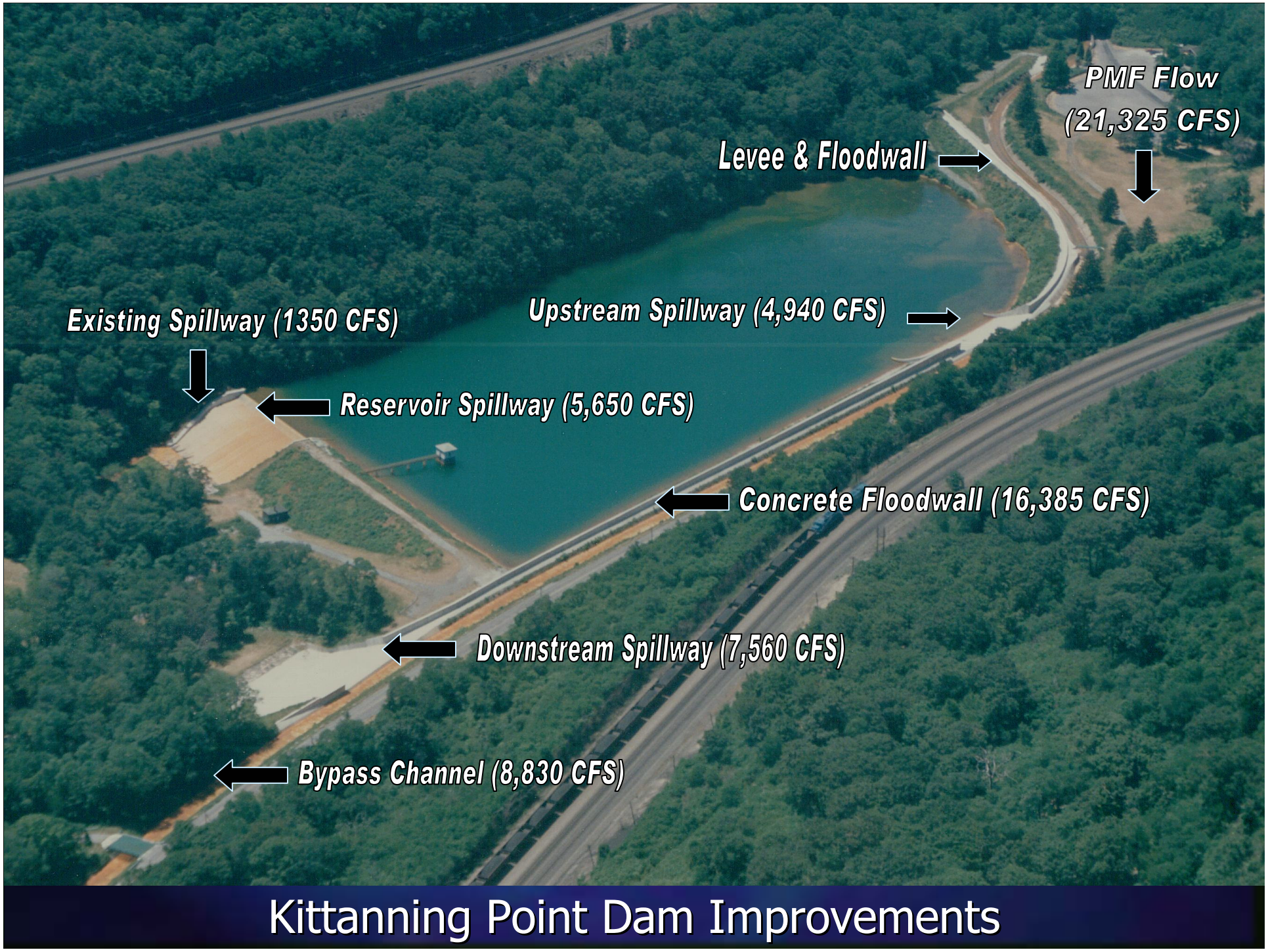
- Above Values Used to Design Hydraulic Structures For Safely Routing PMF Through System

Kittanning Point Reservoir

- Type – Earth Dam
- Date of Original Construction – 1886
- Height – 45 Feet, Crest – 600 Feet
- Normal Pool Elevation – 1501.5 MSL
- Storage Capacity – 53 Million Gallons
- Normal Pool Area – 12.6 Acres
- Spillway – 34 Ft. Broad Crested Weir
- Available Head – 5.3 Feet

Kittanning Point Dam Design Elements

- Protection of Kittanning Point Dam Paramount
- Limited Freeboard (5’) Means Limited Spillway on Dam
- Solution – Divert PMF to Bypass Channel Using Levee & Floodwall
- Convergence of Glen White Run & Kittanning Run Causes Hydraulic Jump and Standing Waves
- Overflow Spillway Needed Here to Divert Some Flow into Reservoir or Risk Breaching Bypass Channel
- New Reservoir Spillway Required for this Overflow
- Another Overflow Spillway Needed Below Dam to Divert Excess Channel Flow into Impounding Reservoir



Kittanning Point Dam Improvements

Upstream Side-Channel Spillway to Prevent Hydraulic Jump at Stream Juncture (4,950 CFS Capacity – 150’ Broad Crested Weir)

Upstream Side-Channel Overflow Spillway

Existing 34 Ft. Principal Spillway (1,350 CFS)

New 150 Ft. Reservoir Spillway (5650 CFS Capacity, Ogee Weir)

Bypass Channel Floodwall (16,385 CFS Capacity) – 12.5 Ft. High

Downstream Side-Channel Spillway, Reduce Bypass Channel Flow
(7,560 CFS Capacity-100 Ft. Broad Crested Weir, Variable Width)

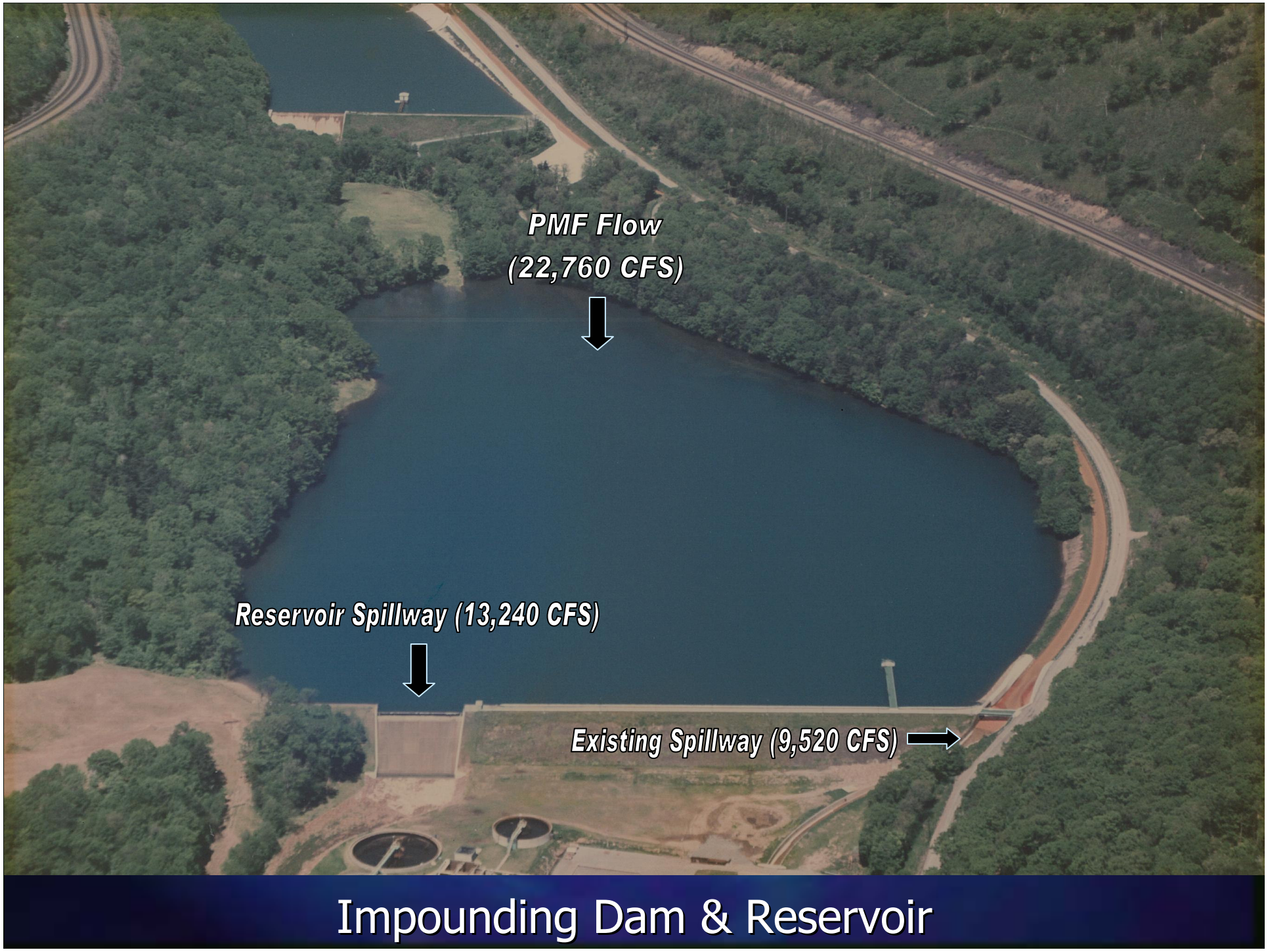
Existing Bypass Channel (8,830 CFS Capacity) – 20 Ft. Wide, 1:1

Impounding Reservoir

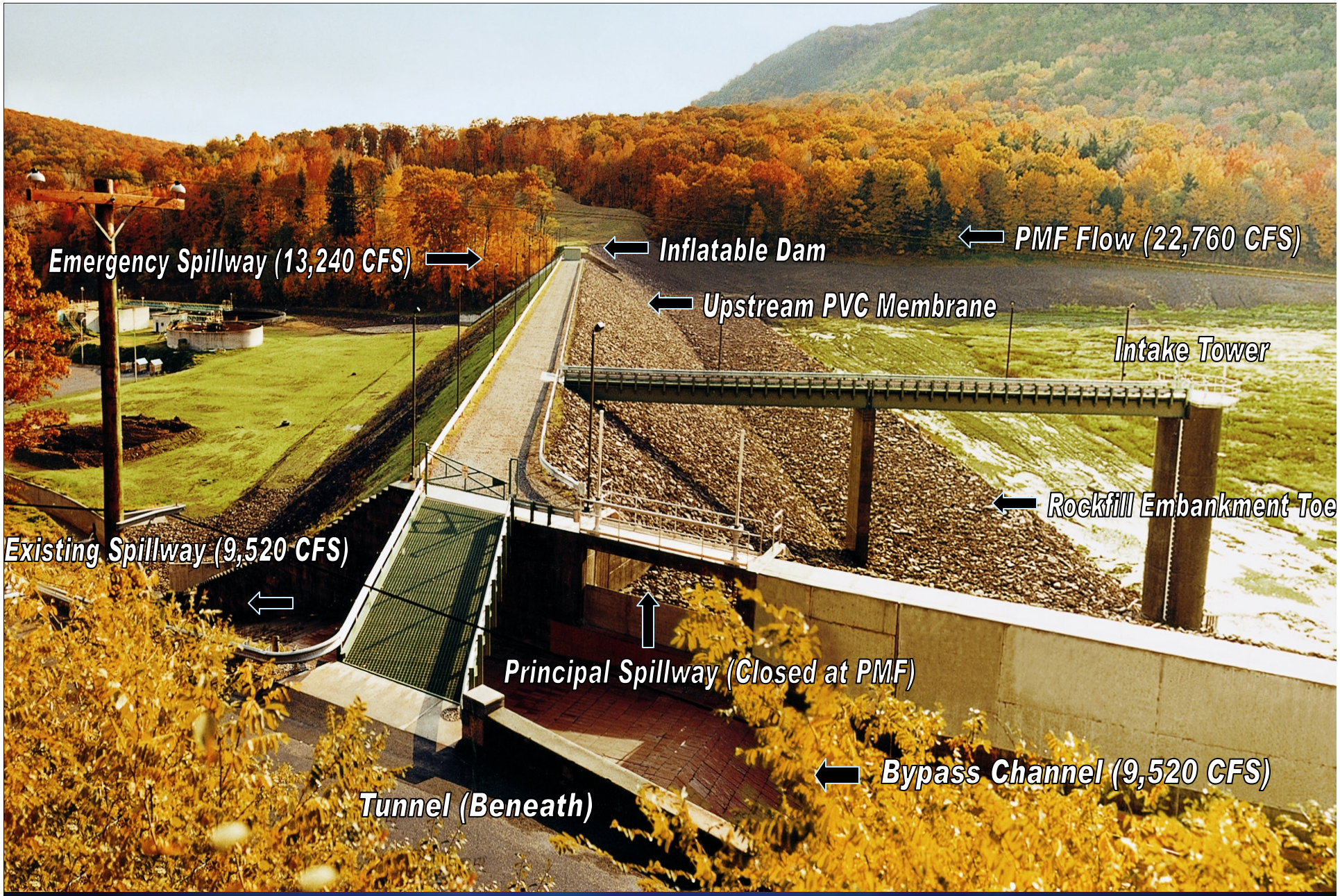
- Type – Rolled Earth Dam
- Date of Original Construction – 1896
- Height – 56 Feet, Crest – 1,100 Feet
- Normal Pool Elevation – 1434.7 MSL
- Storage Capacity – 315 Million Gallons
- Normal Pool Area – 42.8 Acres
- Primary Spillway – 25 Ft. Ogee Weir
- Emergency Spillway – 100 Ft. Side Channel Broad Crested Weir

Impounding Dam Design Elements

- Dam Slope Stability Problems Require Rockfill Toe
- Inflatable Dam Reduces Spillway Length (Deflates During PMF, 5 Ft. of Spillway Head, 70 MG - Storage)
- Stability Analysis Favorable Along with PVC Membrane Waterproofing and Grout Curtain
- New 20 Ft. Stainless Steel Principal Spillway Regulates Pool Elevation, Closes During PMF
- New Multi-Port Intake Tower and Access Bridge
- Bypass Channel and Tunnel Rehabilitation
- Crest Roadway, Lighting, Downstream Toe Drain



Impounding Dam & Reservoir



Upgraded Impounding Dam

Renewed Bypass Channel (8,830 CFS Capacity)

New Bypass Channel & Tunnel Entrance (vitrified clay line plates)

Diversion Structure at Tunnel Entrance

New Primary Spillway (Diverting Water Into Lake Altoona)

Existing Impounding Dam Spillway (3,180 CFS Capacity)

132 Ft. Emergency Spillway (13,240 CFS)-Ogee Weir/Approach Channel

Spillway Chute and Inflated Rubber Dam

Deflector Bucket Rock Armor/Riprap Channel

Overview of Impounding Dam Spillway and Water Plant

Intake Tower Bridge & Operating Platform at Normal Pool

Lake Altoona

- Type – Earth Dam & Concrete Core Wall
- Date of Original Construction – 1913
- Height –73 Feet, Crest – 1,900 Feet
- Normal Pool Elevation – 1359 MSL
- Storage Capacity – 836 Million Gallons
- Pool Area – 89.1 Acres
- Primary–Emergency Spillway – 132 Ft. Broad Crested Weir (w/inflatable dam)

Lake Altoona Dam Improvements

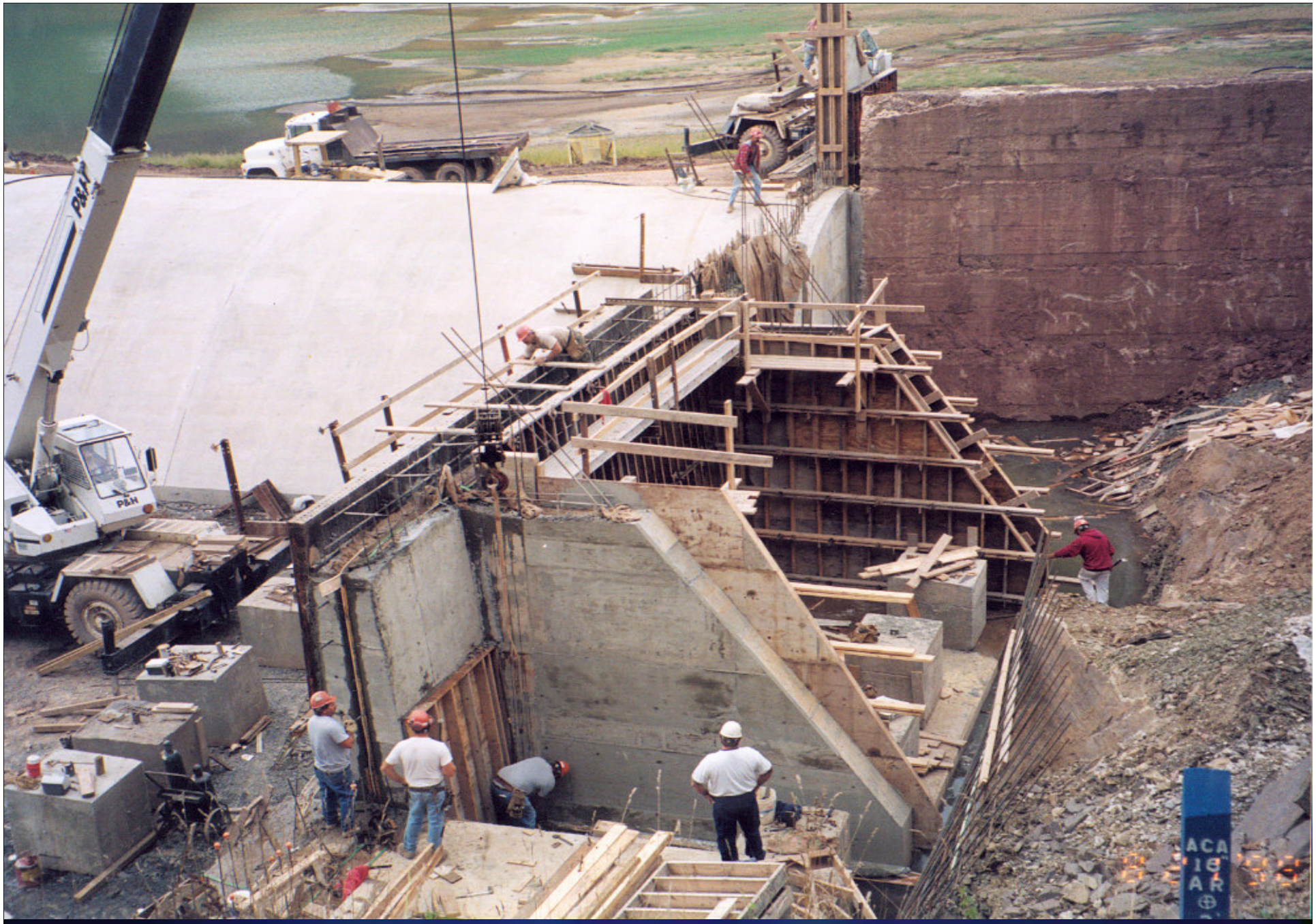
Lake Altoona Design Elements

- 7 Ft. Floodwall on Dam Crest Increases Available Spillway Head & Reduces Spillway Width to 132 Ft.
- Stability Analysis Favorable for Floodwall (Rapid Drawdown Factor of Safety is 1.50 - 1.85)
- Inflatable Dam Maintains Storage (Deflates During PMF, Making Available 4 Ft. More of Spillway Head)
- Side-Channel Spillway Avoids Rapidly Varied Flow and Cross Wave Formation to Adjacent Curvilinear Bypass Channel

Bypass Channel Rehab - Pressure Mortar Surfacing

Floodwall Construction

Spillway Ogee Weir Construction



Side Channel Spillway Walls & Counterforts

Side Channel Spillway Trough Construction

Side Channel Spillway and Bypass Channel

Lake Altoona Spillway Channel & Access Bridge

Lake Altoona Dam Embankment & Access Road

Intake Tower and Flood Wall

New 132 Ft. Spillway with Ogee Weir

Lake Altoona Spillway & Inflated Rubber Dam

Schedule & Cost Summary

- Construction Started - June 1984
- Construction Completed - August 2000
- Construction Cost - $13,500,000
  1. Kittanning Dam - $ 2,700,000
  2. Impounding Dam - $ 3,900,000
  3. Lake Altoona Dam - $ 6,900,000

Questions and Comments