Raising the bellmouth spillway at Black Esk reservoir using PK weirs

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Scheme summary
Hydraulic design of spillway raising with piano key (PK) weirs
Precasting and construction
FACTS AND FIGURES

- Design & construction project
- Raising overflow level by 2.5m
- Storage increased by 40%
- Original estimate £3.5M Construction and Design
ORIGINAL RESERVOIR

- Completed 1962
- Surface area 33ha, storage capacity 2200ML
- Dam 20m high, 250m crest length
- Rolled clay core (glacial till)
ORIGINAL RESERVOIR – BUILT FOR RAISING

Extract from original drawing showing plans for raising by 30 feet (9m)
SPILLWAY RAISING
PIANO KEY WEIRS

JOHN ACKERS

ALL RESERVOIRS PANEL ENGINEER
TECHNICAL DIRECTOR (HYDRAULICS)
Flow modes

- Weir control
- Throat control
- Tunnel running full
PIANO KEY WEIRS – THE OPPORTUNITY

- Designed for a small footprint
- Simple standard designs
- Easy construction
- Possibility of precasting
- PKW 2011
PIANO KEY WEIRS
TYPICAL DESIGN

Etang de Gouillet
PIANO KEY WEIRS
TYPICAL DESIGN

Weir head (m)

Discharge (m$^3$/s)

Ogee weir rating
PK weir rating

Plan view

Fig. 1

Cross section 2-2 (inlet)
Cross section 1-1 (outlet)
PIANO KEY WEIRS
Visit to EDF sites near Limoges

St Marc dam

L’Etroit dam
PIANO KEY WEIRS
ADAPTATION TO BELLMOUTH RIM

Initial 12-cycle version
PIANO KEY WEIRS
ADAPTATION TO BELLMOUTH RIM

Initial 24-cycle version
PIANO KEY WEIRS
ADAPTATION TO BELLMOUTH RIM

Final 24-cycle design
PIANO KEY WEIRS
ADAPTATION TO BELLMOUTH RIM

Final 24-cycle design
PIANO KEY WEIRS
ADAPTATION TO BELLMOUTH RIM

Final 24-cycle design

Inner debris boom
PIANO KEY WEIRS
ADAPTATION TO BELLMOUTH RIM

Final 24-cycle design

CFD model of one 15° cycle
PIANO KEY WEIRS
Computational fluid dynamics (CFD)

68 m$^3$/s

120 m$^3$/s
PIANO KEY WEIRS
Computational fluid dynamics (CFD)

With footbridge support column

168 m$^3$/s
PIANO KEY WEIRS
Computational fluid dynamics (CFD)

168 m³/s

192 m³/s
PIANO KEY WEIRS
Computational fluid dynamics (CFD)

Rating curves for Black Esk PK weirs
PIANO KEY WEIRS
Comparison of rating curves

![Graph of discharge vs. water level for various weir types](image-url)
PIANO KEY WEIRS
Comparison of flood routings

Graph showing comparison of water levels and inflow/outflow between a raised ogee and a PK weir over time.
SPILLWAY RAISING PRECASTING AND CONSTRUCTION

TOM SCOTT

PRINCIPAL ENGINEER, BLACK & VEATCH
INITIAL WORKING AREA CONCEPTS
PREPARATION FOR PIANO KEY WEIRS

March 2013
DEMOLITION OF EXISTING STRUCTURE
DEMOLITION OF EXISTING STRUCTURE

SPILLWAY RAISING – PRECASTING AND CONSTRUCTION

April 2013
THE BENEFIT OF A PONTOON
PREPARATION FOR PIANO KEY WEIRS

June–July 2013
PRECAST PIANO KEY WEIRS
PIANO KEY WEIRS PRECASTING

SPILLWAY Raising – PRECASTING AND CONSTRUCTION

2013-06-17
PIANO KEY WEIRS
PRECASTING
PRECAST BALLAST UNITS
DELIVERY TO SITE
INSTALLATION OF PIANO KEY WEIRS
INSTALLATION OF PIANO KEY WEIRS
INSTALLATION OF PIANO KEY WEIRS
INSTALLATION OF PIANO KEY WEIRS
WORKS NEARLY COMPLETE

September 2013
WORKS NEARLY COMPLETE
WORKS NEARLY COMPLETE
WORKS NEARLY COMPLETE

November 2013
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Together

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