BRIEF SUMMARY OF PROJECTS CARRIED OUT
BY
THE HYDRAULICS RESEARCH INSTITUTE

Design & testing of cooling system of power plant

1- Cairo West Power Plant Intake Structure

Consultant : Siemens, Germany

Period : 1987 – 1993

The study objective was to optimize the layout and hydraulic design of the cooling water intake under different operating conditions of the power plant and different river flows.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model study of the intake structure. The optimal hydraulic dimension of the intake and sump structures to prevent swirls, pre-rotation and cavitation were determined.

2- Shoubra El-Khima Power Plant Intake Structure

Consultant : Bechtel, USA.

Period : 1988 – 1989

The power plant sometimes suffered from severe corrosion in the suction pipes of the intake structure. The objective was to determine the reasons for this corrosion, and how to prevent it.

The study comprised field investigations, data collection, bathymetric surveys, and desk calculations.

3- Damietta Power Plant Hydro-Thermal Study

Consultant : Bechtel, USA.

Period : 1988 -1989

The study objective was to design the cooling system that was required for the Power Plant. The hot water recirculation had to be prevented in order to guarantee the performance of the cooling system. The impact of the cooling system on the environment of the river in the plant vicinity was assessed to meet the regulations of the Ministry of Public Works and Water Resources.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model study of the outfall structure. The optimal hydraulic configurations of the outfall structure was reached.

4- Cairo West Power Plant Hydro-thermal Study

Consultant : HRI

Period : 1989 -1990

The study objective was to design the cooling system required to increase the power plant capacity. The hot water recirculation had to be prevented in order to guarantee the performance of the cooling system. The impact of the cooling system on the environment of the river in the plant vicinity was assessed to meet the regulations of the Ministry of Public Works and Water Resources.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model of outfall structure. The optimal dimensions of the outfall structure was reached.

5- Cairo South Power Plant Hydro-Thermal Study

Consultant : HRI

Period : 1991-1992

The study objective was to design the cooling system required to increase the power plant capacity. The hot water recirculation had to be prevented in order to guarantee the performance of the cooling system. The impact of the cooling system on the environment of the river in the plant vicinity was assessed to meet the regulations of the Ministry of Public Works and Water Resources.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model study of the outfall structure. The optimal dimensions of the outfall structure was reached.

6- Cairo North Power Plant Hydro-Thermal Study

Consultant : HRI

Period : 1992- 1993

The study objective was to design the cooling system required to increase the power plant capacity. The hot water recirculation had to be prevented in order to grantee the performance of the cooling system. The impact of the cooling system on the environment of the river in the plant vicinity should be assessed to meet the regulations of the Ministry of Public Works and Water Resources.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model of outfall structure. The optimal dimensions of the outfall the structure was reached.

7- El-kurimat Power Plant

Consultant : Ebasco, USA

Period : 1992 – 1994

The study objective was to optimize the layout and dimensions of the cooling water intake and the outfall structure under different operation conditions of the power plant and different river flows conditions. Sedimentation had to be prevented in the intake. The hot water recirculation had to be prevented in order to guarantee the performance of the cooling system The impact of the cooling system on the environment of the river in the plant vicinity was assessed to meet the regulations of the Ministry of Public Works and Water Resources.

The study comprised field investigations, data collection, bathymetric surveys, and a hydraulic scale model of the outfall structure. A scale model operated covering a river reach of 5 km was constructed to study the sediment transport in the plant vicinity. The optimal hydraulic dimensions of the outfall structure was reached.

8- Proposed El-Lahoun Hydropower Plant

Consultant : HRI

Period : 1987 – 1992

The study objectives were to determine the flow velocities and water levels downstream and upstream of the El-Lahoun regulator, investigate the characteristics of created back-water curve upstream the new regulator, and also to investigate the expected morphological changes downstream the plant.

This can be carried out using a fixed bed model to measure the flow velocity downstream and water level upstream and downstream of the new El-Lahoun regulator.

9- El-Lahun Hydropower Plant

Consultant :HRI

Period : 1992 – 1993
: 1995 – 1996

The study objectives of the first and second phases were to establish the optimal layout of the hydropower plant in the lock of El-Lahoun Barrage. The characteristics of the approaching water flow had to be investigated in order to minimize the head loss and to increase the power generation efficiency. The morphological changes downstream the study area due to the construction of the hydropower plant had to be evaluated.

The study comprised field investigations, data collection, bathymetric surveys and hydraulic fixed bed and movable bed scale models to study the approaching channel, the load reflection of the power plant and the morphology of the downstream. The optimal layout and the protection of the downstream of the hydropower plant were reached.

10- Construction of Hydropower plant on Sheikh Zaid Canal

Consultant : HRI

Period : 1997 - 1998

The main objective of the study was to prepare preliminary feasibility study for construction hydropower plant on Sheikh Zaid Canal.

The study was carried out by determining the water requirements for the project area and the annual expected discharges that can be used in hydropower cooling system.

11- El-Dabaa Power Plant

Consultant :HRI

Period : 1993 – 1995

The study objective was to test the hydraulic performance of the intake and outfall configurations of the first Egyptian Nuclear Power Plant located on the Mediterranean Coast.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model of the outfall structure including the wave action near the shore. The optimal hydraulic dimensions of the outfall structure were reached were reached.

12- Sidi Krir Power Plant

Consultant : HRI

Period : 1994 – 1995

The study objective was to test the layout of the cooling water intake and outfall structures which are located on the Mediterranean Coast.
The study comprised field investigations, data collection, bathymetric surveys.
The study presented the information needed in a design Report to help in the stage of hydraulic and structural design.

13- Sidi Krir Power Plant

Consultant : HRI

Period : 1998 - 1999
The study objective was to carry out the required hydrographic survey and water quality sampling, which are necessary to carry out the hydraulic studies to design the cooling system of the project. This can be achieved by carrying out all field measurements and water quality sampling, which are necessary for optimal design of the cooling system. These field

measurements included the bathymetric survey and hydrographic measurements covering an area of 8 x 4 km^2.

14- Assuit (El-Walidia) Power Plant

Consultant : HRI

Period : 1995 – 1997

The study objective was to optimize the layout and dimensions of the cooling water intake and outfall structures under different operating conditions of the power plant and for different river flows. Sedimentation was to be prevented from entering the intake. The hot water recirculation was to be prevented in order to grantee the performance of the cooling system. The impact of the hot water on the environment of the river in the plant vicinity was assessed to meet the regulations of the Ministry of Water Resources and Irrigation. The performance of the intake structure was checked to prevent the pre-rotation, swirls, and the formation of cavitation.

The study comprised field investigations, data collection, bathymetric surveys and a hydraulic scale model of the outfall structure. A scale model covering a river reach of 5 km was constructed to study the sediment transport in the Plant vicinity.
A third hydraulic scale model of the intake structure was constructed. The optimal hydraulic dimensions of the intake and outfall structures were reached.

15- El-Kurimat Power Plant Inlet

Consultant : HRI

Period : 1996-1997

The study objective was to study the effect of operating the plant on the flow pattern at the intake structure. Also, to find out the best layout of the cooling water system.

An undistorted fixed-bed model was constructed with scale 1 : 12 to represent a reach of the river of about 485 m length and 84 m width at the intake structure of the plant.

16- Ayoun Mussa Power Plant

Consultant : Bechtel, USA

Period : 1996 – 1997

Ayoun Mussa power plant (AMPP) will use the Suez Gulf water for a once through cooling water through a dredged diked channel. The Plant cooling water will be conveyed offshore to the outfall through two subswface pipes. The Plant will have two power generation units of 350 MW each. The water used by the Plant, including cooling water service water and desalinization water, has a discharge of 25.96 m^3 s at the intake and 25.92 m^3/s through. The temperature rise across the condenser is 10 ^{o}c.

The study objective was to obtain the optimal design of the cooling water system, which

fulfills the environmental criteria and prevents the hot water recirculation. The study was also aimed at designing the required bed protection to prevent scour at the outlet vicinity.

The study comprised the construction of tow physical models. A near-field undistorted model with a scale of 1:25 of the outfall and a far-field model of scales of 1 : 100 horizontal and 1:20 vertical study were constructed.

17- Ghazlan Power Plant

Consultant : Bechtel, USA

Period : 1998 – 1999

The Saudi Consolidated Electric Company (SCECO East) was planning to construct Ghazlan II Power Plant consisting of four power-generating units (units 5,6,7 and 8) with once-through circulating cooling water (CW) system. The project is located on the southern shoreline of the Arabian Gulf near Dammam to the west of the existing Ghazlan I Power Plant. The Ghazlan II Power Plant project receives its cooling water from the Gulf through a series of pips embedded in the intake breakwater. The breakwater has a U -shape and forms an enclosed intake-stilling basin with the shoreline. Water from the Arabian Gulf passes through the pipes, into the stilling basin before reaching the onshore intake structure. The function of the basin inside the breakwater is to allow sediment that may be carried by the water, to settle down before reaching the intake structure.

The study objectives were to test the proposed design basin to evaluate its performance with clear water and with sediment deposition conditions at HWL and LWL. Also, to determine the size of the riprap required preventing erosion

The power plant will discharge the cooling water into the Arabian Gulf through a concrete lined open channel. Riprap will be used to protect the seabed in the vicinity of the outfall from erosion.

The study comprised the construction of two undistorted physical models. The Intake-Stilling Basin of scale1:16 to protect the outfall apron of scale 1:20 undistorted model.

18- Cairo Oil Refining Company Cooling System

Consultant : HRI

Period : 1996 - 1997

The study objectives were to test the existing cooling system to fulfill the requirements of the environmental criteria set by the Egyptian Ministry Works & Water Resources and prevent the hot water recalculation. The aims also include improving the flow field and prevent sedimentation in the existing intake, as well as design a new intake and pump-house with maximum capacity of 12000 m^3/hr.

A mathematical model to estimate the cooling water flow behavior and to predict the surface thermal plume decay and centerline trajectory has been developed by HRI. This model was used to test the cooling system. A 1:15 undistorted hydraulic physical model for the Ismailia Canal at the CORC site is constructed at the HRI. The model represents 450 m of the canal, the existing and proposed pump-house are also represented.

19- Effects of Construction two Additional Units to North-Cairo Power Plant

Consultant : HRI

Period : 1999 – 2000

The study main objective was to study effects of construction two additional units to the existing North-Cairo power plant. The study was conducted using field measurements and hydraulic survey for 1.0 km upstream the plant inlet and 3.0 km downstream the inlet. The study also covered measuring the water velocity distribution for five sections and analyzing the collected data and measurements.

The study conducted in possibility of constructing two additional units, each one with power capacity of 320 Mw and cooling discharges of 13 m^3/sec. The study recommended carrying out hydraulic studies using physical models to make the final design of plant inlet and outlet.

20- Design Ghezlan Power Plant Exit #2 *in* Saudi Arabia

Consultant : HRI

Period : 1999 –2000

The study main objective was to study the efficiency of suggested design for power plant exit at Arab Gulf and performing the necessary configurations to achieve the optimum hydraulic performance for absorbing the water energy at exit in case of operating or stopping the current station. The study also aimed at specifying the required protection for exit to avoid scouring problems.

The study was carried out using a physical model for exit and conducting the hydraulic tests for optimal solution.

21- Study of Ghezlan Intake # 2 *in Saudi Arabia*

Consultant : HRI

Period : 1998 - 1999

The main study objectives were to study the suggested design performance of stilling basin, reducing swirling and vortices and preventing scour and moving suspended materials to pump intake.

Two physical models were applied with scale 1:16 to represent about 891 x 360 m^2, the first with fixed bed and the other with movable bed at minimum and maximum gulf water levels.

22- Water Analysis for Power Plant *Western Suez Gulf*

Consultant : HRI

Period : 1998 – 1999

The main objective of the study was making field measurements and studying water quality necessary to power plant cooling system. The cooling water has discharge of 25.92 m^3/s and temperature higher than the gulf water temperature with 8.5 ^oC. The study comprised hydrographic survey for 2.0 km parallel to shore line and survey of 3.0 km perpendicular to the shoreline covering 40 sections. The study also included the tide measurements during hydrographic survey, data collection for October and November, 1998, water velocity distribution, contour mapping for water bed, velocity vertical sections at different sectors, and analyzing water quality at different depths so that the proper recommendations can be offered.

23- El-Nubaria Power Plant

Consultant : HRI

Period : 2000 -2001

The main objectives were to study the environmental effects of thermal pollution on Nubaria Canal and to study effects of power plant cooling system inlet and outlet on navigation.

The study comprised construction, calibration and investigation using undistorted physical model with scale 1:40. Different alternatives and suggestions were searched using the model to reach the optimal hydraulic system and the most economic shapes for cooling system inlet and outlet. The study also searched possibility of adding another generating unit.

24- Sharm El-Sheikh Power Plant

Consultant : HRI

Period : 2001 –2002

The main study objective was to search the suitability of suggested location for power plant. The study included hydrographic survey for suggested location covering area of 6.0 km^2, measuring water velocities and water currents, measuring tide, analyzing bed samples, and determining

coral reef in the area.

25- Effects of Increasing Generated Power on Cooling System *of North-Cairo Power Plant*
Consultant : HRI

Period : 2001 –2002

The main objective was to study the effects of increasing generated power from 110 Mw to 750 Mw on the cooling system of the plant. The study included comprehensive survey for Ismailia Canal upstream the power plant to study the hydraulic properties of flow. Therefore, water velocity distribution was calculated and bed samples analysis was executed.
Undistorted fixed bed physical model was constructed with scale 1:40 representing accurately the cooling system inlet and outlet. Water velocity distribution and flow streamlines shapes were measured in the model and compared with prototype. The study also comprised the different operation cases of the plant with different discharges. The study recommended modification of suggested design of inlet and outlet shapes to avoid bad effects on surrounded environment and navigation in the closed area, and also to avoid recirculating hot water out from exit and returning it to inlet.

26- Design of Inlet and Stilling Basins for Ghezlan Power Plant

Consultant : HRI

Period : 1999 **-** 2000

The study main objectives were to study the suggested performance and design of stilling basin and investigating the different alternatives to improve the discharge uniformity to avoid vortices. Consequently avoiding scour and moving sediment to pumps inlet.

The study comprised a fixed bed physical model and moving bed model at minimum and maximum water levels.

27- Hydrographic Survey and Water Desalination for the Power Plant West of the Suez Gulf

Consultant : HRI

Period : 1999-2000

The study objective was to conduct a hydraulic survey to determine the required water for the cooling system.

28- Field Survey Measurements in front of the Cairo West Power Plant

Consultant : HRI

Period : 1999-2000

The study objective was to conduct the hydraulic investigations and measurements in front of the Cairo West Power Plant.

29 – North Cairo Power Plant: Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2002 – 2003

The specific objectives of the study were to:

- Test the possibility of implementing Module II;
- Define the appropriate location of the intake/discharge structures of Module II with respect to the intake/discharge structures of Module I;
- Test the performance of Module I and II under different operational modes and different canal conditions; and
- Verify the navigation safety in vicinity of the cooling systems.

The study comprised field investigations, data collection, and bathymetric survey. A physical model was constructed as the best tool to have a direct insight of the flow phenomena under consideration. The model has an undistorted scale of 1:40 with a fixed bed for the whole model bed except at the intake structures that have the facilities to install mobile bed materials.

The results of executed tests revealed that the cooling system operates soundly for any operational mode apart from the one pump mode of operation during the critical period of the minimum canal flow (winter closure). Also, it could be concluded that the dredging of the canal bed to the level of 11.5 m and the construction of the Right Bank vertical wall, in addition to a left side slope of the canal of 3H:2V helped in reaching good mixing conditions. It was recommended to check the possibility of constructing the second Module with the current canal conditions in order to reduce the construction costs.

30 – Nubaria Combined Cycle Power Plant: Proposal for a Hydrothermal Model Study

Consultant : HRI

Period : 2002 – 2003

The purpose of this study was to obtain the local dilution and dispersion behavior of hot water at the near field for different configurations of the outfall structure and different hydrodynamic conditions, as well as to test the effect of the Plant operation on the navigation safety

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The study comprised field investigations, data collection, and bathymetric survey. A physical model was proposed as the best tool to have a direct insight of the flow phenomena under consideration. The suggested model scale was 1:30-1:40. Dye tracer would be supplied to the

cooling water with the aim of observing the advection and spreading of the cooling water by photographic and video methods.

The dilution of the cooling water and the vertical temperature profile are to be measured at various locations in the plume. The optimal hydraulic dimensions of the intake and outfall structures to prevent swirls and pre-rotation are also to be determined**.**

31– Hydraulic Model Design of El-Kurimat Power Plant: Model Construction and Calibration

Consultant : HRI

Period : 2002 – 2003

In the context of power generation expansion, one 630 MW steam unit and one 750 MW combined cycle unit are to be added to El-Kurimat Power Plant. The main objective of the study was to develop a clear understanding of the River morphology and flow distribution in the vicinity of the existing intakes and proposed future-units intake. Also, the study aimed at determining a comprehensive solution to the sedimentation problem at the existing intake structure as well as to examine the hydraulic possibility of constructing a new intake-pump house and discharge structure in order to serve the future expansion in the Power Plant.

The Delft-3D hydrodynamic model was employed. The total length of the modeled reach was 9,000 m and the average width was in the range of 1,000 m to 2,000 m. It included a distance of 1,200 m upstream El-Kurimat Island and 1,900 m downstream the outfall of the Power Plant. This total length is the most suitable length that does not affect both the quality of results and the time schedule.

32 – Talkha Power Plant: Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2002 – 2003

The main objective of the study was to check the possibility of constructing a new power unit in Talkha Power Plant and test the performance of the cooling systems and their impact on the River environment and operation.

The study comprised field investigations, data collection, and bathymetric survey. A hydraulic scale model was constructed to test the different scenarios of operating the cooling system. The model was scaled according to Froude similarity laws, with an undistorted geometrical scale of 1:40. The model represented 1.5 Km of Damietta Branch in front of the Power Plant. It consisted of three main parts: the entrance, the modeled reach of the River, and the exit.

The study results revealed that the performance of the cooling system is acceptable with

respect to most of the River conditions and normal operational modes during the winter period, except for cases, in which the River discharge is less than 60 m^3/s. It was also recommended to construct a separate model with relatively larger scale to have a direct insight of inflow characteristics, vortex preventing, and intake detailed design. This will help in securing a satisfactory operation of the pumps in the prototype.

33 – Kurimat Power Plant: Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2003 – 2004

The main objective of the study was to test the performance of the cooling systems and their impact on the River environment and operation.

A physical model with an undistorted geometrical scale of 1:50 was constructed to get better understanding of the phenomenon. The model represented 2.5 Km of the River Nile in front of the Power Plant. It consisted of three main parts: the entrance; the modeled reach of the river; and the exit.

Based on the model results, it was recommended to construct a submerged sill and bottom vanes in front of the outfall structures. In addition, dredging and riprap protection in the vicinity of the outfall structures are highly recommended.

34– Hydrographic Survey of New El-Nubaria Power Plant

Consultant : HRI

Period : 2003 – 2004

The main objective of the study was to evaluate and test the cooling system of the intake and outlet structures for the third unit.

The hydrographic survey involved 3 Km of El-Nassery Canal and 4 Km of El-Nubaria Canal. Field measurements were executed, including the collection of bed samples.

The contour map of the study area was then drawn so that to be used in setting the planned physical model.

35– Ameliorating the Carrying Capacity of El-Zomor Canal

Consultant : HRI

Period : 2003 – 2004

The main objective of the study was to improve El-Zomor Canal from its intake up to its outlet. Also, the study aimed at investigating the possibility of providing water to El-Zomor Canal from El-Nassery Canal.

A mathematical model "SOBEK1-D" was used to examine the hydraulic efficiency of the canal, in the context of constructing a new pump station on El-Nassery Canal with a capacity of 7 m^3/s.

The results revealed that the Canal could not accommodate the design discharge in the period of maximum demand. It was strongly recommended to raise the bank level downstream the proposed pump station with a total cost of 1,600,000 Egyptian Pounds.

36– Investigating the Location of El-Darb New Pump Station

Consultant : HRI

Period : 2003 – 2004

The main objective of the study was to determine the optimum hydraulic and economic location for the new pump station.

The study comprised field investigations, data collection, and bathymetric survey. A mathematical model (SOBEK-1-D) that represents 1,250 m from Al-Rannan Canal was used to predict the water levels and velocities in case of constructing the new pump station.

The study revealed that Al-Rannan Canal should be dredged to maintain the design water levels. Also, it was recommended to construct a protection layer at the outfall of the proposed pump station.

37– North Cairo Power Plant: Canal Morphology Desk Study & Experimental Model Design

Consultant : HRI

Period : 2004 – 2005

The main objective of the study was to investigate the morphological changes of EI-Ismailia Canal in order to:

- Find out, if the scour that occurred in the period between year 2001 and year 2004 is a temporary phenomenon or not; and
- Specify the protection works, if needed.

The study included the collection of field data that was used to construct a physical hydraulic model so that to get better understanding of the morphological behaviour in front of the Power Plant. The hydraulic model had a movable bed to accurately simulate the erosion and

sedimentation. The simulated area represented a reach of approximately 4 km of El-Ismailia Canal.

According to the model results it was strongly recommended to use a bed level of 9.2 m in the stability calculations of the proposed sheet pile for Module II.

38– El-Tebeen Power Plant: Field Survey and Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2004 – 2005

The main objective of the study was to test the environmental effect of constructing the New Tebeen Power Plant and to test the performance of the cooling systems and their impact on the river environment and operation.

The study comprised field investigations, data collection, and bathymetric survey. An undistorted physical model with a scale of 1:50 was constructed to easily inspect the cooling system performance. The model represented 2 Km of the River Nile in front of the Power Plant. It consists of three main parts: the entrance, the modeled reach of the River, and the exit.

The study revealed that both the intake and outfall structures work safely under the different hydraulic conditions.

39– West Cairo Power Plant Field Investigation

Consultant : HRI

Period : 2004 – 2005

The main objective of the study was to obtain the stability of the River bed and banks at the Plant site.

The study comprised field investigations, data collection, and bathymetric survey that covered a reach of 5 Km (2 Km upstream the Power Plant intake and 3 Km downstream of it).
The results showed that the water surface slope is 3 cm/Km in average and the average water velocities vary between 0.14 m/s and 1.05 m/s.

40– El-Kurimat Power Plant Hydrographic Survey

Consultant : HRI

Period : 2004 – 2005

The main objective of the study was to obtain the stability of the River bed and banks at the plant site.

The study comprised field investigations, data collection, and bathymetric survey that covered a reach of 3 km.
The study revealed that there is no change in the bed profile at the western branch of El-Kurimat Island. Moreover, the bed levels downstream the small island were lowered by 1.25 m along a distance of 100 m beside the eastern bank.

41 – El-Nubaria Power Plant Field Investigations

Consultant : HRI

Period : 2004 – 2005

The aim of this survey was to obtain a recent view of the River bed and banks' levels of to be used for the physical model that to be constructed.

The hydrographic survey involved 2.85 Km of El-Nassery Canal and 3.4 Km of El-Nubaria Canal. Field measurements were executed, including the collection of bed samples.

The contour map of the study area was then drawn so that to be used in setting the planned physical model.

42 – New Dammietta Hydropower Plant: Proposal for the Hydraulic Model Investigation

Consultant : HRI

Period : 2004 – 2005

The purpose of this hydraulic model investigation was to address the main aspects of optimizing the flow conditions in the vicinity of the powerhouse inlet structure and confirming the general arrangements of the River bed protection works.

The bathymetric survey would cover 100 m upstream Dammietta Barrage and 1,200 m downstream it. A physical model with a scale of 1:20 that represents Dammietta Barrages and the hydropower structures is to be constructed.

It was recommended to perform the study in a period of 7 months, of which one month is dedicated to the hydrographic survey.

43– El-Kurimat Power Plant Hydrographic Survey

Consultant : HRI

Period : 2005– 2006

The main objective of the study was to obtain the stability of the River bed and banks at the Plant site and compute the required dredging volume.

The study comprised field investigations, data collection, and bathymetric survey that covered a reach of 5 km.
The survey revealed that the dredging works at the Power Plant site has to be carried out on two stages. The first stage covers the part at the eastern branch of the small Island. The calculated dredging volume was 167,155 m^3.

The second stage covers the part in front of the intake, in which the calculated dredging volume was 5,710 m^3.

44– AL-Atf Power Plant Hydrothermal and Morphological Modeling (Proposal)

Consultant : HRI

Period : 2005-2006

The purpose of the hydraulic model investigation was to obtain the local dilution and dispersion behavior of the hot water at the near field for different configurations of the outfall structures and different hydrodynamic conditions, as well as the effect of the Plant operation on the safety of navigation.

The study comprised field investigations, data collection, and bathymetric survey. An undistorted physical model with a scale of 1:50 is to be constructed to easily inspect the cooling system performance. The model represents 2 Km of the River Nile in front of the Power Plant. It consists of three main parts: the entrance, the modeled reach of the River, and the exit.

Based on the survey and in order to meet the objectives of the study, the required test program includes 16 physical model tests. These tests will cover all River conditions as well as all operation modes of the Power Plant. HRI will combine the tests of the two models as the water temperature affects the sediment transport phenomena.

45 – El-Nubaria Power Plant: Module III 750 MW Combined Cycle Project (Proposal)

Consultant : HRI

Period : 2005-2006

The purpose of this study was to conduct water sampling and analysis of El-Nassery Canal, Behaira Governorate at the location where the intake structure of El-Nubaria Power Plant III

project is proposed (100 m upstream of Abdel Hady Rady Barrage on El-Nassery Canal).

Water samples will be collected from each site using auto samplers in more than one polyethylene container with a capacity of 1 Litre. These containers were washed first with tap water and then by distilled water. Water samples are to be measured immediately for temperature, Dissolved Oxygen (DO), pH, and Electrical Conductivity (EC) using the multi-probe system and model Hydrolab-Surveyor.

46– El-Tebbin Power Plant Cooling System Investigation: Model Construction and Calibration

Consultant : HRI

Period : 2005-2006

The main objective of the study was to test the performance of the cooling systems and their impact on the River environment and operation.
A physical model with a scale of 1:20 that represents 2.5 km of the River Nile in front of the Power Plant was constructed to get more insight the phenomenon under consideration. The model has a movable bed from plastic 5 cm deep. According to the hydrographic and topographic survey, which was performed in 2005, the global coordinates of different cross sections are known. These cross sections were then scaled down to the model dimensions and placed at their proper coordinates in the research hall of the HRI.
The model then was calibrated by controlling the discharge, water surface slope, and flow velocity measurements**.**

47– El-Nubaria Power Plant (Module III): Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2005-2006

The main objective of the study was to test the performance of the cooling systems and their impact on the canal environment and operation. Moreover, the following goals were of a major concern:

- Assess the performance of the power plant cooling system under different operational modes and canal conditions;
- Environmental impact assessment; and
- Ensure navigation safety.

A physical model with an undistorted geometrical scale of 1:40 was constructed to examine the possible alternatives for operating the Power Plant. The model represented 2.5 Km of El-Nubaria Canal in front of the Power Plant and 2.5 Km of El-Nassery Canal. It consisted of

three main parts: two entrances, one for El-Nubaria Canal and the other for El-Nassery Canal, two modeled reaches of El-Nubaria and El-Nassrry Canal, and the exit.

The results revealed that by increasing the discharge flow in the winter period to be 46 m^3/s in El-Nassery Canal and keeping the discharge flow in El-Nubaria Canal at 70 m^3/s and by tilting the outfall structure to be 30º to the main flow direction of El-Nubaria Canal the dilution process was improved and produced a temperature rise above the ambient less than the permissible.

48– El-Tebbin Power Plant: Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2005-2006

The main objective of the study was to test the performance of the cooling systems and their impact on the River environment and operation.
A physical model with a scale of 1:20 that represents 2.5 km of the River Nile in front of the Power Plant was constructed to get more insight the phenomenon under consideration.

The study revealed the following:

- The cooling water discharge ranges between 0.54 and 5.68% of the River flow during minimum and maximum River flow, respectively
- No warm water recirculation was recorded in the vicinity of the intake structures, i.e., the system works efficiently when the plant was in operation.
- The width of the mixing zone in the area surrounding the outfall structure of the two power units did not exceed one fifth of the River width. The mixing zone width decreases with the increase of the River flow.
- The proposed intake structure is sufficient for the required discharge for the cooling system.

49- El-Nubaria Power Plant (III): Hydrothermal and Morphological Modeling of El-Nubaria Canal after Dredging

Consultant : HRI

Period : 2005-2006

The main objective of the study was to investigate the effect of the new canal cross sections on the performance of the cooling system and the stability of the cooling system's structures. The study aimed at investigating the following aspects:

- Perform a hydrothermal study to check the performance of the cooling system from the environmental and operational points of view. Emphasis will be placed on the low flow period.

- Perform a morphological study to check the bed load deformation within the cooling system vicinity in order to get the required data to check the stability of the cooling system structures including the stability of the sheet piles.

- Perform a sensitivity analysis to account for emergency, i.e. drop of surface water level due to unexpected discharges out of the canal in the cooling system vicinity.

An undistorted scale of 1:40 was used to construct the physical model required for the study. To obtain a movable bed type, a light PVC material was used to cover the model bed in the vicinity of the cooling system. Before dredging, the dominant bed level of El-Nubaria Canal in the vicinity of the Power Plant was + 5.0 m above MSL. After dredging the Canal bed level is + 4 m above MSL with longitudinal slope of 8cm/km.

The model results revealed that the system is safe from the operational point of view in all the Canal flow conditions as there is no recirculation of the heated water from the discharge structures to the intake structure. Also, the results showed that the bottom vanes work properly. It was recommended to redesign the cooling system to improve the dilution of the thermal plume in the low flow period. The recommended solutions were as follows:

- Change the width of the outfall of module III to 7.5 m instead of 10.5 m.
- Add a wing wall to the outfall of module III to direct the heated water plume parallel to the shore line of El-Nubaria Canal.
- Create an approach channel adjacent to the outfall of module III with 50 m X 30 m.
- Change the orientation of the outfall of module III from 30º to 20º to the main flow direction.

50- Kurimat Power Plant New 750 MW Combined Cycle Unit: Proposal for a Hydraulic Model Study of the Intake Structure

Consultant : HRI

Period : 2005-2006

The main objectives of the physical hydraulic model study for the pump intake structure were as follows:

- Test the proposed pump intake design and develop modifications, if needed, to arrive at flow condition, at which the pumps are free from unacceptable flow conditions caused by vortices, pre-rotation, and high non-uniform velocity distribution.

- Identify low velocity zones, through visualization technique such as dye, near the bottom of the intake especially near traveling screen area that may be conducive to the

deposition of suspended sediments.

A reach of approximately 200 m x 45 m of the Nile River at the intake vicinity will be modelled to simulate the approach flow condition. The River model will be formed from cement-sand mortar, while the water intake model will be constructed from wood and plexiglass to permit flow visualization. The sill and the bottom vanes will be represented in the model, as well as the effect of the proposed groins in the approach flow to the intake. All pumps will be modeled as well as the complete pump sump.

The test program will include baseline investigation, then if the results do not meet the criteria, modification shall be executed and further test are to be performed.

51- El-Kurimat Power Plant: Hydrothermal Modeling of the Cooling System

Consultant : HRI

Period : 2005-2006

The main objective of the study was to examine and evaluate the effect of the new proposed location of El-Kurimat III Power Plant on the River environment, the **following goals were** of a major concern:

- Provide a clear understanding of the performance of the cooling systems and the flow distribution in the vicinity of the new proposed outfall units.
- Investigate the impact of the cooling system of the new power unit on the River conditions under different operational modes.
- Ensure navigation safety.

To achieve these goals, a hydrodynamic mathematical model "DELFT 3D" was employed. The size of the grid was 1 m x 2 m within the intake and outfall structures vicinity. Grids of 20 m x 20 m, 10 m x 30 m and 13 m x 23 m were used apart from the area of influence of both the intake and outfall structures.

The model results revealed that the cooling water discharges range from 2.6% to 14.8 % of the River flow during the minimum and the maximum supply periods respectively. The width of the mixing zone in the area surrounding the outfall structures of unit III is very small and does not block the entire width of the River. Also, the results showed that the operation of both outfalls don not affect the safety of navigation, as the cross flow velocity never exceeds the critical value of 0.3 m/s.

52– New El-Ain Sokhna Coal Fire Power Plant Hydraulic Investigation (Proposal)

Consultant : HRI

Period : 2006-2007

The objectives of the study are to:

- Investigate the cooling cycle of the existing intake and outfall;
- Determine the sedimentation regions;
- Determine the location of the new intake and outfall for the new Power Plant (600 MW);
- Determine the hot plume characteristics at different Sea conditions and different Plant operation scenarios for the existing and new power plants; and
- Modify the outfall design to prevent accumulation of the hot water and to fulfill the environmental requirements.

In order to achieve the abovementioned objectives, data collection, field investigations, and modeling are required. The extent of the survey area will cover the project area with a distance of 9 km alongshore. This distance covers the coastal region between the Container Terminal and the existing Power Plant, 3 km north of the Container Terminal and 3 km south of the existing Power Plant. Cross-shore profiles are to be surveyed with an interval of 100 m and the profile will extend 4 km or 20 m water depth relative to MSL whichever is closer. Intensive bathymetric survey around the existing intakes and outfalls will be implemented.

Numerical model simulations with shoreline model (Unibest) and 2-D hydrodynamic model using Delft 3D will be carried out. The two-dimensional model (Delft3D) is to investigate and satisfy the objectives of the Project. The data required for mathematical modeling studies including wave data, current data, recent bathymetric, topographic and hydrographic surveys and Admiralty charts. These data will be collected or measured as explained above.

53- Investigating the Implementation of New Combined Cycle Units to Sidi Krir Power Plant

Consultant : HRI

Period : 2006-2007

The objectives of this study were to determine:

- The sedimentation regions;
- The location of the new intake and outlet for the new module (250 MW steam unit); and
- The hot plume characteristics at different Sea conditions and different Plant operation scenarios for the existing and new module.

Also, the study aimed at modifying the outlet design to prevent accumulation of hot water and to fulfill the environmental requirements.

A numerical mode"Delft-3D" was used to investigate and satisfy the abovementioned objectives. A high grid resolution was applied in the area of the intake and outlet and a low resolution was implemented far away of the area of their influence. The grid cell size (25 m x

35 m) was fine inside the Power Plant area and the adjacent regions while it was course (80 m x 110 m) further away. The wave parameters such as radiation stresses, wave heights and others were interpolated by the model to the curvilinear grid. For hydrodynamic simulations, a wave height of 1 m coming from the northwest, as an averaged wave height for the region, was utilized.

The appropriate location for constructing the new unit should be as mentioned in scenario-C, in which the new intake is located at the right side of the existing intake of units 1&2 between contour depth of 11 m and 12 m, and the new outlet is located near to the existing outlet of units 1&2 at the right side between contour depth of 7 m and 8 m.

54- North Cairo Power Plant: Protection Works and Mathematical Model Study

Consultant : HRI

Period : 2006-2007

The study objectives were to:

- Suggest and design different alternatives for Riprap protection works in order to increase the stability of the sheet piles;
- Test the effect of the selected alternatives on the capacity of the canal by using a 1-D mathematical model' and
- Select the alternative, which has minimum affect on the capacity of the canal.

The study involved field investigations, data collection, and bathymetric surveys. One-dimensional hydrodynamic mathematical model "SOBEK", which includes the hydraulic characteristics of all the canals of the study area, was applied. Different scenarios and alternatives were tested and compared to select the most appropriate solutions.

The model results revealed the following:

- The total losses due to bottlenecks along the first reach are about 42 cm.
- The maximum discharge that could be carried in the existing conditions is 17.5 Mm^3/day.
- The velocity increased by 6.6% at the hydropower intake after adding the protection work.