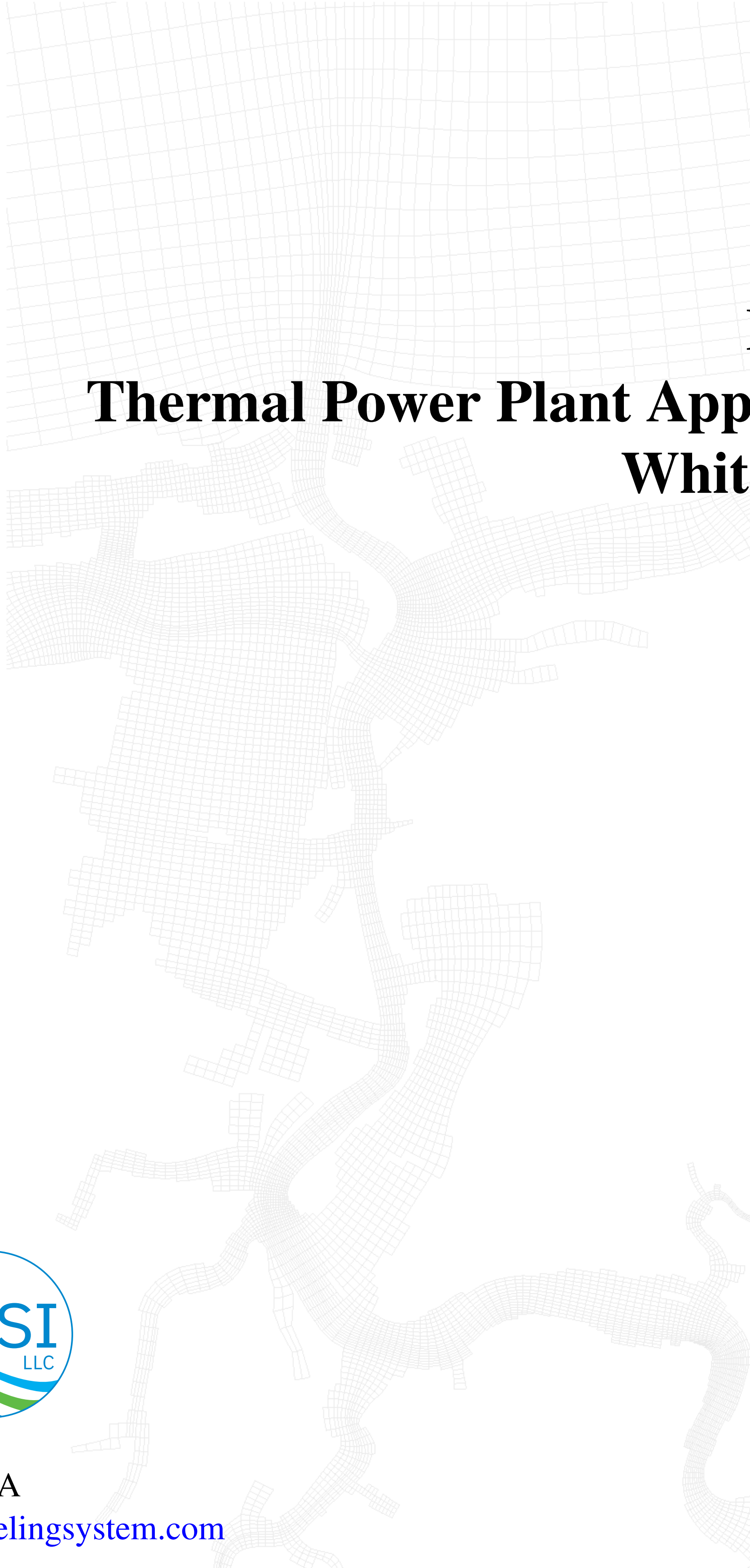

EFDC+
Thermal Power Plant Application
White Paper

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Abstract

Abstract will be done by July 8th.

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EFDC	Environmental Fluid Dynamics Code
EFDC+	Environmental Fluid Dynamics Code Plus

Chapter 1

Introduction

1.1. Background

1.2. Thermal Power Plant Cooling Water

Environmental Fluid Dynamics Code Plus (EFDC+) has features specifically designed for thermal simulation of a power plant's cooling systems. In Environmental Fluid Dynamics Code (EFDC)+, the cooling water withdrawal from a nearby river or lake and discharge from the plant are represented by the withdrawal and return boundaries. The user can add them by specifying the flow rate Q at the withdrawal and return cells (**?**).

Heat energy added to or removed from a receiving waterbody can be estimated using:

$$H_T = Q_c \rho c_p \Delta T \tag{1.1}$$

where,

H_{WR} is the rate of heat energy exchange due to temperature rise/fall (J/s),

Q_C is the withdrawal flow rate (m^2/s),

ρ is the water density (kg/m^3),

c_p is the specific heat of water ($c_p = 2400 J/kg/^{\circ}C$), and

ΔT is the temperature difference between the discharged water and the receiving water ($^{\circ}C$).

So, for any industrial process that uses once-through cooling water we can define the following:

Q_{cool} is the process water flow rate that is being pumped from the water body. The sign convention is positive for a standard withdrawal. The thermal sinks and sources H_T are specified in the transport equation for heat:

$$H_{intake} = -Q_{cool} \rho c_p T_1 \tag{1.2}$$

$$H_{discharge} = Q_{cool} \rho c_p (T_1 + \Delta T) \tag{1.3}$$

where,

H_{intake} is the heat removed from the withdrawal cell or intake,

$H_{discharge}$ is the heat added back to the water body at the power plant discharge location,

T_1 is the ambient intake temperature ($^{\circ}C$), and

ΔT is the temperature rise of a power plant.

1.3. Thermal Power Plant Forced Evaporation

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The Forced Evaporation (FE) Analysis capability has been developed to quantify increased evaporation induced by increased water temperatures due to releases from thermoelectric power plants. These power plants withdraw cooling waters, which once run through the plant and are returned to rivers or lakes at a higher temperature than the ambient water temperature. This higher temperature water causes additional evaporation (forced evaporation) from the waterbody. This additional evaporation is counted as water consumption by regulators as it is no longer available to downstream users.

Evaporation is dependent on wind speed, atmospheric humidity, and water temperature. There are a number of methods to compute FE using different wind functions as listed in Table **??**. Using these various evaporation methods, the model is first run with the power plant, and then run again without the power plant. EE then subtracts the output from two models and displays the difference which is the consumption of water from the power plant. Once temperature is activated and the correct Surface Heat Exchange option has been selected, the user can choose which evaporation approach is desired. Even if evaporative losses are not a major concern, the evaporative mass fluxes should normally be activated for most models.

EFDC/EFDC_Explorer Forced Evaporation (FE) toolset results have been compared to the Electric Power Research Institute's (EPRI) FE estimates. EPRI's once through cooling FE analysis for river discharges is based on a USGS report on water consumption by thermoelectric power plants (**??**).

References