Development of Rainfall-Discharge Model for Future NPP candidate Site

An, Ji-hong [*], Eric Yee
KEPCO International Nuclear Graduate School (KINGS), 658-91 Haemaji-ro, Seosaeng-myeon, Ulju-gun, 689-882Republic of Korea
[*]*Corresponding author: anijihong@gmail.com*

1. Introduction

Sitting a nuclear power plant (NPP) requires safety analyses that include the effects of extreme events such as flooding or earthquake. Especially, the safety of nuclear power plants can be seriously affected by flooding, both for sites on rivers and for sites on the sea coast as happened in the Fort Calhoun nuclear power station case which leaded to cold shutdown in 2011. In light of South Korean government's 15-year power supply plan that calls for the construction of new nuclear power station in Yeongdeok, it becomes more important to site new station in a safe area from flooding. Because flooding or flooding related accidents mostly happen due to extremely intense rainfall, it is necessary to find out the relationship between rainfall and run-off by setting up feasible model to figure out the peak flow of the river around nuclear related facilities. By this study, most suitable model for future nuclear power plant site in Yeongdeok to be used to predict peak amount of riverine flooding was developed by examining historical rainfall and discharge data from the nearest gage station which is Jodong water level gage station in Taehwa basin.

2. Methodology and Results

Steps and procedures taken for this study are described as below.

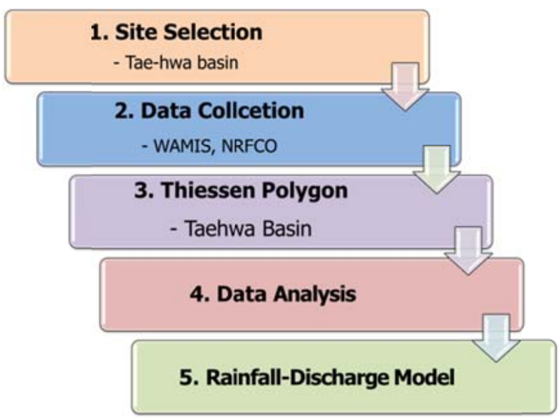


Fig. 1. Steps and Procedures for the Study

2.1 Site Selection

For precipitation-discharge flow analysis, the Taehwa catchment has chosen because it is located in the vicinity of the future Yeongdeok nuclear power station and the rainfall event in this basin is ruled by only one rainfall gage station (Ulsan station) and not influenced by other neighboring stations which is considered to have uniform rainfall distribution.

Fig. 2. Location of New NPP site and Taehwa basin

The 660.86 ㎢ of Tae-hwa catchment area was delineated into six sub-basin which is Taehwa River, Dongcheon, Samho, Sayeon, Daeam dam and Jodong.

Table I: Characteristics of 6 Taehwa sub-basins

Sub-basin	Name	Area (㎢)	Watershed Length (km)
1	Taehwa River	66.19	15.23
2	Dongcheon	172.48	28.46
3	Samho Gage	89.25	13.13
4	Sayon Dam	124.35	20.06
5	Daeam Dam	70.2	15.76
6	Jodong Gage	138.39	21.63
6 EA		660.86	

2.2 Data Collection

Maps of the Taehwa basin and its six individual sub-basin boundaries along with its basic geographical characteristics were initially obtained from the WAMIS (Water Resources Management Information System) homepage operated by Ministry of Land, Infrastructure and Transport of Korea. Hourly precipitation data ranged from 2010 to 2015 at Ulsan station located inside the Taehwa basin were subjected to statistical analysis. Also, Taehwa river discharge measurements were collected from NRFCO (Nakdong River Flood Control Office) for the same period.

2.3 Composition of Thiessen Polygon

In order to assign weight at each gauge station in proportion to the catchment area that is closest to that gauge, Thiesssen polygons were composed and investigated. However, because whole Taehwa basin is in the influence of Ulsan station only without being affected by other neighboring stations such as Pohang, Yeongcheon, only precipitation data from Ulsan station were took into consideration for further flood analysis.

Fig. 2. Thiessen Polygon for the Taehwa basin

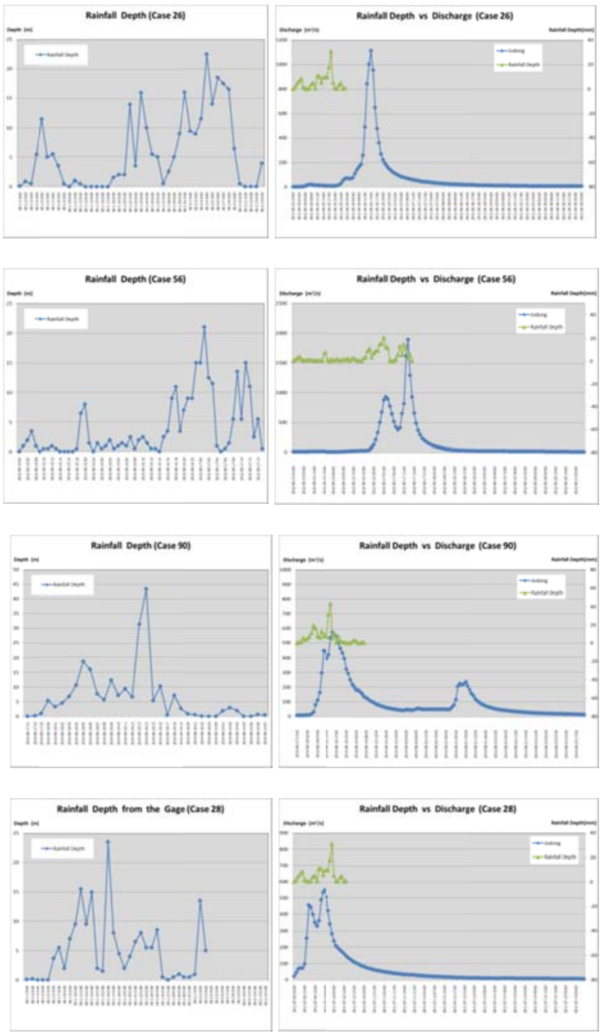
2.4 Data Analysis

All the collected precipitation records and discharge values with one hour interval were classified into 100 rainfall events. 5 events recorded largest amount of cumulative rainfall out of 100 from 2010 to 2014 in selected basin were shown in the table below.

Table II: Largest 5 rainfall events

No.	Case No.	Start	Finish	Rainfall Depth (mm)	Average Intensity (mm/hr)	Flow (m3/s)
1	26	2011-06-24 23	2011-06-26 20	258	5.61	1113.37
2	56	2012-09-15 05	2012-09-17 15	237	4.02	1996.7
3	90	2014-08-17 22	2014-08-19 07	184	5.41	606.29
4	28	2011-07-09 00	2011-07-10 09	170.09	5	556.12
5	9	2010-07-10 22	2010-07-11 23	154.5	5.94	359.56

By matching the individual rainfall cases to its actual discharge data from Jo-dong station, hydrological characteristics such as hyetograph, discharge flow including peak value, and lag time were identified as below.



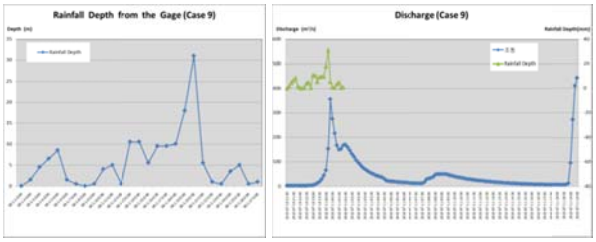


Fig. 3. Individual Rainfall vs discharge analysis

In order to figure out the most feasible precipitation vs run-off equation, all discharge measurement was plotted and analyzed by using regression model as illustrated below.

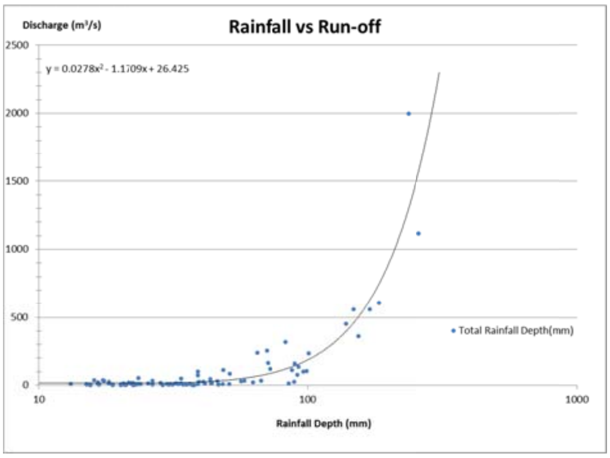


Fig. 3. Rainfall vs discharge relation

3. Conclusion

Because flooding is one of the most essential factor to site new nuclear power plant, and in order to estimate maximum magnitude of flooding, actual historical records of rainfall and discharge was used to find out their relationship in the selected area. By examining and comparing those data, the peak flow in the study catchment is estimated by

$$Q_p = 0.0278\,P^2 - 1.11709\,P + 26.425$$

Where Q_p is the peak discharge in m^3/s and P is cumulative depth of rainfall event in *mm*. This model gives the simplest way to figure out the maximum flow by different depth of rainfall event for the Taehwa basin and also can be used for Yeongdeok which is one of the new nuclear power plant candidate site.

4. Reference

[1] IAEA Safety Standards Series, Flood Hazard for Nuclear Power Plants on Coastal and River Sites, Safety Guide No. NS-G-3.5, p.5, 2003

5. Acknowledgements

This research was supported by 2015 Research Fund of the KEPCO International Nuclear Graduate School (KINGS), Republic of Korea.