Strengthening the Scientific Foundation of Water Quality Programs

Project Number: **LIFE08 ENV /CY / 000460**

Deliverable Number: **D5.1 & 5.2**

Deliverable Name: **Future Meteorological/hydrological Scenarios & Model results for the selected scenarios**

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other program participants (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including Commission Services)	

Contents

Abbreviations:

ACC	Atlantis Consulting Cyprus
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
WDM	Weather Data Management
HSPF	Hydrologic Simulation Program FORTRAN. It is the main hydrology and water quality modelling module of the BASINS system.
WDD	Water Development Department
BOD	Biochemical oxygen demand
DO	Dissolved oxygen
PO_4	Phosphate
NO_2-NO_3	Nitrates
NH_3-NH_4	Total ammonium

1. INTRODUCTION

The aim of this action concerns the modelling of the Kalo Horio Catchment for a future meteorological scenario based on climate change in 2020, and a future hydrological scenario. For this purpose BASINS modelling system software and associated models Aquatox and HSPF (Bicknell et al., 1997, 2000; Donigian et al., 1995), have been used. The results include calculations of pollutant loads and associated water quality impacts for five parameters namely NO_2-NO_3, NH_3-NH_4, Orthophosphate, BOD and F. Coliform.

Lastly the two scenarios will be compared in between them to export conclusions about the pollutant loads concentrations and with the acceptable limits of pollutant loads.

2. METHODOLOGY

2.1 Future Meteorological Scenario

This scenario is about to forecast a future situation in the understudy area. Specifically, we examine the pollutants loads concentration in the salt lake with the assumption that climate conditions changes. Meteorology is the driving factor for the simulation models as it determines the volume and spatial distribution of water flow and water depth in the channels and salt lake.

For this future meteorological scenario the data were derived by downscaling Global Weather Model Results which are based on the moderate global climate change scenario and are valid for the Larnaca Airport Meteorological Station which is located within 1km from the Salt lakes. The results were downscaled by use of the PRECIS model which is widely accepted and used for such application at international level includes the following. The below parameters have been determined for the period 1950 – 2099:

- Precipitation
- Potential evaporation (mm/day),
- Evaporation from canopy (mm/day)
- Evaporation from soil (mm/day)
- Air Temperature
- Wind speed (m/s)
- Due point Temperature
- Solar Radiation
- Total cloud fraction

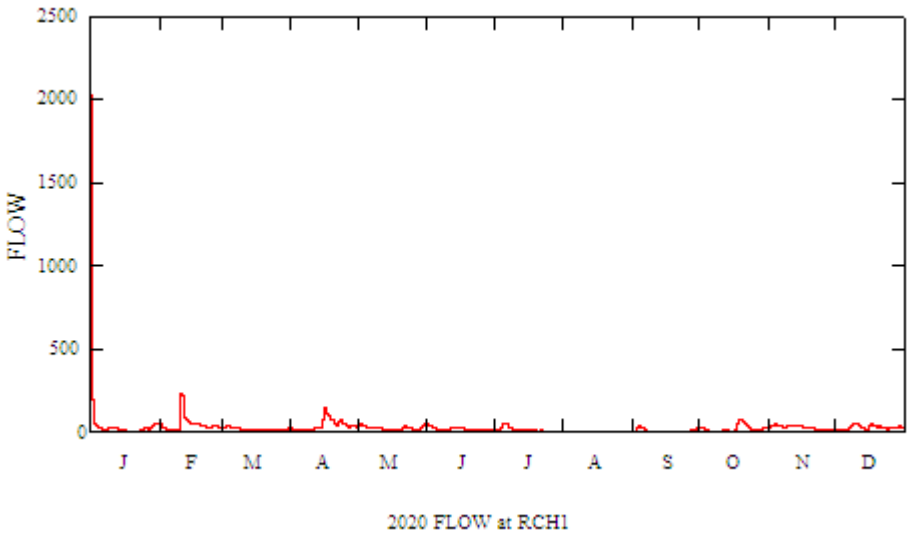
- Total downward surface SW flux (W/m

Afterwards the exported results from PRECIS model are to be run on the BASINS model for the reference years 2009 and 2020. The 2009 reference year will be applied in order to compare and determine variations between the 2009 simulation results derived with observed meteorology and results derived with the simulated meteorology. This comparison will facilitate the interpretation and analysis of the 2020 results.

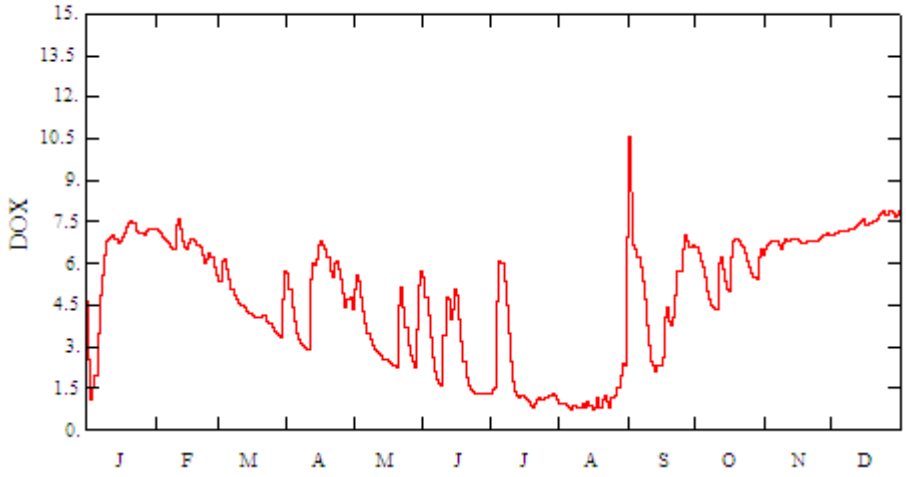
In detail, we gather information for the whole length of the year 2020 in order to observe the concentration of the pollutants load for each month separately. The results concern our sub-catchment from 'Reach 1' until 'Reach 11' (figure 10a) as depicted in the model simulation, where a 'Reach' is the term used for the streams that are included in the model. The 'Reach' 4,7,8 represents the streams, which constitutes the main sources of water runoff to the salt lake. 'Reach' 6 represents the salt marshes.

The results are illustrated in the graphs below and show the future case scenario that includes the following constituents:

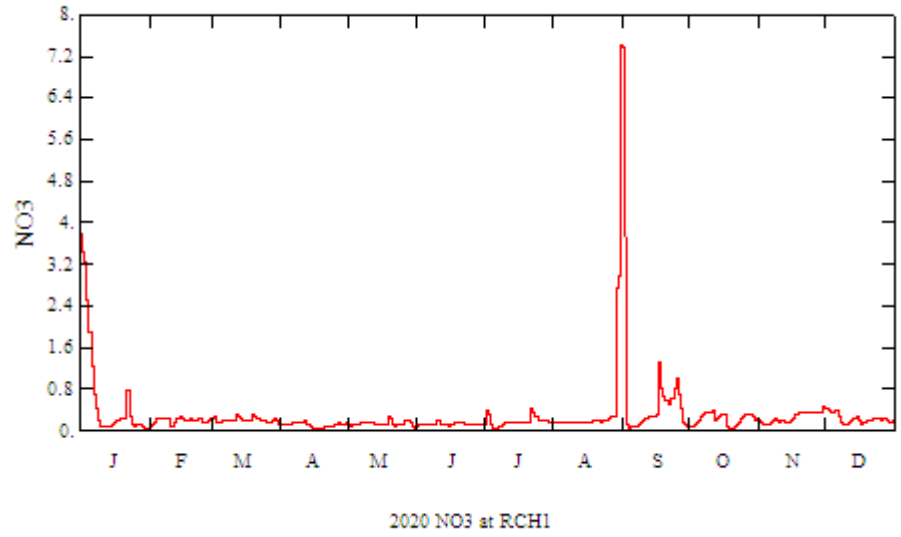
- Flow
- BOD
- DO (Dissolved Oxygen)
- Ammonia (TAM)
- Nitrite-Nitrate as Nitrogen (NO_3)
- Orthophosphate as Phosphorus(PO_4)
- F. Coliform



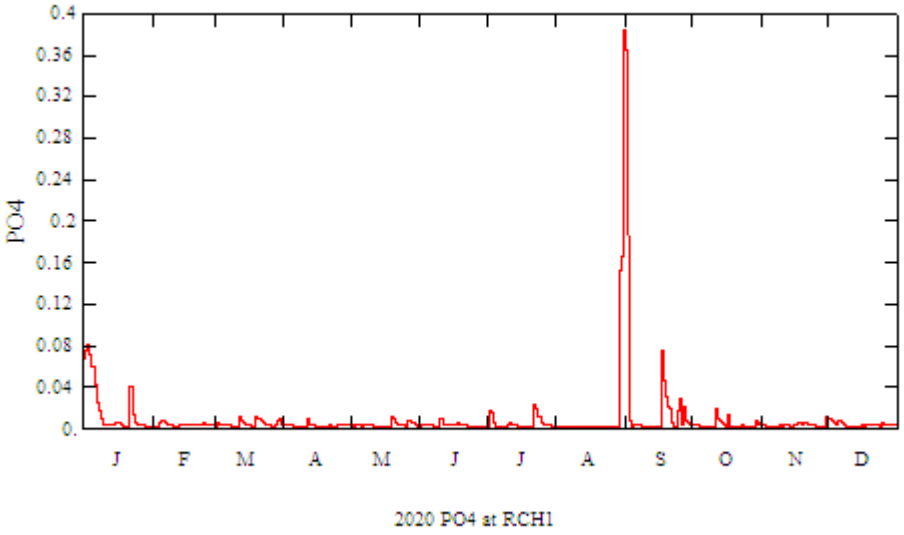
Graph 1: Model simulation result for Flow in 2020 (m3/hour)



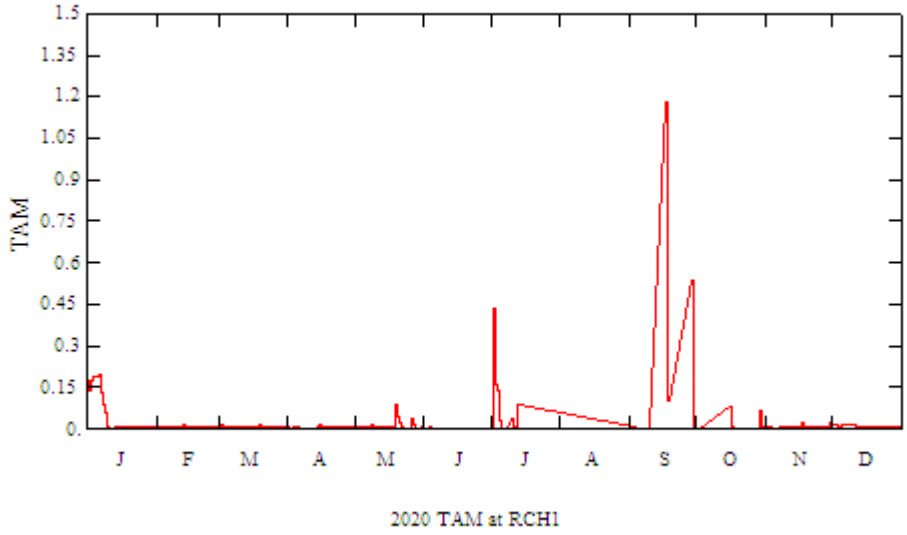
Graph 2: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



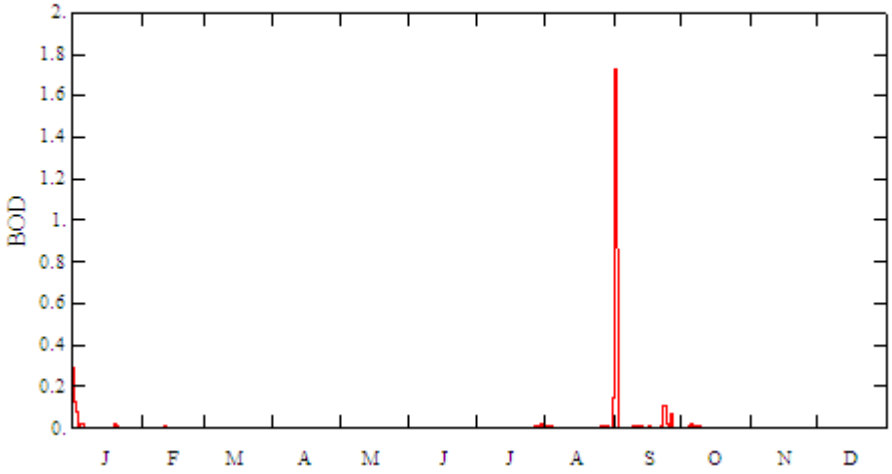
Graph 3: Model simulation result for NO3 in 2020 (mg/L)



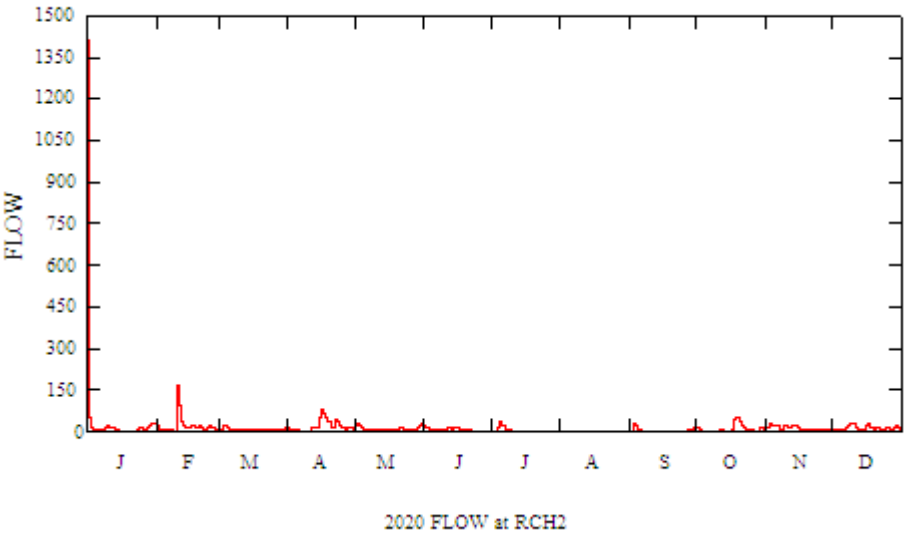
Graph 4: Model simulation result for PO4 in 2020 (mg/L)



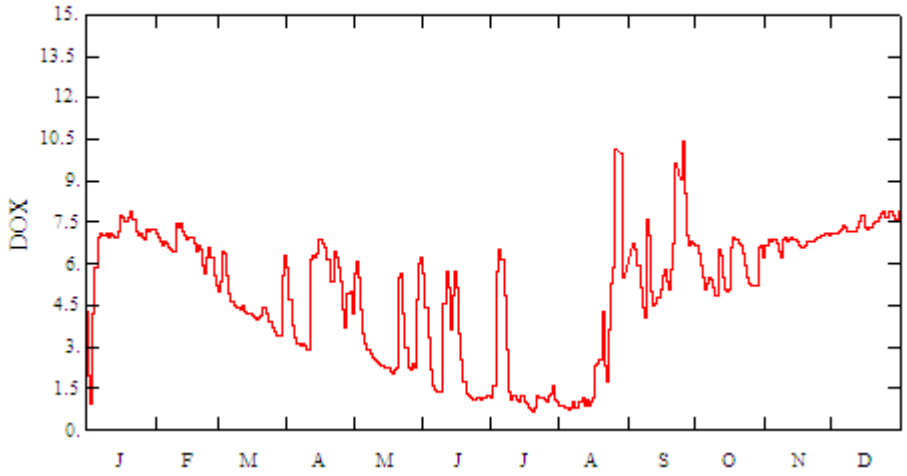
Graph 5: Model simulation result for NH3 in 2020 (mg/L)



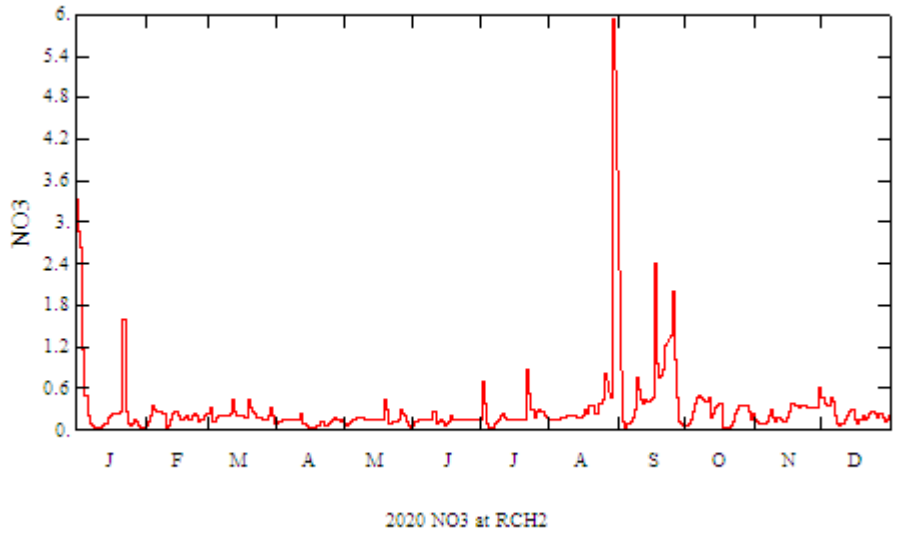
Graph 6: Model simulation result for BOD in 2020 (mg/L)



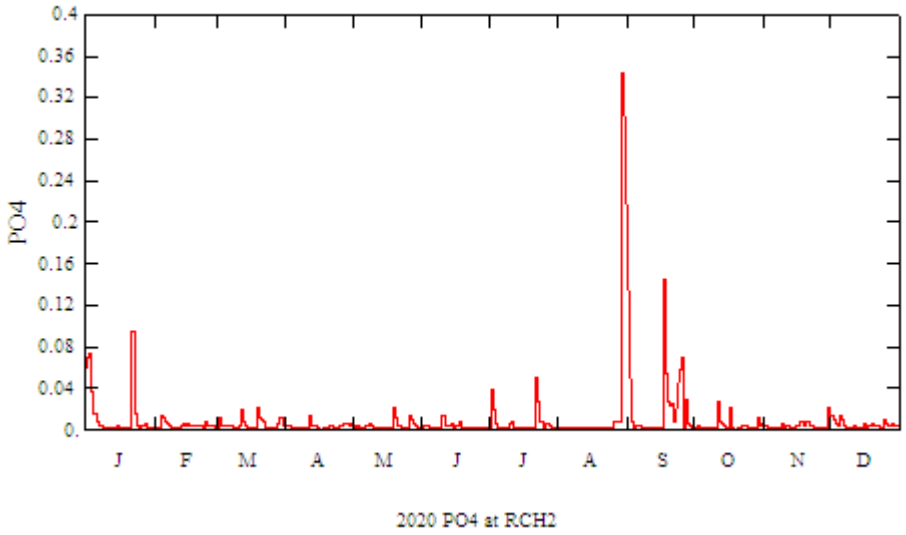
Graph 7: Model simulation result for Flow in 2020 (m3/hour)



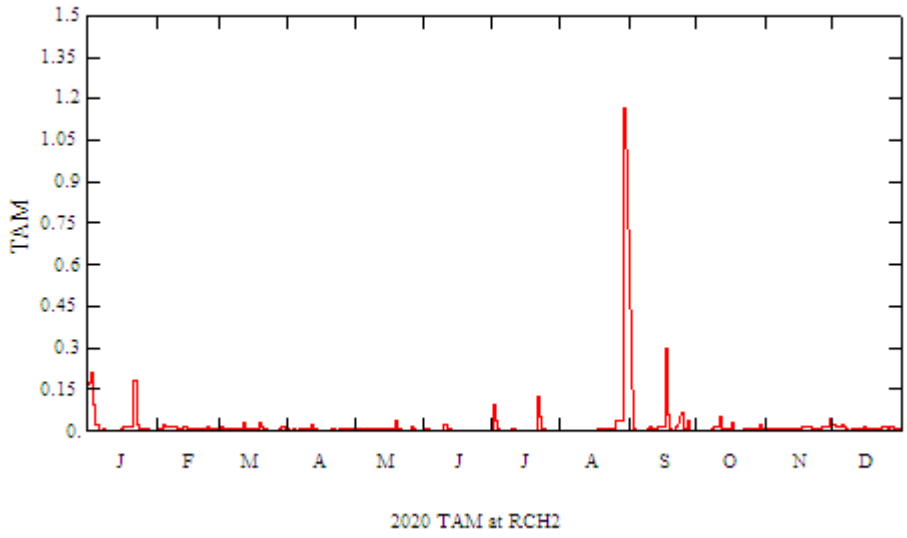
Graph 8: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



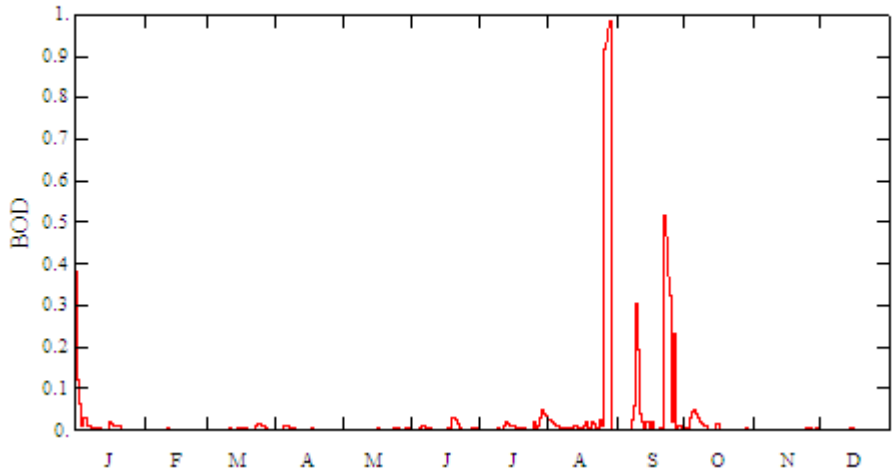
Graph 9: Model simulation result for NO3 in 2020 (mg/L)



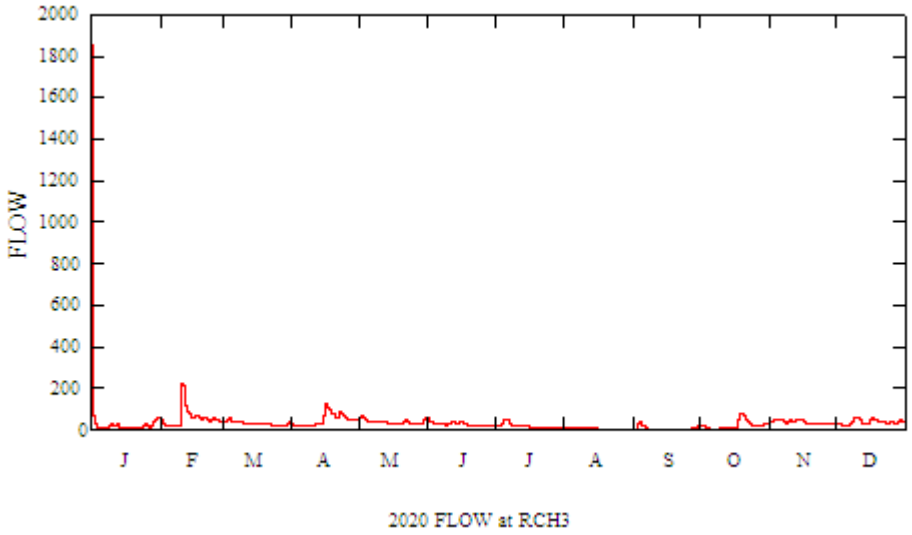
Graph 10: Model simulation result for PO4 in 2020 (mg/L)



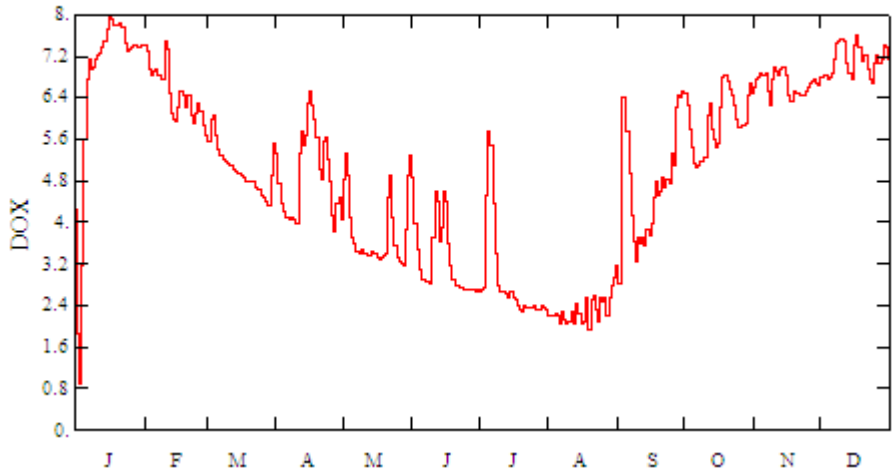
Graph 11: Model simulation result for NH3 in 2020 (mg/L)



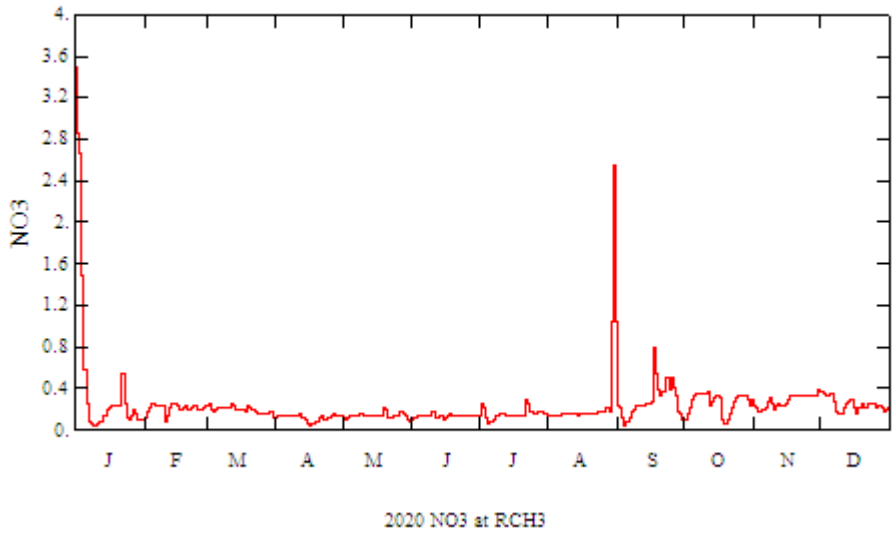
Graph 12: Model simulation result for BOD in 2020 (mg/L)



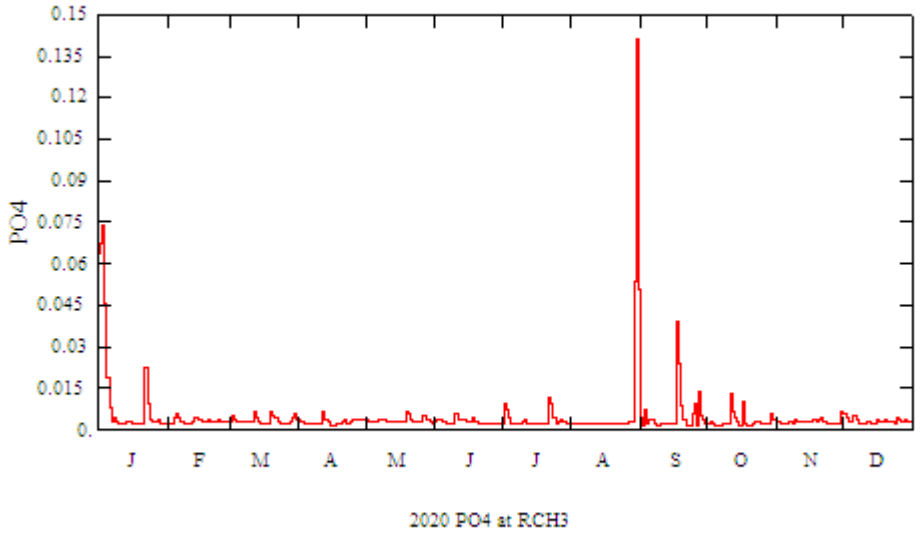
Graph 13: Model simulation result for Flow in 2020 (m3/hour)



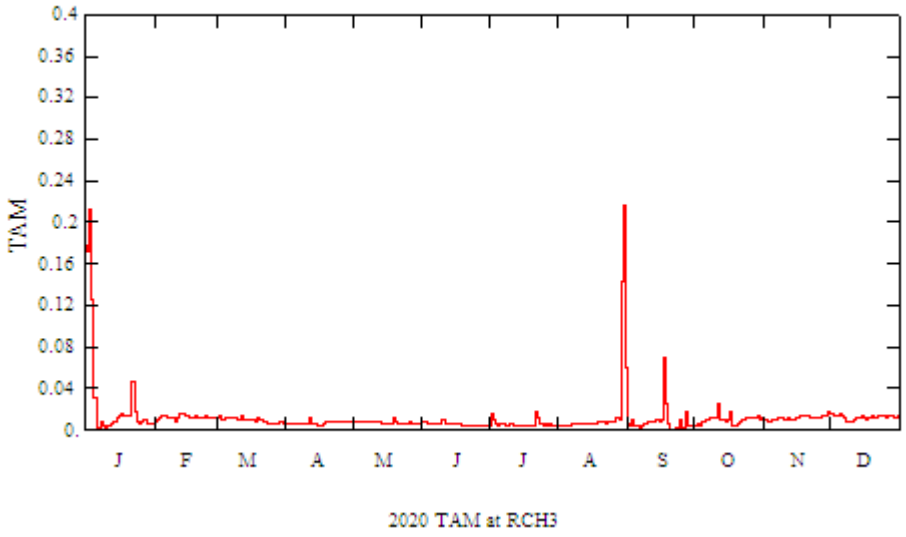
Graph 14: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



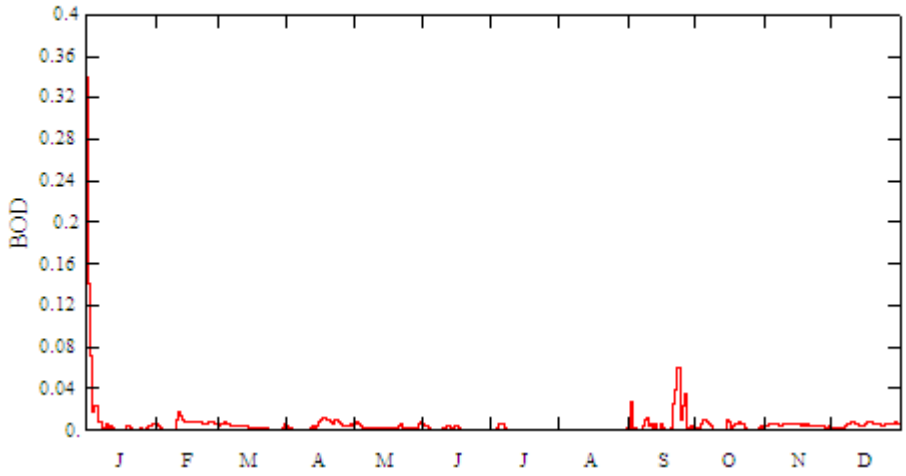
Graph 15: Model simulation result for NO3 in 2020 (mg/L)



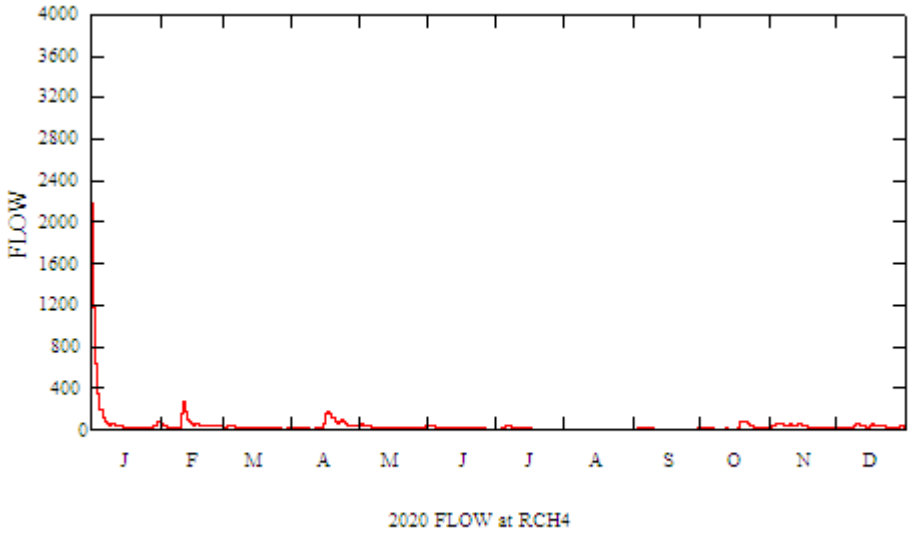
Graph 16: Model simulation result for PO4 in 2020 (mg/L)



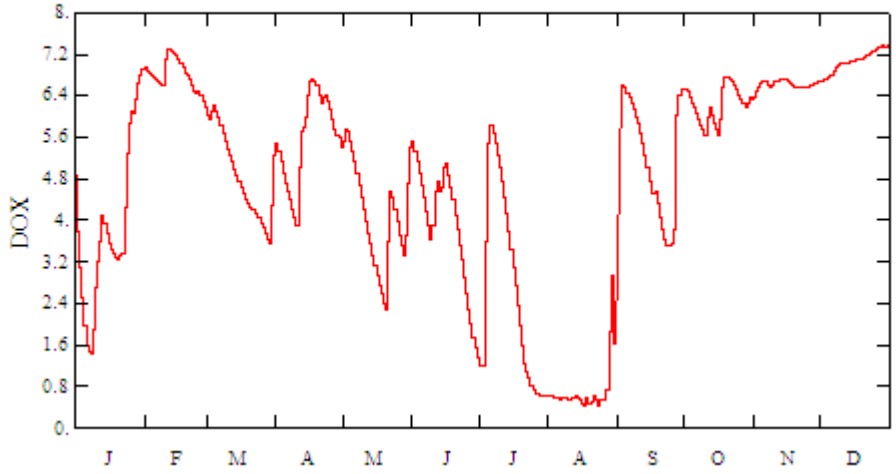
Graph 17: Model simulation result for NH3 in 2020 (mg/L)



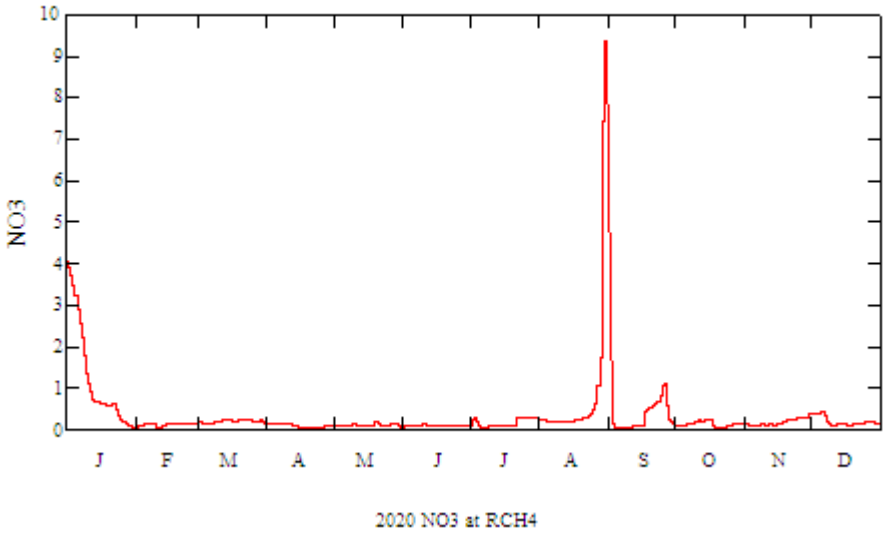
Graph 18: Model simulation result for BOD in 2020 (mg/L)



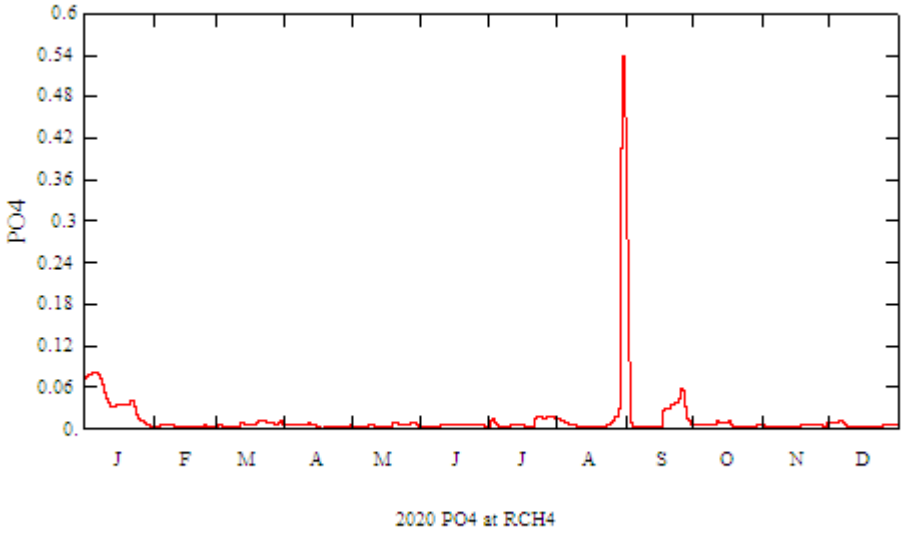
Graph 19: Model simulation result for Flow in 2020 (m3/hour)



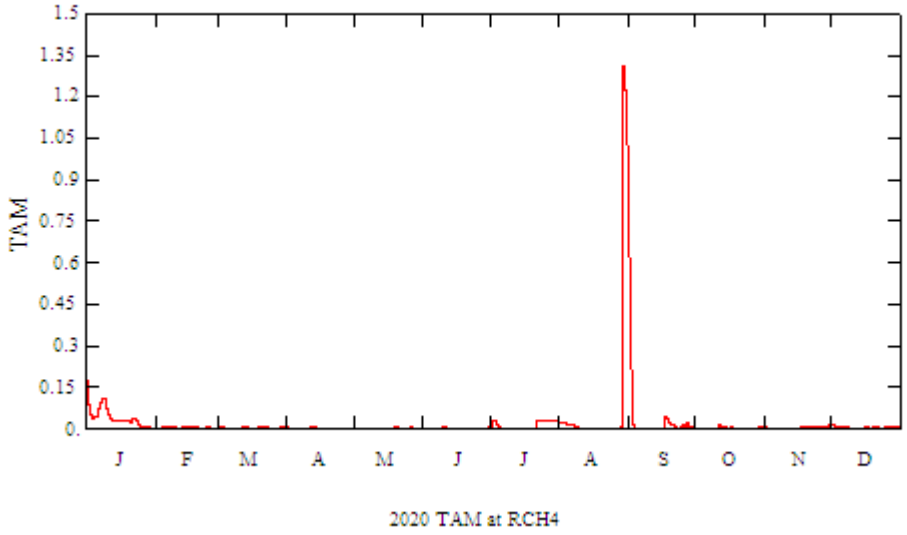
Graph 20: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



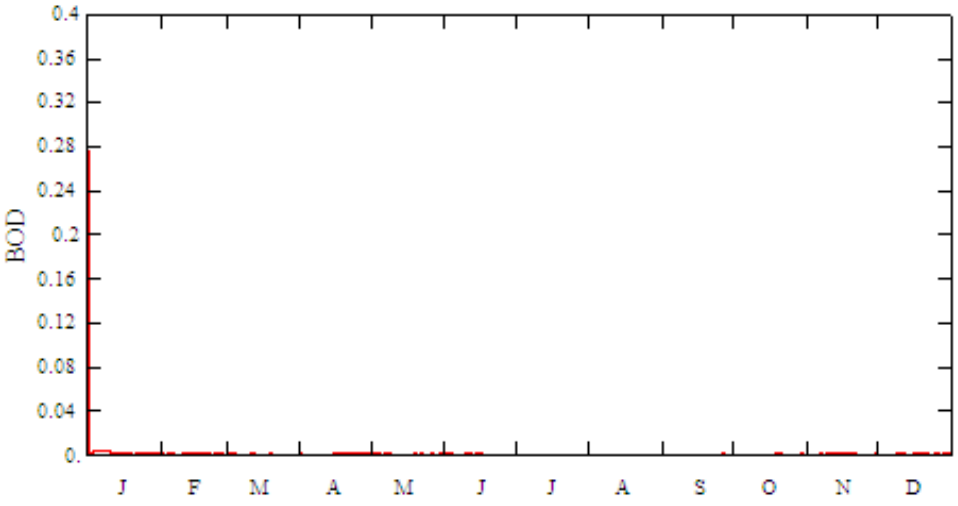
Graph 21: Model simulation result for NO3 in 2020 (mg/L)



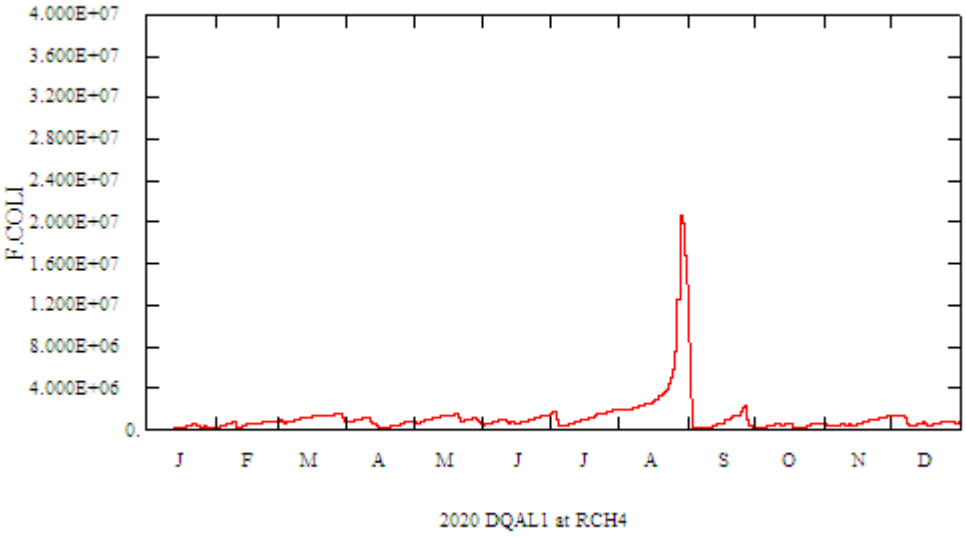
Graph 22: Model simulation result for PO4 in 2020 (mg/L)



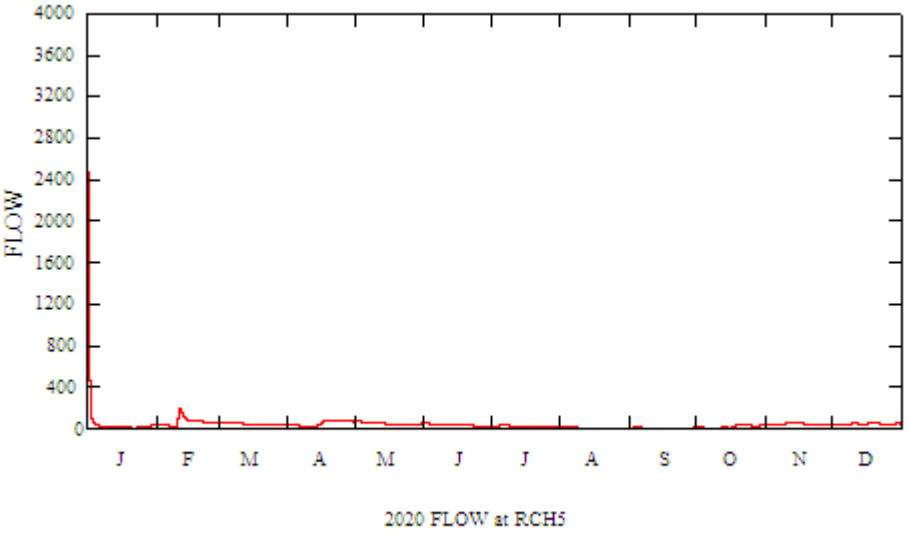
Graph 23: Model simulation result for NH3 in 2020 (mg/L)



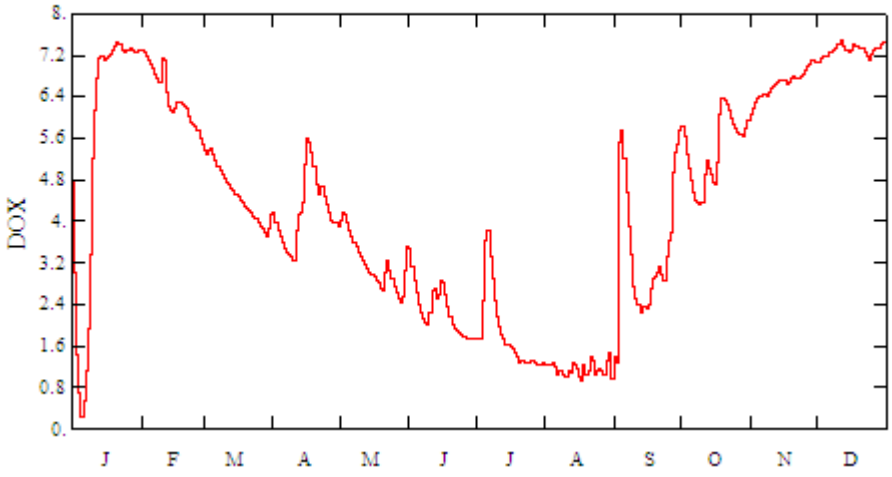
Graph 24: Model simulation result for BOD in 2020 (mg/L)



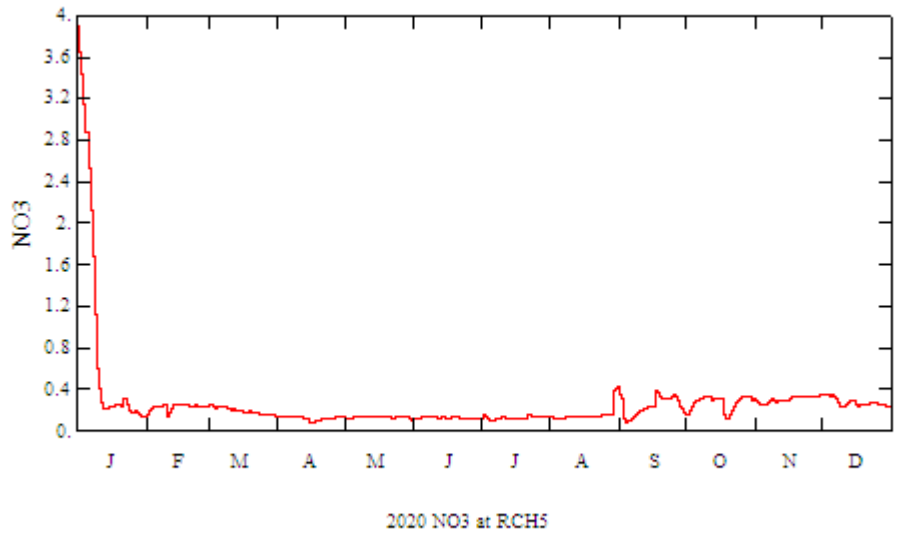
Graph 25: Model simulation result for F.Coliform in 2020 (/100ml)



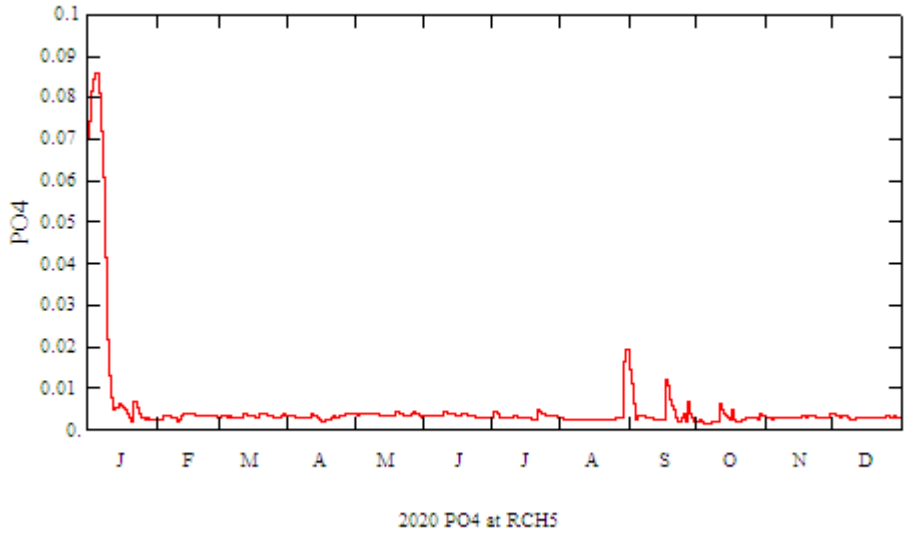
Graph 26: Model simulation result for Flow in 2020 (m3/hour)



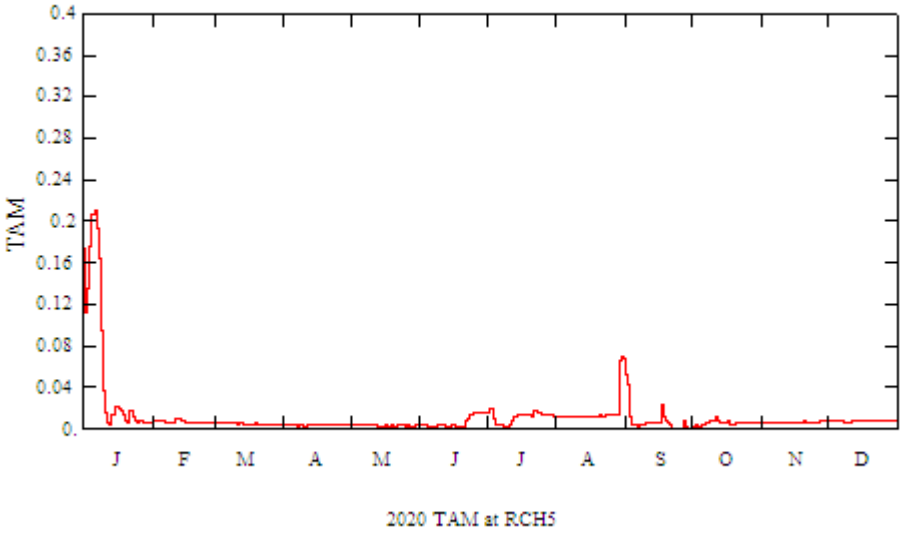
Graph 27: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



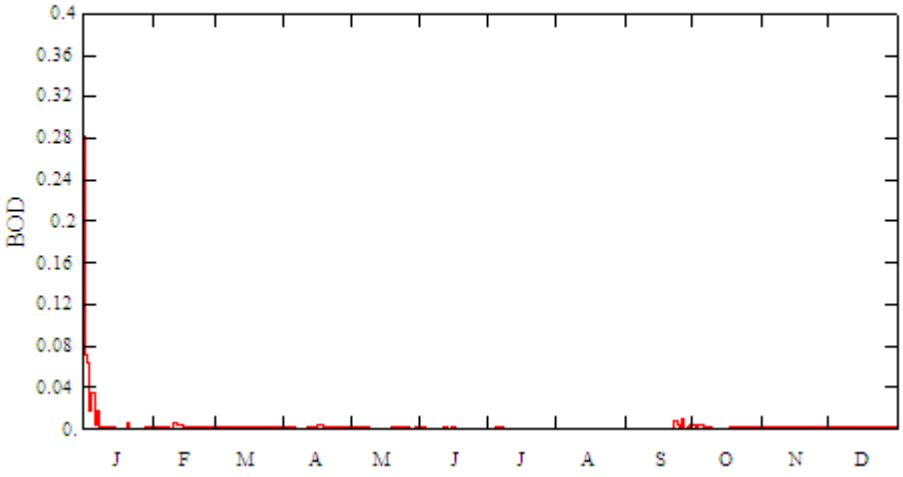
Graph 28: Model simulation result for NO3 in 2020 (mg/L)



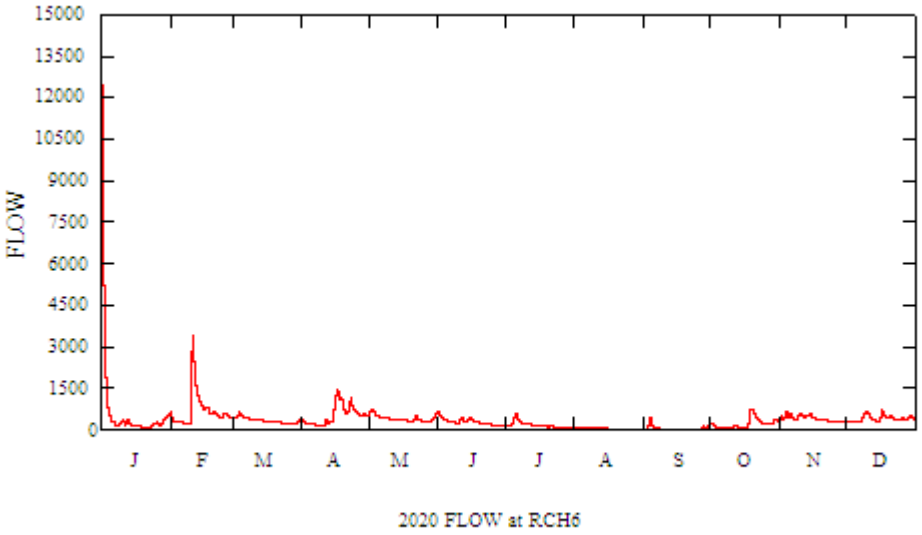
Graph 29: Model simulation result for PO4 in 2020 (mg/L)



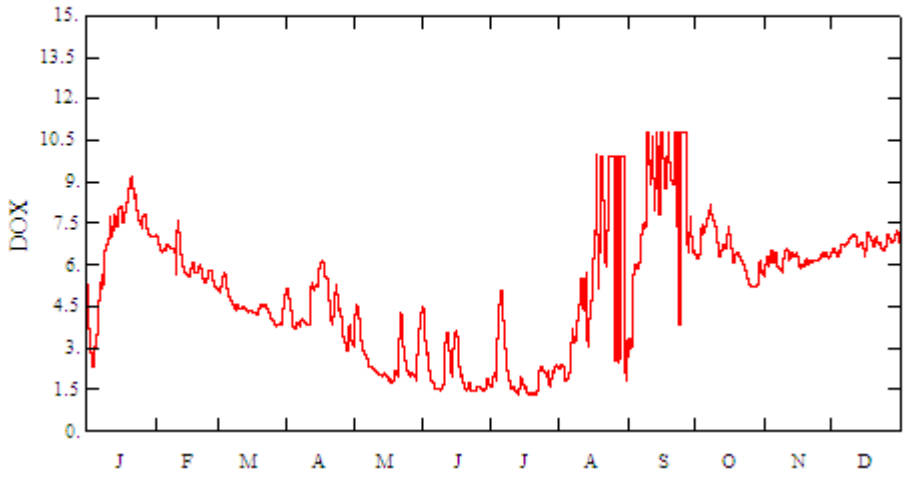
Graph 30: Model simulation result for NH3 in 2020 (mg/L)



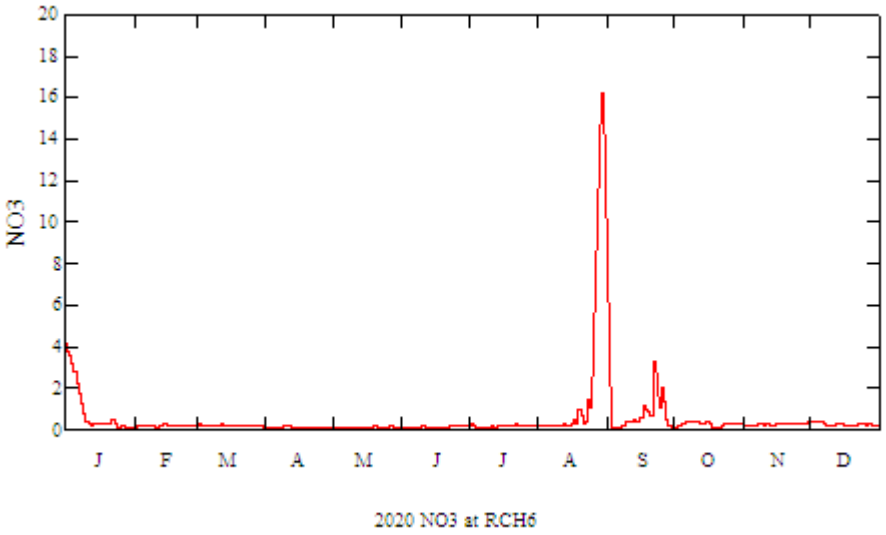
Graph 31: Model simulation result for BOD in 2020 (mg/L)



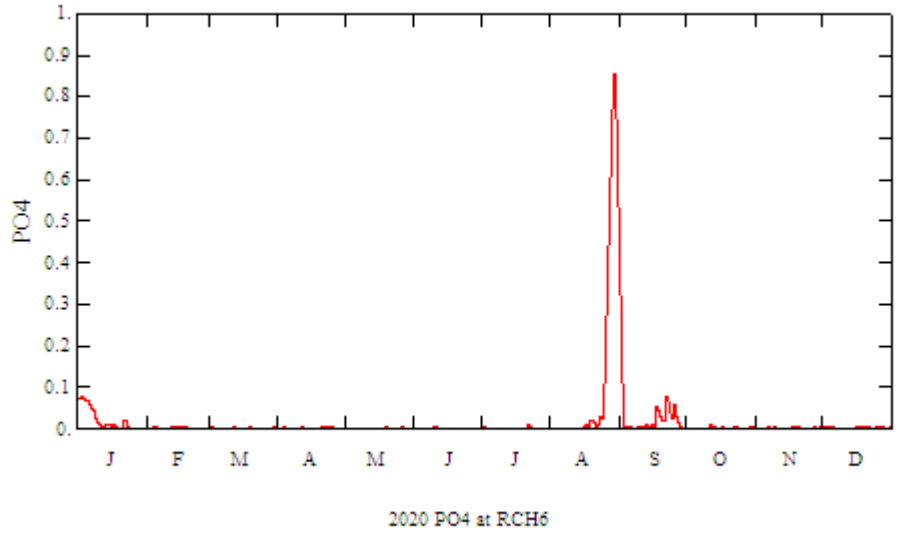
Graph 32: Model simulation result for Flow in 2020 (m3/hour)



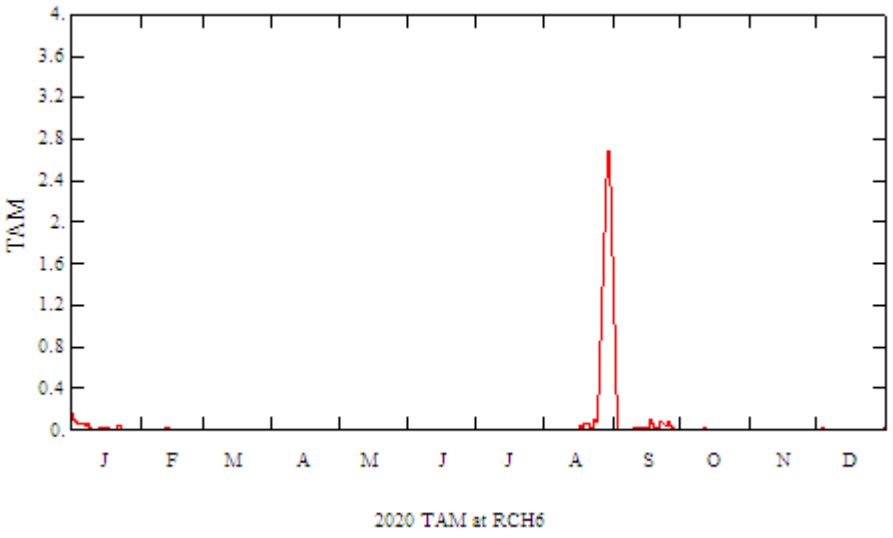
Graph 33: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



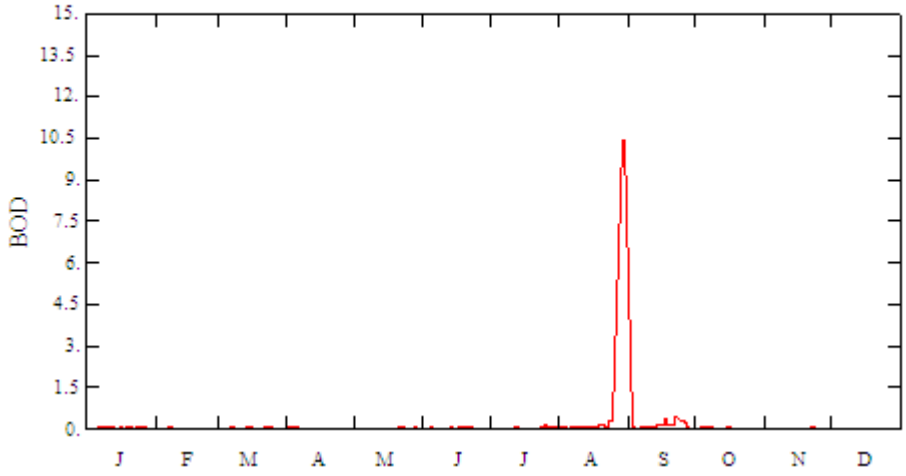
Graph 34: Model simulation result for NO3 in 2020 (mg/L)



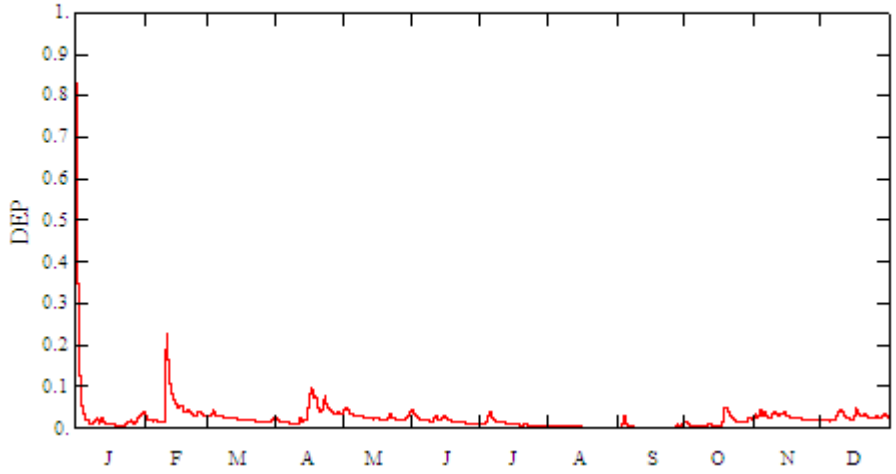
Graph 35: Model simulation result for PO4 in 2020 (mg/L)



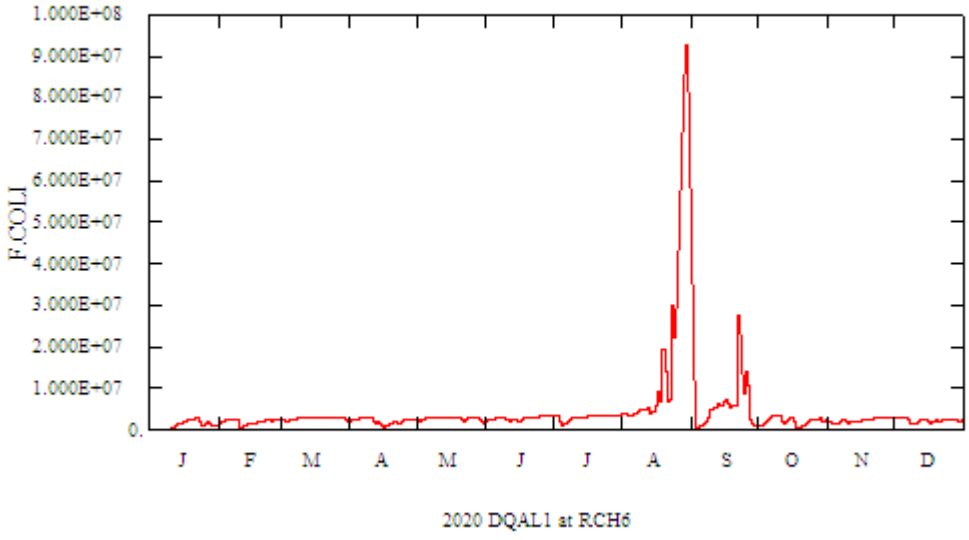
Graph 36: Model simulation result for NH3 in 2020 (mg/L)



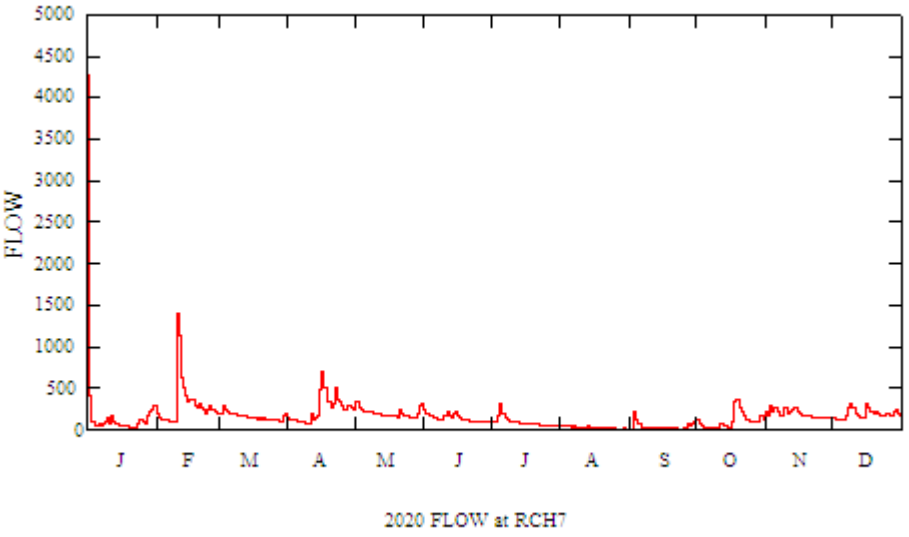
Graph 37: Model simulation result for BOD in 2020 (mg/L)



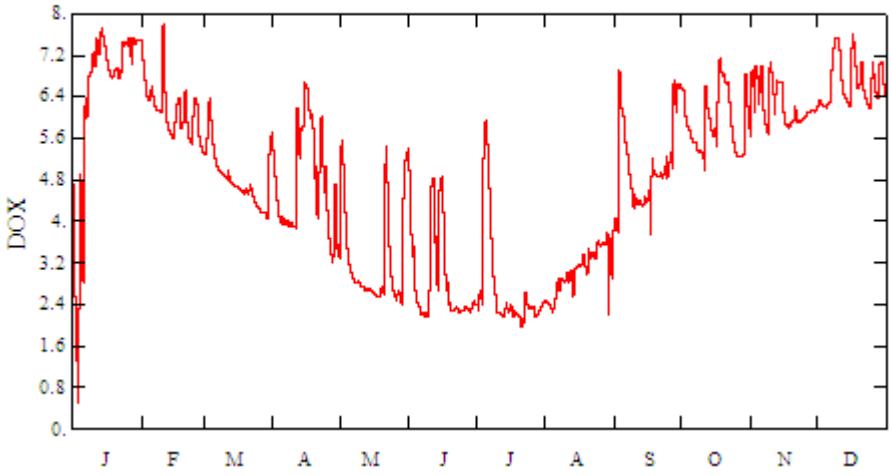
Graph 38: Model simulation result for DEPTH in 2020 (m)



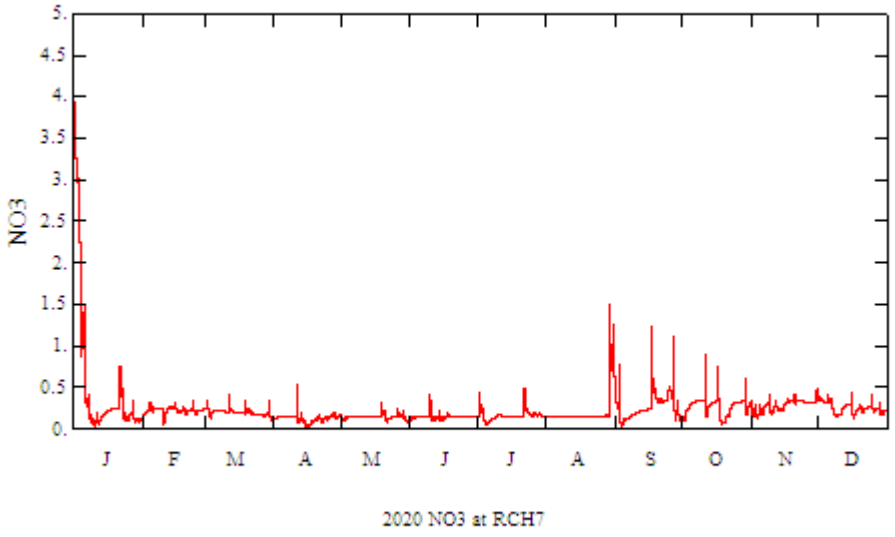
Graph 39: Model simulation result for F.Coliform in 2020 (/100ml)



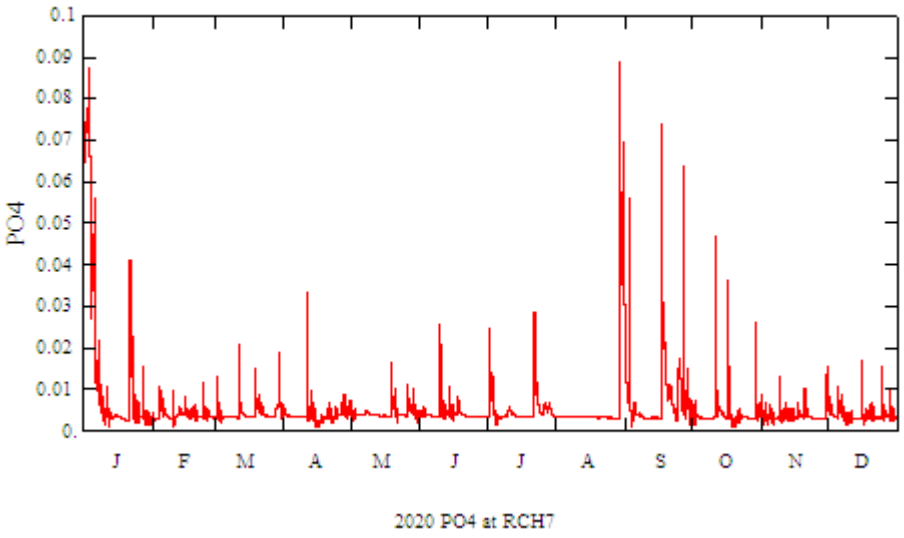
Graph 40: Model simulation result for Flow in 2020 (m3/hour)



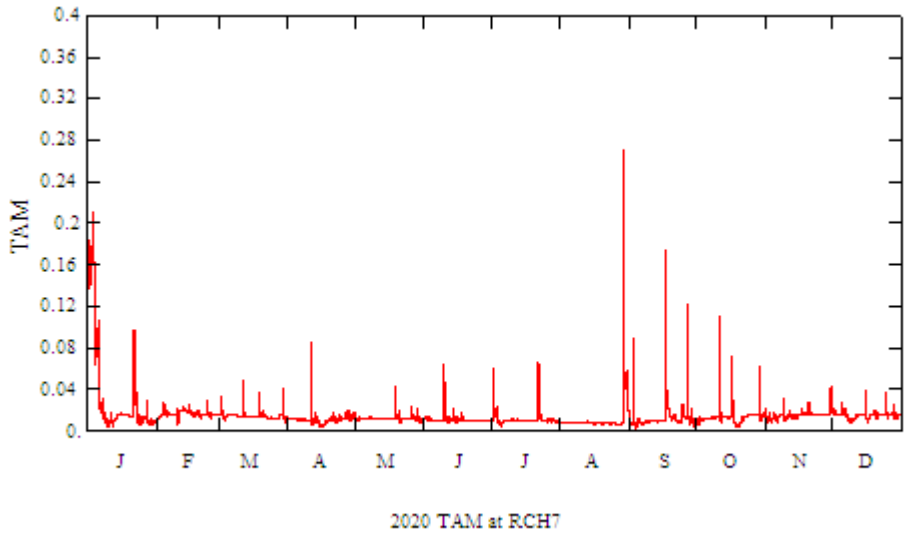
Graph 41: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



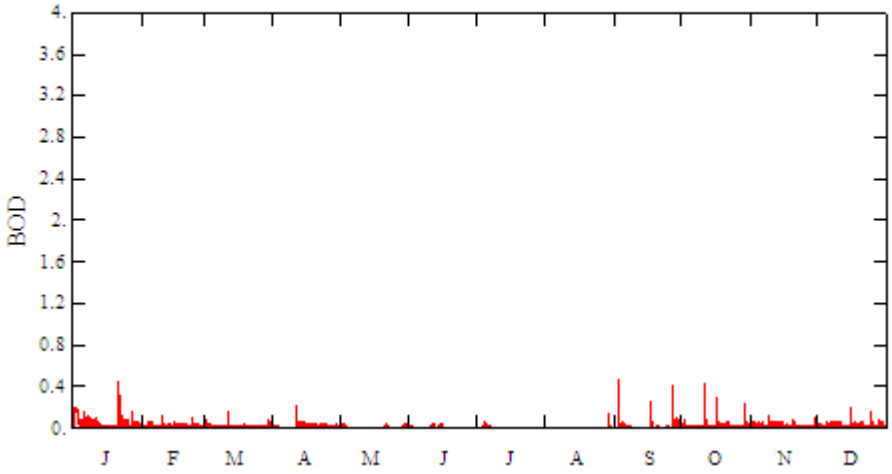
Graph 42: Model simulation result for NO3 in 2020 (mg/L)



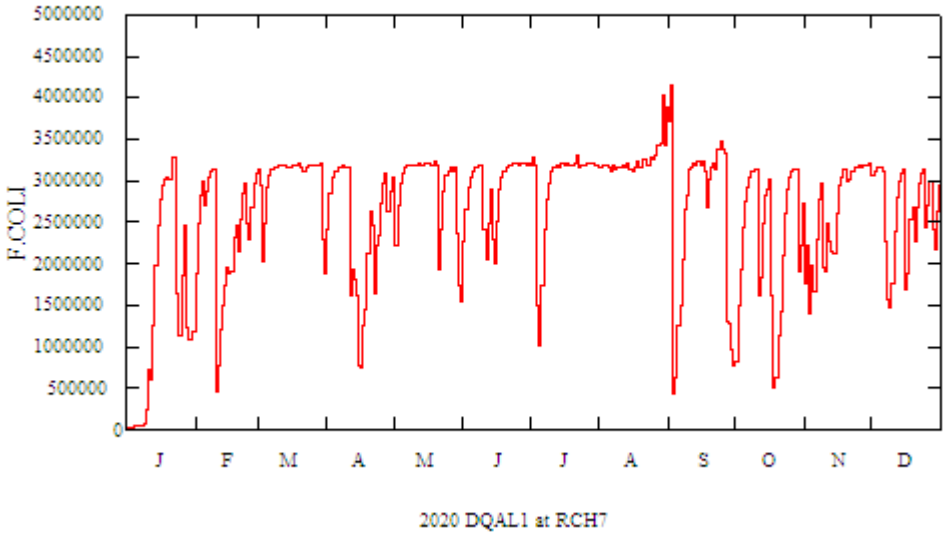
Graph 43: Model simulation result for PO4 in 2020 (mg/L)



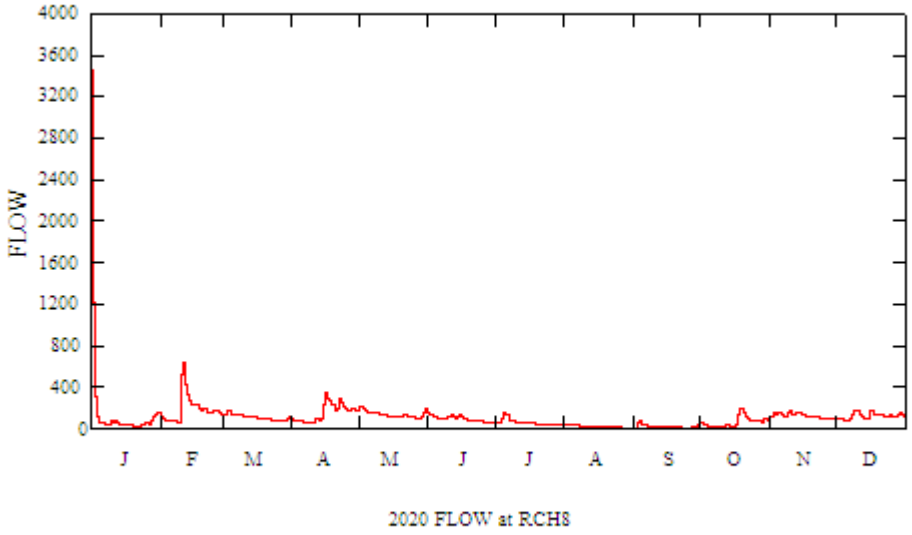
Graph 44: Model simulation result for NH3 in 2020 (mg/L)



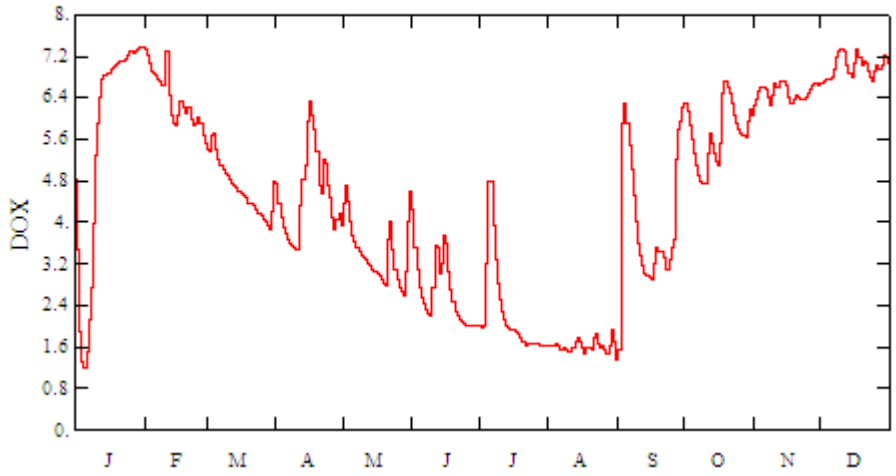
Graph 45: Model simulation result for BOD in 2020 (mg/L)



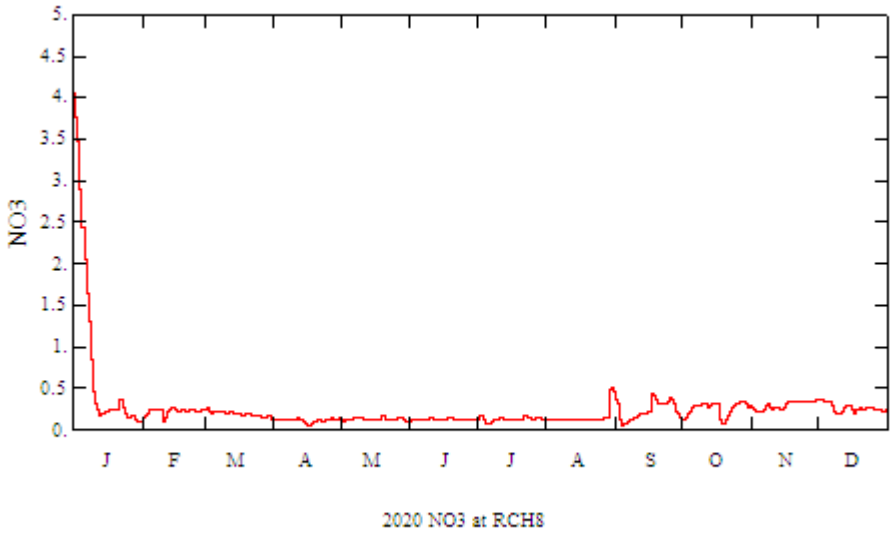
Graph 46: Model simulation result for F.Coliform in 2020 (/100ml)



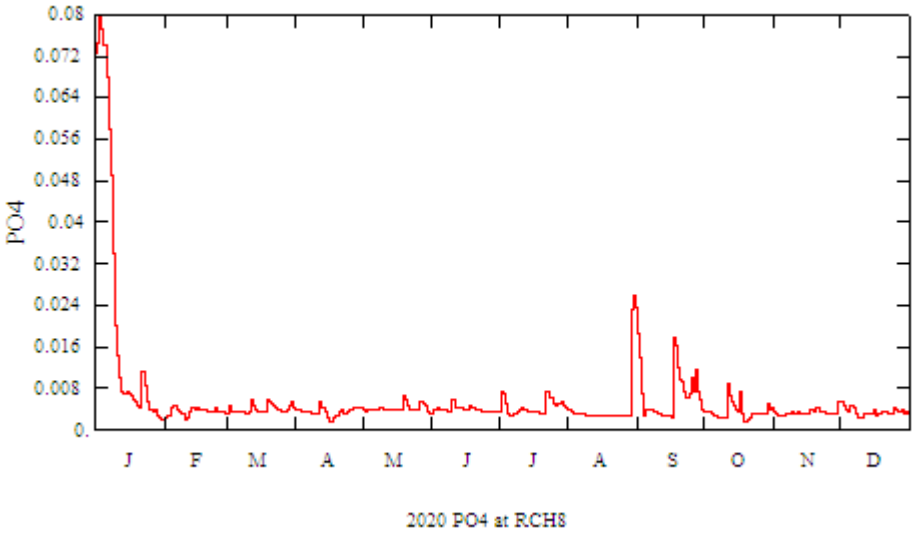
Graph 47: Model simulation result for Flow in 2020 (m3/hour)



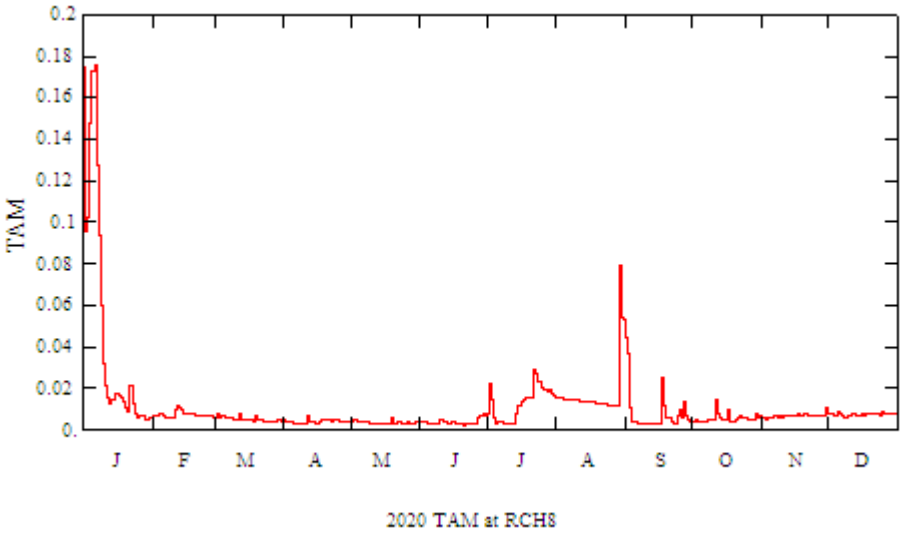
Graph 48: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



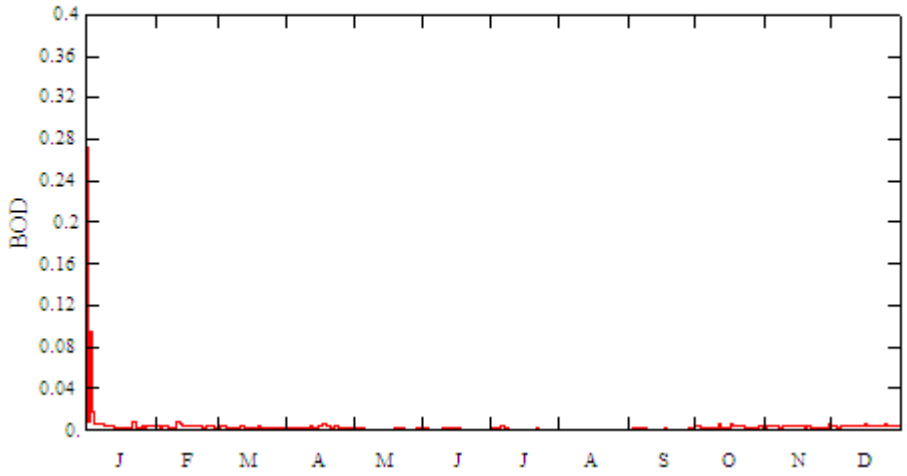
Graph 49: Model simulation result for NO3 in 2020 (mg/L)



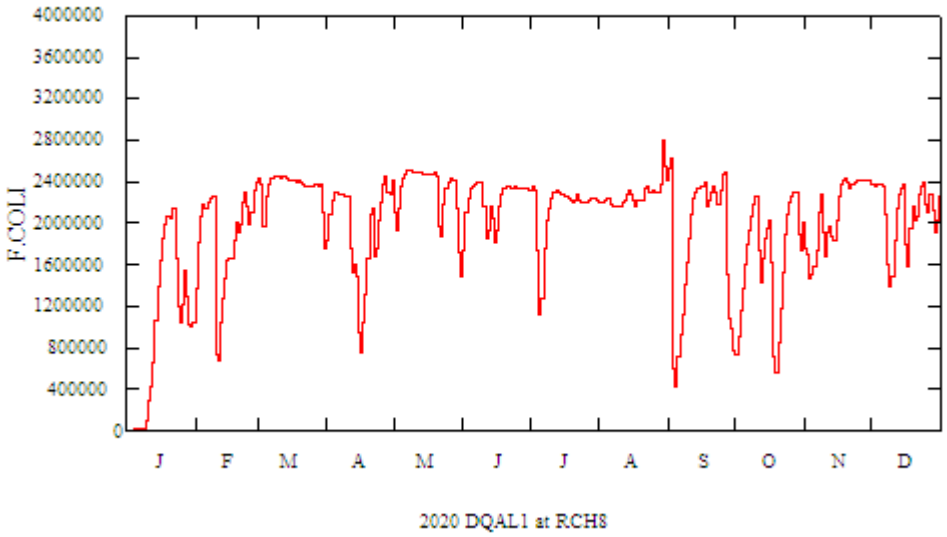
Graph 50: Model simulation result for PO4 in 2020 (mg/L)



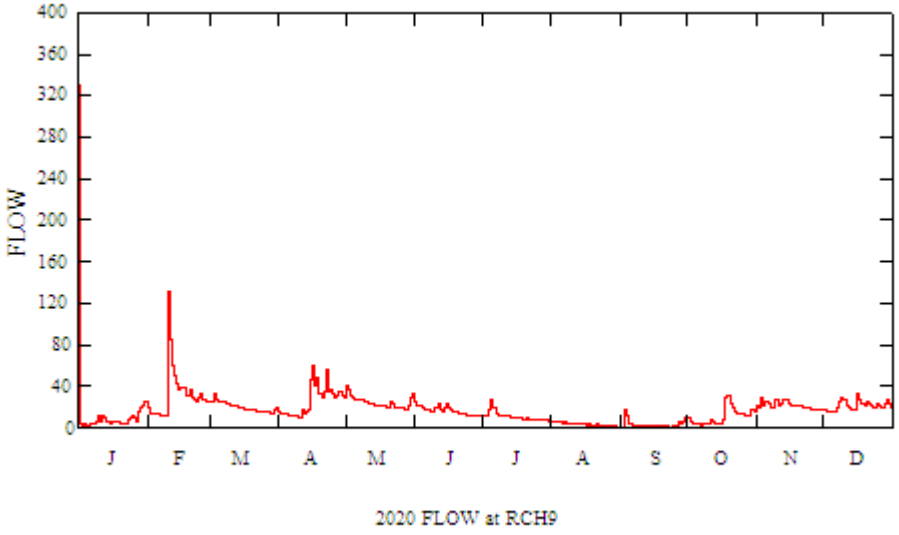
Graph 51: Model simulation result for NH3 in 2020 (mg/L)



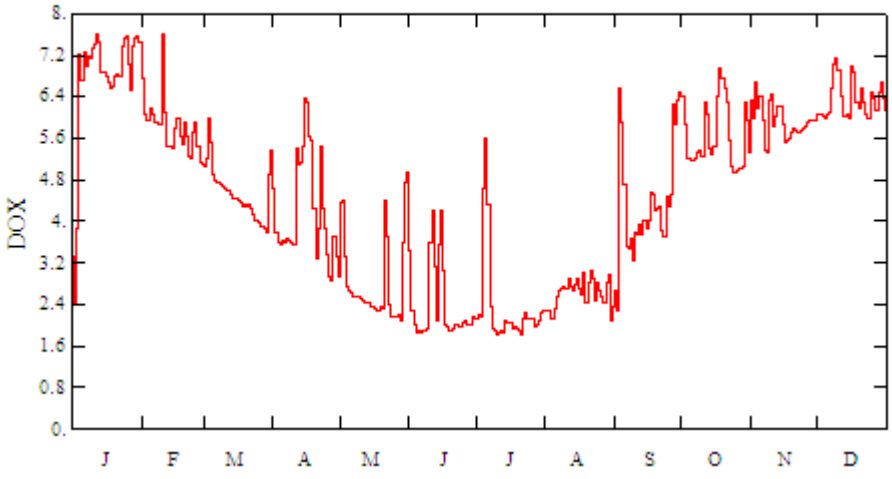
Graph 52: Model simulation result for BOD in 2020 (mg/L)



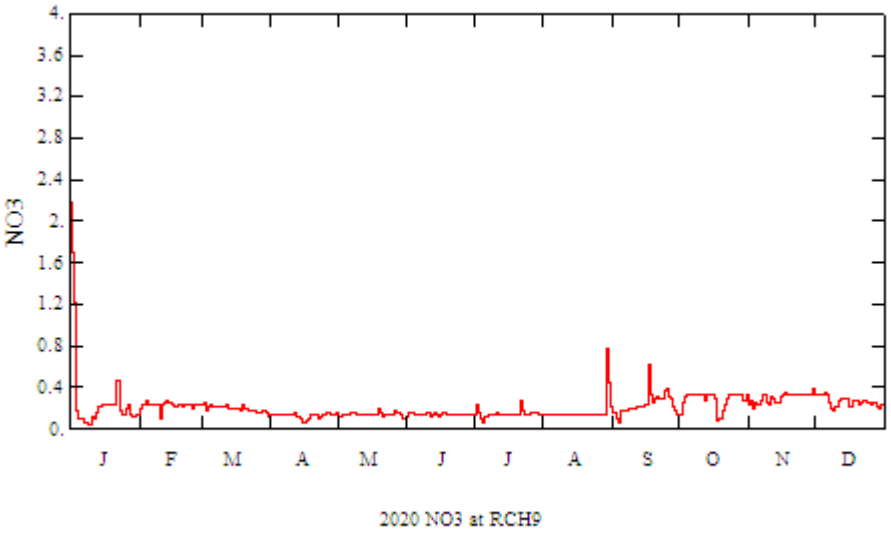
Graph 53: Model simulation result for F.Coliform in 2020 (/100ml)



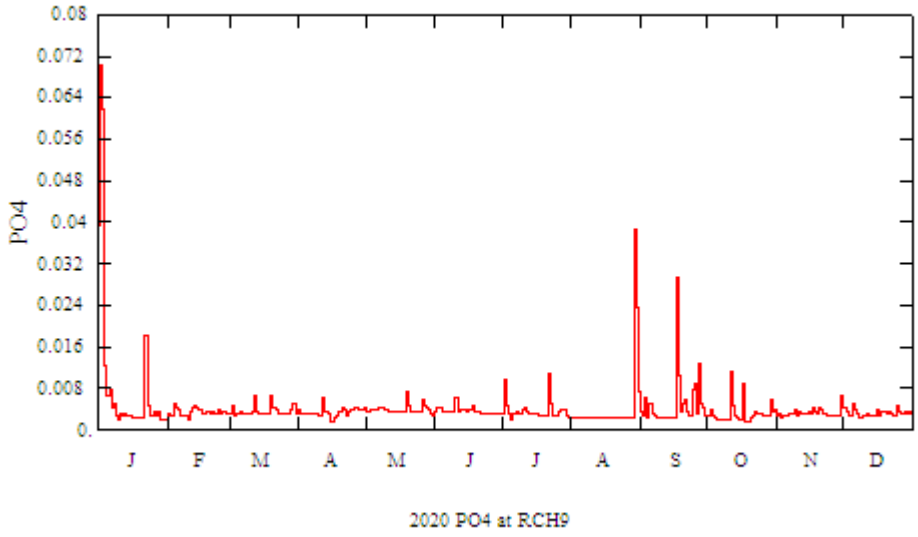
Graph 54: Model simulation result for Flow in 2020 (m3/hour)



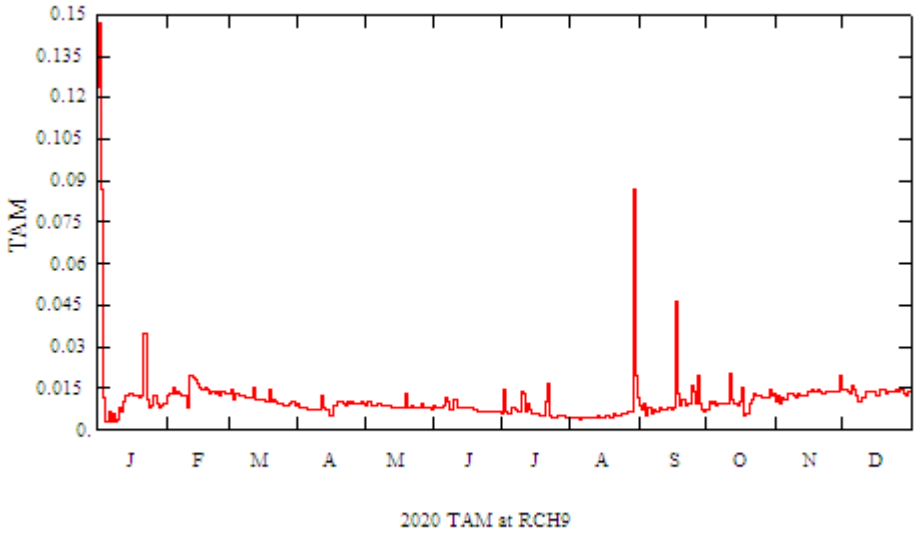
Graph 55: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



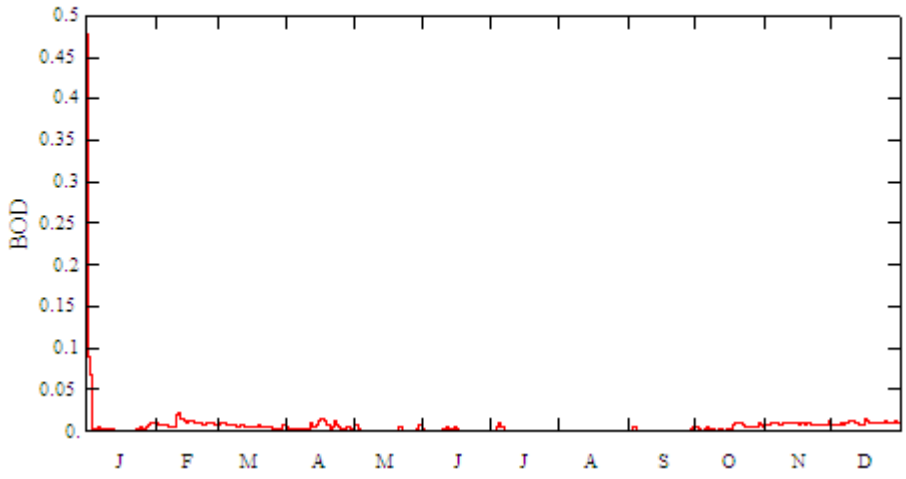
Graph 56: Model simulation result for NO3 in 2020 (mg/L)



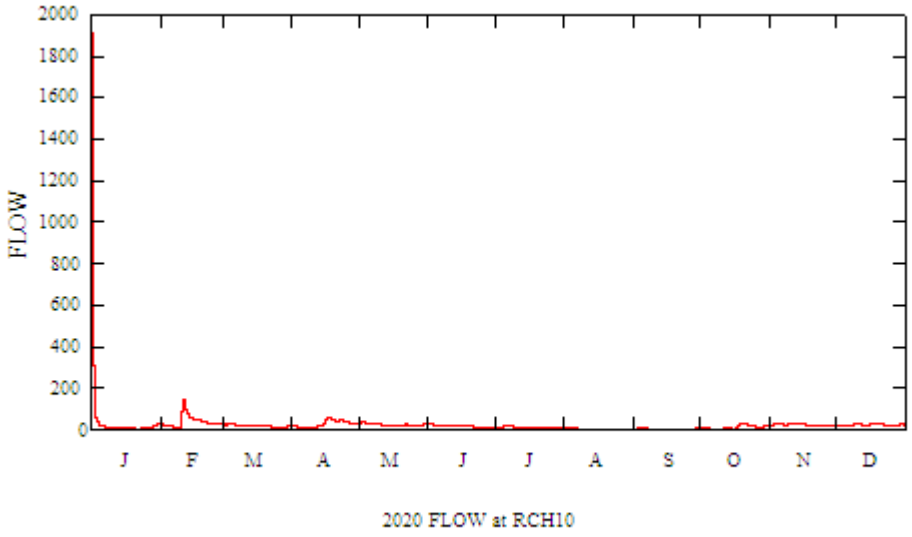
Graph 57: Model simulation result for PO4 in 2020 (mg/L)



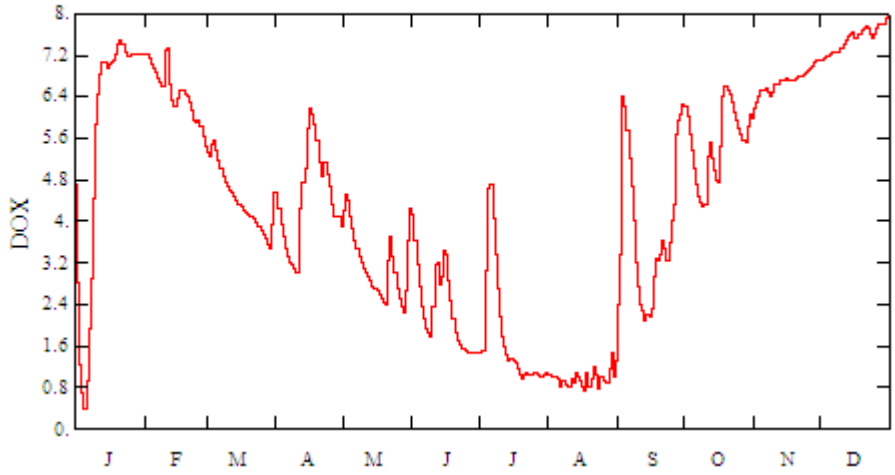
Graph 58: Model simulation result for NH3 in 2020 (mg/L)



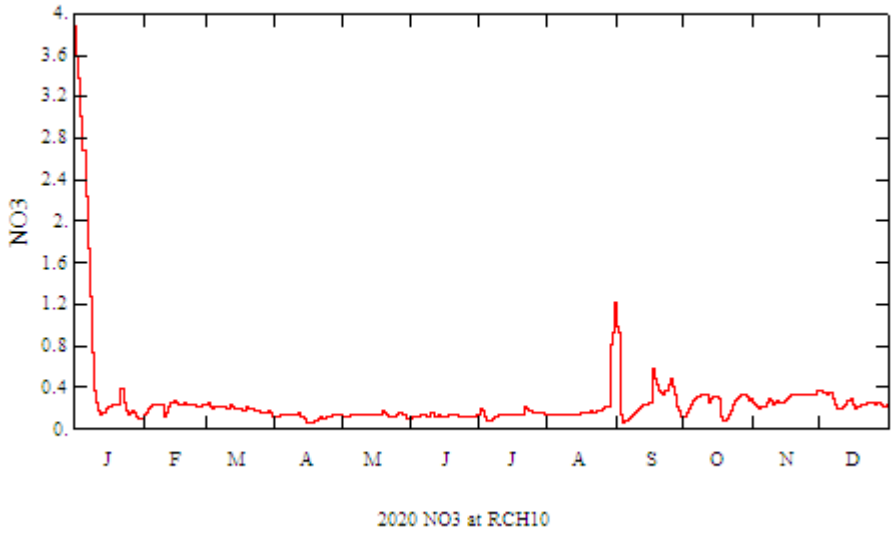
Graph 59: Model simulation result for BOD in 2020 (mg/L)



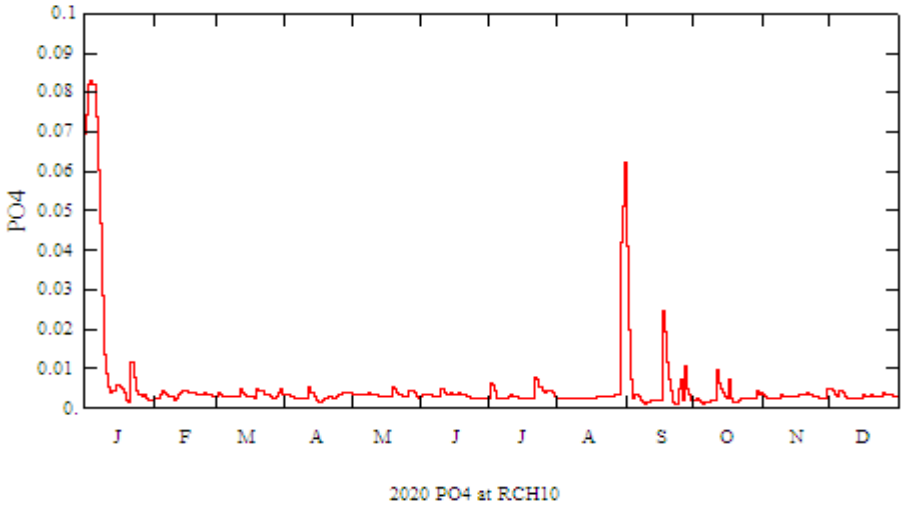
Graph 60: Model simulation result for Flow in 2020 (m3/hour)



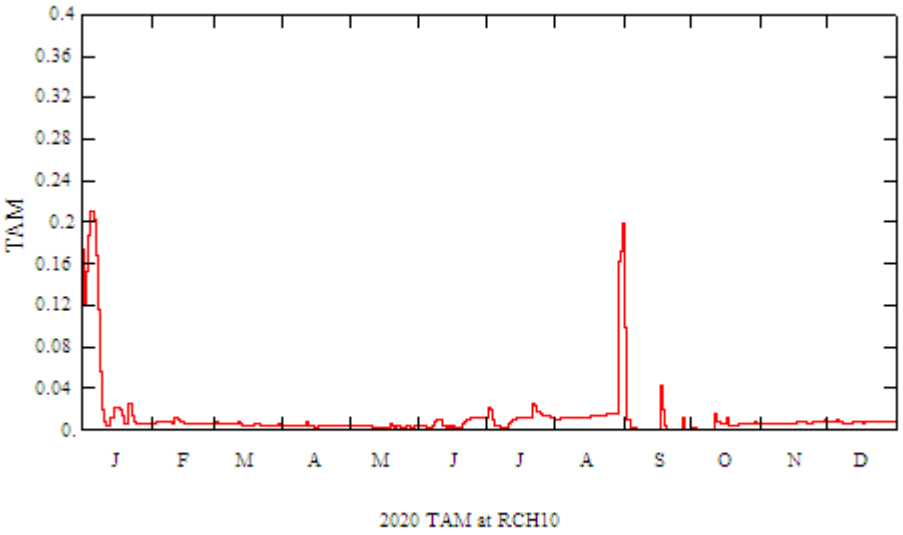
Graph 61: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



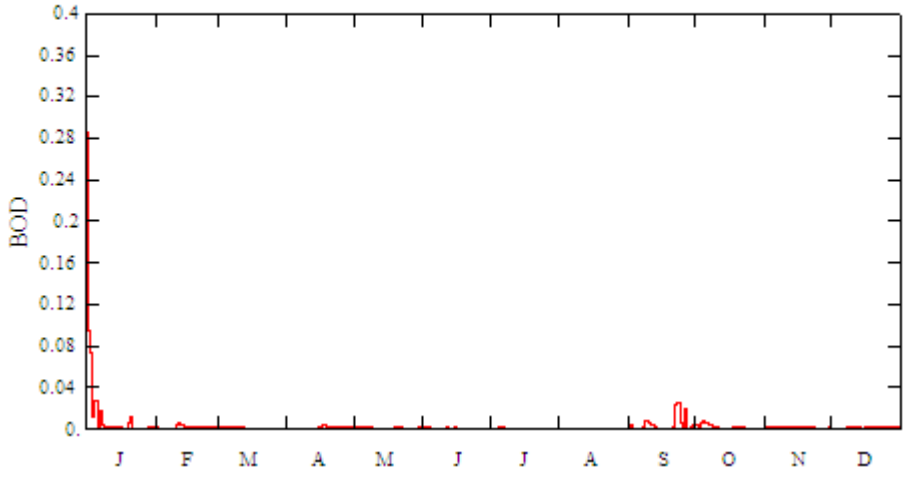
Graph 62: Model simulation result for NO3 in 2020 (mg/L)



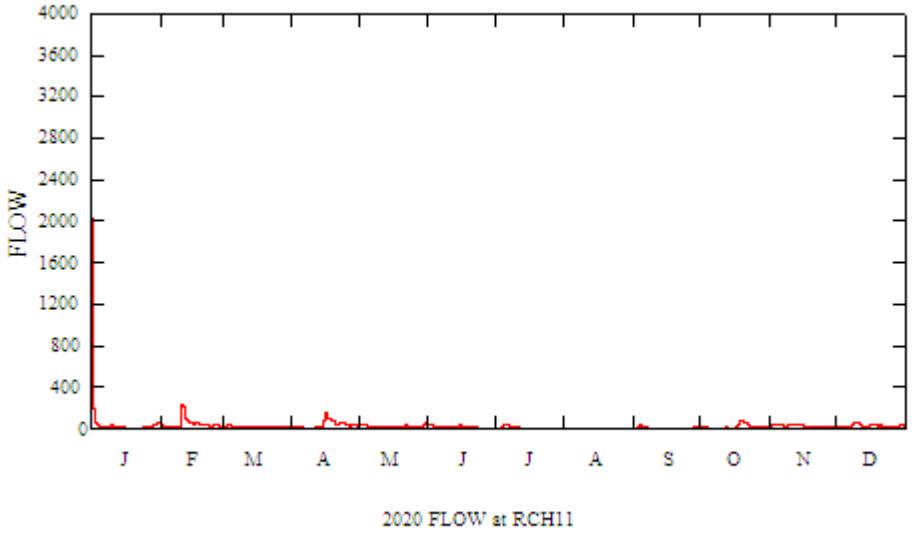
Graph 63: Model simulation result for PO4 in 2020 (mg/L)



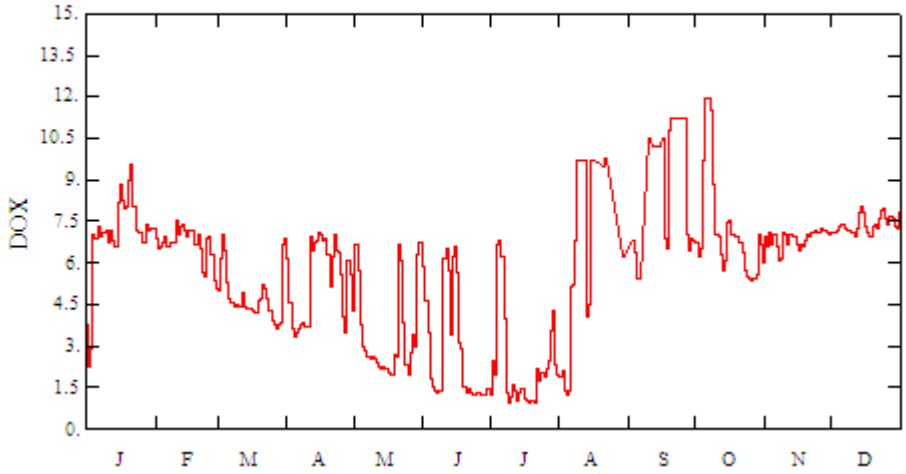
Graph 64: Model simulation result for NH3 in 2020 (mg/L)



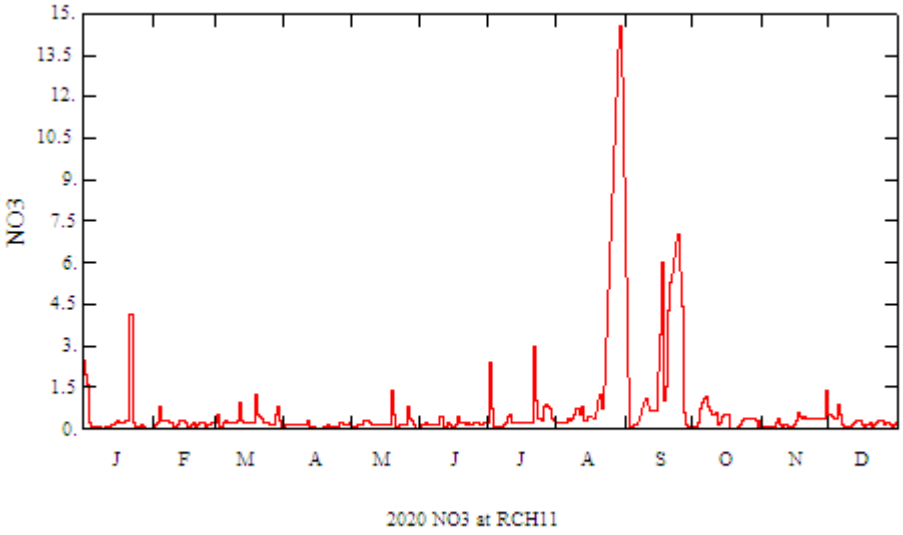
Graph 65: Model simulation result for BOD in 2020 (mg/L)



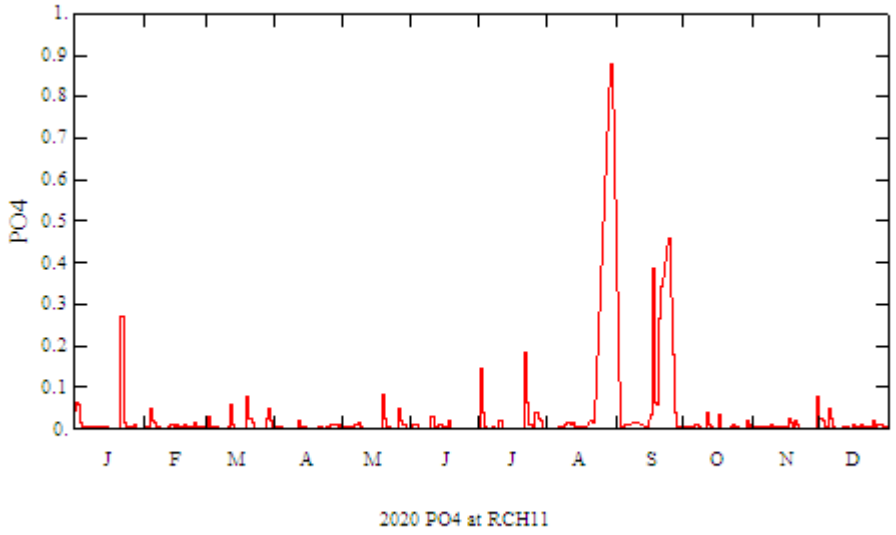
Graph 66: Model simulation result for Flow in 2020 (m3/hour)



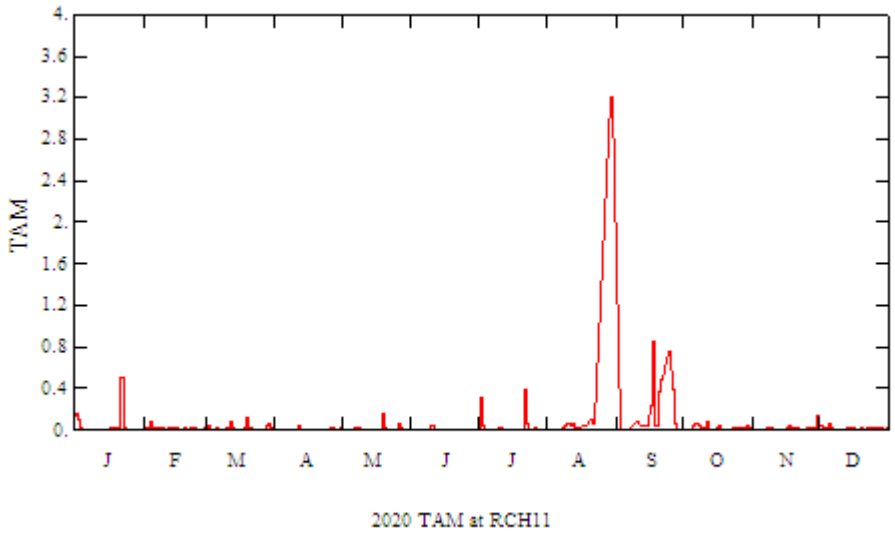
Graph 67: Model simulation result for Dissolved Oxygen in 2020 (mg/L)



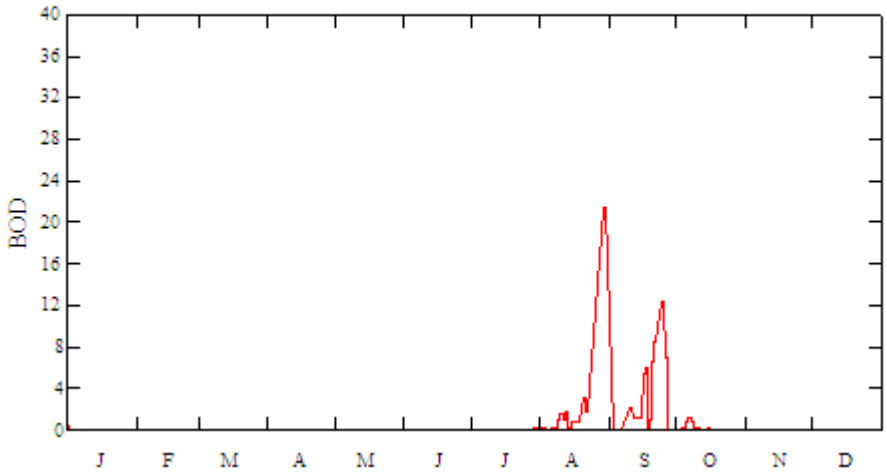
Graph 68: Model simulation result for NO3 in 2020 (mg/L)



Graph 69: Model simulation result for PO4 in 2020 (mg/L)



Graph 70: Model simulation result for NH3 in 2020 (mg/L)



Graph 71: Model simulation result for BOD in 2020 (mg/L)

2.2 Quality criteria

Water quality criteria were determined based on legislative requirements and additional requirements placed by the project team which aimed specifically at preserving good ecological status. The development of these targets concerns only ecological values as no other uses of the salt lake area (pertaining to water quality) were identified. Given the lack of systematic background data regarding pollutant concentrations and their relationship to good ecological status, the selected

values were determined from the monitoring undertaken within the WATER project and were based largely on expert opinion. The following table summarises the criteria selected.

It has been decided that the annual average criteria concentration should also be applied as a running three-monthly average limit. Thus the average pollutant concentration of any arbitrarily selected 90-day period should conform to this limit.

Given the sporadic nature of rainfall and the fact that a significant portion of storm-water runoff is attributed to the occurrence of short-lived extreme rainfall events, it appears impractical and unrealistic to enforce the peak daily limit under all conditions. The limit therefore allows for up to 10% of samples / daily prediction values to exceed this criterion.

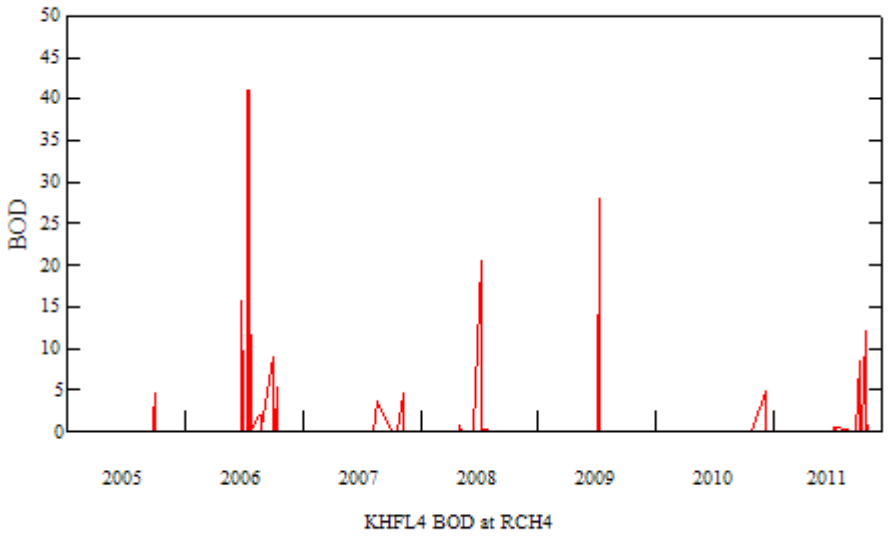
TABLE 1: Applicable Water Quality Criteria.

Pollutant	Units	Acceptable Limits (legislative)	Additional comments	Background values based on measurements	Quality criterion (Annual Average)	Quality criterion (daily peak)	Potential Sources
Nitrates	mg/L	2 – 3	Over 10 mg/L can be define as a high level of pollution	0.03-19.2	3	10	Runoff from irrigation basins
Nitrites	mg/L	0.2 – 0.3	Over 0.5 mg/L can be define as a high level of pollution	0-0.18	0.2	0.5	Industrial and/or urban waste
Ammonium	mg/L	$\leq$ 0.5		0.3-12.7	0.5	5	Urban waste and/or fertilization
Phosphates	mg/L	$\leq$ 2		0.02-0.09	1	2	Industrial waste
BOD^5	mg/L	$\leq$ 25	Over 40 mg/L can be define as a high level of pollution	16-65	20	40	
DO	µg/L	>5 mg/l.	A concentration of at least 4 mg/l is considered necessary for good ecological status may be acceptable	1.1 - 25.34	4	5	

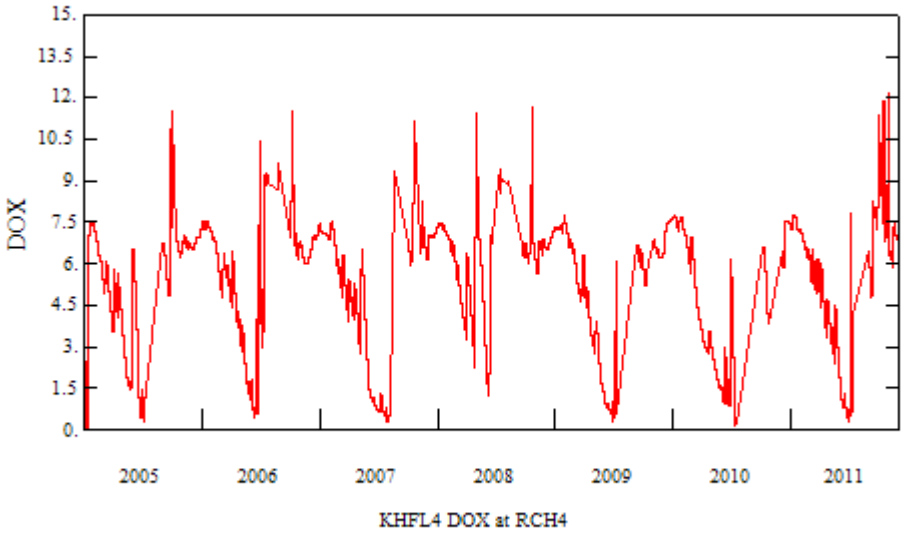
E. coli	/100 mL	1/100 mL	F. Coli constitutes a part of	$2.42x10^3$			

2.3 Future Hydrological Scenario

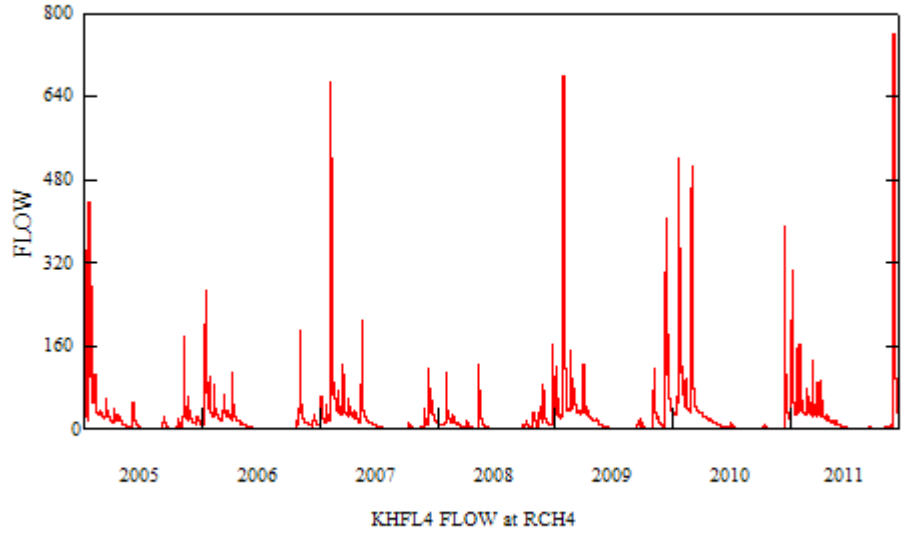
We are now about to examine the next case scenario, Hydrological for 'Reach' 4,6,7,8 which constitutes the main sources of water runoff to the salt lake..As described above this scenario is to raise conclusions for the pollutants concentration loads in the salt lake by this time changing the land use. Specifically in sub catchment 8 we change the land use from non-irrigated arable to discontinuous urban. For the application of this scenario we used the BASINS model. The exported results are illustrated in the graphs below.



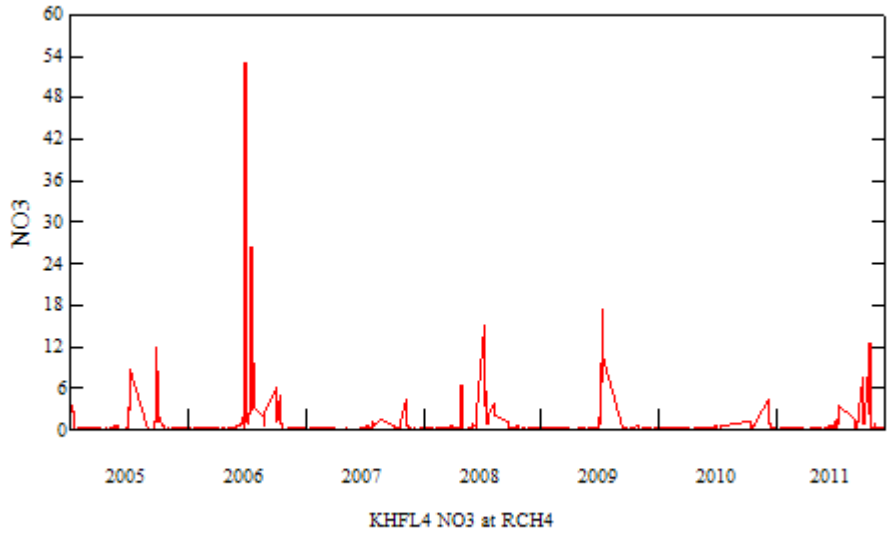
Graph 72: Model simulation result for BOD (mg/L)



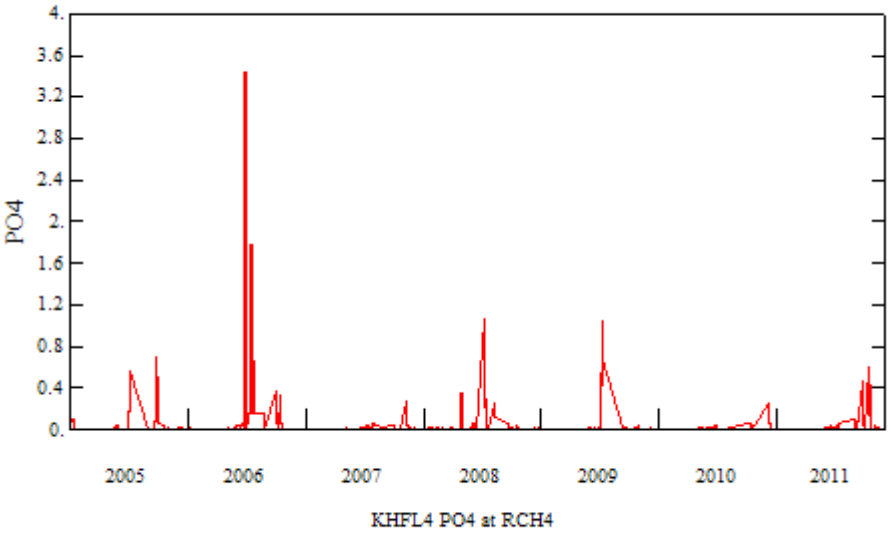
Graph 73: Model simulation result for DO (mg/L)



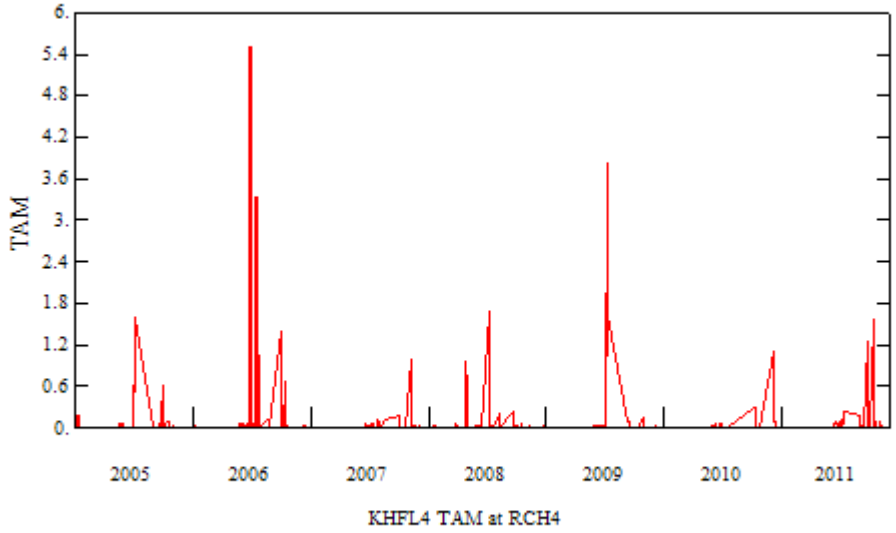
Graph 74: Model simulation result for Flow (m3/hour)



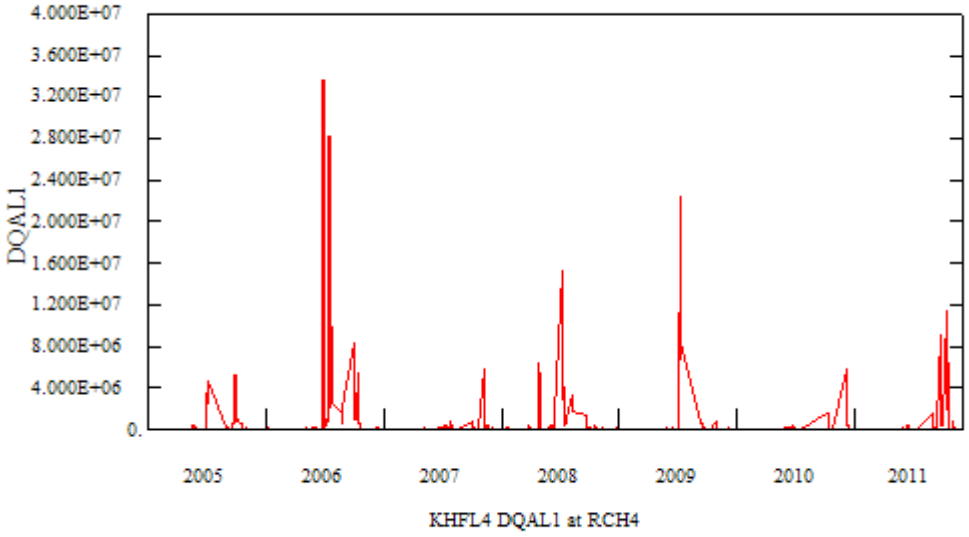
Graph 75: Model simulation result for NO3 (mg/L)



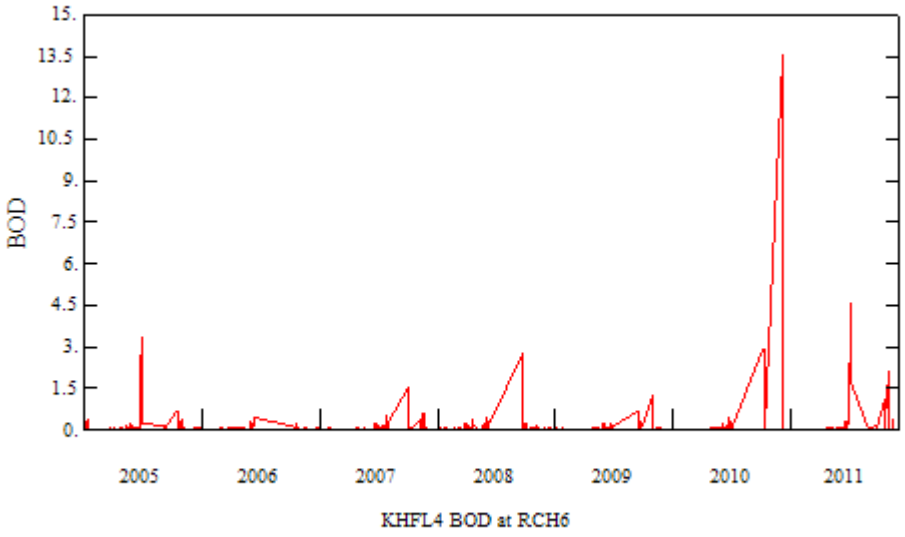
Graph 76: Model simulation result for PO4 (mg/L)



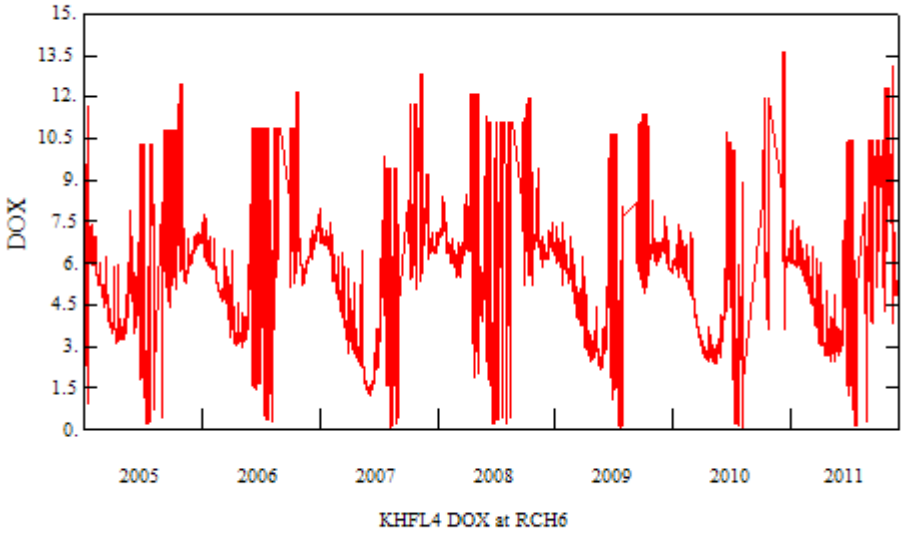
Graph 77: Model simulation result for NH3 (mg/L)



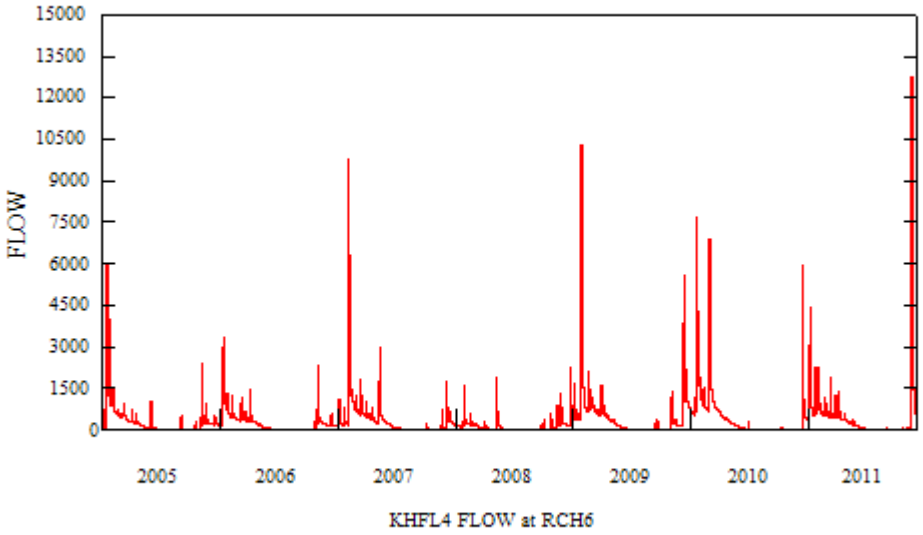
Graph 78: Model simulation result for F.Coliform (/100ml)



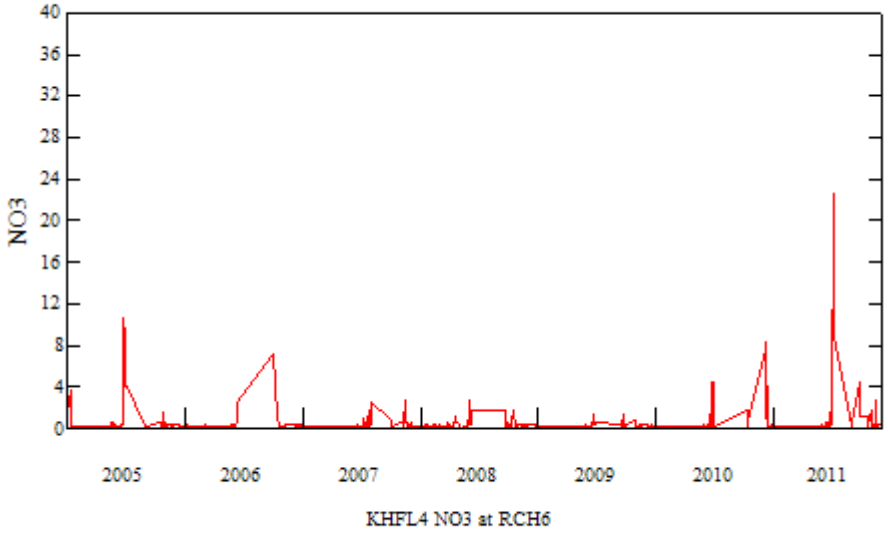
Graph 79: Model simulation result for BOD (mg/L)



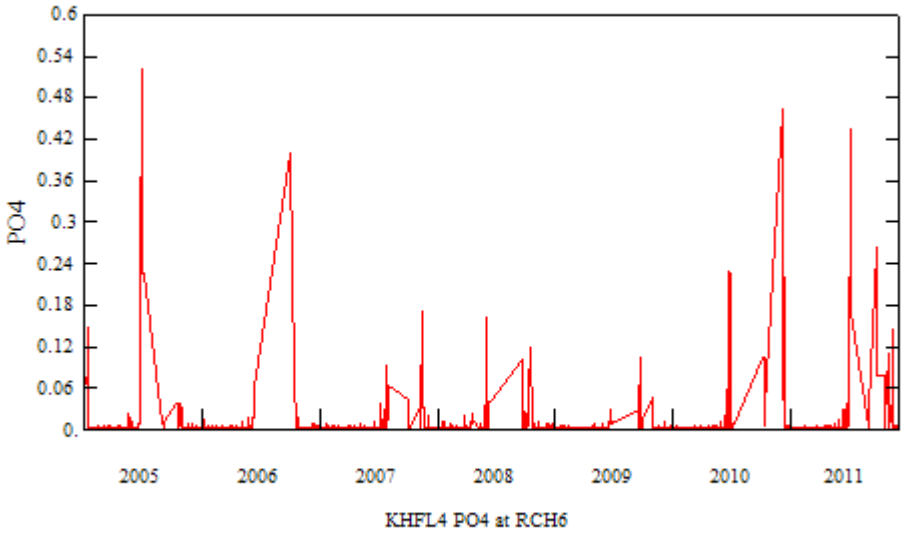
Graph 80: Model simulation result for DO (mg/L)



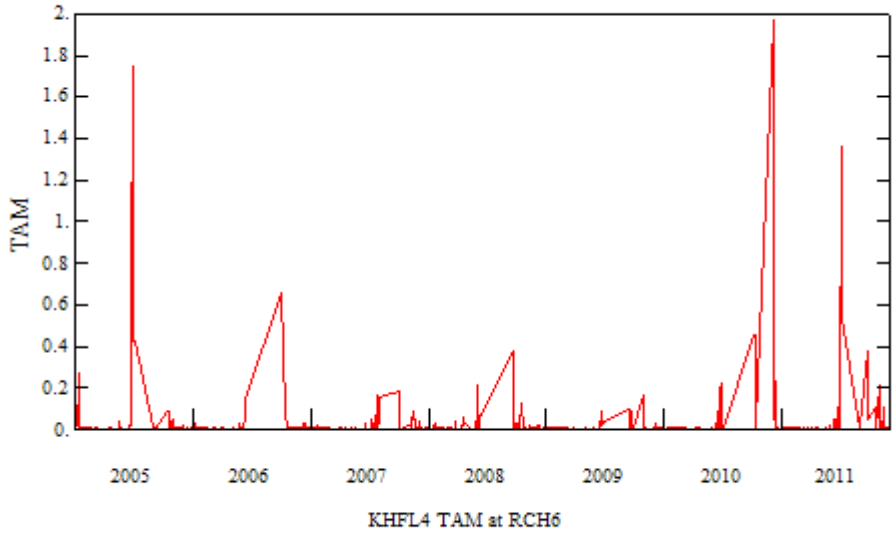
Graph 81: Model simulation result for Flow (m3/hour)



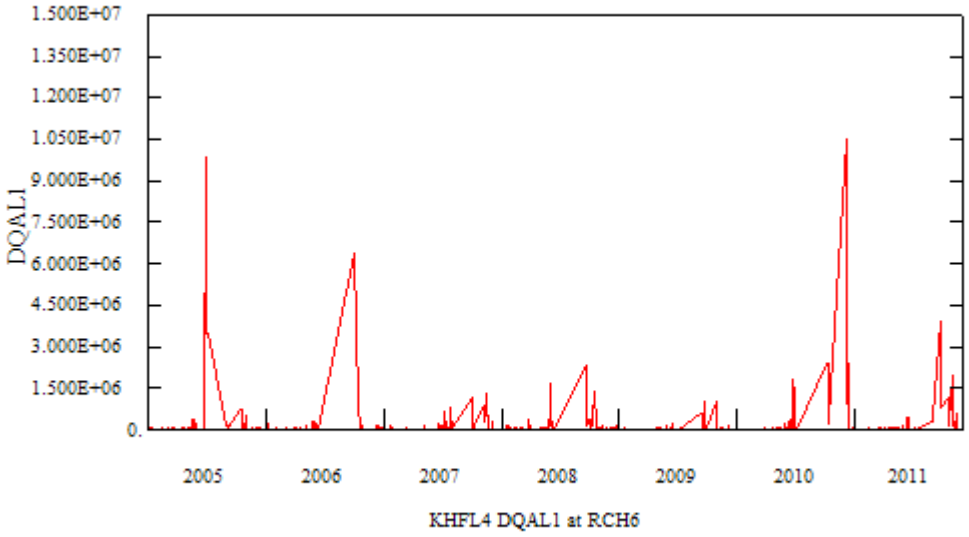
Graph 82: Model simulation result for NO3 (mg/L)



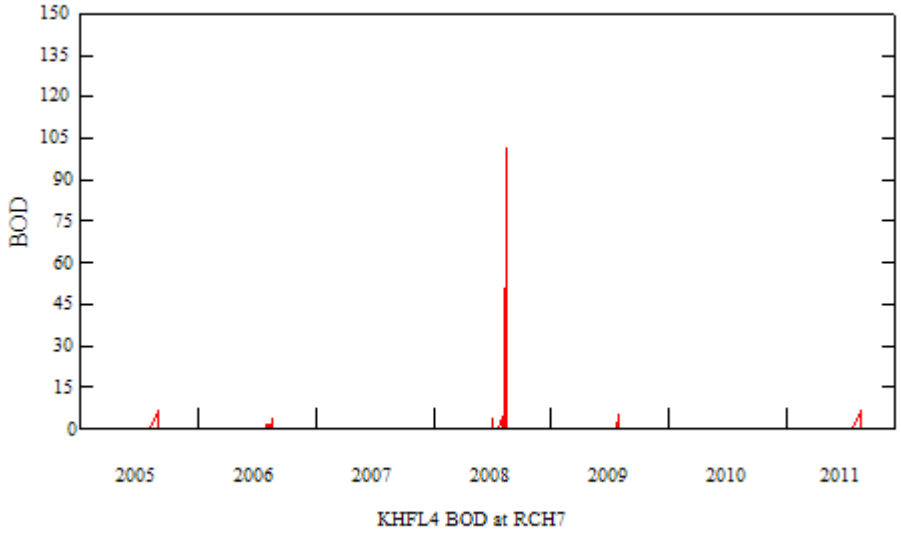
Graph 83: Model simulation result for PO4 (mg/L)



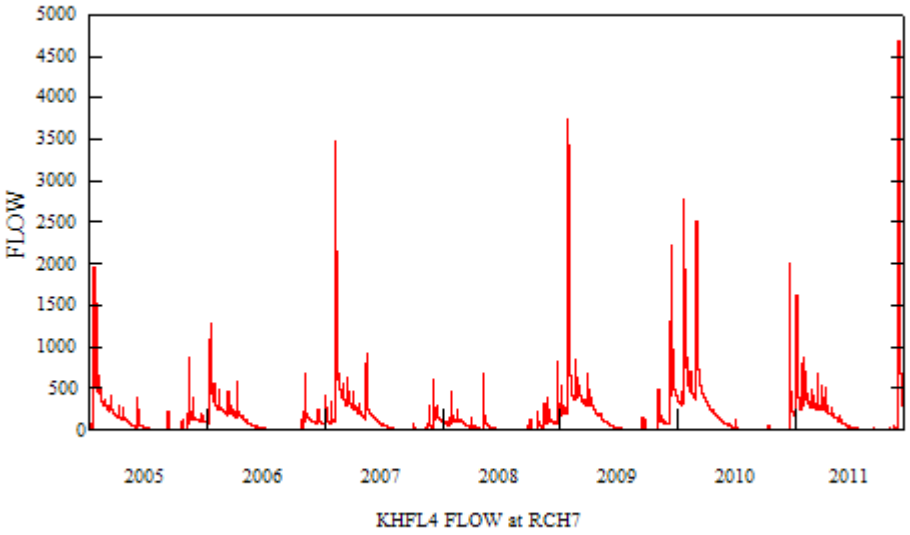
Graph 84: Model simulation result for NH3 (mg/L)



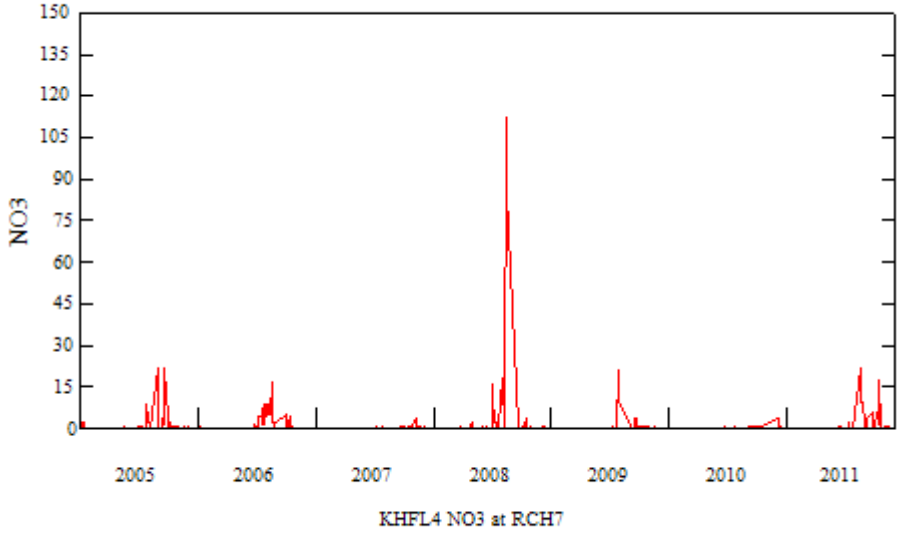
Graph 85: Model simulation result for F.Coliform (/100ml)



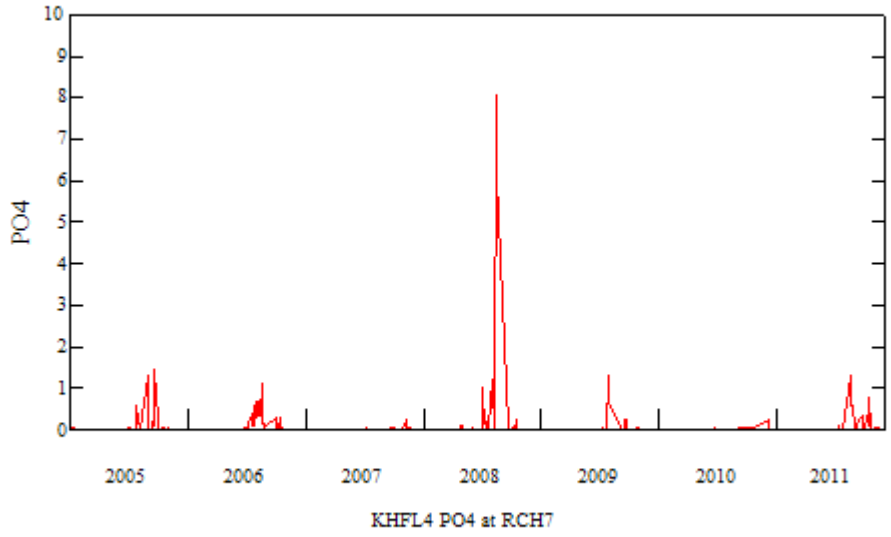
Graph 86: Model simulation result for BOD (mg/L)



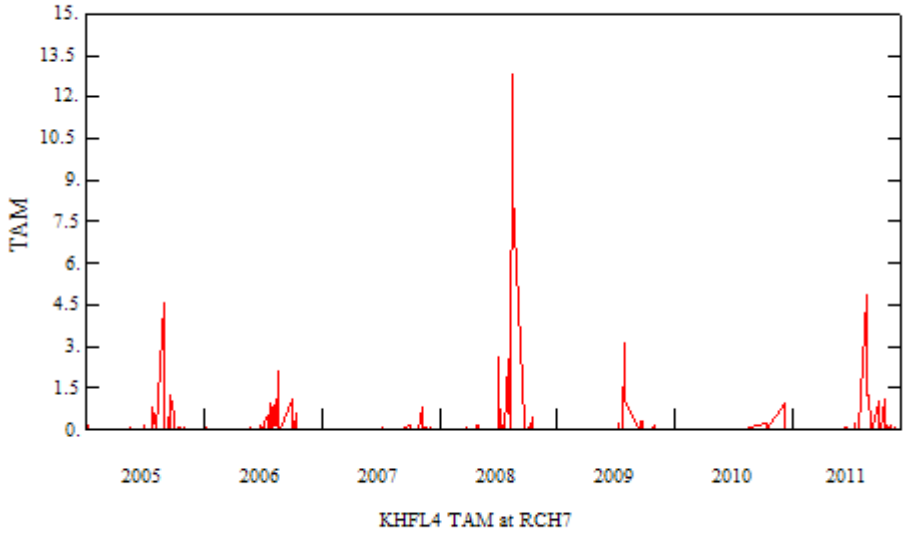
Graph 87: Model simulation result for Flow (m3/hour)



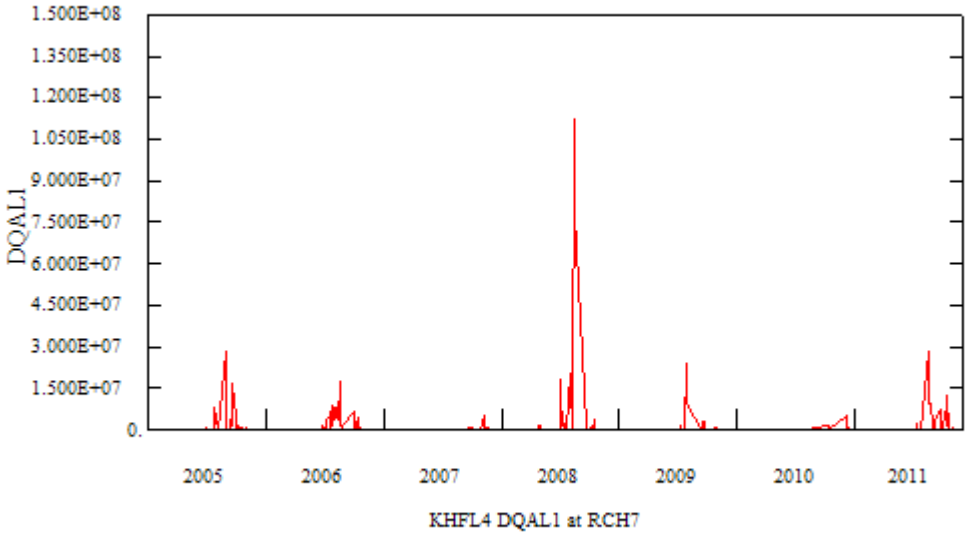
Graph 88: Model simulation result for NO3 (mg/L)



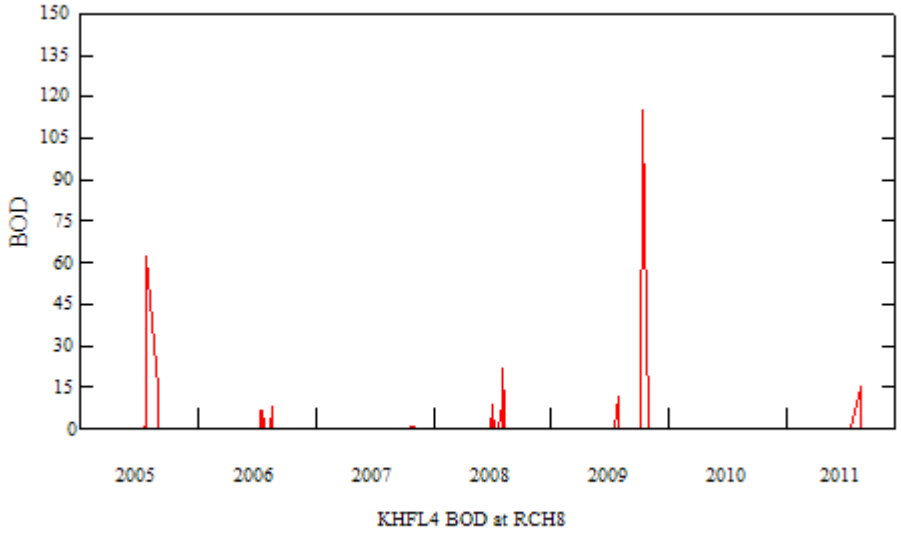
Graph 89: Model simulation result for PO4 (mg/L)



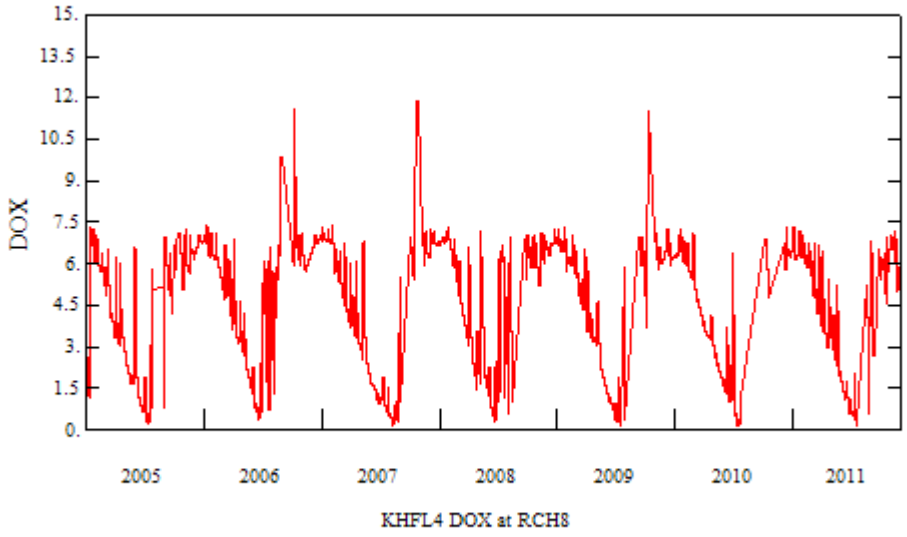
Graph 90: Model simulation result for NH3 (mg/L)



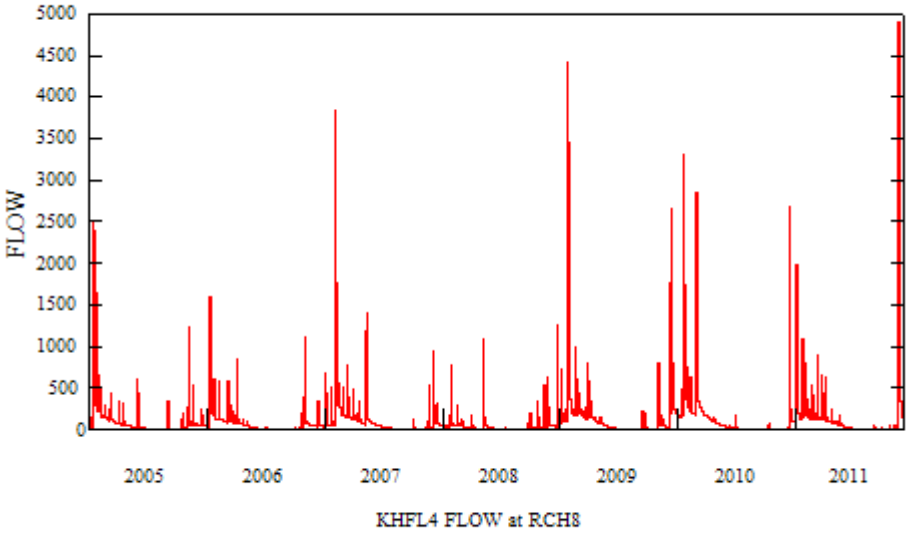
Graph 91: Model simulation result for F.Coliform (/100ml)



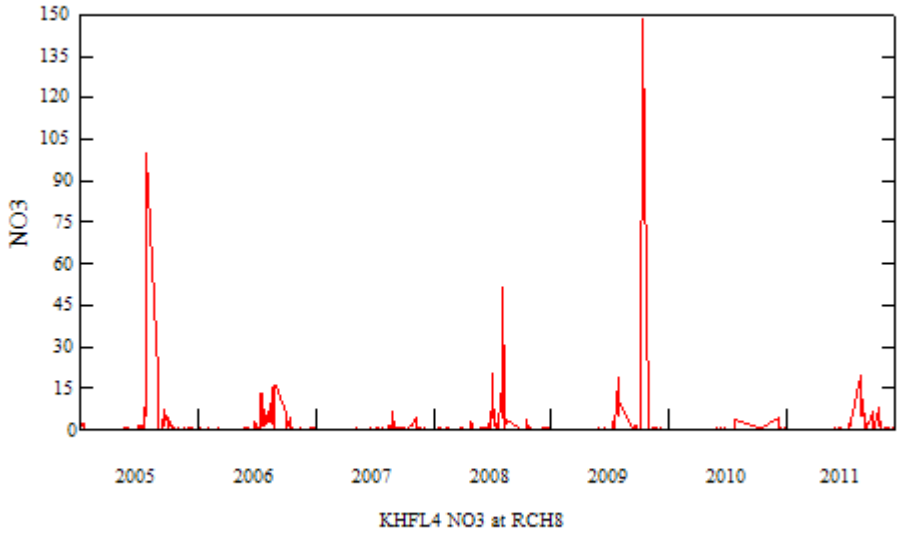
Graph 92: Model simulation result for BOD (mg/L)



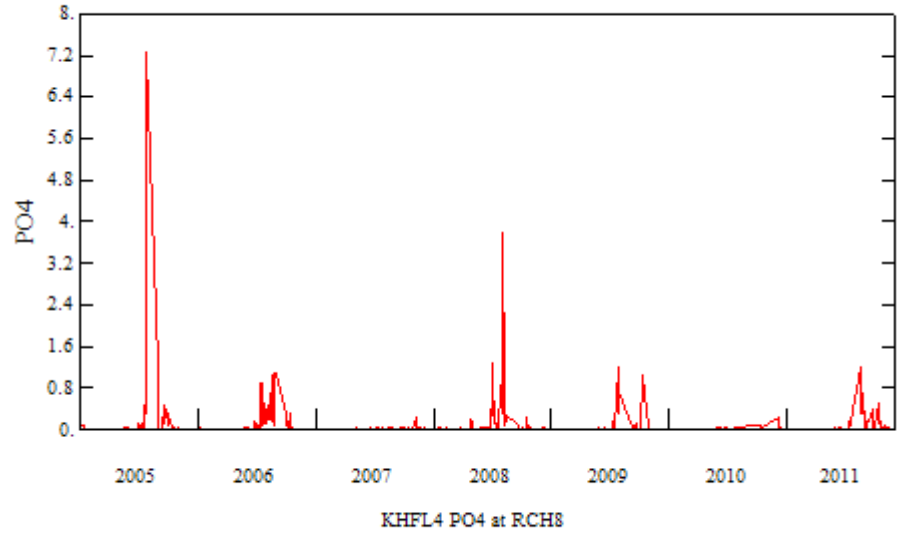
Graph 93: Model simulation result for DO (mg/L)



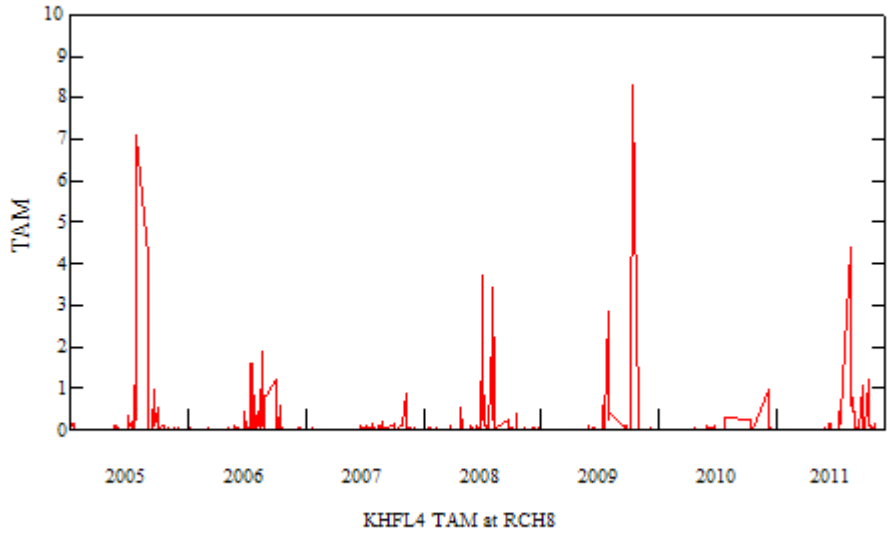
Graph 94: Model simulation result for Flow (m3/hour



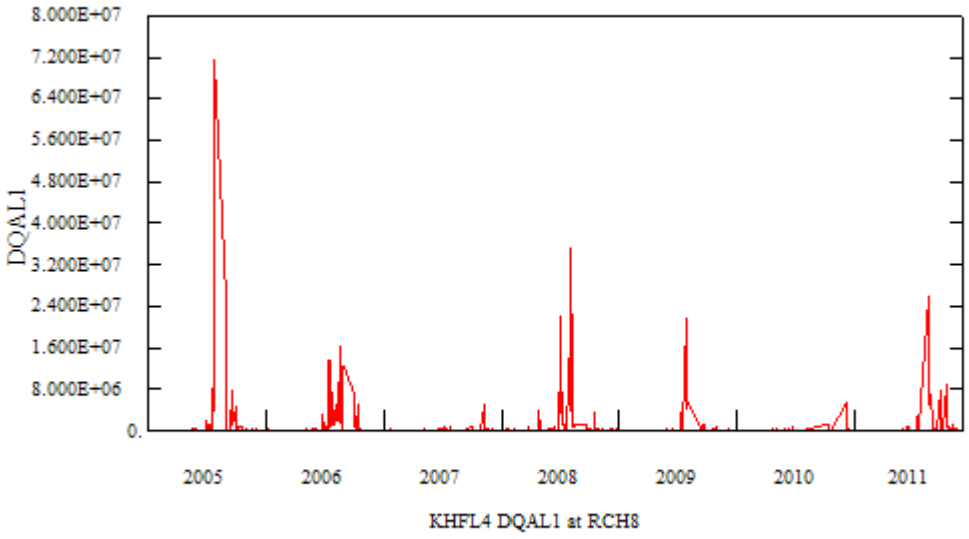
Graph 95: Model simulation result for NO3 (mg/L)



Graph 96: Model simulation result for PO4 (mg/L)



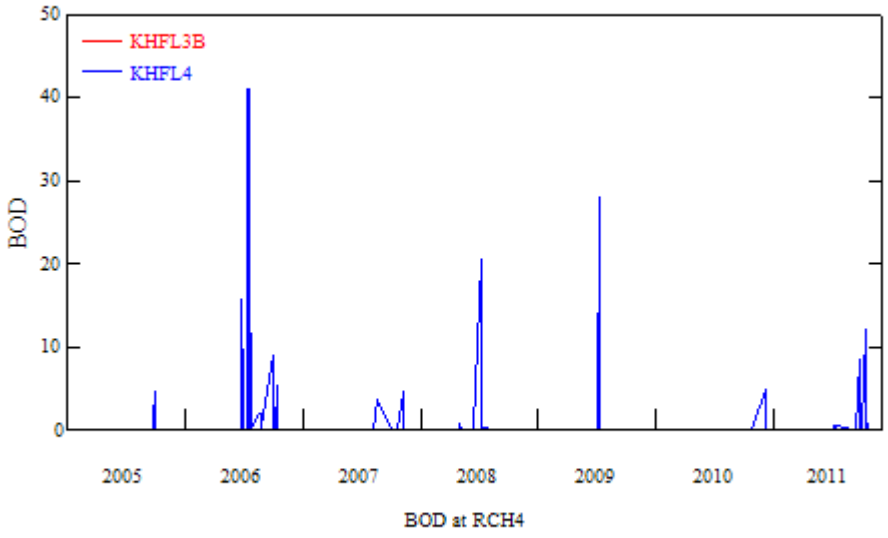
Graph 97: Model simulation result for NH3 (mg/L)



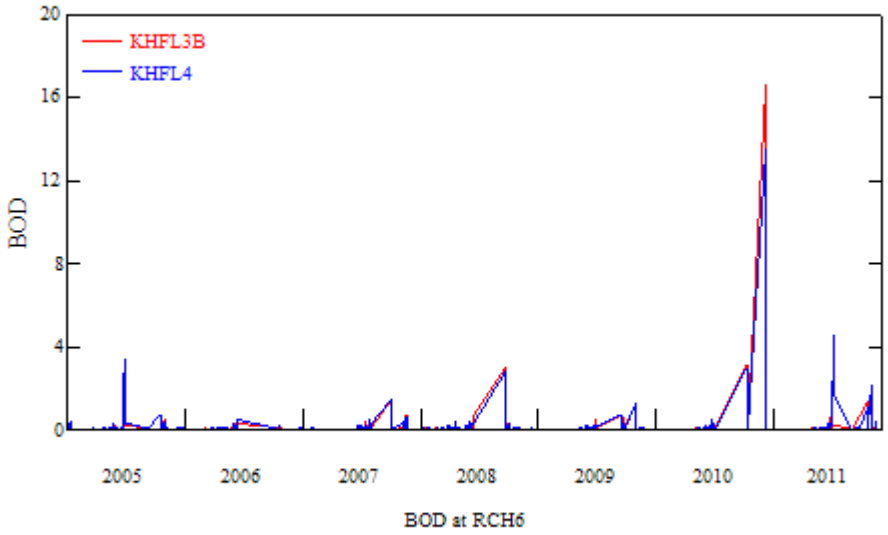
Graph 98: Model simulation result for F.Coliform (/100ml)

2.4 Comparison of scenarios, future Meteorological Vs Hydrological

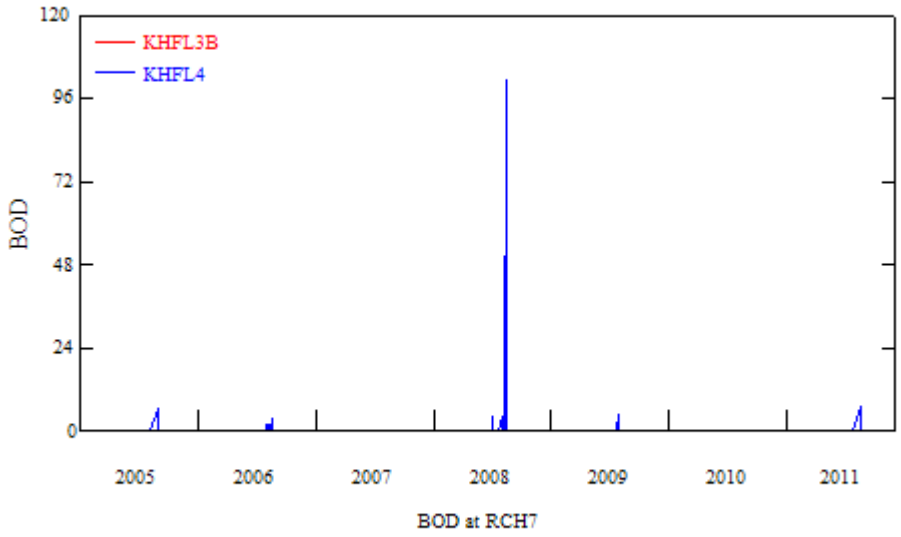
Comparing the two scenarios we conclude that hydrological shown lower concentrations of the pollutant loads in the understudy area. The above results are illustrated clearly in the following graphs.



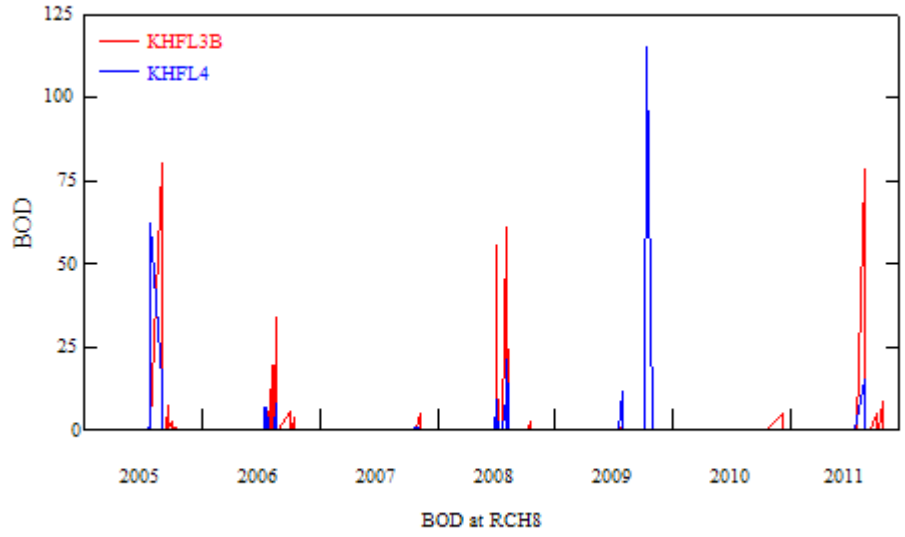
Graph 99: Model simulation result for BOD (mg/L)



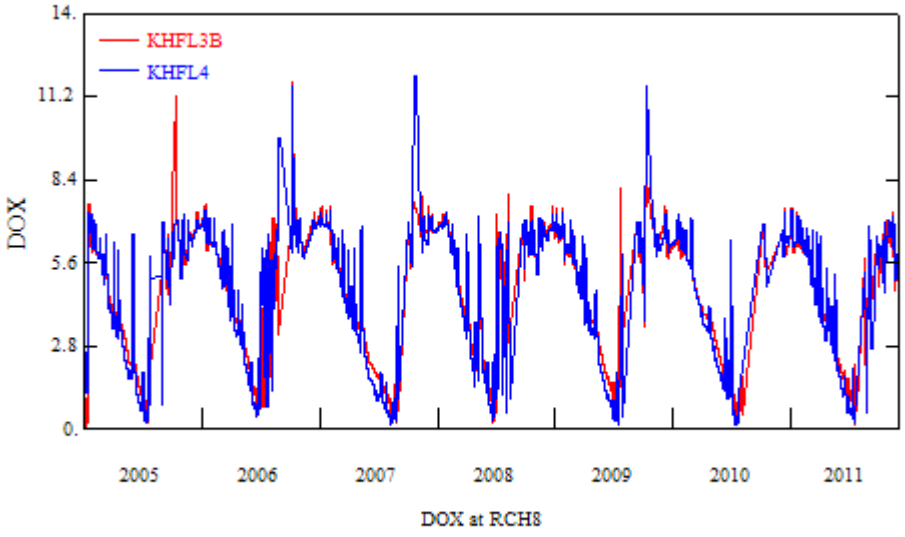
Graph 100: Model simulation result for BOD (mg/L)



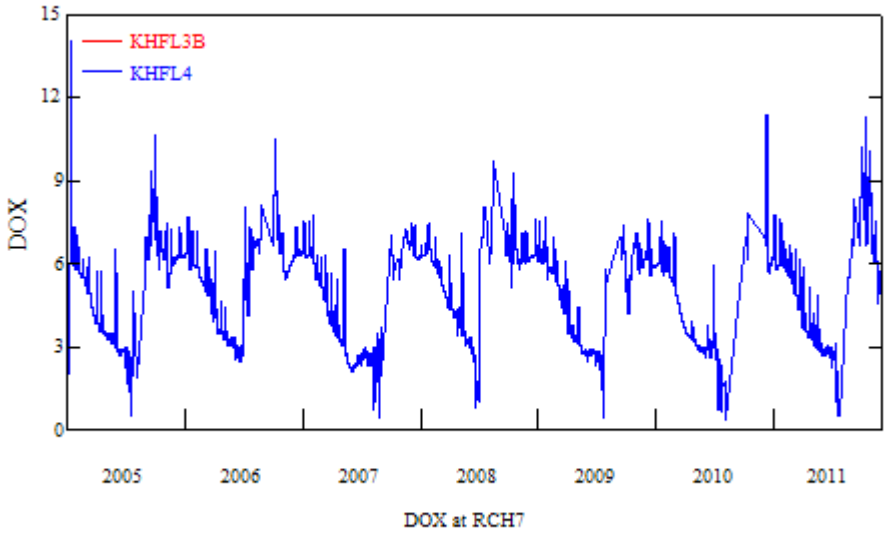
Graph 101: Model simulation result for BOD (mg/L)



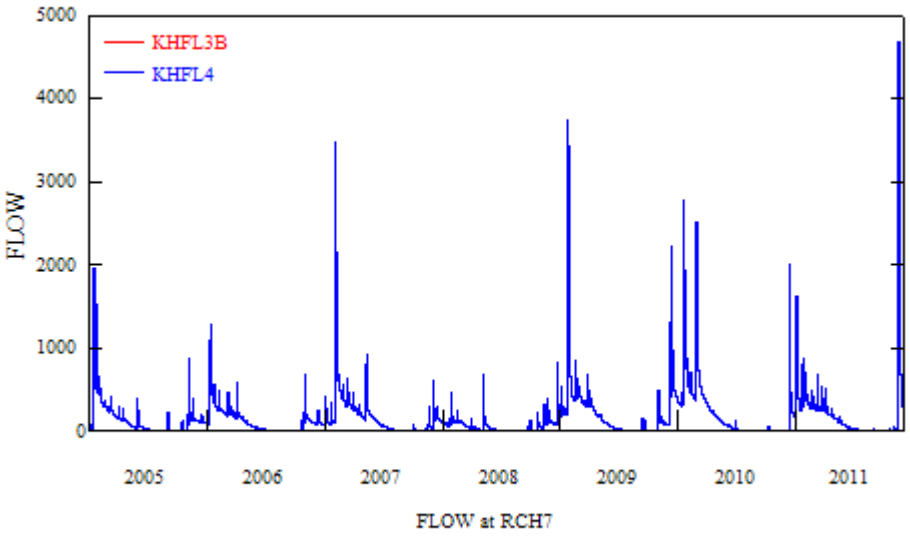
Graph 102: Model simulation result for BOD (mg/L)



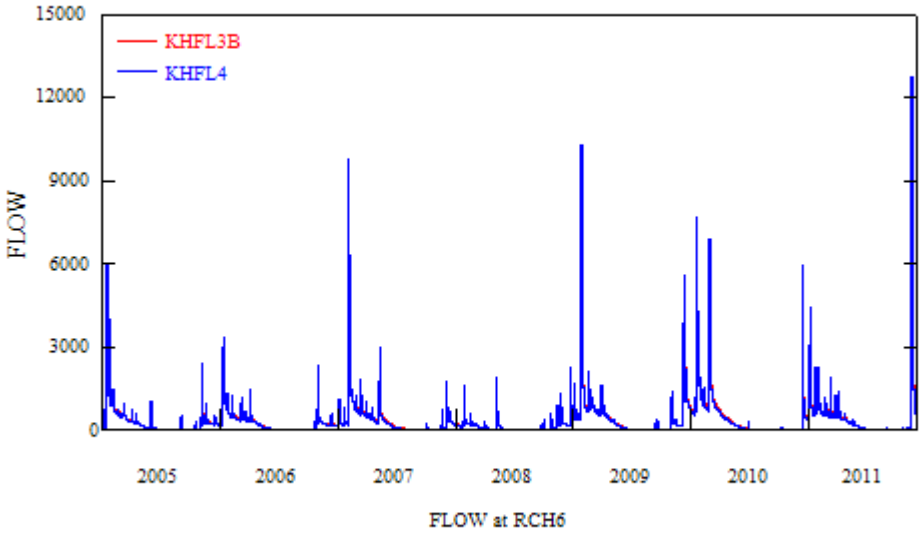
Graph 103: Model simulation result for DO (mg/L)



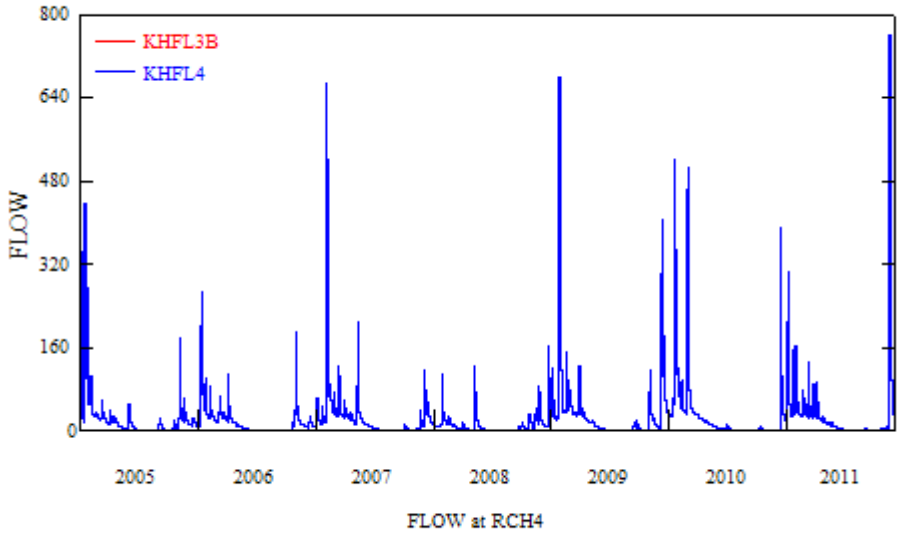
Graph 104: Model simulation result for DO (mg/L)



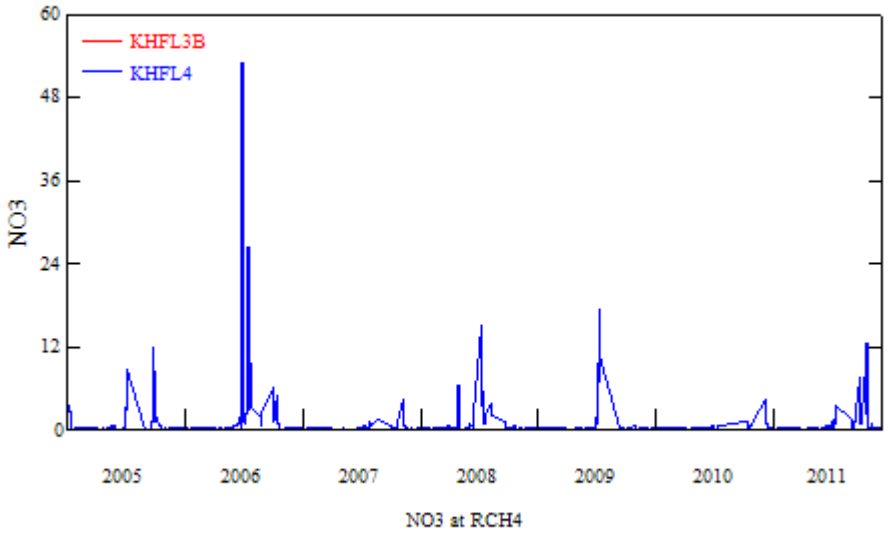
Graph 105: Model simulation result for Flow (m3/hour)



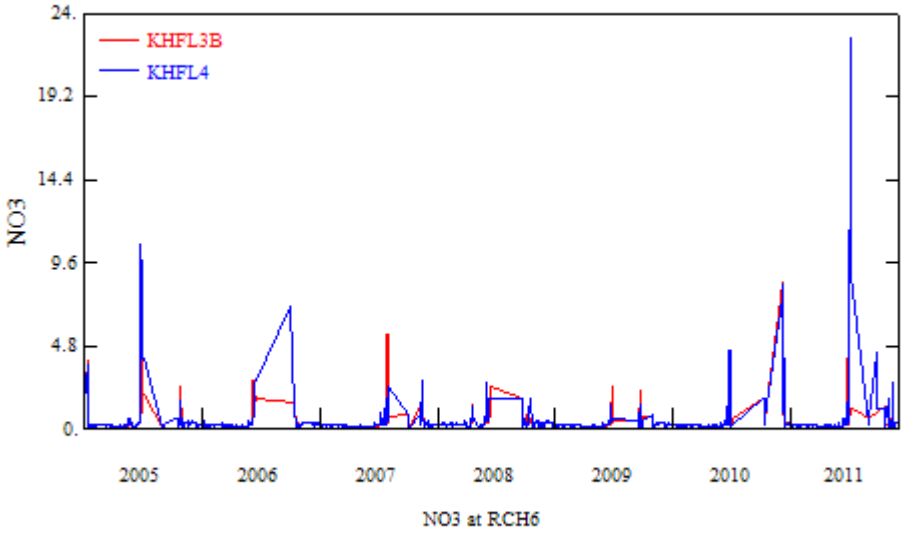
Graph 106: Model simulation result for Flow (m3/hour)



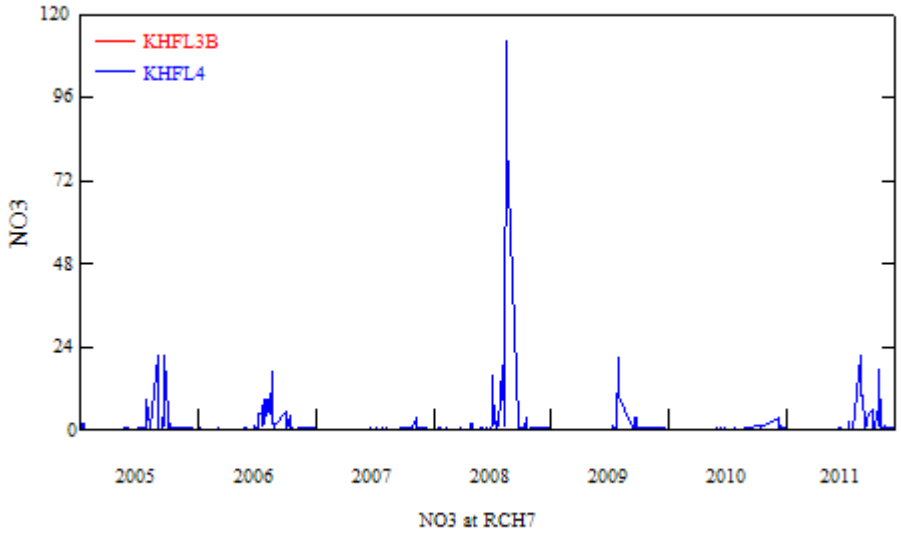
Graph 107: Model simulation result for Flow (m3/hour)



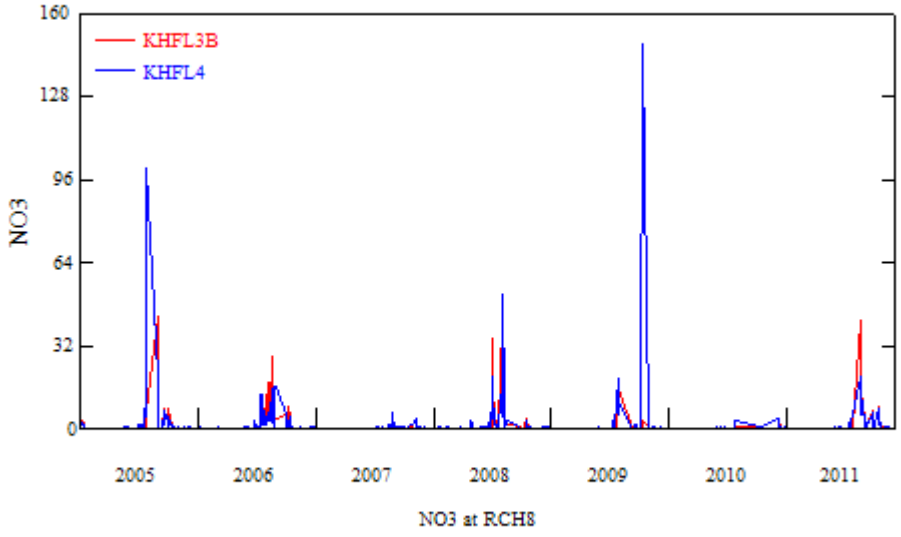
Graph 108: Model simulation result for NO3 (mg/L)



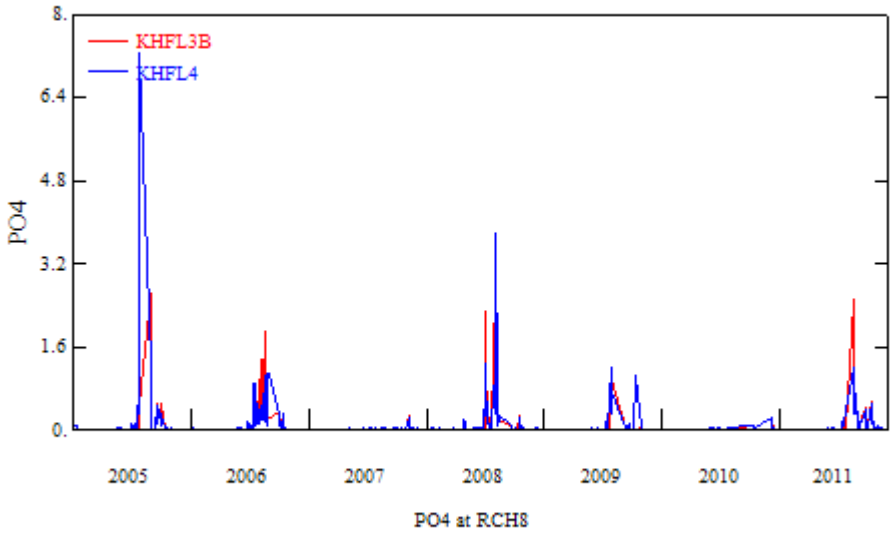
Graph 109: Model simulation result for NO3 (mg/L)



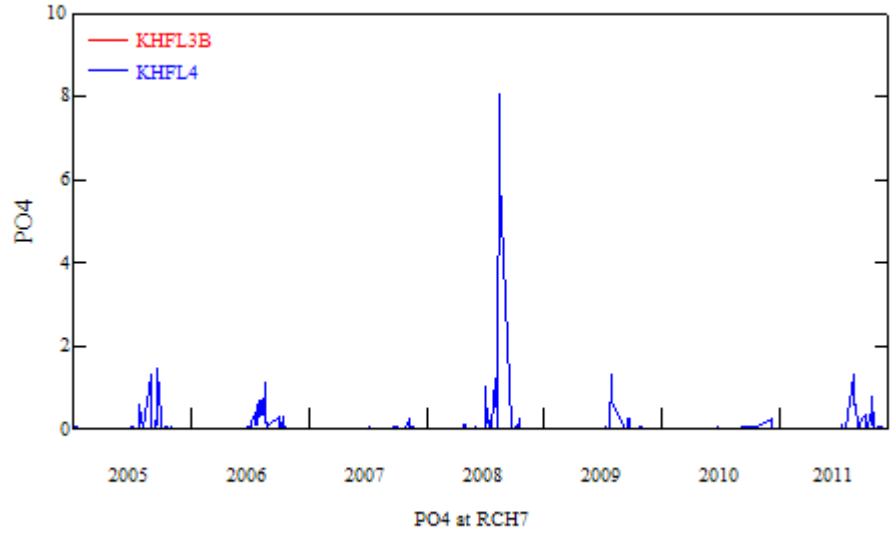
Graph 110: Model simulation result for NO3 (mg/L)



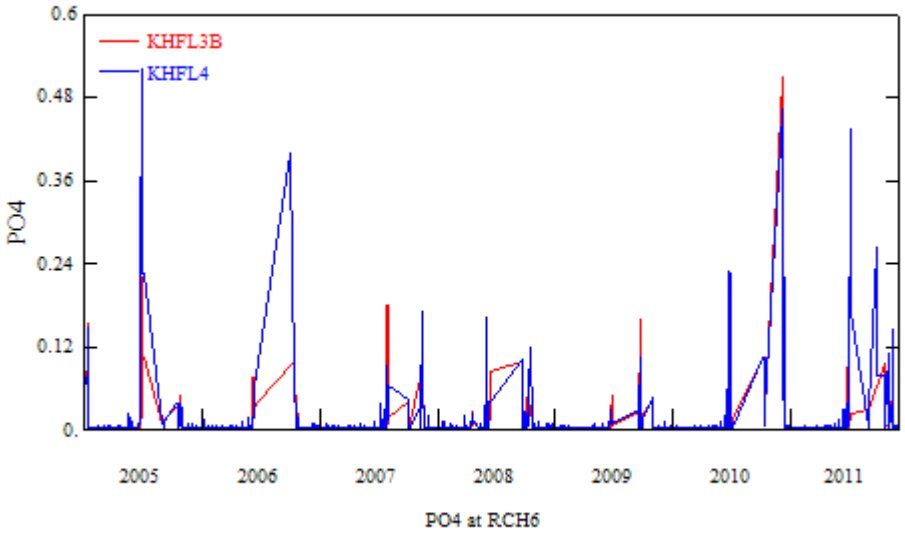
Graph 111: Model simulation result for NO3 (mg/L)



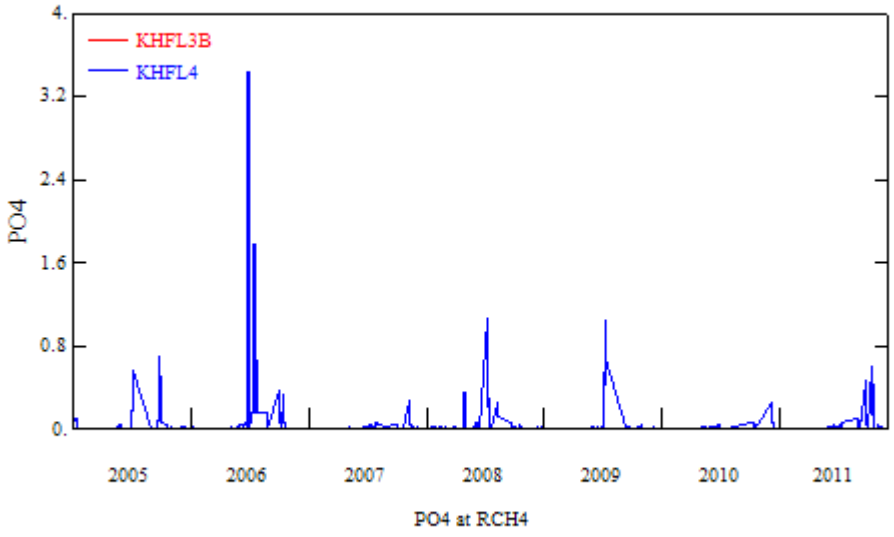
Graph 112: Model simulation result for PO4 (mg/L)



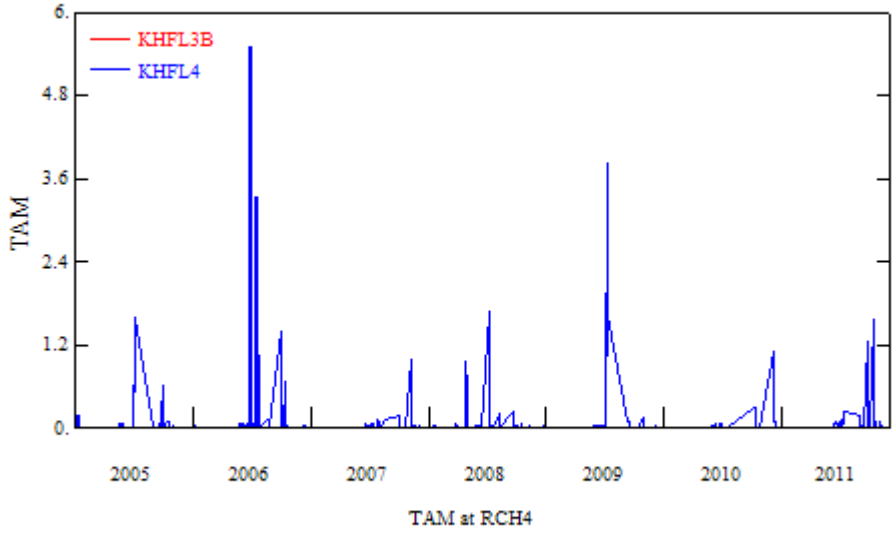
Graph 113: Model simulation result for PO4 (mg/L)



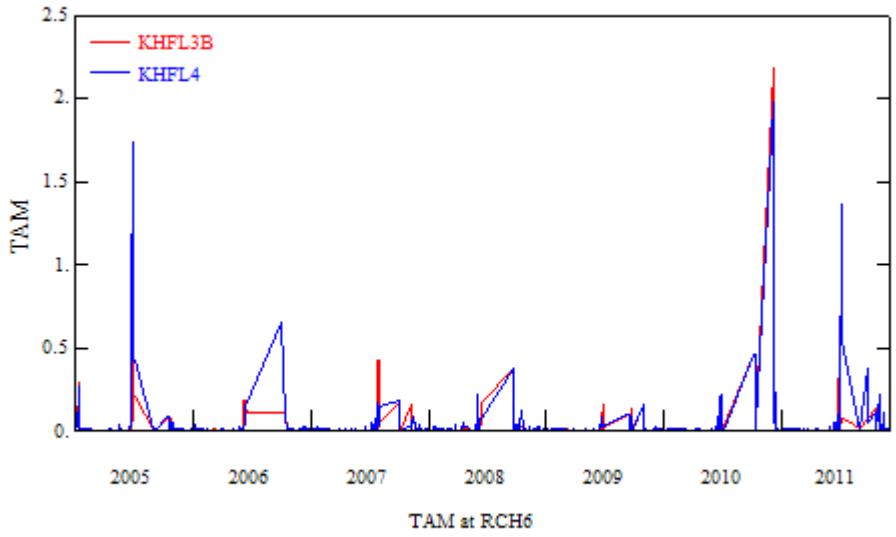
Graph 114: Model simulation result for PO4 (mg/L)



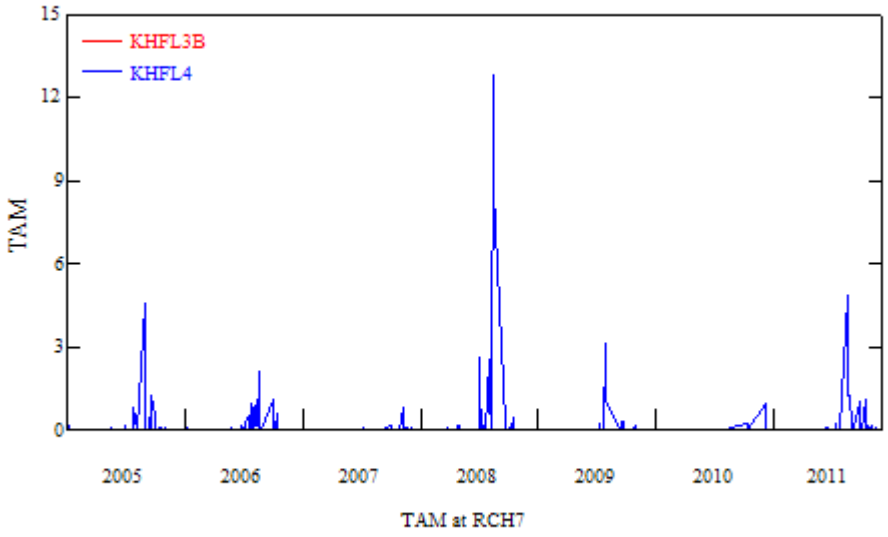
Graph 115: Model simulation result for PO4 (mg/L)



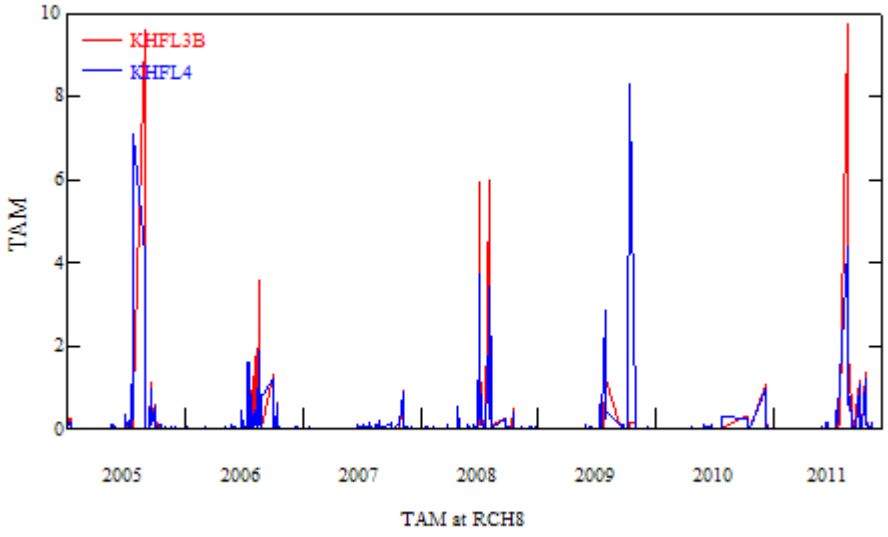
Graph 116: Model simulation result for NH3 (mg/L)



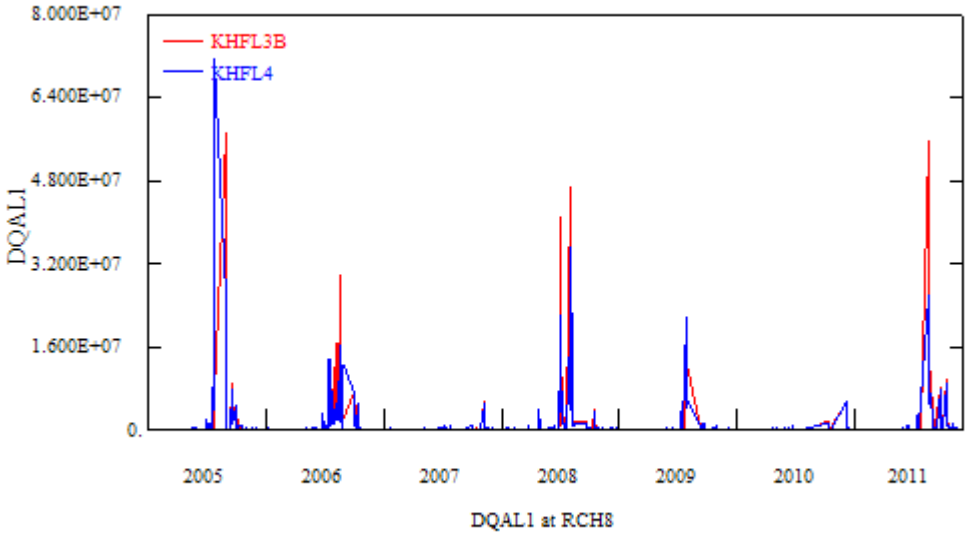
Graph 117: Model simulation result for NH3 (mg/L)



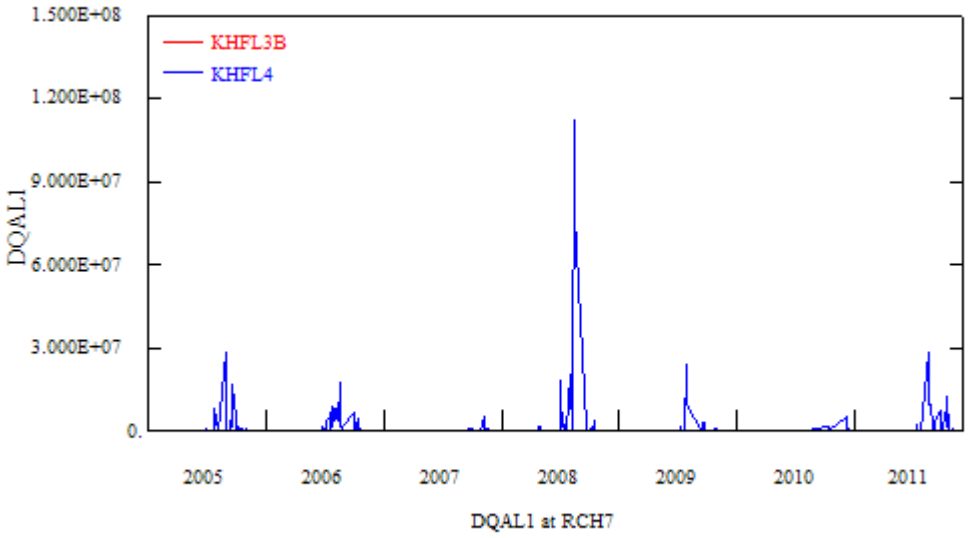
Graph 118: Model simulation result for NH3 (mg/L)



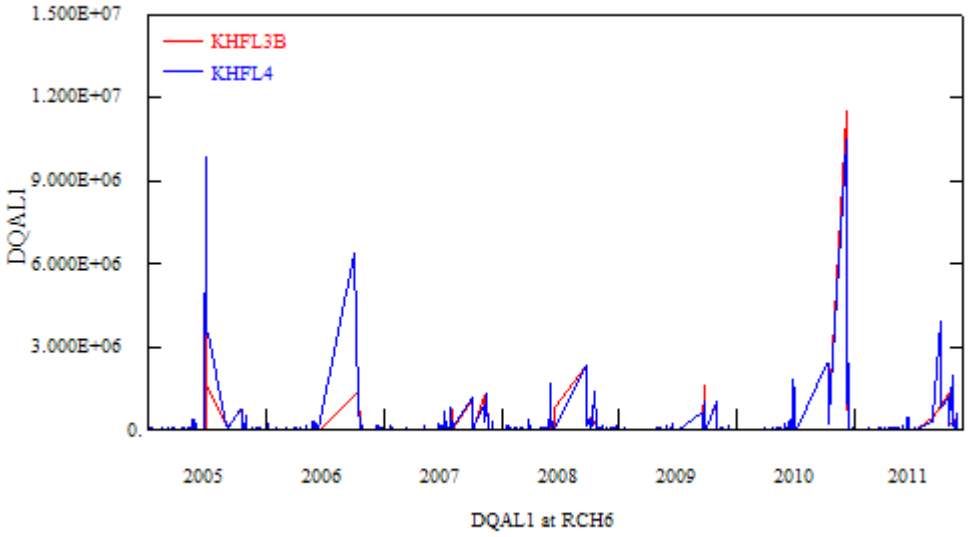
Graph 119: Model simulation result for NH3 (mg/L)



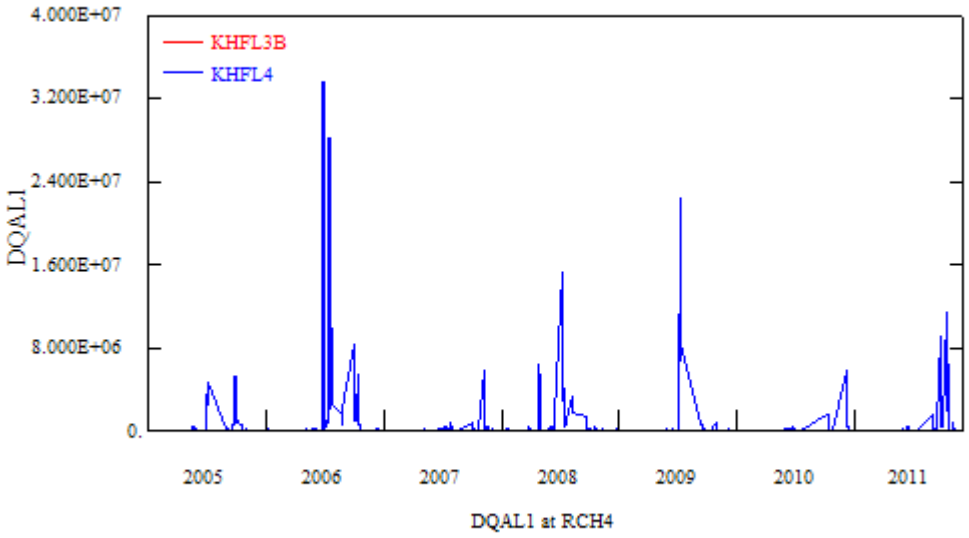
Graph 120: Model simulation result for F.Coliform (/100ml)



Graph 121: Model simulation result for F.Coliform (/100ml)



Graph 122: Model simulation result for F.Coliform (/100ml)



Graph 123: Model simulation result for F.Coliform (/100ml)

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6.http://water.epa.gov/

7. http://www.metoffice.gov.uk/precis/

4.Annex

Table 1: PRECIS downscaling results, Larnaca Airport

year	month	day	PREC	EVAP	ATEM	WIND	SOLR	PEVT	DEWP	CLOU
2020	1	1	0	3.99	9.1	5.58	0.659534	0.59	4.126	0.12
2020	1	2	0	3.66	8.11	4.43	0.494177	0.56	2.84	0.13
2020	1	3	0	3.06	9.02	2.86	0	0.53	4.76	0.45
2020	1	4	2.91	1.94	13.35	5.76	0.328744	1.03	10.714	0.98
2020	1	5	0.11	3.53	13.82	7.62	0.625924	0.81	9.322	0.57
2020	1	6	2.01	2.26	12.83	4.63	0.614885	1.09	9.826	0.37
2020	1	7	0	4.18	10.37	4.03	0.614064	0.8	5.686	0
2020	1	8	1.27	2.78	11.31	3.86	0.67452	0.52	8.202	0.5
2020	1	9	2.11	2.49	14.67	7.51	0.949054	1.34	11.482	0.98
2020	1	10	4.53	2.83	12.63	8.2	0.815126	0.98	8.58	0.59
2020	1	11	0	4.74	9.15	4.7	0.793463	0.91	2.46	0
2020	1	12	5.47	3.33	13.07	7.71	0.660106	1.81	10.3	0.53
2020	1	13	0	6.42	9.03	6.39	0.638675	1.24	1.196	0
2020	1	14	0	4.86	7.12	6.02	0.556563	0.8	0.586	0.16
2020	1	15	0	6.27	9.04	8.58	0.858528	0.86	1.642	0
2020	1	16	0	5.6	10.06	6.67	0.554442	0.88	3.008	0.01
2020	1	17	0	5.3	10.36	4.99	0	0.9	3.672	0
2020	1	18	0	5.05	11.54	4.11	0.742955	0.95	5.532	0.25
2020	1	19	0	4.69	12.96	3.99	0.951779	0.88	8.064	0.4
2020	1	20	0.06	5.65	15.37	4.99	0.909728	1	9.042	0.96
2020	1	21	0.04	3.22	14.93	3.7	0.947606	0.69	9.576	1
2020	1	22	0.96	3.92	16.23	4.22	0.487654	0.94	10.512	1
2020	1	23	2.51	6.22	16.93	4.93	0.853894	1.19	12.808	1
2020	1	24	1.57	0.81	13.38	4.09	0.554705	0.59	11.216	0.55
2020	1	25	1.64	1.68	10.64	3.29	0.444666	0.73	8.978	0.55
2020	1	26	1.07	2.19	11.06	5.98	0.571712	1.11	7.77	0.85
2020	1	27	0.93	0.91	10.02	3.71	0.353965	0.45	8.708	0.75
2020	1	28	5.13	1.64	9.91	2.77	0.137302	0.67	7.33	0.56
2020	1	29	3.77	1.44	10.03	4.29	0.684728	1.04	7.334	0.37
2020	1	30	4.25	0.08	7.65	3.68	0.195122	0.06	6.138	0.5
2020	1	31	4.25	0.08	7.65	3.68	0.661642	0.06	6.138	0.5

PREC= precipitation (mm/day)
EVAP= evaporation (mm/day)
ATEM= air temperature (C)
WIND= wind speed (m/s)
SOLR= solar radiation
PEVT= potential evapotranspiration (mm/day)
DEWP= dewpoint temperature
CLOU= cloud cover