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# Managing Performance for Small to Medium Sized Water Utilities: A Component and System Based Approach

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# Motivation and Research Question

**Lake Country BC, TUESDAY, NOVEMBER 16, 2010**

A Water Service Interruption due to a **water main break and Boil Water Notice** have been issued for users in the vicinity of Okanagan Centre area. Effected customers include users west of Camp Road and Davidson Road intersection to Okanagan Lake.

(Source: http://lakecountrybc.blogspot.ca/2010/11/water-main-break.html)


Source: practicalplumbingadvice.tumblr.com

**Glenmore-Ellison Improvement District (GEID) BC, JULY 19 , 2013**

**Water main break** overnight July 18-19th in the 4400 block Anderson rd. **Water off for all residents on Anderson Rd North to Teather.** Also affects black rd. Crews Enroute. Expect water off 'til 4pm Thursday.

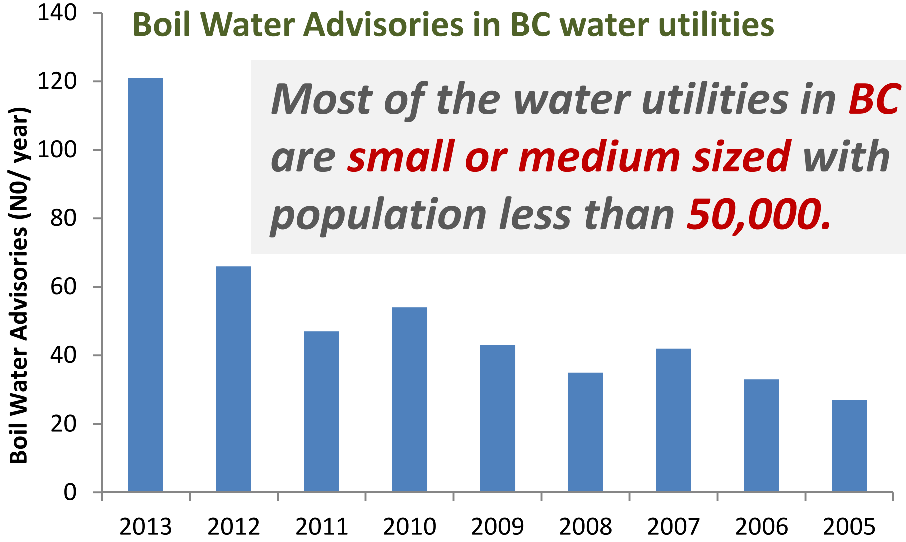
(Source: http://glenmoreellison.com/news/news/Home_Page_Alert/12/07/19/WATER_BREAK_ANDERSON_BLACK_RD)

**City of Vernon BC, SEPTEMBER 19, 2013**

Flushing removes accumulated sand and silt from the water mains and is a process used to improve water quality for public health. **Annual Water Main flushing** continues in the City of Vernon and Electoral Areas. When crews are flushing in your area you may notice a **reduction in water pressure**, additional sediment or **discoloration of the water.** During this time, you may choose to **boil or not drink the water.**

(Source: http://www.rdno.ca/index.php/services/engineering/water/greater-vernon-water/annual-water-main-flushing)

# Performance Issues in Smaller Utilities




***Most of the water utilities in BC are small or medium sized with population less than 50,000.***

As per water.ca website, the water supply systems in province of British Columbia had gone through maximum no. of water quality advisories in the past.

(Source: http://www.water.ca/textm.asp)

| | | | |
|---|---|---|---|
| Water Quality Advisory | Kingbaker Creek Resort Water System | 31-May-12 | **Source Water Contamination** |
| Water Quality Advisory | Lakeshore Waterworks Ltd. | 29-Oct-12 | **Flushing or Fire Flow Testing** |
| Water Quality Advisory | Riddell Bay Water Society | 02-Nov-12 | **Other** |
| Do Not Use Water Notice | Hampton Campground Water System | 03-Dec-12 | **Source Water Contamination** |
| Water Quality Advisory | Naramata Water System | 18-Feb-13 | **Construction /Repairs / Maintenance** |
| Water Quality Advisory | La Casa On The Lake Water System | 09-May-13 | **Source Water Contamination** |
| Water Quality Advisory | South East Kelowna Irrigation District | 04-Jun-13 | **Turbidity** |
| Water Quality Advisory | Cherryville Estates MHP Water System | 31-Jul-13 | **Equipment Failure** |
| Water Quality Advisory | Log Barn Fruitstand Water System | 26-Sep-13 | **Inadequate Disinfection / Treatment** |

(Source: http://www.interiorhealth.ca/YourEnvironment/InspectionReports/Pages/WaterNotifications.aspx)

## Research Motivation and State of the Problem

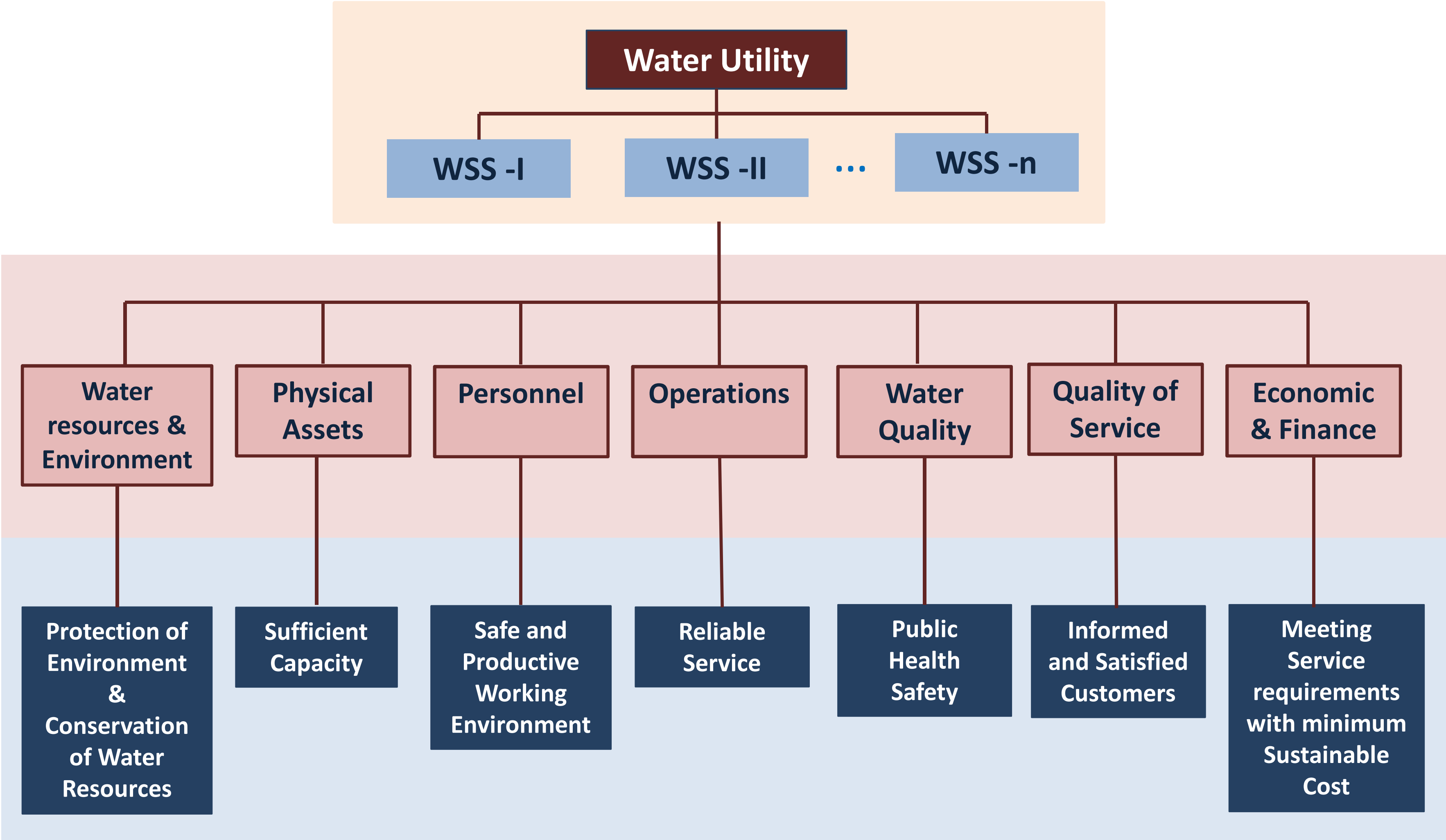
- As per 2013 public report, the wastewater and water utilities have been participating in National Water and Wastewater Benchmarking Initiative (NWWBI) since 2003 and 2005, respectively in Canada.
- Most of them are large water utilities (50% of Canadian utilities covering more than 60% of the population) with population > 50,000 **(AECOM 2013).**
- So far, the participation of small and medium sized water utilities (SMWU) has almost been negligible in NWWBI.

## Research Motivation and State of the Problem

SMWU are facing serious challenges to meet broad sustainability objectives due to:

- lack of technical, human and financial resources ;
- limited knowledge about the benchmarking process; and
- less economies-of-scale, such utilities are discouraged from deficiency performance.

## Functional Components of a Water Utility




In this research, the sustainability criteria for SMWU are defined as, ***"all the functional components of a water utility are desired to meet their respective performance objectives".***

## Performance Indicator - Definition

- Performance Indicator (PI) is a parameter or a value **derived from other** parameters (**data variables**), which provides information about the achievements of an activity, or a process **with a significance extending beyond that directly associated with the calculated value** of the parameter itself.

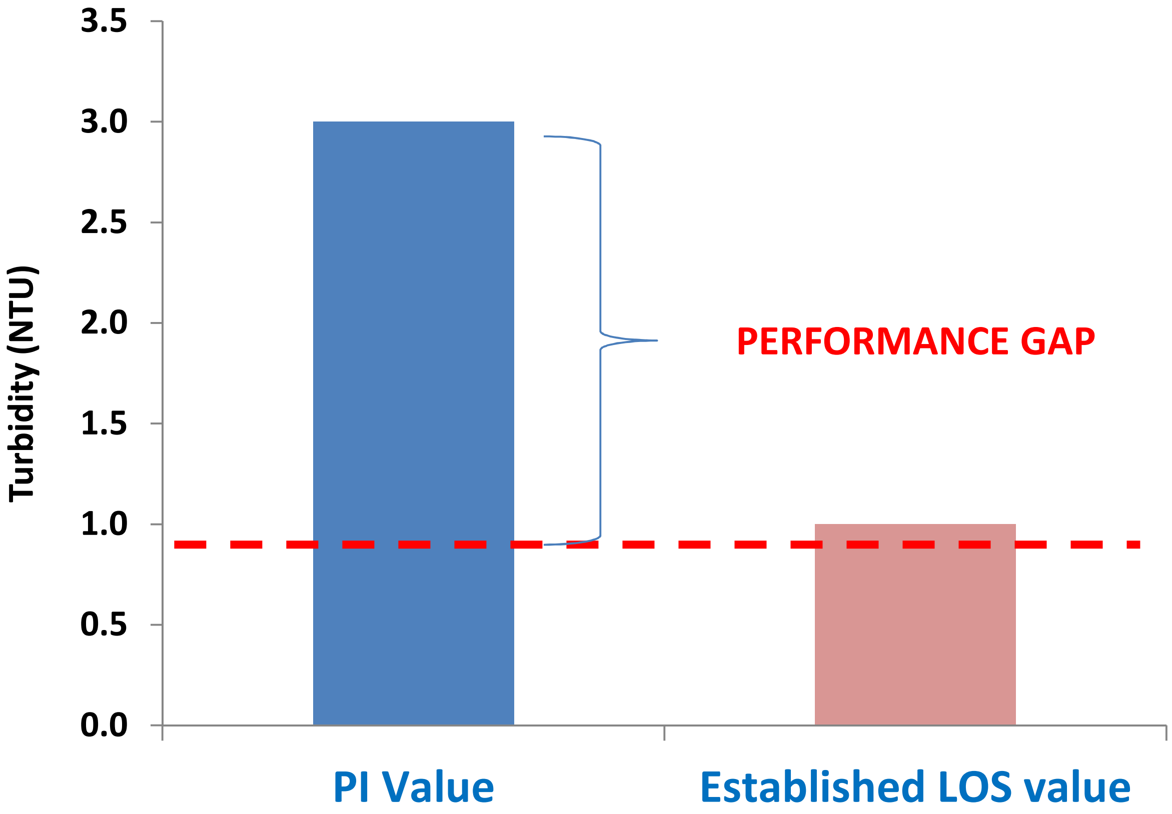
- Example:

Data Variables

[(No of Pressure Complaints) / (1000 people served)]

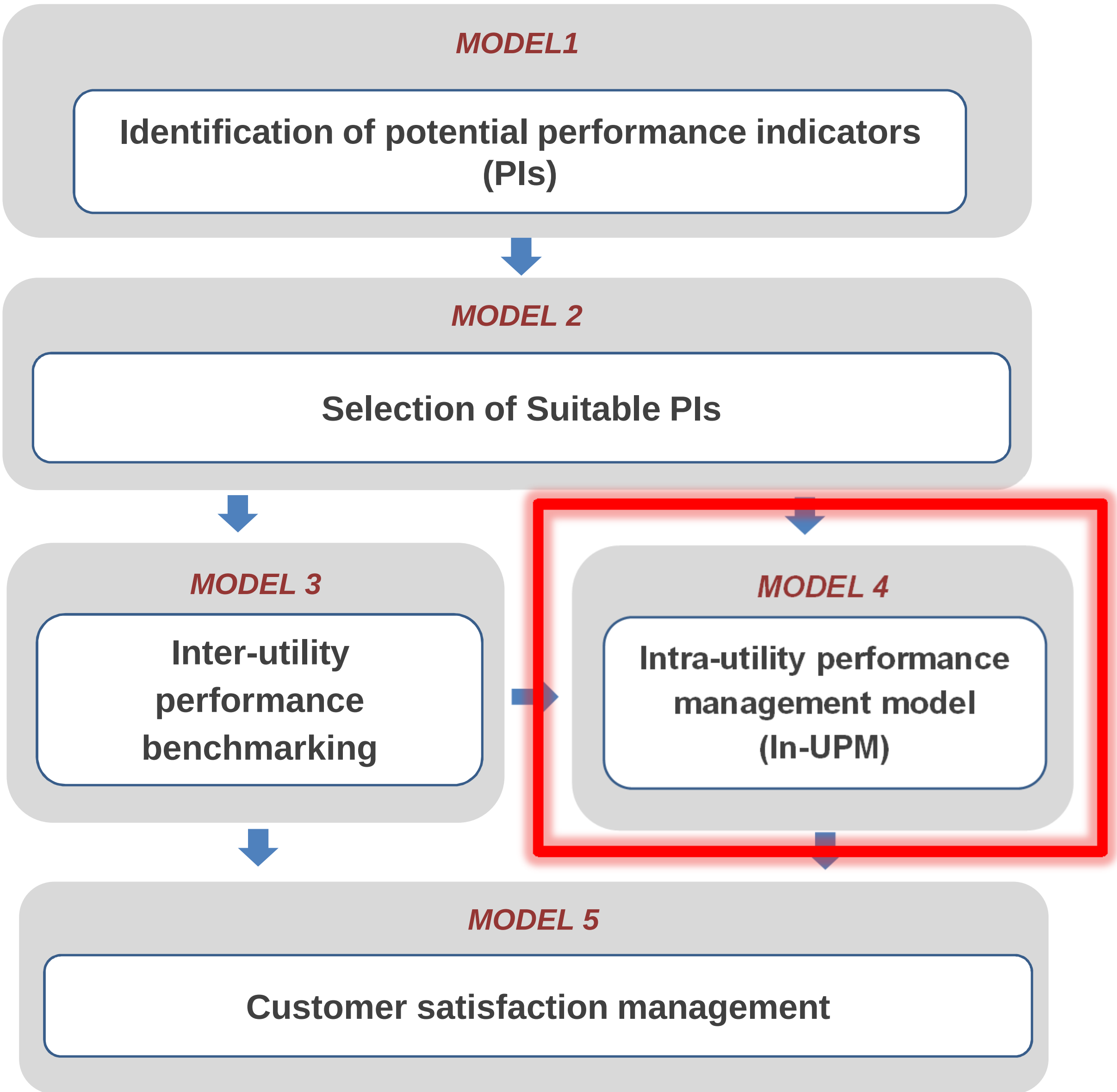
- Hydraulic performance of water distribution systems
- Customers satisfaction
- Denominator makes it comparable with other utilities

## Performance Assessment - Concept

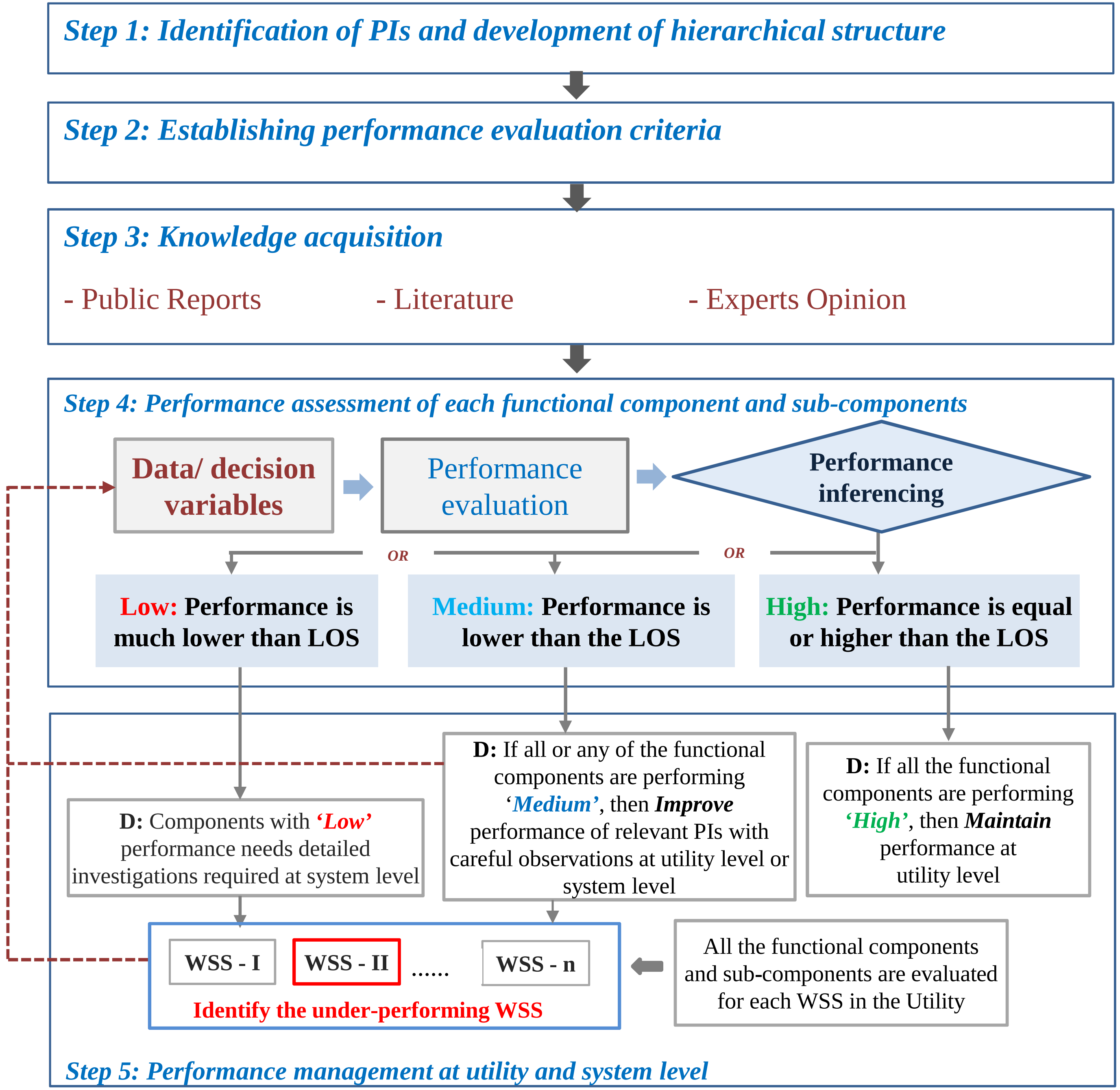



LOS : Level of service

# Overall Performance Management Framework for SMWU



# In-UPM Framework



## Example

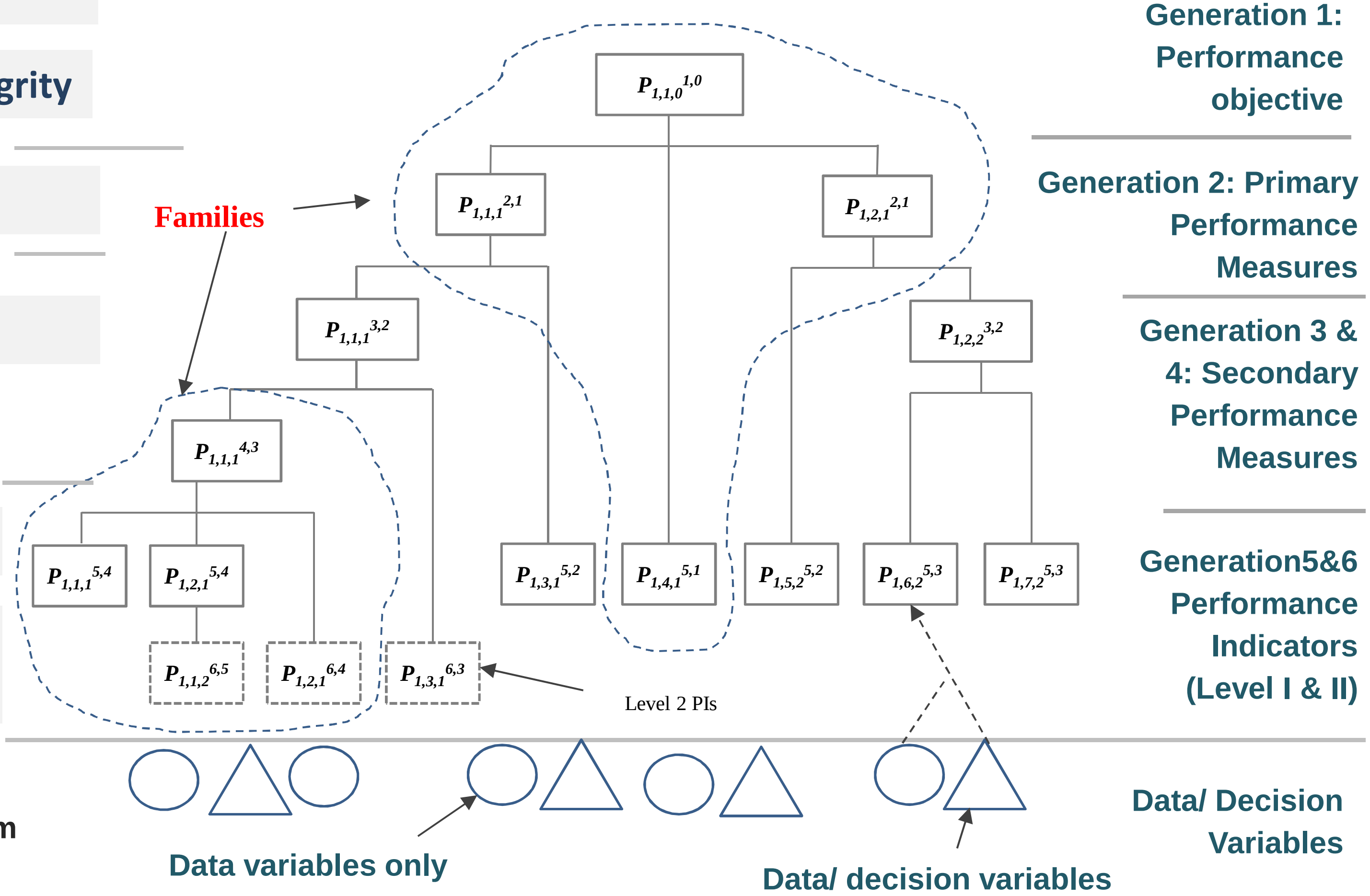
## Operational Integrity

**DS Performance**

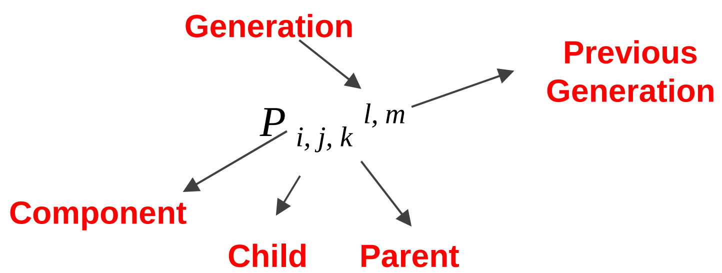
**DS Failures**

**Main Breaks**

**Hydrant Failures**




DS: Distribution System



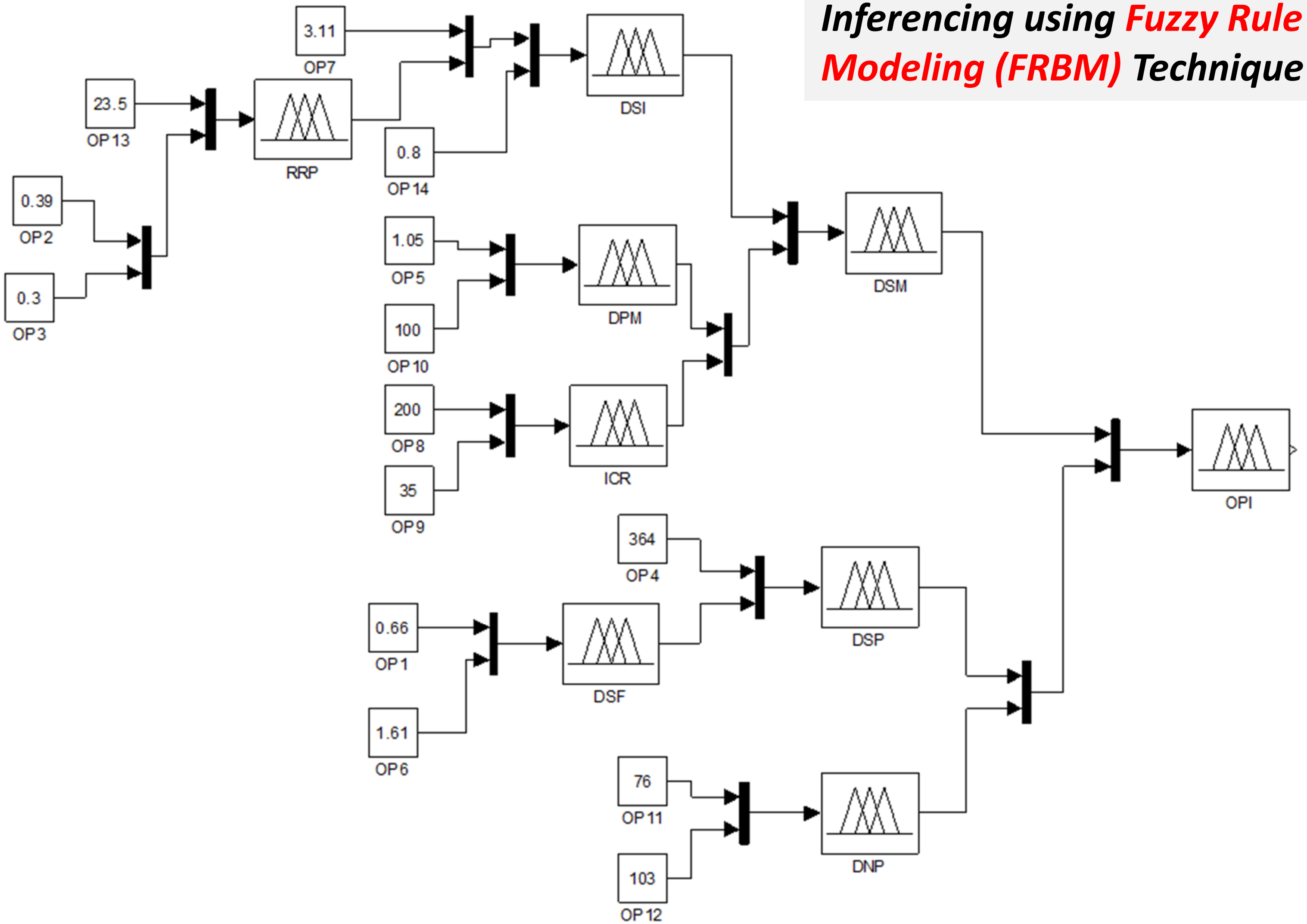

# (In-UPM) Methodology

# In-UPM – An Example of Operational Component

| Generation 1 Performance objective | Generation 2 - Primary PMs | Generation 3&4 - Secondary PMs | Generation 5&6 - Performance Indicators | Data Variables / Decision Variables | Decision Actions |
|---|---|---|---|---|---|
| $P_{4,1,0}^{1,0}$ - Operational Integrity | $P_{4,1,1}^{2,1}$ - Distribution system integrity<br>$P_{4,2,1}^{2,1}$ - Distribution system performance<br>$P_{4,3,1}^{2,1}$ - Distribution network productivity | $P_{4,1,1}^{3,2}$ - Distribution system maintenance<br>$P_{4,2,1}^{3,2}$ - Delivery point maintenance<br>$P_{4,3,1}^{3,2}$ - Inspection and cleaning routine<br>$P_{4,4,2}^{3,2}$ - Distribution system failure<br>$P_{4,1,1}^{4,3}$ - Rehabilitation and replacement of pipes | $P_{4,10,4}^{5,3}$ - OP1: Pipe breaks (C1,D12)<br>$P_{4,2,1}^{5,4}$ - OP2: Pipes replaced (C1,D8)<br>$P_{4,3,1}^{5,4}$ - OP3: Pipes rehabilitated (C1,D7)<br>$P_{4,12,2}^{5,2}$ - OP4: Non-revenue water (A1,C6,D11)<br>$P_{4,6,2}^{5,3}$ - OP5: Service connection rehabilitation (C6,D10)<br>$P_{4,11,4}^{5,3}$ - OP6: Inoperable hydrants and valves (C12,D13)<br>$P_{4,4,1}^{5,3}$ - OP7: Valves replaced (C13,D9)<br>$P_{4,8,3}^{5,3}$ - OP8: Hydrants inspection (C12,D6)<br>$P_{4,9,3}^{5,3}$ - OP9: Cleaning of storage tanks (C5,D4)<br>$P_{4,7,2}^{5,3}$ - OP10: Operational meters (C6,D14)<br>$P_{4,13,3}^{5,2}$ - OP11: Network efficiency (A3,C1)<br>$P_{4,14,3}^{5,2}$ - OP12: Customer density (C1,E1)<br>$P_{4,1,1}^{5,4}$ - OP13: Average pipe age (C14)<br>$P_{4,5,1}^{5,3}$ - OP14: Implementation level of risk based pipes' rehabilitation and replacement plan | **A1:** Average annual demand<br>**A3:** Average daily demand<br>**C5:** Total capacity of treated water storage reservoirs<br>**C6:** Total number of service connections<br>**C12:** Total number of hydrants<br>**C13:** Total number of valves<br>**C14:** Average pipe age<br>**D4:** Volume of the treated water reservoirs cleaned<br>**D6:** Hydrants inspected during<br>**D7:** Lengths of mains rehabilitated<br>**D8:** Lengths of mains replaced<br>**D9:** Number of replaced valves<br>**D10:** Number of service connections repaired<br>**D11:** Annual billed metered consumption<br>**D12:** Mains failures/ breaks<br>**D13:** Number of leaking hydrants<br>**D14:** Operational meters | **D4:** Increase frequency of cleaning the treated water reservoirs to at least once a year<br>**D6:** Increase hydrant inspection frequency<br>**D7:** Increase optimally the rehabilitation rate of water mains<br>**D8:** Increase optimally replacement rate of water mains<br>**D9:**Increase replacement rate of faulty or leaking valves to increase distribution system integrity<br>**D10:** Increase service connection inspection rate to detect minor or major repairs in order to improve system integrity and reduce water loss<br>**D14:** Increase implementation level of risk based pipes' rehabilitation and replacement plan<br><br>**Note:** Optimization of rehabilitation and replacement of water pipes means that it should be done with risk planning keeping in view the pipe age, and hydraulic and structural integrity. |

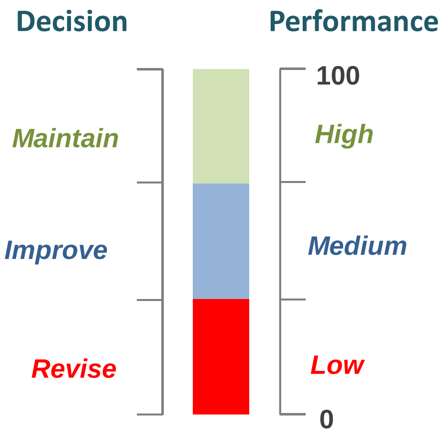
# In-UPM – Analysis for Operational Component using *MATLAB-SIMULINK*

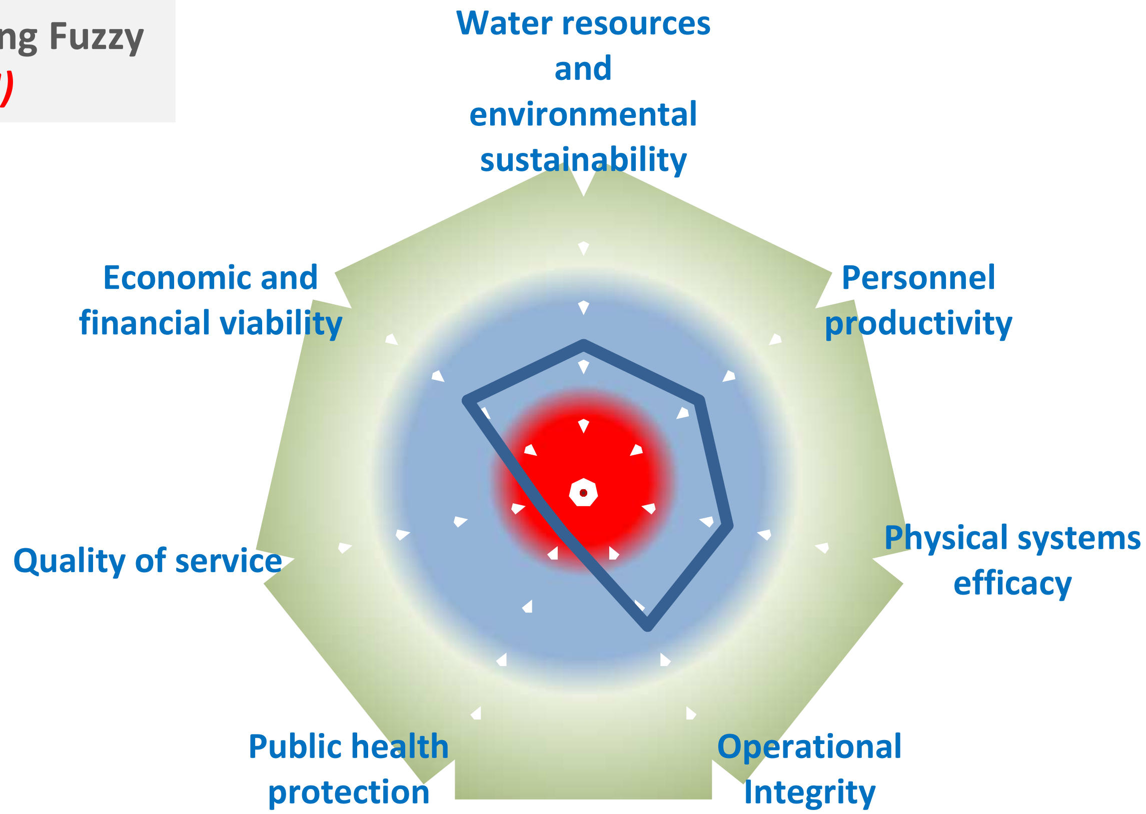
***Inferencing using Fuzzy Rule Based Modeling (FRBM) Technique***



# In-UPM Results for FY 2012

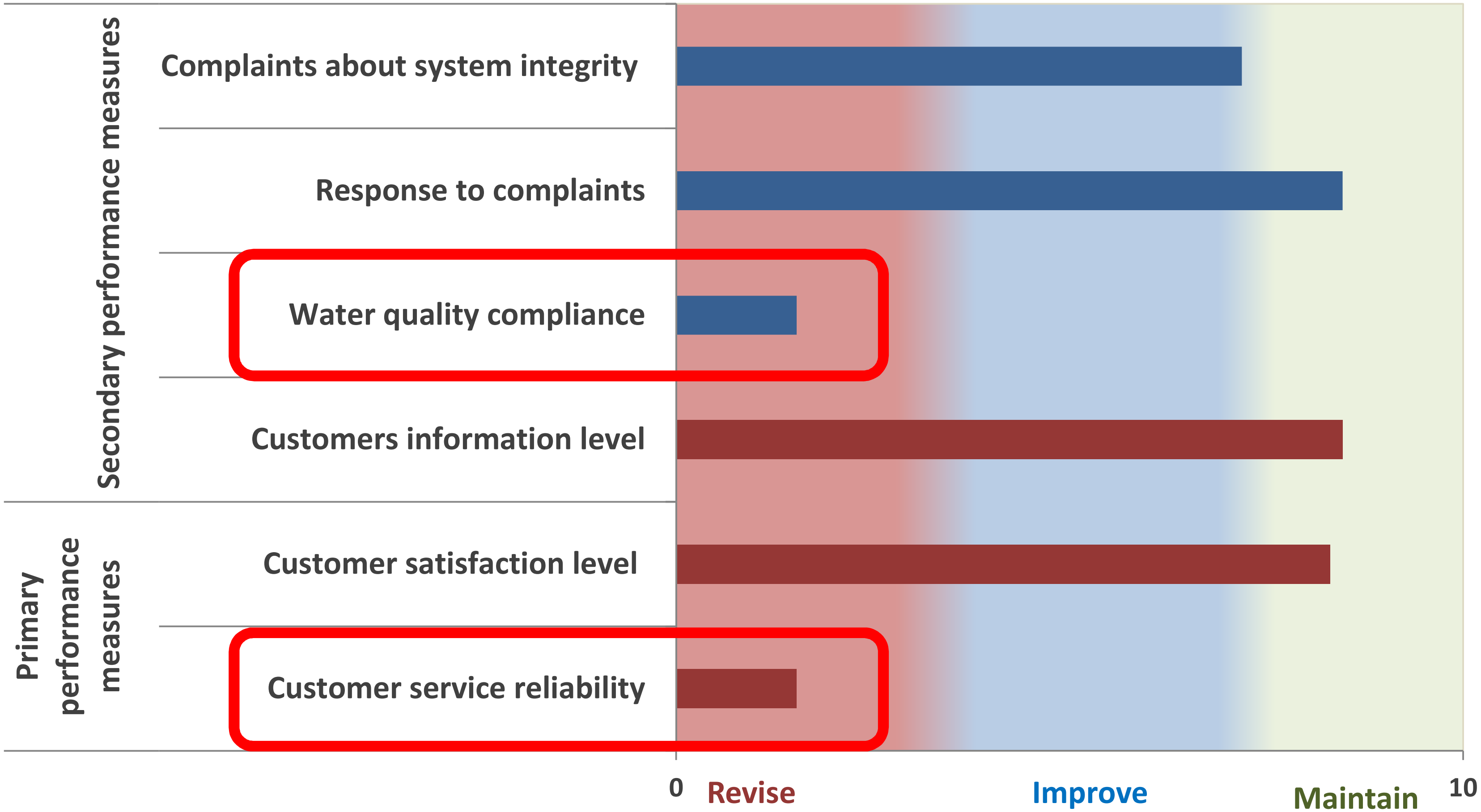
Performance inferencing using Fuzzy *Rule Based Modeling (FRBM)*




*Utility Level Performance Assessment*

# In-UPM Results at Utility Level

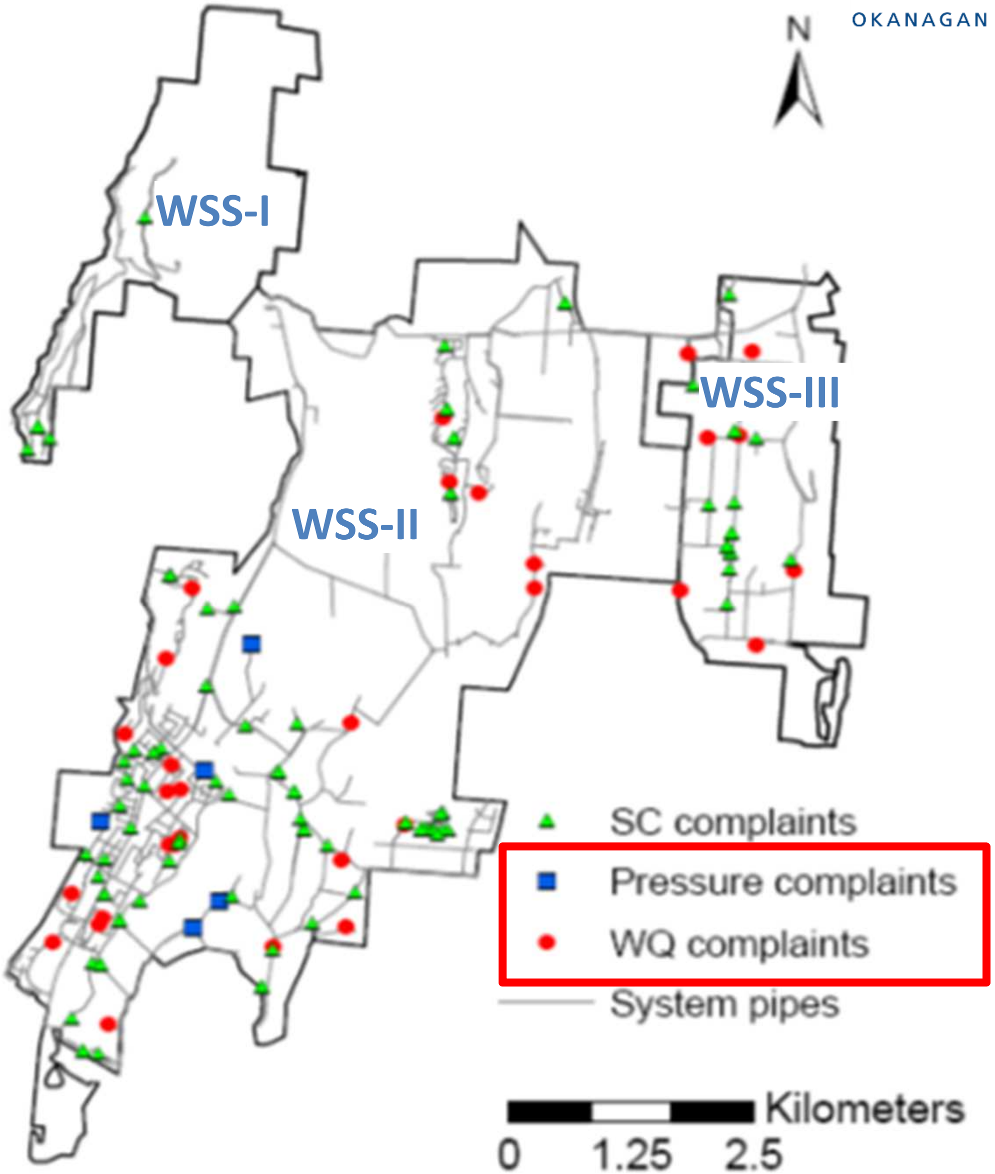



***Quality of Service** Component*

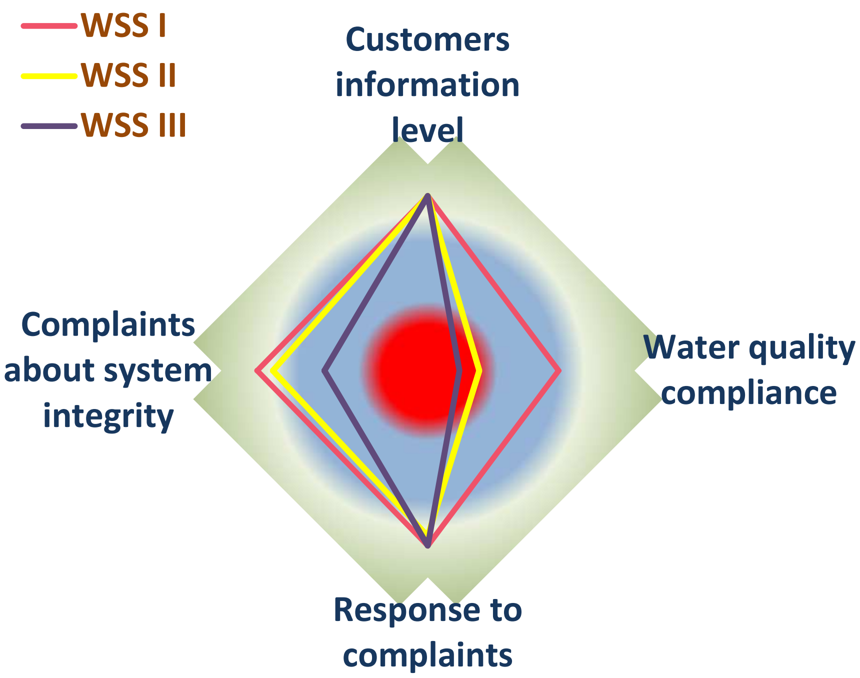
## In-UPM – Case Study

- **A Water Utility in Okanagan Basin**
- **Total Population:** 16,000
- **Land Use:**
  - Agriculture
  - Residential
  - Commercial
- **3 water supply systems (WSSs)**

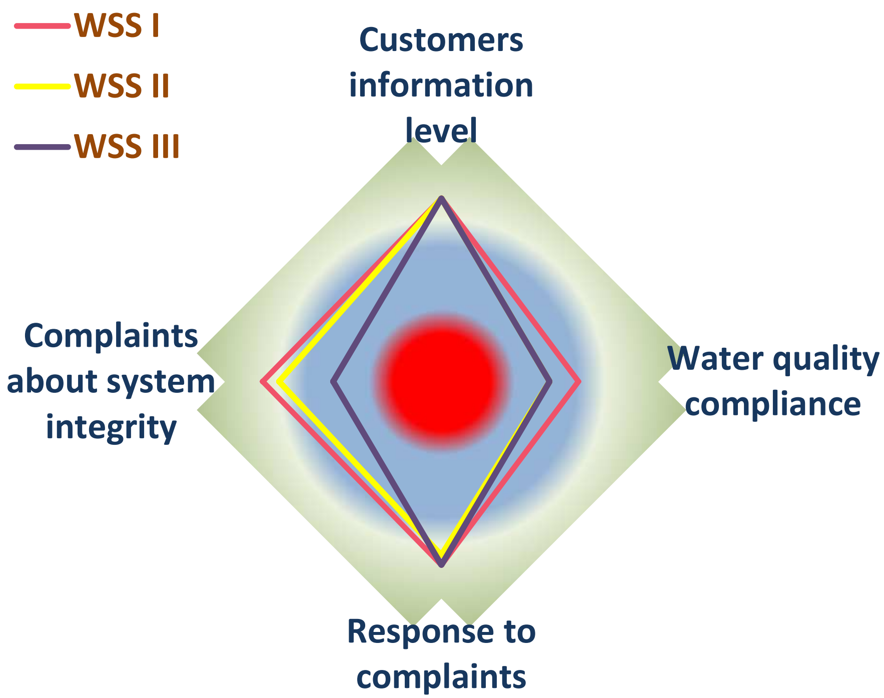
***System Level** Evaluation*



# In-UPM Results at System Level



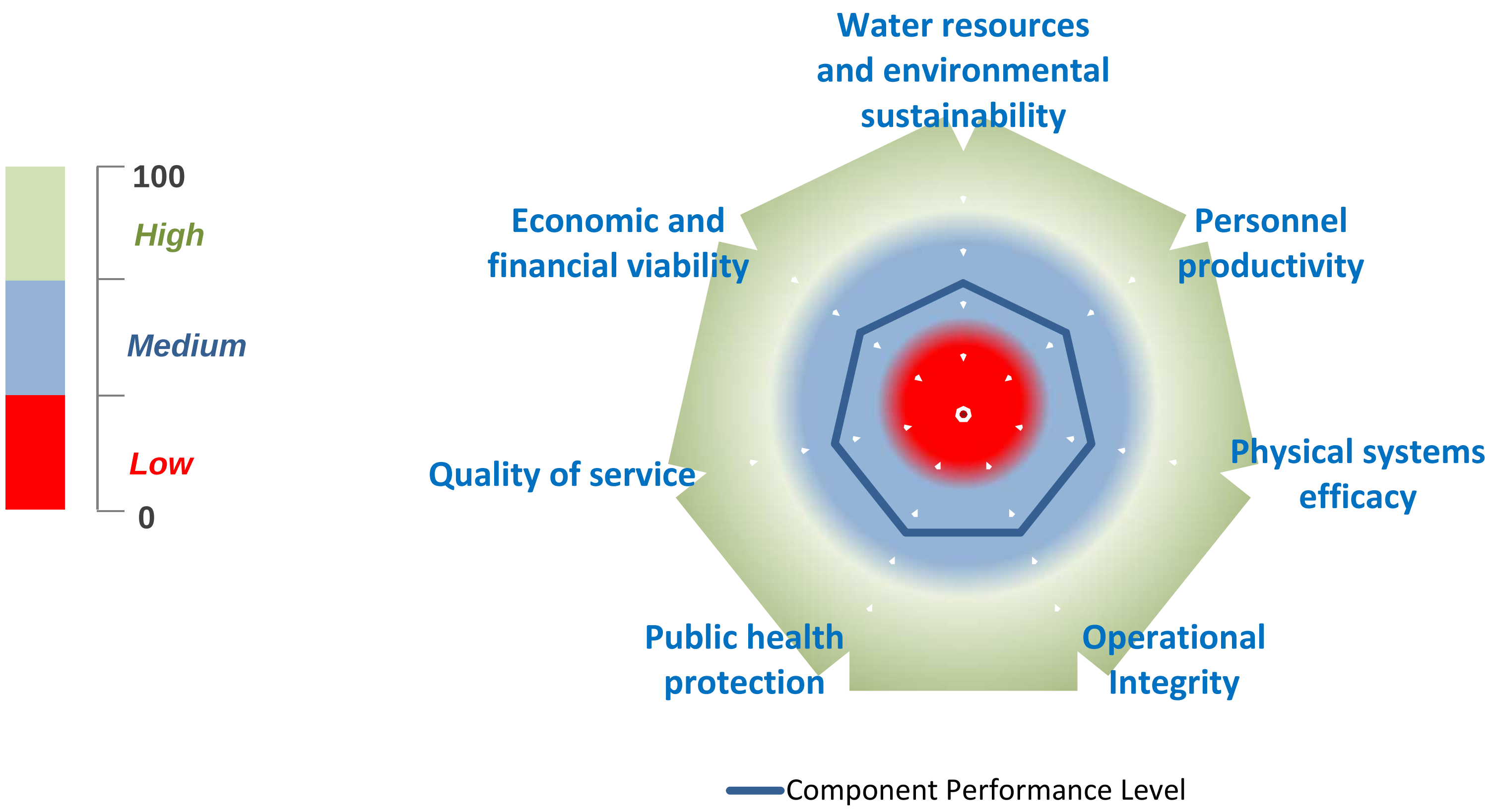

Before source water improvement




After source water improvement

Secondary level PMs for *'Service Reliability'* and *'Customer Satisfaction'*

# In-UPM Results after Improvement Actions (2014)




Improvement Action: ***Source Water Change***

## Conclusions

- The deductive approach provides an opportunity for the higher management to appraise the **overall sustainability performance** of different functional components of their utilities.
- Managers can **hone in** the performance of different processes (**sub-components**) within the component.
- For performance inferencing, the model can **handle the uncertainties** associated with data limitations and expert opinion using fuzzy rule based modeling.
- The model can assess the performance of the **utility as a whole**, and/or **different water supply systems**, individually, operating within a utility for any assessment period.

## Recommendations

- The proposed hierarchical framework of In-UPM is flexible to include **additional performance factors** with changes in infrastructure, availability of additional data and expected participation of SMWU in national benchmarking process in future.

- In this research, due to the **absence of real performance benchmarking** of SMWU, the universe of discourse developed for performance factors is based on national benchmarking reports, literature, and knowledge base. It is recommended that these **ranges might be revised (calibrated) in future** using more accurate regional benchmarking information.

## References


- Haider, H. 2015. Performance management framework for small to medium sized water utilities: conceptualization to development and implementation, PhD Thesis, The University of British Columbia, Canada. http://hdl.handle.net/2429/53582

- Water Canada, 2013. http://www.water.ca/textm.asp

- Interior Health Canada, 2013. http://www.interiorhealth.ca/YourEnvironment/InspectionReports/Pages/WaterNotifications.aspx

## Thanks

**Questions?**