$$P_n = P_0 (1 + r)^n \quad (3)$$

$$r = (\frac{P_n}{P_0})^{\frac{1}{N}} - 1 \quad (4)$$

Notes:
P_n = number of community members in year n, measured in lives.
P_0 = number of community members in year 0 or at the beginning of the design, measured in lives.
n = duration or year
r = average yearly growth of the number of community members
N = difference in years with year 0

- Linear Regression Method

$$P = a + bx \quad (5)$$

$$a = \frac{\sum P \sum x^2 - \sum x \sum Px}{N \sum x^2 - (\sum x)^2} \quad (6)$$

$$b = \frac{N \sum Px - \sum x \sum P}{N \sum x^2 - (\sum x)^2} \quad (7)$$

Notes:
a & b = constants
P = targeted number of community members
x = value taken from independent variable
N = number of data owned

From the projection results of the three methods, the projection method with the lowest standard deviation and an R-value closest to 1 is chosen, which indicates that the projection of the number of people with years is getting stronger or has a correlation [13].

2.2.2 Projection of clean water needs for FIK UI.

After projecting the number of community members, the projection results will be multiplied by the standard of clean water needs from SNI 03-7065-2005 regarding the Plumbing System Planning Procedures. Referring to this regulation, FIK UI is included in building use of facilities for high schools and higher, with a water use standard of 80 liters/student/day. The need for clean water that has been obtained by multiplying the projected number of populations with these standards is multiplied again by a factor of 1.15 – 1.2 as the maximum need for clean water [14].

2.2.3 Determination of the components and units of Water Treatment Plant (WTP)

In this step, the units used in the designed WTP as a complement to the slow sand filter will be determined. The units' determination is based on the physical, chemical, and biological characteristics of the raw water, which will then be adjusted to national and international standards regarding WTP and slow sand filter design. The standards that will be used for this step are:

- *Spesifikasi Unit Paket Instalasi Pengolahan Air* by *Pusat Penelitian dan Pengembangan Permukiman Balitbang Kementerian Pekerjaan Umum* (2014) [15]

Based on the literature reviewed, it can be concluded that with 60 cm of silica sand and 40 cm of granular activated carbon or GAC, the slow sand filter designed is estimated to be able to remove iron with an efficiency of 95.07%, manganese by 97.09%, and fecal coliform by 99%.

3.2 Design calculations and shop drawings

3.2.1 Projection of the Number of FIK UI Community Members

The projection results for the growth in the number of FIK UI students using the arithmetic method have the lowest standard deviation value (52,69) and the correlation coefficient closest to 1 (0,261). Meanwhile, for the projection of the number of staff (lecturers and educational staff) of FIK UI, the arithmetic method has the lowest standard deviation value (2,5) and the correlation coefficient closest to 1 (0,787). Therefore, the projection method that will be used is the arithmetic method.

Table 2. 2022-2042 Projection Results for the Number of FIK UI Community Members using Arithmetic Method. (source: author's analysis, 2020)

TOTAL PROJECTION OF FIK UI COMMUNITY MEMBERS			
YEAR	**STUDENTS**	**STAFF**	**TOTAL**
2022	1456	144	1599
2027	1596	156	1752
2032	1737	169	1906
2037	1878	181	2059
2042	2019	194	2212

3.2.2 Projection of Clean Water Needs for FIK UI

Assuming that there is an increase in the standard of clean water needs from time to time, for the year 2022 80 liters/student/day as stated in SNI 03-7065-2005 will be used and for 2042, it will be 100 liters/student/day. In addition to the need for clean water for consumption, the need for water for the laboratory will be considered because FIK UI has laboratories and experimental rooms in the FIK UI Education & Laboratory building. The amount of clean water needed for the laboratory is assumed to be 10% of the community's total clean water necessities. The amount of clean water needed that has been obtained by multiplying the projected number of populations with the standards mentioned in the previous section is multiplied again by a factor of 1,2 as the maximum daily water necessity [14]. The total demand for clean water at peak hours will be added to the installation flow rate to obtain the design discharge. Installation discharge is an additional discharge to prevent overload or overflow during the operation of the WTP. It is assumed to be 10% of the maximum daily clean water necessity [21].

Table 3. 2022-2042 Total Clean Water Needs Projection for FIK UI (source: author's analysis, 2020)

YEAR	TOTAL	STANDARD CLEAN WATER NEEDS	COMMUNITY CLEAN WATER NEEDS	LABORATORY WATER NEEDS	TOTAL CLEAN WATER NEEDS
	Lives	L/life/day	L/day	L/day	L/second
2022	1599	80	127920	12792	1.63
2042	2212	100	221233	22123	2.82

Table 4. 2022-2042 Designed WTP debit projection for FIK UI (source: author's analysis, 2020)

YEAR	TOTAL CLEAN WATER NEEDS	MAXIMUM FACTOR	DAILY MAXIMUM CLEAN WATER NEEDS	INSTALLED DEBIT	DESIGNED DEBIT
	L/second		L/second	L/second	L/detik
2022	1.63	1.2	1.95	0.20	2.15
2042	2.82	1.2	3.38	0.34	3.8

3.2.3 Determination of WTP units

It has been concluded that in the WTP for FIK UI, the slow sand filter unit does not require chemical pre-treatment and in fact, raw water from the intake can be directly channeled to the filter unit [17]. Therefore, the proposed WTP unit flow is as follows:

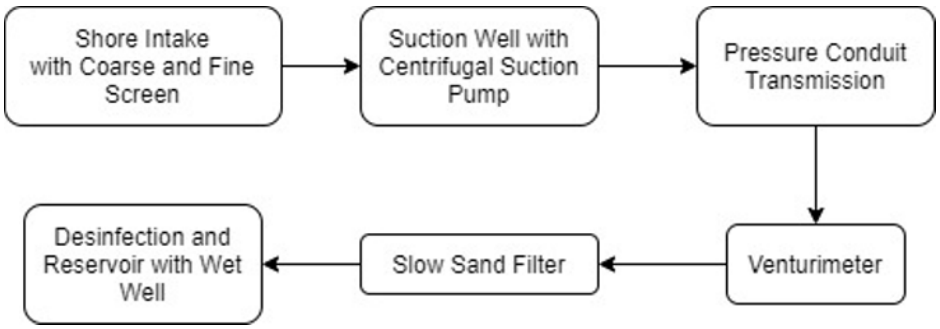

Fig 1. The chosen and implemented WTP unit flow chart.

Fig 2. Planned location for the construction of the designed WTP

3.2.4 Determination of the location of the WTP

The development of the designed WTP for FIK UI is marked with a slightly transparent yellow area in the image above in **Figure 2**. This location has an area of approximately 16300 m^2. This location is chosen because it is considered close to the raw water source and the service destination. The location is approximately 75 meters from Lake Agathis and 206 meters from the FIK UI Education & Laboratory Building. This location is surrounded by the PNJ campus building, UI Hospital, and Depok-Antasari Toll Road. The intake point is 81 meters from the nearest building, namely the PNJ campus, and is 285 meters from the nearest housing complex, Beji Timur. The elevation of the land at this location is in the range of 70-72 masl.

3.2.5 Calculations and shop drawings for the WTP units

1. Shore Intake

One shore intake unit is designed with a unit depth of 2 meters, a water gate height of 1,5 meters, and a water gate width of 1 meter. There is one coarse screen (2 cm space between bars) and one piece of fine screen (0,5 cm space between bars). The intake length is 6 meters, and the area of the unit is 6 m^2.

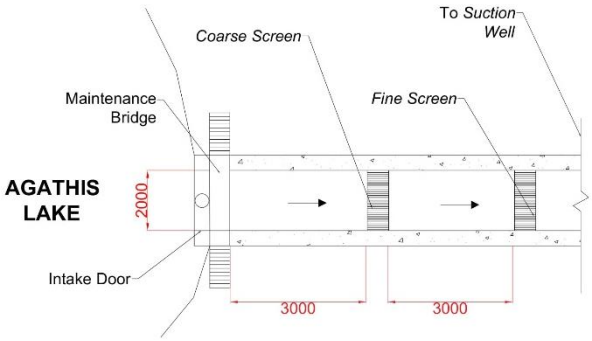

Fig 3. Top view of the intake unit (units in millimeters) (source: author's analysis, 2020)

2. Suction Well

Two suction well units were designed with a length of 2,6 meters, a width of 1,7 meters, and an area of 5,6 m^2 for each well. In each well, there is a centrifugal type suction pump with pumping power of 0,28 kW each.

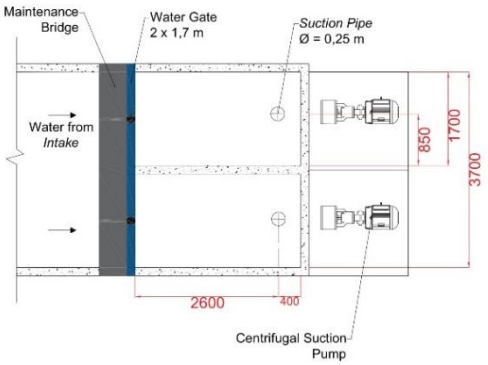

Fig 4. Top View of the Suction Well (units in millimeters).

3. Transmission

The transmission pipe is designed to be made of cast-iron with a length of 44,8 meters, a slope of 0,067, and a pipe diameter of 25 cm.

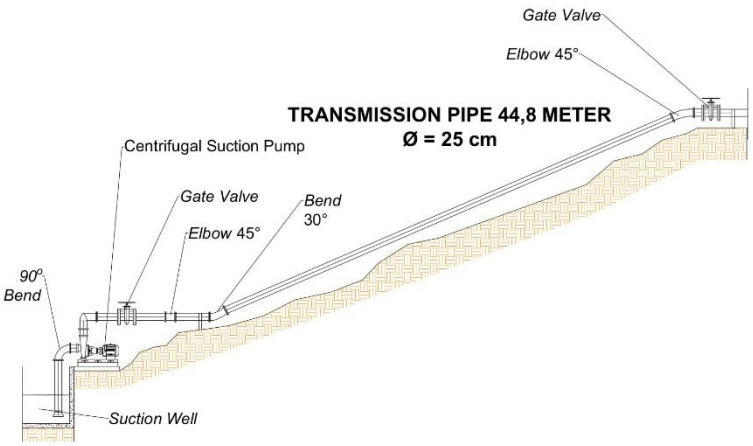

Fig 5. Side view of the Transmission Duct.

4. Venturimeter Debit Measurement Tool

The venturi meter is designed to have an overall length of 260 cm, a throat length of 20 cm, a throat diameter of 20 cm, an entrance length of 50 cm, pressure hole diameters of 2,5 cm, a conical section length of 135 cm, and a divergent outlet section length of 40 cm.

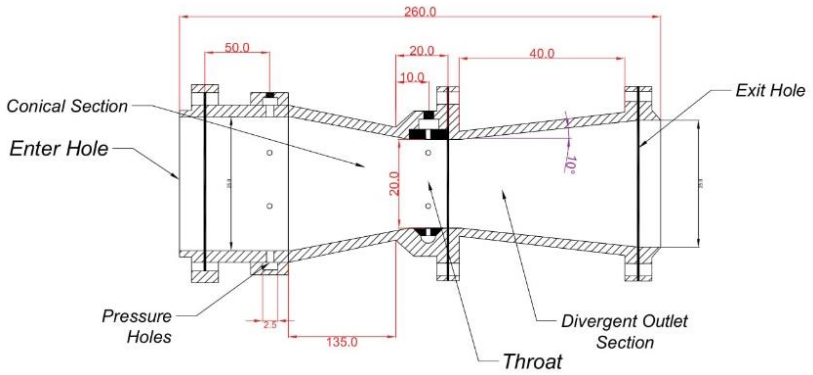

Fig 6. Section detail of the Venturimeter (units in millimeters).

5. Slow Sand Filter

Two slow sand filter units were designed, with each unit having a length of 8 meters, a width of 4 meters, and an area of 32 m^2. The filtration rate of the filter is 0,2 m/hr. The media used were 60 cm thick silica sand and 40 cm thick GAC. Adjacent to the filter tank, there is a 2-meter-long valve tank and a 4-meter-long outlet tank.

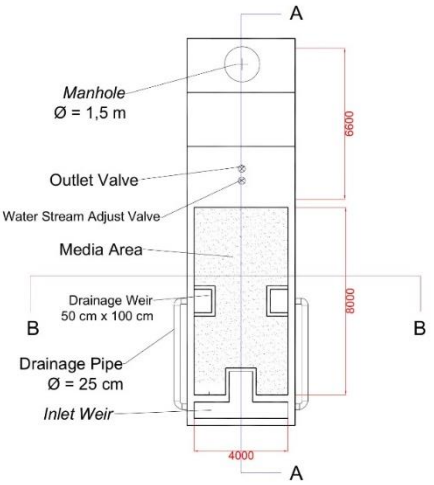

Fig 7. Top View of the Tank of the Slow Sand Filter (units in millimeters).

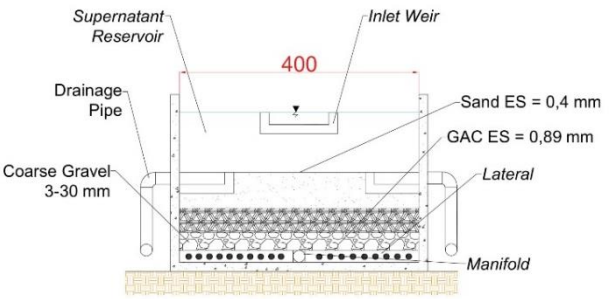

Fig 8. B-B Section Cut of the Tank of the Slow Sand Filter (units in centimeters).

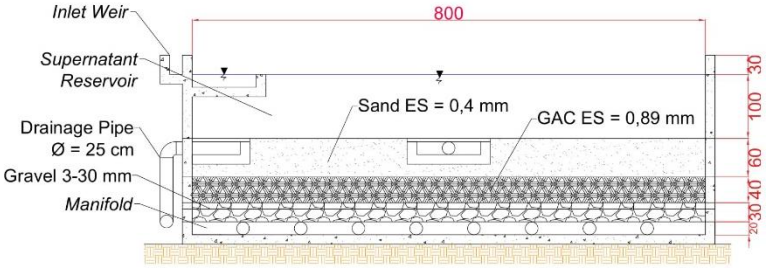

Fig 9. A-A Section Cut of the Tank of the Slow Sand Filter (units in centimeters).

6. Disinfection Tank and Reservoir

One unit of disinfection tank and one unit of the reservoir is designed. The disinfection tank is 1,2 meters wide and 2,4 meters long, with eight bulkheads where the tank flows vertically. The reservoir has a side length of 6,5 meters and a depth of 2,3 meters. Adjacent to the reservoir, four wet wells measure 2,5 meters x 1,5 meters with a depth of 2,5 meters. Above each wet well, there is a 0.13 kW pump that will transport ready-to-consume water from the well to FIK UI.

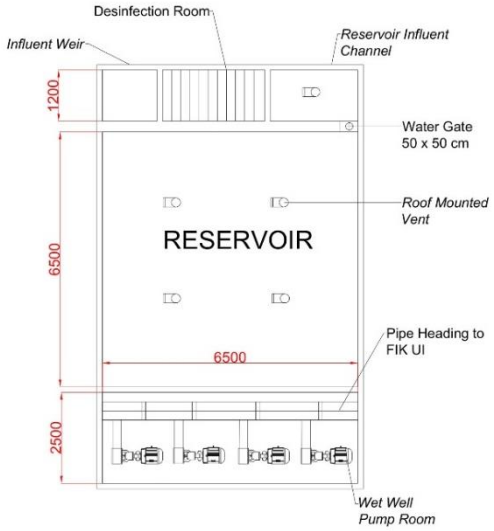

Fig 10. Top View of the Disinfection Tank and the Reservoir (units in millimeters).

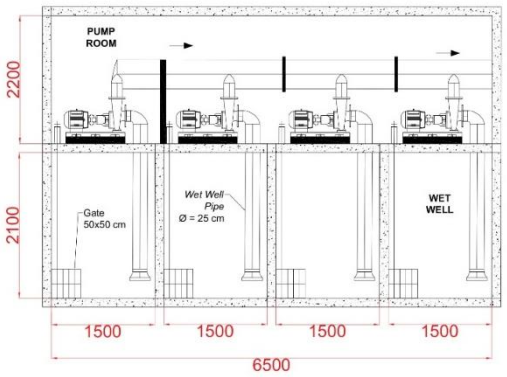

Fig 11. Wet Well Details (units in millimeters).

7. Filter Media Washing and Activation Unit

The washing unit is built to clean the filter media, namely silica sand and GAC, to overcome clogging. The activation unit is used for the reactivation of carbon in GAC after it is washed. The washing unit consists of a water and media mixing bath, washing tank, and media drying bath. Two filter media washing units are designed with an area of 28 m^2 each. As for the activation chamber, one unit with a length of 3,6 meters and a width of 5,6 meters is made.

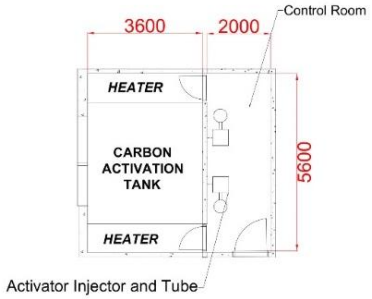

Fig 12. Details of the GAC Carbon Activation Room (units in millimeters).

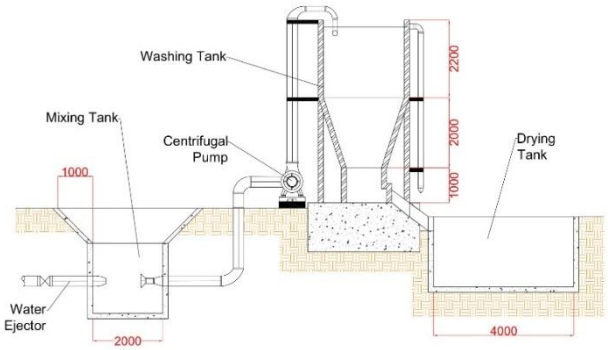

Fig 13. Details of the Filter Media Washing Unit (units in millimeters).

3.3 Layout of the WTP

In each WTP unit, utility rooms such as laboratories, staff rooms, offices, employee toilets, etc. will be added so that the WTP can operate properly, and the comfort of employees who work at the WTP can be ensured. The details of the number of utility rooms for each WTP unit are as follows:

- Intake and suction well contain two staff rooms, one storage room, one security room, one small laboratory, two pump control rooms, and two restrooms.
- Slow sand filter contains two truck garages, one meeting room, one office room, one staff room, one storage room, one small laboratory, two restrooms, and one security room

.

- Disinfection and reservoir contains one control and disinfectant injection room, one small laboratory, one staff room, and one restroom
- Filter media washing unit contains one staff room, one storage room, one restroom, parking area, GAC activation control room, smoking area, and one security room.

In total, the required area for the WTP including all the utility rooms is 2112,89 m^2.

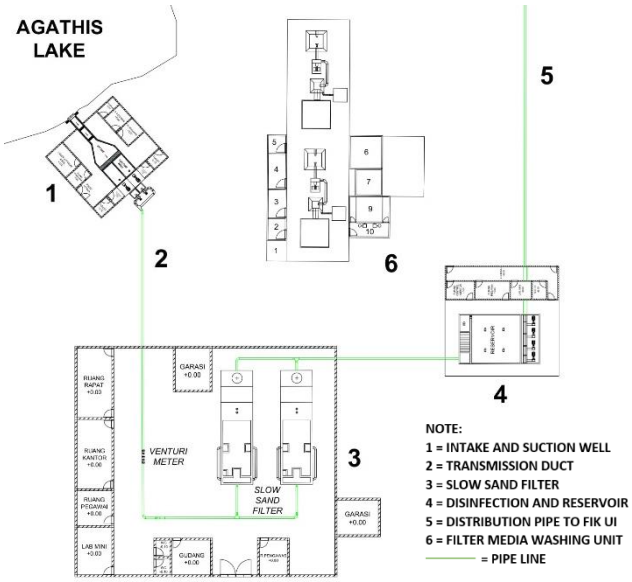

Fig 14. Layout Plan of the Overall WTP Complex.

4 Conclusion

1. Based on the projection results, the total need for clean water for the FIK UI community from 2022 to 2042 is 1,63 L/s to 2,82 L/s. The design discharge obtained is based on the calculation of the maximum daily discharge and design discharge according to Qasim et al. [21] to serve FIK UI in 2022-2042 is 2,15 L/s to 3,8 L/s.
2. Based on the review of literature, journals, and experiments conducted by other researchers, a slow sand filter with a thickness of about 60 cm for the silica sand layer (top) and 40 cm for the granular activated carbon layer (under the silica sand layer) can achieve a removal efficiency of iron and manganese parameters of 95,07% and 97,09% respectively [9], and fecal coliform parameters of 99%.
3. The design of the WTP for serving FIK UI from 2022 to 2042 is as follows.

- One intake unit with a length of 6 meters, a depth of 2 meters, and a width of 1 meter, equipped with a coarse screen and fine screen.
- Two suction well units with a length of 3 meters, a width of 1,7 meters, and a depth of 2 meters.
- One unit of transmission pipeline with a diameter of 25 cm and a length of 44,8 meters, which has increased by 3 meters, and is driven by a 0,28-kW centrifugal pump.
- One unit for measuring the main discharge before entering the venturimeter type filtration unit.
- Two slow sand filter units with a filtration tank length of 8 meters and width of 4 meters.
- One unit of disinfection contact tank with a total length and width of the unit of 4,5 meters (plus the reservoir inlet channel) and 1,2 meters, with the reservoir unit's total length and width (plus wet well) being 9 m and 6,5 meters respectively.
- Two filter media washing units are consisting of a 2 m x 2 m mixing bath, a 2 m x 2 m washing tank, a 4 m x 4 m drying tank, a 2 m x 2 m washing residue water tank, a 4,5 m x 4,5 m temporary silica sand containment tank, a 3,6 m x 3,6 m GAC containment tank, and a 3,6 m x 5,6 m GAC carbon activation chamber.
- An addition of utility rooms in the intake-suction right unit, slow sand filter, disinfection-reservoir, and filter media washing with the required total land area of 2112,89 m^2.
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Acknowledgement

We would like to thank to. Faculty of Nursing Universitas Indonesia's Head of Facility for giving important informations and allowing us to make the faculty as our focus object for this paper. This paper funded by PUTI Proceedings research grant.

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