Republic of Indonesia
Ministry of Public Works and Housing

THE PROJECT FOR

PROMOTING COUNTERMEASURES AGAINST

LAND SUBSIDENCE IN JAKARTA

Final Report

October 2022

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
KOKUSAI KOGYO CO., LTD.
PASCO CORPORATION

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CHAPTER 1 OUTLINE OF THE PROJECT

1.1 Background

Indonesia is a country located in the southern part of Southeast Asia with a population of about 2.70 billion, GNI per capita of 3,870 US dollars (figure in 2020), area of 1.92 million km^2 (Website of Ministry of Foreign Affairs of Japan, July 2020). As the capital city of Indonesia, Jakarta has a population of about 10,171,000 people (Government Statistics of Indonesia, 2015) and is rapidly developing as an economic and political center. Meanwhile, with over-abstraction of the groundwater as one cause, land subsidence of more than 2 m has occurred in the northern part of the capital Jakarta since 2000. This is considered to be mainly due to over-abstraction of the groundwater at factories or buildings, accompanied by recent economic growth and population concentration in the capital. Especially, the tendency is remarkable in lowlands in the northern part where economic activity is concentrated, and in some areas damage such as sea water flooding at high tide is becoming obvious. Based on 1925, the land subsidence rate in 2015 is 3 to 4 m, and the land subsidence of 5 cm or more per year has occurred. It is subsiding at a rate rarely seen in the world. Land subsidence is occurring in a wide range including the center of Jakarta, resulting in enhancing flood risks such as floods and storm surges, increasing flood damage, bringing inhibition of civic life such as stagnation of logistics. The impact on the economy is great.

Countermeasures against land subsidence will require not only monitoring, but also several measures such as restriction of groundwater abstraction, development alternative water sources and promotion of adaptation measures. In order to establish a system in which related government organizations cooperatively promote these countermeasures under one action plan, the following are needed: 1. To propose effective mitigation measures to stop land subsidence and to conduct rough cost estimation of the measures, 2. To investigate risks of land subsidence and to estimate the costs of adaptation measures, 3. To raise awareness about countermeasures against land subsidence among stakeholders, and 4. To promote the activities for implementing countermeasures.

Under these circumstances, the Government of the Republic of Indonesia (hereinafter referred to as “GOI”) requested Japanese Technical Cooperation, named “The Project for Promoting Countermeasures against Land Subsidence in Jakarta” (hereinafter referred to as "the Project”) to the Government of Japan, aiming to promote countermeasures against land subsidence in Jakarta through integrated groundwater and surface water management. Japan International Cooperation Agency (hereinafter referred to as “JICA”) implemented the Detailed Planning Survey from August 2016 to May 2017 with the aim of confirming the necessity of the Project, the validity of the request, and studying the basic matters concerning land subsidence and groundwater abstraction. As a result, Directorate General of Water Resources, Ministry of Public Works and Housing (hereinafter referred to as “DGWR”), and other authorities concerned of GOI and JICA agreed on the framework of the project, and signed the minutes of discussion (R/D) in July 2017 for the implementation of the Project.

The Project was commenced with the schedule for 3 years since April 2018 to March, 2021. However, the Project period has extended to the end of September, 2022 because of severe social activity restriction due to the pandemic of COVID-19 starting in early 2020.

From December 31, 2019, to the following January 1, 2020, the Jakarta metropolitan area experienced major flooding resulting 62 persons of death and 450 thousand victims. Based on the situation above, GOI requested JICA to accelerate the implementation of the master plan and to give added value to the joint commitment. In response to this request, JICA agreed to prepare the survey as one of the additional scopes of the Project and the survey was commenced in January, 2021. As the urgent measures, the Value Engineering for the detailed design of Bekasi River Improvement was evaluated, and solutions for inland water control in Kemayoran Area was proposed. And comprehensive flood control measures were proposed in JABODETABEK area considering the investment of Japanese yen loan in future.

1.2 Project Title

The Project is entitled “Project for Promoting Countermeasures against Land Subsidence in Jakarta”

with the type of assistance of technical cooperation project.

1.3 Expected Goals, Outputs and Ex-Post Evaluation of the Project

1.3.1 Expected Goals

The Project aims to promote countermeasures against land subsidence in Jakarta and to strengthen capacity for planning and implementing the countermeasures by related government organizations in Indonesia through establishing a planning and implementation framework and action plan.

1.3.2 Outputs

The outputs of the project consist of five items shown in Table 1-1.

Table 1-1 Outputs of the Project

Output 1	The data collection, analysis, and data management system about land subsidence and groundwater is established, the present condition of land subsidence and groundwater abstraction is understood and analysis for the relationship of them and future conditions are implemented.
Output 2	Mitigation measures to stop land subsidence are studied and effective countermeasures are implemented on a trial basis.
Output 3	Damages and risks caused by land subsidence are investigated and adaptation measures are studied.
Output 4	Understanding of causes, risks, mitigation and adaptation measures against land subsidence is promoted and awareness about the countermeasures is raised among stakeholders.
Output 5	A planning and implementation committee for land subsidence countermeasures is established, and an action plan for land subsidence countermeasures is formulated.

1.3.3 Indicators for Ex-post Evaluation (Three years after the project completion)

(1) Implementation status regarding monitoring of groundwater level and land subsidence by monitoring well
(2) Status of securing own funds (fiscal year budget) for implementing the action plan formulated in the project and implementation status of countermeasures and their effectiveness
(3) Status of formulating projects based on Action Plan including support by JICA and other donors

1.4 Relation to SDGs

The GOI established national indicators to achieve SDGs in 2017. As the indicator for “Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity”, “Control and law enforcement for ground water use” is added as the national indicator. The Project is to facilitate optimal management and use of ground water as a countermeasures against land subsidence. In this context, the Project helps to achieve the SDGs in Indonesia.

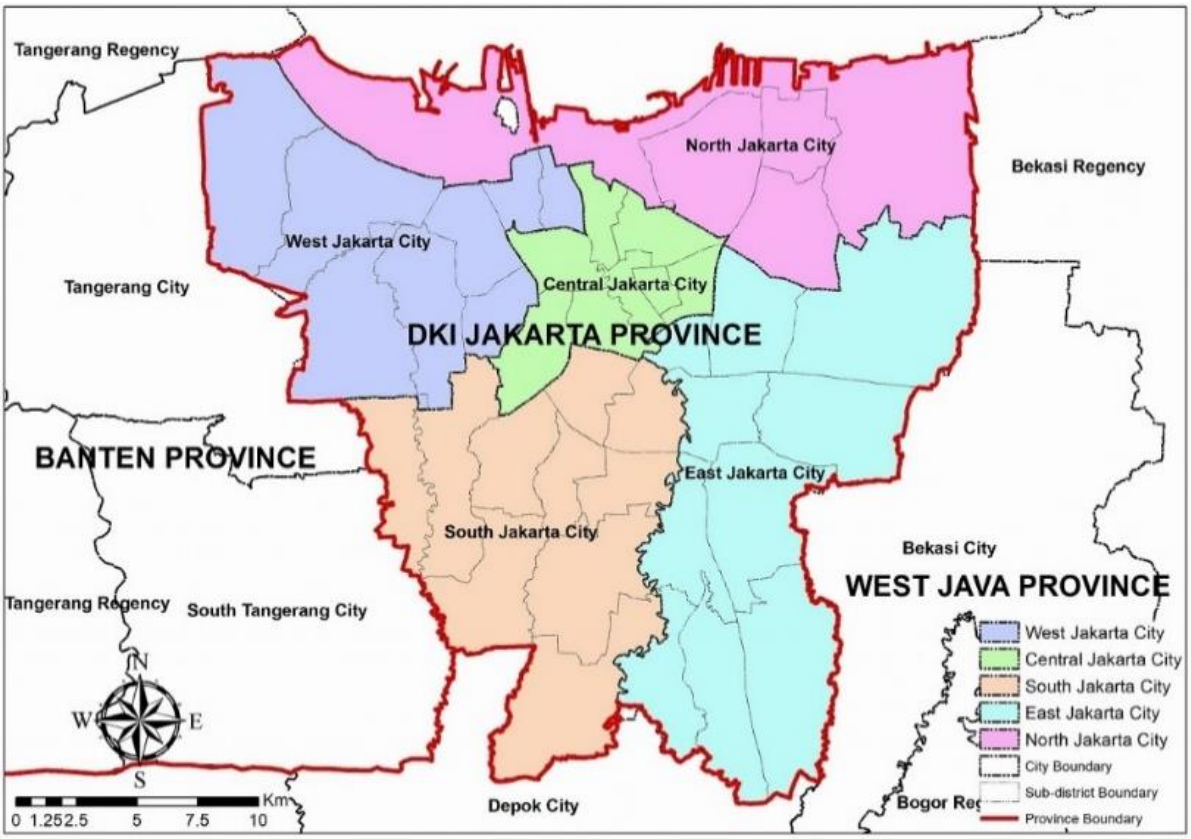
Table 1-2 Groundwater Management as SGDs Indicator in Indonesia

Target	Indicator		Remark
	No.	Contents	
6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.	6.4. 1	Change in water-use efficiency over time	Global Indicator
	6.4.1(a)	Control and law enforcement for ground water use	National Indicator
	6.4.1(b)	Agricultural water saving incentives/plantation and industry.	National Indicator
	6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Global Indicator

Source：RINGKASAN METADATA INDOKATOR TUJUAN PEMBANGUNAN BERKELANJUTAN
(https://sdgs.bappenas.go.id/wp-content/uploads/2017/09/Buku_Ringkasan_Metadata_Indikator_TPB.pdf)

1.5 Target Area and Project Period

The target area of the Project is whole Special Capital Province (DKI) Jakarta with area of 662.33 km^2, as shown in Figure 1-1, however, surrounding cities/regions are included for some analyses/studies such as the satellite imagery analysis and the study on acceleration of flood control MP in JABODETABEK as an additional work, etc. The Project is implemented into two stages. The 1st stage was conducted from April, 2018 to May, 2019. The 2nd stage was scheduled from July, 2019 to March, 2021. However, due to the COVID-19 pandemic, the 2nd stage was extended to September, 2022.



Source: The Project Team

Figure 1-1 Relationship between Expected Goals and Each Output

1.6 Outline of the Project Area

1.6.1 Natural Conditions

(1) Topography and Geology

Figure 1-2 shows the outline of geological setting in DKI Jakarta. The yellow in the figure is a sand-based coastal sediment, the light blue is an alluvial layer, the orange is a Holocene (alluvial) formed volcanic deposit, and the brown is a Quaternary Pleistocene the Banten Tuff.

The alluvial formation is widely distributed on the north side of Jakarta, and coastal sediments formed in the same period are distributed in this. The south side is mostly composed of volcanic deposits. This forms a gently sloping fan topography. The river flows down in the fan-shaped landform, and the alluvium is deposited along the river. It forms a flat topography mainly in the northern area where the alluvium deposits. The area composed of volcanic sediments slopes gently from south to north, and the rivers flowing in it have a slightly lower topography.

Moreover, in the northernmost area, there are areas where the ground height is about 2 m or lower than the sea level like the Pluit area, and it is considered that the area with ground height of 0 m or less is widely distributed in the city area.

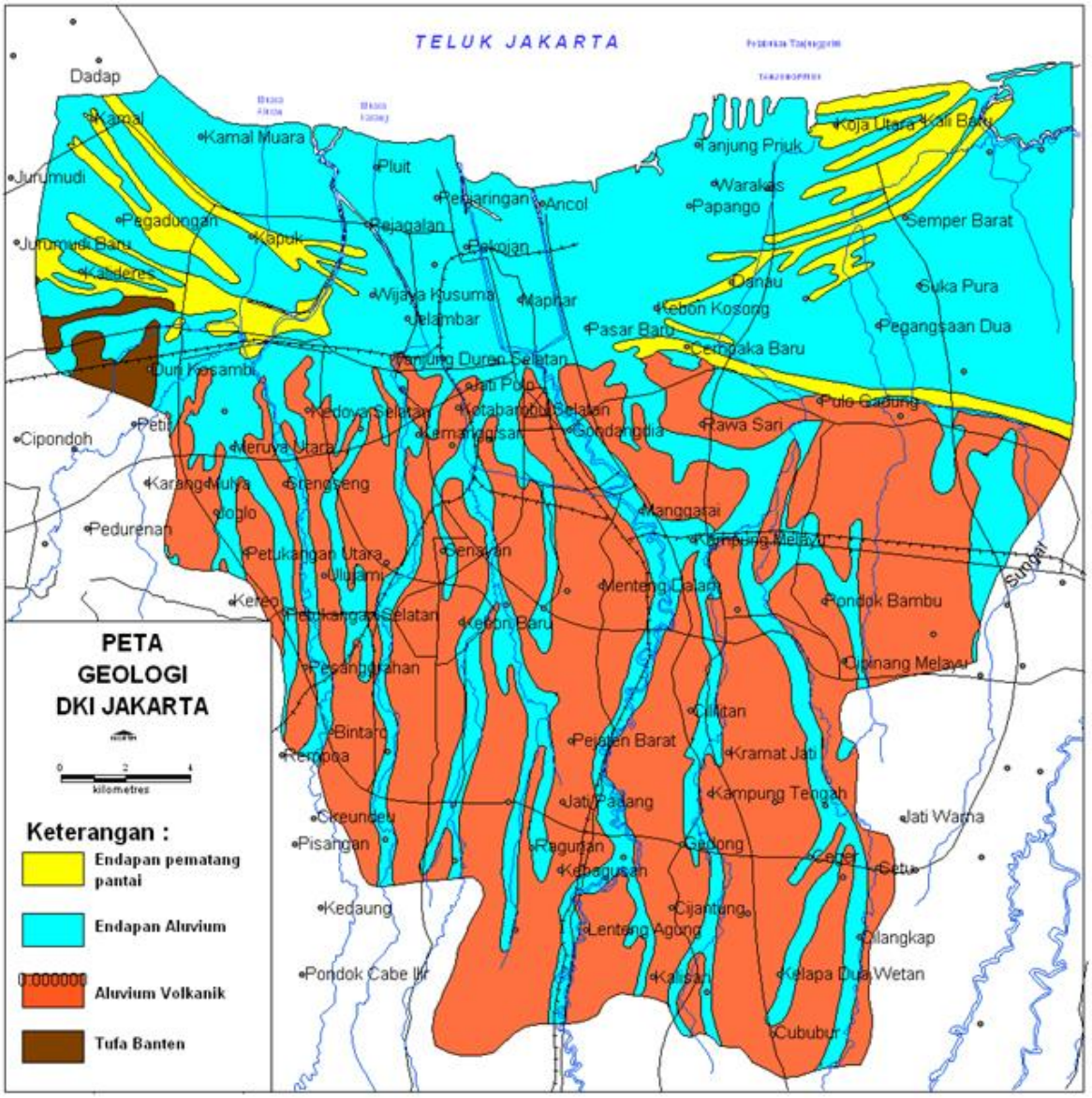
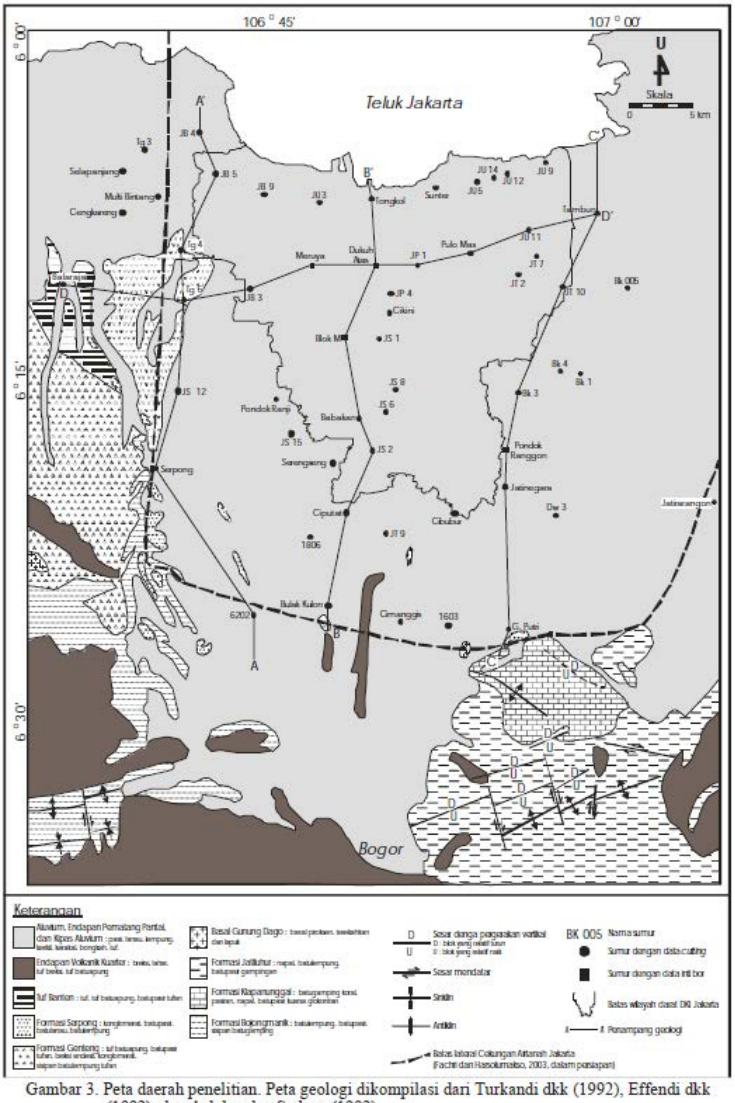


Figure 1-2 Outline of Geology in DKI Jakarta

On the other hand, Figure 1-3 shows the geological map “Peta geologi dikompilasi dari Turkandi dkk (1992)” shown in the document “Stratigrafi dan Hidrostratigrafi Cekungan Airtanah Jakarta (2002)”.



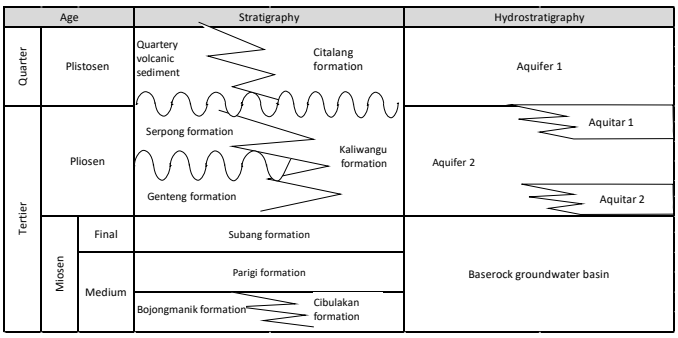
Gambar 3. Peta daerah penelitian. Peta geologi dikompilasi dari Turkandi dkk (1992), Effendi dkk (1992), dan Achdan dan Sudana (1992).

Source: "Stratigrafi dan Hidrostratigrafi Cekungan Airtanah Jakarta (2002)"

Figure 1-3 Outline of Geology around DKI Jakarta

According to Figure 1-3, the range of the Jakarta Special Region is interpreted as the same as the outline of the geology. However, since strata consist of alluvium, coastal sediments and alluvial fan sediments, Figure 1-2 can be considered as a more detailed version of Figure 1-3.

Figure 1-4 shows the geological stratigraphy around DKI Jakarta according to this document.



Source: "Stratigrafi dan Hidrostratigrafi Cekungan Airtanah Jakarta (2002)"

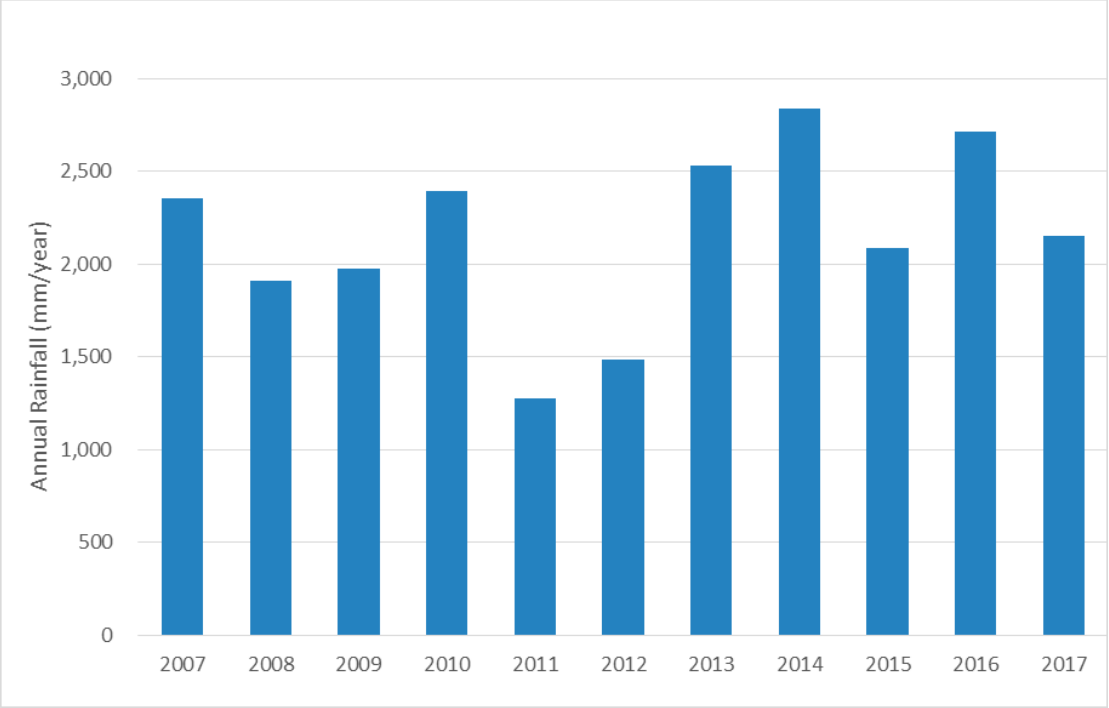
Figure 1-4 Stratigraphy of Jakarta

(2) Hydrology

Annual rainfall from 2007 to 2017 and average monthly rainfall at Kemayoran Meteorological Station located in Central Jakarta are shown in Figure 1-5 and Figure 1-6, respectively.

1) Annual Rainfall

The average annual rainfall is 2,150 mm/year and the maximum and minimum in this period are 2,800 mm/year and 1,200 mm/year, respectively. This average rainfall corresponds to 2.4 times of the world average (880 mm) and 1.2 times of Japan's average (1,718 mm). It is noted that the Japan's average is based on the annual rainfall from 1970 to 2000, and the source of world average is the United Nations Conference on Water held in 1977.

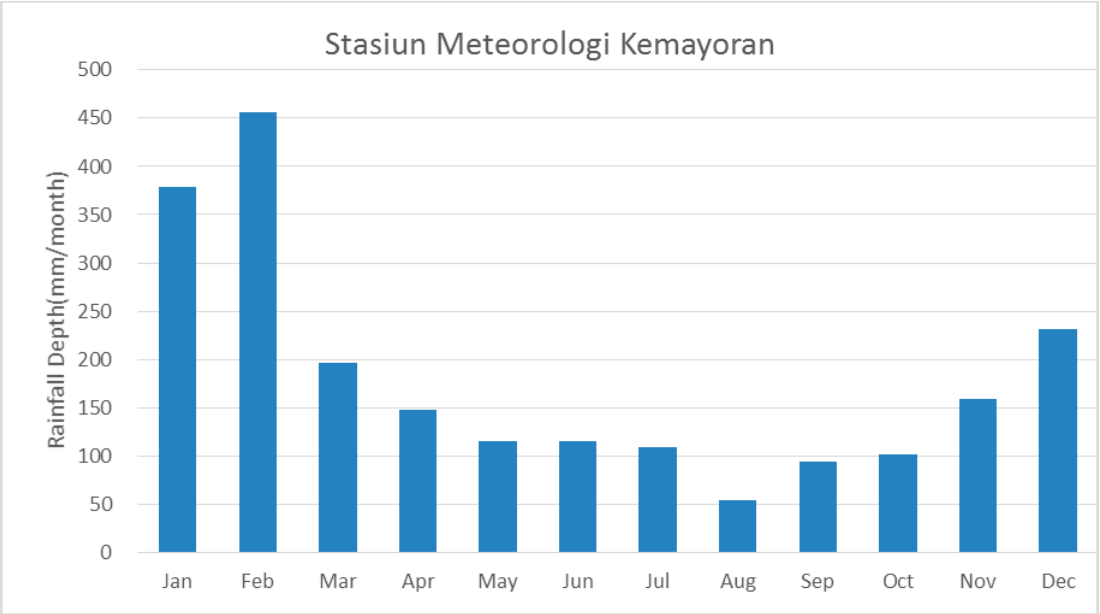


Source: The Project Team based on BMKG data

Figure 1-5 Annual Rainfall at Kemayoran Station (2007 – 2017)

2) Monthly Rainfall

Jakarta has rainy and dry season, running from November to March and from April to October, respectively. The maximum monthly rainfall is 450 mm/month in February and the minimum is 50 mm/month in August.



Source: The Project Team based on BMKG Data

Figure 1-6 Monthly Rainfall at Kemayoran Station

1.6.2 Social Conditions

(1) Population

Table 1-3 shows the transition of population in DKI Jakarta. The overall population trend is rising, particularly in North Jakarta and East Jakarta. According to the UN estimate, the population of DKI Jakarta in 2030 is expected to increase to about 12.7 million. Annual population growth rate of DKI Jakarta from 2005 to 2020 was 1.1%, while the rate from 2020 to 2030 is 2% and a higher growth rate than before is expected. On the other hand, "Final Report Preparation of Master Plan for Water Supply Service Improvement in DKI Jakarta 2015-2035 (hereinafter referred to as the "2014 Master Plan") compiled in 2014 projects that the population of DKI Jakarta in 2030 would be 12.5 million (analysis result by DKI Jakarta and consultant). As for the trend of population growth for DKI Jakarta, the UN forecast and the 2014 Master Plan show almost the same results.

Table 1-3 Population in DKI Jakarta

	2005	2010	2015	2020	2030
North Jakarta	1,446,728	1,653,178	1,747,315	1,778,981	-
West Jakarta	2,322,232	2,292,997	2,463,560	2,434,511	-
East Jakarta	2,393,788	2,705,818	2,843,816	3,037,139	-
Central Jakarta	861,531	917,754	914,182	1,056,896	-
South Jakarta	1,995,214	2,071,628	2,185,711	2,226,812	-
Total	9,041,605	9,640,406	10,177,924	10,562,088	12,687,000

Note: Total number includes the population of Kepulauan Seribu

Source: Figures in 2005, 2010, 2015 and 2020 - Statistics DKI Jakarta Provincial Office, "Jakarta in Figures"
Projected figure in 2030 – the United Nations, "The World's Cities in 2018 Data Booklet"

(2) Industries and Economic Situation

The transition of regional GDP in Jakarta Special Region is shown in Table 1-4. Regional GDP has grown from 5 to 6 % since 2015, and manufacturing, hotel and restaurant businesses, which are generally considered to have high water demand, were also growing continuously. However, in 2020, negative growth was recorded due to the stagnation of economic activities caused by the spread of COVID-19. In the future, if behavioral regulations are relaxed, the economic activities will become more active and will gradually recover. The demand for clean water is also expected to grow continuously. The number of enterprises decreased between 2010 and 2015 as shown in Table 1-5, while that is increasing in all categories in 2018. According to previous interviews with the manufacturing companies in DKI Jakarta, many of the factories have already moved out of DKI Jakarta, including drinking water and beverage manufacturing companies that were expected to have high water demand. The main functions of the existing companies in DKI Jakarta are headquarters and warehouses. As other industries considered to have a relatively large demand for water, factories such as textiles and building materials production can be found in DKI Jakarta.

Table 1-4 GRDP of DKI Jakarta (2010 Constant Price)

Industry	2015	2016	2017	2017	2017	2017
Agriculture, Forestry and Fishing	1,375	1,388	1,392	1,394	1,398	1,401
Mining and Quarrying	2,956	2,912	2,916	2,945	2,827	2,645
Manufacturing	186,803	193,625	207,918	219,718	217,047	194,600
Electricity and Gas	3,924	3,905	4,345	5,228	5,856	5,224
Water Supply, Sewerage, Waste Management and Remediation Activities	652	666	686	738	764	743
Construction	195,805	198,680	208,862	251,896	219,737	207,533
Wholesale and Retail Trade, Reoair of MotorVehicles and Motorcycles	234,748	245,877	259,765	275,954	291,239	270,734
Transportation and Storage	45,905	51,658	56,261	61,329	66,488	61,484
Accommodation and Food Service Activities	72,600	76,873	81,390	85,360	91,316	76,511
Information and Communication	141,501	156,516	172,428	188,923	210,970	234,439
Financial and Insurance Activities	155,163	168,798	178,831	183,681	199,004	207,673
Real Estate Activities	97,810	102,396	106,782	111,361	116,584	118,828
Business Activities	106,647	116,290	128,237	139,487	155,071	151,796
Public Administration and Defence, Compulsory Social Security	62,319	64,389	61,594	67,894	70,325	66,228
Education	71,210	74,591	75,905	80,496	84,908	87,153
Human Health and Socila Works Activities	23,426	25,256	26,920	28,667	30,628	36,709
Other Services Activities	51,720	56,098	61,128	66,139	72,036	69,094
Total	1,454,564	1,539,917	1,635,359	1,735,208	1,836,198	1,792,795

Note: 2010 constant price – real value based on prices in 2010

Source: Statistics DKI Jakarta Provincial Office, “Jakarta in Figures”

Table 1-5 Number of Large and Medium Scale Establishments and Workers in DKI Jakarta

Industrial Code	Industrial Classification	2010		2015		2018	
		Establishment	Workers	Establishment	Workers	Establishment	Workers
10	Food Products	228	25,301	188	21,143	269	42,860
11	Beverages			9	1,142	22	4,774
13	Textiles	117	14,368	56	10,928	56	8,153
14	Wearing Appareal	457	85,375	281	62,564	411	55,202
15	Tanning and Dressing of Lea	70	5,730	53	3,500	75	4,663
16	Wood and Products of Wood Cork except furniture and Goods Matting of Bamboo, Rattan and the Like	25	1,972	16	1,438	33	1,682
17	Paper and Paper Products	50	4,346	33	2,010	63	4,391
18	Printing and Reproduction of Recorded Media	182	15,474	122	10,752	230	15,130
19	Coal and Refined Petroleum Products	2	234	1	185	10	3409
20	Chemical and Chemical Products	107	33,899	66	16,643	116	26,039
21	Pharmacy, Medical Chemistry and Traditional Medicine			29	6,808	41	10,637
22	Rubber and Plastic Products	202	19,256	139	19,294	223	24,771
23	Other Non Metalic Mineral Products	23	10,240	20	7,952	55	10,520
24	Basic Metals	32	6,585	19	4,026	54	8,512
25	Fabricated Metal Products Except Machinery and Equipment	95	41,500	97	13,748	108	10,268
26	Computers, Electronic Equipments and Optics			20	4,342	28	4,662
27	Electrical Equipments	38	10,380	40	12,693	73	17,699
28	Machinery and Equipment	64	11,153	18	6,281	50	7,945
29	Motor Vehicles, Trailers and Semi Trailers	30	27,501	33	36,143	41	32,567
30	Other Transport Equipment	25	19,930	18	22,577	25	12,251
31	Furniture	100	16,849	25	3,829	57	5,590
32	Other Manufacturing	19	991	37	9,582	47	10,836
33	Repair and Installation of Machinery and Equipment			3	522	30	2179
Total		1,866	351,084	1,323	278,102	2,117	324,740

Note: Industry codes follows the Indonesia Standard Industry Classification (KBLI) 2015. Those that were not divided into multiple categories in the previous code are combined into one (food products and beverages), and those that were divided into multiple categories are integrated into the applicable classification (machinery and equipment) in the 2015 code.

Source: Statistics DKI Jakarta Provincial Office, "Jakarta in Figures"

1.7 Relevant Organizations

(1) The leading counterpart: Directorate General of Water Resources (hereinafter referred to as "SDA"), Ministry of Public Works and Housing (hereinafter referred to as "PUPR")
(2) The leading relevant organizations: Special Capital Province of Jakarta (hereinafter referred to as "DKI Jakarta"), Research and Development Center for Water Resources, Research and Development Agency, PUPR (hereinafter referred to as "PUSAIR")
(3) Other relevant organizations:
Central Government

- Ministry of National Development Planning (hereinafter referred to as "BAPPENAS")
- Regional Infrastructure Development Agency, PUPR
- Directorate General of Human Settlement (hereinafter referred to as "Cipta Karya"), PUPR
- Geological Agency, Ministry of Energy and Mineral Resources

- Directorate of Watershed Management Planning and Evaluation, Ministry of Environment and Forestry

DKI Jakarta

- Regional Development Planning Agency (hereinafter referred to as "BAPPEDA")
- Water Resources Office
- Regional Water Supply Company of DKI Jakarta (hereinafter referred to as "PAM JAYA"), etc.

1.8 Implementation Structure

1.8.1 Establishment of Joint Coordination Committee

As mentioned above, the leading counterpart is DGWR of PUPR and relevant agencies of DKI Jakarta, BAPPENAS, Cipta Karya of PUPR, Regional Infrastructure Agency of PUPR, Badan Geologi of ESDM, KLHK etc. are involved. As stipulated in RD, the Joint Coordination Committee (JCC) is to be established. As shown in Table 1-6, structure of JCC was discussed and modified in the 1st JCC Meeting held on March 22, 2018 and the Minister of PUPR decree on formation of coordination team for the Project was issued on July 31, 2018 based on the modification.

Table 1-6 History of Issuance of Minister of PUPR Decree on Formation of JCC

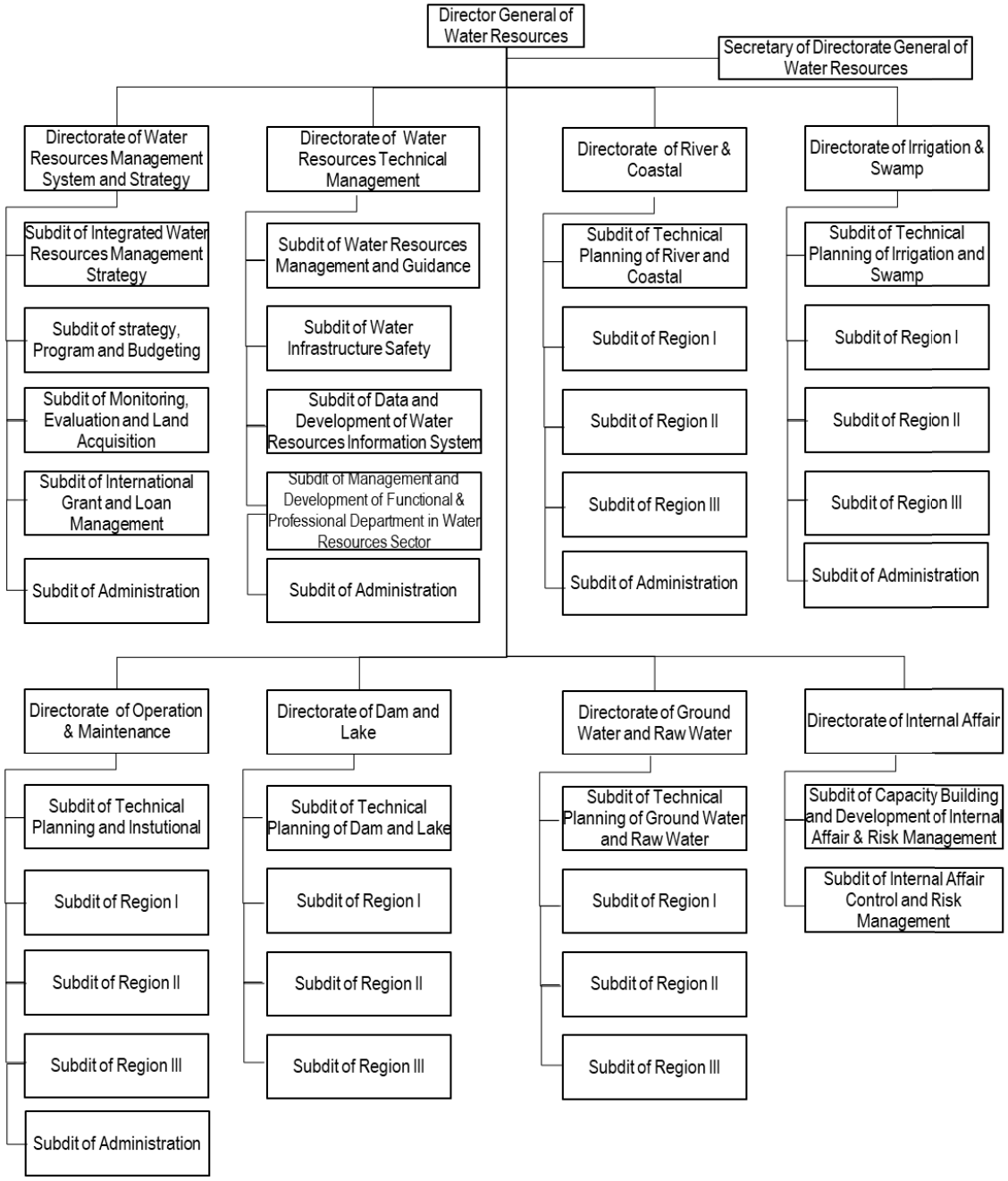
Date	Event
May 22, 2018	Structure of JCC was discussed and the following modifications were made in the 1st JCC Meeting. • "Industry and Energy Agency, DKI Jakarta" and "Environmental Agency, DKI Jakarta" should join Working Group 3 since they have tasks related to mitigation measures. • "Regional Disaster Management Agency, DKI Jakarta" and "Communication, Informatics and Statistic Agency, DKI Jakarta" are appointed as Team Leader and Deputy Team Leader of Working Group 4, respectively. Besides, "Special Planning, Human Settlements and Land Affairs Agency, DKI Jakarta" and "Environmental Agency, DKI Jakarta" join.
July 31, 2018	JCC members are officially nominated by the Minister of PUPR Decree based on modified JCC structure by 1st JCC Meeting. The decree stipulates that the required cost for operation of the JCC shall be borne by the national budget of DGWR of PUPR.

It is noted that the team leader or deputy team leader of each working group is appointed to DKI Jakarta agencies.

1.8.2 Restructuring of Counterpart Organization

In 2020, drastic restructurings were made in major counterparts, DGWR of PUPR and DKI.

In PUPR, restructuring of whole organization was made based on the Minister of Public Works and Housing Decree No. 13, 2020 on Organization and Tasks. In DGWR, the Raw Water and Groundwater Center and the Dam Center were upgraded to Directorates, and the Directorate of Water Resources Management, which worked as the secretariat of JCC, was changed to the Directorate of Water Resources Technical Management. Besides, the Research and Development Agency scaled back and many staff moved to the Technological Agencies by nine sectors, namely dam, coast, river, swamp, irrigation, Sabo, hydraulic and geotechnics, groundwater and hydrology and water environment which are under DGWR.



Note: Technological Agencies (*Balai Teknik*) and River Basin Management Offices *(Balai/Balai Besar Wilayah Sungai*) are excluded.

Figure 1-7 Organization Structure of DGWR of PUPR (since June, 2020)

In DKI, restructuring was made at the beginning of 2020 based on the Governor Decree No. 156, 2019, and task of groundwater management was shifted from the Industry and Energy Agency (DPE) to Water Resources Agency (DSDA). This shift might be done according to the movement in the central government with the concept that "groundwater is treated as one of the water resources, which used to be as one of underground natural resources".

In the DSDA, organization change was also made. Formally, whole river and coastal issues were managed by dividing 3 regions, namely east, central and west, except water supply and sewerage. It has changed to sectoral organizations such as the flood and drainage division, the geology, raw water conservation and water supply division, the high tide and coastal management division, and the sewerage division. The structural organizations before and after restructuring and jurisdiction related to land subsidence are shown in Figure 1-3 and Table 1-3, respectively.

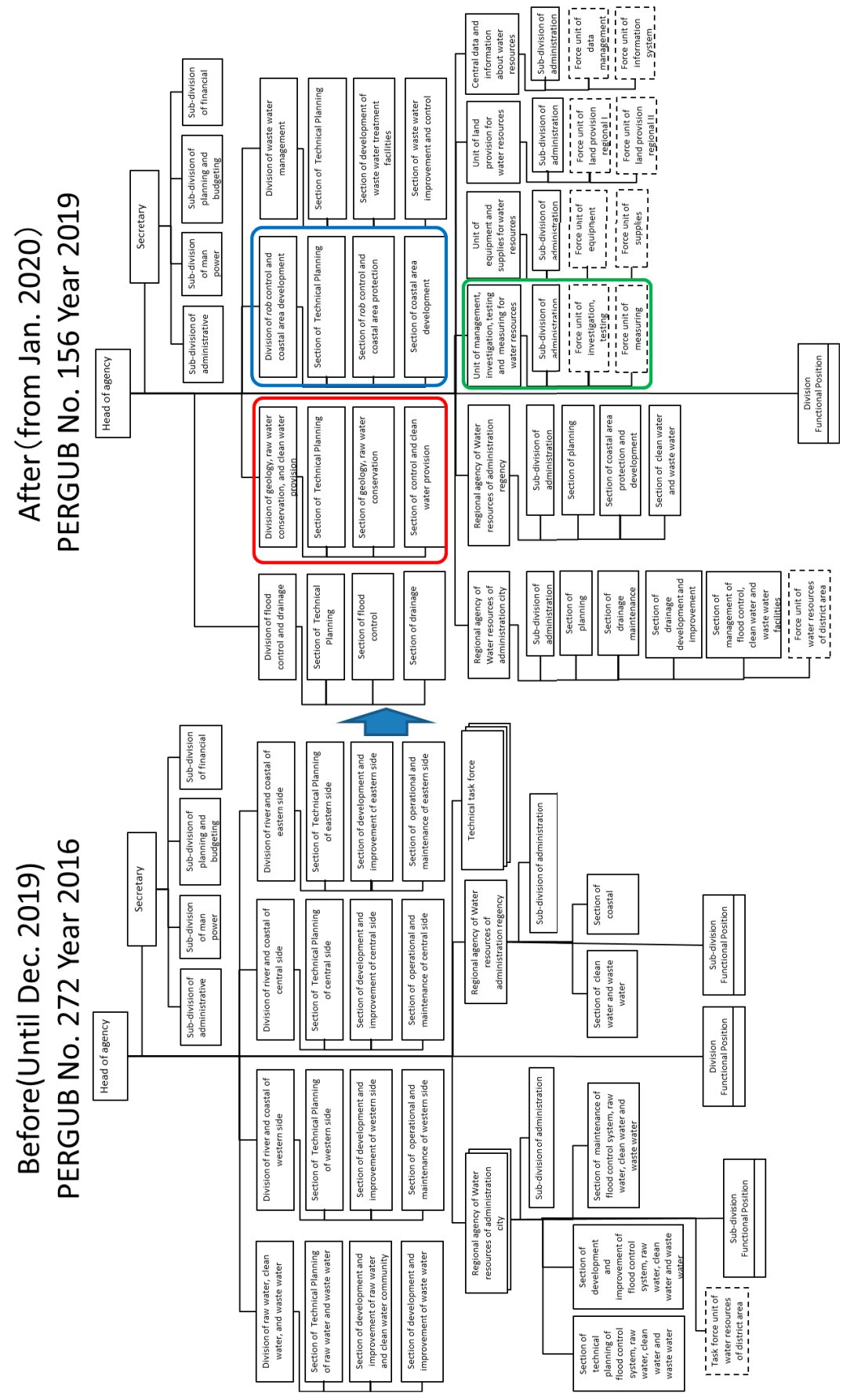


Figure 1-8 Organization Structure of DSDA of DKI

Table 1-7 Jurisdictions related to Land Subsidence in DSDA

Item	Section in Charge		
	Indonesia	English	Japanese
GW Management, Infiltration, Water Supply	Bidang Geologi, Konservasi Air Baku dan Penyediaan Air Bersih	Division of Geology, Raw Water Conservation and Clean Water Provision	地質・原水保全・上水部
Land Subsidence Monitoring including Construction	Bidang Pengendalian Rob dan Pengembangan Pasisir Pantai	Division of High Tide Control and Coastal Area Development	高潮対策・海岸開発部
GW Abstraction Monitoring	Unit Pengelola Penyelidikan, Pengujian dan Pengukuran Sumber Daya Air	Unit of Management, Investigation, Testing and Measurement for Water Resources	管理・調査・試験・計測ユニット

1.9 Training in Japan

(1) 1st Training in Japan

The training in Japan was held from 22 to 27 October 2018 (6 days) with the following purpose and schedule:

< Purpose >

- Sharing knowledge and experiences on countermeasures against land subsidence in Japan and accommodating them into action plans to be prepared in the project.
- Learning the history of countermeasures against land subsidence visually from the case in Tokyo and encouraging awareness reform of officials (fostering the sense of ownership)
- Understanding the necessity of system development to implement countermeasures against land subsidence in collaboration with the related organizations

< Schedule >

Monday	22 October	Briefing, courtesy call to JICA Headquarters, and lecture by Dr. Nagata, JICA Senior Adviser
Tuesday	23 October	Lectures by Prof. Morita, Shibaura Institute of Technology, and the Ministry of Land, Infrastructure, Transport and Tourism
Wednesday	24 October	Filed survey of zero meter area in Tokyo
Thursday	25 October	Lectures by Bureau of Environment, Tokyo Metropolitan Government and the Ministry of the Environment
Friday	26 October	Seeing countermeasures against land subsidence on board, and lecture by Sekisui Techno Molding Co., Ltd.
Saturday	27 October	Experiment on reproduction of land subsidence phenomenon, wrap-up meeting, and evaluation

A curriculum to learn the experience of countermeasures against land subsidence in Japan from the multilateral aspects was organized. The curriculum consisted of academic aspect (Prof. Morita), measures taken by a local government (Tokyo Metropolitan Government) (Dr. Tsuchiya and the Bureau of Environment, Tokyo Metropolitan Government and the Ministry of the Environment), measures taken by the central government (the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of the Environment), and utilization of technology owned by a private company (Sekisui Techno Molding Co., Ltd.) based on the theoretical approach (Integrated water resources management, Dr. Nagata, JICA Senior Adviser). In addition, field visits were carried out from onshore and on board to

see the land subsidence phenomena and countermeasures in Tokyo. This aimed to further understand what the trainees learned and discussed in the lectures through seeing the actual phenomena and structures.

A workshop was organized in the wrap-up meeting on the final day of the training to recall the lectures, discussions and site visits during the training and prepare action plans accelerating countermeasures against land subsidence in Jakarta. The action plan was presented at the second JCC meeting in January 2019 after further discussion in Jakarta and incorporation of more detailed information of experiences in Tokyo and progress of projects in Jakarta.



October 24: Site visit at zero meter area in Tokyo

(Dr. Tsuchiya, a member of domestic supporting committee)



October 25: Lecture on countermeasures against land subsidence and groundwater conservation in Japan

(Mr. Ito, The Ministry of the Environment)



October 25: Site visit to see the countermeasures against land subsidence and groundwater conservation

(Mr. Ito, The Ministry of the Environment)



October 27: Experiment on reproduction of land subsidence phenomenon, wrap-up meeting

Figure 1-9 1st Training in Japan

(2) 2nd Training in Japan

The 2nd training in Japan was held from February 3 to 8, 2020 (6 days) with the following purpose and schedule.

< Purpose >

- Sharing knowledge and experiences on countermeasures against land subsidence in Japan and accommodating them into action plans to be prepared in the project.
- Learning the history of countermeasures against land subsidence visually from the case in Tokyo and encouraging awareness reform of officials (fostering the sense of ownership)
- Understanding the necessity of system development to implement countermeasures against land subsidence in collaboration with the related organizations

< Schedule >

Monday	February 3	Briefing, courtesy call to JICA Headquarters, and lecture by Dr. Nagata, JICA Senior Adviser
Tuesday	February 4	Lectures by the Ministry of Land, Infrastructure, Transport and Tourism and Bureau of Environment, Tokyo Metropolitan Government
Wednesday	February 5	Filed survey of zero meter area in Tokyo
Thursday	February 6	Lectures by Prof. Morita, Shibaura Institute of Technology, and the Ministry of the Environment
Friday	February 7	Seeing countermeasures against land subsidence on board
Saturday	February 8	Experiment on reproduction of land subsidence phenomenon, wrap-up meeting, and evaluation

For the purpose of acceleration of Tokyo's experience in the action plan, the trainees during the 1st training attended again. Following the intention of the Minister of PUPR that the project output shall be extended to other cities suffering from land subsidence, trainees from the River Basin Organization (Balai) in Semarang and Cirebon also attended. On the other hand, trainees from DKI Jakarta could not attend due to administration problems.

A curriculum to learn the experience of countermeasures against land subsidence in Japan from the multilateral aspects was organized. The curriculum consisted of academic aspect (Prof. Morita), measures taken by a local government (Tokyo Metropolitan Government) (Dr. Tsuchiya and the Bureau of Environment, Tokyo Metropolitan Government and the Ministry of the Environment), and measures taken by the central government (the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of the Environment). In addition, field visits were carried out from onshore and on board to see the land subsidence phenomena and countermeasures in Tokyo. This aimed to further understand what the trainees learned and discussed in the lectures through seeing the actual phenomena and structures. In the wrap up meeting, issues and solutions in each city were discussed.



February 3 (Mon): Courtesy Call to JICA



February 4 (Tue): Lecture by MLIT



February 5 (Wed): Field Survey (Signboard)



February 5 (Wed): Field Survey (Coastal Management Office)



February 7 (Fri): Field Survey (On Board)



February 8 (Sat): Wrap up Meeting

Figure 1-10 2nd Training in Japan

1.10 Seminar and Workshops

Besides the training in Japan mentioned above, capacity building program has been conducted through the workshop/seminar participation as shown in Table 1-8. The number of participants to the Project is counted about 2,000 in total.

Table 1-8 Jurisdictions related to Land Subsidence in DSDA

No	Date	Type	Name
1	2018/7/12	Workshop	"Answering the Challenges Groundwater Problems" hosted by NGO
2	2018/11/27	Seminar	Global Water Partnership Seminar "Evaluation of Causes of a Massive Land Subsidence and Effectiveness of Measures to Control of Them in Jakarta"
3	2019/1/16	Forum	1st Academic Forum
4	2019/1/28,29	Seminar	WB Seminar
5	2019/7/22	Conference	Focus Group Discussion on NCICD
6	2019/8/7,8	Seminar	Technical Seminar (Lecture, Site visit)
7	2019/8/22~ 2019/8/27	Conference	World Water Week in Stockholm
8	2019/9/3	Conference	International Commission on Irrigation and Drainage (ICID)
9	2019/10/8	Forum	2nd Academic Forum
10	2019/10/15	WS	West Jakarta City
11	2019/10/23 2019/11/05	WS	North Jakarta City
12	2019/11/12	WS	West Jakarta City
13	2019/11/18	Forum	G20 Climate Sustainability Working Group (CSWG) in Thailand
14	2019/11/20	WS	Land Subsidence in South Java by ESDM
15	2019/11/22~ 2019/11/24	Forum	3rd International Seminar of Indonesian Association of Hydraulic Engineers (HATHI)
16	2019/11/27	WS	Land Subsidence Issues in North Java
17	2019/12/18	WS	East Jakarta City
18	2020/6/26	Conference	Focus Group Discussion hosted by NGO
19	2020/7/30	WS	Online Workshop for West Jakarta City
20	2021/9/9	Meeting	Online Technical Transfer for Monitoring Well（DSDA）
21	2021/10/27	Forum	Focus Group Discussion by ITB
22	2022/3/24	TT	Monitoring Well
23	2022/4/13	TT	Groundwater Simulation (PUPR、DKI)
24	2022/6/28	TT	Monitoring Well

Remarks: WS: Workshop, TT: Technical Transfer



Figure 1-11 Number of Project Participants

1.11 Project Activities and Outputs

As mentioned in Sub-section 1.5, the Project was implemented dividing 2 phases. In Phase 1, various survey/investigation and discussions have been made. Based on these results, the short term (till 3 years), the middle term (3 to 10 years) and the long term (after 10 years) action plans were made. As the short term action plan, some pilot areas were selected based on the InSAR analysis results and specific action plans were made for each pilot areas, as well as the action plans for whole DKI Jakarta. The short term action plans for whole DKI and for each pilot area are summarized in Table 1-9 and Table 1-10, respectively.

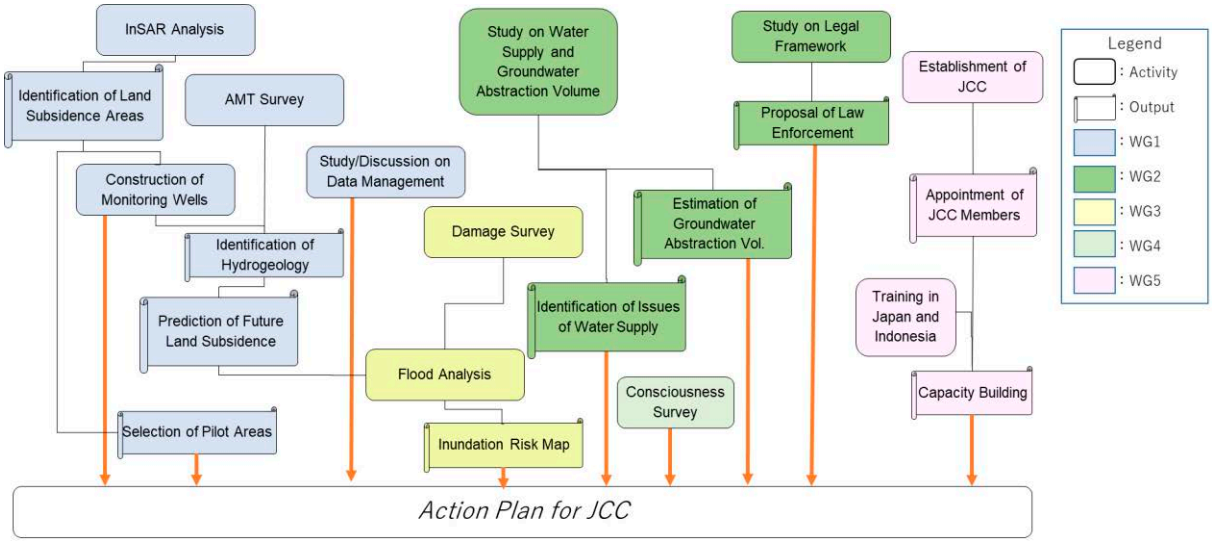


Figure 1-12 Activities and Outputs in Phase 1

Table 1-9 Short Term Action Plan for Whole DKI Jakarta

Output	Action Plan
Output 1	● Data Integration on MONAS (by ESDM) Platform ● Assistance for Land Subsidence Monitoring Report ● Construction of New Land Subsidence ● Monitoring Wells by Indonesian Sides
Output 2	● Study on Current Efforts for Non Revenue Water and Suggestion for Improvement ● Examination on Other Alternative Water Resources
Output 3	● Preparation of Hazard Map ● Estimation of Social Cost of Land Subsidence
Output 4	● Installation of Signboard ● Preparation of Materials and Manuals for Public Awareness
Output 5	● Assistance for Planning and Implementation Committee (PIC) Establishment ● Review and Finalization of Middle-Long Term Action Plans

Table 1-10 Short Term Action Plan for Pilot Areas

Area	Characteristics	Short Term Action Plan (Output No.)
Panjaringan	Housing and Commercial Area	• Joint inspection for large-scale buildings (2) • Installation “Kios Air” for low income class (2) • Rain harvest storage facilities (2)
Jakarta Fishing Port	Most Severe Land Subsidence Area	• Joint Committee among KPK, BUMN and DKI (whole) • Work Shop for marine products processors (4) • Joint inspection for marine products factory (2) • Practice management of periodic survey (1) • Review the water charge (2) • Introduce the rain harvest use (2)
Cengkareng	Land Subsidence Already Stopped	• Grasp actual condition about calming down (4) • Prepare materials for public information (4)
Daan Magot	Future Land Subsidence Risk Area	• Evaluation and improvement suggestion for the plan of integrated water management (2)
Cilincing/ Cakung	Industrial Area	• Joint inspection for factories (2) • Grasp condition about rain harvest use and water recycle (2)
Palmerah	Commercial Area	• Joint inspection for commercial buildings (2) • Introduce the rain harvest use and water recycle (2)

Due to the pandemic of COVID-19 during the Phase 2 of the Project, all the short term action plan shown in Table 1-9 were not able to be implemented because of restriction of social activities in Indonesia. On the other hand, several additional scopes of works were added such as construction of additional land subsidence monitoring well, rainwater harvesting system and signboard. The actions shown in Figure 1-13 have been implemented in Phase 2 of the Project by means of remote project management. And the Planning and Implementation Committee (PIC) establishment and the formulation

of the PIC Action Plan were made. Details of these activities and outputs are discussed in the following chapters of this report.

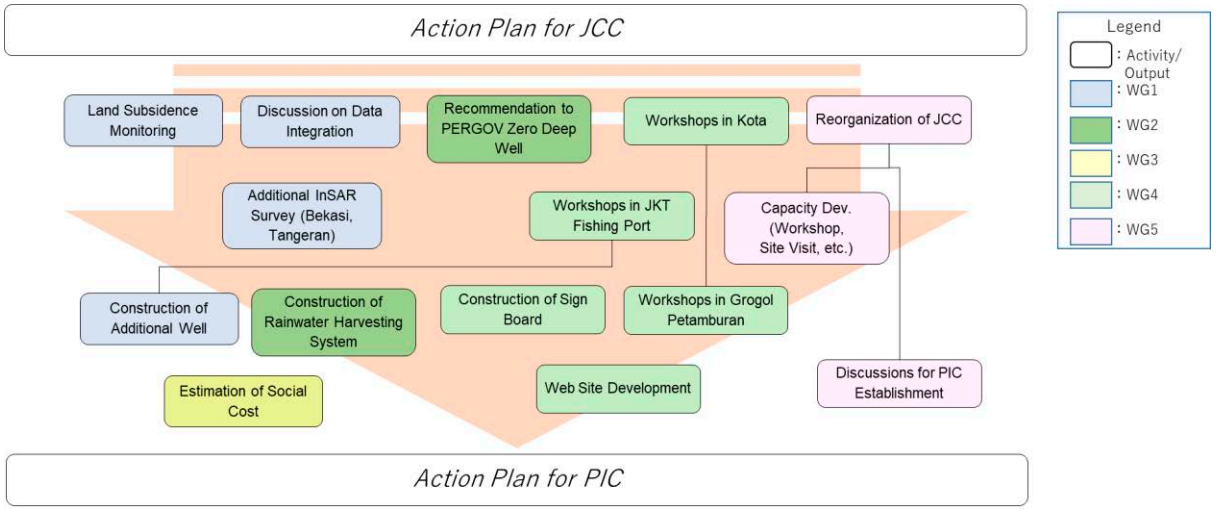
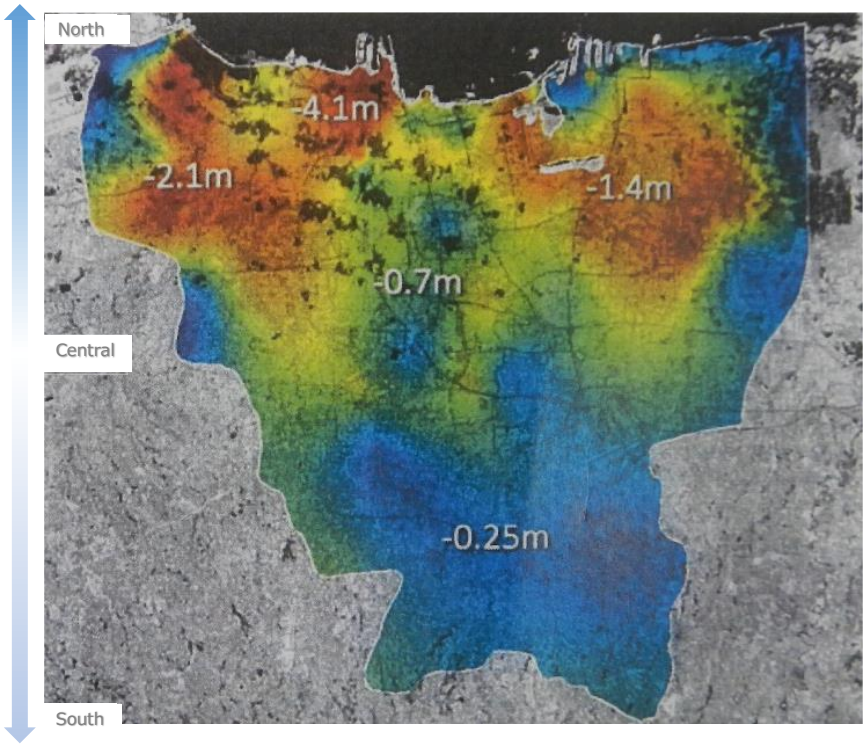


Figure 1-13 Activities and Outputs in Phase 2 (Short Term Action)

CHAPTER 2 CURRENT AND FUTURE SITUATION OF LAND SUBSUDIENCE AND GROUNDWATER ABSTRACTION

2.1 Situation of Land Subsidence

Figure 2.1 shows the distribution of land subsidence from 1974 to 2014 in DKI Jakarta made by DPE. According to this figure, severe land subsidence has occurred around Pluit in the northern part, around Kamal Muara and Cengkareng in the western part, and around Kelapa Gading and Cakung in the eastern part. Near Pluit in the northern part, the cumulative land subsidence depth reached 4.1 m at one point.



Source: DPE

Figure 2.1 Distribution of Land Subsidence depth from 1974 to 2014 in DKI Jakarta

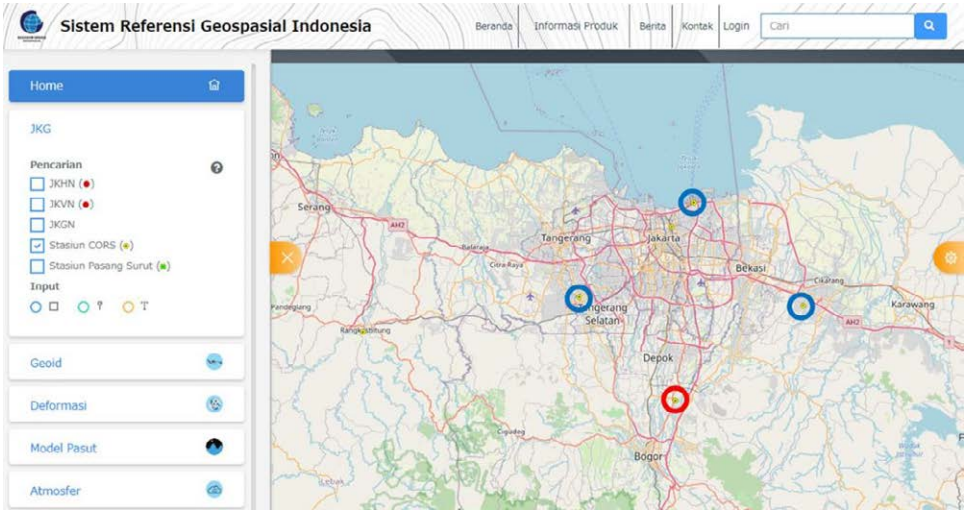
In this project, the team is proceeding the collection of the leveling survey data such as GNSS (Global Navigation Satellite System) survey by each point, and analyzing regional tendency by the spatial analytical method using satellite data.

2.1.1 Land Subsidence Monitoring System

(1) Levering Survey Data around DKI Jakarta

In Japan, public control point is managed by the Geospatial Information Authority and local governments, and its data is published to citizens for free of charge. While in Indonesia, this type of data is produced and managed by separate organizations depending on the projects, and only the information on the national control points provided by BIG are available publicly (no vertical control points found in Jakarta area according to BIG). Therefore, the project team confirmed the status of land subsidence measurement by relevant organizations in Indonesia, through interview and internet survey, to understand the situation of land subsidence from geodetic survey data. Table 2.1 shows current status of vertical survey measurement data collected by the project team.

Table 2.1 Status of Height Measurement

Name	Status
BIG	【Status of data management】 ・ Managing state-owned control points. ・ Data of vertical control points does not exist (the nearest vertical control point is placed at the premise of BIG in Bogor) ・ CORS are installed around the area of Jakarta.  Source: http://srgi.big.go.id/srgi2 (BIG) **Figure 2.2 Distribution of Benchmarks and CORS around Jakarta (Red: BM, Blue: CORS)** 【Status of data collection】The project team requested BIG to provide CORS data and obtained the consent, on condition that BIG is participating to the project. Data will be provided after necessary process is completed.
ITB	【Status of data management】 ・ GNSS survey data after 1990's is managed. (Also leveling data of former period) ・ The survey is still continued in regular basis, but the number of observation point is reduced depending on the budget support. 【Status of data collection】 Data is the property of ITB, and not freely available so far. Therefore, information is referred from published documents.
DPE	【Status of data management】 ・ GNSS survey of 60 points were conducted in 2014, and continuous surveys were conducted in 2017 and 2018 with additional survey points. 【Status of data collection】 DPE stated that 2017 and 2018 data are unreliable as the leveling point may have artificially moved. Therefore, these data were not collected.
PUSAIR	【Status of data management】 ・ GNSS Survey data is stored (after 2002 data) ・ Need confirmation and comparison with survey data from other sources. 【Status of data collection】 Provided.
JCDS	【Status of data management】 ・ The material which contains the result of survey and calculation of subsidence depth are exists. 【Status of data collection】 Digital format of survey data was obtained. Observation points overlap with the survey result published from ITB. This indicates the original data is possibly shared with ITB. Need to confirm.

(2) Land Subsidence Monitoring Network

1) Existing Land Subsidence Monitoring Wells

The existing land subsidence monitoring wells that have been confirmed so far are shown in Table 2.2. The location of each monitoring well is as shown in Figure 2.3.

Among the land subsidence monitoring wells which DPE has been monitoring automatically, only the land subsidence monitoring well that was installed in 2016 at Kamal Muara is in operation. Operation of the other land subsidence monitoring wells has been stopped due to mechanical failure. Since 2021, the management of Kamal Muara's monitoring well has been transferred from DPE to DSDA. After the transition to DSDA, it was confirmed with DSDA the operating status of the monitoring well and the data management status. The results were as follows.

- ✓ The data logger is working, and it is possible to import data from the data logger to computer.
- ✓ However, since the software for organizing the data is not inherited from DPE, it cannot be confirmed whether the imported data is normal data or not.
- ✓ Therefore, it is not possible to judge whether the monitoring equipment is functioning properly based on the captured data.

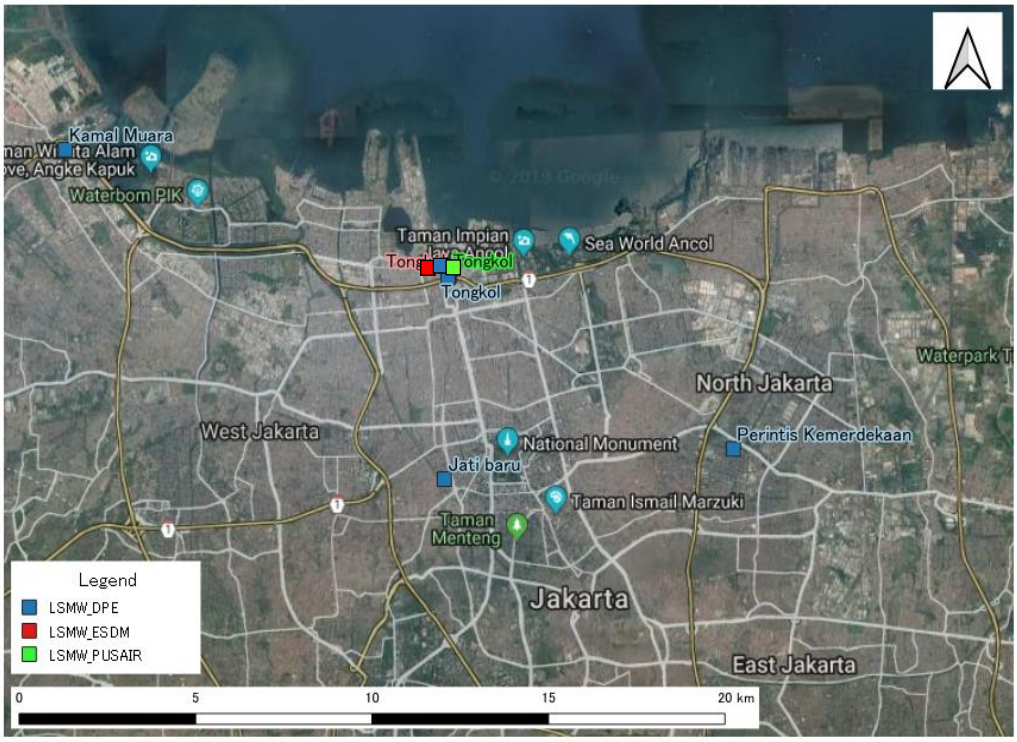
Regarding this, the JICA Study Team proposed to obtain software for data analysis and management, and existing data from former DPE officials, and then DSDA should manage those data appropriately.

Although the land subsidence monitoring wells belonging to BKAT in Tongkol is only monitored once a year, double tube method where the amount of land subsidence can be visually confirmed is used. Hence, highly reliable measurement values can be obtained. The cumulative land subsidence for 29 years from 1990 to 2019 is 458 mm and in recent years the speed of land subsidence is about 1 cm per year.

Table 2.2 Existing Land Subsidence Monitoring Wells

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Organization</th><th rowspan="2">Year built</th><th colspan="2">Observation System</th><th rowspan="2">Condition</th><th rowspan="2">Notes</th></tr>
<tr><th>Measurement Depth</th><th>Method</th></tr>
<tr><td rowspan="3">Tongkol
(BKAT site)</td><td>BKAT</td><td>1990</td><td>300 m</td><td>(roughly)
Double tube type</td><td>Working</td><td>Measurement of the withdrawal amount of inner tube by ruler</td></tr>
<tr><td>PUSAIR</td><td>2016</td><td>There are 10 points of observation up to the depth of 50 m</td><td>Magnetic type</td><td>Working</td><td>Measurement of the position of magnets installed in stratum by a dedicated probe</td></tr>
<tr><td>DPE</td><td>1989</td><td rowspan="4">There are 4 points of observation up to the depth of 150 m, and There are 4 points of observation from the depth of 150 m to 300 m</td><td rowspan="4">Wire type</td><td rowspan="3">Failure stop</td><td></td></tr>
<tr><td>Perintis Kemerdekaan</td><td>DPE</td><td>2009</td><td rowspan="2">Measurement of the pressure head: 7 depth, Measurement of the groundwater level: 2 depth</td></tr>
<tr><td>Jati Baru
(DPE site)</td><td>DPE</td><td>2012</td></tr>
<tr><td>Kamal Muara</td><td>DPE</td><td>2016</td><td>Working</td><td>Measurement of the pressure head: 4 depth</td></tr>
</table>

Source: JICA Study Team



Source: JICA Study Team

Figure 2.3 Location of Existing Land Subsidence Monitoring Wells

2) Location Map of the Land Subsidence Monitoring Wells Constructed by the JICA Project 2019

Figure 2.4 shows the location of the land subsidence monitoring wells constructed by JICA Project 2019.

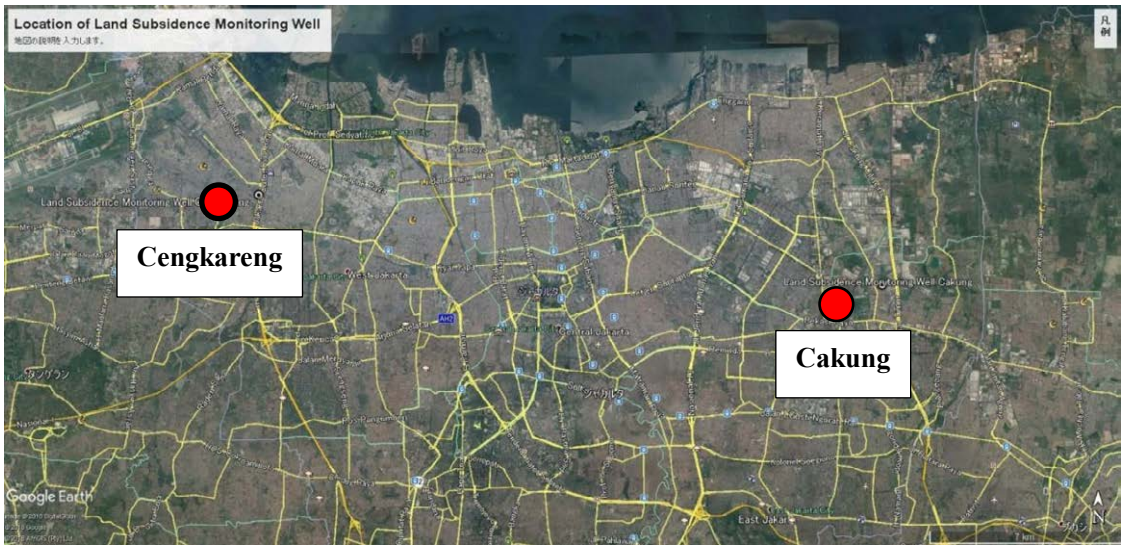


Figure 2.4 Location Map of the Land Subsidence Monitoring Wells by JICA Project 2019

Six monitoring points are exist, i.e. four existing monitoring wells constructed by the Indonesian side shown in Figure 2.4 and two observation wells newly constructed in this project. However, 3 out of 4 observation wells constructed by DPE are out of order, and the actual monitoring points are 4 points. All of these are located in the northern part of Jakarta.

(3) Annual change of land subsidence

The annual change of land subsidence of each Kota was calculated and plotted on a graph using the vertical survey data of JCDS (Jakarta Coastal Defense Strategy (2011-2013)). This data set contains comparatively longer term observation records with 42 points of measurement. The number and location of the observation points are shown in Table 2.3 and Figure 2.5.

Table 2.3 Number of Observation Points

Name of Kota	Number (42)
Pusat (Center)	11
Utara (North)	13
Timur (East)	4
Selatan (South)	6
Barat (West)	8

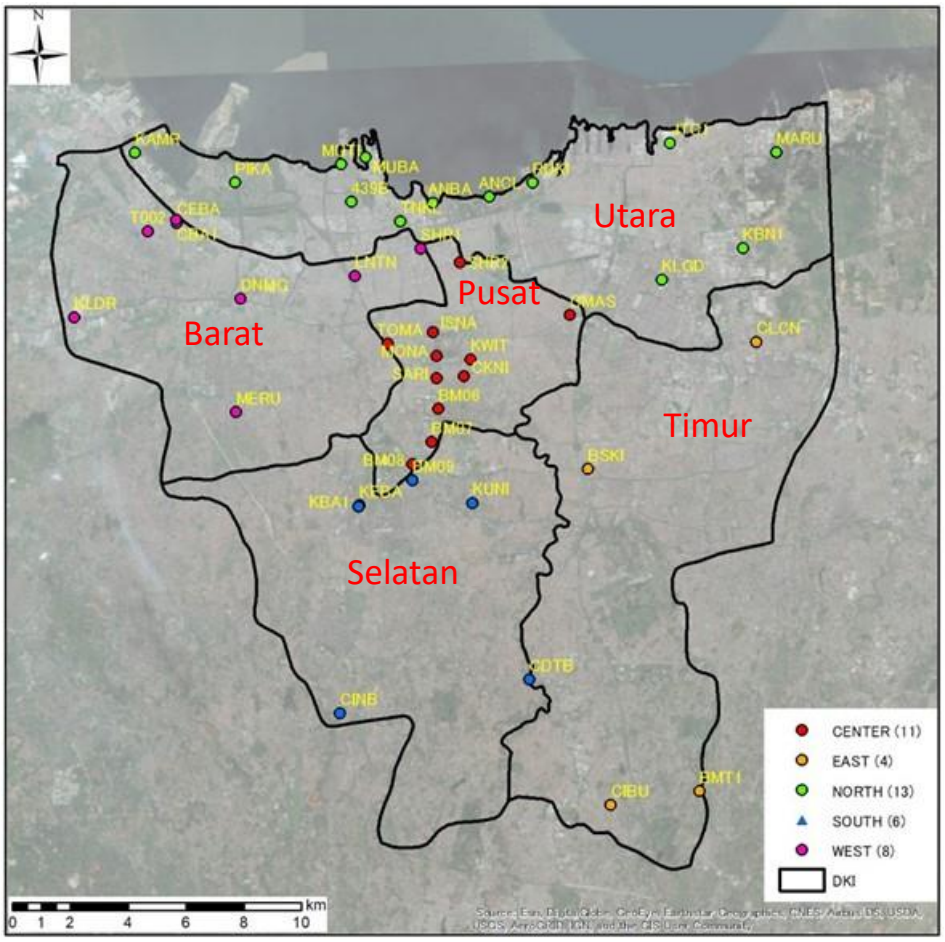


Figure 2.5 Distribution of Observation Points

Source: Created by the Project Team

Figure 2.6 to Figure 2.10 show a cumulative subsidence depth of 42 leveling points, which are combined from leveling survey data from 1974 to 2000, GNSS survey data from 2000 to 2010, and InSAR analysis data since 2010. In these figures, the cumulative subsidence depth in 2000 was set to zero.

These figures indicated the trends in the long-term change of land subsidence as follows.

- The point where leveling data exists from 1974 to 2000 indicated that a remarkable subsidence has already appeared since 1974, and has accelerated in the 1990s and 2000s. (However, it is necessary to verify the continuity of the leveling data and the GPS data of KUNI around KUNINGAN TIMUR in the South Jakarta Kota and CIBU around KELAPA DUA WETAN in the East Jakarta Kota. This is because the subsidence depth of these points suddenly becomes intense in the 2000s.)
- Land subsidence in the North Jakarta Kota particularly in the coastal area such as in MUBA around Pluit is remarkable, with recorded value of cumulative subsidence of 3.5 m from 2000 to 2017. Land subsidence in the West Jakarta Kota is also large, from 50 cm to 2 m. The maximum cumulative subsidence depth in each Kota are as follows.

Pusat : 1,018 mm (SHR2 (Jl. Pangeran Jayakarta & Jl. Pisang Batu))
Utara : 3,550 mm (MUBA (Zhang Marina Indonesia Fish Market))
Barat : 2,005 mm (T002 (Suku Dinas Kebersihan Tegal Alur))
Selatan : 972 mm (KBA1 (Taman Martimbang IV))
Timur : 587 mm (BSKI (Apartement Basura City))

- Regardless of the land subsidence depth, land subsidence has been slowing down at all point since 2010. Such decrease in land subsidence rate is also confirmed even at MUBA around Pluit, in North Jakarta Kota, where severe subsidence has occurred. Based on this fact, land subsidence in Jakarta has tended to be calmer in recent years. (However, as mentioned in "3.1.3. Results of InSAR Analysis", there are areas that are partly sinking.)

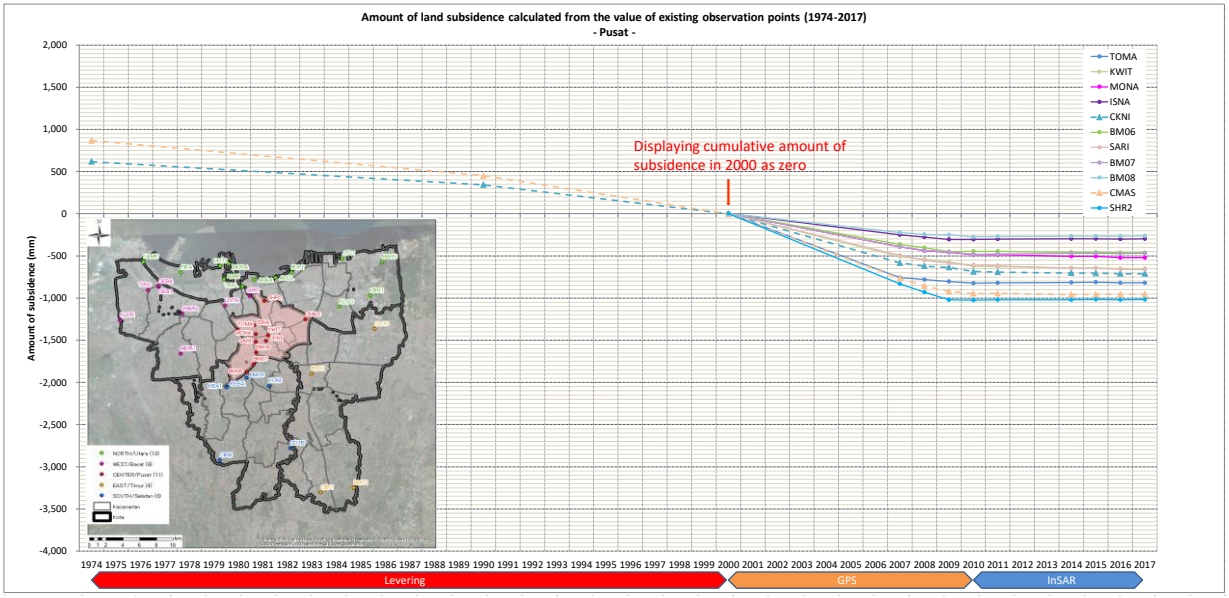


Figure 2.6 Progress of Land Subsidence (Pusat)

Source: Created by the Project Team Referring to Data from JCDS

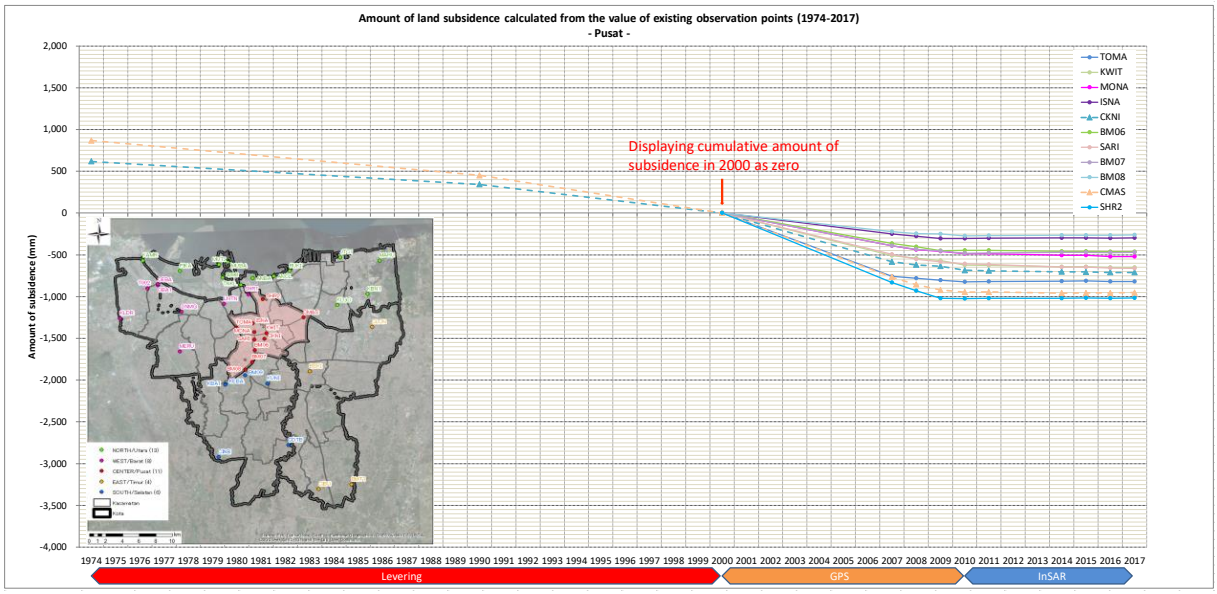


Figure 2.7 Progress of Land Subsidence (Utara)

Source: Created by the Project Team Referring to Data from JCDS

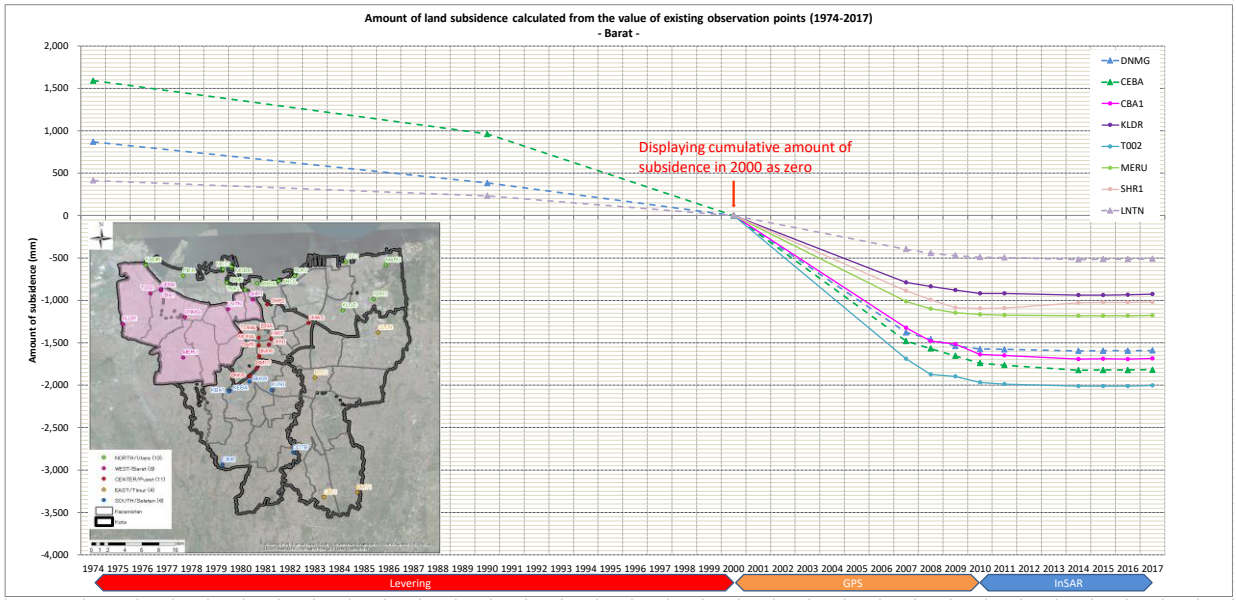


Figure 2.8 Progress of Land Subsidence (Barat)

Source: Created by the Project Team Referring to Data from JCDS

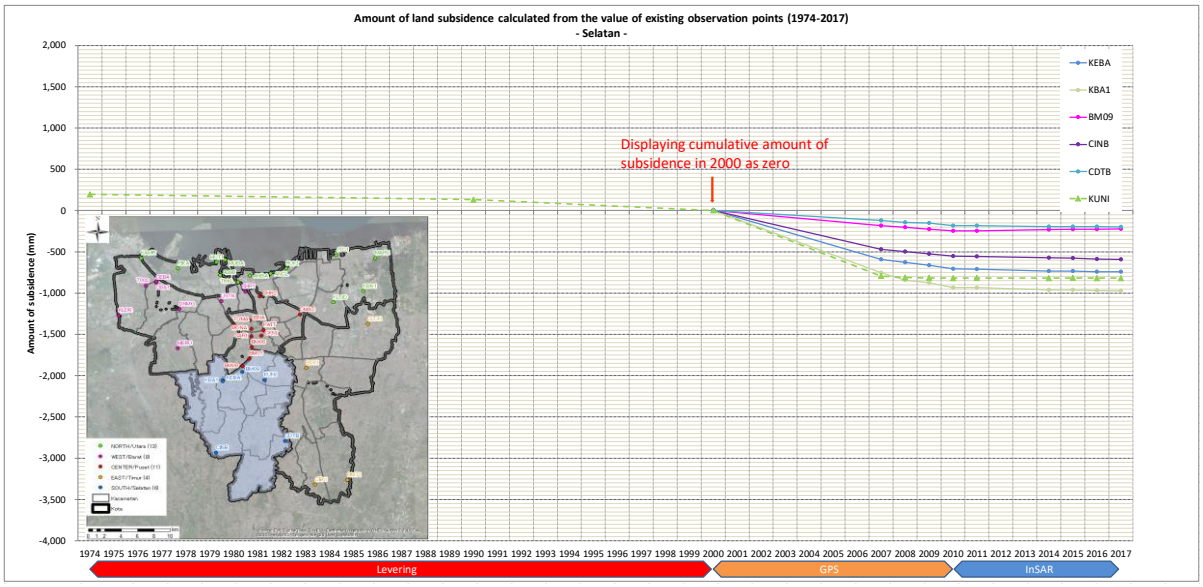


Figure 2.9 Progress of Land Subsidence (Selatan)

Source: Created by the Project Team Referring to Data from JCDS

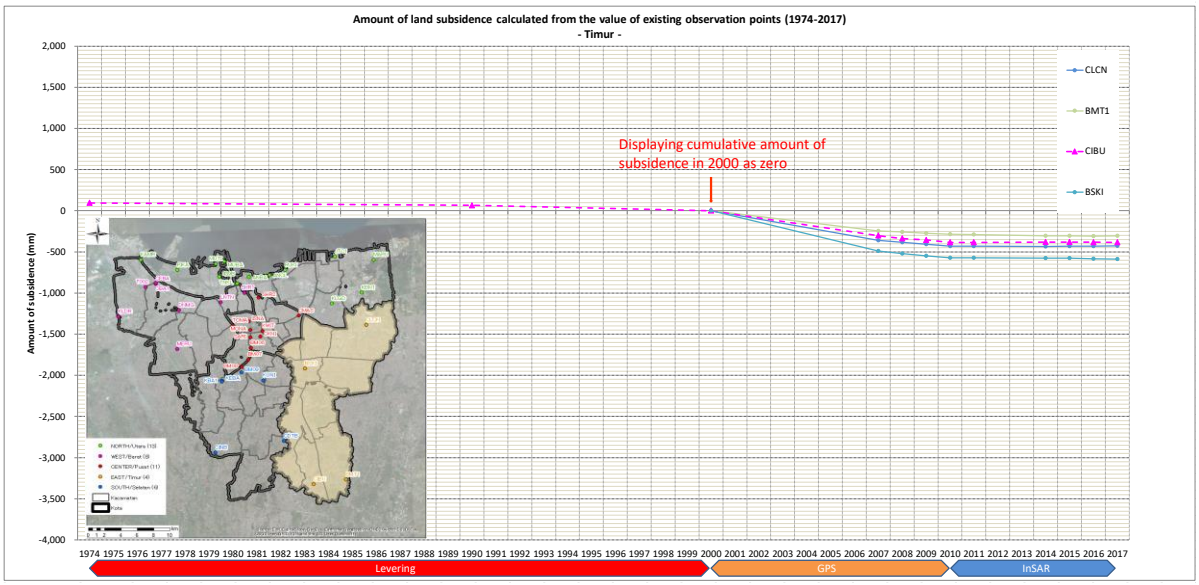
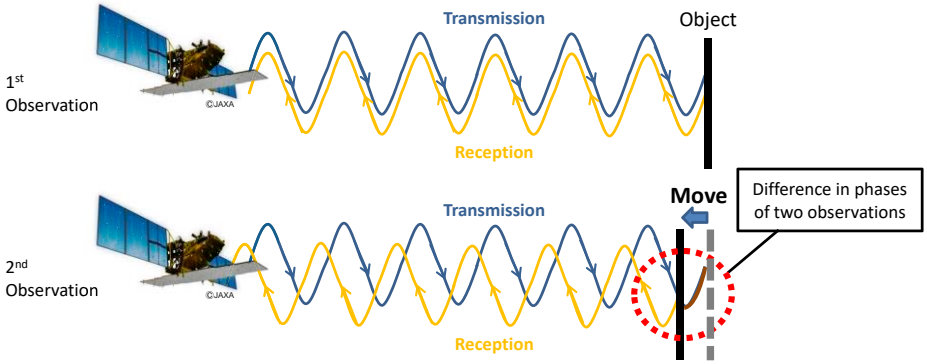


Figure 2.10 Progress of Land Subsidence (Timur)

Source: Created by the Project Team Referring to Data from JCDS

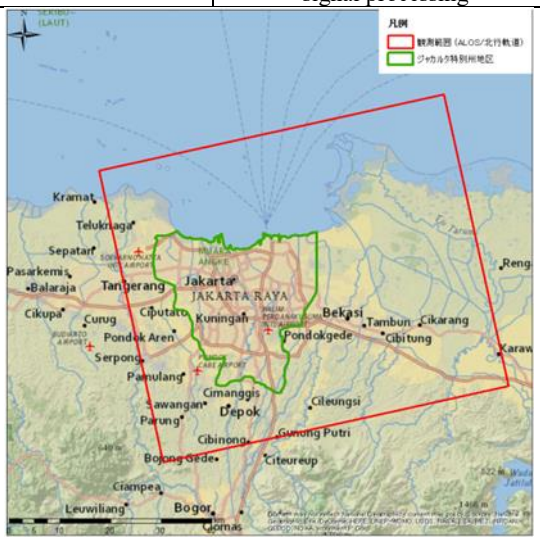
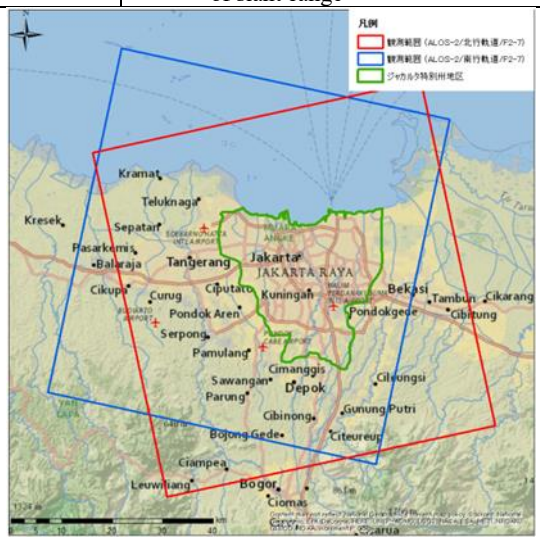
2.1.2 InSAR analysis

InSAR analysis is a measurement method to determine how much the object has moved using more than two observation data. The conceptual diagram of the InSAR analysis is shown below. Observation data used in this project and the positional relationship between the range of observation and area of interest are shown below.



Source: Created by the project team

Figure 2.11 Idea of Measuring Displacement of Land by InSAR Analysis

Item	ALOS/PALSAR	ALOS-2/PALSAR-2
Central frequency	L band (wave length: 23.6cm)	L band (wave length:23.6cm)
Satellite/Sensor	ALOS/PALSAR	ALOS-2/PALSAR-2
Period of operation	2006/1/24 - 2011/5/12	2014/5/24 - present
Procured number of scenes	20 ・North bound : 20	16 ・North bound : 9 ・South bound : 7
Observation mode (Polarised wave)	FBS: Fine Beam Single polarization (HH) FBD: Fine Beam Dual polarization (HH/HV)	SM3: StripMap3 (HH)
Resolution	10m	10m
Processing level	Level 1.0 Raw data : the complex data before signal processing	Level 1.1 SLC data : the complex image data of slant-range
		
ALOS/PALSAR Observation Area	ALOS-2/PALSAR-2 Observation Area	

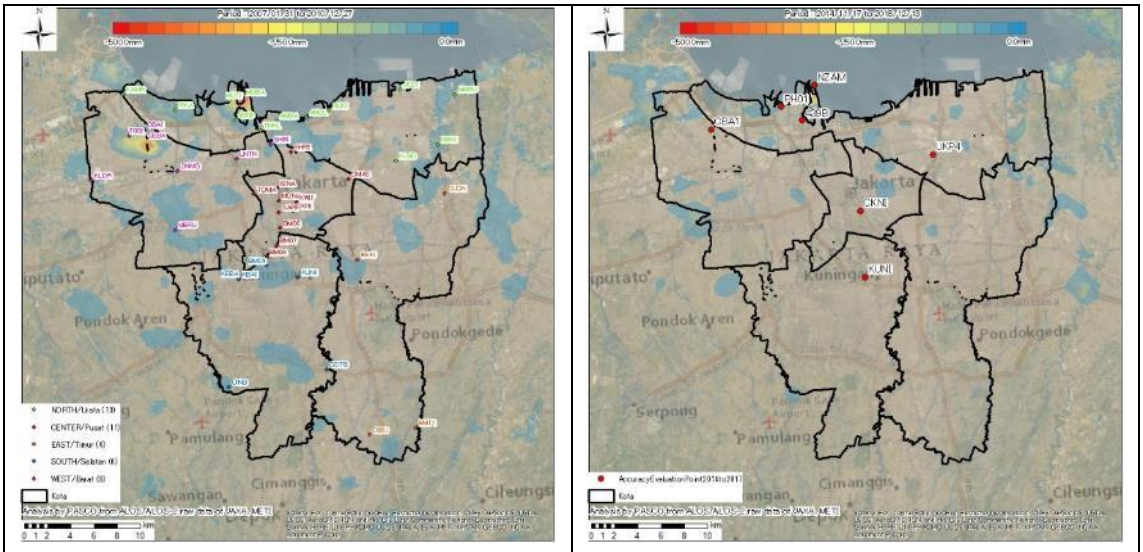
Source: Created by the project team

Figure 2.12 Observation Data and Area of SAR Used for the Analysis

The project team conducted a reliability evaluation between the public leveling data of past project and the distribution of ground displacement (relative ground displacement between two different periods) using InSAR analysis. Data used for reliability evaluation is as shown in Table 2.4, the positional relationship between distributions of ground displacement and leveling location is as shown in Figure 2.13, index of reliability evaluation is as shown in Table 2.5, and the result of evaluation is presented in Table 2.6.

Table 2.4 Data used to evaluation reliability of InSAR analysis

Survey data	InSAR data
・Leveling, GNSS ・Period : 2007 - 2010 ・Number : 42	・InSAR ・Period : 2007 - 2010 ※Correspond to ALOS/PALSAR operation
・Leveling, GNSS ・Period : 2014 - 2017 ・Number : 7	・InSAR ・Period : 2014 - 2017 ※Correspond to ALOS-2/PALSAR-2 operation



2007~2010 | 2014~2017

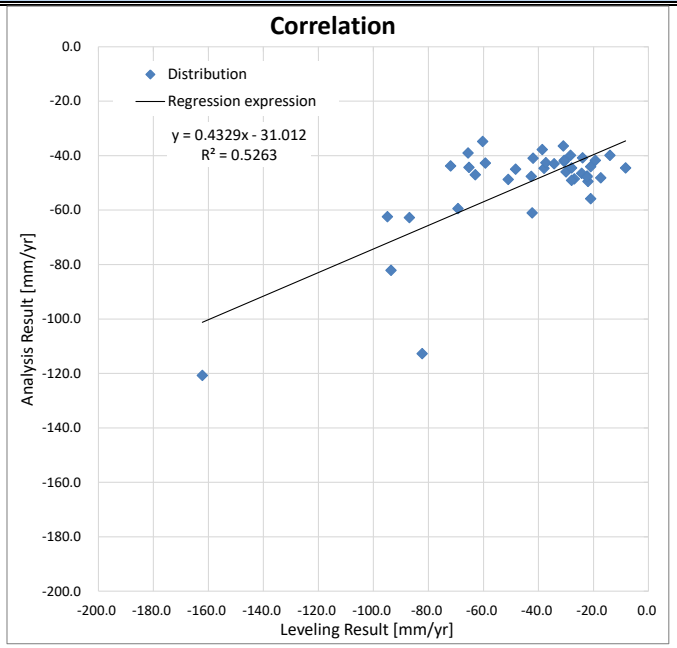
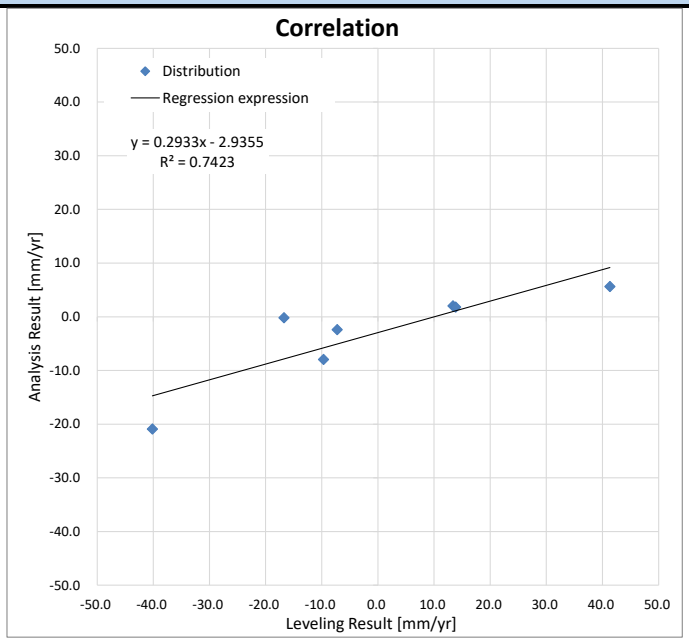
Figure 2.13 Location of points used for the evaluation

Source: The project team

Table 2.5 Index of evaluation

Item	Detail
Correlation (Scatter diagram)	Evaluate the level of correlation using the scatter diagram which horizontal axis is survey result, and vertical axis is InSAR analysis result.
Regression expression	Evaluate the level of correlation from the slope of 'a' and intercept 'b', by deducting one dimensional approximate line.
Determination coefficient: R^2 (coefficient of correlation: r)	Evaluate the level of correlation by computing the determination coefficient and coefficient of correlation against survey results.
RMSE[mm]	Evaluate dispersion by computing RMSE of analysis against survey results.
Max difference[mm]	Indicate the maximum difference between the value of each survey point and InSAR analysis result.
Number of points exceeding3 cm	Count the number of points which the difference of survey result and InSAR analysis result exceed 3 cm.

Table 2.6 Result of evaluation

Item	Description
Period : 2007 - 2010	
Correlation	
Regression expression	y = 0.4329x - 31.012
Determination coefficient R^2 (coefficient of correlation r)	R^2 = 0.5263 （r = 0.725）
RMSE [mm]	21.236 [mm]
Max difference [mm]	36.205 [mm]
Number of points excessing 3 cm	6／40 （15.0%）
Period : 2014 - 2017	
Correlation	
Regression expression	y = 0.2933x - 2.9355
Determination coefficient R^2 (coefficient of correlation r)	R^2 = 0.7423 （r = 0.862）
RMSE [mm]	17.801 [mm]
Max difference [mm]	35.698 [mm]
Number of points excessing 3 cm	5／7 （71.4%）

※Validated data for reliability evaluation by the following statistical index below were selected in the period of ALOS (2007 - 2010), i.e. 40 out of 42.

① Calculating the 25 percentile (Q1), 75 percentile (Q3) and inter-quartile range (IQR = Q3-Q1) from squared error between leveling and analysis result.

② Selecting validated data based on the inter-quartile range (IQR). (Rejection of statistical outlier)

[Outlier] ≦ (Q1 - 1.5×IQR) ≦ Squared Error ≦ (Q3 + 1.5×IQR) ≦ [Outlier]

In the period of ALOS (2007 - 2010), although the gradient of regression expression is far from y = x, there is a positive correlation from Determination coefficient (coefficient of correlation). The RMSE shows that the accuracy of analysis result is averagely below 2 cm. Meanwhile, the maximum difference is 3.6 cm and the number of points excessing 3 cm is more than 15%. We determined that the evaluation result might have been heavily affected by the dispersion because of the number of used data for evaluation.

In the period of ALOS-2 (2014 - 2018), although the gradient of regression expression is far from y = x, there is a positive correlation from Determination coefficient (coefficient of correlation) as well. The RMSE shows that the accuracy of analysis result is averagely below 2 cm. Meanwhile, the maximum difference is 3.6 cm and the number of points exceeding3 cm is more than 70%. We determined that the dispersion due to a small number of data used have greatly affected the evaluation result.

Japanese cities conduct periodical survey and the number of leveling bench marks reaches many hundreds especially in cities with large urban area. This leads to the improvement of reliability when evaluating data. Considering the present provision of survey infrastructure in Jakarta, it is difficult to conduct highest accuracy levelling with many hundreds points periodically. In this circumstance, it would be recommended to conduct periodical survey at limited but carefully selected points, also use past data from NCICD or other reliable sources, for reliable evaluation (see 2.3 about GNSS survey).

In the observation well (300 m benchmark) installed in August 2009 in Pluit, the state of subsidence is continuously confirmed. As of February 7, 2019, a sink of about 7 cm was confirmed from the line marked on December 21, 2018. Furthermore, it has been confirmed that the accumulated subsidence depth since its installation in 2009 is about 51 cm. Then again, the value of subsidence of InSAR results during the same period indicates a cumulative amount of subsidence of about 61 cm although it includes an estimated period (four years from 2011 to 2014) where satellite analysis is not possible. Since the same amount of subsidence was shown, it can be said that the result of contributing to the reliability evaluation was obtained.

As the result of above evaluation which compared the result of InSAR analysis and existing 42 GNSS survey points data (ALOS) and 7 points data (ALOS2), RMSE at each evaluation points were within 3cm. Furthermore, InSAR analysis result showed the identical trend of subsidence with the research by ITB, and also similar distribution pattern with the analysis by a European company (FUGURO). It is assumed that InSAR analysis is correct enough against the purpose of this project.



(a) 2009/8



(b) 2019/2/7

Figure 2.14 Observation Well in Pluit (300 m Benchmark)

Source: The project team

2.1.3 Result of InSAR analysis (Distribution of Land subsidence – DKI Jakarta)

The project team created three kinds of output using InSAR analysis as shown in the Table below.

Table 2.7 List of Output from InSAR Analysis

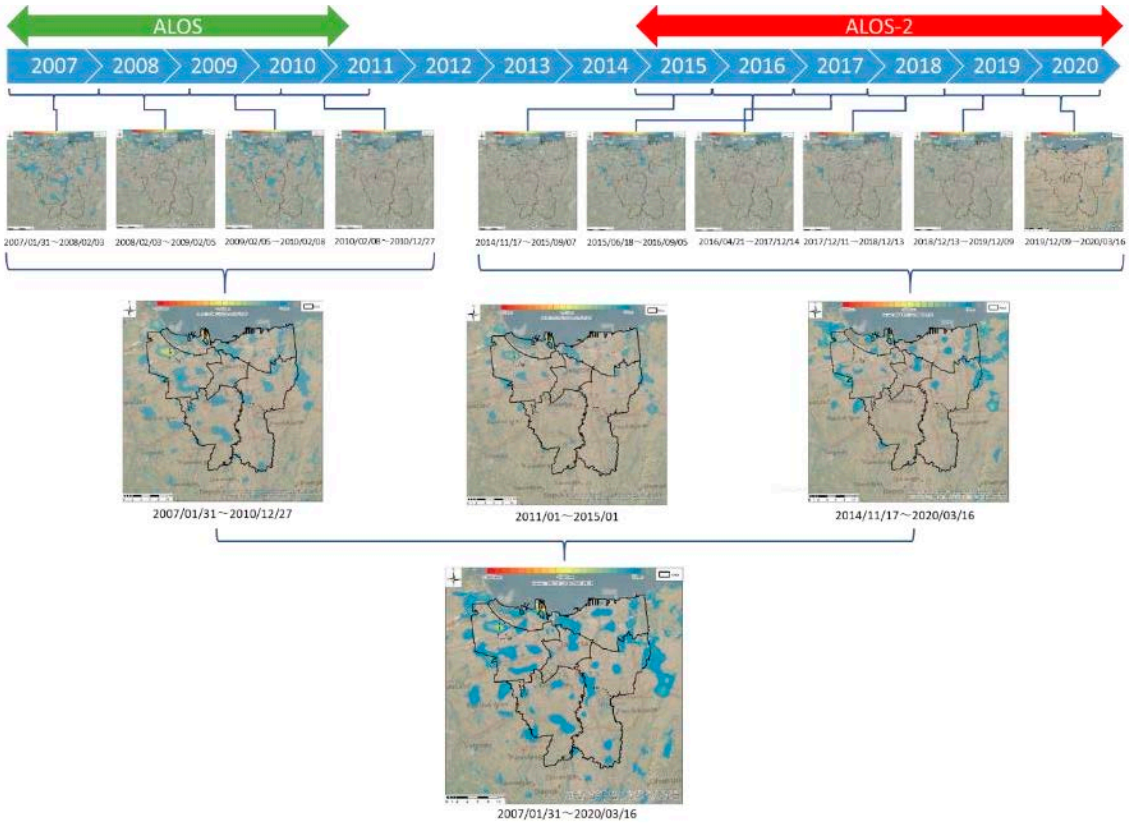
No	Output	Description
1	Contour map of land subsidence	Contour map of land subsidence, i.e. adding color to the land subsidence distribution map (2007-2010, 2014-2020).
2	Summary of land subsidence by Kecamatan	Statistical map of land subsidence in Kecamatan level.
3	Cross-sectional diagram of land subsidence	Diagram of the change of land subsidence depth, created based on the InSAR analysis calculation result from 2007 to 2020.

(1) Contour map of land subsidence

Contour map of land subsidence distribution which created with InSAR analysis is shown below. The project team created the estimated contour map from 2011 to 2014 using analysis data in ALOS and ALOS-2 data. The conceptual diagram of the estimation method is shown below.

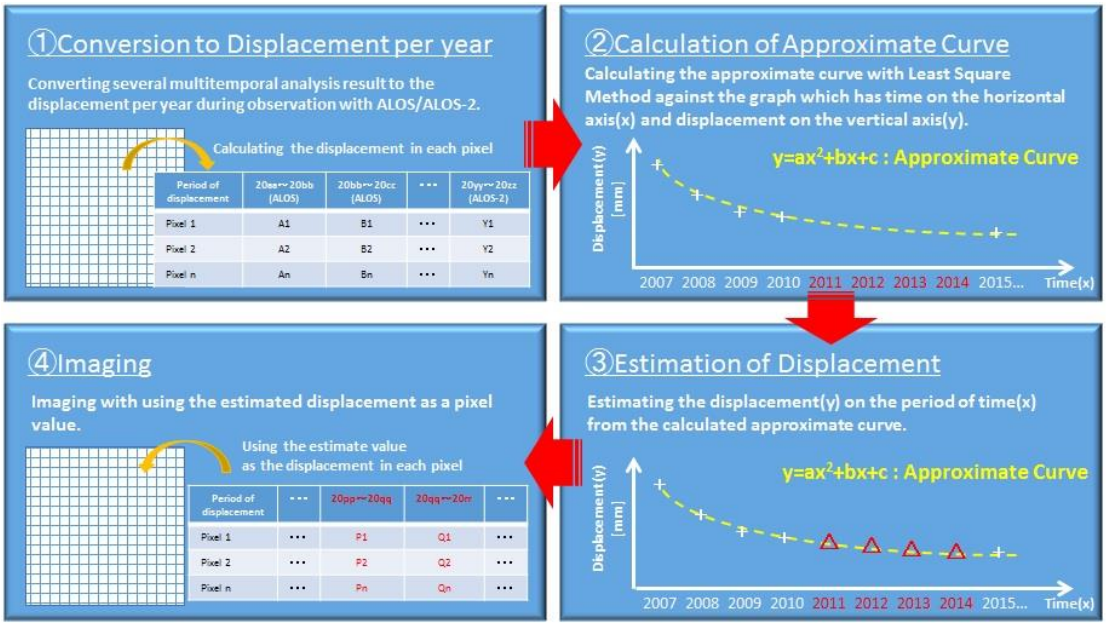
In 2007-2010, we saw a noticeable subsiding part in the first half of the northern and the northwest region. The PENJARINGAN area in the north is a landfill site, and the map shows that this area subsided due to the ground consolidation. Besides, since the BARAT and TIMUR districts in the northwest are coincident with areas where industrial/commercial facilities are densely populated, a strong relevance of land subsidence to land use is conceived. On the other hand, in the second half of the analysis period (2014-2020) a tendency for the subsidence in the northern part to calm down was found, but the northwestern part shows a constant subsidence tendency.

The subsidence in a part of the northwest is slowing down in 2014 to 2020, but subsidence occurred in the DKI Jakarta boundary part i.e. in the northwest and the area in the eastern suburbs (Sugara Jaya district, near Bekasi district). The DKI Jakarta boundary part in the northwest overlapped when the third terminal of Soekarno-Hatta International Airport which started its operation in 2014. Thus, the result suggests that the new subsidence is caused by groundwater extraction due to the increase in the construction of the airport, hotel, or others. The contour map with intervals of 1 year in 2007-2020 is shown in the accompanying document, and the distribution of land subsidence for each area is described in the latter part of this report.



Source: Created by the project team

Figure 2.15 Change of Land Subsidence



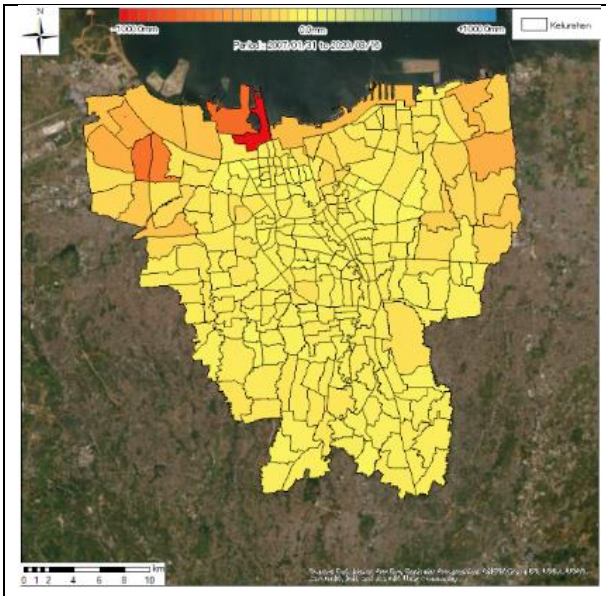
Source: Created by the project team

Figure 2.16 Method of Estimating the Value of Land Subsidence

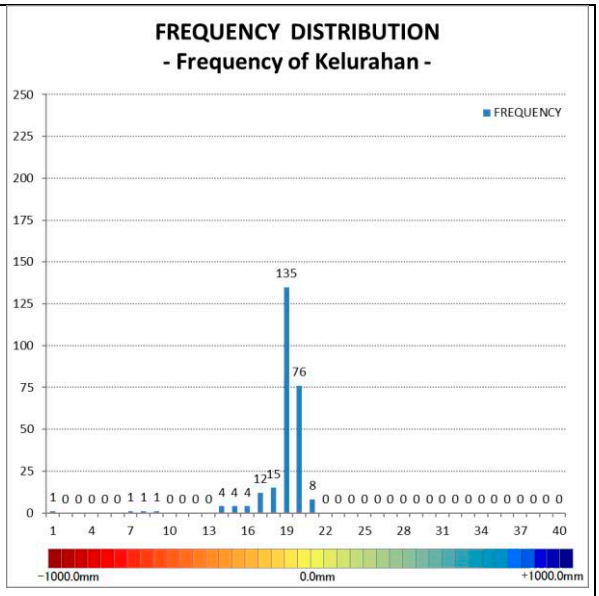
(2) Summary of land subsidence by Kecamatan

To understand the distribution of each region's subsidence depth, as shown below (left), the analysis is conducted based on DKI Jakarta's districts (Kelurahan). The distribution of subsidence depth was shown by color-coding the subsidence depth for each classification. It shows the subsidence depth obtained from satellite analysis in the 14 years from 2007 to 2020. The subsidence depth is quantized to 40 categories based on the definition shown in the lower part of figure below. The histogram of subsidence depth is shown below (right). The result shows a significant land subsidence in the north and the northwest. Also, the subsided area is expanding in the eastern part. A significant subsidence occurred in the Penjaringan in the north and northern part of the West Jakarta and north part of the East Jakarta.

The figure below shows the distribution of subsidence depth during the 14 years from 2007 to 2020. The distribution of subsidence depth for each region in one-year intervals is shown in the accompanying document together with the above contour figure.



Kelurahan



Histogram of subsidence depth

STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Max [mm]	−950	−900	−850	−800	−750	−700	−650	−600	−550	−500	−450	−400	−350	−300	−250	−200	−150	−100	−50	0
Min [mm]	−1000	−950	−900	−850	−800	−750	−700	−650	−600	−550	−500	−450	−400	−350	−300	−250	−200	−150	−100	−50
Frequency	1	0	0	0	0	0	1	1	1	0	0	0	0	4	4	4	12	15	135	76
STEP	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Max [mm]	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Min [mm]	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950
Frequency	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Quantization of land subsidence depth

Source: Created by the project team referring data from JCDS and InSAR analysis

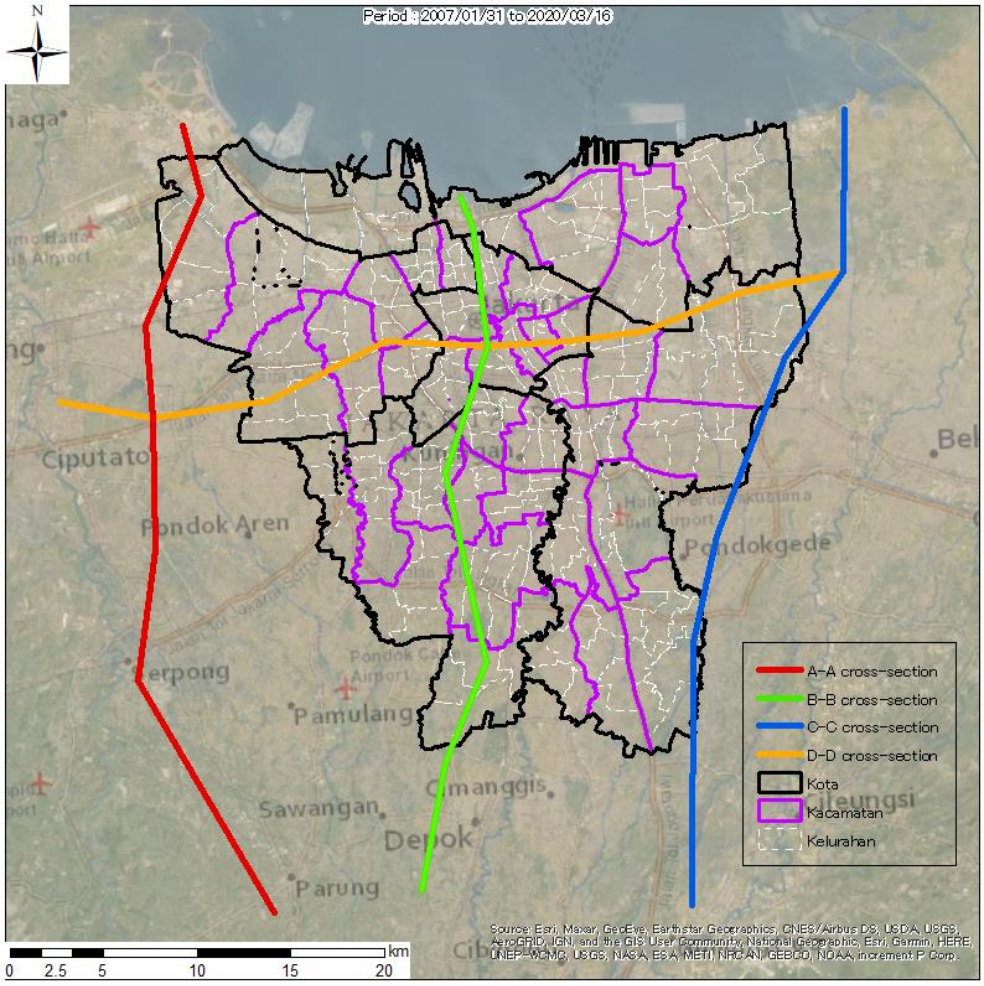
Figure 2.17 Summary of Land Subsidence in Each Administration Area

(3) Cross-sectional diagram of land subsidence

The change in subsidence depth at the hydraulic geological cross-sectional position is presented in the graph below, converted into the distribution of subsidence depth every year using the analysis results from 2007 to 2020.

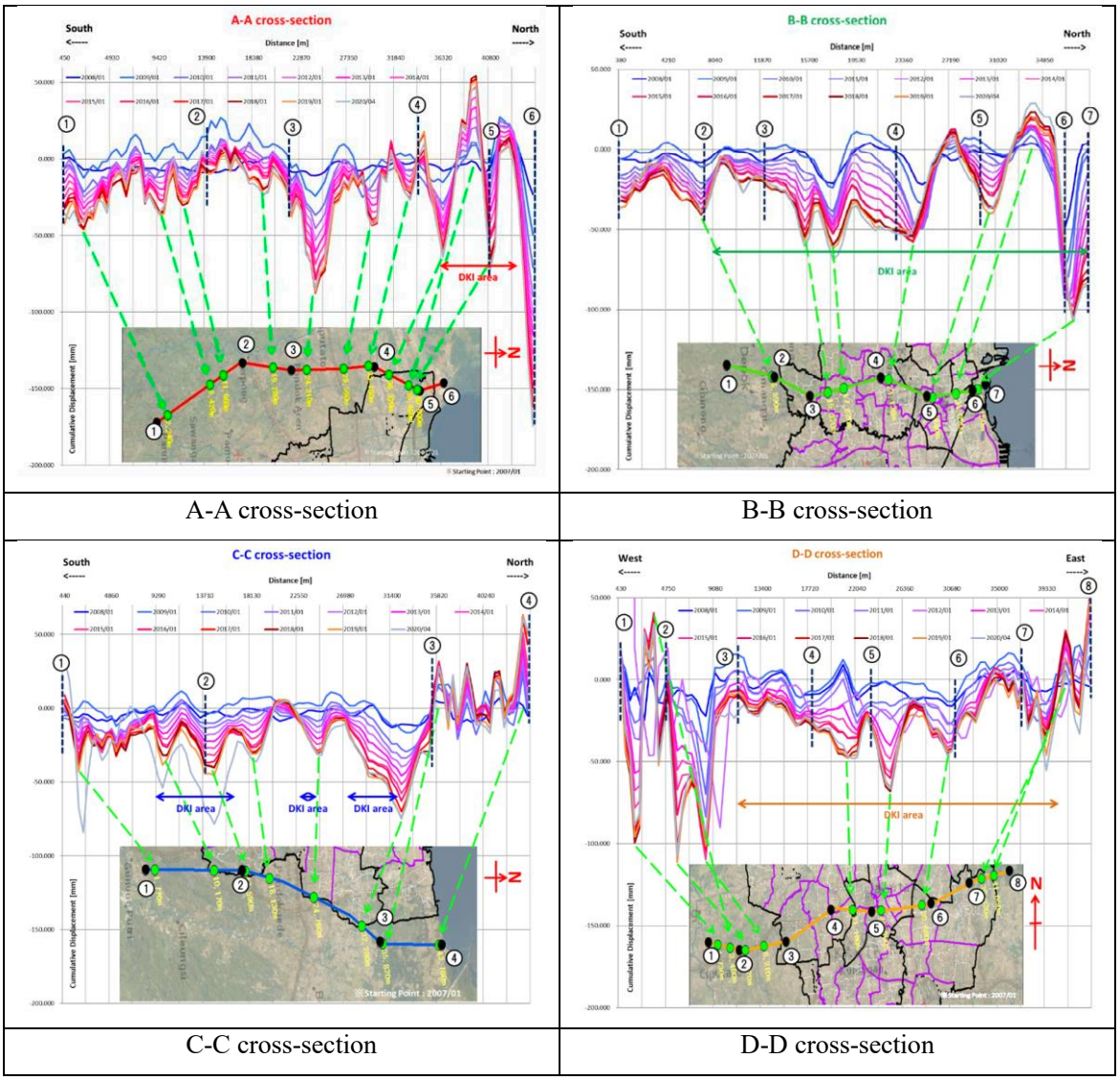
The graph shows a tendency for an overall sinking in all cross-sections. In the area with many wetlands outside the DKI Jakarta, such as the northern part of the C-C cross-section and the western part of the D-D cross-section, the waveform unevenness is severe. This phenomenon may happen with the influence of specular reflection of the water surface in the wetland area, noise component due to water vapor, or other causes when observing the ground surface with radar. We confirmed a partly significant fluctuation in the positive direction, or uplifted, in the northern part overlapping with the A-A cross-

section of the DKI Jakarta. According to Google Maps, farmland and wetlands located around this area (near the elementary school; State Elementary School located about 2 km east from the boundary of DKI) until about 2008, landfill spreads from around the year after 2009 in the next year, and houses, facilities, or others are increasing after 2014. Further, around March 2012, we confirmed soil and sand in the vegetation area. This period also overlaps with the time of flood caused by heavy rain, so this area can be considered as a place where soil, sand, or trash have accumulated. In other words, it is possible to capture the ground uplift on account of sedimentation due to landfill or dirt and sand, debris, and other similar things.



Source: Created by the project team

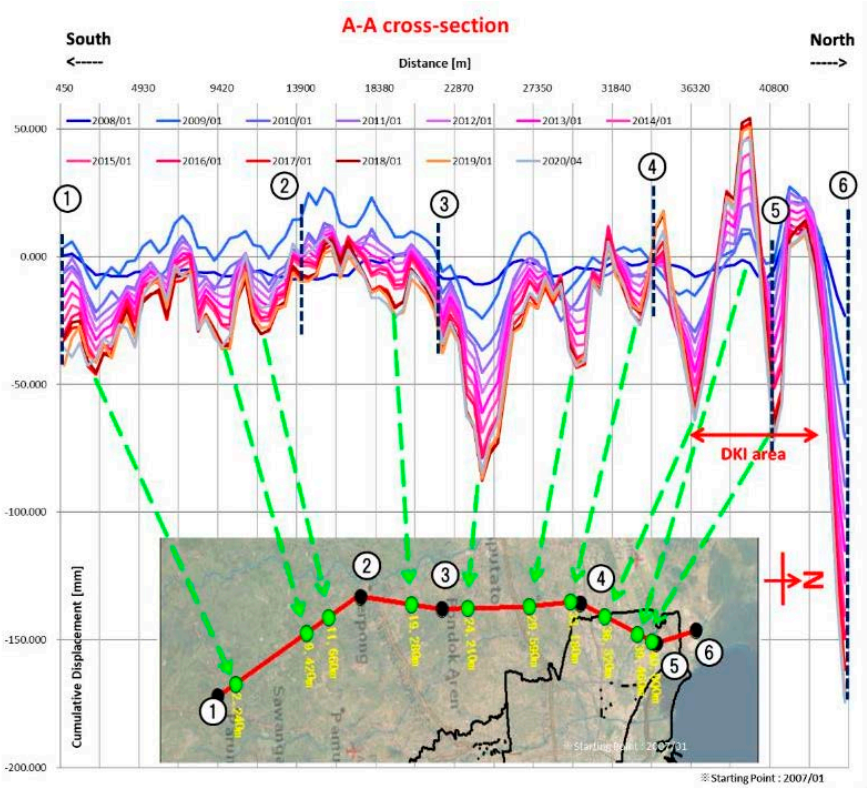
Figure 2.18 Course of Cross-section



A-A cross-section	B-B cross-section
C-C cross-section	D-D cross-section

Source: Created by the project team referring data from JCDS and InSAR analysis

Figure 2.19 Temporal Change of Land Subsidence depth from Cross-sectional View



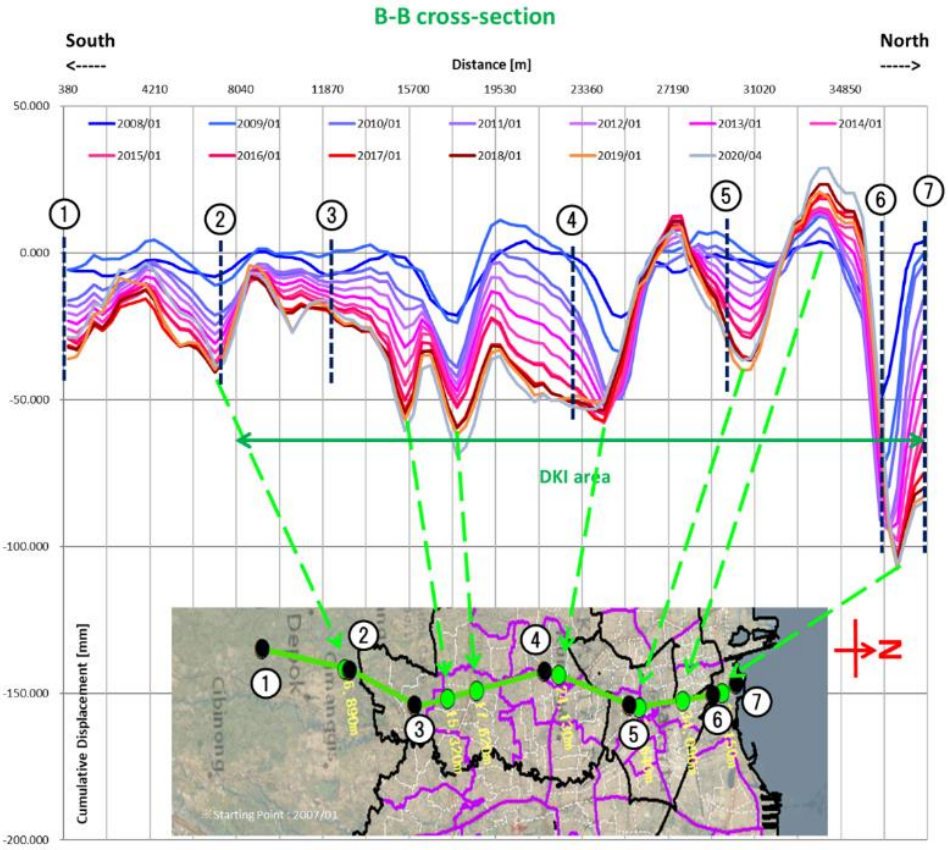
Points	Length from Spot 1 (m)	Fluctuation between 2007-2020 (mm)
Spot 1	START	—
Point 1	2,240	-39.937
Point 2	9,420	-35.196
Point 3	11,660	-20.013
Spot 2	—	—
Point 4	19,280	-23.821
Spot 3	—	—
Point 5	24,210	-84.594
Point 6	29,590	-42.902
Point 7	33,180	-26.800
Spot 4	—	—
Point 8	36,320	-64.043
Point 9	39,460	+45.917
Point 10	40,800	-71.981
Spot 5	—	—
Spot 6	END	—

※ Number shows polygonal line of cross-section and numbered in the order from South to North or from West to East

※ The areas with large changes in the subsidence are shown in relation to the cross-sectional position. The distance from the starting point (1) on the cross section is shown in yellow.

Source: Created by the project team referring data from JCDS and InSAR analysis

Figure 2.20 Cross-sectional View of Land Subsidence (A-A)



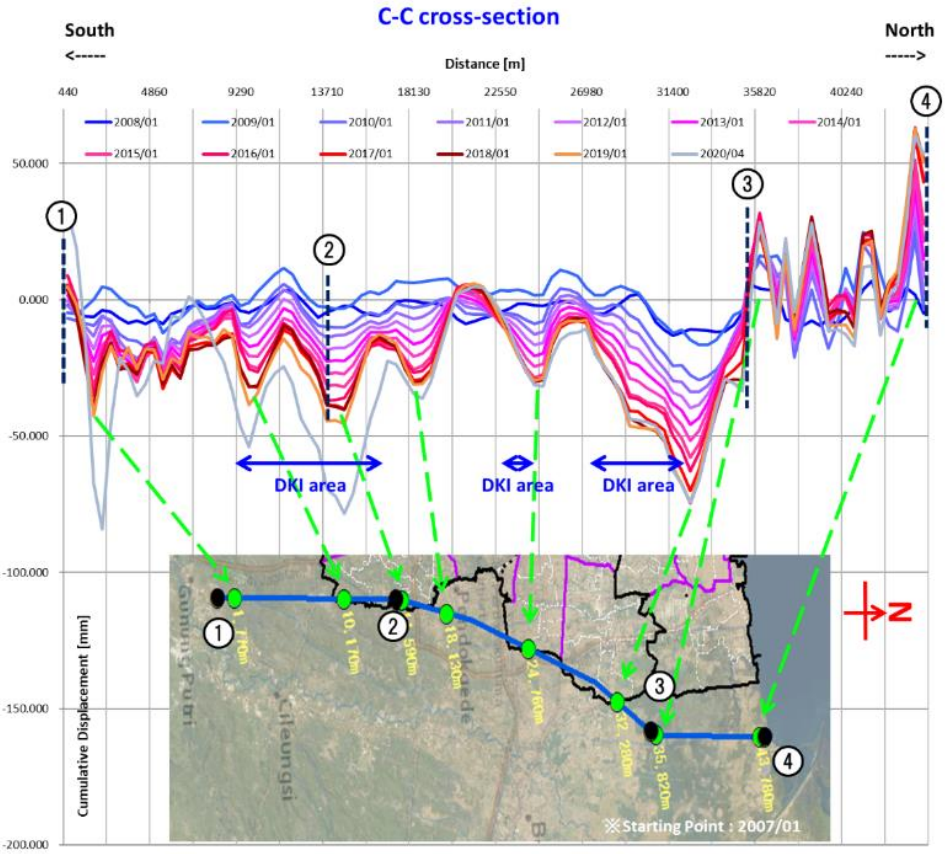
Points	Length from Spot 1 (m)	Fluctuation between 2007-2020 (mm)
Spot 1	START	—
Point 1	6,890	-38.379
Spot 2	—	—
Spot 3	—	—
Point 2	15,320	-60.539
Point 3	17,620	-69.053
Spot 4	—	—
Point 4	24,130	-50.558
Spot 5	—	—
Point 5	30,640	-35.851
Point 6	34,090	＋28.944
Spot 6	—	—
Point 7	37,150	-106.632
Spot 7	END	—

※ Number shows polygonal line of cross-section and numbered in the order from South to North or from West to East

※ The areas with large changes in the subsidence are shown in relation to the cross-sectional position. The distance from the starting point (1) on the cross section is shown in yellow.

Source: Created by the project team referring data from JCDS and InSAR analysis

Figure 2.21 Cross-sectional View of Land Subsidence (B-B)



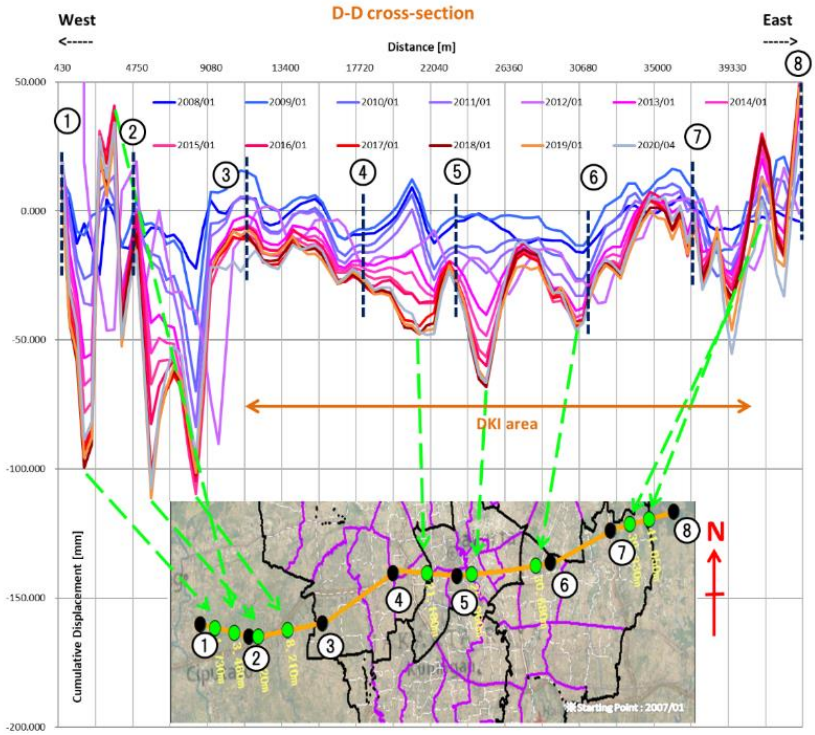
Points	Length from spot 1 (m)	Fluctuation between 2007-2020 (mm)
Spot 1	START	—
Point 1	1,770	-67.156
Point 2	10,170	-41.885
Spot 2	—	—
Point 3	14,590	-78.411
Point 4	18,130	-34.443
Point 5	24,760	-31.727
Point 6	32,280	-74.349
Spot 3	—	—
Point 7	35,820	+28.439
Point 8	43,780	+60.214
Spot 4	END	—

※ Number shows polygonal line of cross-section and numbered in the order from South to North or from West to East

※ The areas with large changes in the subsidence are shown in relation to the cross-sectional position. The distance from the starting point (1) on the cross section is shown in yellow.

Source: Created by the project team referring data from JCDS and InSAR analysis

Figure 2.22 Cross-sectional View of Land Subsidence (C-C)



Points	Length from spot 1 (m)	Fluctuation between 2007-2020 (mm)
Spot 1	START	—
Point 1	1,730	-88.676
Point 2	3,460	＋34.317
Spot 2	—	—
Point 3	5,620	-107.484
Point 4	8,210	-94.914
Spot 3	—	—
Spot 4	—	—
Point 5	21,180	-46.743
Spot 5	—	—
Point 6	25,060	-66.556
Point 7	30,680	-43.527
Spot 6	—	—
Spot 7	—	—
Point 8	39,330	-55.288
Point9	41,050	＋4.083
Spot 8	END	—

※ Number shows polygonal line of cross-section and numbered in the order from South to North or from West to East

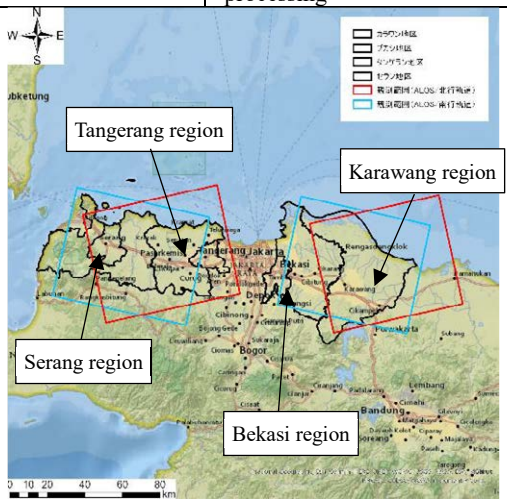
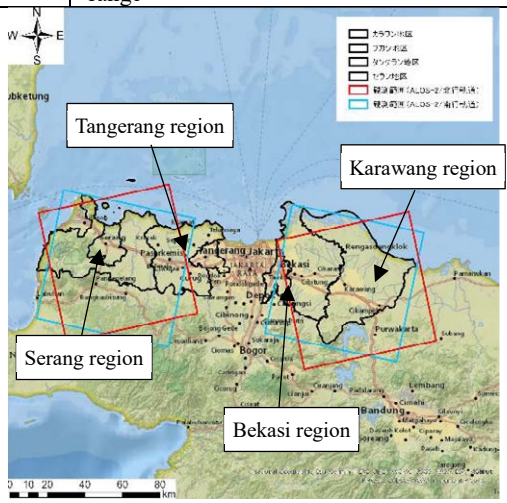
※ The areas with large changes in the subsidence are shown in relation to the cross-sectional position. The distance from the starting point (1) on the cross section is shown in yellow.

Source: Created by the project team referring data from JCDS and InSAR analysis

Figure 2.23 Cross-sectional View of Land Subsidence (D-D)

2.1.4 Result of InSAR analysis (Distribution of Land Subsidence – Bekasi and Tangerang)

ALOS and ALOS -2 analyses were carried out in Bekasi and Tangerang districts adjacent to Jakarta. The following figure shows the data from the SAR satellite used in the analyses and the relationship between the observation range and the target location.

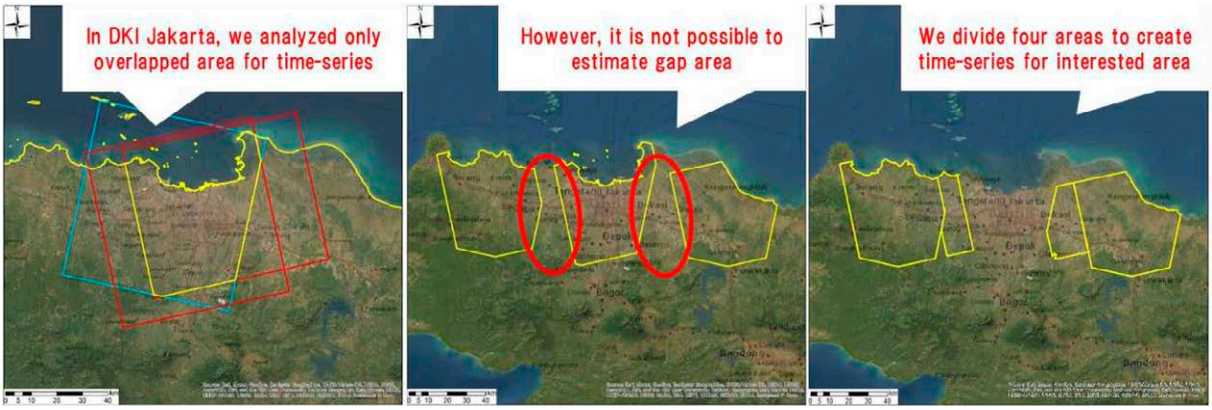
	ALOS/PALSAR	ALOS-2/PALSAR-2
Center Frequency	L band (wave length: 23.6cm)	L band (wave length: 23.6cm)
Satellite/Sensor	ALOS/PALSAR	ALOS-2/PALSAR-2
Period of Operation	2006/1/24 - 2011/5/12	2014/5/24 - present
Procured number of scenes	20 North bound: 10 South bound: 10	16 North bound: 8 South bound: 8
Observation mode (Polarization)	FBS: Fine Beam Single polarization (HH) FBD: Fine Beam Dual polarization (HH/HV)	SM3: StripMap3 (HH)
Resolution	10m	10m
Process Level	Level 1.0 Raw data: the complex data before signal processing	Level 1.1 SLC data: the complex image data of slant-range
		
ALOS/PALSAR Observation Area		ALOS-2/PALSAR-2 Observation Area

Source: Created by the project team

Figure 2.24 Satellite Data Specification and Area Used for the Analysis in Bekasi and Tangerang

The figure below shows the land subsidence obtained from the analysis of image data observed by the ALOS satellite from 2007 to 2010 and the image data obtained from the ALOS-2 satellite from 2014 to 2020. During 2011 to 2014, when no image data is available, the subsidence isoclines are calculated in the same way as Jakarta's estimation method.

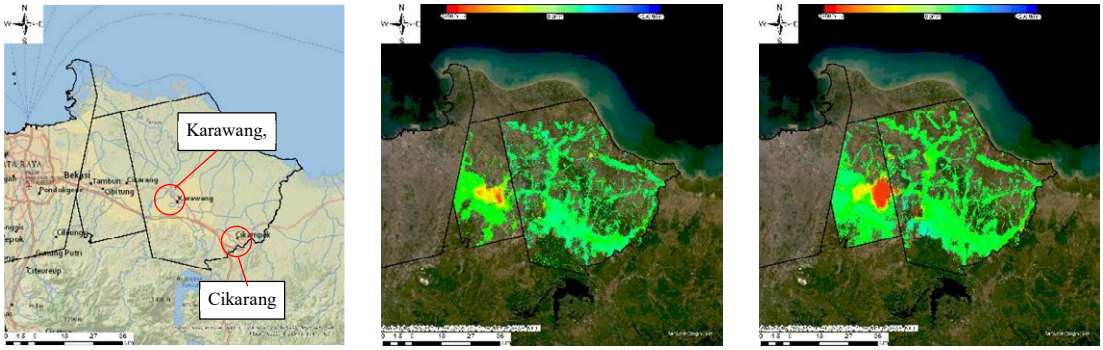
Further, we created a time-series graph throughout the ALOS and ALOS-2 periods. We overlaid the image data and remove non-overlapping area (Figure 2.25, left). However, this resulted in gaps in the target area (Figure 2-25, middle), particularly in Bekasi and Tangerang. Therefore, we used the existing image data from the institutions in DKI Jakarta to divide the target area into four areas and to fill the gaps (Figure 2.25, right).



Source: Created by the project team

Figure 2.25 Division for Analysis in Bekasi and Tangerang

InSAR analysis result confirmed a continued large-scale subsidence from 2007 to 2010 in the vicinity of Cikarang in the Bekasi. The subsidence lasted and expanded to the subsidence range in the ALOS-2 period, with the maximum subsidence of about 30 cm from 2007 to 2010, and it sank nearly 70 cm only between 2015 and 2020 period. Assuming that a similar subsidence tendency was observed in the estimated period from 2011 to 2015, the land had sunk of more than 1 m in 14 years since January 2007 (i.e. about 7cm/year). Due to the low coherence in the InSAR analysis, land subsidence within several parts is not clearly shown. However, land subsidence is confirmed in the western Karawang continuously over the periods of ALOS and ALOS-2. The subsidence distribution chart for the periods of 2007-2010 (ALOS) and 2015-2020 (ALOS-2) is shown in the figure below.



Map of Bekasi

ALOS

January 31, 2007 - April 4, 2010

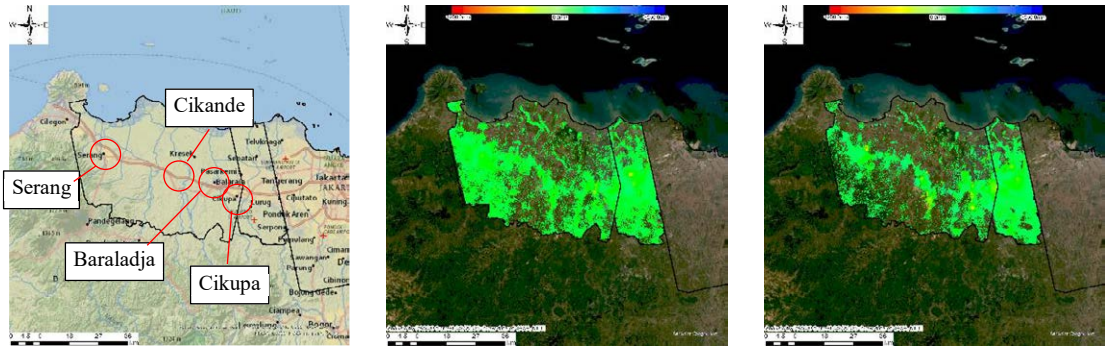
ALOS-2

May 7, 2015 - August 2, 2020

Source: Created by the project team

Figure 2.26 Subsidence During ALOS and ALOS-2 Periods in Bekasi

In the Tangerang area, large-scale land subsidence similar to that occured in Jakarta and Bekasi is not confirmed, but moderate land subsidence occurs locally. During 2007 to 2010, a land subsidence trend, at maximum subsidence with about 15 cm, is verified around Pasar Kemis, and during 2015 to 2020, subsidence of more than 20 cm at the maximum occurs in the northeastern part of Serang. Subsidence also occurred in Cikupa, Balaraja, and the southern part of Cikande. The following figure shows the settlement distribution during 2007-2010 and 2015-2020.



	ALOS	ALOS-2
Map of Tangerang	February 17, 2007 - December 24, 2010	February 23, 2015 - April 7, 2020

Source: Created by the project team

Figure 2.27 Subsidence During ALOS and ALOS-2 Periods in Tangerang

2.1.5 Suggestions for InSAR Analysis

Continuing the use of InSAR analysis for understanding the status of land subsidence, the followings are suggested.

(1) Quality Assurance for Analysis Results

As described in the results, although we used the dataset related to accuracy evaluation, approximate equations, and correlation coefficients indicating several centimeters' errors, the verification data contributing to reliability evaluation were small. In the future, considering the observation period of ALOS-2 or the period of ALOS-4 satellite scheduled to be launched, it is necessary to continuously increase verification data by acquiring data so that we can collect leveling or GNSS observation data at overlapping times. This evaluation is also mentioned in the "Satellite Utilization Manual for Ground Subsidence Observation (Preparation of the Office of Groundwater and Ground Environment, Soil Environment Division, Water and Air Quality Bureau, Ministry of the Environment)" referred to in this analysis, and we recommend to supplement the existing survey by the combination of field survey and leveling. The project team conveyed the significance of this to DSDA which is the main organization to proceed monitoring in Jakarta, and recommended to conduct GNSS survey in parallel with InSAR analysis.

(2) Future InSAR Analysis System

Identification of the subsidence in broad range using InSAR analysis is accurate and effective. In the future, Indonesian staff shall be able to conduct the analysis. For this goal, system creation and human development is necessary. Currently, the Indonesia National Aerospace Laboratory (LAPAN) and the Institute Technology Bandung are considered as the organization where people can do analysis. This InSAR analysis is necessary to be developed to a service for practical use, and a system in a company with the ability to create data constantly or in the technical department within the administration should be created. However, since it would take several years for human development to accumulate the specific experience, for the time being, the system establishment should be conducted while carrying out on-the-job training such as specialized education and intern at universities in parallel with the support of overseas consultants and analysis at the above research institutes.

Through discussions with DSDA, the project team found that DSDA has budget constraints to effectively bring this technology into their monitoring, as well as the lack of technical staff who can conduct InSAR analysis. Basically, we recommend to do InSAR analysis annually. But considering the situation of DSDA,

we suggested continuing this activity by making cost effective plan like. An example is to do InSAR analysis once every 2-3 years to capture the tendency and new occurrence of land subsidence and fill the gap years by high precision GNSS survey at locations needed to be monitored.

Discussion with DSDA about InSAR analysis in future

（December 2021）

- DSDA had an intention to take InSAR analysis in their land subsidence monitoring if conditions allow.
- There were two major issues DSDA needs to tackle:

①Acquiring budget for InSAR

The cost for InSAR analysis varies depending on the frequency and methods. The project team suggested to make the most optimal plan for their purpose. Followings are some examples of monitoring plan.



E.g.1：Annually



E.g.2：Alternately conduct InSAR analysis and GNSS Survey



E.g.3：Conduct InSAR analysis once in several years, and GNSS survey regularly until next InSAR

Furthermore, contract type could be revised to reduce the overhead if the contract is completed annual basis. Making the contract multiple year could make the once purchased data by the contractor reusable, and this contributes to reduce the data cost as well as other administration costs.

②Capacity building

If DSDA conducts InSAR analysis by themselves, a long-term commitment for the trainings including the basic of remote sensing, programming, software operations, and InSAR analysis for land subsidence will be required. Suggestions from the project team are, first to improve the capability to understand the analysis result correctly, and secondly outsource the analysis to the professional of InSAR analysis such as university or company.

2.1.6 Setting Critical Zone of Land Subsidence

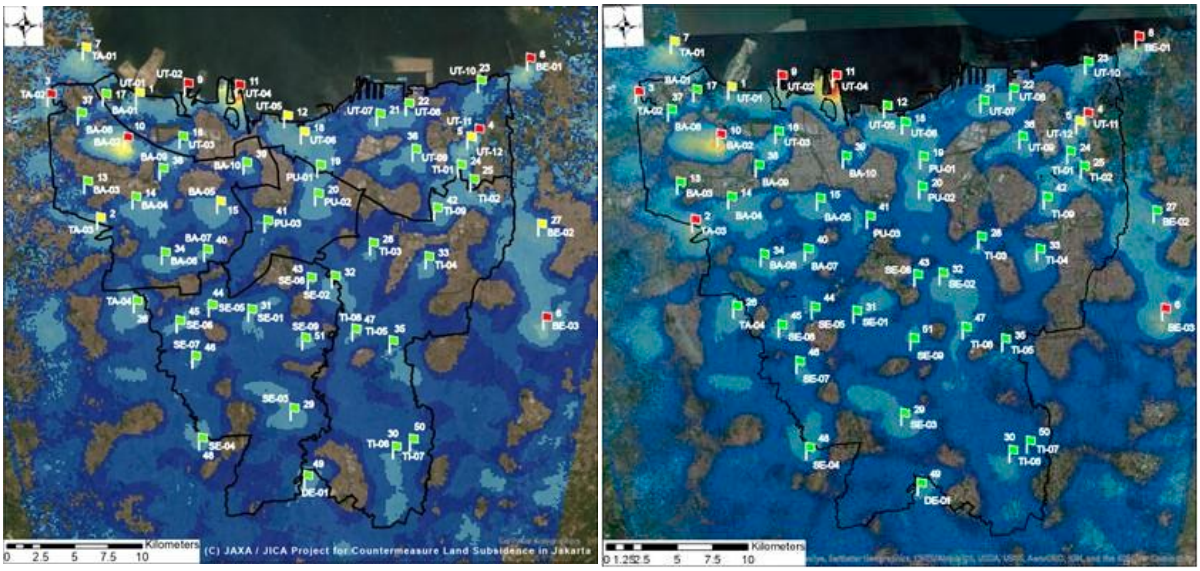
Land subsidence is occurring widely in Jakarta and surrounding cities, but its significance is different in each area. To identify the areas where urgent measures are required, the significance level was assigned depending on the volume and recent trend of subsidence. These areas are called "Critical zone" in this project, and high-risk areas (red zone) are concentrated in the northern part of Jakarta which is near the coast.

The criteria of categorization are described in Table 2.8. In this project, land subsidence of 20 mm/year is regarded as an obvious land subsidence, and this value is treated as the basis of categorization which is divided in 3 levels. In Figure 2.28, each point in the critical zone shows the location with the largest subsidence depth. Effective treatment is recommended to be taken depending on the level of risk.

Among the areas with risk level "A", some areas show the significant improvement, therefore comparison of this critical zone and InSAR data of each period (and plot chart) will be needed to make action plans for the future.

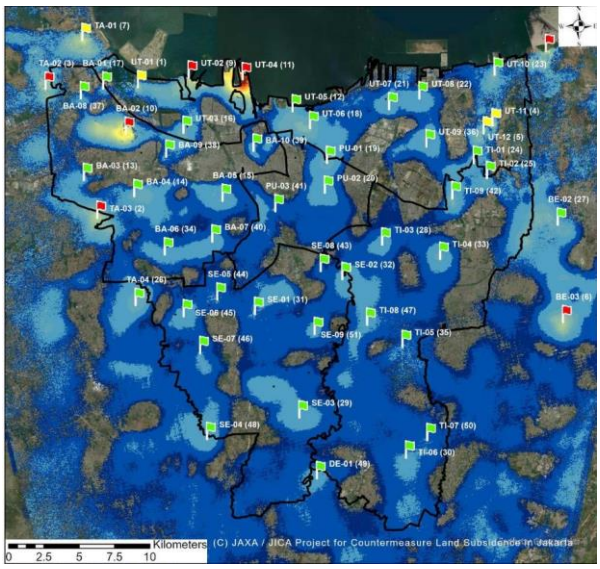
Table 2.8 Category of Critical Zone

Level	Color	Criteria
A (High)	Red	over 50 mm/y (2007-2020.03) *or* Over 20 mm/y (2007-2020.03) and over 20 mm/y (2014-2020.03, ALOS2)
B (Middle)	Yellow	over 20 mm/y (2007-2020.03) and under 20 mm/y (2014-2020.03, ALOS2) * Subsidence level in recent years is smaller than A
C (Low)	Green	under 20 mm/y (2007-2020.03)



Calculated from the data of 2007‐2017

Calculated from the data of 2007‐2018



Calculated from the data of 2007‐2020 (Mar)

Figure 2.28 Critical Zone

2.2 Development of Land Subsidence Monitoring Network

2.2.1 Construction of Land Subsidence Monitoring Wells

(1) Construction Locations by JICA Project

In this JICA project, land subsidence monitoring wells were constructed at three locations in 2019 (the first stage of the project) and 2022 (the second stage of the project). These monitoring wells were constructed at the area where remarkable land subsidence occurred during the 11 years from 2007 to 2017 (See Figure 2.29).

① Site-1 Cengkareng: West Jakarta Kota（2019 First Stage)

② Site-2 Cakung: East Jakarta Kota (2019 First Stage)

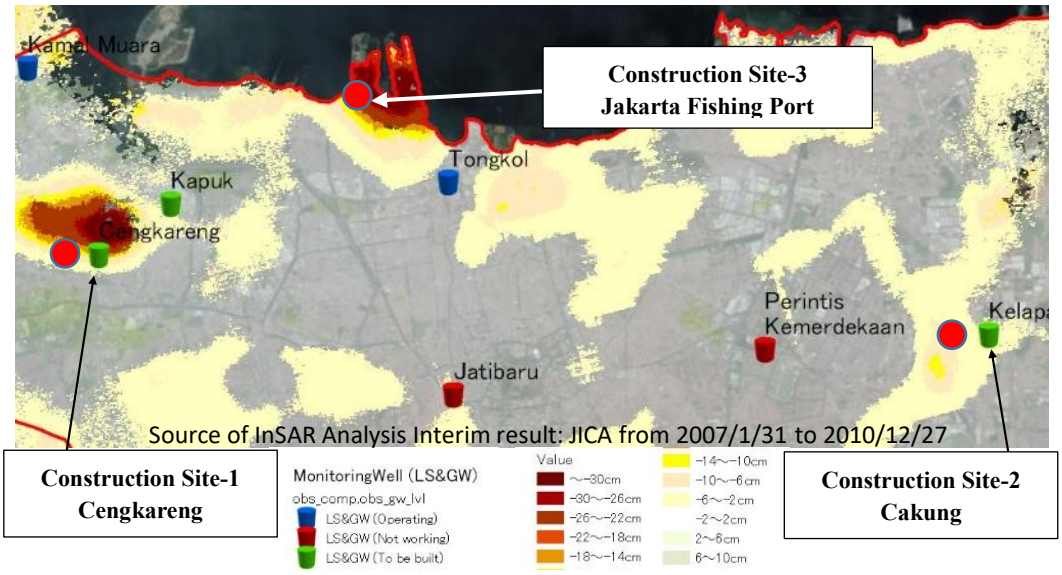
③ Site-3 Jakarta Fishing Port: North Jakarta Kota (2022 Second Stage）

Among these sites, site 3 of the monitoring wells at Jakarta Fishing Port was constructed at the fishing port site of Pluit, which was proposed in the existing report of this project. Regarding the construction of a new monitoring wells at this site, the DKI Jakarta planned to promote the construction in 2020 based on the proposal of the JICA study team. However, it became impossible to construct due to the budget of DKI as an effect of the Covid-19 pandemic, therefore JICA decided to construct it as an addition in this project.

The Jakarta fishing port has a benchmark built in 2009 in the fishing port office. This benchmark had subsided of more than 40 cm in 10 years. In addition, the leveling conducted in 2020 confirmed that the annual subsidence depth was 10 cm or more. This leveling result and the InSAR analysis result confirmed that the land subsidence has progressed remarkably in recent years.

On the other hand, the JICA study team investigated the usage of the well at the fishing port. The team found that the groundwater abstraction from the well which is currently being used at the fishing port point will be stopped near future. Therefore, by constructing monitoring wells at this point, (1) the current situation of land subsidence and groundwater level distribution can be grasped, and (2) the land subsidence situation and the change in groundwater level after the groundwater abstraction is stopped. We expected that the situation of land subsidence and changes in groundwater distribution after the groundwater abstraction is stopped can be confirmed in the short to long term. Hence, new land subsidence wells are constructed at this point in the second stage of this project.

In selecting these specific land subsidence observations well construction sites, discussions were held with related organizations and the site was confirmed with the relevant organizations to select specific construction location.



Source: JICA Project Team

Figure 2.29 Construction Location by JICA Project

(2) Specification of Each Monitoring Well (Depth of well screen)

1) Specification of each observation well (length, screen depth)

The specification of the three monitoring wells constructed at each site are shown in Table 2.9 and Table 2.11. The screen depth of each well indicates the depth of the outer pipe.

a) Construction in the First Stage

a. Cengkareng

Table 2.9 Specification of Monitoring Well (Cengkareng)

Name of Well	WELL-1	WELL-2	WELL-3
Well Structure	**double-pipe**	**double-pipe**	**single-pipe**
Length of Well (m)	250 (243m)	170m	30m
Depth of Screen Section	202 ~ 214m (12m) 220 ~ 226m (6m) 232 ~ 238m (6m)	74 ~ 80m (6m) 98 ~ 110m (12m) 123 ~ 141m (18m) 147 ~ 159m (12m)	12～18m (6m)
Total Length of Screen Section (m)	**24m**	**48m**	**6m**

One week after installation of Well-3, groundwater levels in the three wells were confirmed to be different in each screen section: Well-1: GL-14m, Well-2: 23m, and Well-3: 5m. The lowest groundwater level was also confirmed on April 23 at Well-2, where the screen was installed in the second aquifer, which is the section where the groundwater level decreased during the test borehole drilling.

The depths of the water pressure gauges installed in each borehole were determined based on the groundwater level changes shown in Table 2.11 through May 20, 2019, at the time of construction.

Table 2.10 Summary of groundwater level changes (Cengkareng)

	9th April 2019	23rd April 2019	20th May 2019	8th August 2019	3rd Sept. 2019	Depth of Gauge
Well-1	GL.-14.0m	GL.-12.1m	GL.-12.4m	GL.-12.1m	GL.-12.1m	GL.-20.0m
Well-2	GL.-24.0m	GL.- 31.7m	GL.-41.1m	GL.-43.8m	GL.-44.1m	GL.-50.0m
Well-3	GL.-5m	GL.-3.9m	GL.-4.3m	GL.-4.9m	GL.-5.2m	GL.-11.0m

b. Cakung

Table 2.11 Specification of Monitoring Well (Cakung)

Name of Well	**WELL-1**	**WELL-2**	**WELL-3**
Well structure	**double-pipe**	**double-pipe**	**single-pipe**
Length (m)	280m	140m	30m
Depth of Screen Section	160 ~ 184m (24m) 202 ~ 208m (6m) 220 ~ 226m (6m) 232 ~ 238m (6m)	87 ~ 105m (18m) 129 ~ 135m (6m)	12 ~ 24m (12m)
Total Length of Screen Section (m)	**42m**	**24m**	**12m**

Groundwater level observations for each monitoring well at the Chakun site were conducted on April 30, 2019. The results are shown in the following table. The results showed that the lowest groundwater level was observed in well -2, where the screen was installed between 80 m and 140 m depth.

The depth of the water pressure gauge installed in each borehole was determined based on the groundwater level changes shown in Table 2.12 through May 20, 2019, at the time of construction. However, due to groundwater levels in Well-2 (Middle Well) at this site reducing the distance between the pore water pressure gauges and the groundwater surface, the installation depth of the pore water level gauges was increased to GL.-23.4 m on June 18, 2020.

Table 2.12 Summary of the groundwater level changes (Cakung)

	30th April 2019	24th May 2019	5th August 2019	3rd September 2019	Depth of Gauge	Note
Well-1	GL.- 7.3m	GL.- 8.8m	GL.- 8.9m	GL.- 9.1m	GL.- 16.0m	
Well-2	GL.- 12.1m	GL.- 14.2m	GL.- 16.9m	GL.- 17.5m	GL.- 22.0m	GL.-23.4m(2020 June)
Well-3	GL.- 2.2m	GL.- 3.4m	GL.- 4.5m	GL.- 4.7m	GL.- 10.0m	

b) Construction in the Second Stage

a. Jakarta Fishing Port Site:

At this site, as of January 21, 2022, three new land subsidence monitoring wells are being constructed.

At this site, two boreholes, one for ground shrinkage observation and the other for groundwater level

observation, are to be constructed at Well-1 for the following reasons.

- The initial depth of WELL-1 was set at 220 m. However, when the slide pipe and outer tube of the double-tube pipe were inserted up to 203 m, the borehole wall around the slide pipe and outer tube became significantly bulged, making it impossible to insert the pipes deeper than that. At this stage, WLL-1 reached the sand layer in the Third Aquifer, so it was decided to use this as a ground shrinkage observation hole, and to drill and install a separate 200 m observation hole that would reach the Third Aquifer.

The wells were constructed in the order of WELL-2, WELL-3, and WELL-1.

Table 2.13 Specification of Monitoring Well (Cakung)

Name of well	WELL-1		WELL-2	WELL-3
Well structure	**double pipe**	**single pipe（PVC）**	**double pipe**	**single pipe**
Length (m)	shrinkage observation hole 203m	Groundwater Level Observation Boreholes 200m	155m	70m
Screen section depth （GL.-m）		170～200m（30m）	119～143m（24m）	23～35m（12m） 53～65m（12m）
Screen section total（m）		**24m**	**24m**	**24m**

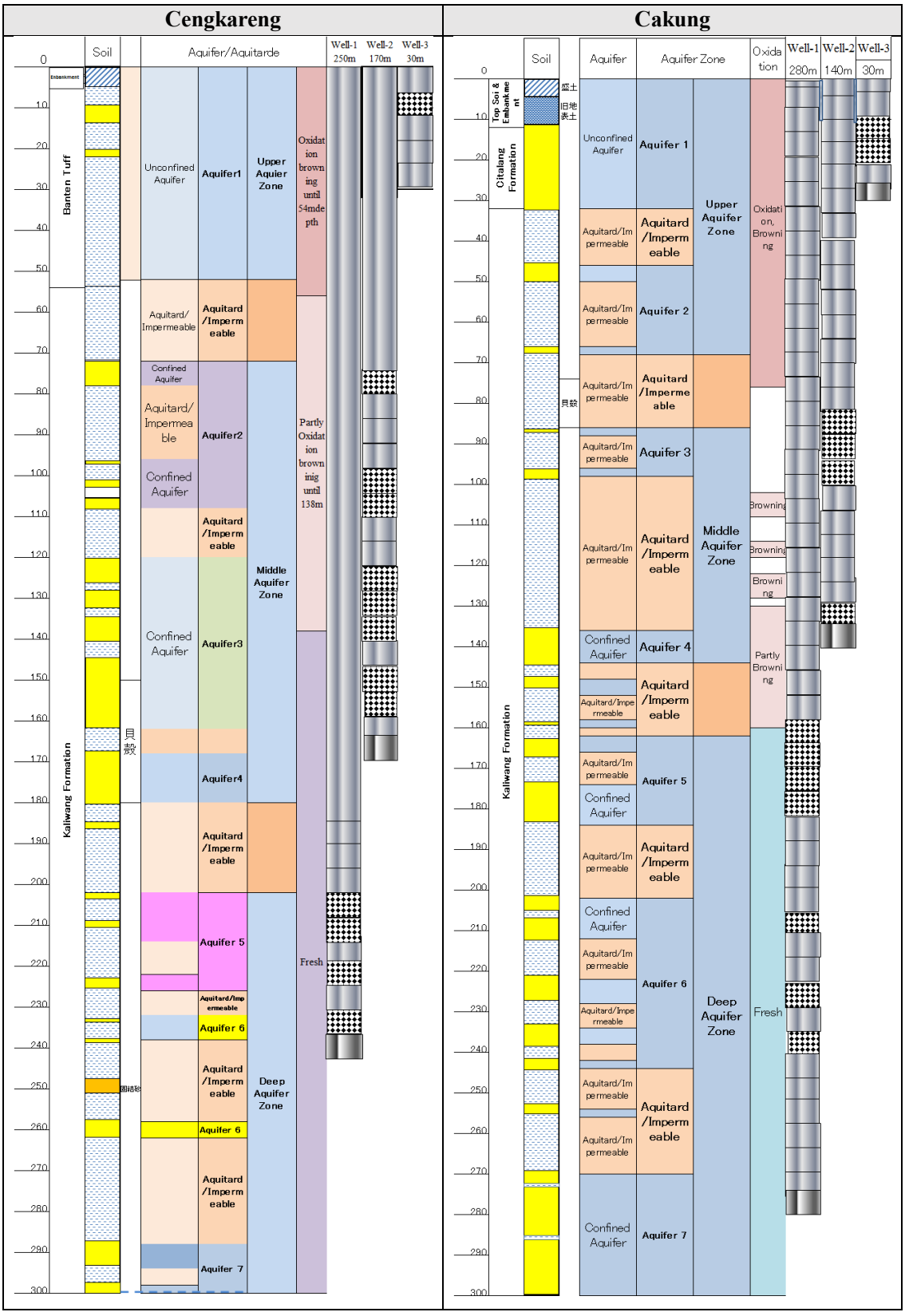
After the construction of Well-1, groundwater levels in the three wells were confirmed to be different in each screen section: Well-1: GL-37.5 m, Well-2: 26.6 m, and Well-3: 2.9 m. Subsequent observations also confirmed that groundwater levels were different in each well.

On the other hand, although the groundwater level slightly decreased during drilling of the test borehole at this site when the impermeable layer between the first and second aquifers was drilled, no significant change in the groundwater level was observed during the subsequent drilling of the second and third aquifers. This may have been due to the fact that the concentration of muddy water was increased during drilling, as the borehole walls at this site were noticeably bulging out and collapsing. However, groundwater levels after construction showed different in each well at different depths, and it is judged that each well is observing groundwater levels in the first, second, and third aquifers. It is necessary to confirm this through continued observation in the future.

The depth of the water pressure gauge installed in each borehole was determined based on the groundwater level changes shown in Table 2.10 through September 10, 2022, at the time of construction.

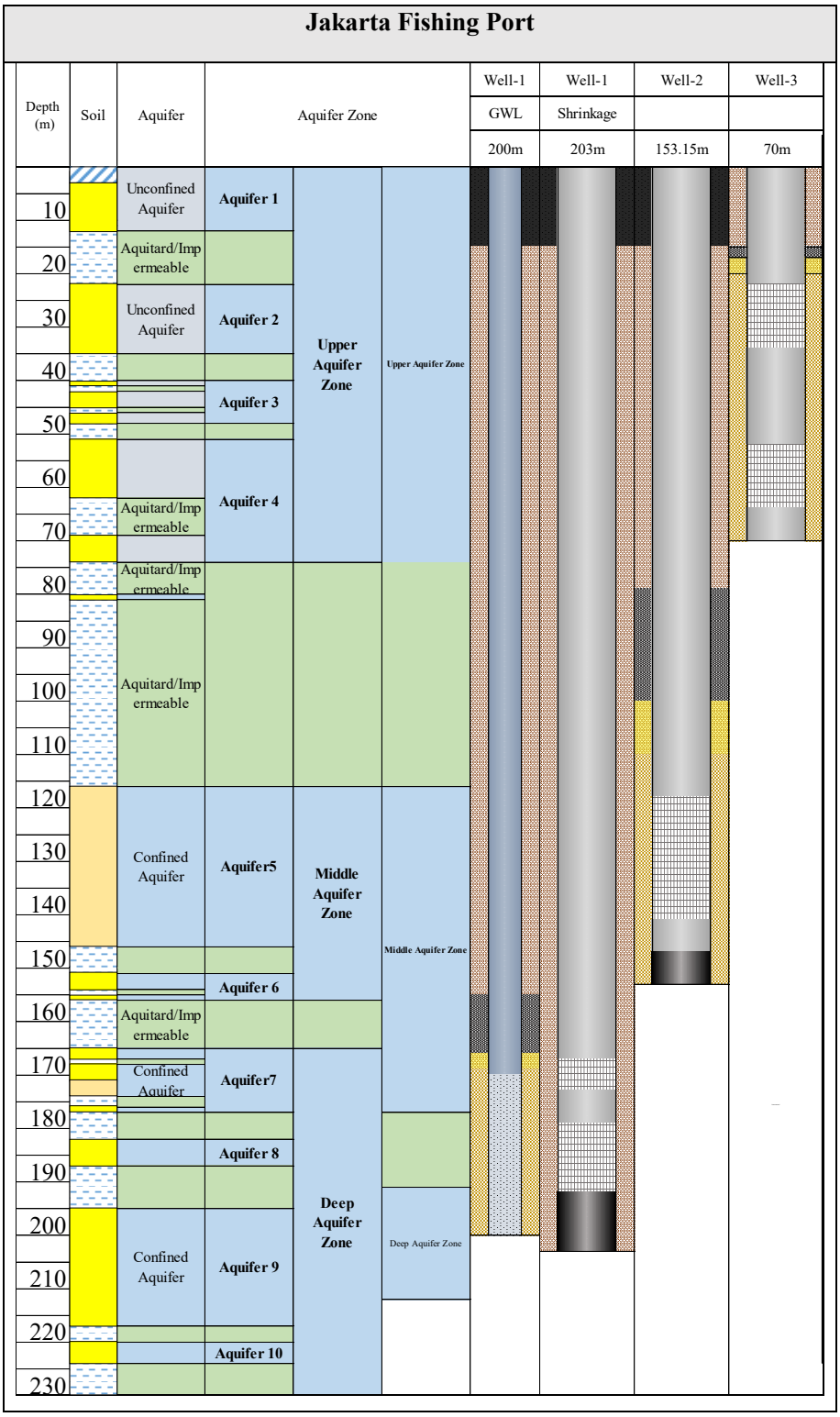
Table 2.14 Summary of the groundwater level changes (Jakarta fishing port)

	18th August 2022	20th August 2022	10th September 2022	Depth of Gauge
Well-1	GL.-37.5m	GL.-36.5m	GL.-36.5m	GL.-70.0m
Well-2	GL.-26.6m	GL.-27.4m	GL.- 27.4m	GL.-50.0m
Well-3	GL.-2.9m	GL.-2.9m	GL.-2.9m	GL.-20.0m



Source: JICA Project Team

Figure 2.30 Schematic Diagram of Land Subsidence Monitoring Well (First Stage)



Source: JICA Project Team

Figure 2.31 Schematic Diagram of Land Subsidence Monitoring Well (Second Stage)

The table below shows the photographs of each point before the construction of the observation well.

Table 2.15 Condition of Each Site before Construction Work (First Stage)

	
Cengkareng Site	**Cakung Site**

Table 2.16 Monitoring House (First Stage)

Monitoring house of each location	
Cengkareng Site	**Cakung Site**
	
Monitoring Wells and Data Logger	
	
Monitoring Wells	**Data Logger**

Table 2.17 Condition of Site before Construction Work (Second Stage)

	
Jakarta Fishing Port Site	

Table 2.18 Monitoring House (Second Stage)

	
Observation well construction	**observation hut**
	
observation well	**Inspections of stakeholders**

2) Construction Period

a) First Stage (Cengkareng, Cakung Site)

Well construction was started by a test drilling at the end of October 2018, and the construction of monitoring wells at both sites were completed on April 13, 2019. Meanwhile, construction of the protection house was completed by middle of May 2019.

Observations have been started where confirmation of the monitoring/observation equipment function was conducted until the end of June 2019 and monitoring has been started from July 1, 2019.

b) Second Stage (Jakarta Fishing Port Site)

The well construction work was started by a test boring in November 2021, and the construction work is underway as of January 21, 2022.

3) Technical Transfer at the Time of Construction

For construction of land subsidence monitoring well at the Phase-1, technical transfer for construction

of the Japanese-style double-tube type land subsidence monitoring wells to Mr. Rosihan and Mr. Didik (the on-site supervisors of PT.) was carried out. In addition, instruction to secure the construction accuracy was provided to them.

From the middle stage of the construction work, both parties actively proposed improvement plans for the improvement, and it became possible to implement construction smoothly although there were problems.

In addition, during the construction of the Phase-2 of JICA new land subsidence observation well, Expert of the JICA Survey Team were stationed at the site during the construction period amid the Covid-19 pandemic. During this period, a CP organization collaborated with DSDA to create manuals and transfer of technology on review and revision methods.

2.2.2 Proposal of New Construction Site for the Land Subsidence Monitoring Network

In addition to the wells constructed by JICA in this project, the land subsidence monitoring wells are arranged as shown in Figure 2.32.

However, only five sites are currently in operation: Kamal Muara, Tongkol, Cengkareng, Cakung, and Jakarta Fishing Port. In addition, the land subsidence monitoring well at Kamal Muara may also be faulty. Therefore, total number of the land subsidence monitoring wells are shortage throughout DKI.



Figure 2.32 Location of existing Land Subsidence Monitoring Wells

Base on the reason above, we proposed development policy of the land subsidence monitoring network as follows.

Table 2.20 and Figure 2.23 show the location of the new land subsidence monitoring well construction site for the expansion of the land subsidence monitoring network in the future, along with the construction priority rank.

The construction priority ranks are as follows;

- **Rank A:** An area that needs to be construct with highest priority

Among three (3) sites (nine (9) land subsidence monitoring wells) selected by JICA before the start of this project, Tongkol sites that could not be constructed in this project are also included in this rank.

- **Rank B:** An area with high priority next to Rank A.

The following area which are considered to be necessary to monitor the current state and the future changes of land subsidence and groundwater level in order to establish land subsidence monitoring network in Jakarta in the future.

- Area which land subsidence is remarkable
- Area of which land subsidence is relatively significant and necessary to monitor the current state of land subsidence and future changes in ground subsidence and groundwater level.

- **Rank C:**

A facility that can be used as a land subsidence monitoring well or monitoring well (e.g. Benchmark of the Jakarta Fishing Port Authority) has already been constructed by the DPE and other organizations in the target area or in the vicinity thereof, and priority of construction of new monitoring well is low

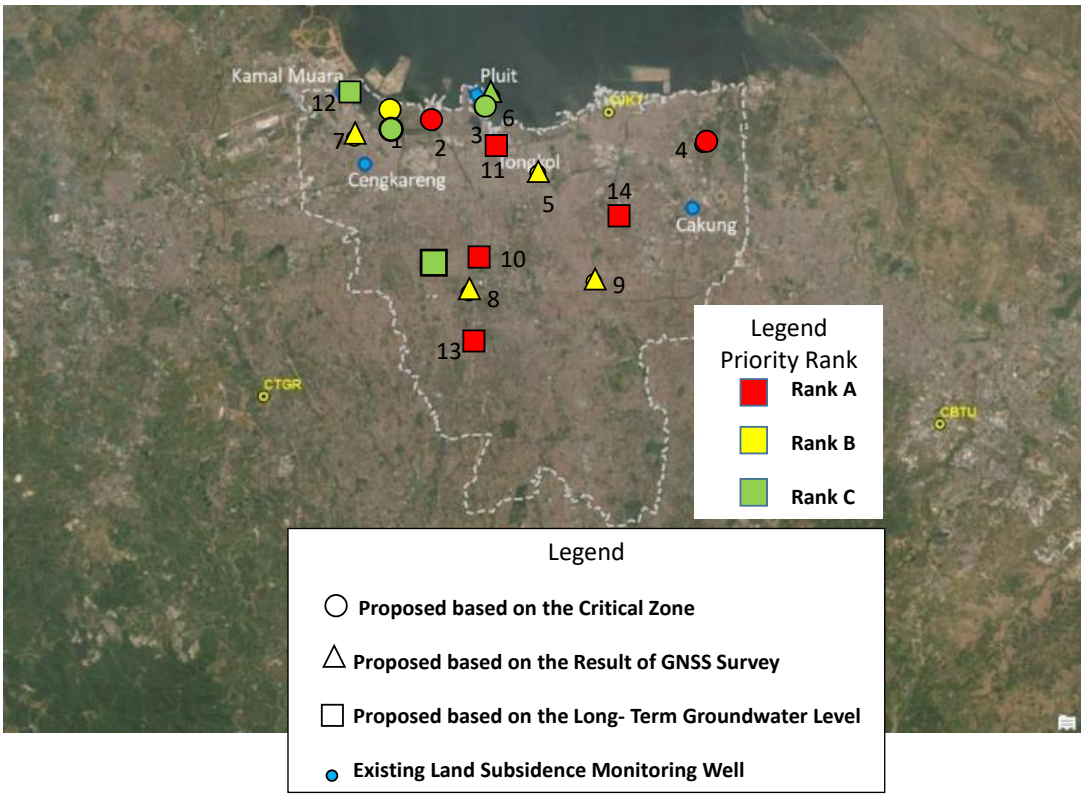
Table 2-19 Priority Rank of New Land Subsidence Monitoring Well Construction Site

Item	Priority Rank	No. on the Map	ID	Location Name	Type	Note
Critical Zone by the Result of InSAR Analysis by JICA	B	1	UT-01	Pantai Indah	Critical Zone B	-
	B	2	UT-02	Muara Angke	Critical Zone A	-
	C	3	UT-04	Pluit	Critical Zone A	Constructed in the 2nd Phase of this Project by JICA
	A	4	UT-11	Rorotan	Critical Zone A	Subsidence is remarkable in northeastern Jakarta. It is also a future development area.
GNSS Survey Result by ITB	B	5	SHR2	Jl. Pangeran Jakarta & Jl. Pisang Batu	Displcement from 2000 to 2017 1,018 mm	-
	C	6	MUBA	Zhang Marina Indonesia Fish Market	Displcement from 2000 to 2017 3,550 mm	-
	B	7	T002	Suku Dinas Kebersihan Tegal Alur	Displcement from 2000 to 2017 2,005 mm	-
	B	8	KBA1	Taman Martimbang IV	Displcement from 2000 to 2017 972 mm	-
	B	9	BSKI	Apartment Basura City	Displcement from 2000 to 2017 587 mm	-
Long-Term Groundwater Level Measurement Result by PUSAIR	B	10	Gedung DPR/MPR		2000s Down, 2010s still low	-
	A	11	Tongkol 7 & 8		2000s Down, 2010s Up	One of the first three locations selected in the project
	C	12	Kamal Muara		2000s Down, 2010s Down	
	A	13	PAM JAYA Dharmawangsa		2000s Down, 2010s UP	Observe the relationship between subsidence and groundwater level in southern Jakarta where there is a lot of groundwater yield
	A	14	Pulomas		2000 s Down, 2010s Down	Point where the groundwater level continues to lowering

Note; Priority Rank

Rank A: Location where Land Subsidene Monitoring wells need to be constructed with high priority
Rank B: Location where monitoring well needs to be constructed following RankA
Rank C: Location where alternative monitoring wells have already been constructed by DPE and other organizations, so the priority of new construction is low.

Source: JICA Study Team



Source: JICA Study Team

Figure 2.33 Land Subsidence Monitoring Well Construction Site by Priority

In these proposals, DKI Jakarta and JICA were supposed to construct two new monitoring stations in 2020-2021, one station in each year. However, due to the influence of the Covid-19 infection, it became impossible to carry out the construction by DKI, and as mentioned above, JICA carried out the construction at the Jakarta fishing port site in the second stage.

For the construction of land subsidence monitoring wells in the future, it is necessary that DKI will take the lead in formulating a construction plan based on the above table and figure, proceeding with the construction, and expanding and constructing the observation network.

2.2.3 Manuals for the Well Construction/ Maintenance/ Data Management

In constructing the land subsidence monitoring well, the following three (3) manuals were prepared in collaboration with the CP organization.

During the Phase 1 of the Project, the draft manuals were prepared with referring to the lessons from the construction of wells. At the time of constructing JICA land subsidence monitoring well at the Jakarta Fishing Port site, these manuals were revised through the joint work of the JICA Study Team. The technology was transferred to Indonesian side so that the land subsidence monitoring well can be constructed, the monitoring well can be maintained properly, and the collected data from the well can be managed continuously by DKI in the future.

(1) Manual for Construction Land Subsidence Monitoring Wells

A revised version was created that reflects the points for improvement and additional descriptions regarding the construction method for the construction of the new observation well in the second stage.

The main improvement is that the geology of the Jakarta fishing port where the monitoring wells were

constructed in the second stage is considered to be more likely to be soft compared to the Cengkareng and Cakung construction sites. Therefore, the slide pipe which had a diameter of 5 inches in the first stage of construction has been changed to a diameter of 6 inches.

In the manual, it is stated that 5 inch diameter and 6 inch diameter pipes can be used properly depending on the geological condition.

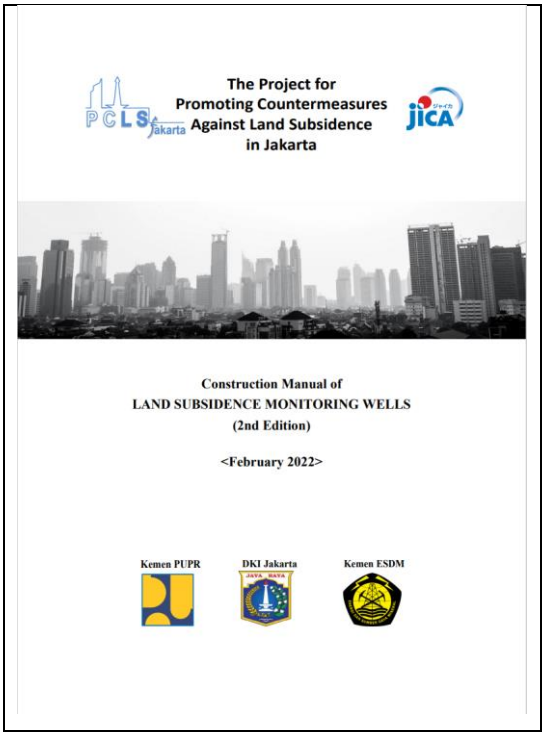


Figure 2.34 Technical manual for the construction of land subsidence monitoring well.

(2) User Manual & Maintenance Manual for Land Subsidence Monitoring System & Measuring Equipment

A revised version was created on how to maintain the monitoring equipment.

The main points of revision were the addition of descriptions on the handling and countermeasures for equipment malfunctions that occurred during the second stage of the monitoring equipment for the monitoring wells constructed in the first stage.

As a main additional description, it is described how to deal with malfunctions of the solar system, data logger, displacement gauge, and pore water pressure gauge (on-site check, response to the manufacturer, etc.).

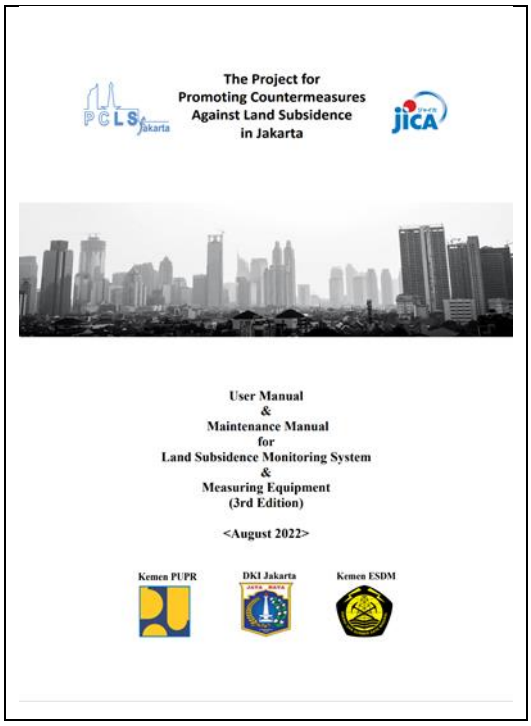


Figure 2.35 Maintenance and management manual for the constructed land subsidence observation well and the installed instruments/measuring equipment.

(3) Manual for Data Management of Land Subsidence Monitoring Data

With the support of JICA, a manual that briefly summarizes how to incorporate and utilize land subsidence monitoring data into the database "MONAS" which established by related organizations (mainly BKAT) was prepared.

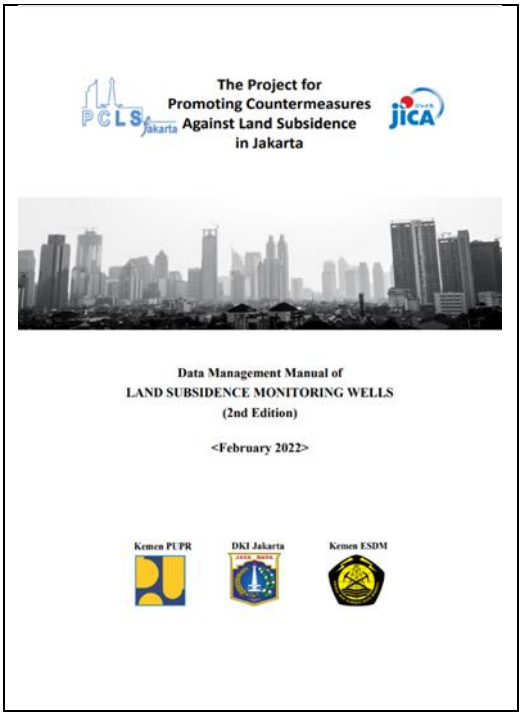


Figure 2.36 Manual for management and usage of obtained land subsidence and groundwater level data.

2.3 GNSS Survey

Levelling (including GNSS survey) was conducted at 10 areas including the already-existing NCICD benchmarks. First, a reference benchmark for each area was decided and measured by GNSS survey, then surrounding benchmarks and monitoring wells were measured by levelling to acquire elevation. Post processing of the measurement data was conducted with the support of ITB which has parameter data for survey calculation. The detail of this survey is described below.

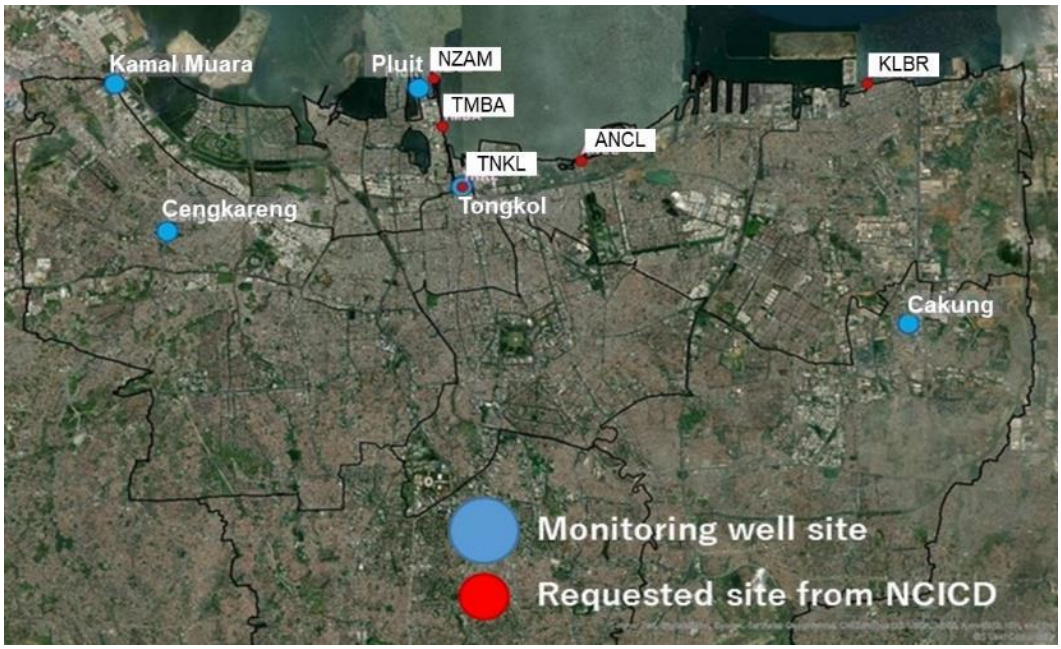
2.3.1 Overview of the Survey

(1) Purpose

Levelling (including GNSS levelling) is currently the most accurate survey method of elevation. Therefore it was conducted in this project to evaluate the accuracy of land subsidence measurement acquired from InSAR analysis and monitoring well. Survey data also complements these measurement methods. This was the first data capture since this project started, so technical support for survey under the right planning and field works by the Japanese expert were provided to local survey operators.

(2) Measurement Area

Survey area is shown in the picture below. In some areas, several monitoring wells and benchmarks were measured within 1 premise.



Source: Created by the project team

Figure 2.37 Measurement Area

Table 2.20 Survey Works

Method	Target	Quantity
GNSS Survey	Existing temporal benchmark	5 points
Levelling 1	Monitoring well and benchmarks placed in each site	5 areas
Levelling 2	Existing benchmark managed by NCICD	5 points

(3) Teaming

Survey works and data processing were conducted by the support from following teams, and a survey expert from Japan provided necessary advice and technical support on site.

- GNSS and levelling survey : Local surveying company
- Data processing, evaluation, and advice : ITB (Dr. Heri Andreas)
- Special support : Dr. Pulung (PUSAIR/NCICD)

(4) Method

GNSS and levelling methods were applied.

1) GNSS Survey

GNSS survey was conducted at each monitoring well site to set the benchmark height. A survey network was created for each survey, and the measurement was continued by receiving GNSS signals for over 12 hours (see Figure 2.38).

2) Levelling

Using the height information measured by above GNSS survey, the relative height of monitoring well, benchmarks placed around each monitoring well, and NCICD benchmarks were measured (see Figure 2.38) and converted to the actual height.



Source: Created by the project team

Figure 2.38 Survey Work: GNSS (left), Levelling (right)

(5) Technical Support

Various technical supports were given from the perspectives described in Table 2.21.

Table 2.21 Items of Technical Support and Evaluation

Items to support	Overview	Evaluation
Planning	The work plan is along with the requirements of TOR.	・ Requirements were satisfied. ・ Preliminary research was conducted for planning.
Equipment	Equipment satisfies required accuracy	・ GEOMAX product was used. ・ Adequate number of equipment was prepared.
Staff	Adequate number of operators are allocated for each position.	・ Adequate (GNSS : 2 persons/site, Levelling : 5 persons/site)
Safety management	Safety measures are implemented.	・ Minimum level of safety measure for protecting equipment ・ Safety of staff needs to be more considered on the road.
Experience	Experienced surveyor is accompany on survey sites	・ Well experienced.
Quality management (Levelling)	Satisfy the survey standard.	・ Standard process were kept in each site.
Quality management (GNSS)		

2.3.2 Result of Survey

The result of survey for each point is described in the table below. Absolute height (height above sea-level) was calculated from the height measured by GNSS survey.

Table 2.22 Result of survey

(BM; Bench Mark, MW: Monitoring Well)

Point_id	Place_name	Latitude	Longitude	Ell.Heigth(m)	Ortho.Heigt(m)	ObjType	Method
CEGK	Cengkareng	-6.1429072	106.7286912	22.31523	4.97253	BM	GNSS
CE-BM01	Cengkareng			22.297	4.954	BM	Leveling
CE-BM02	Cengkareng			22.291	4.948	BM	Leveling
CE-1b	Cengkareng			22.061	4.719	MW	Leveling
CE-1a	Cengkareng			22.925	5.583	MW	Leveling
CE-2b	Cengkareng			22.062	4.719	MW	Leveling
CE-2a	Cengkareng			23.009	5.666	MW	Leveling
CE-3b	Cengkareng			22.06	4.718	MW	Leveling
CE-3a	Cengkareng			22.958	5.615	MW	Leveling
CKNG	Cakung	-6.1707194	106.9381076	23.45197	5.51447	BM	GNSS
CA-BM01	Cakung			23.072	5.135	BM	Leveling
CA-BM02	Cakung			23.209	5.272	BM	Leveling
CA-BM03	Cakung			23.207	5.27	BM	Leveling
CA-1b	Cakung			23.304	5.367	MW	Leveling
CA-1a	Cakung			24.347	6.41	MW	Leveling
CA-2b	Cakung			23.305	5.368	MW	Leveling
CA-2a	Cakung			24.338	6.401	MW	Leveling
CA-3b	Cakung			23.3	5.362	MW	Leveling
CA-3a	Cakung			24.311	6.374	MW	Leveling
KMAL	Kamal Muara	-6.0980975	106.7143599	18.88848	1.57208	BM	GNSS
KMAL-MW	Kamal Muara			19.394	2.077	MW	Leveling
KMAL-BM_Lama	Kamal Muara			20.833	3.517	BM	Leveling
PLIT	Pluit	-6.0991864	106.7994943	19.8909	2.2458	BM	GNSS
PL-a	Pluit			21.114	3.469	BM	Leveling
PL-b	Pluit			19.968	2.323	BM	Leveling
TNKL	Tongkol_1(BM)	-6.1290866	106.8120976	19.15704	1.51364	BM	GNSS
TO-1	Tongkol_2(BM)			19.198	1.555	MW	Leveling
NZAM(BM NCICD 04)	NCICD 04	-6.0961705	106.8039118	19.5397	1.8946	BM	Leveling
TMBA	TMBA	-6.110754	106.806392	22.38015	4.73505	BM	Leveling
ANCL(NCICD0029)	ANCL	-6.121192511	106.8456251	20.207	2.55984	BM	Leveling
KLBR	KLBR	-6.09765	106.926418	24.83162	6.89365	BM	Leveling
TONGKOL	Tongkol_2(Monitoring well)	-6.1290866	106.8120976	19.1608	1.51364	BM	Leveling



Source: Created by the project team

Figure 2.39 Measurement Sites

2.3.3 Suggestions

Although acquiring accurate height information from survey data has a great significance, it is not always possible from economical and geographical condition since the land subsidence occurs in a wide area. Therefore, combining other data from InSAR and monitoring wells is desirable. The following two points are suggested for the future. The periodical monitoring is included in the Action Plan of PIC, as described in the Chapter 7.

(1) Periodical Survey

This was the first measurement at many points, so the same survey needs to be conducted one more time to calculate the amount of land subsidence. Periodical survey of every six months or one year is ideal, but it is effective even if the interval is longer. Because regularly comparing the survey data, InSAR data, and monitoring well data is effective to check the status of land subsidence with higher accuracy.

(2) Quality Management

Accuracy of existing survey data is not fully trusted under the current situation, therefore it is needed to establish a survey procedure and evaluation method and also evaluation structure to effectively enhance the capability of organisations which are involved with land subsidence can operate. We suggest to allocate technical staff who have the ability of quality control and manage quality control, with the support of experts of BIG.

2.4 Existing Groundwater Level Monitoring Data

2.4.1 Existing Data of each Institution

The groundwater level monitoring in DKI Jakarta area has been conducted by ESDM, PUSAIR, and DPE. The information of existing data shown below in Table 2.23, where the groundwater level situation is described based on the groundwater conservation map of ESDM, groundwater level monitoring data of PUSAIR, and groundwater level monitoring data (by Automatic Recorder) of DPE.

Table 2.23 Existing Data of Each Institution

Name	Status of Data Management	Status of Data Collection
PUSAIR	Groundwater monitoring data (144 points / 1980 ~/ Yearly)	Data: collected
ESDM	Groundwater conservation map (2009, 2013, 2018)	Waiting for the 140-250 m depth groundwater conservation map of the 2018 edition
BKAT (ESDM)	Groundwater monitoring data【using telemeter】 (16 points / 2015 ~/ Automatic Recording)	Data: collected from HP (however, few data)
	Groundwater observation data (150 points / 2015 ~/ Yearly)	Not collect, because it is used for groundwater conservation map
	Land subsidence monitoring data (Measurement of stratum shrinkage: 1 depth / 1990 ~/ Yearly)	Data: collected
DPE	Groundwater monitoring data【using telemeter】 (11 points / 2018 ~/ Automatic Recording (※However, data acquisition intervals are irregular))	Data: collected data at 7 points, missing data at other points
	Land subsidence and Groundwater monitoring data (Kamal Muara) (Measurement of stratum shrinkage: 8 depth, measurement of pressure head: 4 depth / 2016 ~/ Automatic Recording)	Data: collected
	Land subsidence and Groundwater monitoring data (Perintis) (Measurement of stratum shrinkage: 8 depth, measurement of pressure head: 7 depth, measurement of groundwater level: 2 depth / 2009 ~/ Automatic Recording)	Equipment: failure Data: collected data around Oct 2014
	Land subsidence and Groundwater monitoring data (Jati Baru) (Measurement of stratum shrinkage: 8 depth, measurement of pressure head: 7 depth, measurement of groundwater level: 2 depth / 2012 / Automatic Recording)	Equipment: failure Data: collected data around May to Oct 2015
	Land subsidence and Groundwater monitoring data (Tongkol) (Measurement of stratum shrinkage: 8 depth / 1989 ~/ Automatic Recording)	Equipment: failure Data: not collected (not provided)

Source: JICA Study Team

2.5 Groundwater Level Monitoring Data

2.5.1 Groundwater Level Monitoring Data by BKAT MONAS

BKAT's groundwater level observation data is collected in the database MONAS (MONitoring Air tanah dan Subsidence Cekungan Air Tanah JAKARTA) created by BKAT as a result of this project and published online.

Based on the groundwater level observation data stored in the database of MONAS, the groundwater level change in Jakarta Special Province is examined in this study.

(1) About the MONAS

MONAS is a data base to collect groundwater level observation data that are carried out by BKAT or other institutions in DKI Jakarta. This information is disclosed to the residents of DKI Jakarta, related parties and related organizations. It is a data management system created to promote information sharing and awareness of the situation regarding changes in groundwater levels in Jakarta.

This database was established by the C/P side in collaboration with the JICA study team as part of the results of this project. As a data related to land subsidence observation, the GPS observation results that was conducted by BKAT are also summarized. In addition, the observation data (ground subsidence depth, groundwater level) of the two land subsidence observation wells constructed by JICA are currently being adjusted to be shared in this database.

BKAT started developing a successor system of MONAS named PASTI which will be used to share their monitoring well data (see sub-chapter 2.6).

(2) Groundwater Level Monitoring Network in DKI Jakarta by the MONAS

At present, groundwater level monitoring data of 17 wells are collected in MONAS continuously. Figure 2.40 and Table 2.24 show the location and list of the groundwater level monitoring wells by BKAT of MONAS.



Source: JICA Study Team

Figure 2.40 Location of Groundwater Monitoring Well of the MONAS

Table 2.24 List of Groundwater Monitoring Well of MONAS

No. of Well	Well Code	Coodinates		Depth of Well (m)	Target Aquifer	Screen depth					Observation Data period	
		X	Y			S-1	S-2	S-3	S-4	S-5		
1	31750100015001	106.74594	-6.13151	130 m	Middle Aquifer	42-45	96-99	126-129			2019/8/16	2019/10/10
2	31750600015001	106.9342	-6.14478	150 m	Middle Aquifer	33-36	69-72	147-150			2019/8/8	2020/7/16
3	31740100015001	106.74346	-6.2208	150 m	Middle Aquifer	60-69	90-96	114-120			2019/9/2	2019/10/14
4	31720800015001	106.91792	-6.20231	150 m	Middle Aquifer	51-57	84-89	123-129			2019/8/13	2020/12/5
5	3174100115001	106.75565	-6.27136	150 m	Middle Aquifer	72-78	102-108	126-132			2019/12/4	2019/12/13
6	31710600045001	106.80701	-6.24851	150 m	Middle Aquifer	50-53	64-67	76-82	102-105	110-113	2019/9/2	2020/6/14
7	31720200035001	106.86689	-6.32483	150 m	Middle Aquifer	60-66	86-92	106-112			2019/12/11	2020/11/12
8	36030100011	106.461	-6.2139	150 m	Middle Aquifer	81-87	105-111	120-126			No data	
9	36710510035001	106.579251	-6.214662	150 m	Middle Aquifer	48-51	60-72	90-96	102-105		Nodata	
10	36711000115001	106.66679	-6.07425	150 m	Middle Aquifer	60-66	78-84	102-126			2019/5/9	2020/12/18
11	36740300025001	106.7382	-6.33822	129 m	Middle Aquifer	48-54	63-66	87-93	120-123		2019/12/4	2020/11/13
12	32750110015001	106.92248	-6.38139	132 m	Middle Aquifer	48-54	72-78	120-126			2019/7/26	2020/12/18
13	36710510035001	106.6301	-6.15606	150 m	Middle Aquifer	60-66	84-90	96-102			2019/7/29	2020/10/30
14	32160900065001	107.039421	-6.1114984	150 m	Middle Aquifer	81-87	96-99	102-108	111-114		2019/5/28	2019/11/29
15	32160900025001	107.03781	-6.19876	126 m	Middle Aquifer	60-69	72-75	78-81	102-108		2019/8/13	2019/11/11
16	31750200035001	106.81172	-6.12915	150 m	Middle Aquifer	90-102	126-132				2019/4/26	2020/10/10
17	3173080035001	106.83	-6.19	125 m	Middle Aquifer	81-95	101-110				2019/9/19	2020/3/18

Note: No data No.8 and No.9 in MONAS

Source: JICA Study Team

(3) About the Tendency of Groundwater Level Change Based on the MONAS

As shown in Table 2.24, MONAS database was built in the middle of 2019. Therefore, the groundwater level monitoring data is also from the middle of 2019 when the construction of MONAS started, while the longest monitoring period is until December 2020, and the observation period is short. Changes in groundwater level during the monitoring period of the MONAS are shown in the attachment of this document. Due to the short monitoring period, some monitoring wells and results capture seasonal fluctuations in the rainy and dry seasons, but the tendency of long-term groundwater level changes has not yet been grasped. Continuous monitoring is required in the future.

2.5.2 Groundwater Level Change by the Land Subsidence Monitoring Wells by JICA

Here, the situation of groundwater level change based on the land subsidence monitoring wells constructed by JICA 2019 is briefly described. The relationship between land subsidence and groundwater level changes is described in sub-chapter 2.6.2.

(1) Overview of Groundwater Level Change by JICA Monitoring Wells

The JICA land subsidence monitoring well was constructed in May 2019, and monitoring data has been obtained for groundwater level since July of the same year.

As shown Table 2-25, continuous groundwater level monitoring are being carried out at each of the three different aquifers.

At the start of the monitoring, the groundwater level has been confirmed to be located in the middle aquifer, which is considered to be the main target for groundwater pumping. The deepest groundwater level is located at each monitoring point of Cengkareng and Cakung.

Table 2-25 Target Aquifer of Groundwater Monitoring Well in Cengkareng and Cakung

Location of Monitoring Well by JICA	Target Aquifer	Depth of Screen (GL.-m)	Depth of Pore Water Pressure Gauge
Cengkareng	Shallow Well: Unconfined	18-24 (6m section)	GL.-11m
	Middle Well: Upper confined	75-160 (48m section)	GL.-50m
	Deep Well: Lower confined	203-240 (24m section)	GL.-20m
Cakung	Shallow Well: Unconfined	12-24 (12m section)	GL.-16m
	Middle Well: Upper confined	88-134 (24m section)	GL.-22m
	Deep Well: Lower confined	160-240 (42m section)	GL.-10m

(2) About the Change of Groundwater Level

1) Change in each Target Aquifer

In Cengkareng, the observations of Deep Well and Middle Well are considered to show abnormal values from mid-February or mid-March 2020. Since then, manual measurement have been done several times from June 17, 2020. Regarding the abnormality of the water pressure gauge, repair work was done on site. However, Middle Well continued to observe manually because an abnormality was found in the pore water pressure gauge after that, but the movement to the site was restricted due to the influence of the Covid-19. Repair work is being currently underway on site.

As confirmed from the beginning of monitoring to until now, the groundwater level of Shallow Well is the highest, followed by the groundwater level of Deep Well, while the groundwater level of Middle Well is the deepest.

At present, two cycles of groundwater level fluctuations during the rainy season and dry season have been observed since the completion of well construction (July 2019). Continuous observations are needed in the future.

a) Deep Well (Deep Aquifer: Lower Confined Aquifer, Depth of Well: 250m, 280m): Blue Line

The outline of the fluctuation of the groundwater level at each site is as follows.

Cengkareng ; January 2022　GL.- 10.4m

The fluctuation of groundwater is between 10 and 12 m, and the seasonal fluctuation range is about 1 m. As for the change in groundwater level during the monitoring period, a slight upward tendency of the groundwater level is observed.

Cakung ; January 2022　GL.-7.8m

During the entire monitoring period, the fluctuation range of the groundwater level in the rainy season and the dry season is small and stable at about GL.-8 m.

b) Middle Well (Middle Aquifer: Upper Confined Aquifer, Depth of Well: 170m, 140m): Red Line

The change in groundwater level of this well is as small as that of the deep aquifer, but there is a significant difference in groundwater level between Cengkareng on the west side and Cakung on the east side, 42 m and 21 m from the surface, respectively.

The outline of the fluctuation of the groundwater level at each site is as follows.

Cengkareng ;

The groundwater level during the observation period fluctuates between GL.-42 m and 44 m.

As a tendency, the groundwater level tends to be slightly high near the end of the rainy season from 2020 to 2021. The groundwater level as of January 2022 is about GL.-44 m.

Cakung ;

The fluctuation range of the groundwater level in the rainy season and the dry season is about 1 m or less, and the fluctuation of the groundwater level including the seasonal fluctuation is small.

The groundwater level as of January 2022 is about GL.-21 m.

c) Shallow Well (Shallow unconfined Aquifer: Depth of Well: 30m): Green Line

Although the fluctuation range of the groundwater level is small at both points, the groundwater level tends to rise as the rainy season progresses and decrease as the rainy season ends and the dry season progresses. This is thought to capture seasonal fluctuations due to the rainy season and the dry season. Seasonal fluctuations of about 1 m to 1.5 m can be seen at both points due to seasonal fluctuations.

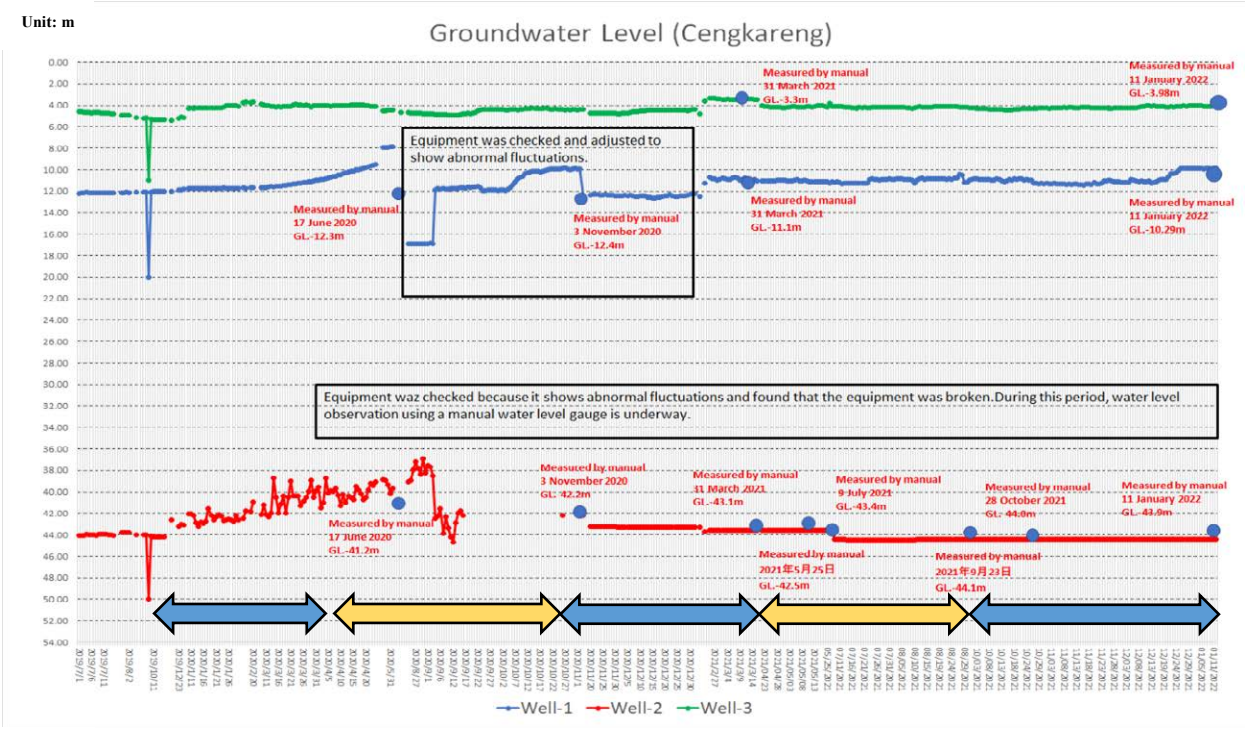
The outline of the fluctuation of the groundwater level at each site is as follows.

Cengkareng ;

The fluctuation ranges of the groundwater level in the rainy season and the dry season is about 1 m. The groundwater level as of January 2022 is about GL.-4 m.

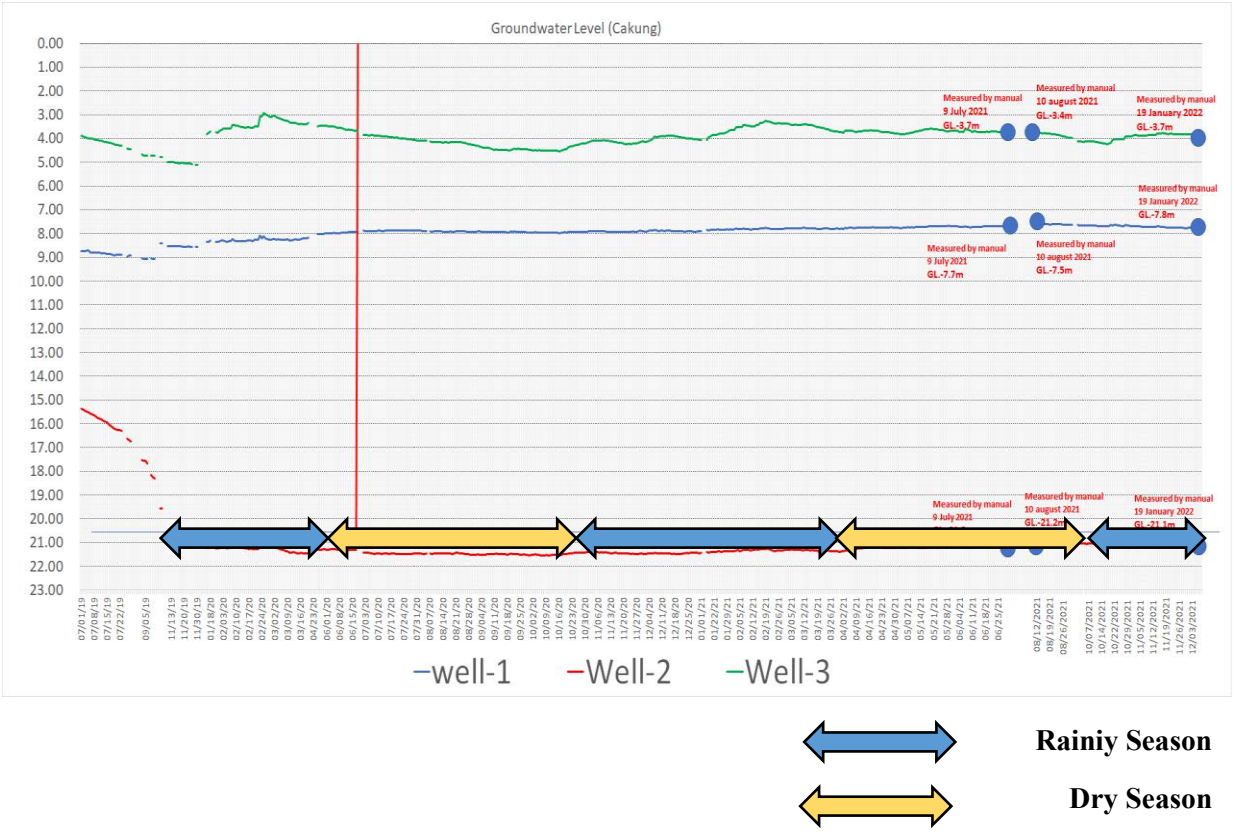
Cakung ;

The fluctuation ranges of the groundwater level in the rainy season and the dry season is about 1 to 1.5 m. The groundwater level as of January 2022 is GL.-3.7 m.



Unit: m

Figure 2.41 Change in Groundwater Level (Cengkareng)



The blue circles in the figure show the results of manual groundwater level measurement.

Source：JICA Study Team

Figure 2.42 Change in Groundwater Level (Cakung)

2) Summary

The groundwater level fluctuations at each site and well have the following characteristics.

a) Deep Well (Deep Aquifer: Lower Confined Aquifer, Depth of Well: 250 m, 280 m)

It is a deep aquifer, where the fluctuation in the groundwater level during the rainy and dry seasons is very small. This indicated that it is not used as a target aquifer for groundwater abstraction and not affected by precipitation.

b) Middle Well (Middle Aquifer: Upper Confined Aquifer, Depth of Well: 170 m, 140 m)

The middle aquifer has the deepest groundwater level among the three wells. The fluctuation range of the groundwater level in the rainy season and the dry season is as small as in the deep aquifer. In addition, the difference in water level at the observation points is large, Cengkareng GL.-42 m and Cakung GL.-21 m.

Since this aquifer is used as the main aquifer in the Jakarta region, it is considered that the groundwater level of the aquifer is low.

c) Shallow Well (Shallow unconfined Aquifer: Depth of Well: 30m)

This aquifer is a surface unconfined aquifer, and although the fluctuation range due to the dry season is small, the groundwater level rises at the end of the rainy season and falls in the dry season, which is considered to be easily affected by precipitation.

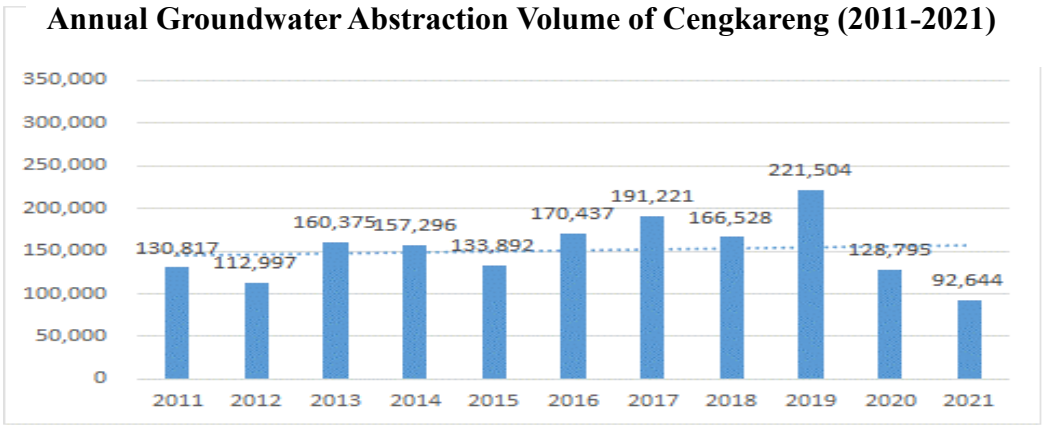
3) Relation between the Groundwater Abstraction Volume and Groundwater Level Area around the Monitoring Wells during Monitoring Period

Fig. 2-31 and Fig. 2-32 show the annual changes in the amount of groundwater abstraction volume from 2011 to 2021 and the monthly changes from 2019 to 2022 for each Kecamatan of Cengkareng and Cakung, where the land subsidence observation wells constructed in the first phase are located. Groundwater abstraction data was obtained from the Tax Office, DKI.

a) Cengkareng

In Cengkareng, the decrease in groundwater abstraction volume has been noticeable since 2019, when the monitoring was started. In terms of monthly abstraction volume, the volume increased abnormally in December 2021. However even if this abnormal volume included, the tendency of the groundwater abstraction volume to decrease is remarkable. Therefore, the groundwater level of the monitoring well does not show significant change or showing a trend of slight increase in Well-2 for the middle aquifer and Well-1 for the deep aquifer. This is considered to be consistent with the fact that the groundwater level does not show a downward trend in monitoring well of Well-1 and Well-2.

We thought that it depends on the groundwater utilization situation in the surrounding area. However, there is a possibility that the groundwater level of these monitoring wells will gradually rise in the future.



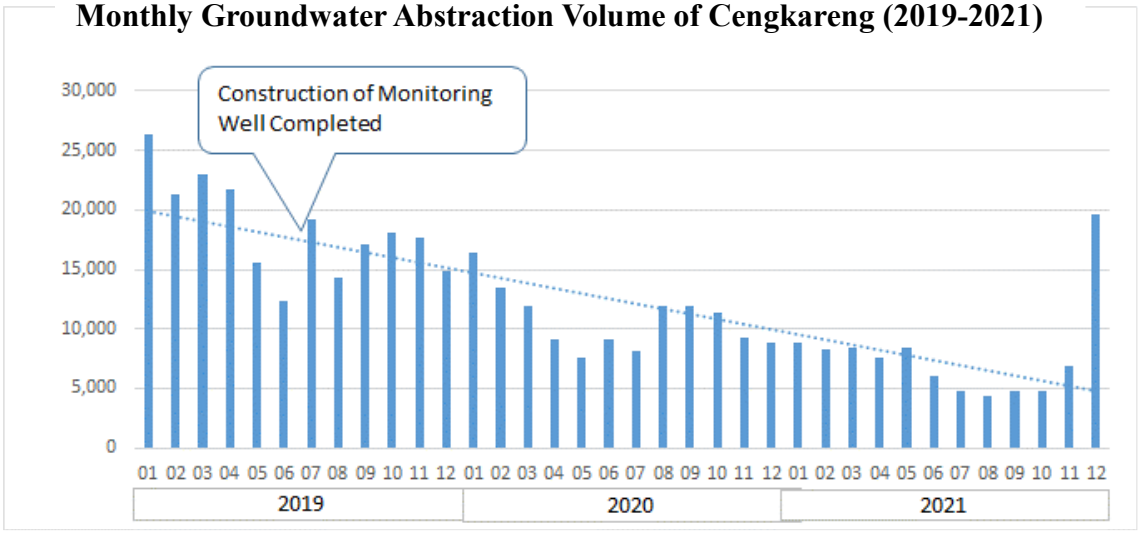


Figure 2.43 Change in Groundwater Abstraction Volume of Cengkareng

b) Cakung

In Cakung, the amount of groundwater abstraction volume has been almost constant since 2019, when the monitoring started. In terms of monthly abstraction volume, the volume increased significantly in November 2020 and May 2021. However even including this significant increase, the groundwater abstraction volume is almost constant. Therefore, the change in the groundwater level during the monitoring period is considered to be small in Well-2 which targets the middle aquifer and Well-1 which targets the deep aquifer.

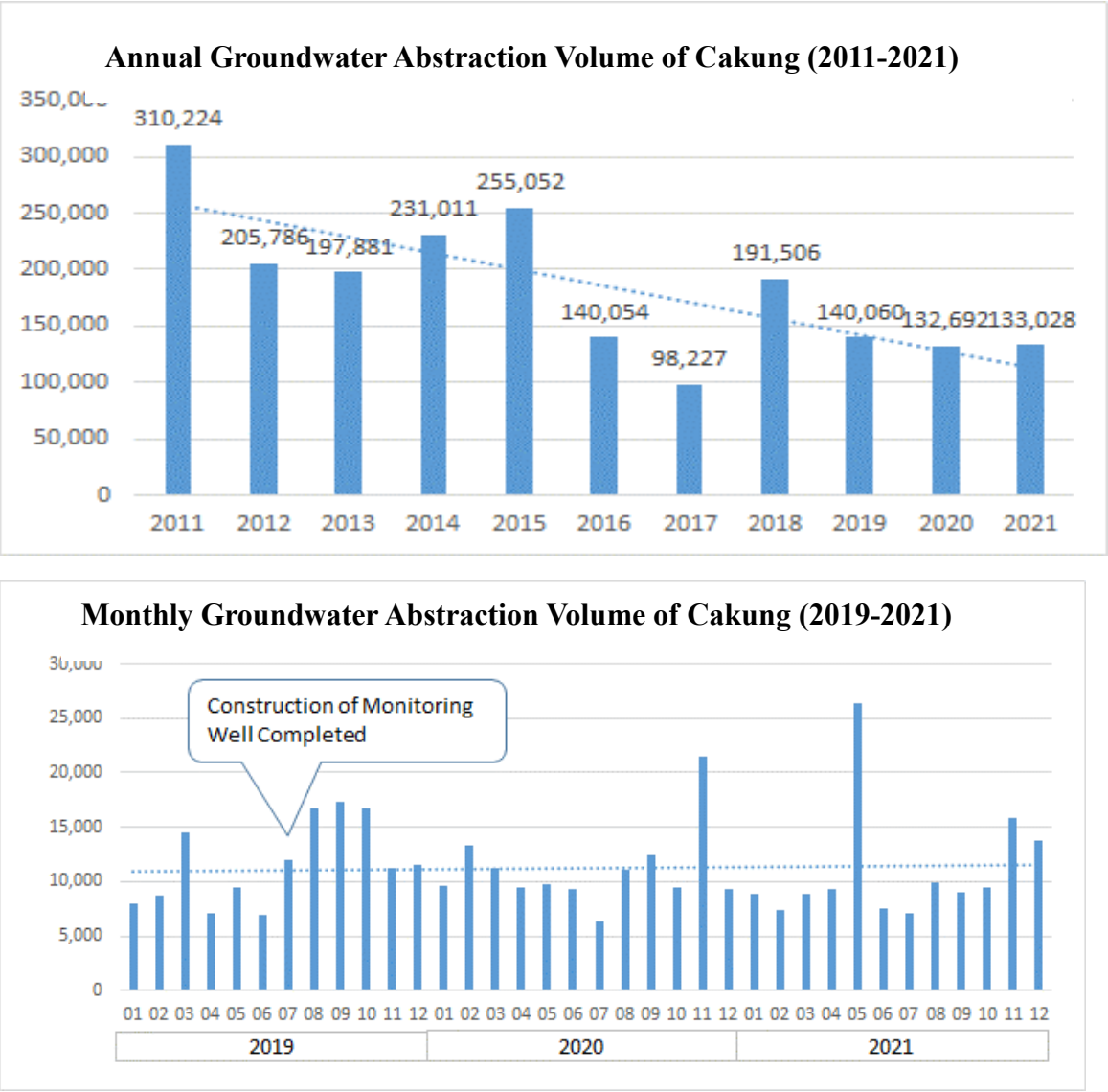


Figure 2.44 Change in Groundwater Abstraction Volume of Cakung

2.5.3 Construction of Groundwater Level Monitoring Network

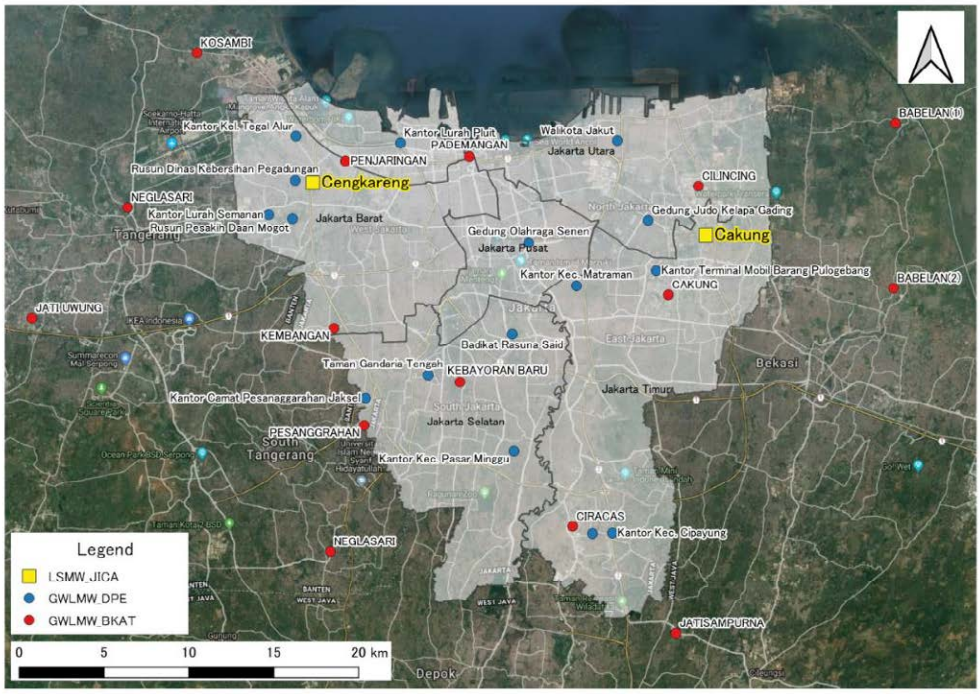
As of August 2018, DPE had the responsibility for groundwater monitoring. DPE conducts groundwater level monitoring with a total of 16 telemetry systems, 11 observation wells inherited from DTA (predecessor of Jakarta Special State Water Management Bureau (DSDA)), and 5 installations by DPE in 2018. In addition, BKAT (Groundwater Conservation Center) which is a subordinate organization of ESDM also conducted continuous observation of groundwater levels at 16 locations. Furthermore, since

two of the land subsidence monitoring wells constructed by JICA is added, the groundwater level is currently automatically observed at 34 locations in and around DKI Jakarta.

By this time, DPE had a plan to build a total of 100 groundwater level observation wells by 2024, where 15 observation wells were requested for budget to be built in 2020 and in 2019. It was planned to be built, but the construction period was shifted to 2020 due to contractual problems.

After that, groundwater level monitoring wells became under the management of DSDA again from 2020, and no new groundwater level monitoring well has been constructed after April 2020 due to the influence of corona.

Figure 2.45 shows the locations of newly constructed wells (land subsidence and groundwater level) by JICA and wells by DPE and BKAT which has automatic measurement system as of May 2019. While Figure 2.46 shows the locations of the 15 groundwater level monitoring wells planned to be constructed in 2020 by DPE. Monitoring wells in red circle shown in Figure 2.45 are continuously measured and recorded by BKAT in the above-mentioned database MONAS.



Source: JICA Study Team

Figure 2.45 Groundwater Level Automatic Measurement Point (as of May 2019)



Source: JICA Study Team

Figure 2.46 Groundwater Level Monitoring Well Construction Site planned by DPE in 2020

On the other hand, DPE had a plan to construct a groundwater level monitoring network for each Kota as shown in Table 2.26 by 2024 after constructing 15 wells. In the future, it is necessary to provide technical proposals continuously so that DSDA can take over the DPE plan and construct groundwater level monitoring wells systematically, and provide technical support in selecting specific groundwater level monitoring well construction sites.

Table 2.26 Groundwater Level Monitoring Well Allocation Plan by City

City	Number of Location	Number of Monitoring Well	Note
North Jakarta	8	24	8 locations in consideration of agricultural land development
Central Jakarta	4	12	
West Jakarta	7	21	7 locations in consideration of urbanization of the Tangerang city border
South Jakarta	4	12	
East Jakarta	7	21	7 locations in consideration of agricultural land development
Total	30	90	

Source: JICA Study Team

2.6 Construction of Well Inventory Data Management System

2.6.1 Current Situation of Well Registration and Groundwater Abstraction Control

Control of drilling and groundwater use in DKI Jakarta follows the process shown in Figure 3-41. Capital Investment and One-stop Integrated Services Office (DPMTSP) provides the application service for new well registration and renewal of permission. DPE works for supervising well construction during drilling and reading meters for groundwater use. Regional Tax and Retribution Agency (BPRD) collects groundwater tax from users based on the result of meter reading by DPE. BKAT and other organizations also manage related data with their own database systems or files.

However, as a result of such restructuring of work process for well registration and groundwater abstraction control, data of registered wells and groundwater abstraction have been scattered and lost.

For example, DPMTSP notifies DPE of the information only covering the application documents for permission, such as name of applicant, number of wells, location/coordinates, usage classifications (domestic, industrial/commercial, building, or stockpiling), classifications of groundwater conservation zones (safety, vulnerability, crisis, or difficulty), well registration numbers, permitted pumping rates, and groundwater tax classifications (non-commercial, small commercial, small industries, large commercial, large industries, or nontaxable) upon approval of application.

However, technical reports of drilling and pumping test results containing geological column drawings and strainer position of installed wells, etc., that are attached with the application documents for permission of groundwater use, are not included in the documents shared with DPE. Furthermore, DPE sends the records of meter reading to BPRD for groundwater tax collection, but the records are not sent to DPMTSP. Therefore DPMTSP cannot check the credibility of past pumping results reported by applicants at the time of renewal of permission at the end.

Scattering and losing data of well registration and groundwater abstraction volume began in 2015 when the one stop services started in DKI Jakarta and DPMTSP (former BPTSP) became the window of application for new well registration and renewal of permission. Documents and data before the introduction of one stop services has not been found. The Environment Management Agency (BPLHD) was in charge of groundwater management in DKI Jakarta until 2014. The responsibility was transferred to the Water Resources Office (former Water Management Office) in 2015 and DPE from the Water Resources Office (DSDA) in 2017. Continuity of data and information on the groundwater management is not maintained at the change of organizational structure. The responsibility related to land subsidence observation and groundwater management and conservation will be transferred again from DPE to DSDA in 2020. At the time of this organizational change, it is necessary to proceed with appropriate data migration, in particular, integration of data before the responsibility was transferred to DPE in 2017 (data held by DSDA) and data after it was transferred to DPE.

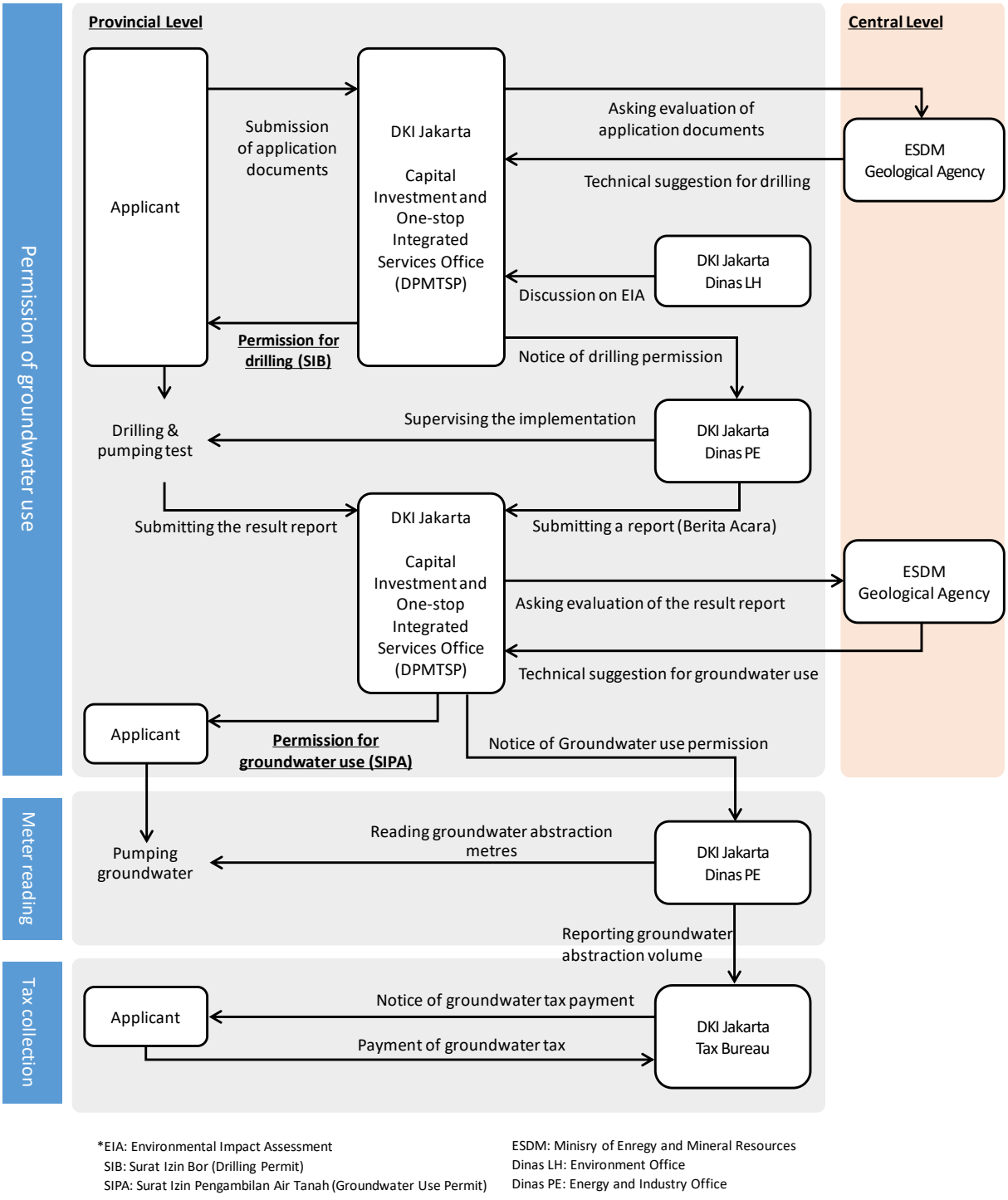


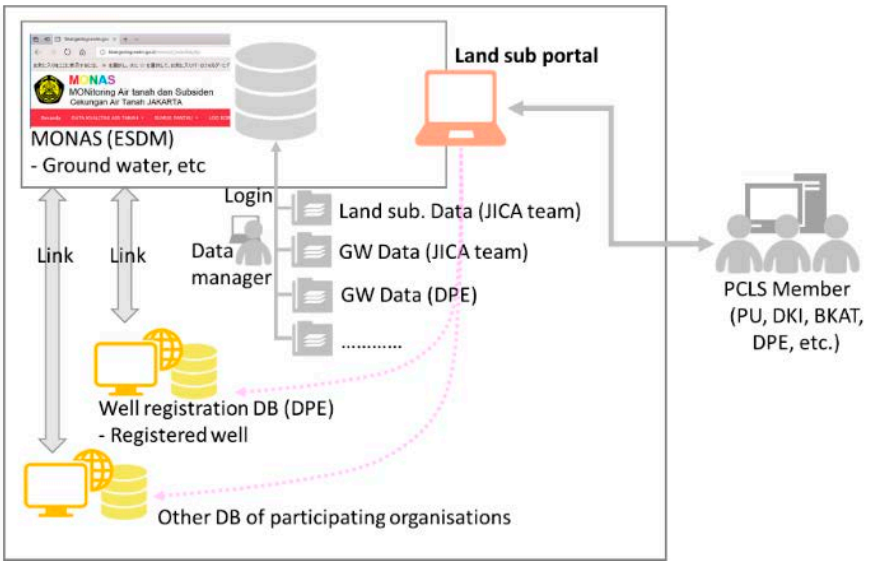
Figure 2.47 Process of drilling and groundwater use control

Source: created by the Project Team based on the result of interview to the Government of DKI Jakarta

Based on the discussion with related organisations, the project team proposed to create a common database by integrating monitoring well data, groundwater data, and land subsidence data.

The development of this database is done by customising MONAS (MONitoring Air tanah dan Subsiden) which has been developed and managed by BKAT. This system is capable of importing data

from the JICA team, PUSAIR, DKI Jakarta, and other organisations. The image of the system was discussed in the WG1 and the direction of the development was agreed in the WG1.



Source: Created by the project team

Figure 2.48 System Design for Data Sharing

2.6.2 Issues and Direction of Developing Data Management System

Collaborative works of various organizations are essential for the countermeasures of land subsidence. The system supports smooth communication, but we need to consider issues for development described below.

① Database system

Concerning the management of data, issues are mainly focused on the mitigation of inefficiency caused by dispersion of data, missing of necessary input, and lack of sharing. Registered well inventory management system is aimed at providing solutions for above issues. The first step is to itemize the data stored in relevant organisations such as DPE, and secondly, develop the system which can be operated for long term. At the time, system for administration works (i.e. internal system) and data sharing system should be separated, as internal system may contain personal information of well owners.

② Integration of data

Synchronising database and operation of participating organisations is an important issue in the management of integrated database. So, it is desirable to design the system as each organization is able to continue using their existing system making effective use of shared database.

In the first period of the project, the project team had discussions with DPE, BKAT, and PUSAIR on this issue. As a result, understanding about the necessity of integrating well inventory data, elevation data, subsidence data, etc. improved among participants. The next step is to discuss the policy, desirable protocols, role dividing relating to the development, and the use of database within Indonesian participants of WG1 who are the actual users of the system.

Judging from the result of discussions so far, we suggest to prepare the open data system which

provides the interface for users to download necessary data when needed, and each data is maintained by the producer and the owner of the data.

③ Standardisation of data

Groundwater level and GNSS observation data are collected and stored by multiple organisations. Considering the shared use of these data, difference of data format leads to inconvenience when used by different organisations. Therefore, we suggest setting standard format between participant organisations for each type of data item.

④ Operation

Stable operation of database system is essential as it is shared by many organisations and provide information for their activities. Following managerial issues must be discussed as well as the development of system.

Table 2.27 System operation (tbd)

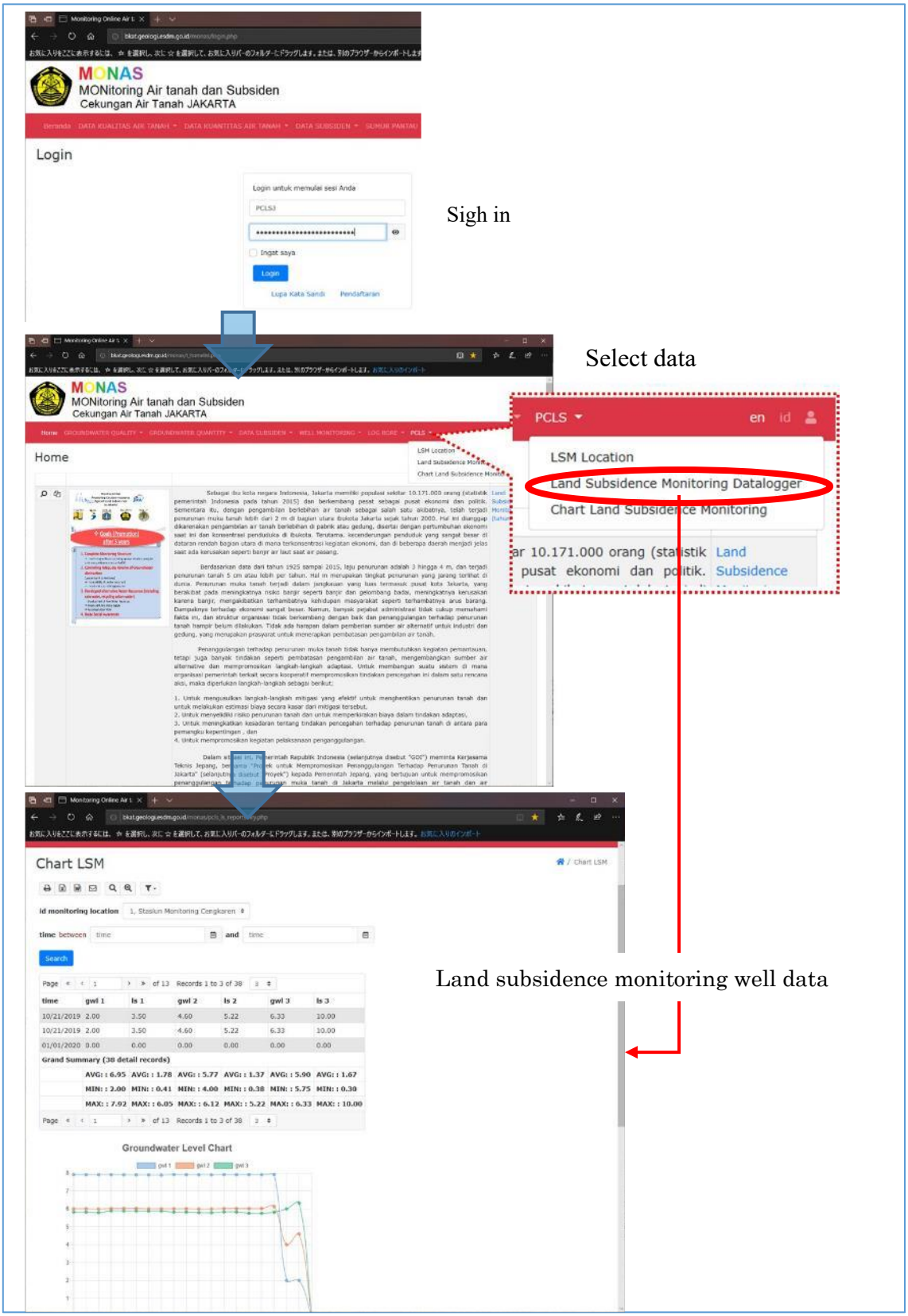
Item	Detail	Organization
Management	・ Design system, Manage development	*BKAT (MONAS owner/ administrator)*
Operation	・ Maintain hardware and software ・ Provide operation site (or IDC) ・ Accept questions from users ・ Check the status of data update	*CP (or outsourcing)*
Cost	・ Share the cost of development and operation between participants	*User organizations*
Data update	・ Update allocated data (each participants)	*CP (or outsourcing)*
Security	・ Conduct activities to keep security of the system (incl. security training)	*CP*
Training	・ Provide training for users	*Project Team,* *CP (or outsourcing)*

2.6.3 Current Status of Development

Following the discussion between BKAT, DKI Jakarta, PUSAIR, and the JICA team, the system was customized to enable data registration from organizations outside BKAT. External organizations are given user accounts to register and the JICA project team registered some datasets for test.

While registered data are published for any users as open data, access control function is applied for some data which needs to be protected by controlling access to it. The general picture of the system is shown below.

(URL: http://bkat.geologi.esdm.go.id/monas/t_homelist.php)



Source: Created by the project team

Figure 2.49 System Image of MONAS at Present

BKAT has developed a new system called PASTI (PEMANTAUAN AIR TANAH DAN SUBSIDENCE TERINTEGRASI) as the successor of MONAS in 2021. PASTI provides more intuitive user interface with maps as users can better understand the situation of land subsidence and its monitoring. Regarding telemetry data of monitoring wells, the system is designed to connect with the telemetry system if its data access protocol is provided. The development has been almost completed at the end of 2021, and preparation for the formal release of the system is being proceeded at the point of this report. (It is reported that BKAT and DSDA already exchanged information about this issue.)

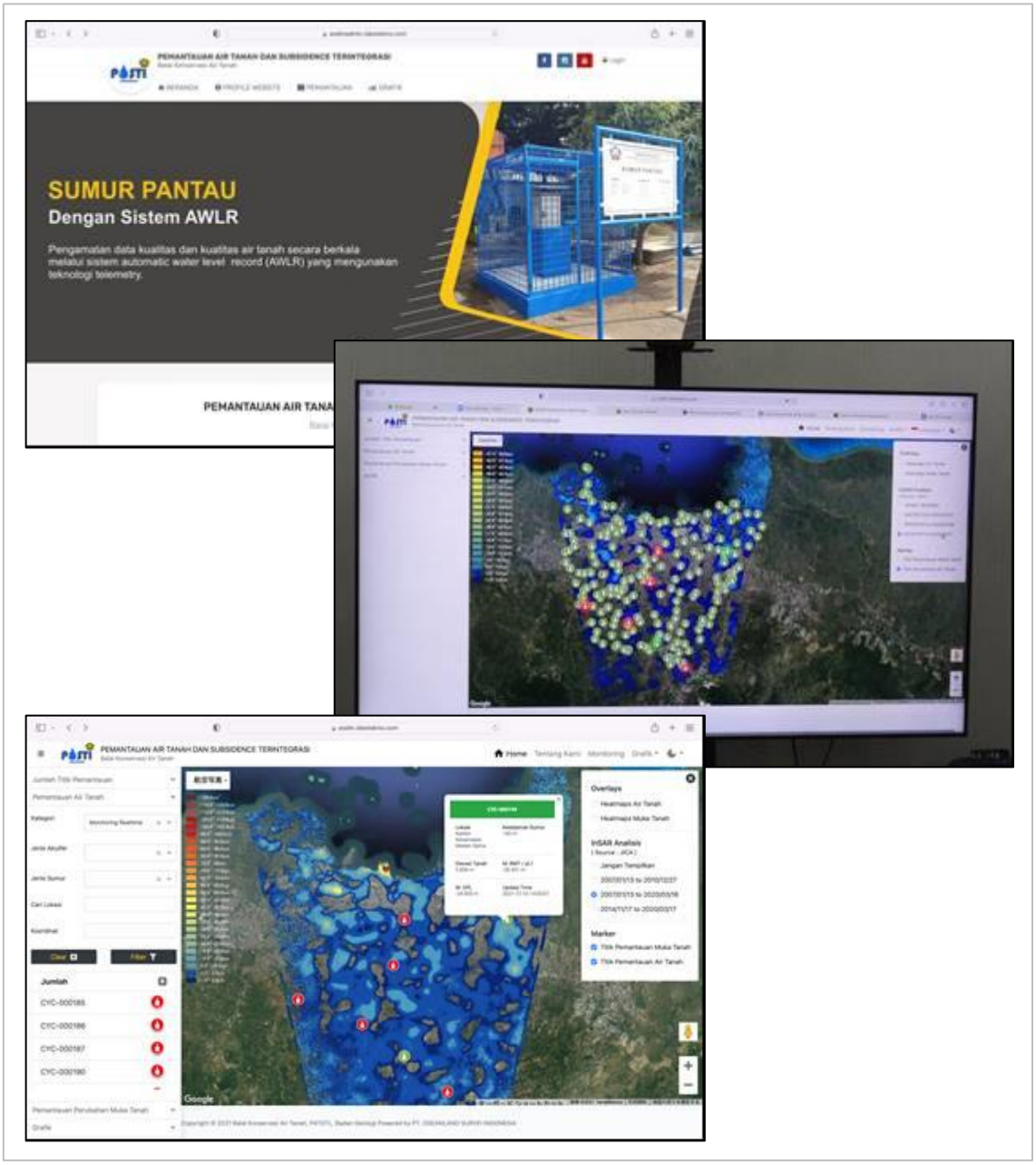


Figure 2.50　PASTI（Under development）

2.6.4 Future Prospects

(1) Future prospects

PASTI is a web system which can be updated as needed, and designed to register data from external organisations. Currently, JICA project data are registered and overlaid on top of monitoring data of BKAT. So we can see how land subsidence data and ground water data are combined, and how these are shared through the system.

In the future, the discussion about conditions of opening data is important for participating organisations. This needs to be developed through the practice of land subsidence monitoring by Indonesia side after the completion of this project. While integrating data into one database such as MONAS and PASTI, this data sharing method, which own data are stored in the external database servers, would not be easily accepted because of organisation's policies about data security. This situation must be considered and some other options for enabling data sharing needs to be developed from the perspectives of end users to deal with land subsidence.

(2) Realizable data sharing structure

Confirming the situation of DSDA and BKAT, a feasible way of data sharing was discussed with the consideration of organisational environment about data sharing. Although integrating database was the ideal way of sharing data here, the reality was far from this idea. Therefore it was suggested that each organisation maintain their system independently allowing mutual access to data of each of them. The project team also suggested to have a portal site as users can easily access to data, and using a home page developed by the project team is one of the most convenient way.

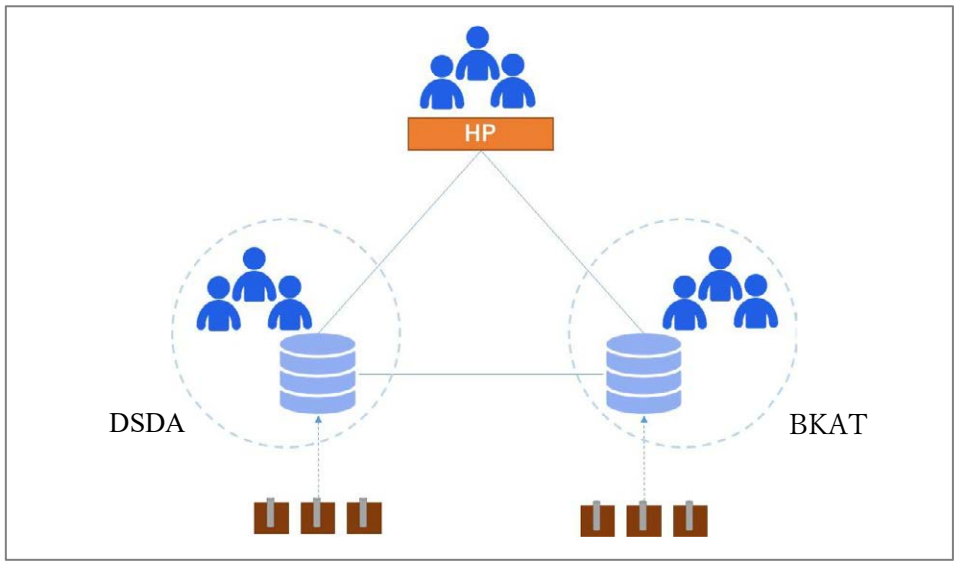


Figure 2.51 Data sharing by creating links to external data sources

The project team had a discussion with DSDA regarding the idea of data sharing above and confirmed that they also had identical thoughts. DSDA thinks that each organisation operates their own database and allow external users use their data through providing links as users can easily access to data provided by participating organizations. Meanwhile, some particular data such as telemetry data could be automatically sent to other organization's system such as PASTI of BKAT, so how to share data should be chosen depending on the type of data and convenience of users. The optimal data sharing is one of the action plan of PIC Working Group 1.

2.7 Current Situation of Land Subsidence

2.7.1 Existing investigation and research

Up to now, there have been 4 existing investigations on hydrogeological structure of Jakarta which was collected by the project team.

Table 2.28 Major Existing Investigations and Research on Hydrogeological Structure

No.	Document name or research agency	Content	Notes
1	Soekardi and Purbohadiwidjojo (1975)	This conceptually represents the hydrogeological structure from Bogor to Ancol. The aquifers is divided into three layers with depths of less than 40 m, depth of 40 to 140 m, depth of more than 140 m.	This is the basis of the aquifer classification of the groundwater conservation map made by ESDM.
2	Stratigrafi dan Hidrostratigrafi Cekungan Airtanah Jakarta, Muhammad Fachri et al. (2002)	Based on the collected geological columnar, a hydrogeological section is created and the aquifer is divided into four layers in relation to the stratigraphy.	This is quoted most in other studies. (about groundwater flow simulation, etc.).
3	ESDM	Based on the collected geological columnar, a hydrogeological section is created.	in draft stage
4	PUSAIR	Based on the collected geological columnar, a hydrogeological section is created.	in draft stage

However, since the hydrogeological section created by ESDM and PUSAIR has not been obtained at the present time, this report describes the hydrogeological structure around Jakarta based on Reference 2.

(1) Features of hydrogeological structure based on reference 2

According to the hydrogeological section of Muhammad Fachri et al. (2002), the features of the hydrogeological structure are as follows.

- At a depth of 30 to 50 m from the surface, Pleistocene stratum (diluvium) exists and sandy soil sandwiched between them forms aquifer 1 (zone 1). Although not shown, the Holocene stratum (alluvium) is deposited in the surface layer of the coastal area.
- The Pliocene stratum is deposited, and sandy soil sandwiched between them forms aquifer 2 (Zone 2) to aquifer 4 (Zone 4).
- Aquifers 2 and 3 (Zones 2, 3) have a relatively large amount of sandy soil, the proportion of which tends to be as high as it is inland. Aquifer 2 (Zone 2) is dominated by cohesive soil. On the other

hand, Aquifer 3 (Zone 3) has rich sandy soil and the tendency is more remarkable in the inland.

- In Aquifer 4 (Zone 4), which has a depth of about 250 m or less, geological data are poor. Therefore its phase is unknown.

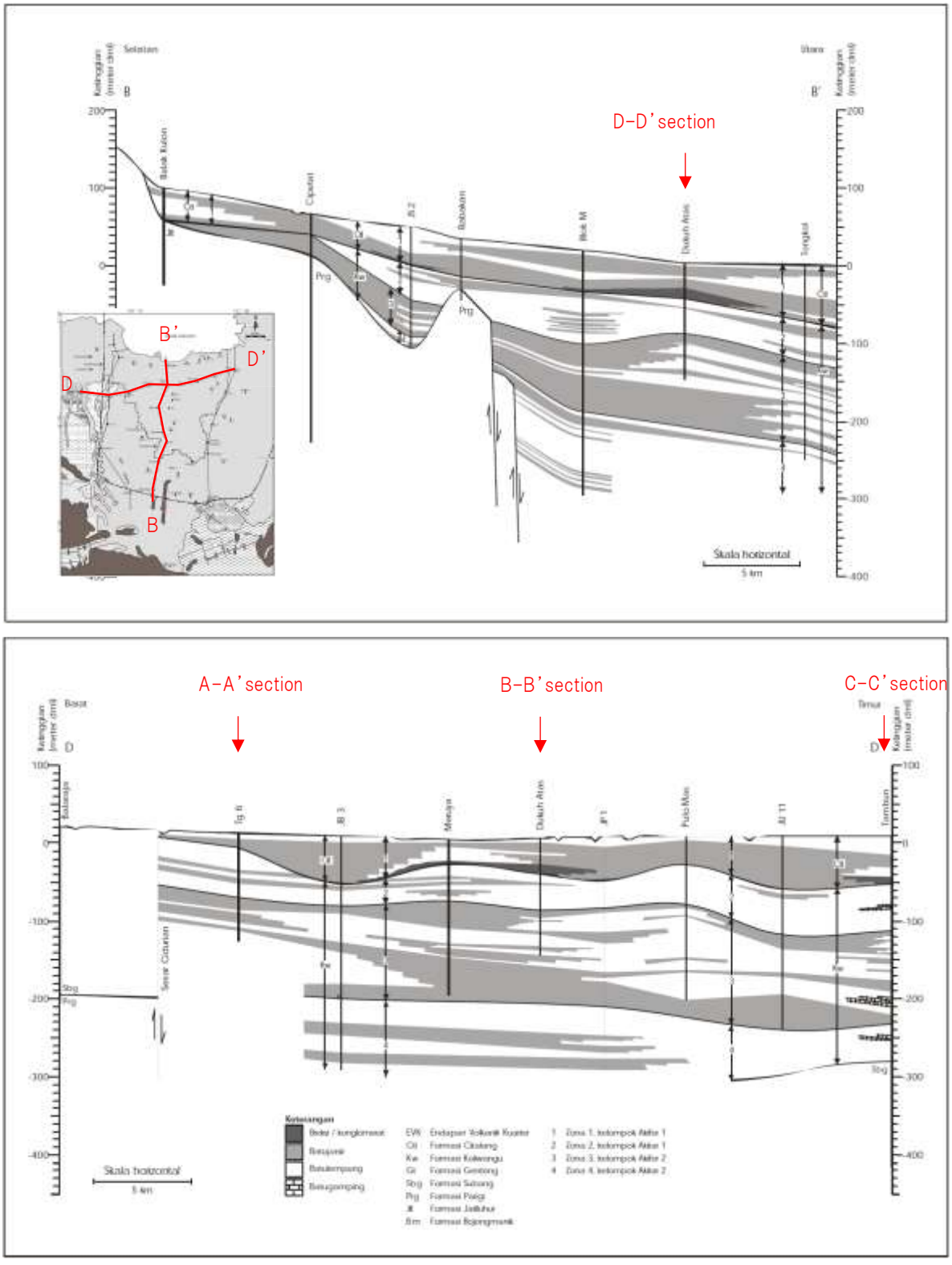


Figure 2.52 (1) Hydrogeological Cross Section of Jakarta

Source：Stratigrafi dan Hidrostratigrafi Cekungan Airtanah Jakarta, Muhammad Fachri et al. (2002)

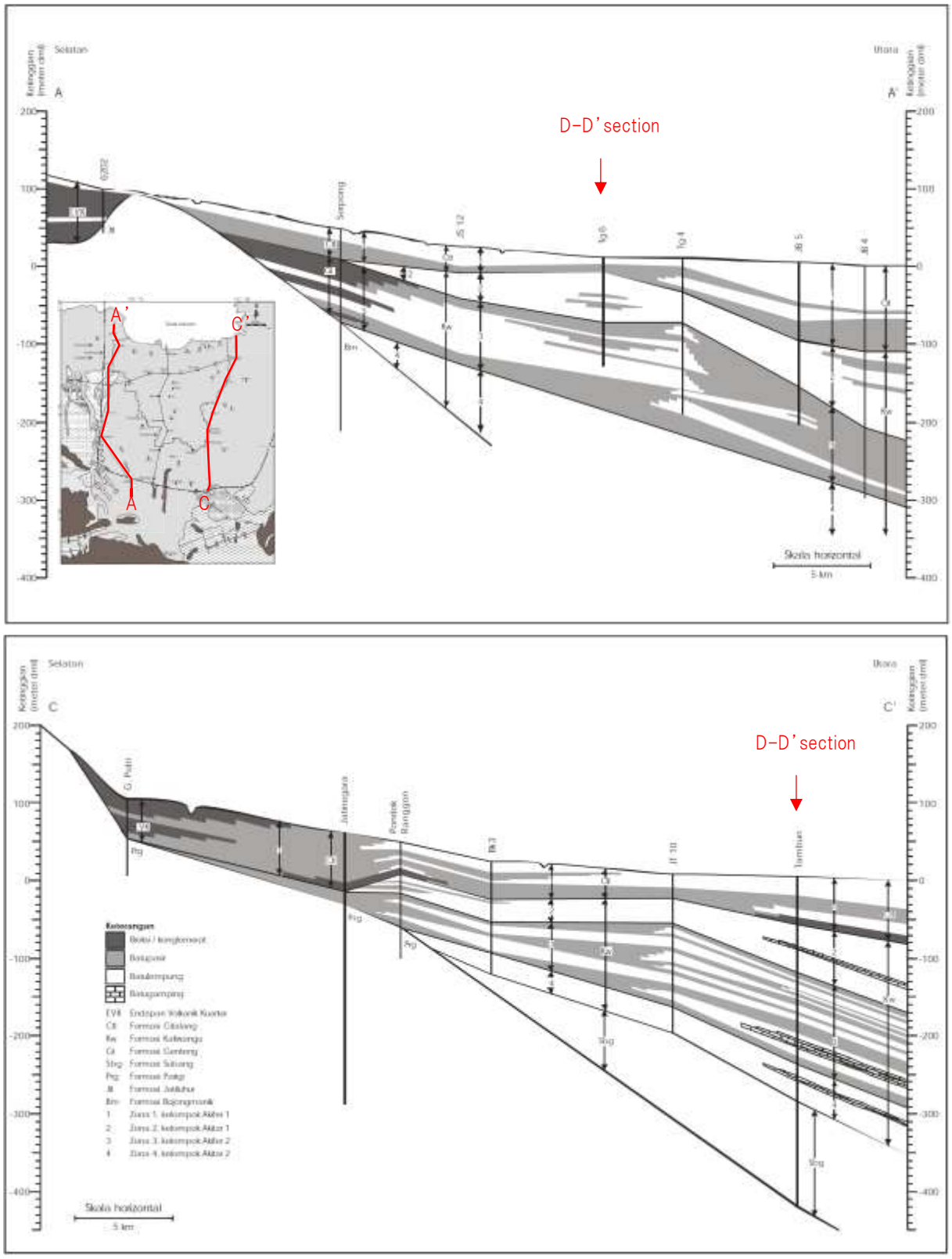


Figure 2.53 (2) Hydrogeological Cross Section of Jakarta

Source：Stratigrafi dan Hidrostratigrafi Cekungan Airtanah Jakarta, Muhammad Fachri et al. (2002)

2.7.2 AMT Survey

(1) Overview of AMT Survey

1) Purpose of the Survey

AMT survey was conducted mainly to understand the thickness and distribution of the Quaternary Formation which is considered to form the main aquifer. In particular, the cohesive soil in the sedimentary layer which is likely to form an aquifer causes land subsidence. Hence, the distribution of sedimentary layers that are likely to form an aquifer are grasped.

2) Outline of the AMT Survey

The details of AMT survey are described in the separately submitted on-site report from local company, but the following briefly describes the outline of the survey method.

As shown in Figure 2-46, electromagnetic waves (EM) on Earth are produced by lightning or micro-pulse from the sun generated on the earth or in the atmosphere. AMT search is a method of observing this electromagnetic wave by the observation device shown in Figure 2-47 and the arrangement of the device shown in Figure 2-48. In AMT exploration, the resistivity can be observed from the ground surface to a depth of about 1,000 m.

Since Jakarta City has a very high electromagnetic noise, the AMT survey with Remote Reference (RR) technique was applied in order to eliminate local electromagnetic noise. The AMT RR is located at Barubeuereum Village, Jatinangor Sub-district, West Bandung Regency.

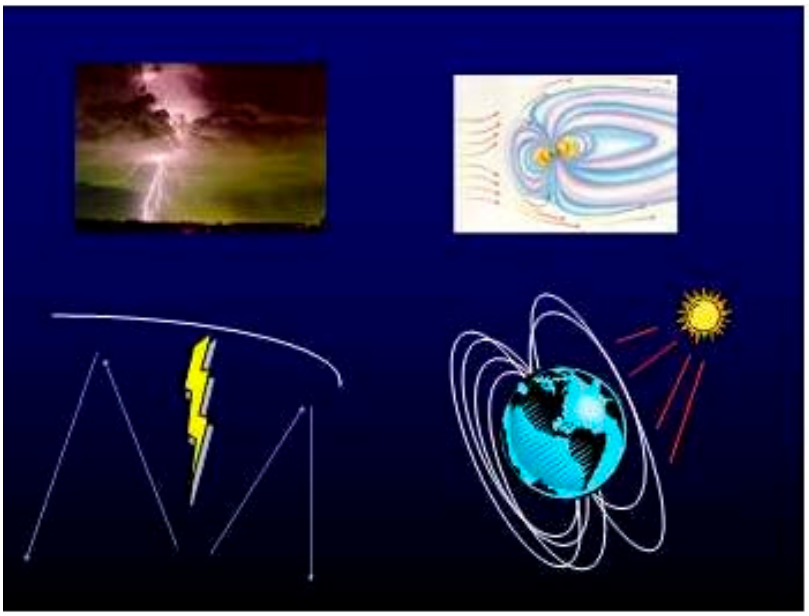


Figure 2.54 Illustration of Natural Electromagnetic (EM)

Source: Kaufman, A.A., and G.V. Keller, 1981



Figure 2.55 Example of Equipment of AMT

1: MT main unit, 2: Coil cable, 3: Coil as magnetic field sensor, 4: Porous-pot as electric field sensor, 5: porous-pot cable, 6: battery

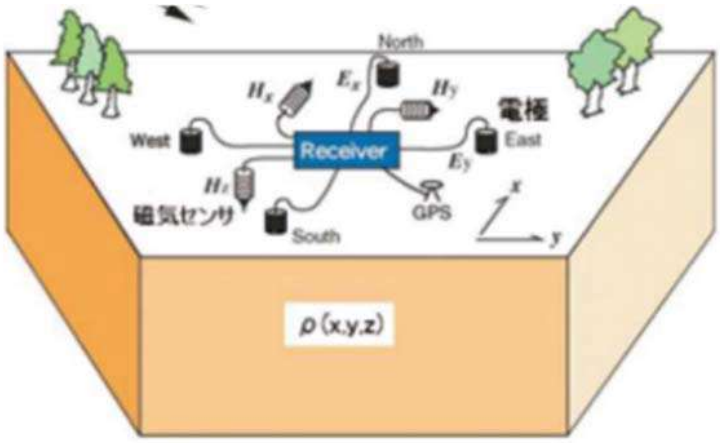


Figure 2.56 Example of AMT survey set up

(2) Location of AMT Survey

In AMT exploration, exploration was conducted at a total of 10 locations shown in Table 2-23 and Figure 2-49. Among them, AMT-1 was carried out in the vicinity of the Cengkareng point where a new land subsidence monitoring well was constructed in this project, while AMT-8 was carried out in the point near the Cakung point.

The points other than the above are in the vicinity of the point where PU, ESDM or DPE carried out the existing deep drilling (about 300 m). In the analysis of AMT survey results, the boring log obtained by these boring results were referred to.

Table 2.29 List of AMT Survey Point

Location Name		Propose Coordinate						Actual Coordinate						Note And Elevation
Site	Existing geologic columnar section	S			E			S			E			
AMT-1	Cengkareng New Well / BG-2014-2	6	08	34.74	106	43	43.18	6	08	34.1	106	43	42.4	Kebun Bibit Cengkareng (Public)/ 19 m
AMT-2	DKI-2012-1	6	20	15.5	106	49	29.1	6	20	15.3	106	49	29.5	Natrabu Minang Restaurant (Private)/ 69 m
AMT-3	PU-2014-1	6	06	57.4	106	47	40.59	6	07	05.8	106	47	41.5	Waduk Pluit Garden (Public)/ 4 m
AMT-4	BG-2014-1	6	09	5.02	106	49	30.78	6	09	05.6	106	49	30.5	Tamansari Stadium / 9 m
AMT-5	PU-2014-5	6	08	47.61	106	52	29.51	6	08	46.0	106	52	31.3	Parking of Athletic Park (Public)/ 15 m
AMT-6	BG-2014-5	6	07	31.13	106	53	52.65	6	07	32.7	106	53	52.9	Rawa Badak Stadium (Public)/ 12 m
AMT-7	PU-2014-3	6	06	17.5	106	57	58.69	6	06	20.4	106	57	58.6	PT. Kawasan Brikat Nusantara(Private)/ 18 m
AMT-8	Cakung New Well	6	10	14.67	106	56	16.8	6	10	14.3	106	56	17.6	Rusun Griya Tipar Cakung (Public)/ 66 m
AMT-9	BG-2014-4	6	12	35.41	106	57	12.35	6	12	38.3	106	57	12.4	Private Land /62 m
AMT-10	BG-2014-3	6	16	12.86	106	50	44.27	6	16	09.7	106	50	45.7	Athletic ground in front of the ministry of interior (Public)/ 30 m

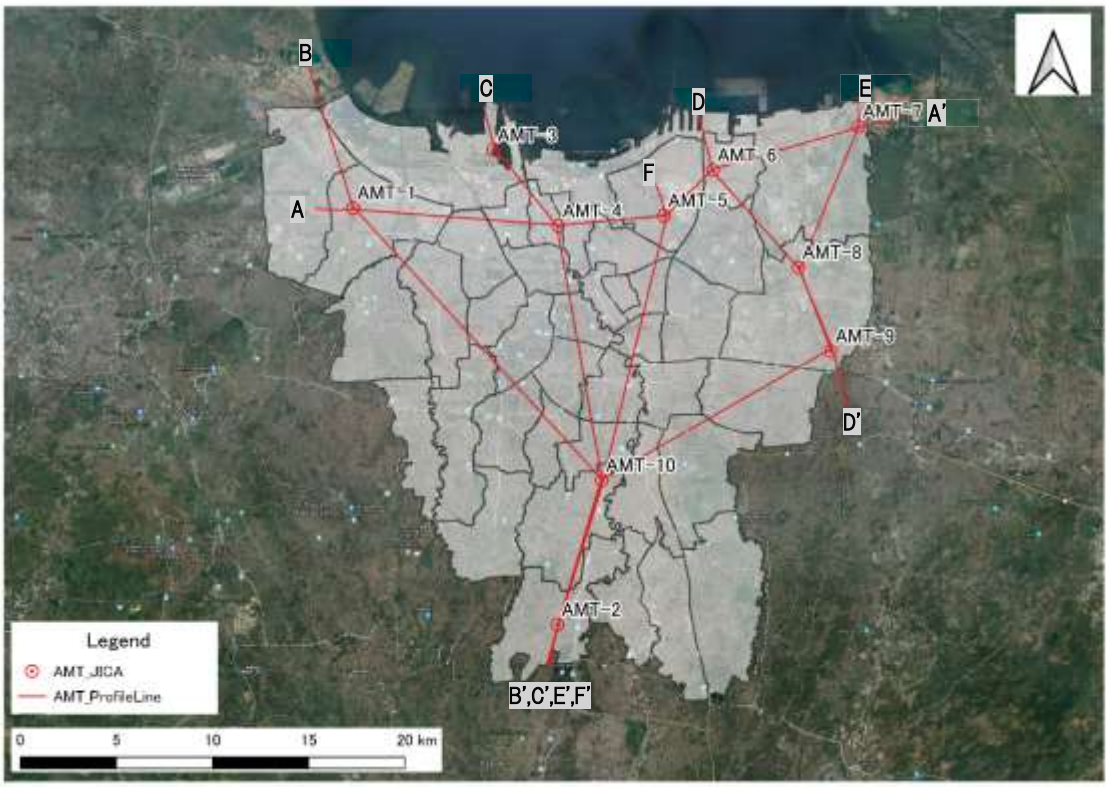


Figure 2.57 AMT Survey Points and the Position of the Hydrogeological Section

Source: The Project Team

(3) Result of AMT Survey

After creating six cross sections, contour lines of base rock were created based on these. In addition, an A-A' geological cross section in the east-west direction was created based on the existing geological columns collected at each AMT point and results of AMT survey.

The cross sectional views based on AMT survey are shown in Figure 2-50, and the contour line of base rock is shown in Figure 2-51 (a). According to this figure, the base rock is sloped in the northeast direction, and there is a depression with a depth of 750 m near the border between North Jakarta and Central Jakarta around Setiabudi (C-C 'section) and Tebet (F-F' section). On the other hand, the base rock rise up to a depth of about 0 to -150 m in Pasar Minggu (AMT-10) and Babakan (AMT-2).

For comparison, Figure 2-51 (b) shows the contour line of base rock obtained by Microtremor Array Survey in existing survey. The northeastern slope and the deepest part of the base rock in this figure shown the same tendency as the AMT survey results. But the depth of the base rock in southern Jakarta in the existing survey is about 300 m, and this result is different from the AMT survey result.

Figure 2-52 shows the A-A 'geological cross section created based on the collected geological columnar, the borehole obtained from the construction of the land subsidence monitoring wells, and AMT survey results. In general, sand and gravel layers forming the aquifer are sandwiched in clay and silt layers, and is not continuous. However, at a depth of 40 m or less, there is relatively thick sand and gravel layers. Further, sparsely distributed sand and gravel layers exist at a depth of 140 m or deeper. On the other hand, clay and silt layers are dominant and there are few sand and gravel layers at a depth of 40-140 m. Based on such sedimentary facies, the stratum at a depth of less than 40 m is equivalent to Aquifer 1 (Zone 1) in the previous survey mentioned in 3.5.1 (1) , the stratum at a depth of 40 to 140 m is equivalent to Aquifer 2 (Zone 2), and the stratum at a depth of more than 140 m is equivalent to Aquifer 3 (Zone 3). Meanwhile, the stratum deposited from the depth of 300 m to the base rock is equivalent to the Aquifer 4 (Zone 4). However, since the depth of deep wells used in factories and offices is mainly about 200 m, it seems that there is no problem in setting the analysis depth to Aquifer 3 when analyzing land subsidence in this project.

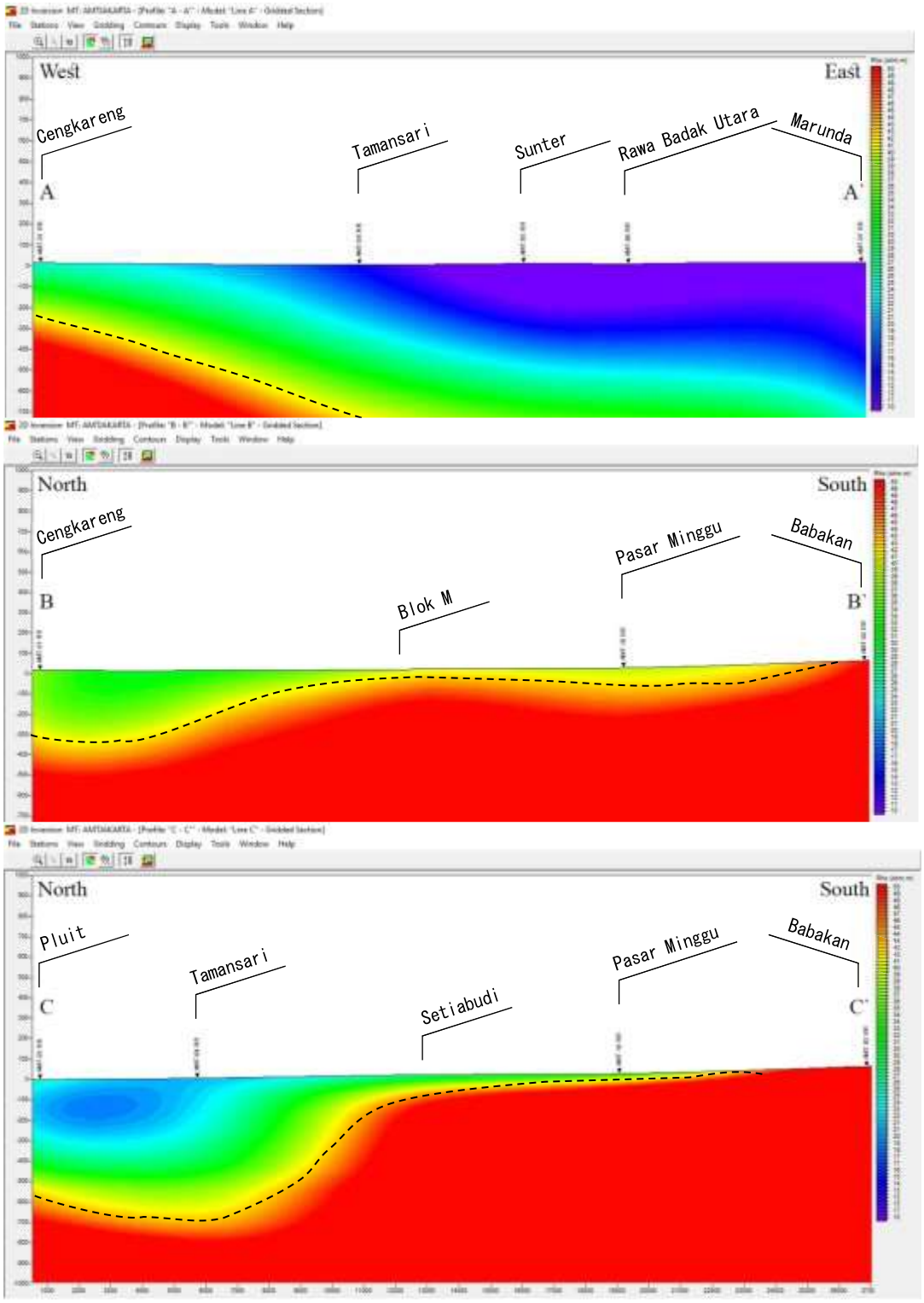


Figure 2.58 (1) Result of AMT survey

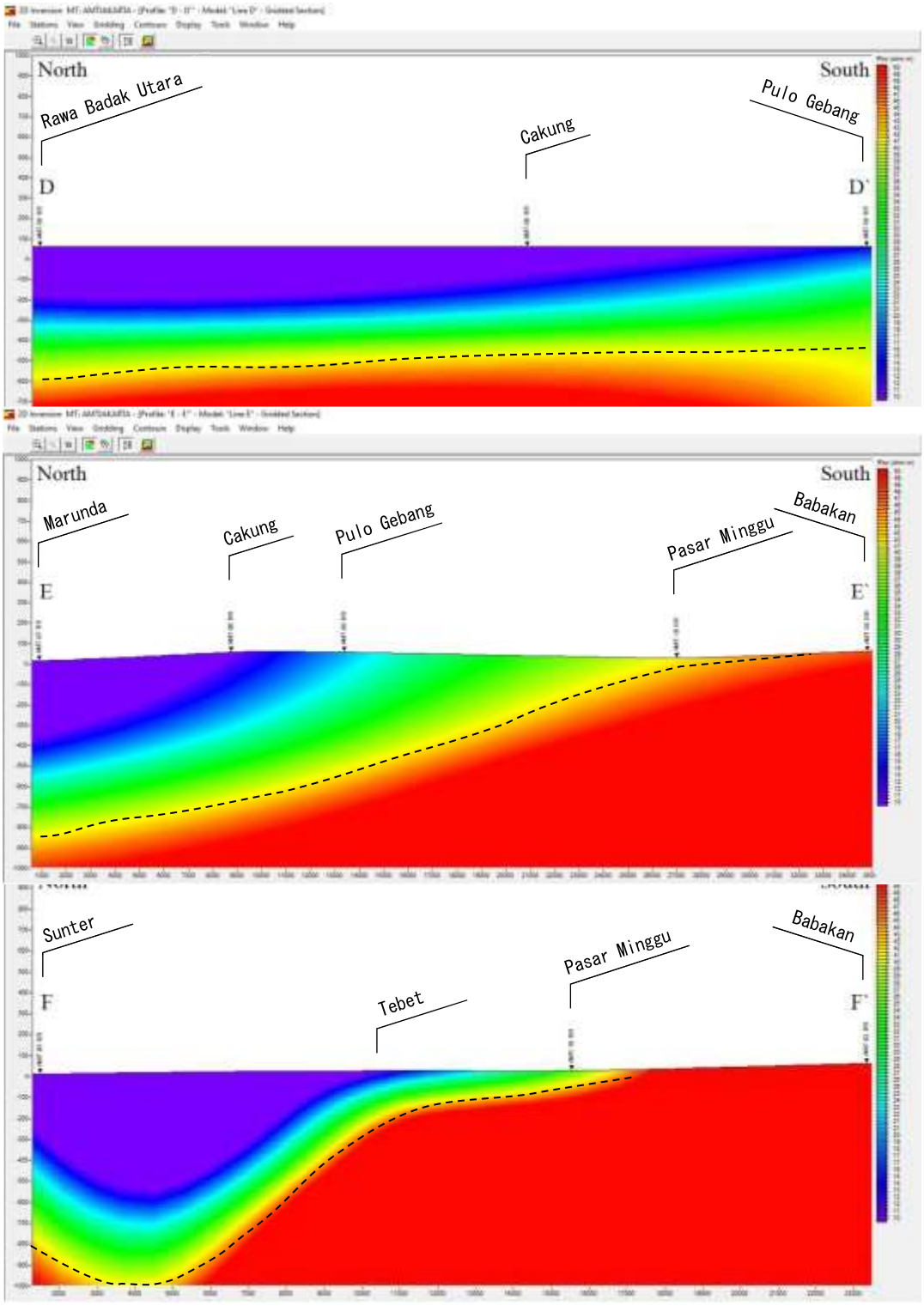
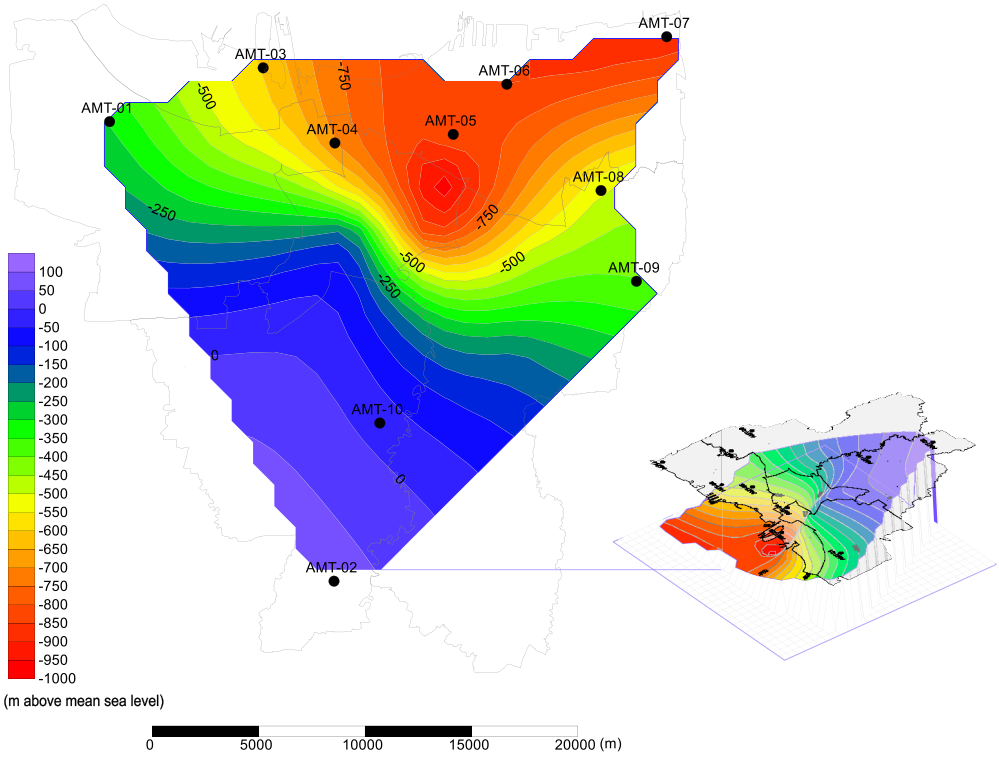
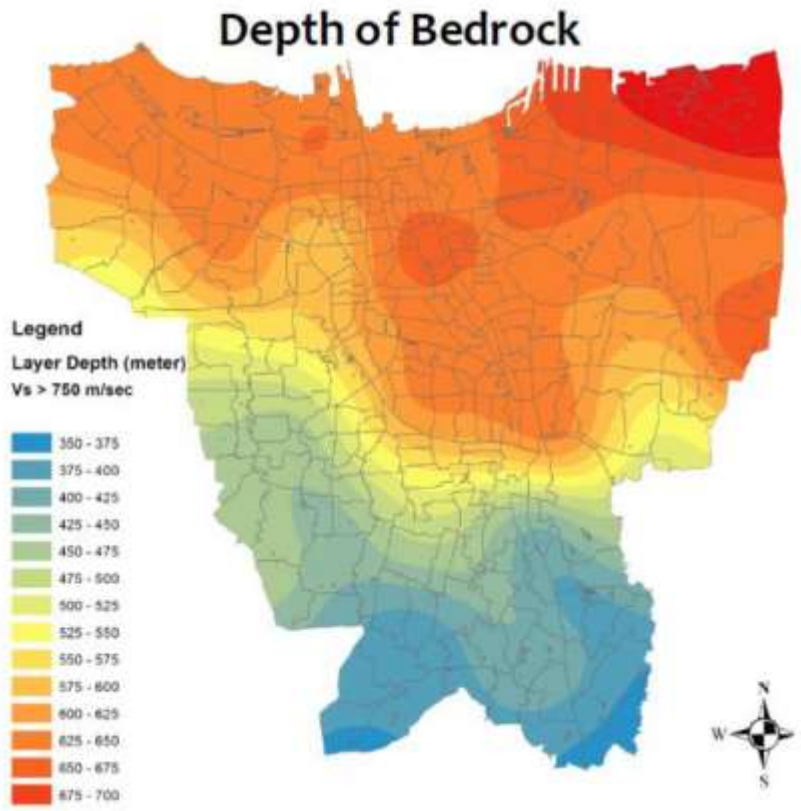


Figure 2.59 (2) Result of AMT survey



(a) Contour line of Base rock based on AMT survey



(b) Depth contour line of Base rock based on existing survey

Source: Geotechnical Condition of DKI Jakarta Related to Land Subsidence, Prof. Dr. Ir. Masyhur Irsyam (2019)

Figure 2.60 Contour line of Base rock based on AMT survey

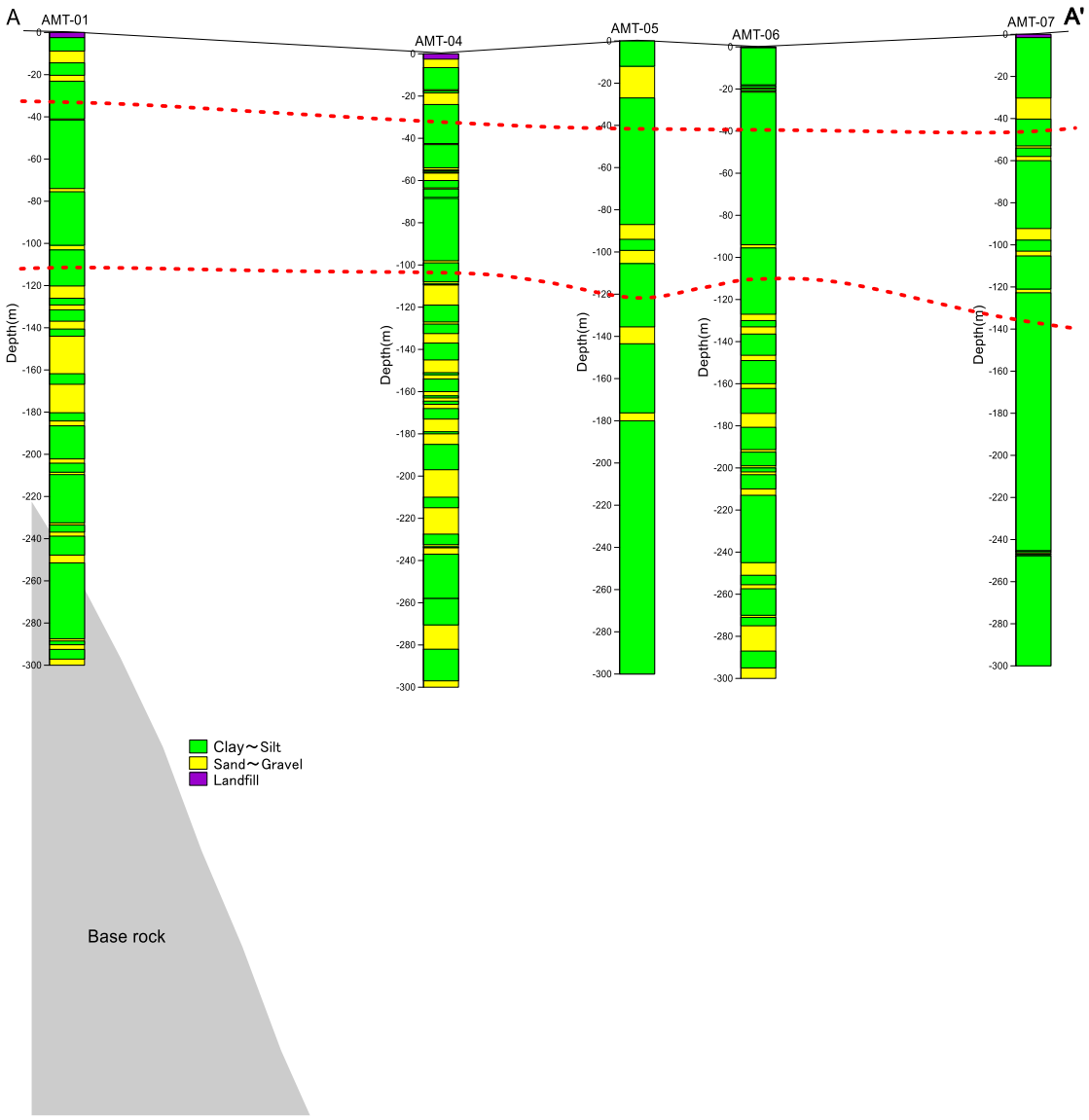


Figure 2.61 A-A 'Geological cross section

(4) Comparison with existing study result

A comparison of the distribution of basement rocks and aquifers by the cross section of resistivity zone according to the results of the previous survey by Muhammad Fachri et al. (2002) (hereinafter 2002 survey) shown in Figure 3-54.

Table 2-24 shows the geological stratigraphy around the target area according to the 2002 survey. The "base rock" in the table is a stratum deposited before the Tertiary Miocene, and the strata deposited up to present time are defined as "sedimentary layers".

Table 2.30 Geological Stratigraphy around the DKI Jakarta

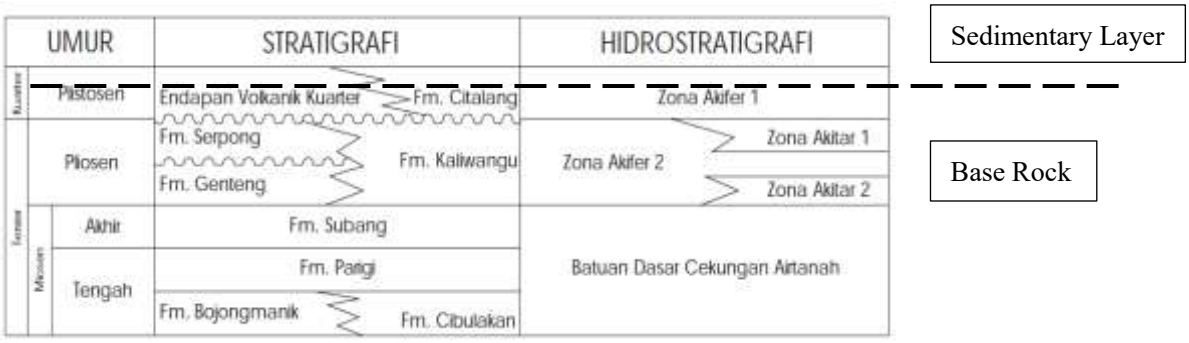


Figure 2-53 shows the section names and their positions in the 2002 survey and this AMT survey (hereinafter referred to as AMT survey 2019).

In this comparison, the A-A cross section of the 2002 survey and the C-C cross section of the AMT survey 2019 (north-south direction) and the D-D cross section of the 2002 survey and the C-C cross section of the AMT aurvey 2019 (east-west direction) are compared.

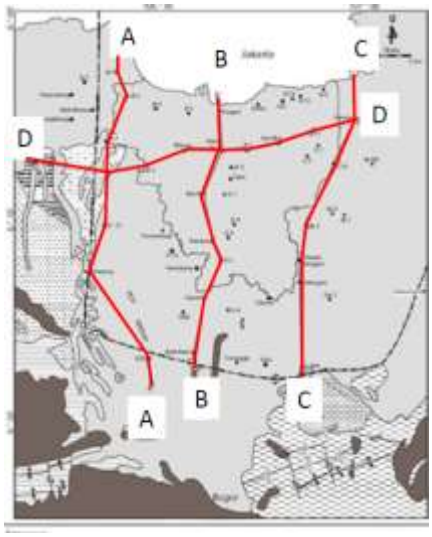
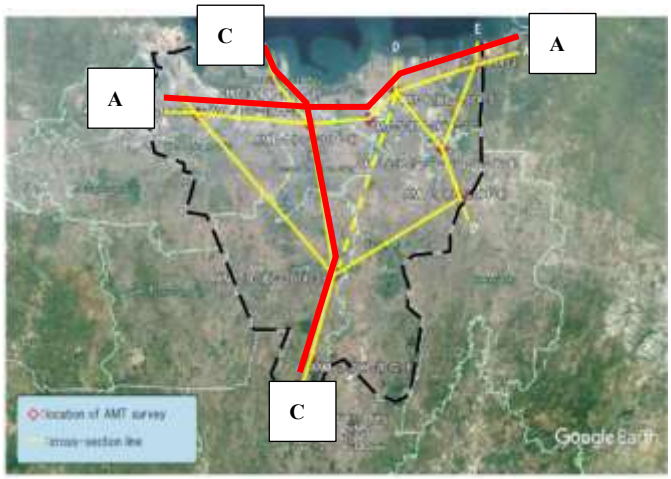
2002 Study	AMT Survey 2019
	

Figure 2.62 Name of Cross Section and its Location

1) B-B cross section 2002・C-C cross section AMT survey 2019 (North-South direction)

Each cross section is shown in Figure 2-54. From the comparison result of each cross section, the

following can be understood.

- The result of both surveys and study indicated that the depth of the base rock suddenly deepen in the north side. However, the position of the transformation point where the base rock deepens rapidly differs between the two cross sections.
- In both cross-sections, the base rock is shallow on the south side. However, there is a difference in the thickness of the sedimentary layer distributed above the base rock in both sections.

These differences are also because the cross-sectional line positions do not match. Due to these reasons, the distribution of base rock on the south side need further examination in order to examine the distribution of aquifers in the upper sedimentary layer and the thickness of the clay layer, which is a geological factor for land subsidence.

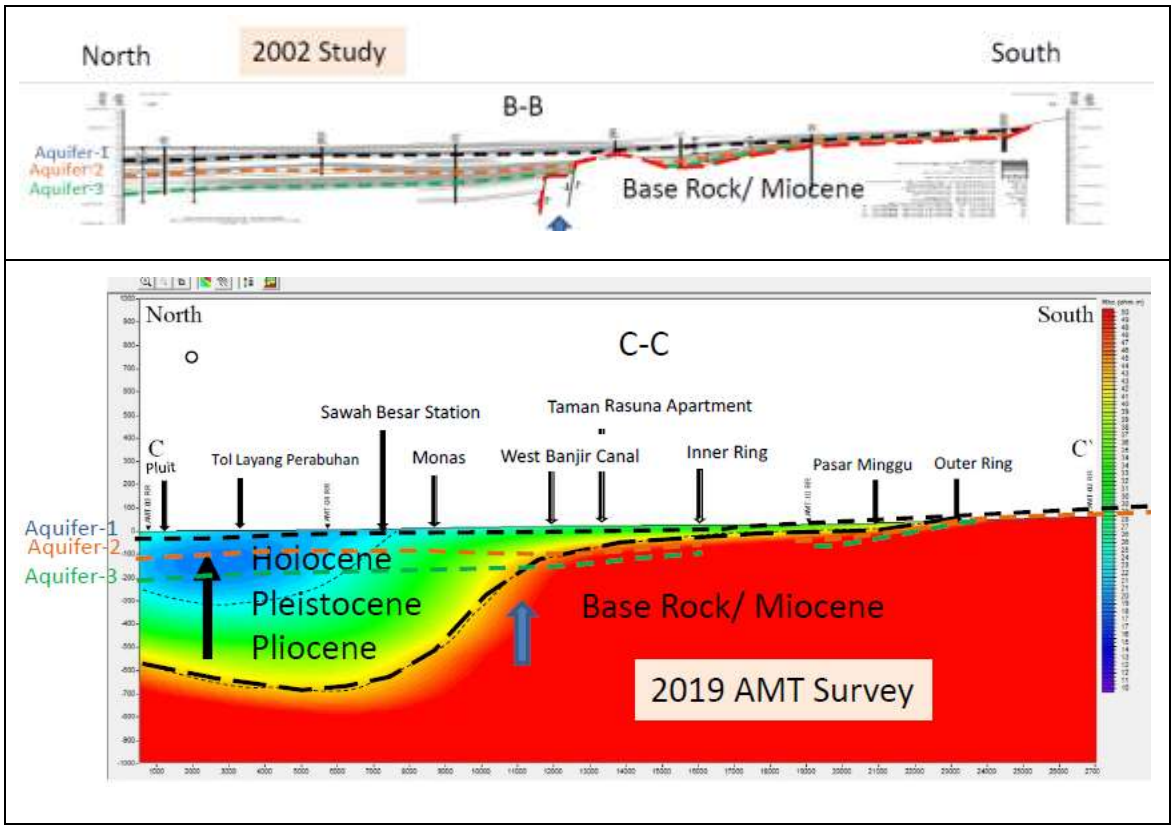


Figure 2.63 Comparison of Cross Section (North – South Direction)

2) D-D cross section 2002・A-A cross section AMT survey 2019 (East–West direction)

Each cross section is shown in Figure 2-55. From the comparison result of each cross section, the following can be understood.

As for the distribution depth of the base rock on the east side, the result of AMT survey 2019 is more than 700 m and deeper than the result of 2002 survey.

In the AMT survey 2019 result, the Cengkareng land subsidence observation well is located at the most western side of section A-A. The continuity distribution of the first aquifer (shallow unconfined aquifer, second aquifer (upper confined aquifer), and third aquifer (deep confined aquifer) in 2002 is consistent

with the distribution of each aquifer confirmed at Cengkareng subsidence observation well.

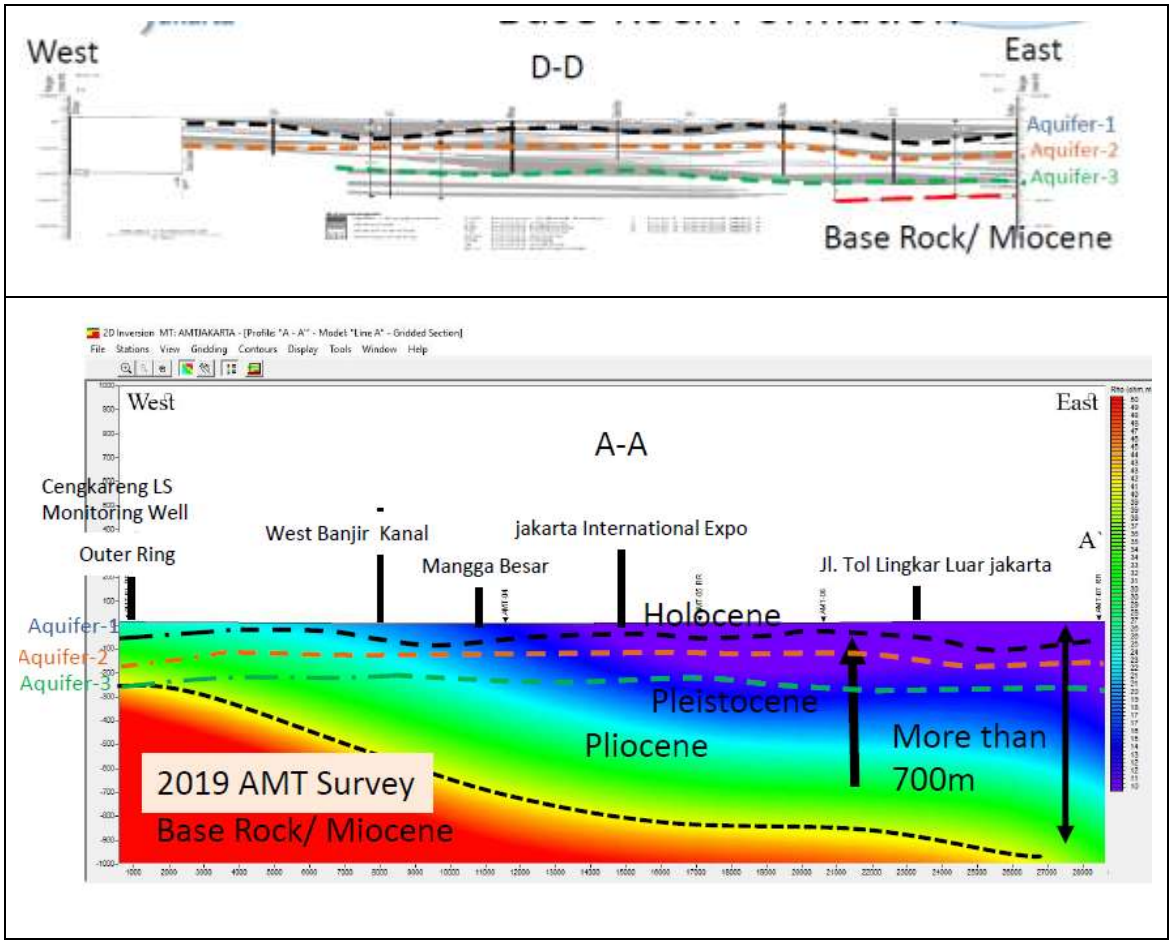


Figure 2.64 Comparison of Cross Section (East-West Direction)

(5) Conclusion and Recommendation

＜Conclusion＞

- The following results are obtained for the distribution characteristics of the basement rocks in both surveys;
  - In the southern region, bedrock (Neogene Miocene) is distributed at a shallow depth from the ground surface.
  - The Neogene Pliocene layer, which is distributed above the basement rocks, becomes thicker toward the northern region, and the Quaternary layer, which is distributed above it, becomes thicker in the northern region.
- In the northern region where the sedimentary layers (Neogene Pliocene and Quaternary) are thickly distributed, it is considered that the distribution of aquifers in the sedimentary layers up to about 250 m from the surface of the ground is generally well understood so far. However, boring data is insufficient on the south side area where the Neogene Pliocene and Quaternary layers, which cover the upper part of the basement rock Miocene, are thin, and the geological condition has not been understood so far.

＜Recommendation＞

- We recommend to examine the balance of groundwater and to survey the geological structure and hydrogeological structure of the entire DKI Jakarta including the southern region (reexamination of existing data, new drilling survey, etc.).

2.7.3 Soil Test (Consolidation Test)

(1) Purpose of the Test and Number of Test

Laboratory test was conducted mainly to grasp the characteristics of consolidation of soil. The specification of the consolidation test is as shown in the table, and the physical test is also carried out in order to grasp the general properties of the test sample. Table 2-25 shows the undisturbed sampling depth from each point.

Table 2.31 Specification of Collected Samples

Site	No.	No. of Sample	Depth (GL.-m)	Soil Condition	Type of Consolidation Test
Cakung	1	UDS-1	2.0-2.5	Embankment	Standard
	2	UDS-2	7.5-8.0	Old Ground Surface	Standard
	3	CS-1	42.0-42.5	Weathered Silt	Heavy (middle)
	4	CS-2	121.4-121.9	Consolidated Silt	Heavy
	5	CS-3	219.5-220.0	Consolidated Clayey Silt	Heavy
	6	CS-4	261.0-261.5	Consolidated Silty Clay	Heavy
	7	CS-5	288.1-288.6	Consolidated Sandy Silt	Heavy
Cengkareng	8	UDS-1	1.5-2.0	Embankment	Standard
	9	UDS-2	42.0-42.5	Weathered Volcanic Clay	Standard
Tongkol	10	UDS-Tongkol-1	7.7-8.2	Unconsolidated to Semi-solidified Silt	Standard
	11	UDS-Tongkol-2	12.5-13.0	Semi-solidified Silt	Heavy
	12	Tes-2	13.3-13.8	Semi-solidified Clay	Heavy
	13	Tes-1	110.5-111.0	Consolidated Clay	Heavy

*) The maximum consolidation load for each type is as follows
Standard : 1255 kN/m^2 (12.79 kgf/cm^2), Heavy (medium) : 2510 kN/m^2 (25.59 kgf/cm^2)
Heavy : 5020k N/m^2 (51.17 kgf/cm^2)

(2) Items of Laboratory Test and Specification

The test items conducted in this study and their specifications are shown in Table 2-26. Among them, the consolidation test is classified into three types i.e. standard, weight type (medium), and weight type (high) according to the degree of tightness of the sample as shown in the annotation of the table.

Table 2.32 Items of Laboratory Test and Specifications

Items	Specification
USCS Chart	ASTM D2487-06
Specific Gravity	ASTM D854
Density	ASTM D4523 and D4524
Atterberg Limits	ASTM D4318
Grain Size analysis	ASTM D422 and D6913

Consolidation Test	ASTM D2435

(3) Result of the Test

The soil test results are shown in Table 2-27.

As of April 17, 2019, the high-pressure consolidation tests has not ended. The compression index (Cc) and the consolidation yield stress (Pc) are described in the table.

The highest compression index (Cc) is about 1.61 which resulted from soft clay sample collected from the surface layer in Tongkol. Meanwhile, the compression index of hard clay varies from 0.33 to 0.78.

Table 2.33 Result of Test

No.	Sample No.	Site	Depth in meter (GL.-m)	Description	USCS Chart	Specific Gravity Gs	Density		Water Content Wn %	Atterberg Limits			Liquidity Index LI	Void Ratio e	Porosity n %	Degree of Saturation Sr %	Passing No.200 sieve %finer by weight	Consolidation	
							Wet ρm t/m^3	Dry ρm t/m3		Liquid Limit LL %	Plastic Limit PL %	Plasticity Index Pl %						Cc	Pc kPa
1	UDS-1	Cakung	2.0-2.5	Fat clay	CH	2.59	1.52	0.91	66.8	76.0	24.4	51.7	0.82	1.76	64	95	81	0.78	67.2
2	UDS-2		7.5-8.0	Fat clay	CH	2.59	1.64	1.06	55.2	81.0	35.0	46.0	0.44	1.46	59	98	99	0.56	389.8
3	CS-1		42.0-42.5	Fat clay	CH	2.52	2.00	1.65	20.9	64.0	17.5	46.5	0.07	0.52	34	100	98	0.33	824.4
4	CS-2		121.4-121.9	Fat clay	CH	2.60	1.81	1.31	38.0	102.1	26.8	75.4	0.15	0.98	50	100	100	0.48	1560.0
5	CS-3		219.5-220.0	Elastic silt	MH	2.49	1.67	1.12	48.9	79.0	37.5	41.5	0.27	1.22	56	100	95	0.07	1480.0
6	CS-4		261.0-261.5	Fat clay	CH	2.65	1.83	1.33	37.3	71.6	30.5	41.1	0.16	0.99	50	100	91	0.25	2450.0
7	CS-5		288.1-288.6	Elastic silt	MH	2.55	1.88	1.46	28.9	62.0	35.9	26.1	-0.27	0.75	43	99	92	0.18	2400.0
8	USD-1	Ceng-kareng	1.5-2.0	Fat clay with sand	CH	2.52	1.52	0.91	66.8	76.0	24.4	51.7	0.82	1.76	64	95	81	0.78	67.2
9	USD-2		42.0-42.5	Fat clay with sand	CH	2.58	1.67	1.10	52.6	75.0	25.0	50.0	0.55	1.36	58	100	83	0.41	44.2
10	USD-Tongkol-1	Tongkol	7.7-8.2	Fat clay	CH	2.49	1.42	0.71	100.2	125.0	32.2	92.8	0.73	2.51	72	99	94	1.61	72.6
11	USD-Tongkol-2		12.5-13.0	Fat clay	CH	2.49	1.59	0.99	61.0	109.0	32.7	76.3	0.37	1.52	60	100	100	0.58	365.5
12	Tes-2		13.3-13.8	Fat clay	CH	2.56	1.62	1.04	55.6	87.7	31.9	55.7	0.43	1.45	59	98	98	0.54	324.7
13	Tes-1		110.5-111.0	Fat clay	CH	2.69	1.82	1.34	35.6	79.7	23.1	56.7	0.22	1.00	50	96	85	0.58	1220.0

2.7.4 Land Subsidence Mechanism

(1) Causes of Land subsidence

Generally, the main cause of land subsidence are load of landfills or artificial structures and excessive groundwater abstraction. The land subsidence due to the load occurs when pore water in the clay layer is squeezed out under the load and shrink. Due to the load, it often results in local land subsidence (unequal settlement, etc.). On the other hand, the land subsidence due to the excessive groundwater abstraction occurs when pore water in the clay layer is squeezed out under the decrease in groundwater level and shrink. Due to the excessive groundwater abstraction, it often results in wide-area land subsidence.

Below, the mechanism of land subsidence in Jakarta will be clarified through the verification of the possibility of these factors based on the data gathered so far.

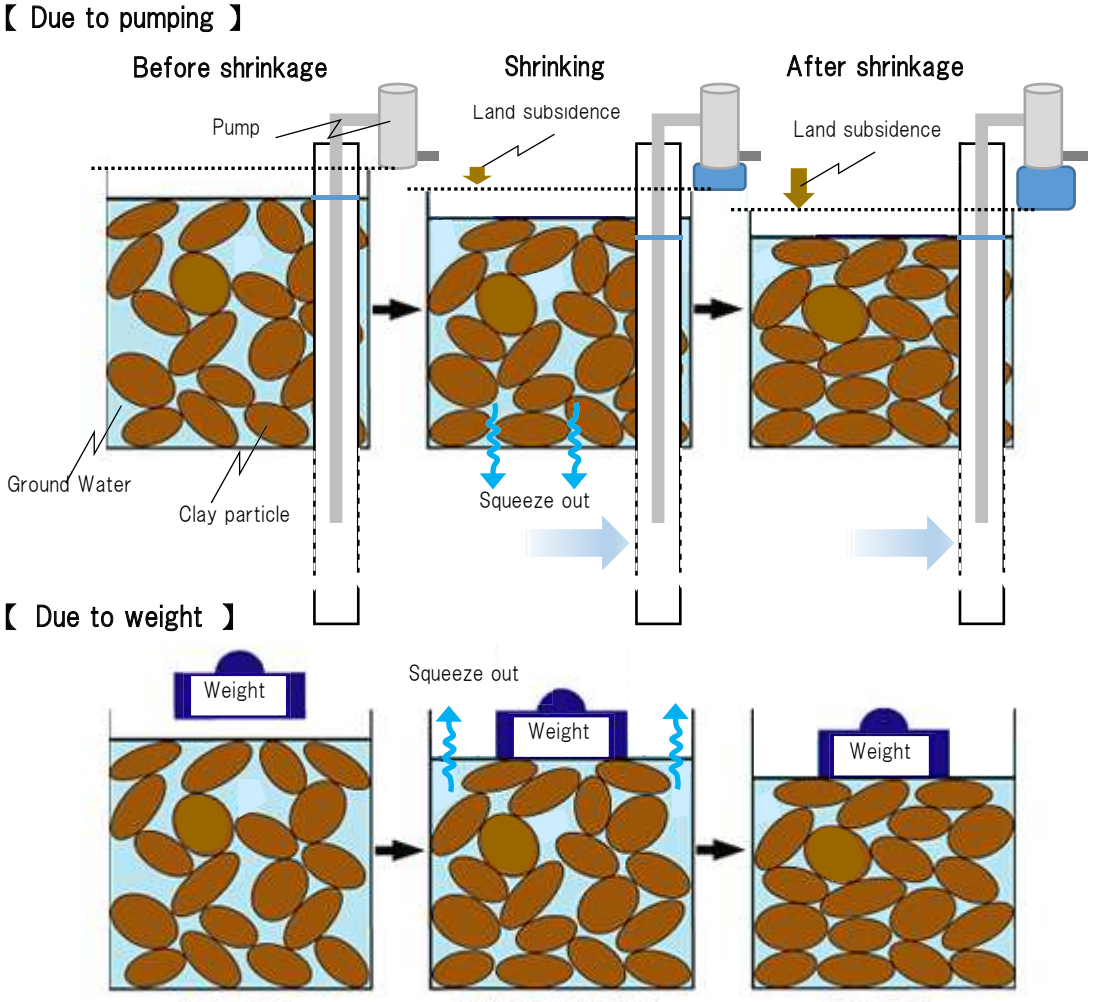


Figure 2.65 Causes of Land Subsidence and Its Mechanism

Source: Created by the Project Team

(2) Shrinkage of the shallow layer due to the load of landfills or artificial structures

Since the shrinkage of soft clay at the surface layer due to the load of landfills or artificial structures can also be a cause of land subsidence, we investigated the change of land use. According to the data collected at the present time, the characteristics and changes of land use can be read.

As Figure 2-57 shows, during the Dutch era, the area around the old city was almost swamp. Figure 2-58 to Figure 2-60 shows the land use in 1930s, 1960s, and 2000. The change of land use characteristics is examined by comparing the land use in 1930s and the 1960s. Forest areas changed to cultivated land (paddy field), and in the process of urbanization, some part of upland fields was converted to residential areas.

However, when compared to the land use in 2000, the wetlands near the coast have changed significantly to residential areas or grasslands. Further, many of the cultivated areas have converted to residential areas. In regards to land subsidence, the areas that show a particularly large subsidence such as Pluit and Cengkareng are originally damp areas which were urbanized, or in the vicinity.

From the above, we investigated the shrinkage of soft clay in the surface layer due to the load of landfills or artificial structures as a factor of land subsidence in Jakarta since the 1970s.



Figure 2.66 Old Map of the Dutch Rule Era

Source: "Map History of Jakarta Metropolitan Area 1853 – 2010", Y.Mimura and H.Matsuda
(http://www.let.osaka-u.ac.jp/geography/gaihouzu/newsletter11/pdf/n11_s6.pdf)

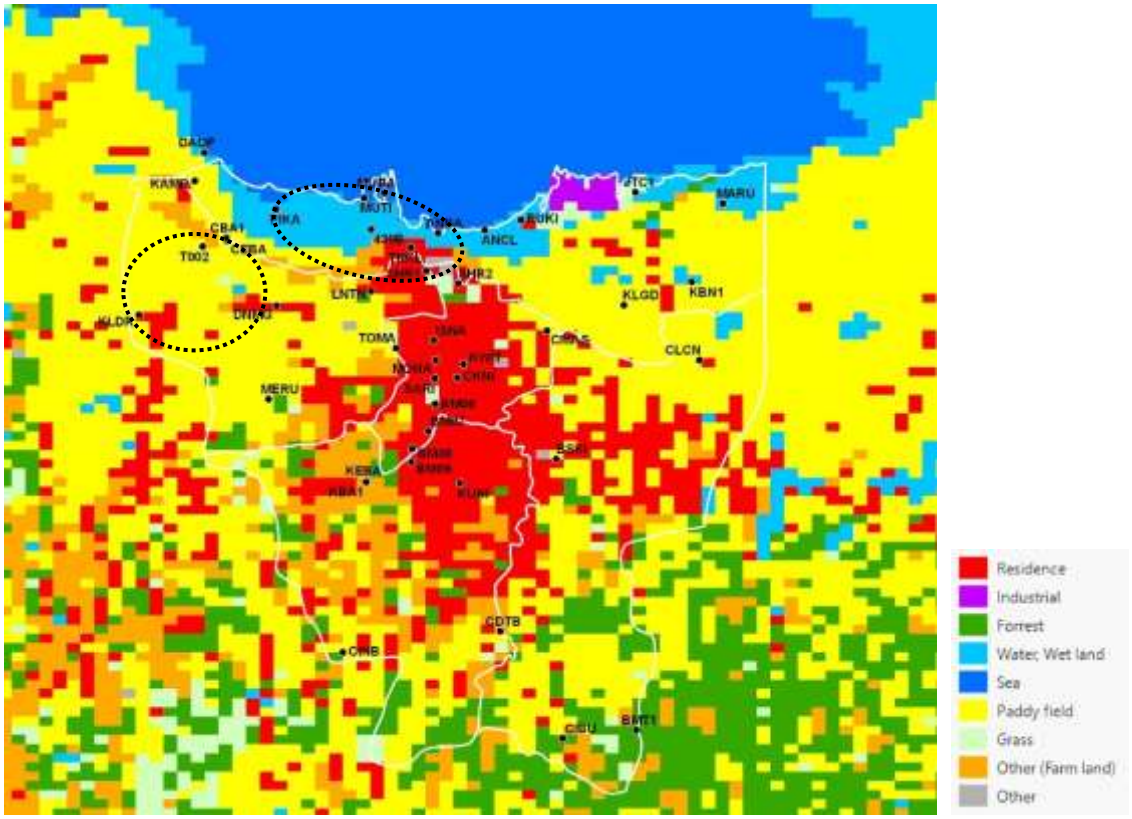


Figure 2.67 Land-Use in 1930

Source: Created by the Project Team Based on "Urbanization and the Environment in Asia: Land Use Data Analysis", A.Yamashita et.al, 2016

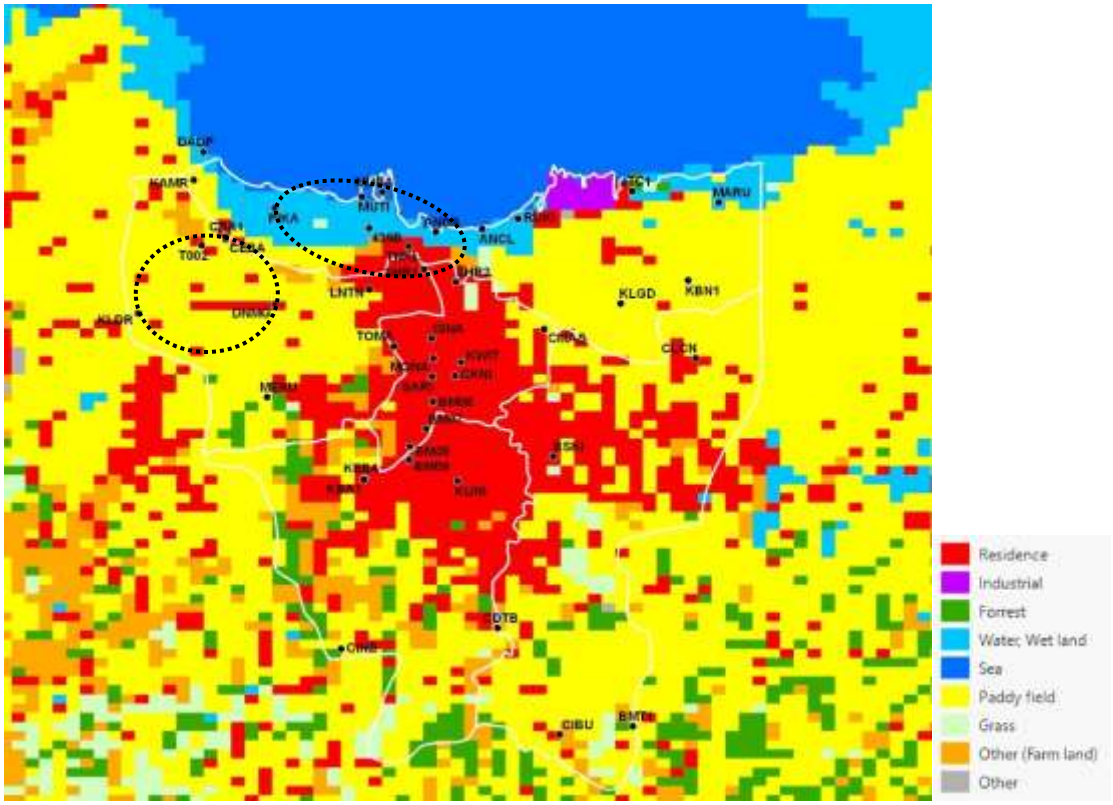


Figure 2.68 Land-Use in 1960

Source: Created by the Project Team Based on "Urbanization and the Environment in Asia: Land Use Data Analysis", A.Yamashita et.al, 2016

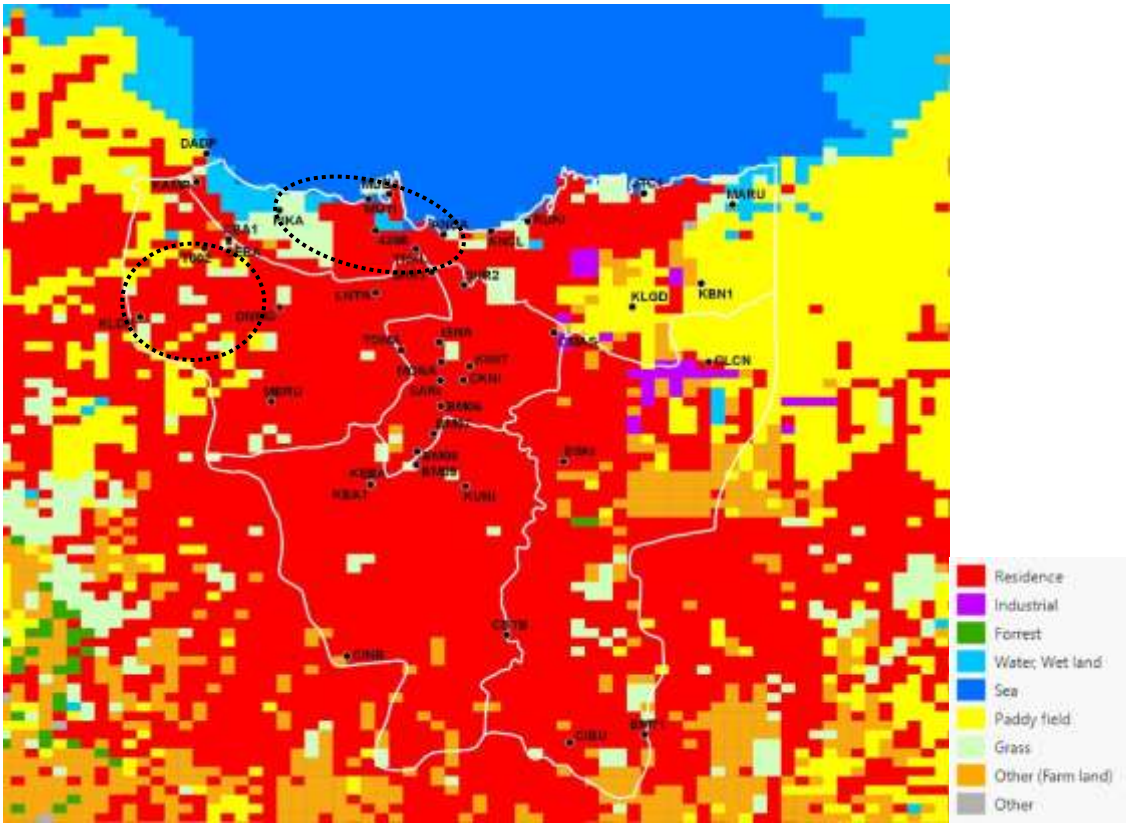


Figure 2.69 Land-Use in 2000

Source: Created by the Project Team Based on "Urbanization and the Environment in Asia: Land Use Data Analysis", A.Yamashita et.al, 2016

(3) Shrinkage of the deep layer due to excessive groundwater abstraction

1) Yearly change of groundwater abstraction volume of the whole DKI

Figure 2-61 shows the groundwater abstraction volume in DKI Jakarta from 1974 to 2015. The groundwater abstraction volume has gradually decreased since 1994, which mainly due to the effect of the changes in economic conditions and the regulations enacted by DKI Jakarta.

- 1974 : Obligation to register wells start
- 1997 : Asian Monetary Crisis
- 1998 : Groundwater Tax collection start (for wells deeper than 40m)
- 2009 : Increasing of Groundwater Tax against companies in PAMJAYA area
- 2010 : Minimum Wage DKI become 1 juta Rp., Large industries in the northern part of Jakarta start moving to out of DKI Jakarta
- 2012 : Governor Decree on Recycle Water Use start
- 2014 : Deep well zero movement in specific area of North Jakarta start

No water sources other than groundwater are available in areas where water supply by PAM Jaya is insufficient or where pipe network development is not progressing. Therefore, since 2014, the number of companies registering 100-150 m deep wells has been increasing during the period of public water supply development. In recent years, the total groundwater abstraction volume has been around 9 million m^3/year, which corresponds to about 25% of the 1995 peak.

Figure 2-61 shows wells registered in DKI Jakarta since 2002 which classified into deep wells of more than 100 m deep and shallow wells of less than 100 m deep. The registered wells data show that groundwater abstraction volume from 100-150 m deep wells accounts for more than 80%.

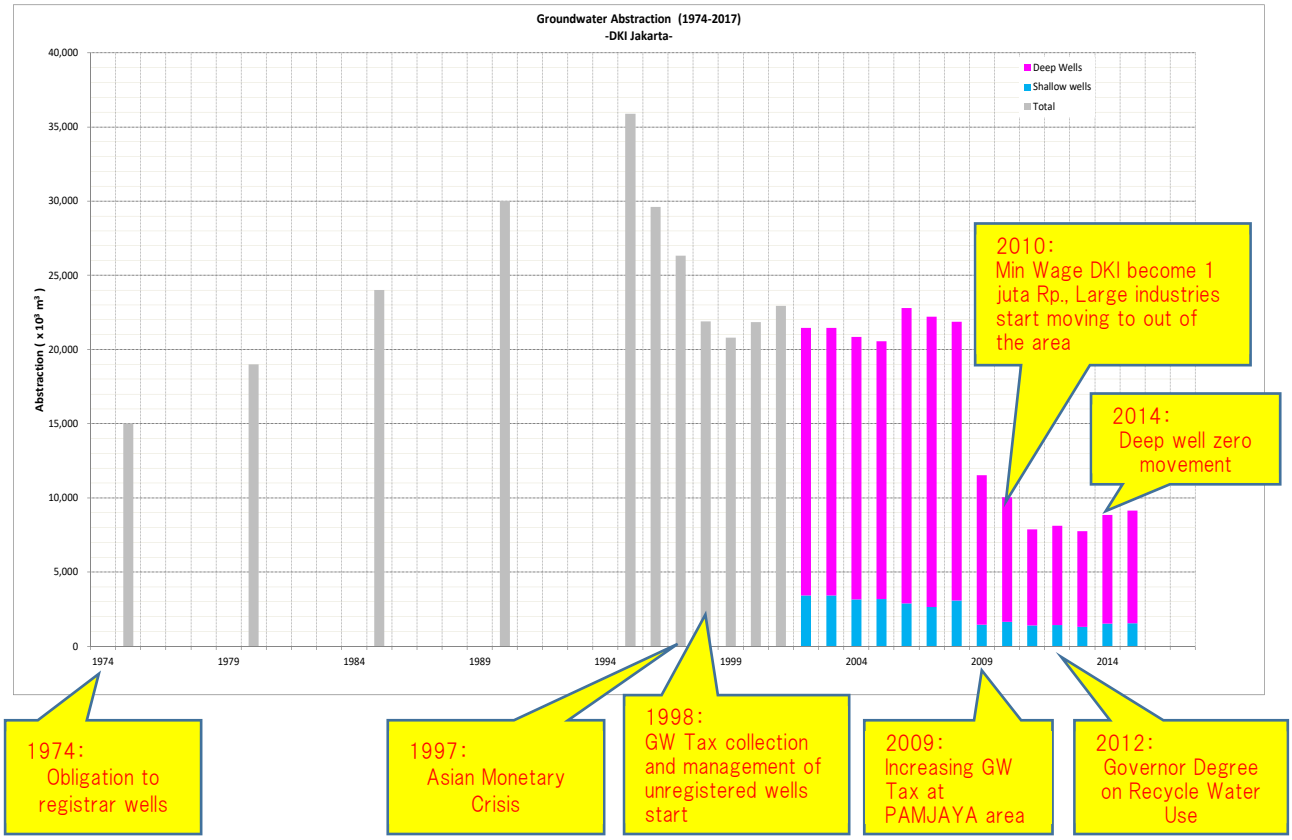


Figure 2.70 Yearly Change of Groundwater Abstraction Volume in DKI Jakarta

Source : Created by the Project Team Based on "Jakarta in Figures" etc.

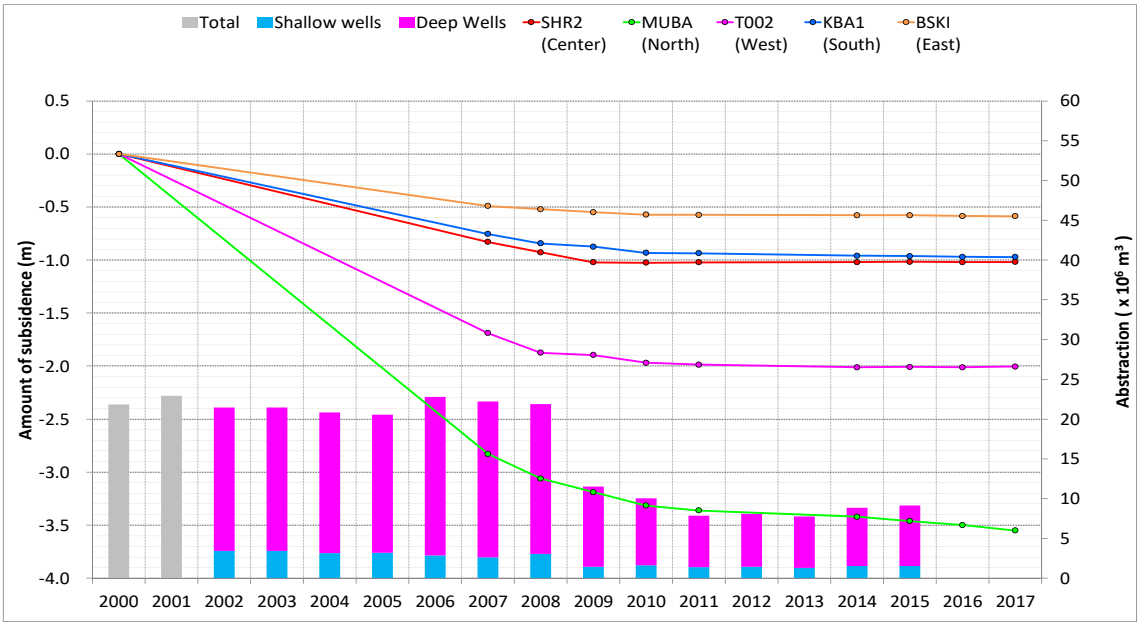
2) Relationship between groundwater abstraction volume and land subsidence and groundwater level in the whole DKI

Figure 2-62 and Figure 2-63 show a comparison between groundwater abstraction volume for the entire DKI Jakarta and the records of typical land subsidence and groundwater level. These comparisons clarify the relationship between the groundwater abstraction and groundwater level, which are the cause of land subsidence. The referenced data is as follows.

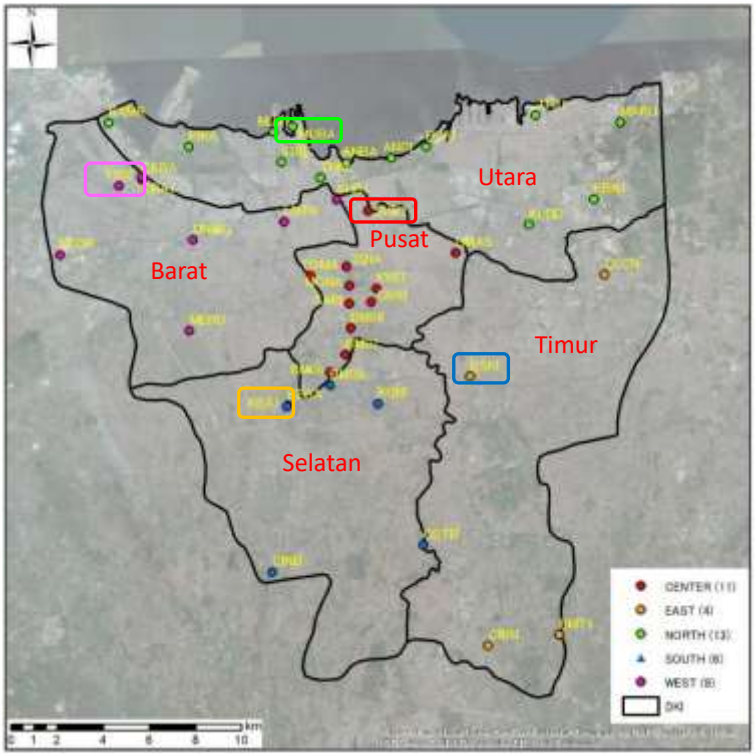
- Groundwater abstraction volume; total groundwater use in whole DKI Jakarta,
- Amount of land subsidence; leveling points of JCDS which record the largest amount of land subsidence since 2000 in each city (see "3.1.1 Land subsidence Monitoring System"),
- Groundwater level; periodic groundwater level monitoring wells in each city that are as close as possible to the above-mentioned leveling points and classified as an aquifer around 40-250 m depth (see "3.3.3 Yearly Change of Groundwater level").

Figure 2-62 shows that the rate of land subsidence has decreased as the groundwater abstraction volume has decreased since the start of the 2010s. In Figure 2-63, the decrease of groundwater abstraction volume is consistent with the trend toward the downward stoppage or upward recovery of groundwater levels.

From these facts, we considered that the groundwater level around 40-250 m depth decrease by excessive groundwater abstraction, and then surrounding consolidation layer shrink.



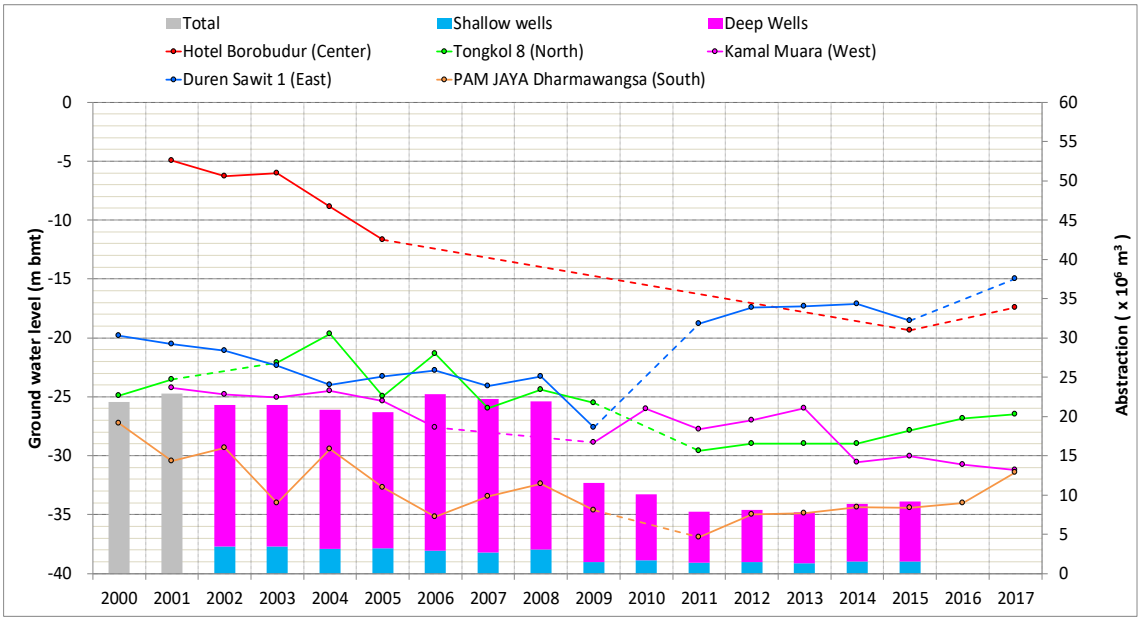
(groundwater abstraction volume and leveling survey result)



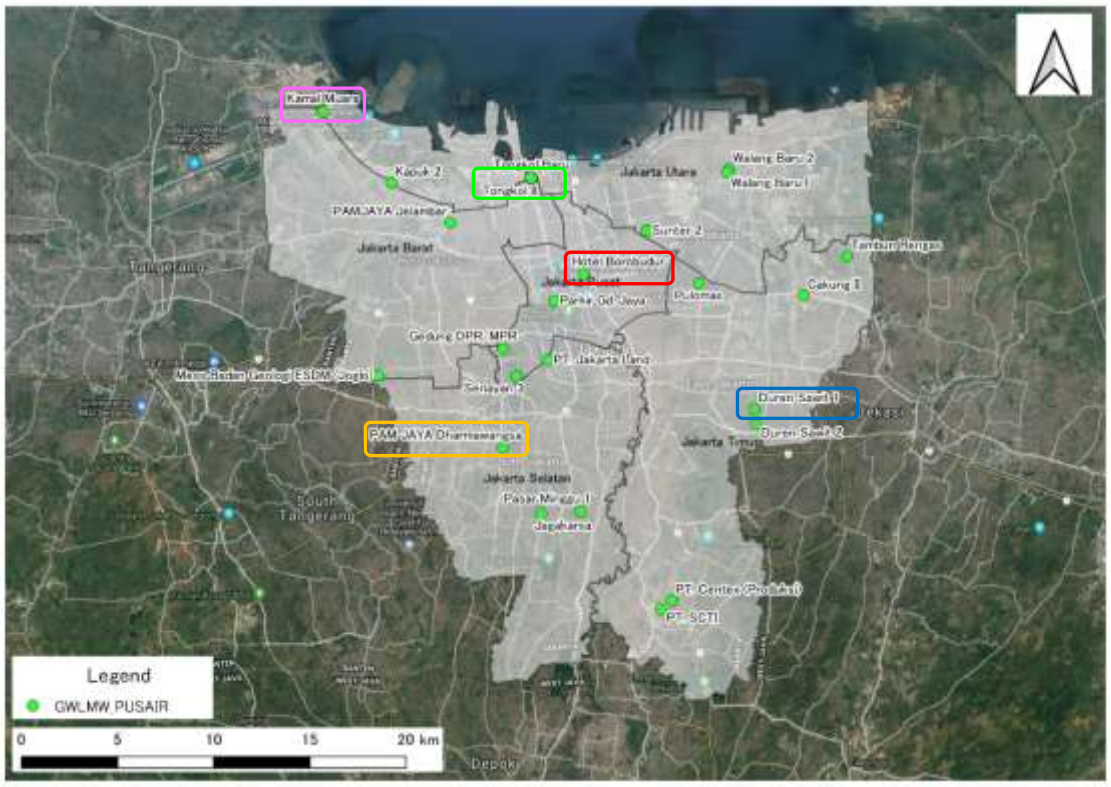
(location of leveling survey points)

Figure 2.71 Comparison between Groundwater Abstraction Volume and Land Subsidence

Source: Created by the Project Team



(groundwater abstraction volume and groundwater level)



(location of periodic groundwater level monitoring wells)

Figure 2.72 Comparison of Groundwater Abstraction Volume and Groundwater Level

Source: Created by the Project Team

2.7.5 Verification and future trend prediction of land subsidence mechanism by one-dimensional land subsidence simulation

As investigated in the previous section, land subsidence due to excessive pumping of groundwater was considered to be the main mechanism of the land subsidence in Jakarta. Therefore, the land subsidence mechanism was verified by one-dimensional land subsidence simulation. In addition, we tried to predict the future of land subsidence in Jakarta.

(1) Analysis points

The analysis points were the following 9 points with clear geological conditions.

- Western / Kamal Muara, Cengkareng, Daan Mogot
- Central / Jakarta fish port, Tongkol, Sunter
- Eastern / Rawa Badak Stadium, Cakung, Marunda



Figure 2.73 Location of analysis points for prediction of future trend of Land subsidence

Source: Created by the Project Team

(2) Modeling of stratum

The hydrogeological structure at each point was modeled based on the geological columns obtained from all core boring and existing geological columns, as shown in Figure 2-67

(3) Calculation method and soil constant

The Terzaghi consolidation equation shown in Figure 2-65 was used to calculate the one-dimensional land subsidence. While the mv method was adopted for calculating the shrinkage of stratum. Table 2-28

shows setting value of each factor for one-dimensional land subsidence analysis. Void ratio and compression index is based on the result of soil test conducted in the all core boring.

(Terzaghi's Consolidation equation)

$$Cv\frac{\partial^2 h}{\partial z^2}=\frac{\partial h}{\partial t} \qquad \text{式(1)}$$

where,

Cv : coefficient of consolidation [m^2/s]

h : groundwater level [m]

z : vertical coordinate [m]

t : time [s]

(Coefficient of Consolidation : Cv)

$$Cv=\frac{k}{m_v\gamma_w} \qquad \text{式(2)}$$

where,

k : hydraulic conductivity [m/s]

m_v : coefficient of volume compressibility [m^2/kN]

γ : unit volume weight of water [kN/m^3]

(Terzaghi's Consolidation equation (deformation))

From equation (1) and equation(2)

$$\frac{\partial}{\partial z}(k\frac{\partial h}{\partial z})=m_v\gamma_w\frac{\partial h}{\partial t} \qquad \text{式(3)}$$

Figure 2.74 (1) one-dimensional land subsidence analysis method using Terzaghi's Consolidation Equation

(Coefficient of Volume compressibility : m_v)

$$m_{vi} = \frac{0.434Cc_i}{1+e}\frac{1}{p} \qquad \text{式(4)}$$

Here,

Cc : compression index [l]

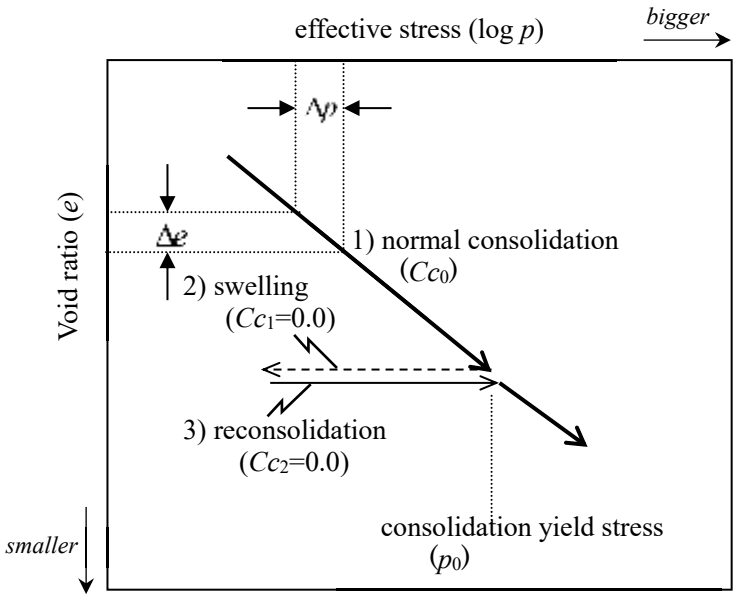
e : void ratio [l]

p : effective stress [kN/m^2]

$i = 0$: normal consolidation

$i = 1$: swelling

$i = 2$: reconsolidation



(Change of Void ratio)

$$\Delta e = (1+e)m_v\Delta p \qquad \text{式(5)}$$

(Shrinkage of stratum : ΔS)

$$\Delta S = m\frac{e}{1+e}\frac{\Delta e}{e} = m\frac{\Delta e}{1+e} = m\frac{(1+e)m_v\Delta p}{1+e} = m\cdot m_v\cdot\Delta p \qquad \text{式(6)}$$

Here,

ΔS : shrinkage of stratum [m]

m : thick of consolidation layer [m]

Figure 2.75 (2) one-dimensional land subsidence analysis method using Terzaghi's Consolidation Equation

Table 2.34 (1) Setting value of each factor for one-dimensional land subsidence analysis

Name	Calculation target layer	Surface level	Top of layer	Bottm of layer	Thickness of layer	Calculation start year	Initial G.W.L	Density of Soil (above G.W.L)	Density of Soil (above Consolidation layer and below G.W.L)	Density of Consolidation layer	Initial Void ratio	Compression index			hydraulic conductivity	Remark
												(normal consolidation)	(swelling consolidation)	(reconsolidation consolidatuon)		
		E.L.m	HTOP GL+m	HBTM GL+m	m		HINIT GL+m	GT kN/m3	GSAT1 kN/m3	GSAT2 kN/m3	e0 –	Cc0 –	Cc1 –	Cc2 –	K m/sec	
Kamal Muara	Conslidation layer1	–	−28	−42.0	14.0	1946	−2.20	16.520	16.552	16.612	2.510	1.610	0.000	0.000	1.25E−10	yellow: UDS−Tongkol−1
	Conslidation layer2	–	−46	−85.0	39	1946	−2.20	16.520	16.552	16.612	1.360	0.410	0.000	0.000	1.25E−10	yellow: UDS−2 (42.0−42.5m)
	Conslidation layer3	–	−98	−252.0	154	1946	−2.20	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E−10	yellow: CS−4
Cengkareng	Conslidation layer1	–	−2.4	−14.7	12.3	1946	−4.20	16.520	16.552	16.612	1.460	0.560	0.000	0.000	1.25E−10	yellow: UDS−2 (7.5−8.0m)
	Conslidation layer2	–	−23.1	−133.0	109.9	1946	−4.20	16.520	16.552	16.612	1.360	0.410	0.000	0.000	1.25E−10	yellow: UDS−2 (42.0−42.5m)
	Conslidation layer3	–	−180.3	−281.9	101.6	1946	−4.20	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E−10	yellow: CS−4
Daan Mogot	Conslidation layer1	–	−1.5	−31.8	30.3	1946	−4.20	16.520	16.552	16.612	1.360	0.410	0.000	0.000	1.25E−10	yellow: UDS−2 (42.0−42.5m)
	Conslidation layer2	–	−47.0	−124.2	77.3	1946	−4.20	16.520	16.552	16.612	1.360	0.410	0.000	0.000	1.25E−10	yellow: UDS−2 (42.0−42.5m)
	Conslidation layer3	–	−172.7	−245.5	72.7	1946	−4.20	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E−10	yellow: CS−4
JKT fish port	Conslidation layer1	–	−9.1	−47.6	38.5	1946	−2.20	16.520	16.552	16.612	2.510	1.610	0.000	0.000	1.25E−10	yellow: UDS−Tongkol−1
	Conslidation layer2	–	−57.4	−94.9	37.6	1946	−2.20	16.520	16.552	16.612	0.980	0.480	0.000	0.000	1.25E−10	yellow: CS−2
	Conslidation layer3	–	−123.3	−276.1	152.8	1946	−2.20	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E−10	yellow: CS−4
Tongkol	Conslidation layer1	–	−7.8	−14.5	6.7	1946	−2.50	16.520	16.552	16.612	2.510	1.610	0.000	0.000	1.25E−10	yellow: UDS−Tongkol−1
	Conslidation layer2	–	−22.4	−116.4	94	1946	−2.50	16.520	16.552	16.612	0.980	0.480	0.000	0.000	1.25E−10	yellow: CS−2
	Conslidation layer3	–	−153.3	−210.4	57.1	1946	−2.50	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E−10	yellow: CS−4

Table 2.34 (2) Setting value of each factor for one-dimensional land subsidence analysis

Name	Calculation target layer	Surface level	Top of layer	Bottm of layer	Thickness of layer	Calculation start year	Initial G.W.L	Density of Soil (above G.W.L)	Density of Soil (above Consolidation layer and below G.W.L)	Density of Consolidation layer	Initial Void ratio	Compression index			hydraulic conductivity	Remark
												(normal consolidation)	(swelling consolidation)	(reconsolidation consolidatuon)		
		E.L.m	HTOP GL+m	HBTM GL+m	m		HINIT GL+m	GT kN/m3	GSAT1 kN/m3	GSAT2 kN/m3	e0 –	Cc0 –	Cc1 –	Cc2 –	K m/sec	
Sunter	Conslidation layer1	–	0.0	−12.0	12.0	1946	−2.50	16.520	16.552	16.612	1.460	0.560	0.000	0.000	1.25E-10	yellow: UDS-2 (7.5-8.0m)
	Conslidation layer2	–	−27.0	−122.3	95.3	1946	−2.50	16.520	16.552	16.612	0.980	0.480	0.000	0.000	1.25E-10	yellow: CS-2
	Conslidation layer3	–	−143.5	−296.3	152.8	1946	−2.50	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E-10	yellow: CS-4
Rawa Badak Stadium	Conslidation layer1	–	−0.3	−19.9	19.6	1946	−2.20	16.520	16.552	16.612	2.510	1.610	0.000	0.000	1.25E-10	yellow: UDS-Tongkol-1
	Conslidation layer2	–	−21.5	−94.0	72.5	1946	−2.20	16.520	16.552	16.612	0.980	0.480	0.000	0.000	1.25E-10	yellow: CS-2
	Conslidation layer3	–	−95.5	−249.9	154.4	1946	−2.20	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E-10	yellow: CS-4
Cakung	Conslidation layer1	–	−11	−12.6	1.6	1946	−2.50	16.520	16.552	16.612	1.460	0.560	0.000	0.000	1.25E-10	yellow: UDS-2 (7.5-8.0m)
	Conslidation layer2	–	−29.2	−136.7	107.5	1946	−2.50	16.520	16.552	16.612	0.980	0.480	0.000	0.000	1.25E-10	yellow: CS-2
	Conslidation layer3	–	−142.2	−239.6	97.4	1946	−2.50	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E-10	yellow: CS-4
Marunda	Conslidation layer1	–	−1.5	−30.3	28.8	1946	−2.20	16.520	16.552	16.612	2.510	1.610	0.000	0.000	1.25E-10	yellow: UDS-Tongkol-1
	Conslidation layer2	–	−40.3	−110.3	70.0	1946	−2.20	16.520	16.552	16.612	0.980	0.480	0.000	0.000	1.25E-10	yellow: CS-2
	Conslidation layer3	–	−122.8	−298.8	176.0	1946	−2.20	16.520	16.552	16.612	0.990	0.250	0.000	0.000	1.25E-10	yellow: CS-4

(4) Setting condition of groundwater level

The groundwater levels at the upper and lower aquifer of the consolidation layer were set as follows based on the characteristic of groundwater level long-term fluctuation at surrounding points.

- Up to Sep. 2019
  The groundwater level continued to decline after 1970 and reached the groundwater level of September 2019.
- From Oct. 2019
  Four cases shown in Table 2-29 were assumed. For Case A-1, the groundwater levels corresponding to 50% of the current groundwater abstraction volume (average from 2011 to 2018) were set based on the relationships between the groundwater abstraction volume and the groundwater levels in each district to which each survey sites belongs.

The condition of the groundwater levels at each point were shown in Table 3-38 to Table 3-46.

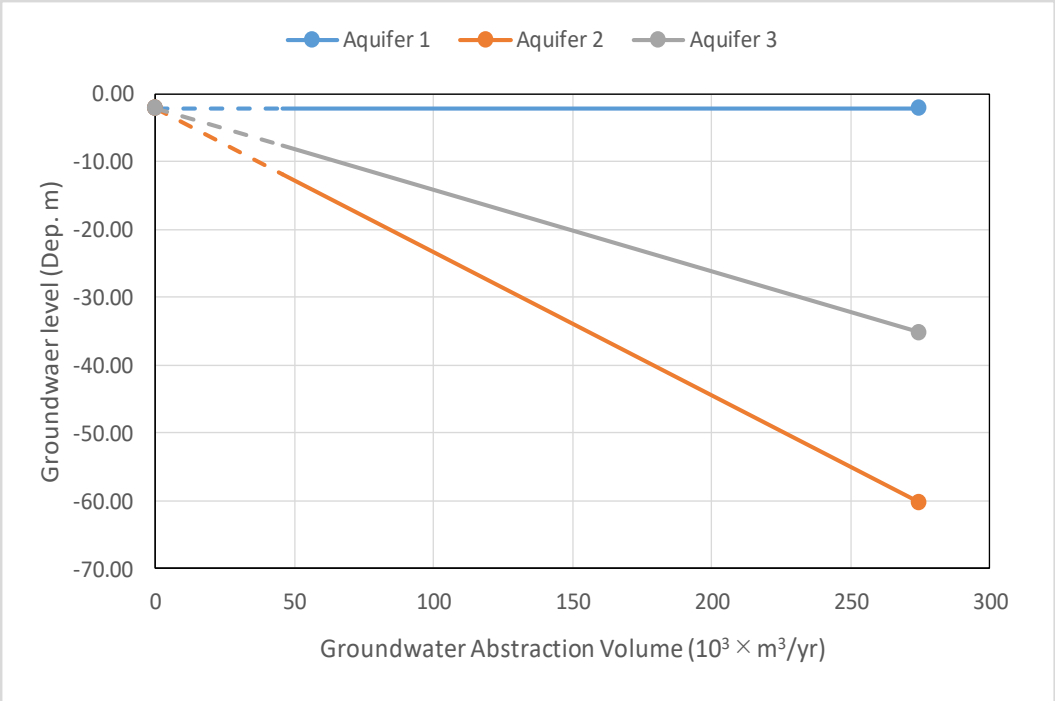
Table 2.35 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 50% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach the groundwater levels corresponding to the groundwater abstraction conditions in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Table 2.36 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Kamal Muara)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.2 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-18.70 m in Aquifer 3, G.L.-31.20 m in Aquifer 2 and G.L.-2.20 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -35.10 m, Aquifer 2: -60.20 m, Aquifer 1: -2.20 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Kalideres district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.
Note 2) The groundwater abstraction volume is based on the total groundwater use in Kalideres district, the groundwater level in Aquifer 3 is based on the pore water pressure at Dep.140 m, the groundwater level in Aquifer 2 is based on the pore water pressure at Dep.96 m and the groundwater level in Aquifer 1 is based on the pore water pressure at Dep.46 m.

Figure 2.76 Relationship between the groundwater abstraction volume and the groundwater levels (Kamal Muara)

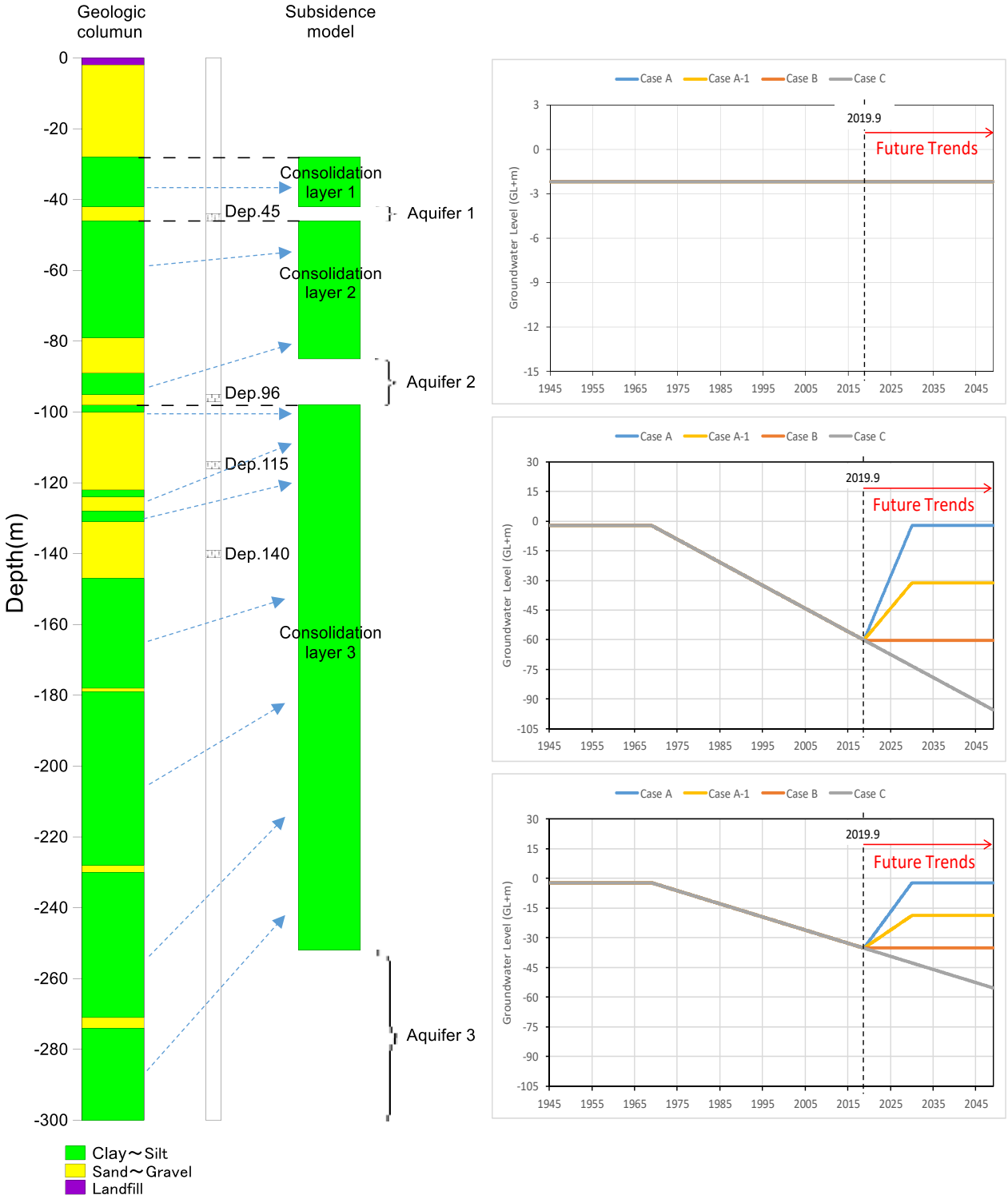


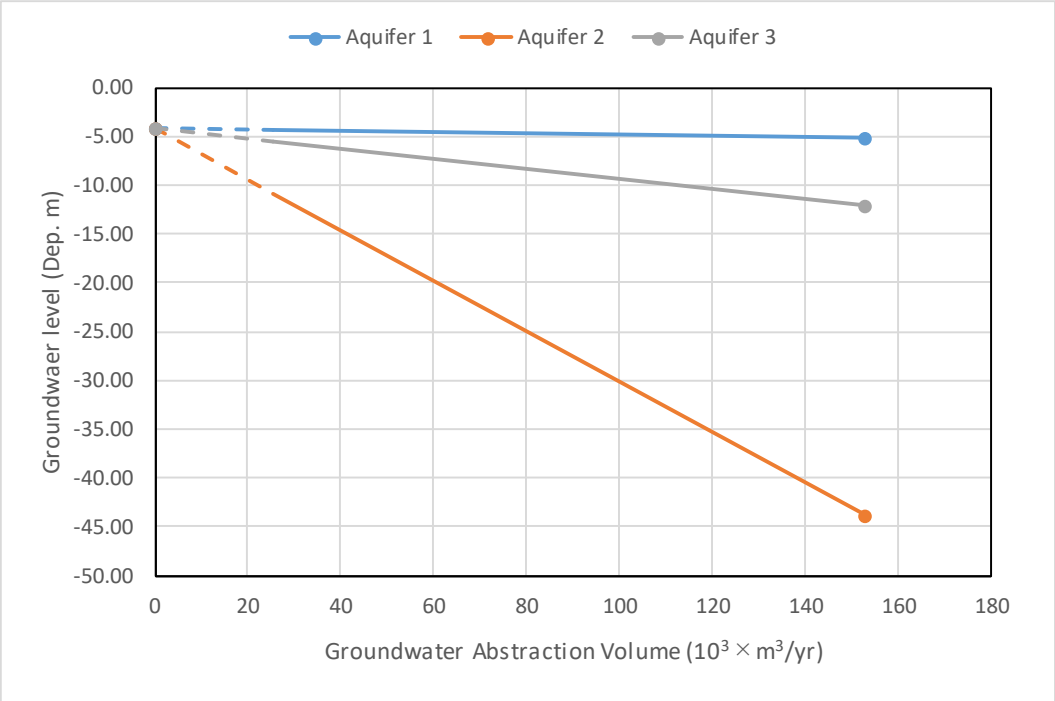
Figure 2.77 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer

(Kamal Muara / Case A, A-1, B, C)

Table 2.37 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Cengkareng)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-4.2 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-8.15 m in Aquifer 3, G.L.-24.05 m in Aquifer 2 and G.L.-4.70 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -12.10 m, Aquifer 2: -43.90 m, Aquifer 1: -5.20 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Cengkareng district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.
Note 2) The groundwater abstraction volume is based on the total groundwater use in Cengkareng district and the groundwater levels are based on groundwater levels of newly land subsidence monitoring wells established by JICA.

Figure 2.78 Relationship between the groundwater abstraction volume and the groundwater levels (Cengkareng)

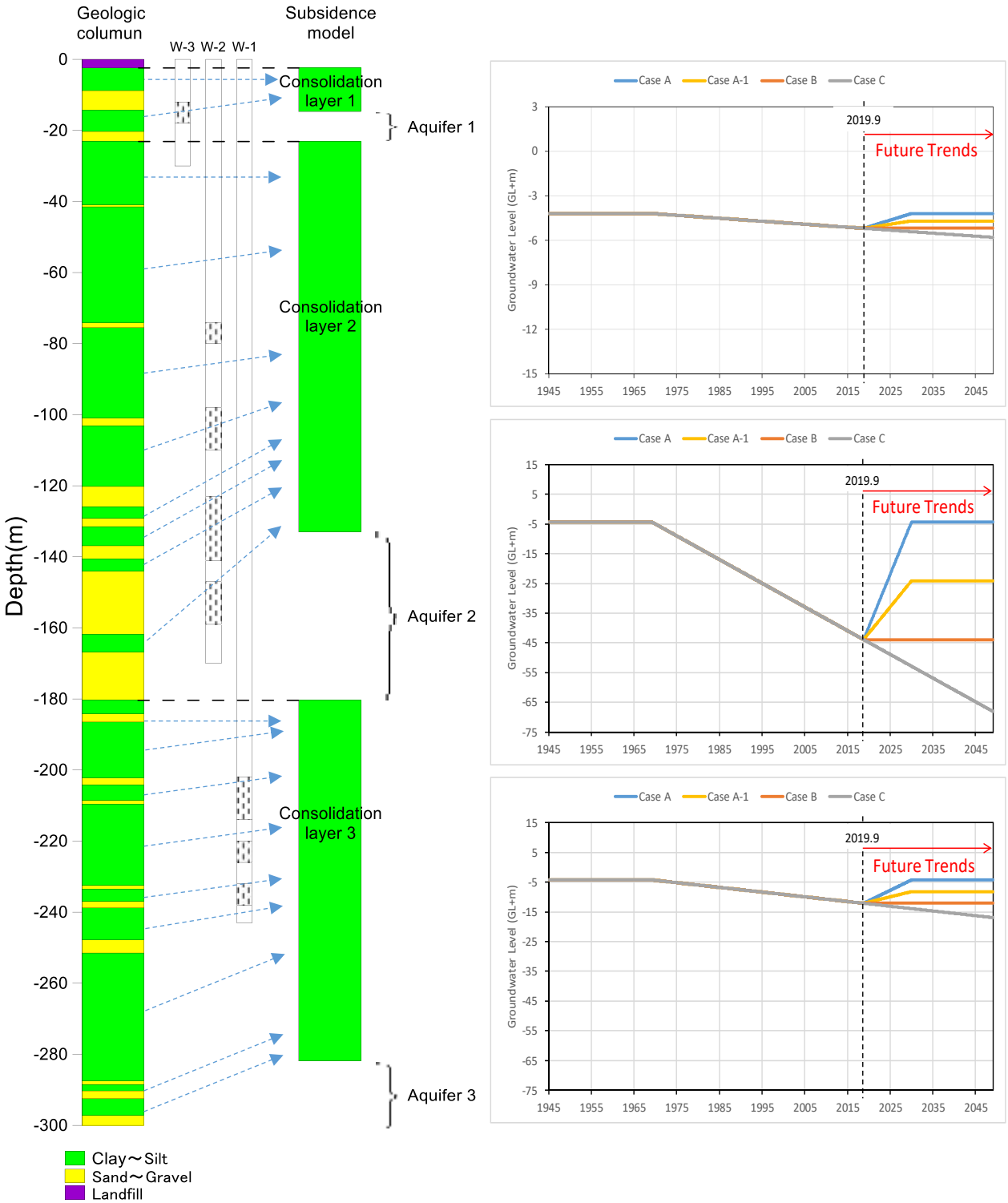


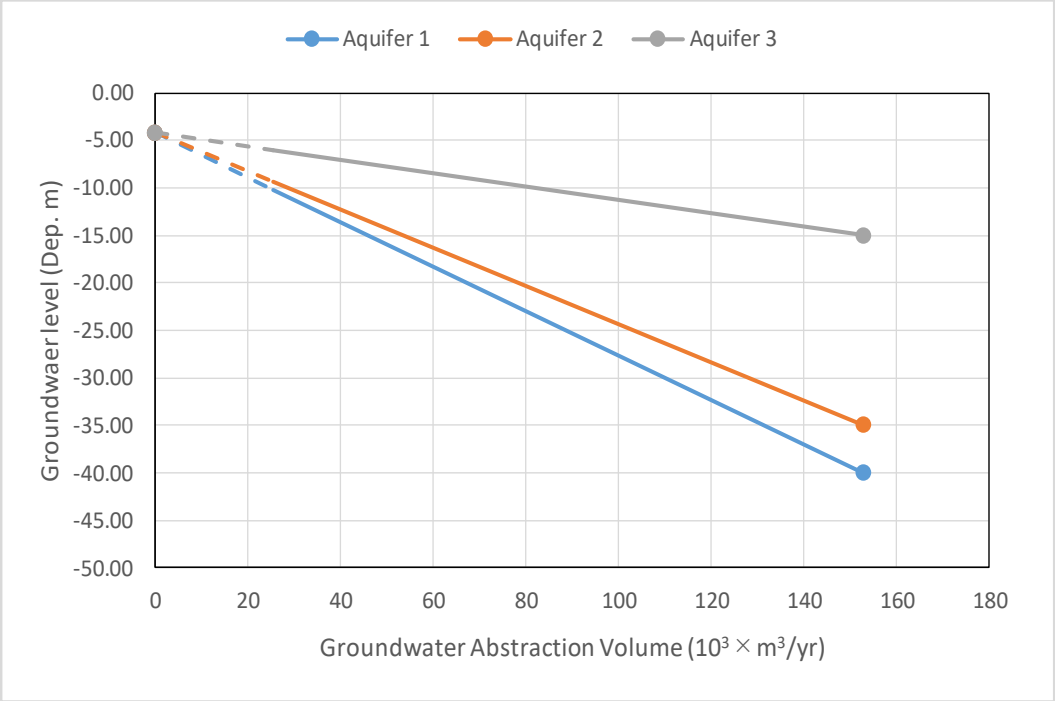
Figure 2.79 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer

(Cengkareng / Case A, A-1, B, C)

Table 2.38 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Daan Mogot)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-4.2 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-9.60 m in Aquifer 3, G.L.-19.60 m in Aquifer 2 and G.L.-22.10 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds the current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -15.00 m, Aquifer 2: -35.00 m, Aquifer 1: 40.00 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Cengkareng district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.

Note 2) The groundwater abstraction volume is based on the total groundwater use in Cengkareng district, the groundwater level in Aquifer 3 is based on Deep W.L. of NCICD analysis*, the groundwater level in Aquifer 2 is based on Middle W.L. of NCICD analysis* and the groundwater level in Aquifer 1 is based on Shallow W.L. of NWICD analysis*.

*:「Road Map Mitigation Land Subsidence (NCICD, 2018)」

Figure 2.80 Relationship between the groundwater abstraction volume and the groundwater levels (Daan Mogot)

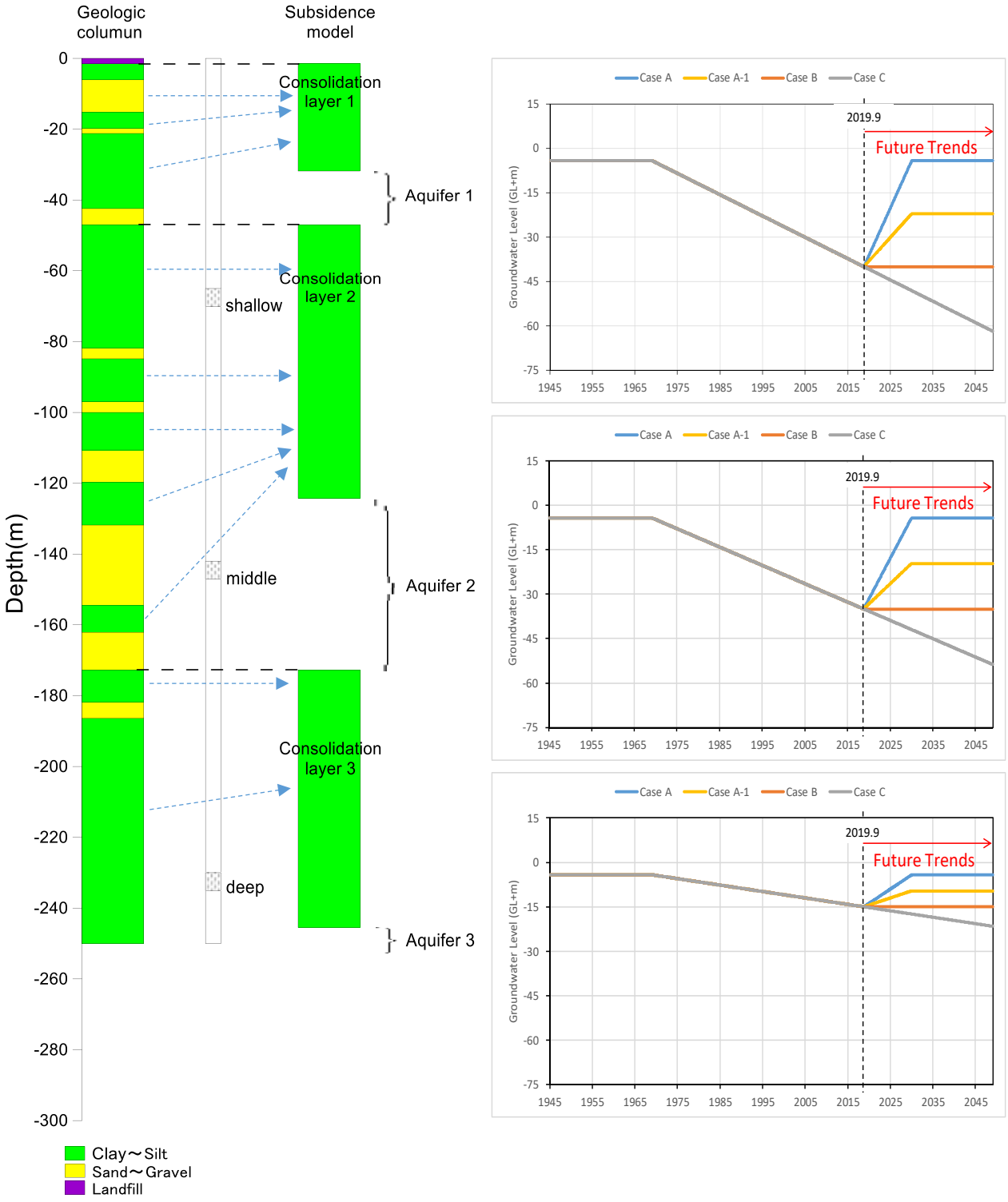
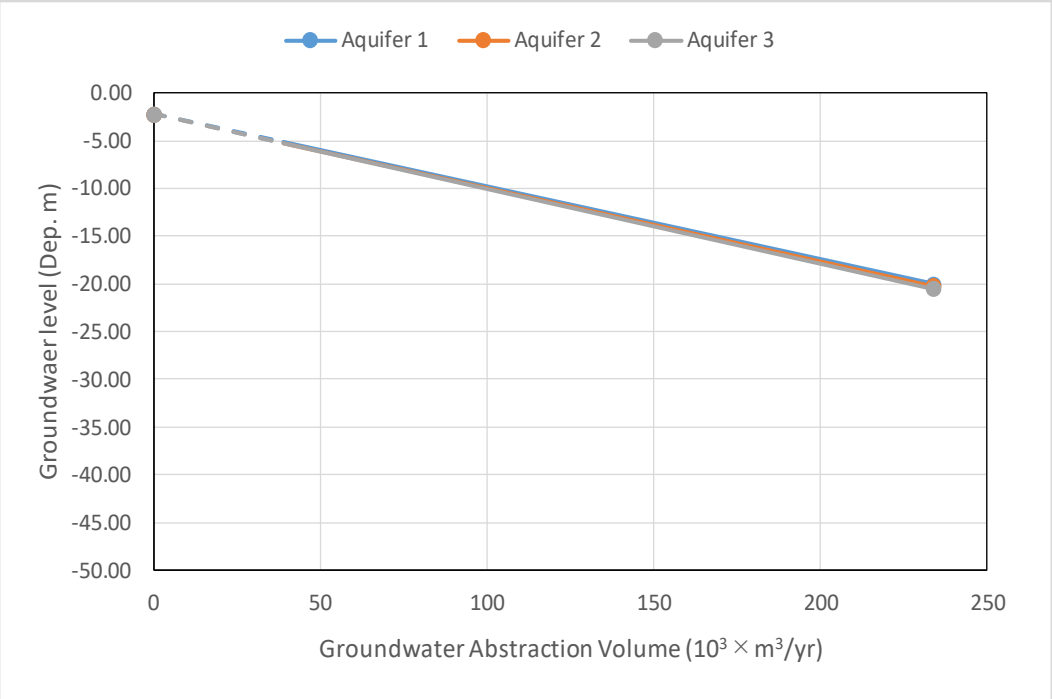


Figure 2.81 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer (Daan Mogot / Case A, A-1, B, C)

Table 2.39 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Jakarta fish port)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.2 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-11.10 m in Aquifer 3, G.L.-11.10 m in Aquifer 2 and G.L.-11.10 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -20.00 m, Aquifer 2: -20.00 m, Aquifer 1: -20.00 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Penjaringan district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.

Note 2) The groundwater abstraction volume is based on the total groundwater use in Penjaringan district, the groundwater level in Aquifer 3 is based on the groundwater level distribution at the 140-250m depth of the groundwater conservation map (2009) and the groundwater levels in Aquifer 2 and Aquifer 1 are based on the groundwater level at 40-140m depth of the groundwater conservation map (2018).

Figure 2.82 Relationship between the groundwater abstraction volume and the groundwater levels (Jakarta fish port)

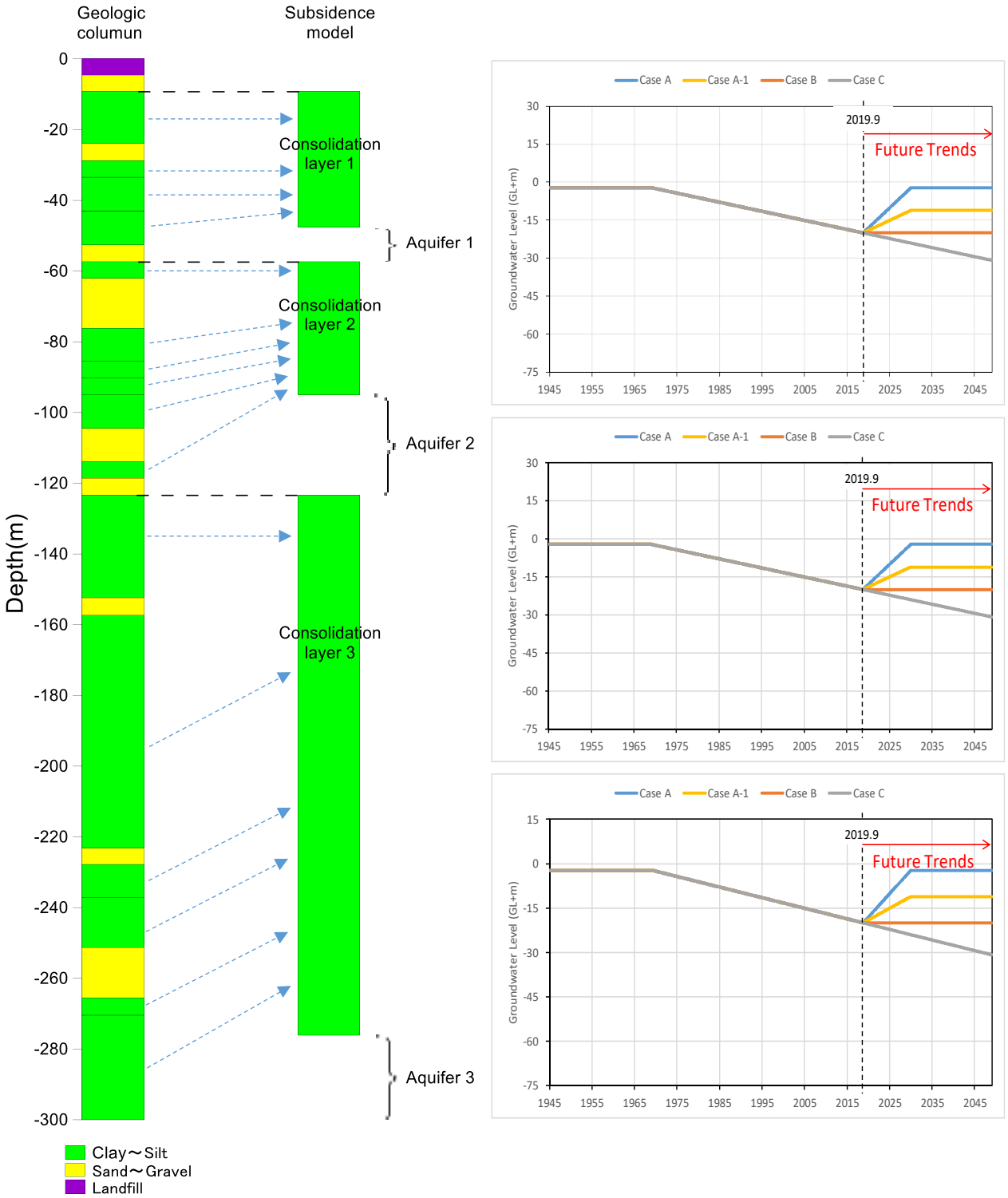
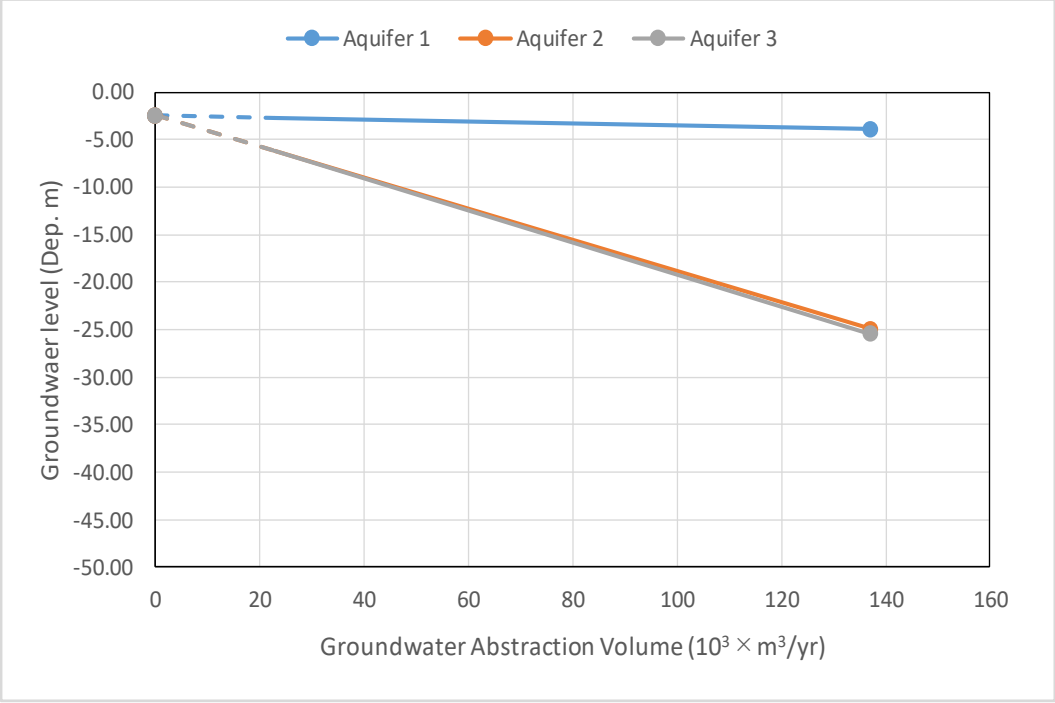


Figure 2.83 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer (Jakarta fish port / Case A, A-1, B, C)

Table 2.40 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Tongkol)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.5 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-13.75 m in Aquifer 3, G.L.-13.75 m in Aquifer 2 and G.L.-3.20 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -25.00 m, Aquifer 2: -25.00 m, Aquifer 1: -3.90 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Pademangan district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.

Note 2) The groundwater abstraction volume is based on the total groundwater use in Pademangan district, the groundwater level in Aquifer 3 is based on the groundwater level of Tongkol 8, the groundwater levels in Aquifer 2 is based on the groundwater level of Tonkol Baru and the groundwater levels in Aquifer 1 is based on the groundwater level of the bore hole conducted by JICA.

Figure 2.84 Relationship between the groundwater abstraction volume and the groundwater levels (Tongkol)

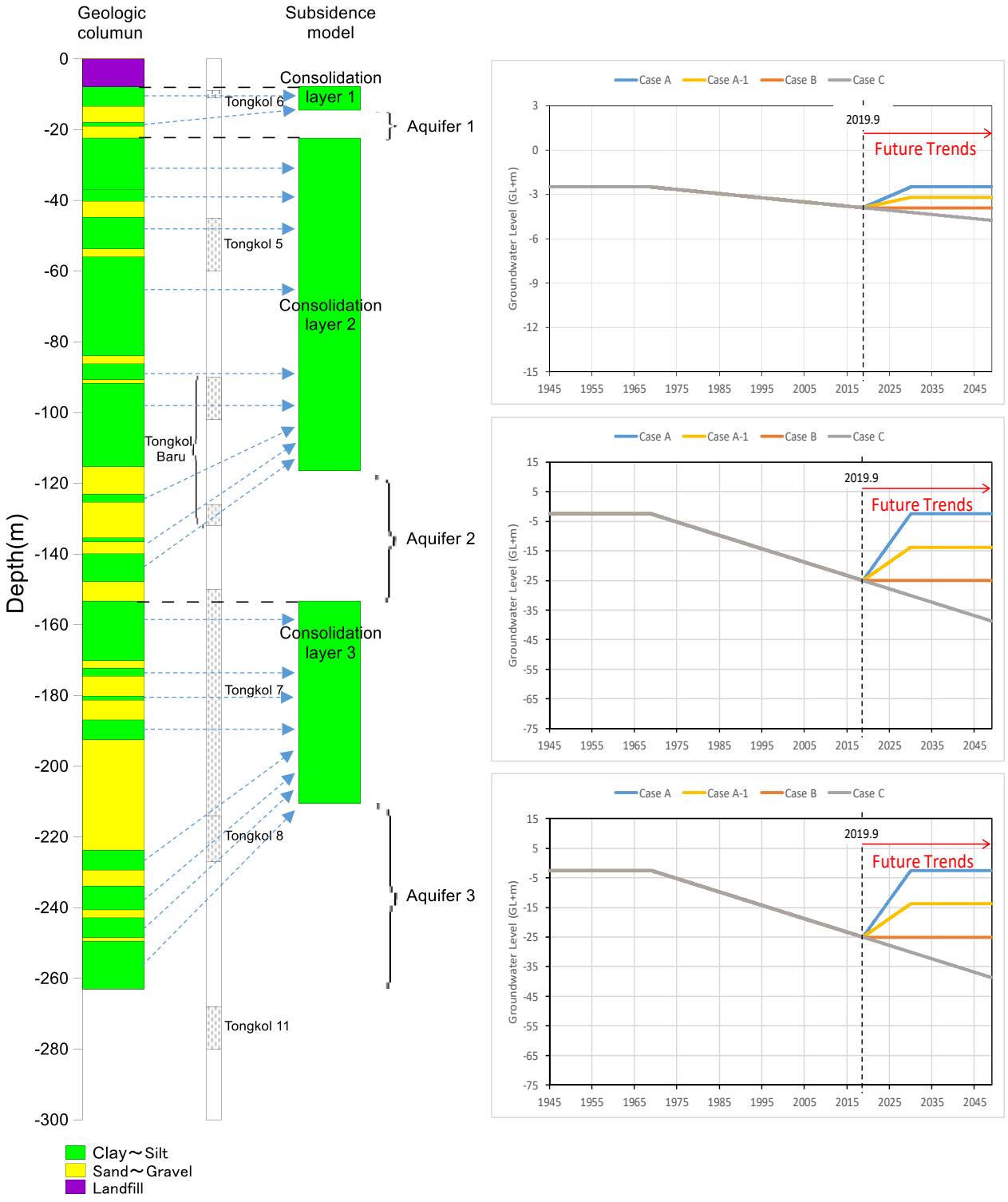


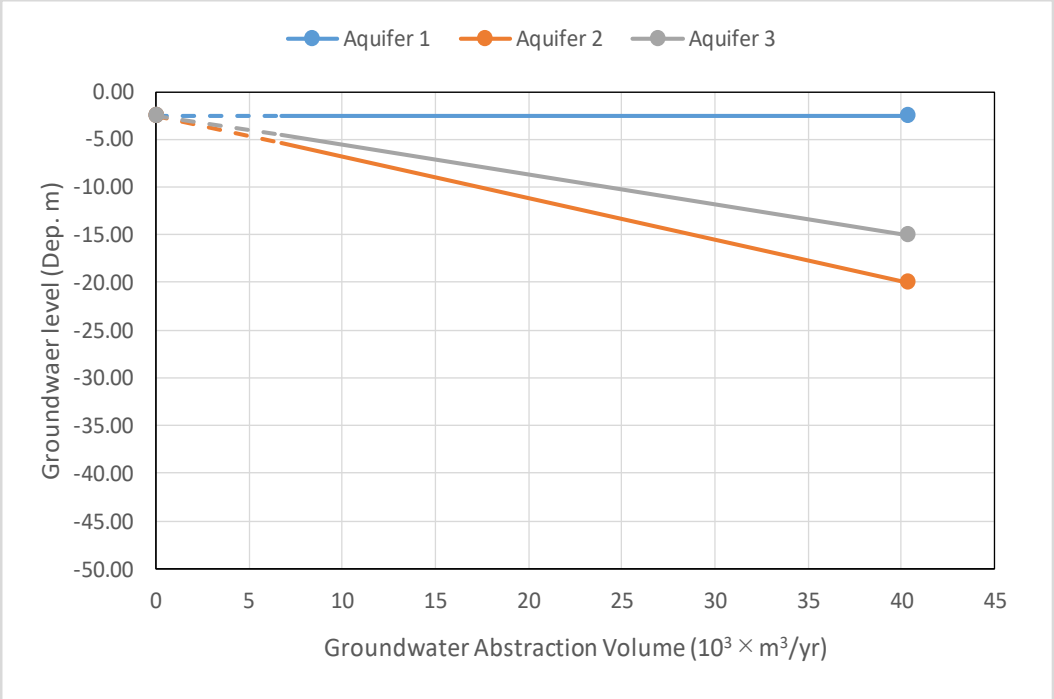
Figure 2.85 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer

(Tongkol / Case A, A-1, B, C)

Table 2.41 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Sunter)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.5 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-8.75 m in Aquifer 3, G.L.-11.25 m in Aquifer 2 and G.L.-2.50 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -15.00 m, Aquifer 2: -20.00 m, Aquifer 1: -2.50 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Tanjung Priuk district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.
Note 2) The groundwater abstraction volume is based on the total groundwater use in Tanjung Priuk district, the groundwater level in Aquifer 3 is based on the groundwater level of Sunter 1, the groundwater levels in Aquifer 2 is based on the groundwater level of Sunter 3 and the groundwater levels in Aquifer 1 is estimated from the groundwater level of an unconfined aquifer at Tongkol.

Figure 2.86 Relationship between the groundwater abstraction volume and the groundwater levels (Sunter)

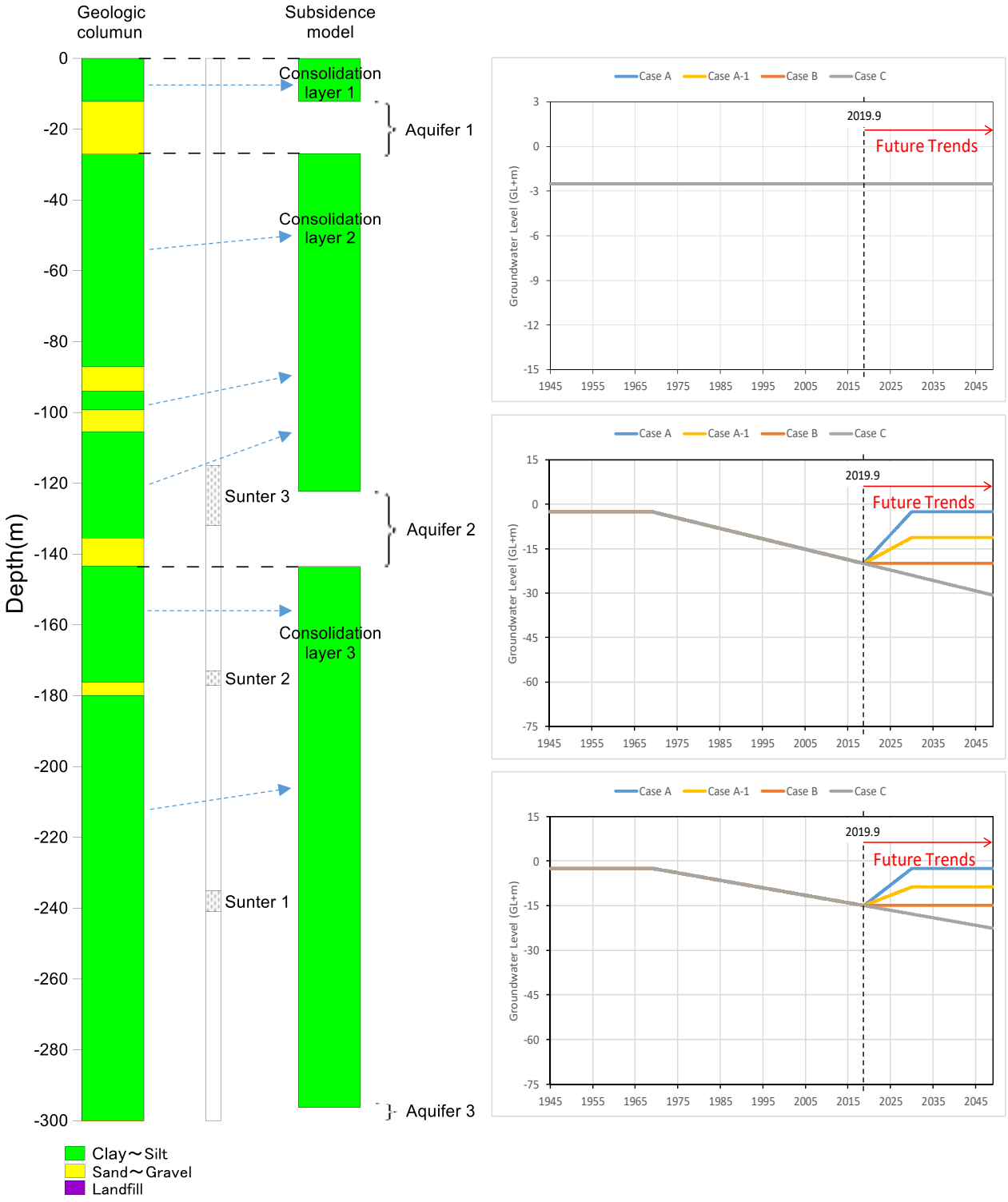


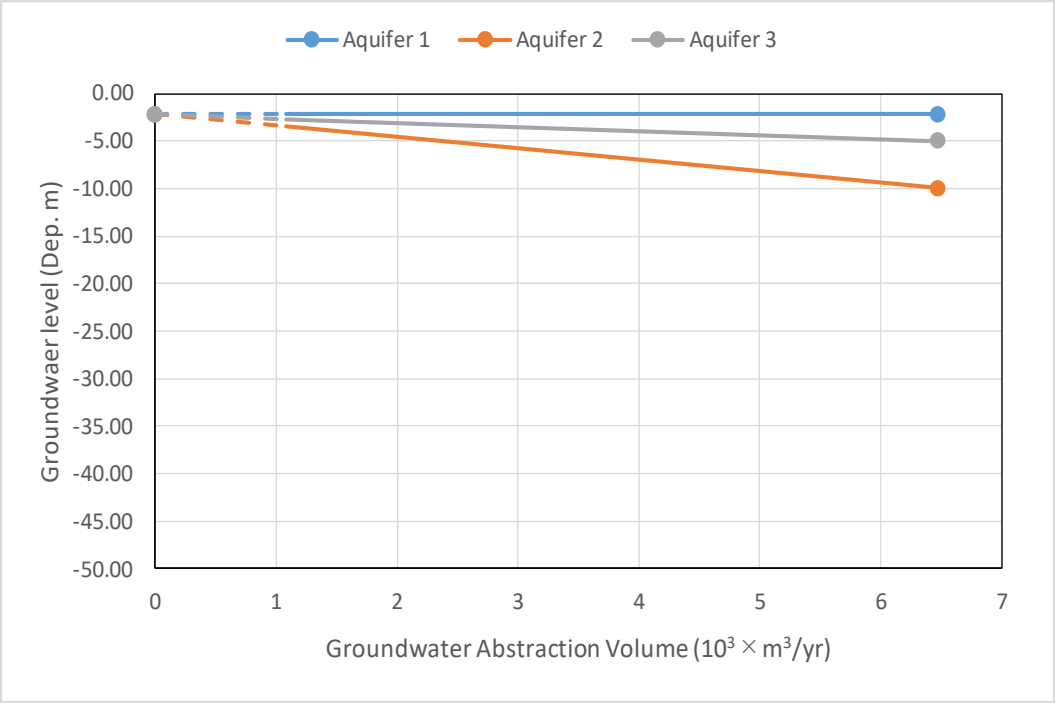
Figure 2.87 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer

(Sunter / Case A, A-1, B, C)

Table 2.42 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Rawa Badak Stadium)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.2 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-3.60 m in Aquifer 3, G.L.-6.10 m in Aquifer 2 and G.L.-2.20 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -5.00 m, Aquifer 2: -10.00 m, Aquifer 1: -2.20 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Koja district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.

Note 2) The groundwater abstraction volume is based on the total groundwater use in Koja district, the groundwater level in Aquifer 3 is based on the groundwater level of WalangBaru 2, the groundwater levels in Aquifer 2 is based on the groundwater level of WalangBaru I and the groundwater levels in Aquifer 1 is estimated from the groundwater level of an unconfined aquifer at Rawa Badak Stadium.

Figure 2.88 Relationship between the groundwater abstraction volume and the groundwater levels (Rawa Badak Stadium)

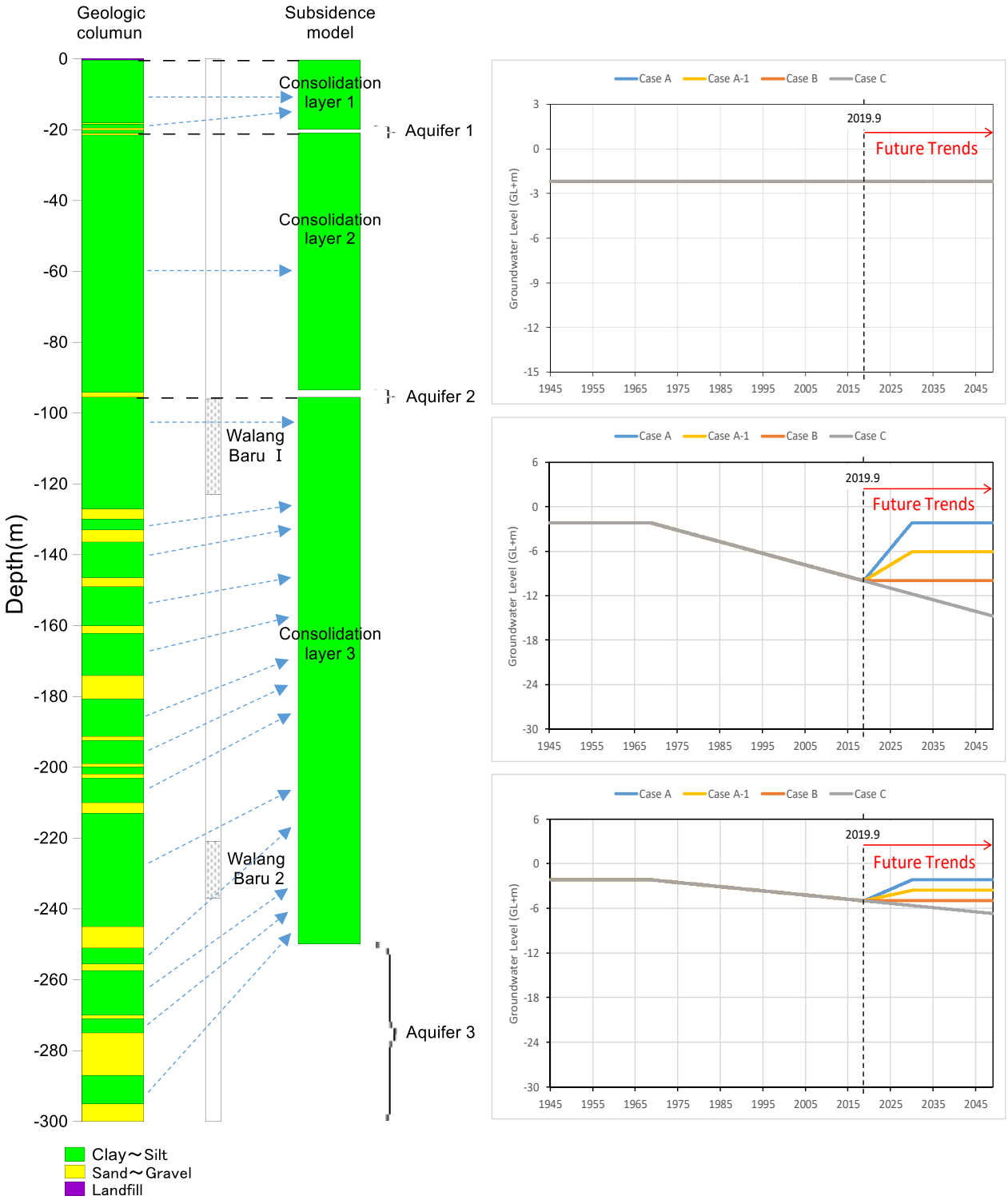


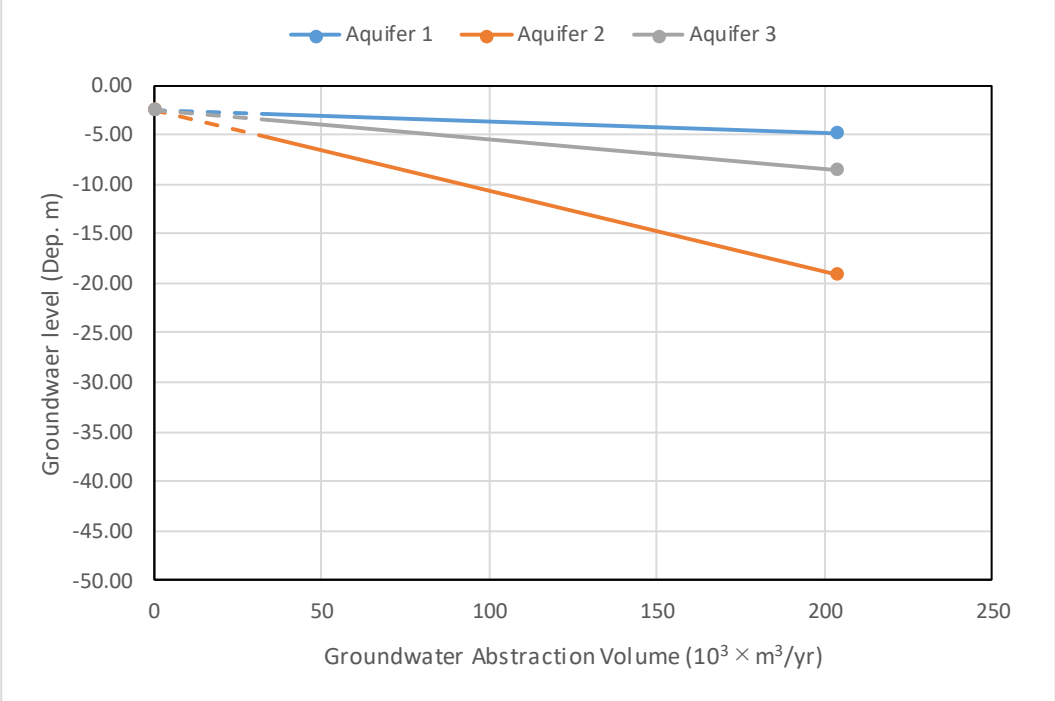
Figure 2.89 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer

(Rawa Badak Stadium / Case A, A-1, B, C)

Table 2.43 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Cakung)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.5 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-5.49 m in Aquifer 3, G.L.-10.80 m in Aquifer 2 and G.L.-3.64 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -8.48 m, Aquifer 2: -19.10 m, Aquifer 1: -4.78 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Cakung district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.
Note 2) The groundwater abstraction volume is based on the total groundwater use in Cakung district and the groundwater levels are based on groundwater levels of newly land subsidence monitoring wells established by JICA.

Figure 2.90 Relationship between the groundwater abstraction volume and the groundwater levels (Cakung)

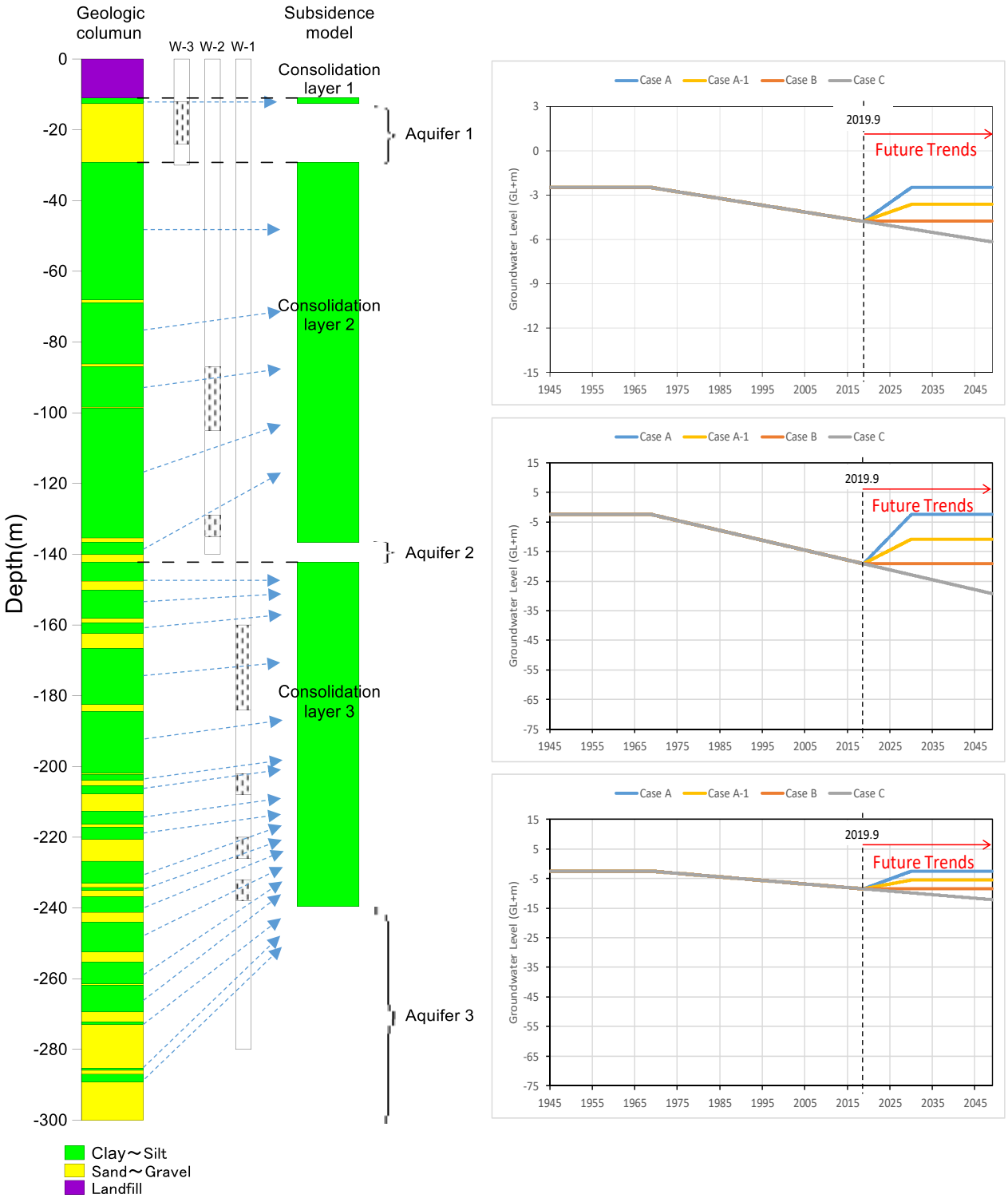


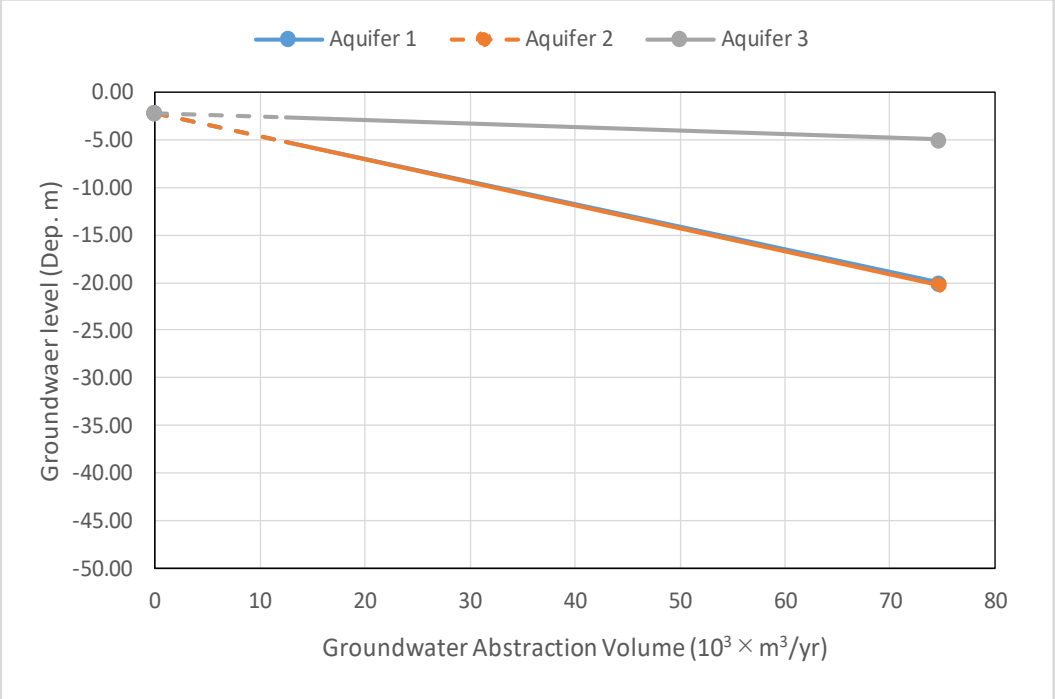
Figure 2.91 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer

(Cakung / Case A, A-1, B, C)

Table 2.44 Groundwater level change scenario for prediction of future trend in one-dimensional land subsidence simulation (Marunda)

Case	Groundwater abstraction condition after Oct. 2019	Groundwater level corresponding to groundwater abstraction conditions after Oct. 2019
Case A	If current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach those original level (G.L.-2.2 m) in Dec. 2030.
Case A-1	If current groundwater abstraction volume will be reduced by 80% by Dec. 2030	The groundwater levels will recover from October 2019 and will reach G.L.-3.60 m in Aquifer 3, G.L.-11.10 m in Aquifer 2 and G.L.-11.10 m in Aquifer 1 in Dec. 2030.
Case B	If groundwater abstraction that exceeds current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -5.00 m, Aquifer 2: -20.00 m, Aquifer 1: -20.00 m) as of Sep. 2019 will be remained.
Case C	If groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Note) The current groundwater abstraction volume:
Average groundwater abstraction volume from 2011 to 2018 in Cilingcig district



Note 1) It is assumed that the groundwater level indicates the value as of September 2019 under the current groundwater abstraction volume (average value from 2011 to 2018), while the groundwater level indicates the natural water level when the groundwater abstraction volume is zero.
Note 2) The groundwater abstraction volume is based on the total groundwater use in Cilingcig district, the groundwater level in Aquifer 3 is based on Deep W.L. of NCICD analysis*, the groundwater level in Aquifer 2 is based on Middle W.L. of NCICD analysis* and the groundwater level in Aquifer 1 is based on Shallow W.L. of NWICD analysis*.
*:「Road Map Mitigation Land Subsidence (NCICD, 2018)」

Figure 2.92 Relationship between the groundwater abstraction volume and the groundwater levels (Marunda)

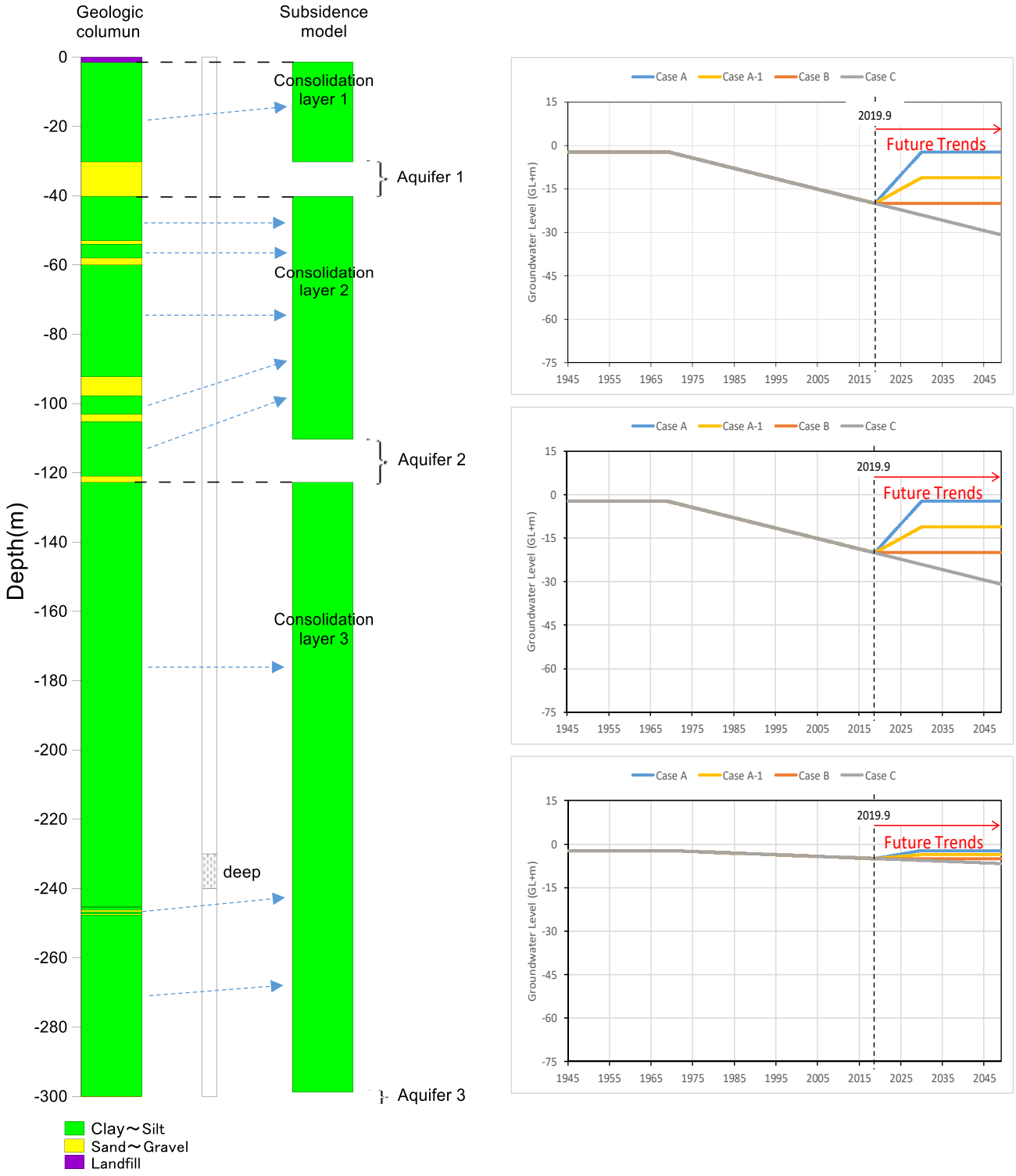


Figure 2.93 Modeling of hydrogeological structure for one-dimensional land subsidence analysis and setting conditions of groundwater level each aquifer (Marunda / Case A, A-1, B, C)

(5) Calculation Result

The results of one-dimensional land subsidence simulation are shown in Figure 2-84 to Figure 2-92. The prediction value of the amount of land subsidence at each point in 2030 are shown in Table 2-39 and the

prediction value of the amount of land subsidence at each point in 2050 are shown in Table 2-40. According to these results, the followings are confirmed.

＜Land Subsidence Mechanism＞

- From the calculation results up to September 2019, the long-term drop in the groundwater level since 1970 possibly cause land subsidence for several meters.
- Shrinkage occurs in the second and third consolidation layers.

＜Prediction of Land subsidence＞

- If the groundwater level drops further without any regulation on groundwater abstraction, land subsidence of 62 to 492 mm (about 0.6 to 4.8 cm/yr) is expected to occur until 2030.
- When the groundwater abstraction is regulated to not exceed the current groundwater abstraction volume and the groundwater level is maintained, land subsidence of 45 to 363 mm (about 0.4 to 3.5 cm/yr) is expected to occur until 2030.
- If the groundwater abstraction regulations will be implemented to reduce the current groundwater abstraction volume by 100% until December 2030 and the groundwater level will recover to the original level, land subsidence of 17 to 142 mm (about 0.1 to 1.4 cm/yr) is expected to occur and stop after that.
- To reduce the land subsidence to less than 1 cm/yr at all locations by 2030, groundwater abstraction volume need to be reduced by more than 50% by December 2030.

From the findings above, land subsidence phenomenon in Jakarta is considered due to excessive groundwater abstraction that causes a drop in groundwater level.

To prevent land subsidence, reducing groundwater abstraction volume as much as possible and promoting groundwater level recovery are necessary.

Table 2.45 Prediction values of the amount of land subsidence until 2030 at each survey sites

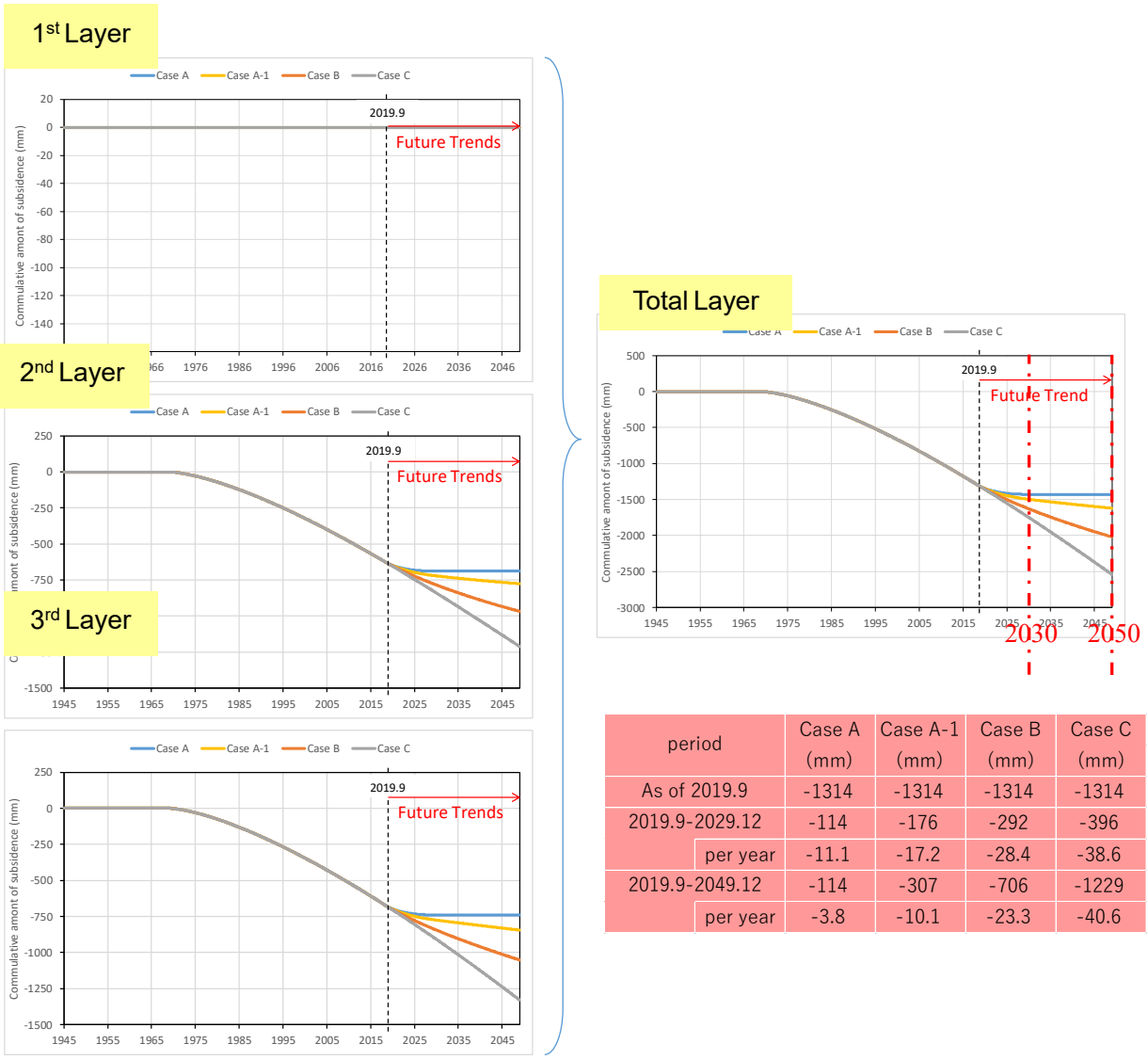
Case	Groundwater abstraction condition	Groundwater level in Dec. 2030	The amount of land subsidence (the current (2019.10) to 2030)								
			Kamal Muara (Western /coastal)	Cengkareng (Western)	Daan Mogot (Western)	Jakarta fish port (Central /coastal)	Tongkol (Central /coastal)	Sunter (Central)	Rawa Badak Stadium (Eastern /coastal)	Cakung (Eastern)	Marunda (Eastern /coastal)
A	100% reduce of the current groundwater abstraction volume	Recover to original level	-114 mm (-11.1 mm/yr)	-62 mm (-6.1 mm/yr)	-142 mm (-13.8 mm/yr)	-102 mm (-10.0 mm/yr)	-48 mm (-4.7 mm/yr)	-36 mm (-3.5 mm/yr)	-17 mm (-1.7 mm/yr)	-35 mm (-3.4 mm/yr)	-133 mm (-13.0 mm/yr)
A-1	50% reduce of the current groundwater abstraction volume	Drastically recovery	-176 mm (-17.2 mm/yr)	-97 mm (-9.5 mm/yr)	-219 mm (-21.4 mm/yr)	-161 mm (-15.7 mm/yr)	-79 mm (-7.7 mm/yr)	-55 mm (-5.4 mm/yr)	-26 mm (-2.6 mm/yr)	-54 mm (-5.2 mm/yr)	-203 mm (-19.8 mm/yr)
B	Remain the current groundwater abstraction volume	Remain the same level	-292 mm (-28.4 mm/yr)	-163 mm (-15.9 mm/yr)	-363 mm (-35.4 mm/yr)	-272 mm (-26.6 mm/yr)	-144 mm (-14.0 mm/yr)	-93 mm (-9.1 mm/yr)	-45 mm (-4.4 mm/yr)	-91 mm (-8.9 mm/yr)	-332 mm (-32.4 mm/yr)
C	Without regulation (Allowed to increase groundwater abstraction volume)	Continue to decrease	-396 mm (-38.6 mm/yr)	-225 mm (-22.0 mm/yr)	-492 mm (-48.0 mm/yr)	-375 mm (-36.6 mm/yr)	-203 mm (-19.8 mm/yr)	-130 mm (-12.7 mm/yr)	-62 mm (-6.1 mm/yr)	-130 mm (-12.7 mm/yr)	-448 mm (-43.7 mm/yr)
	Land subsidence amount ranking		3	5	1	4	6	7	9	7	2

Red : land subsidence more than 1 cm/yr

Table 2.46 Prediction values of the amount of land subsidence until 2050 at each survey sites

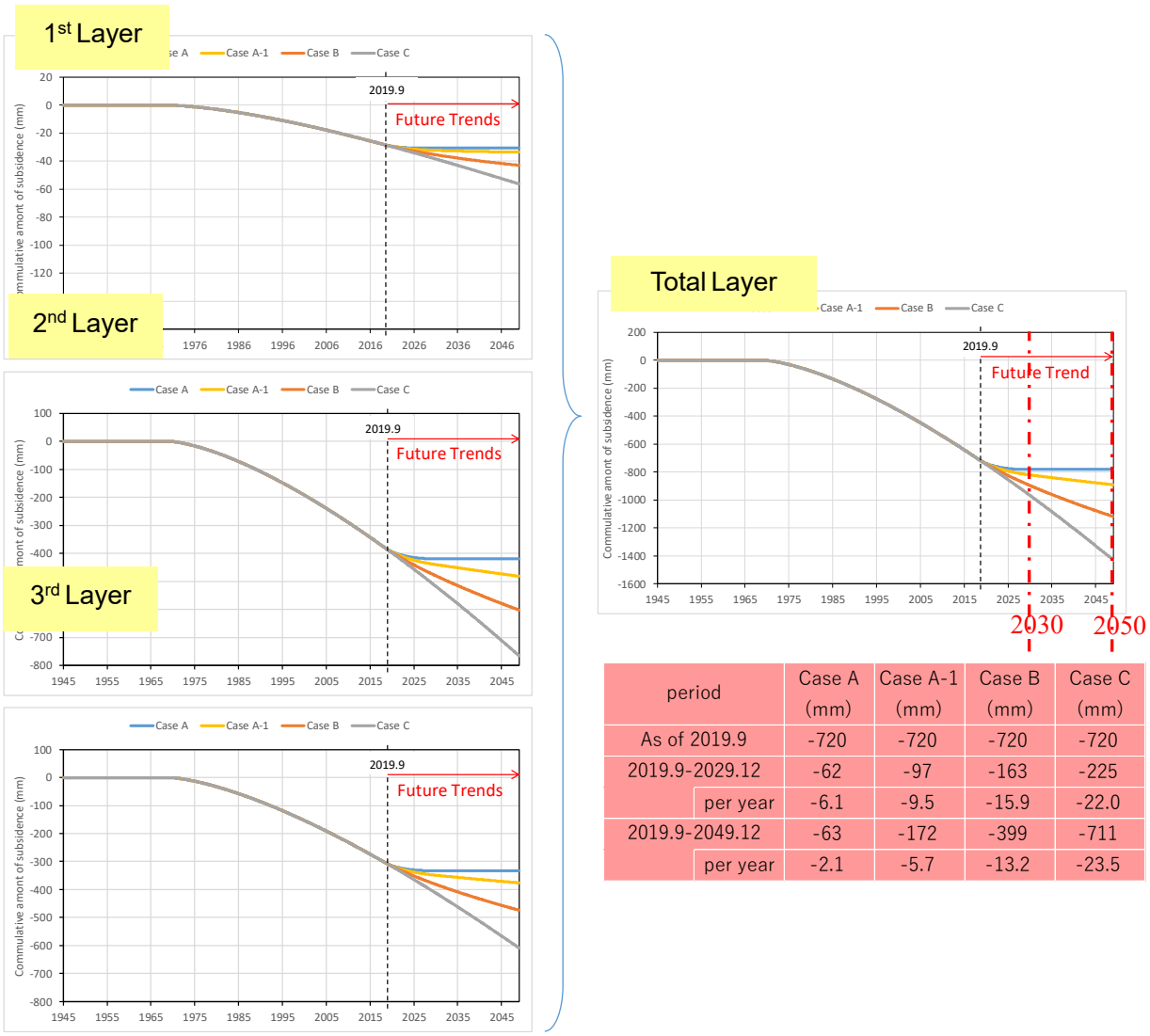
Case	Groundwater abstraction condition	Groundwater level in Dec. 2030	The amount of land subsidence (the current (2019.10) to 2050)								
			Kamal Muara (Western /coastal)	Cengkareng (Western)	Daan Mogot (Western)	Jakarta fish port (Central /coastal)	Tongkol (Central /coastal)	Sunter (Central)	Rawa Badak Stadium (Eastern /coastal)	Cakung (Eastern)	Marunda (Eastern /coastal)
A	100% reduce of the current groundwater abstraction volume	Recover to original level	-114 mm (-3.8 mm/yr)	-63 mm (-2.1 mm/yr)	-142 mm (-4.7 mm/yr)	-102 mm (-3.4 mm/yr)	-48 mm (-1.6 mm/yr)	-36 mm (-1.2 mm/yr)	-17 mm (-0.6 mm/yr)	-35 mm (-1.1 mm/yr)	-133 mm (-4.4 mm/yr)
A-1	50% reduce of the current groundwater abstraction volume	Drastically recovery	-307 mm (-10.1 mm/yr)	-172 mm (-5.7 mm/yr)	-389 mm (-12.9 mm/yr)	-278 mm (-9.2 mm/yr)	-115 mm (-3.8 mm/yr)	-100 mm (-3.3 mm/yr)	-48 mm (-1.6 mm/yr)	-96 mm (-3.2 mm/yr)	-372 mm (-12.3 mm/yr)
B	Remain the current groundwater abstraction volume	Remain the same level	-706 mm (-23.3 mm/yr)	-399 mm (-13.2 mm/yr)	-889 mm (-29.4 mm/yr)	-662 mm (-21.9 mm/yr)	-332 mm (-11.0 mm/yr)	-229 mm (-7.6 mm/yr)	-110 mm (-3.6 mm/yr)	-223 mm (-7.4 mm/yr)	-820 mm (-27.1 mm/yr)
C	Without regulation (Allowed to increase groundwater abstraction volume)	Continue to decrease	-1229 mm (-40.6 mm/yr)	-771 mm (-23.5 mm/yr)	-1537 mm (-50.8 mm/yr)	-1181 mm (-39.1 mm/yr)	-631 mm (-20.8 mm/yr)	-413 mm (-13.6 mm/yr)	-199 mm (-6.6 mm/yr)	-413 mm (-13.6 mm/yr)	-1405 mm (-46.5 mm/yr)
	Land subsidence amount ranking		3	5	1	4	6	7	9	7	2

Red : land subsidence more than 1 cm/yr



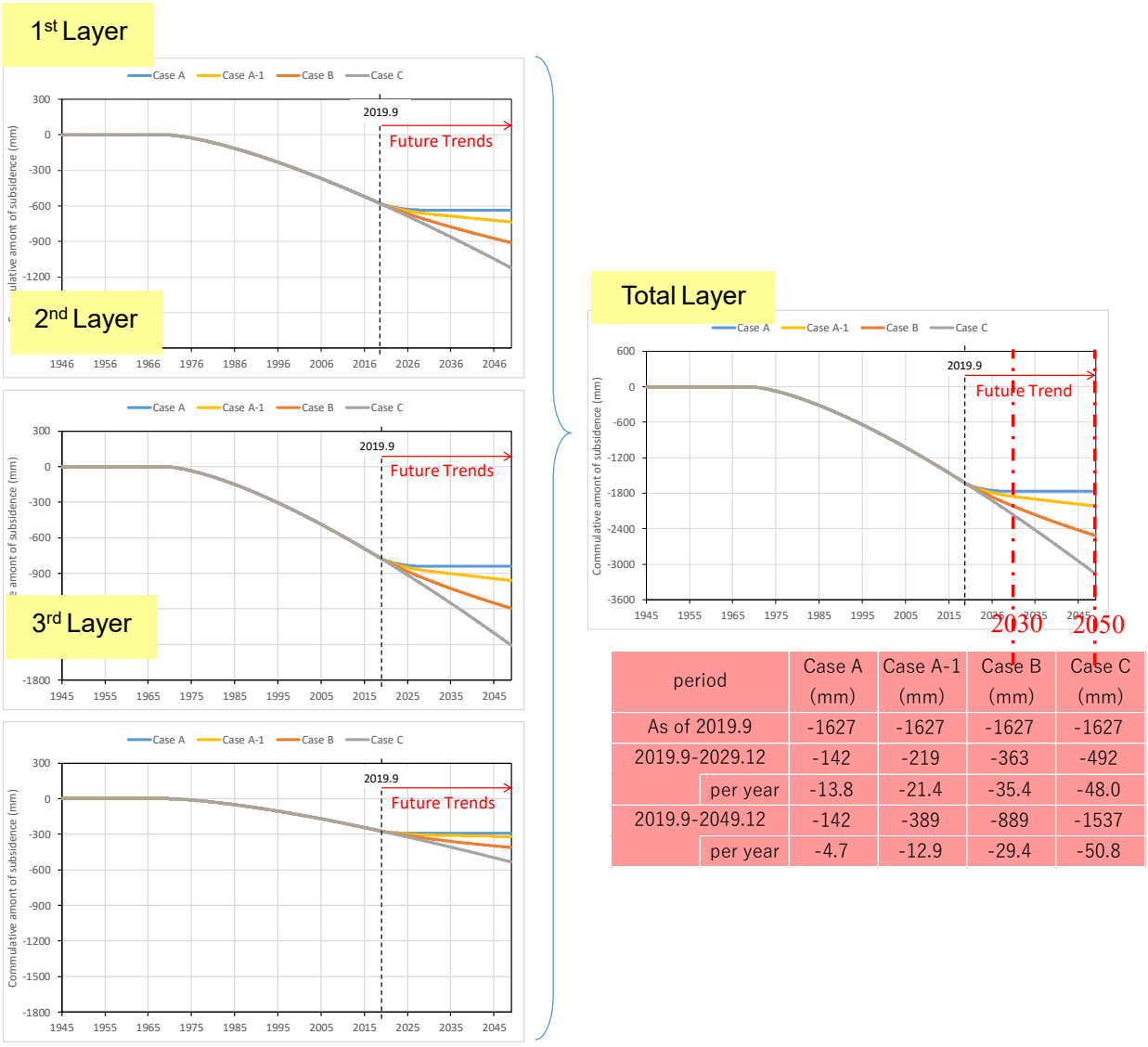
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-1314	-1314	-1314	-1314
2019.9-2029.12	-114	-176	-292	-396
per year	-11.1	-17.2	-28.4	-38.6
2019.9-2049.12	-114	-307	-706	-1229
per year	-3.8	-10.1	-23.3	-40.6

Figure 2.94 Result of land subsidence analysis (Kamal Muara / Case A, A-1, B, C)



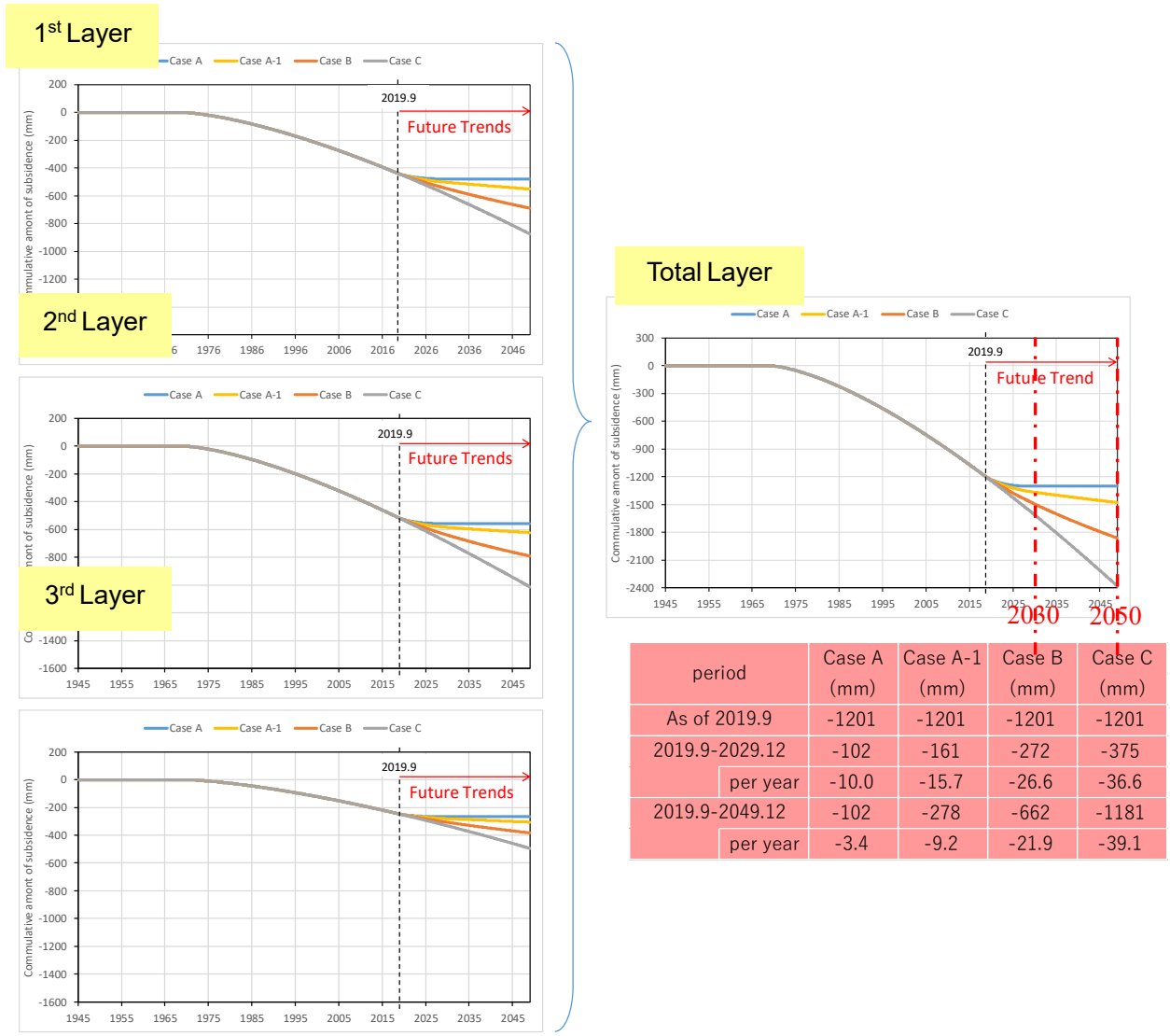
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-720	-720	-720	-720
2019.9-2029.12	-62	-97	-163	-225
per year	-6.1	-9.5	-15.9	-22.0
2019.9-2049.12	-63	-172	-399	-711
per year	-2.1	-5.7	-13.2	-23.5

Figure 2.95 Result of land subsidence analysis (Cengkareng / Case A, A-1, B, C)



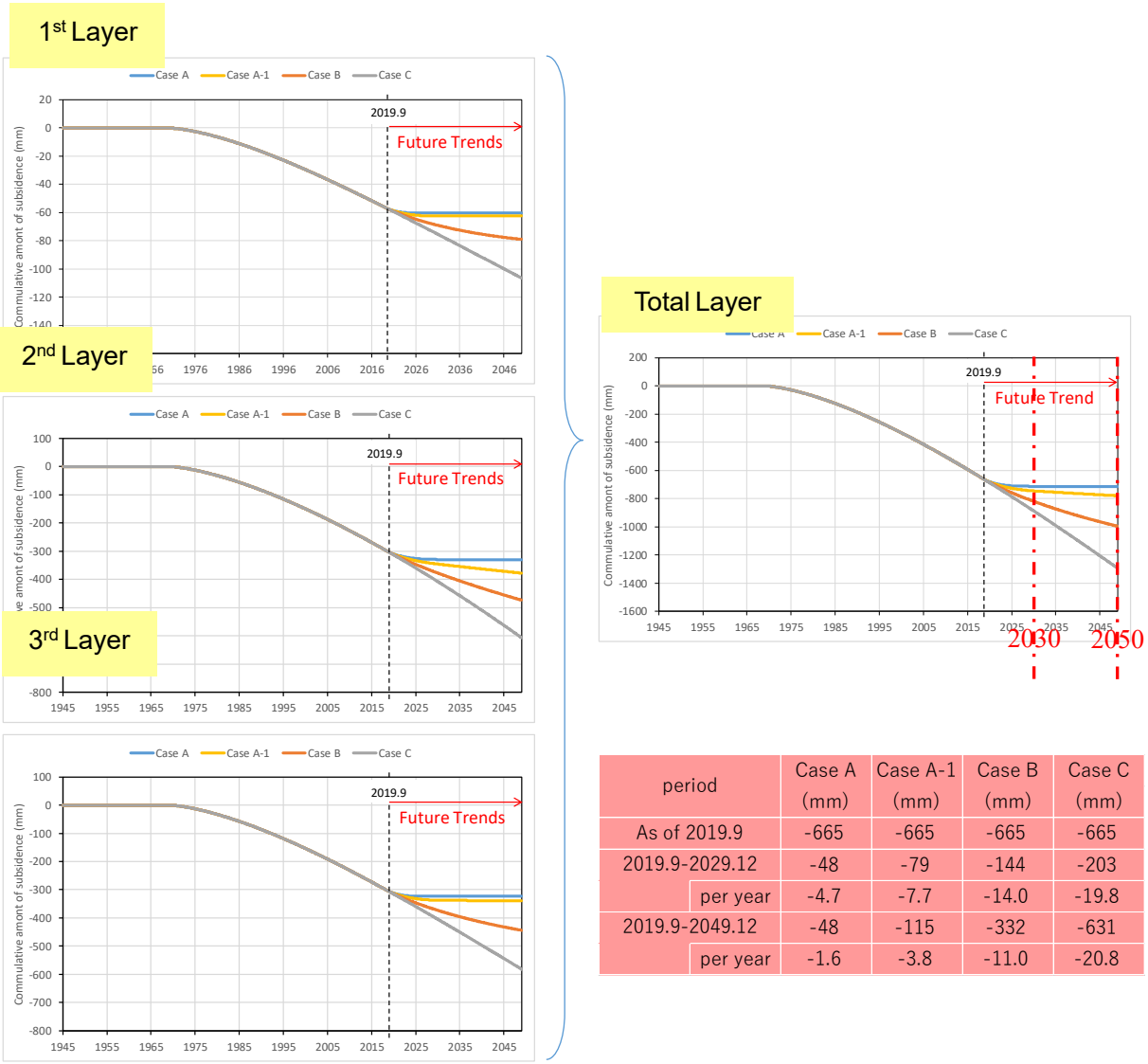
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-1627	-1627	-1627	-1627
2019.9-2029.12	-142	-219	-363	-492
per year	-13.8	-21.4	-35.4	-48.0
2019.9-2049.12	-142	-389	-889	-1537
per year	-4.7	-12.9	-29.4	-50.8

Figure 2.96 Result of land subsidence analysis (Daan Mogot / Case A, A-1, B, C)



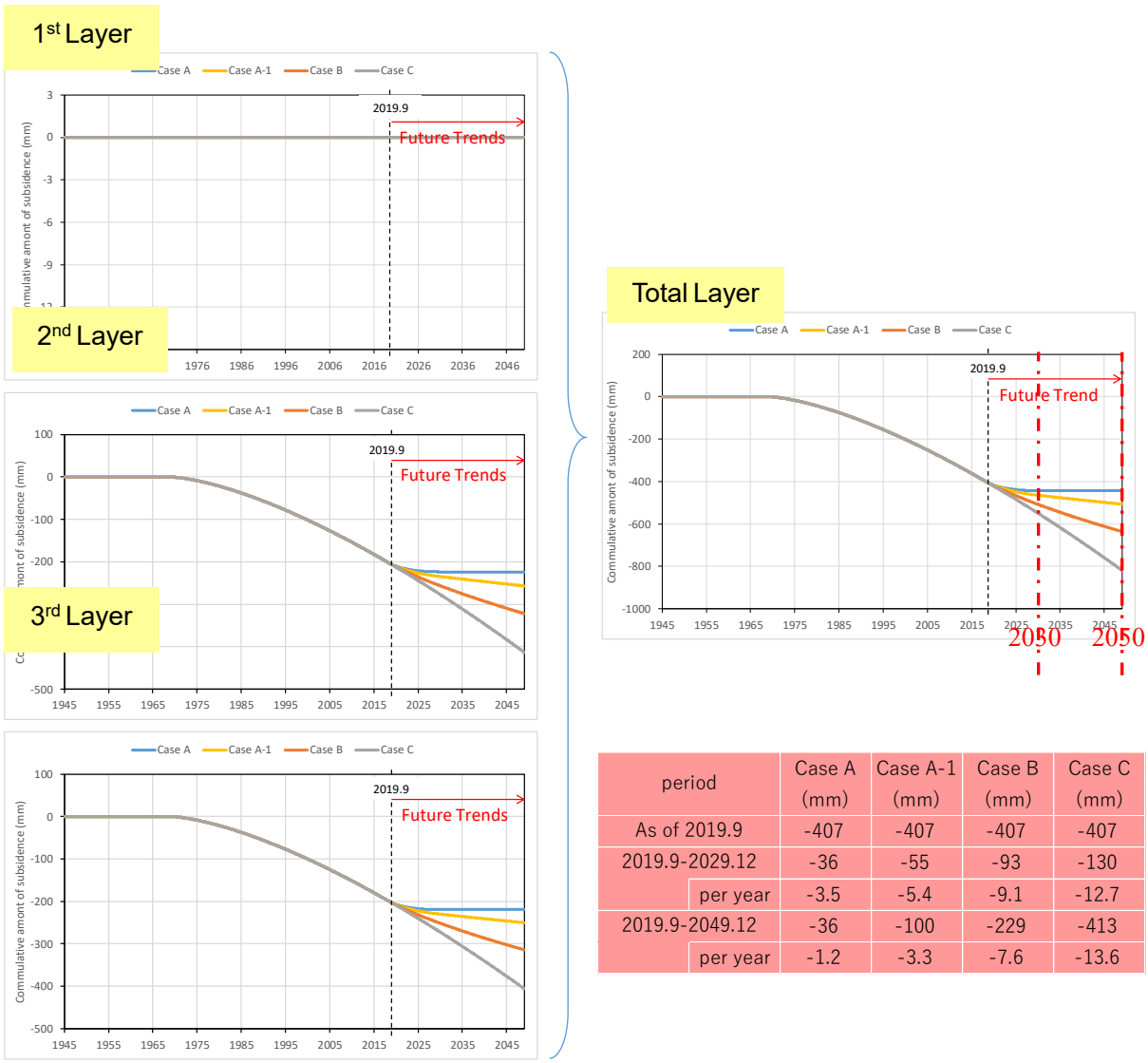
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-1201	-1201	-1201	-1201
2019.9-2029.12	-102	-161	-272	-375
per year	-10.0	-15.7	-26.6	-36.6
2019.9-2049.12	-102	-278	-662	-1181
per year	-3.4	-9.2	-21.9	-39.1

Figure 2.97 Result of land subsidence analysis (Jakarta fish port / Case A, A-1, B, C)



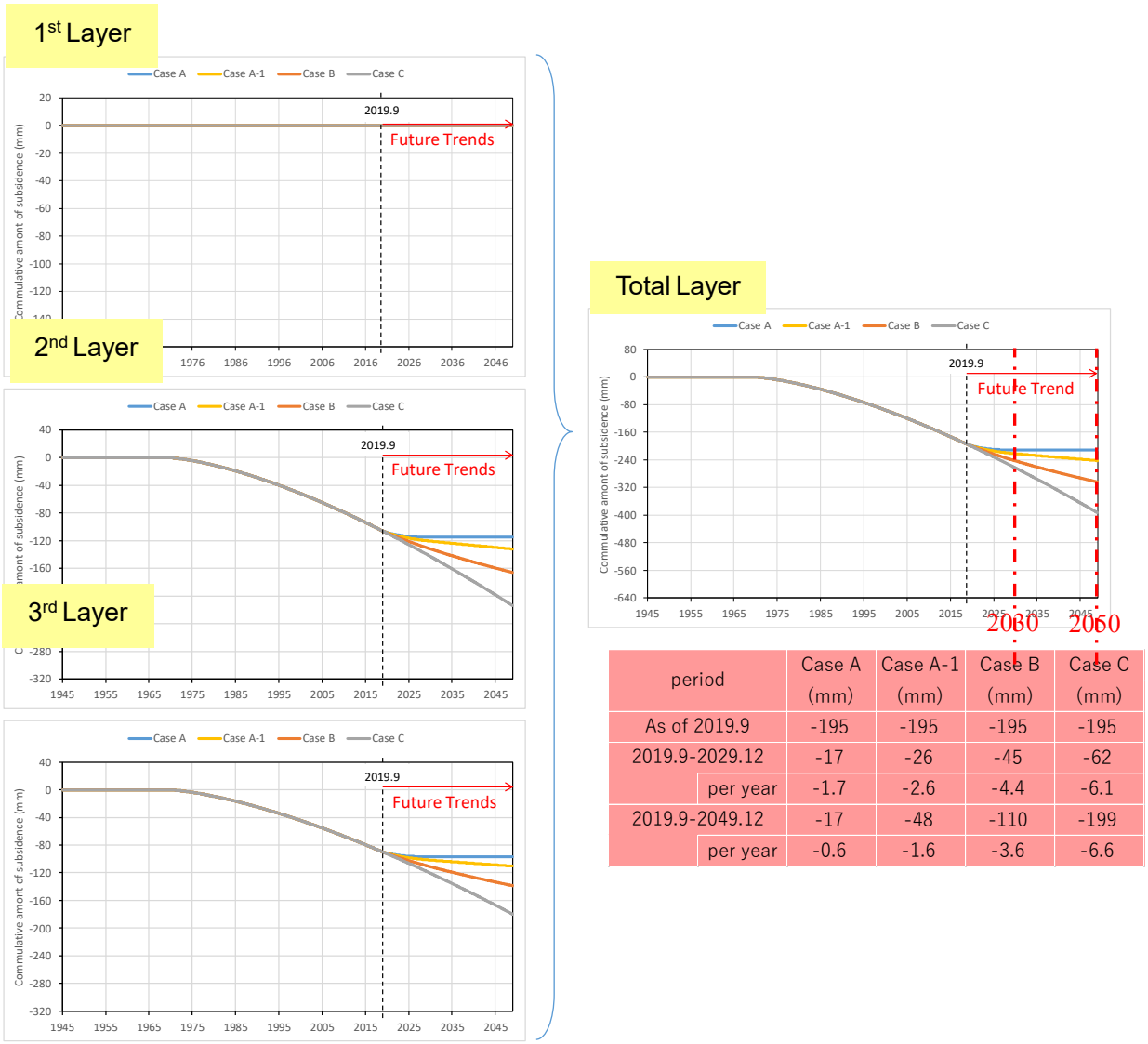
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-665	-665	-665	-665
2019.9-2029.12	-48	-79	-144	-203
per year	-4.7	-7.7	-14.0	-19.8
2019.9-2049.12	-48	-115	-332	-631
per year	-1.6	-3.8	-11.0	-20.8

Figure 2.98 Result of land subsidence analysis (Tongkol / Case A, A-1, B, C)



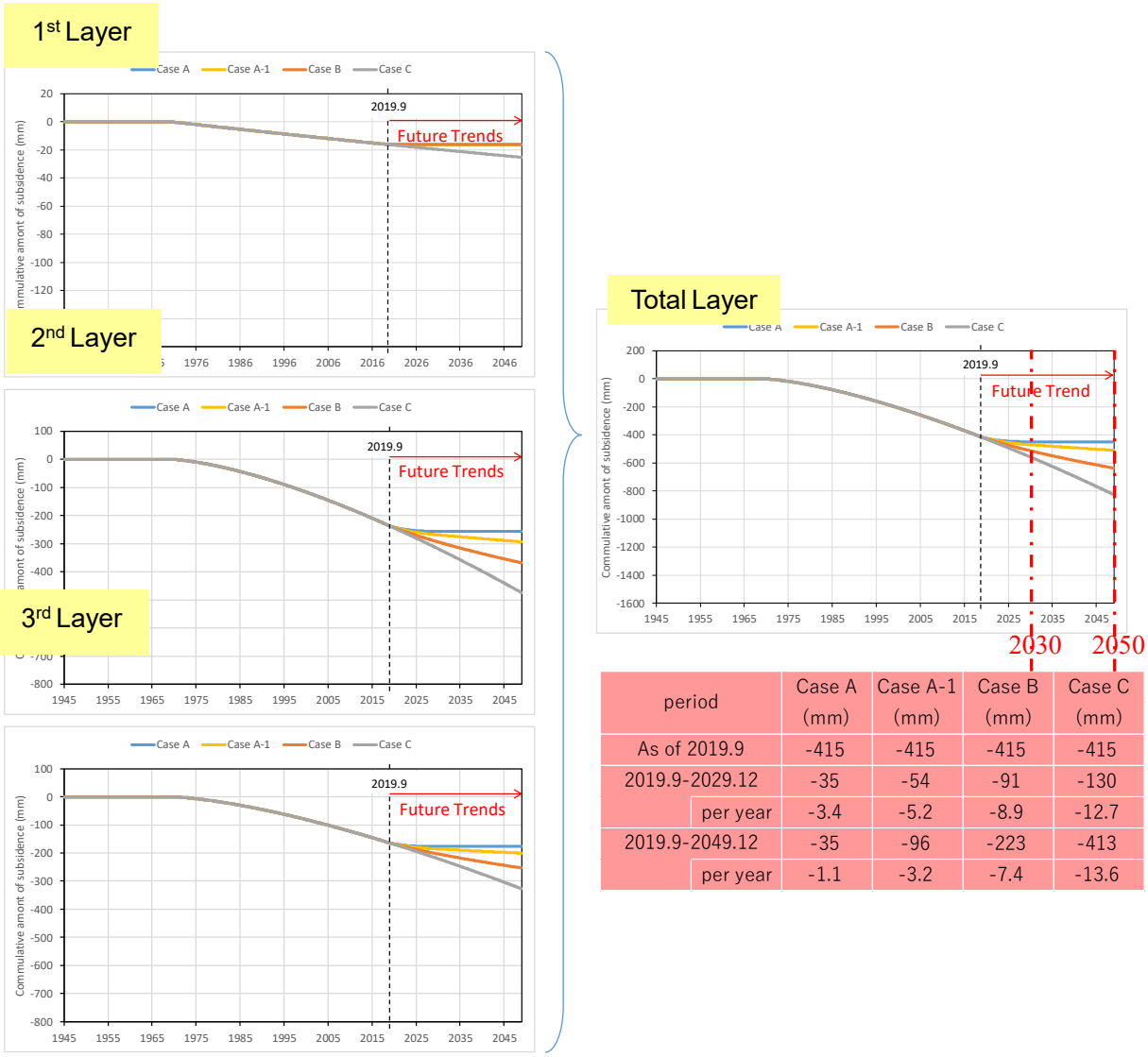
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-407	-407	-407	-407
2019.9-2029.12	-36	-55	-93	-130
per year	-3.5	-5.4	-9.1	-12.7
2019.9-2049.12	-36	-100	-229	-413
per year	-1.2	-3.3	-7.6	-13.6

Figure 2.99 Result of land subsidence analysis (Sunter / Case A, A-1, B, C)



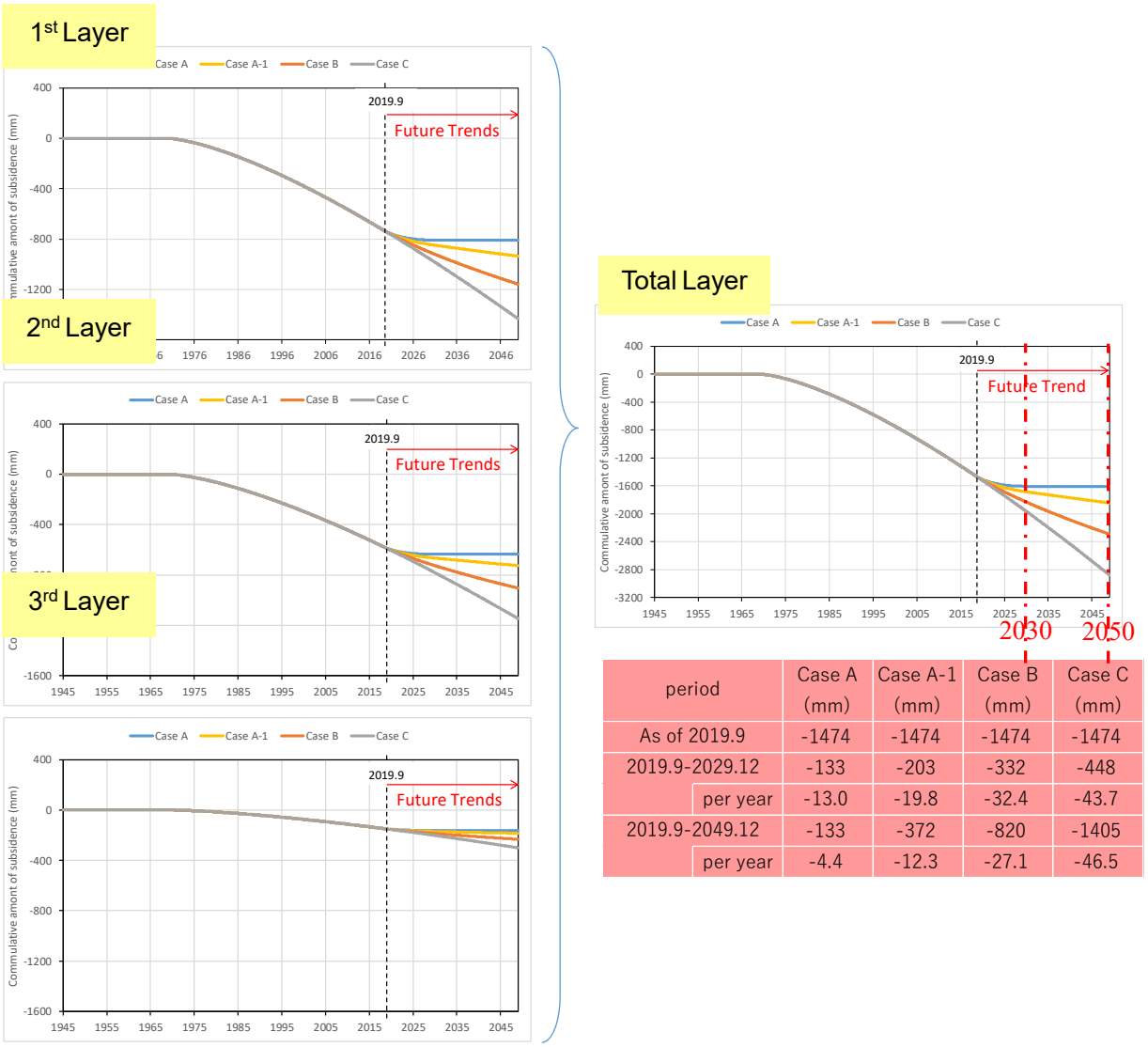
period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-195	-195	-195	-195
2019.9-2029.12	-17	-26	-45	-62
per year	-1.7	-2.6	-4.4	-6.1
2019.9-2049.12	-17	-48	-110	-199
per year	-0.6	-1.6	-3.6	-6.6

Figure 2.100 Result of land subsidence analysis (Rawa Badak Stadium / Case A, A-1, B, C)



period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-415	-415	-415	-415
2019.9-2029.12	-35	-54	-91	-130
per year	-3.4	-5.2	-8.9	-12.7
2019.9-2049.12	-35	-96	-223	-413
per year	-1.1	-3.2	-7.4	-13.6

Figure 2.101 Result of land subsidence analysis (Cakung / Case A, A-1, B, C)



period	Case A (mm)	Case A-1 (mm)	Case B (mm)	Case C (mm)
As of 2019.9	-1474	-1474	-1474	-1474
2019.9-2029.12	-133	-203	-332	-448
per year	-13.0	-19.8	-32.4	-43.7
2019.9-2049.12	-133	-372	-820	-1405
per year	-4.4	-12.3	-27.1	-46.5

Figure 2.102 Result of land subsidence analysis (Marunda / Case A, A-1, B, C)

2.7.6 Prediction Land Subsidence in the Future

In the study in November 2019, the future forecast of land subsidence in DKI Jakarta was examined, and it is predicted as shown in Table 2-41.

- Land subsidence tends to decrease in the order of Cengkareng in the west, Cakung in the east, and Tongkol in the north.
- If the groundwater level drops further without regulating the groundwater abstraction, land subsidence of 130 to 225 mm (about 1 to 2.5 cm/yr) is expected to occur by 2030.
- Even if the groundwater level is maintained by regulating groundwater abstraction that exceeds current groundwater abstraction volume, land subsidence of 91 to 163 mm (about 0.9 to 1.6 cm/yr) is expected to occur by 2030.
- If the groundwater abstraction regulations will be implemented to reduce the current groundwater abstraction volume by 100% by December 2030 and the groundwater level will recover to the original level, land subsidence of 35 to 62 mm (about 0.3 to 0.6 cm/yr) is expected to occur and approximately stop after that.
- To reduce land subsidence to less than 1 cm/yr at all three locations by 2030, groundwater abstraction volume need to be reduced by 50% by December 2030.

Table 2.47 Prediction values of the amount of land subsidence until 2030 at each survey sites

Case	Groundwater abstraction condition	Groundwater level in Dec. 2030	The amount of land subsidence (the current (2019.10) to 2030)		
			Cengkareng (Western)	Tongkol (Central /coastal)	Cakung (Eastern)
A	100% reduce of the current groundwater abstraction volume	Recover to original level	-62 mm (-6.1 mm/yr)	-48 mm (-4.7 mm/yr)	-35 mm (-3.4 mm/yr)
A-1	50% reduce of the current groundwater abstraction volume	Drastically recovery	-97 mm (-9.5 mm/yr)	-79 mm (-7.7 mm/yr)	-54 mm (-5.2 mm/yr)
B	Remain the current groundwater abstraction volume	Remain the same level	-163 mm (-15.9 mm/yr)	-144 mm (-14.0 mm/yr)	-91 mm (-8.9 mm/yr)
C	Without regulation (Allowed to increase groundwater abstraction volume)	Continue to decrease	-225 mm (-22.0 mm/yr)	-203 mm (-19.8 mm/yr)	-130 mm (-12.7 mm/yr)

Remark: Red figure means land subsidence more than 1cm per year.

Source: JICA Study Team

In contrast to the above future forecast, the monitoring results of the land subsidence monitoring wells constructed in 2019, the first stage of this project in 2019, are described in sub-chapter 2.7.2.

Based on the monitoring results so far, the situation and future forecast of land subsidence in Cengkareng (western region) and Cakung (eastern region) are considered as follows.

① Cengkareng（Western Region）

Annual subsidence amount of each well (shrinkage amount of each well target stratum) estimated from the annual subsidence amount (shrinkage amount of each well target stratum) of each well during the monitoring period is considered to correspond to Case A in the table. Annual shrinkage amount is several mm.

① Cakung（Eastern Region）

Annual subsidence of each well (shrinkage of each well target layer) estimated from the annual subsidence of each well (shrinkage of each well target layer) during the observation period is considered to be 3 to 5 mm per year. It is considered to correspond to Case A-1.

Changes in groundwater abstraction volume by 2022 in the Cengkareng (western region) and Cakung (eastern regions) regions are shown in sub-chapter 2.5.2 (2), 3).

In Cengkareng (western region), the amount of groundwater abstracted during the monitoring period (2019-2022) by the land subsidence monitoring well tends to decrease year by year.

In Cakung (eastern region), the amount of groundwater abstracted during the same period was almost identical.

2.7.7 Land Subsidence Monitoring Result by JICA Monitoring Well

The construction of land subsidence monitoring well by JICA was completed in May 2019 and monitoring/measurement was started in July of the same year.

(1) Amount of Land Subsidence (Shrinkage of target layer of each Well)

1) Tendency of the Change of Subsidence (Shrinkage of target layer of each Well) at each Monitoring Site

a) Cengkareng

① Results of observation by observation equipment

The amount of subsidence (shrinkage of target layer of each well) is very small from January to February 2020 for Deep Well, Middle Well, and Shallow Well. However, the subsidence (shrinkage of target layer of each well) has been progressing since March 2020, and it has been subsidence slightly since May 2020. However, shrinkage amount after September 2020 is as follows:

Deep Well : 2 mm

Middle Well : 3 mm

Shallow Well : 4 mm

The amount of shrinkage of each well between December 2020 and December 2021 is as small as 1 to 2 mm per year. At this point, the shrinkage of the target layer of each well is considered to have not progressed significantly at this time.

On the other hand, if the above-mentioned formation shrinkage for each well during the four-month period from April to August 2020 is converted to one year (12 months), the following shrinkage is

obtained, which is generally in agreement with the annual formation shrinkage for each well based on visual observation, as described below.

Deep Well：2mm×3= 6mm

Middle Well：3mm×3= 9mm

Shallow Well：4mm×3= 12mm

② Visual observation results

Visual observations began on March 9, 2020 and continued through August 8, 2022, as shown in Figure 2 103.

During the period from March 2020 to September 2020, each well shows a few mm of shrinkage, but the amount of formation shrinkage has increased in Middle Well (Well-2) and Deep Well (Well-1) since the end of March 2021. The observation confirmed that the amount of formation shrinkage in Middle Well (Well-2) has a significant impact on the overall amount of formation shrinkage.

In Shallow Well (Well-3), only slight strata shrinkage (5 mm) was observed after May 2022.

b) Cakung

① Results of observation by observation equipment

The amount of shrinkage of the target layer at this point is as small as 1 cm or less per year throughout the monitoring period.

On the other hand, shrinkage of the target layer is observed in the following two periods after the time when the equipment is considered to have become settle with the ground. All of these periods correspond to the period from the middle of the dry season to the beginning of the rainy season.

The amount of shrinkage of the target layer during the period from the end of the rainy season to the dry season is as follows.

July to October, 2020

Deep Well : 5 mm

Middle Well : 5 mm

Shallow Well : 3 mm

August to October, 2021

Deep Well : 3 mm

Middle Well : 2 mm

Shallow Well : 2 mm

The digital displacement observation sensors installed in each of the wells at this site were all damaged by lightning after January 2022 and are beyond repair; therefore, observations of ground shrinkage using the sensors have not been conducted since January 2022. We recommended that the C/P recommend and conduct regular visual observations as described below in the future.

② Visual observation results

Visual observations began on March 9, 2020 and continued through August 8, 2022, as shown in Figure

2 104.

During the period from March 2020 to September 2022, formation shrinkage was observed in Middle Well (Well-2) and Deep Well (Well-1), and during this period, formation shrinkage of about 3 mm each was observed. Thereafter, no formation shrinkage was observed in any of the wells until August 2021, but since then, formation shrinkage has been observed in Middle Well (Well-2) and Deep Well (Well-1) during the year from August 2021 to August 2022 (as in Chengkaren, the amount of shrinkage in Deep Well (Well-1) also includes the amount of shrinkage in Middle Well (Well-2)). Shallow Well (Well-3) was observed to contract by 1 mm in May 2022.

The same amount of formation shrinkage was also observed at this site for Deep Well (Well-1) and Middle Well (Well-2), but since both shrinkage amounts were small, it is judged that no significant formation shrinkage (land subsidence) has occurred.

These results indicate that the amount of shrinkage in Middle Well (Well-2) is large at the Chiangkaren site, and that the same amount of formation shrinkage was observed in Deep Well (Well-1) and Middle Well (Well-2) at Chakung, but the amount of formation shrinkage in each well is small, thus it is considered that no significant land subsidence has occurred at any of the well sites. It is necessary to confirm changes in the amount of ground shrinkage through continuous observation by the Indonesian side in the future.

With regard to the observation wells constructed in the first phase, there were periods of missing data due to equipment failure or malfunction in instrumental observations, and the accuracy of the observed data was somewhat questionable in some areas. On the other hand, the results of visual observation of formation shrinkage show that the amount of shrinkage in each well is Well-1 > Well-2 > Well-3, and the amount of formation shrinkage in Well-2 and Well-3 is reasonably related to the amount of formation shrinkage in Well-1.

Although the amount of formation shrinkage in each well is as small as about 1 cm/year in both locations constructed in the first phase, each observation well in each location is judged to be functioning as an observation well for the formation shrinkage.

On the other hand, the observation wells at the Jakarta fishing port constructed in the second phase are expected to require a certain amount of time to acclimate to the ground, similar to the observation wells constructed in the first phase, and it is necessary to confirm the amount of formation shrinkage and well operation status during future observations by the Indonesian side.

In Chakung, the digital displacement sensor was damaged by a lightning strike, so observation of formation shrinkage by the sensor is not possible. In Chiang Kalen, the electrical equipment up to the solar system and data logger has been improved, and the sensor is currently operating without any problems, but it is considered difficult to eliminate the occurrence of electrical problems, and there is a possibility that observations will be interrupted by the sensor in the future. Therefore, it is recommended that "visual observation of the amount of formation shrinkage," be used for future observations by visiting each observation point regularly once a month. In addition, while the amount of formation shrinkage for each aquifer is observed at each observation well, it is important to confirm the relationship between the amount of land subsidence and the amount of formation shrinkage at the observation well site by conducting surface surveys (GPS survey, level survey, etc.) once a year.

We recommended that DKI establish and implement a continuous observation system for the regular "visual observation" and "surface survey" mentioned above.

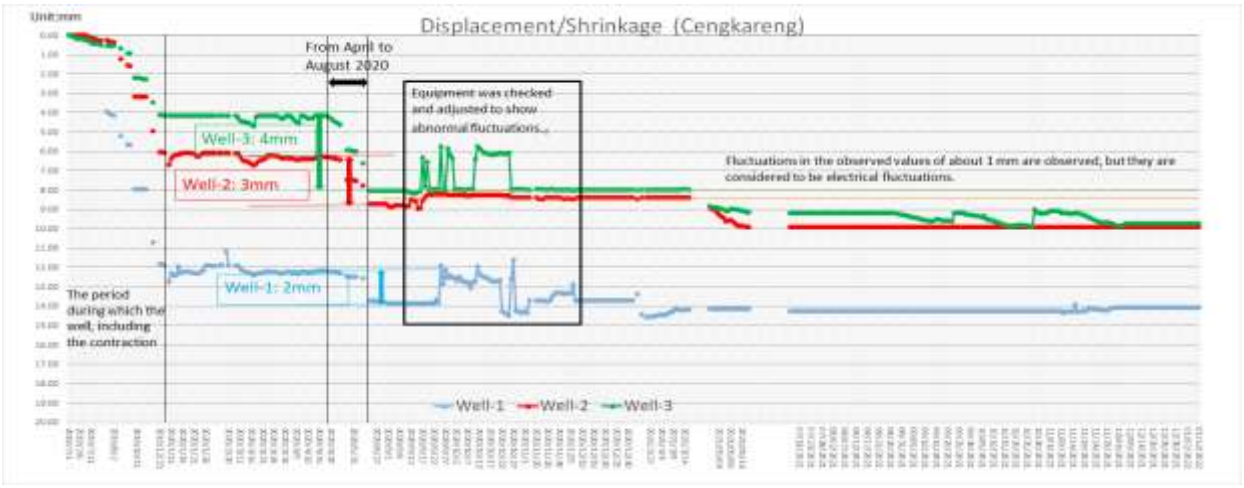


Figure 2.103 Amount of Land Subsidence (Shrinkage of the target layer) of each Monitoring Well (Cengkareng)

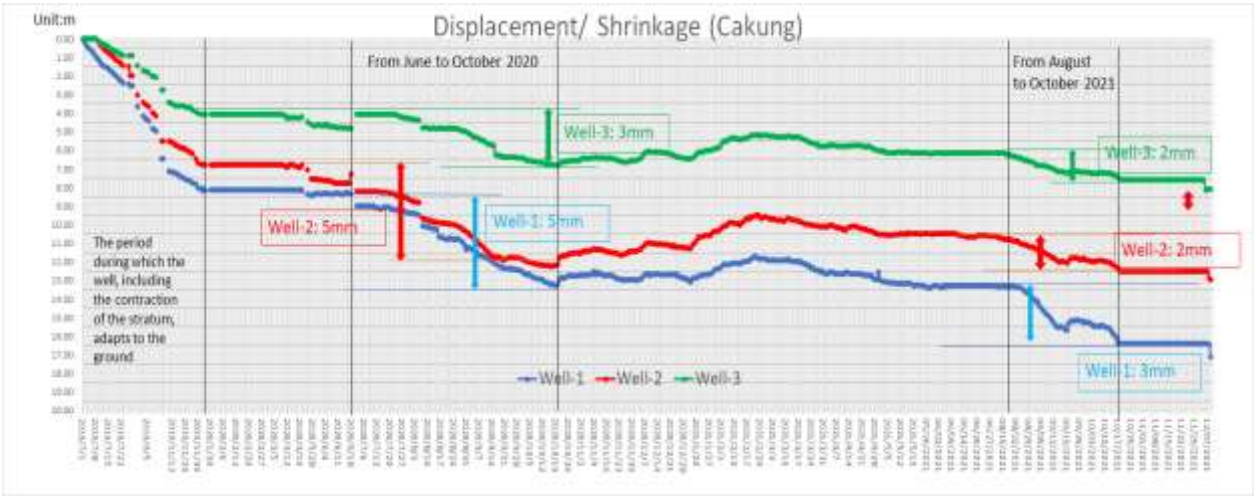


Figure 2.104 Amount of Land Subsidence (Shrinkage of the target layer) of each Monitoring Well (Cakung)

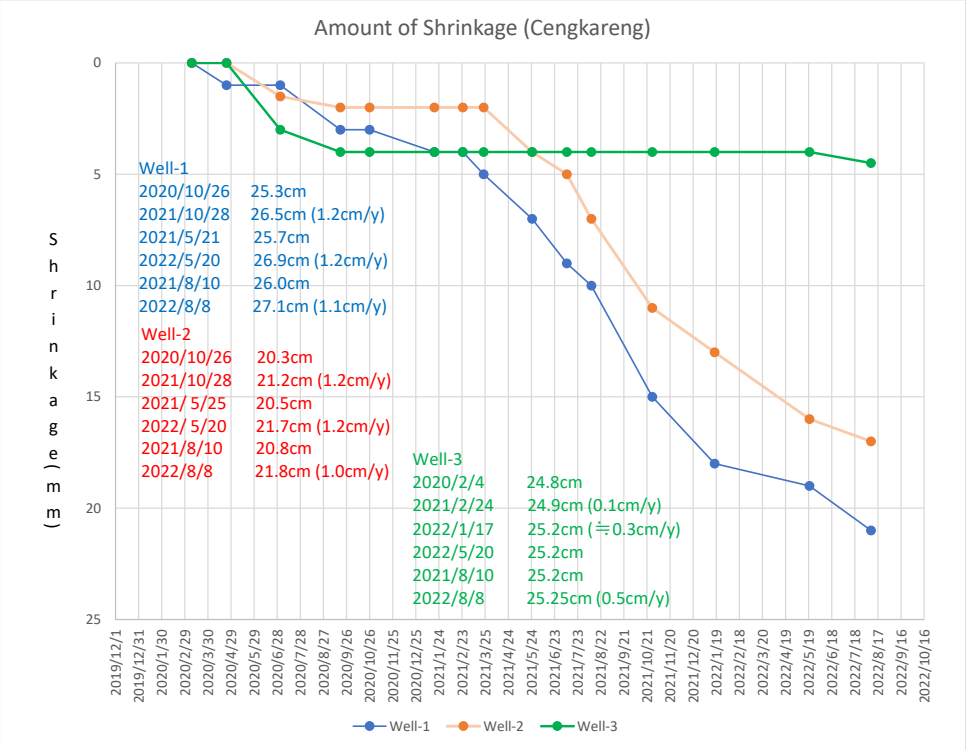


Figure 2.105 Visual observation of formation shrinkage in each well target formation (Cengkareng)

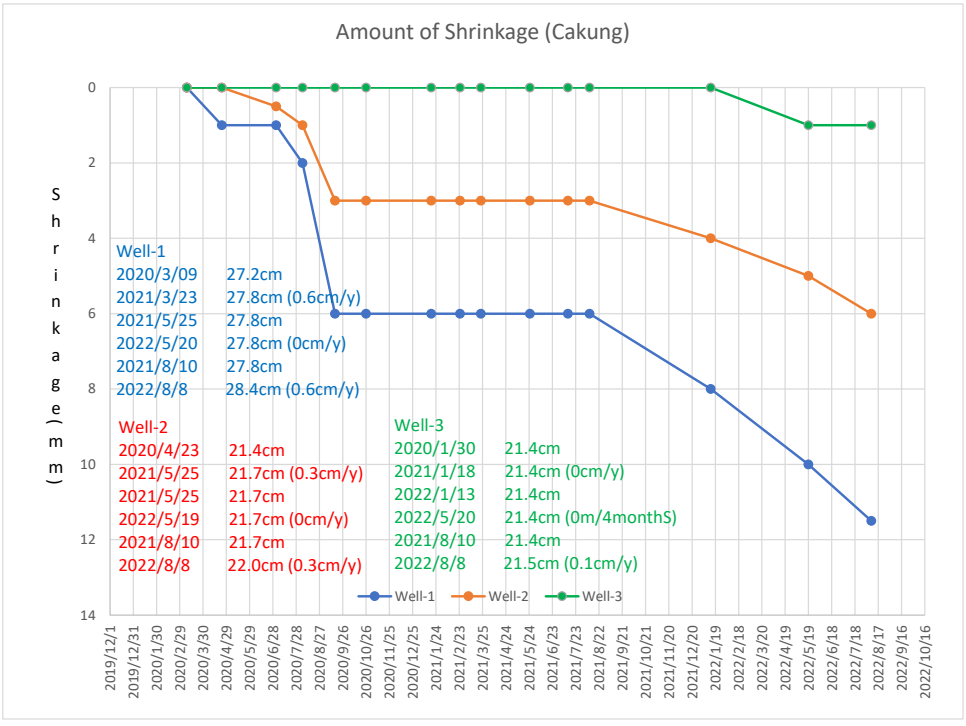


Figure 2.106 Visual observation of formation shrinkage in each well target formation (Cakung)

(2) Relation between Groundwater Level Change

1) Relationship between instrumental observation results and groundwater level changes

a) Cengkareng

Figure 2.107 shows the amount of shrinkage of layer and the change in the groundwater level of each well.

According to the figure, the following tendencies are observed

For Deep Well and Middle Well, the amount of shrinkage of layer is small and the fluctuation of the groundwater level is also small.

For Shallow Well, seasonal fluctuations between the rainy season and the dry season are observed throughout the observation period, but no significant changes in the shrinkage of layer is observed.

b) Cakung

Source: JICA Study Team

Figure 2.108 shows the amount of shrinkage of layer and the change in the groundwater level of each well.

According to the figure, the following tendencies are observed:

For Deep Well and Middle Well, tendency of change in the amount of shrinkage of layer similar to the change of the Shallow Well is observed.

For Shallow Well, clear and relatively remarkable groundwater level fluctuations are observed in the rainy season and dry season, and the amount of shrinkage of layer changes accordingly.

At this monitoring site, the shrinkage of layer of the Shallow Well possibly affect the shrinkage of layer of other monitoring wells. While for Deep Well, the shrinkage of layer with a very small amount is also conceivable.

2) Relationship between visual observation results and groundwater level changes

a) Cengkareng

Figure 2.107 shows the formation shrinkage and groundwater level change for each well.

The groundwater level changes for each well during the period of visual formation shrinkage observation at this site (March 2020 to August 2022) are shown below.

Deep Well（Well-1）: No significant seasonal variations were observed, but the overall trend over the period was a slight increase in groundwater levels.

Middle Well（Well-2）: No significant seasonal variations are observed; groundwater levels show a trend of decreasing from around GL.-41 m to around GL.-43 m in the period up to July 2020, followed by a decrease to around GL.-44 m in September 2021. Since then, groundwater levels have been around GL.-44 m with some fluctuations until August 2022.

Shallow Well（Well-3）: The groundwater level is considered to be more affected by the wet and dry seasons than other wells, but the groundwater level is about GL.-4 m.

Shrinkage of the strata has been significant between April 2021 and January 2022, but groundwater levels in Middle Well (Well-2) have not been observed to drop significantly during this period, although a slight downward trend has been observed.

b) Cakung

Figure 2.108 shows a graph of formation shrinkage and groundwater level change for each well.

The groundwater level changes for each well during the period of visual formation shrinkage observation at this site (March 2020 to August 2022) are shown below.

Deep Well（Well-1）:

No seasonal variations were observed; groundwater levels tended to rise slightly in the period up to August 2021, but since then groundwater levels have shown a mostly stable to very slight downward trend.

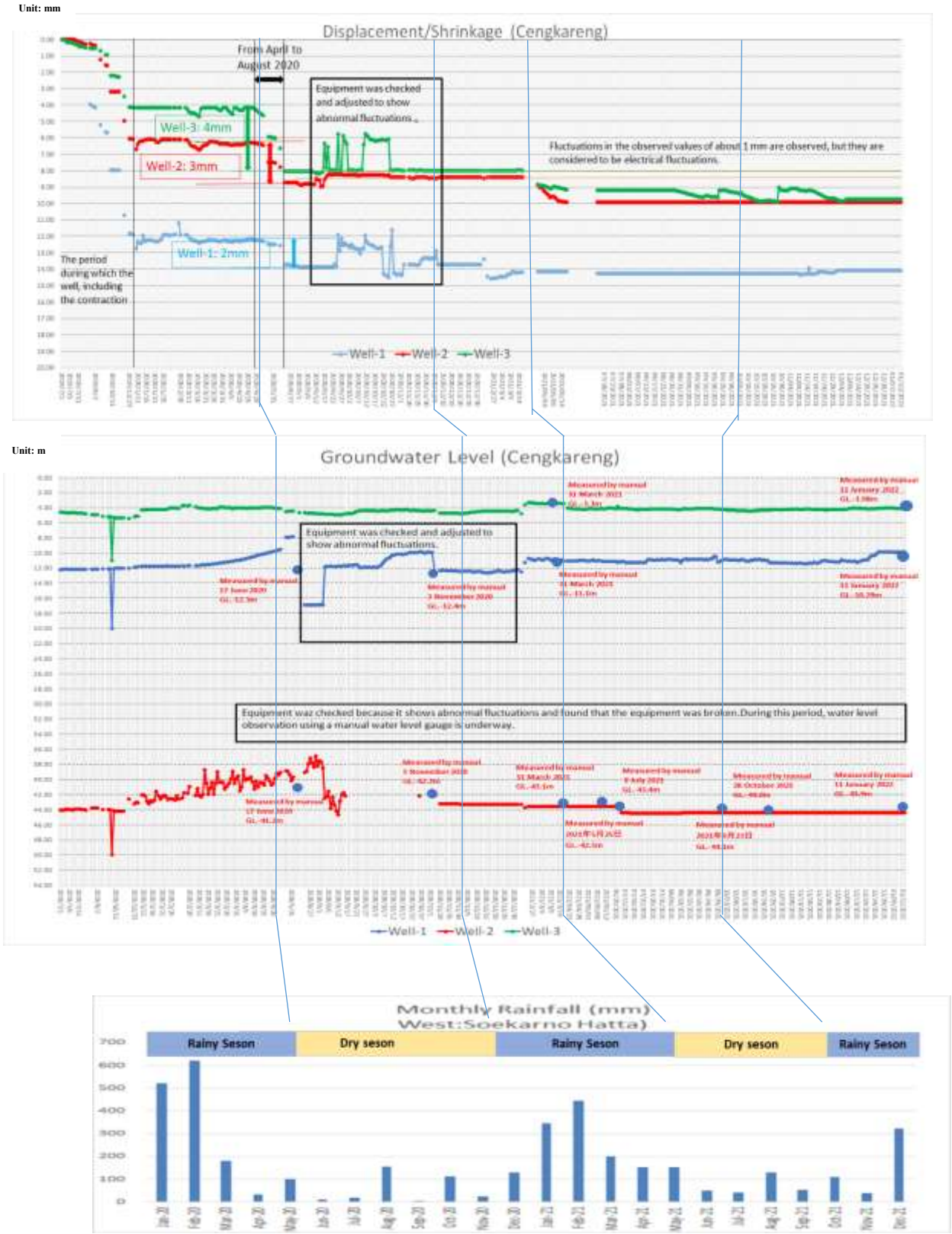
Middle Well（Well-2）:

No significant seasonal variations was observed; groundwater levels tended to rise slightly in the period up to August 2021, but groundwater levels have stabilized since then and were about GL.-21 m in August 2022.

Shallow Well（Well-3）:

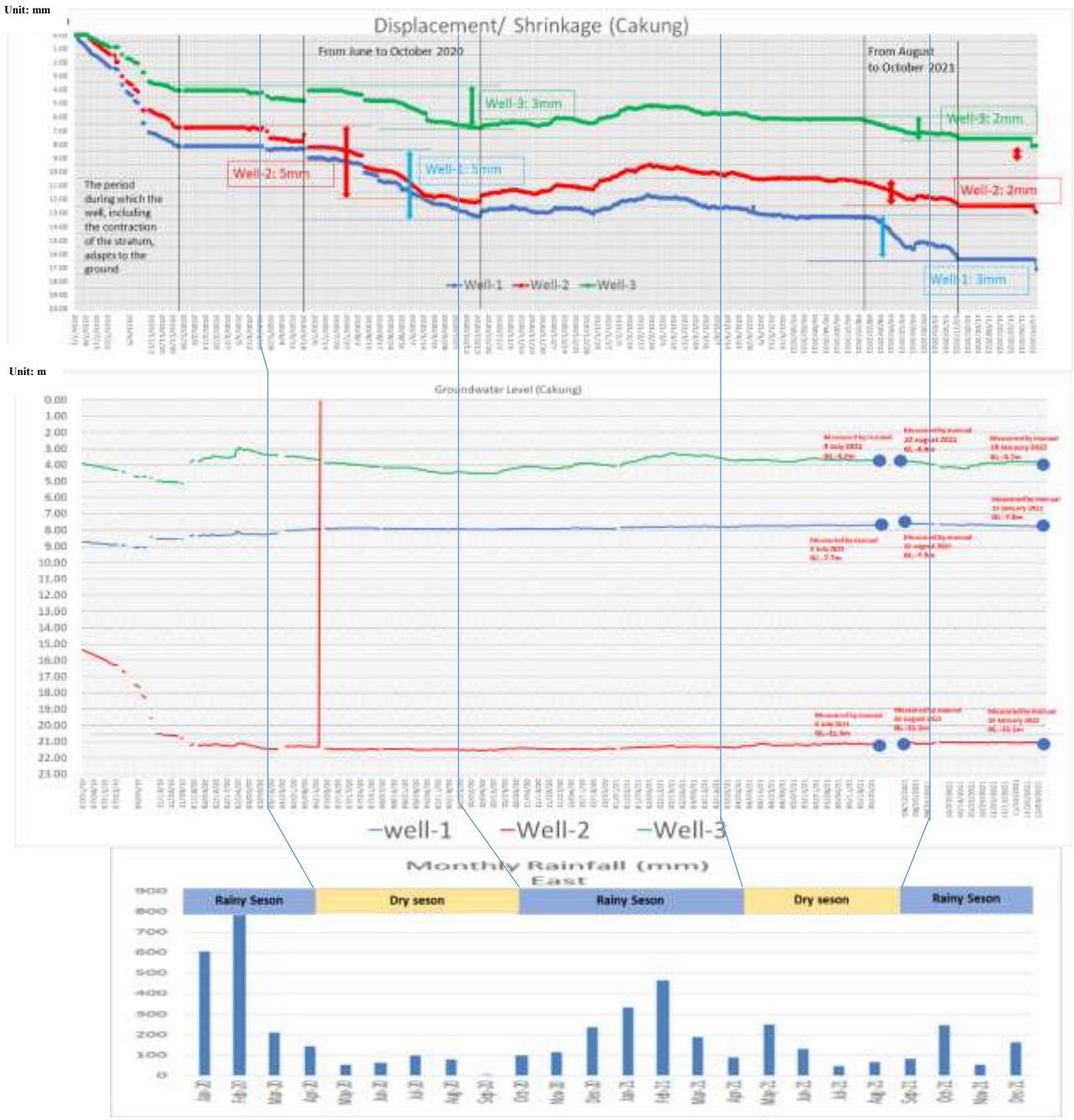
The influence of wet and dry seasons is more significant than other wells, and a difference in groundwater level of about 1 m was observed; in August 2022, the level was about GL.-3.7 m.

There is a trend of formation shrinkage in each well from March to September 2020. However, no significant change in groundwater levels is observed in each well during this period. On the other hand, formation shrinkage is seen after August 2021, and around August 2021, as mentioned above, there is no significant decline in groundwater levels in the Deep Well (Well-1) and Middle Well (Well-2), but there is a trend toward conversion of groundwater level changes. These changes in groundwater level fluctuations and the occurrence of slight formation shrinkage should be examined in combination with changes in groundwater use in the surrounding area through long-term observations.



Source: JICA Study Team

Figure 2.107 Relationship between Landsubsidence(Shrinkage of Layer) and Groundwater Level Change（Cengkareng)



Source: JICA Study Team

Figure 2.108 Relationship between Landsubsidence(Shrinkage of Layer) and Groundwater Level Change（Cakung)

(3) Relationship with Future Forecast of Land Subsidence

Assuming the annual land subsidence rate (yearly amount of shrinkage of layer) after January 2020, the amount is small and estimated to be less than 10 mm/yr at both monitoring site. This annual land subsidence (shrinkage of layer) rate corresponds to the following cases in the future subsidence amount prediction of each site show in Table 2-41.

Cengkareng : Amount is about Case A (when the amount of groundwater abstraction is reduced 100%) predicted in the future.

Cakung : Amount is about Case A-1 (when the amount of groundwater abstraction is reduced 50%) of future forecast

Based on the relationship between the annual amount of land subsidence (shrinkage of layer of each well) observed during the monitoring period until now and the future forecast, it is considered that the groundwater level is considered to be not decreased in Cengkareng and the groundwater abstraction volume the surrounding area is thought to be already decreased. Therefore, the tendency of the groundwater level to rise in the medium term need to be confirmed by continuing the monitoring.

On the other hand, in Cakung, although the change in groundwater level does not tend to decrease significantly, land subsidence (shrinkage of layer) is observed, even though the subsidence amount is very slight.

In addition, about 1 km northwest of the Cakung site, the development of large-scale commercial and residential facilities is currently underway as Sedaya City. If groundwater will be used by abstraction in these facilities in the future, there is a possibility that the groundwater level will drop significantly in this area and it will cause shrinkage of layer (land subsidence).

Therefore, the current state of land subsidence (shrinkage of layer) and groundwater level changes need to be confirmed, as well as their future changes through continuous monitoring.

2.8 Groundwater Analysis

2.8.1 The Necessity of Groundwater Analysis

Since the main cause of land subsidence in Jakarta is excessive groundwater pumping, it is necessary to consider appropriate groundwater use in order to control land subsidence. For this purpose, groundwater analysis is important to quantitatively evaluate the water balance in DKI Jakarta (including the area around DKI). If the water balance in DKI Jakarta is clarified by groundwater analysis, the amount of groundwater that can be used at which points can be evaluated quantitatively and concretely.

To control the current excessive groundwater pumping, surface water development, rainwater harvesting, and reclaimed water use need to be implemented. However, since these measures are difficult to implement in the short term, groundwater analysis will be an important tool to consider a phased approach (appropriate groundwater use).

Ultimately, the results of the groundwater analysis are important to be utilized to develop an effective and efficient water use plan (a plan that balances supply and demand) that appropriately uses surface water, groundwater, rainwater, and recycled water in DKI Jakarta (Including phased response).

On the other hand, groundwater analysis can also be used for proper management of groundwater (information collection, analysis and evaluation, communication, and decision-making). Furthermore, it can be used to visualize groundwater flow and help local people understand groundwater, thereby raising awareness of the importance of groundwater conservation.

2.8.2 Selection of the Groundwater Analysis method

(1) Selection of the Groundwater Analysis method

In order to conduct extensive groundwater analysis in the entire Jakarta Special State, 3D groundwater analysis is necessary. Various methods for 3D groundwater analysis are available, such as MODFLOW and GETFLOWS. To conduct the analysis under various conditions (rainfall, topography, geology, groundwater pumping conditions), the operability of the model is also an important option. Also, technical support and transfer to the Indonesian government should be considered.

Considering the above, MODFLOW is selected as the most appropriate model based on its open source nature, the fact that it is the method used by the Indonesian government for groundwater analysis (I-MOD; used in PUSAIR, etc.), and its mobility (efficient calculation time, etc.).

Table 2-48 Groundwater Analysis model in the world

Tool	Developed by	Mesh	Surface water	Unsaturation	Saturation	multiphase flow	Deformation	Method
MODFLOW	USGS	S/US	○	○	○		○	FV/IFD
MIKE-SHE	DHI	S	○	○	○			FD
FEFLOW	DHI	S/US	○	○	○		○	FE/CVFE
HydroGeoSphere	Aquanty	S/US	○	○	○			CVFE
OpenGeoSys	OGS Com	S/US	○	○	○		○	FE
TOUGH2	LBNL	S/US		○	○	○		IFD
TOUGHREACT	LBNL	S/US		○	○	○		IFD
FEMWATER	USACE	S/US		○	○			FE
HYDRUS	PC-Progress	S/US		○	○			FE
GETFLOWS	University of Tokyo, etc.	S	○	○	○	○		FV
Dtransu-3DEL	Okayama Univ. et al.	S/US		○	○			FE

【Developed by】USGS : United States Geological Survey, DHI : Dutch Hydrological institution, OGS Com : Open Source Community, LBNL : Lawrence Berkeley National Laboratory, USACE : United States Army Corps of Engineers, Aquanty : https : //www.aquanty.com/、 PC-Progress : https : //www.pc-progress.com/en/default.aspx

【Mesh】 S : Structured mesh, US : Unstructured mesh

【Method】 FV : Finite Volume Method, IFD : Integral finite-difference methods、FD : finite-difference methods, FE : Finite Element Method, CVFE : Control Volume Finite Element Method

(2) Contents of Groundwater Analysis

The following items should be considered when conducting groundwater analysis.

- Re-examination of the hydrogeological structure (comparison with existing studies)
- Classification of aquifers and impermeable layers and setting of hydraulic constants (coefficient of permeability)
- Establishment of hydrogeological model for analysis
- Groundwater analysis using an appropriate groundwater analysis model (MODFLOW) for the site

a. This analysis uses GMS (Groundwater Modelling System, Auaveo, Inc.), which is equipped with multiple versions of MODFLOW developed by the USGS (United States Geological Survey).
b. The GMS can be easily used in various versions, including the core version MODFLOW-2005, MODFLOW-NWT with enhanced stability of numerical solutions, and MODFLOW-USG, which can be applied to unstructured grid models (currently the USGS has integrated the core version as MODFLOW6).
c. In addition, MODFLOW-USG is equipped with a wide range of practical functions required for modelling examinations, such as GIS, solid modelers, inverse analysis, and graphic tools.
d. In this study, MODFLOW-NWT is applied since it is necessary to incorporate the modeled 3D geological structure quickly and to solve the long-term evolution of unconfined and pressurized groundwater flow in a stable manner.

(3) Concrete Analysis method

The specific scope of the groundwater analysis, the analysis conditions, and the results obtained from the analysis are as follows.

■Target Area
DKI Jakarta and its neighborhood
■Analysis condition
- Topography and Geology
- Land use
- Vegetation
- Rainfall
- River conditions
- Groundwater pumping rate
- Groundwater observation

■Analysis result
- Water balance for the entire DKI Jakarta
- Groundwater flow
- Future prediction of groundwater level
- Visualization of groundwater

(4) Utilization of groundwater analysis results

The following are examples of how the results of groundwater analysis can be used.

■Utilization
- Understand the impact of excessive use of groundwater on groundwater
- Predict the future groundwater levels
- Visualize the groundwater
- Improve the understanding on groundwater conservation in DKI Jakarta and its residents (understanding of the need for groundwater conservation)
- Utilize for public relations activities for groundwater conservation
- Propose appropriate ways of using groundwater (including gradual use)
- Future prediction of groundwater level in consideration of climate change (taking into account salt water run-up, etc.)

2.8.3 Model Establishment for Groundwater Analysis

The examination flow is as below.

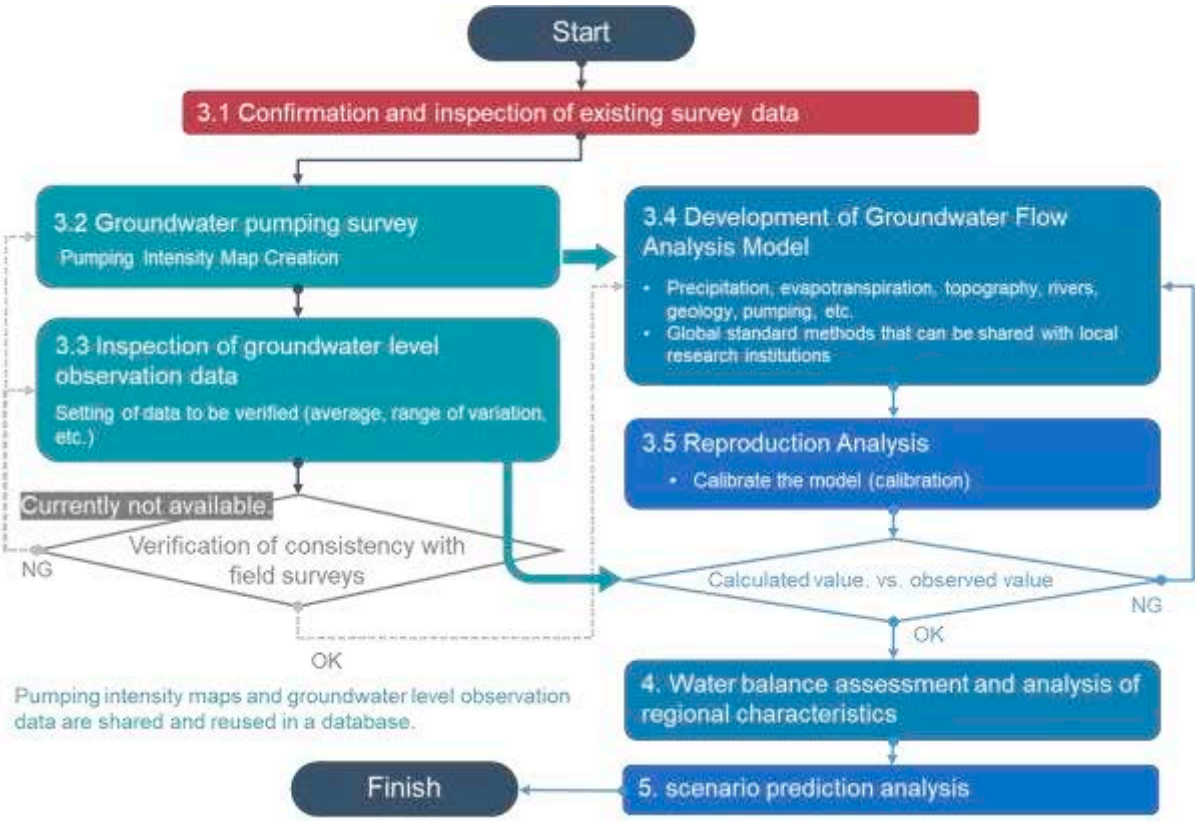
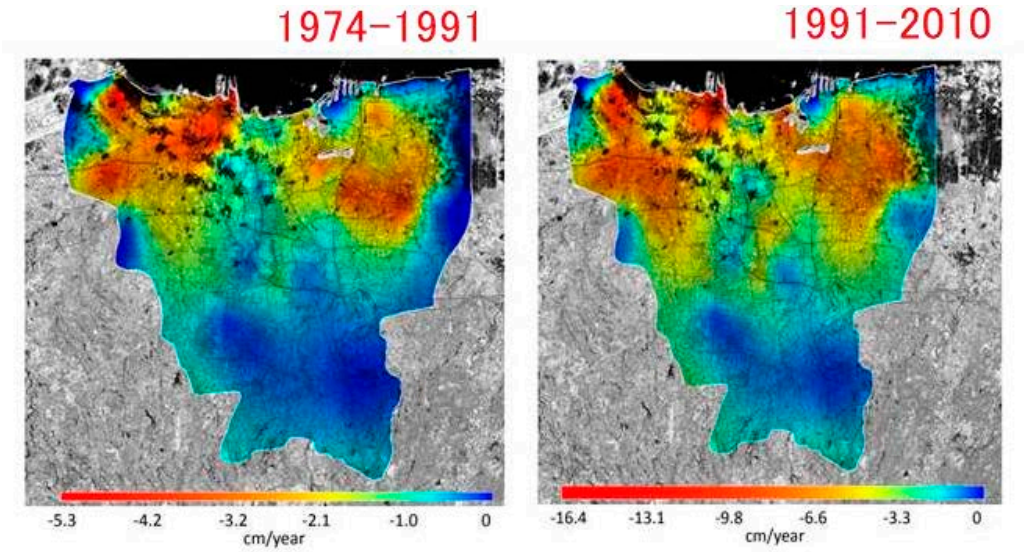


Figure 2-109 Examination Flow

(1) Organizing existing survey data

The following is a summary of the existing survey data. As for the amount of ground subsidence, the results show that the amount of subsidence is larger in coastal areas as shown below.



SOURCE : ABIDIN, H. Z., ANDREAS, H., GUMILAR, I., & BRINKMAN, J. J. (2015). STUDY ON THE RISK AND IMPACTS OF LAND SUBSIDENCE IN JAKARTA. PROCEEDINGS OF THE INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES, 372, 115-120.

Figure 2-110 Amount of Land Subsidence (1974 ~ 2010)

Regarding the pumping amount of registered wells (shallow wells and deep wells), as shown below, the annual pumping amount is shown in Document-1 (9 million m^3/y), Document-2 (50 to 80 million m^3/y), and Document-3 (20 million m^3/y). Therefore, it is difficult to clearly identify the pumping amount of the registered wells. However, the pumping amount of the registered wells confirmed in this survey is 11 million m^3/y, which is a smaller value than the previous data. Based on this result, we believe that it is possible to assume a pumping rate that is two to five times higher than the results of this survey on the pumping rate of registered wells.

Document-1

Table 1 Groundwater extraction from 2013–2015

Area	Total number of deep wells			Groundwater extraction (m^3)		
	2013	2014	2015	2013	2014	2015
Central Jakarta	641	678	676	817,255	902,159	1,069,829
West Jakarta	745	735	736	1,088,695	1,113,293	1,217,673
South Jakarta	1,613	1672	1680	3,833,332	4,886,166	5,182,929
East Jakarta	981	960	956	1,500,107	1,385,193	1,247,004
North Jakarta	426	428	427	518,727	562,977	426,049
TOTAL	4,406	4,473	4,475	7,758,116	8,849,788	9,143,484

Source: Ministry of Public Works, DKI Jakarta Province (2016)

HUTABARAT, L. E., & ILYAS, T. (2017). MAPPING OF LAND SUBSIDENCE INDUCED BY GROUNDWATER EXTRACTION IN URBAN AREAS AS BASIC DATA FOR SUSTAINABILITY COUNTERMEASURES. INTERNATIONAL JOURNAL OF TECHNOLOGY, 8(6), 1001-1011.

Figure 2-111 Document-1, Groundwater extraction (2013~2015)

Document-2

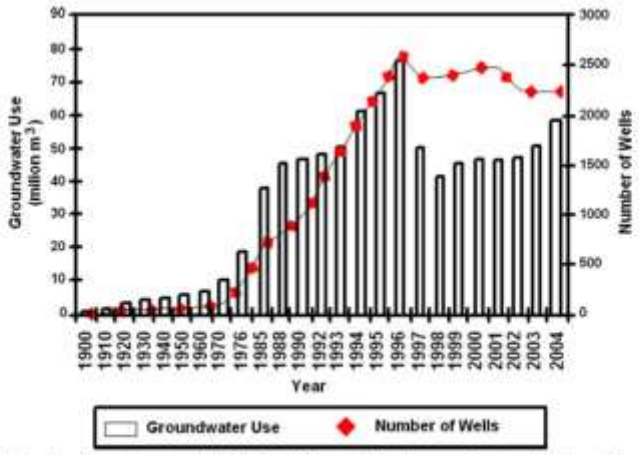
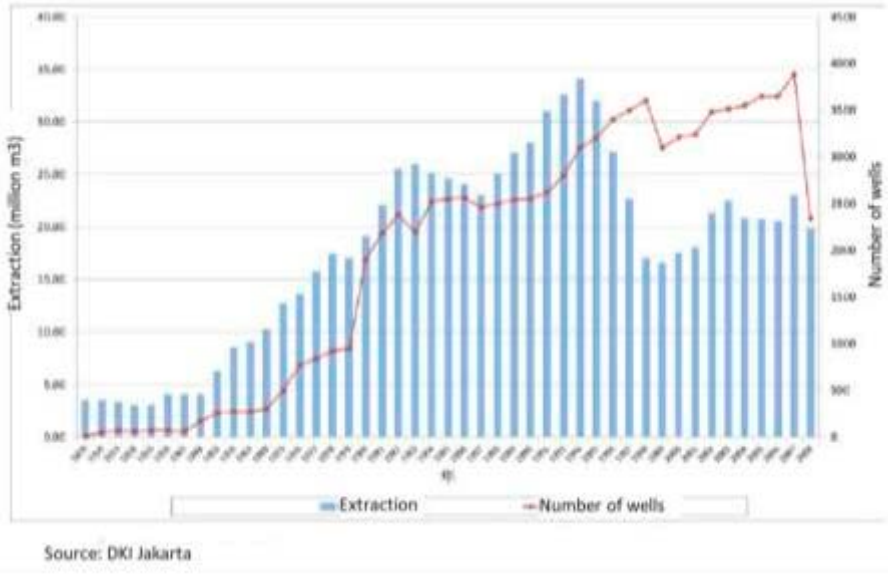


Fig. 2 Numbers of wells in the abstraction period 1900–2004. Source: Based on monitoring data from Directorate of Environmental Geology (1900–2001) and the Mining Agency of West Java Province (2001–2004). After Wangsaatmadja et al. 2006

DELINOM, R. M. (2009). STRUCTURAL GEOLOGY CONTROLS ON GROUNDWATER FLOW : LEMBANG FAULT CASE STUDY, WEST JAVA, INDONESIA. HYDROGEOLOGY JOURNAL, 17(4), 1011-1023.

Figure 2-112 Document-2, Changes in groundwater extraction and number of operating wells over the years.

Document-3



*The average groundwater extraction volume is about 20 million m3.

Figure 2-113 Changes in groundwater extraction and number of operating wells over time

(2) Groundwater extraction survey (preparation of pumping intensity map)

1) Understanding the status of groundwater pumping

■Obtained Data

- Monthly pumping volume in 2015, 4829 locations
- No link between location information and pumping volume
- Only address and owner are clearly indicated
- No screen depth (only classification of shallow wells and deep wells)

■Processing outline

- Matching of pumping point (location) and pumping volume using address and owner's name as tags
- Succeeded in matching more than 97%.
- Aggregation of pumping volume by industry
- Correction of abnormal values
- Aggregation into 100 m, 200 m and 1 km mesh pumping intensity maps

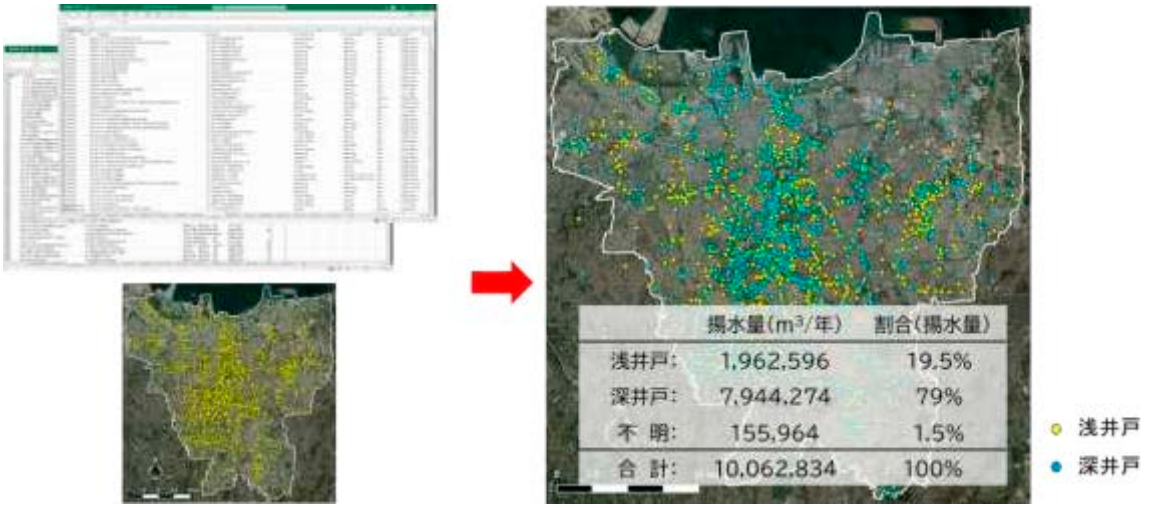


Figure 2-114 Location of registered wells



Figure 2-115 Pumping rate in 100×100m mesh (shallow well)

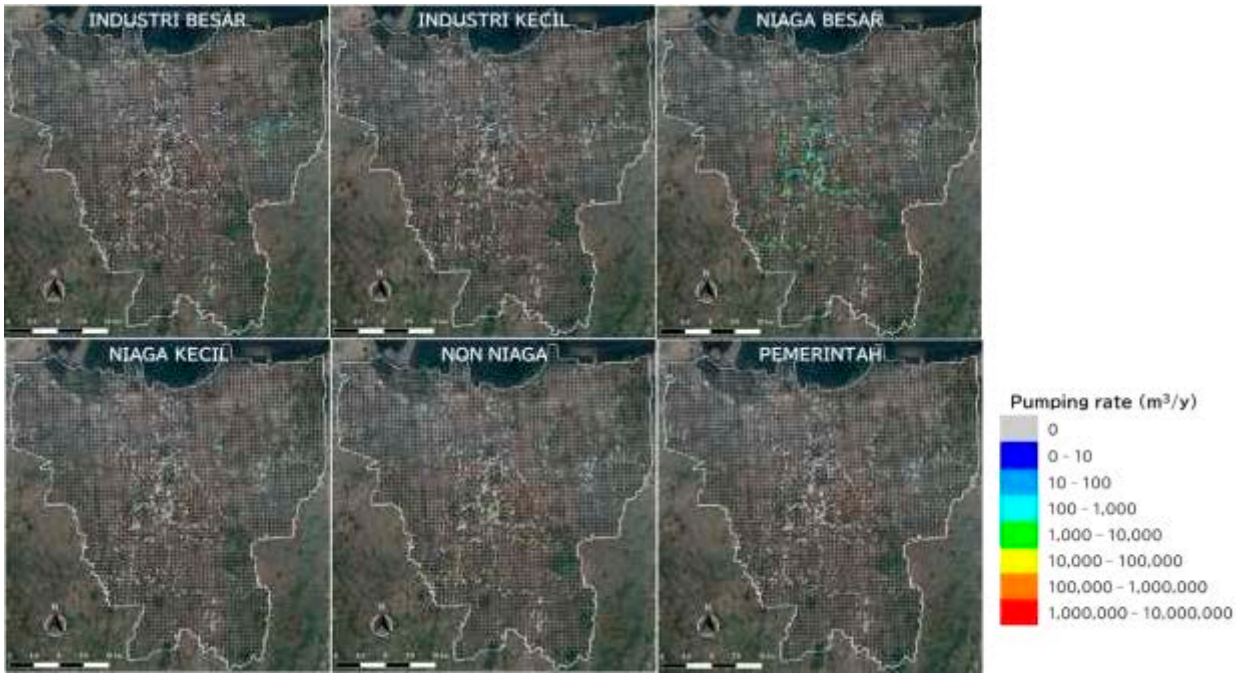


Figure 2-116 Pumping rate in 100×100m mesh (deep well)

2) Setting the pumping volume of registered wells

For the setting of the pumping data of the registered wells, the data was classified into shallow wells and deep wells. In addition, the data was organized by industry so that the amount of pumping could be identified. Further, since many of the registered wells did not specify their pumping volume, the wells with pumping volume listed were firstly organized, and then the average pumping volume by industry was calculated and assigned to the wells with unlisted pumping volume to determine the final pumping volume.

① The amount of groundwater pumped (wells with stated pumping volume) was classified into

shallow wells and deep wells, and each was organized by industry.
Shallow wells : 948 wells out of 1,254 (40%), pumping volume : about 1.5 million m^3/year (18%)
Deep wells : 1,265 out of 1,814 (60%), pumping rate : about 6.5 million m^3/year (82%)

② Since the registered wells includes some with pumping capacity listed and some without (unclear), the overall pumping volume was calculated by assigning the average pumping volume by industry to the wells with no pumping capacity listed. The results are as follows.
Shallow wells : 1,254 wells (40%), pumping rate : about 1.9 million m^3/year (17%)
Deep wells : 1,814 wells (60%), pumping rate : about 9.1 million m^3/year (83%)

a) Compilation of pumping data (with pumping volume listed)

【Summary of pumping volume in the target area】

	Pumping volume (m^3/y)	Ratio (Pumping volume)	Number	Ratio (Number)
Shallow well :	1,472,312 (0.047m^3/s)	18.3 %	1,252	40.8 %
Deep well :	6,576,349 (0.209m^3/s)	81.7 %	1,814	59.2 %
Total :	8,048,661 (0.255m^3/s)	100.0 %	3,066	100.0 %

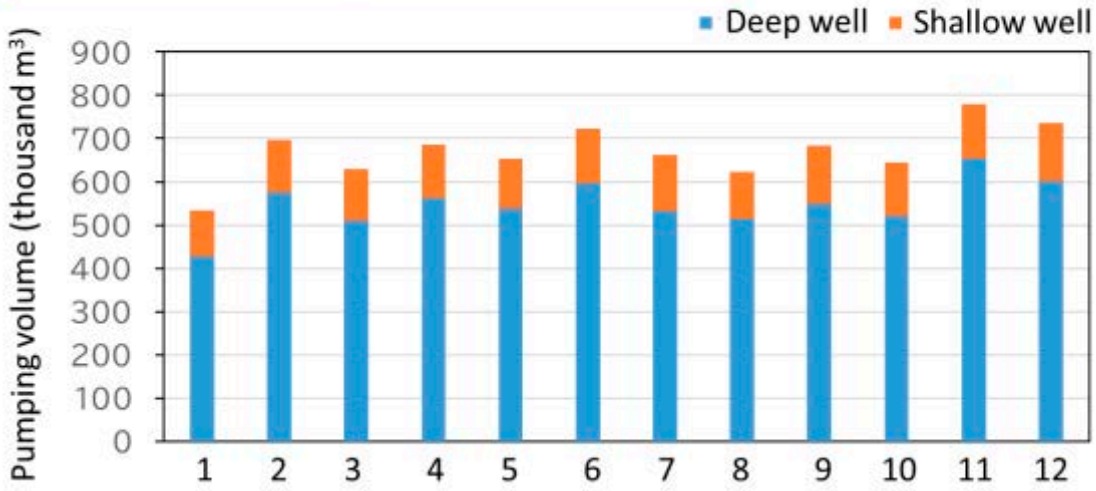


Figure 2-117 Summary of pumping volume in the target area (anomalous values in October were corrected)

Shallow well

Unit:m³

Industry	1	2	3	4	5	6	7	8	9	10	11	12	Total
INDUSTRI BESAR	5,128	5,555	4,924	4,033	23,195	9,068	11,543	6,164	5,797	7,209	6,920	7,572	97,107
INDUSTRI KECIL	7,045	6,893	6,125	5,403	3,015	9,499	8,599	4,843	12,566	8,267	11,438	9,686	93,377
NIAGA BESAR	51,040	54,670	66,276	60,564	58,145	67,334	62,283	58,449	67,121	66,270	63,544	65,780	741,474
NIAGA KECIL	21,788	27,092	23,199	35,261	18,039	22,419	25,611	20,824	21,216	22,891	23,085	25,594	287,016
NON NIAGA	21,119	27,184	20,296	18,588	13,305	19,055	20,812	19,365	26,595	20,011	21,554	25,455	253,339
PEMERINTAH	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	106,119	121,393	120,819	123,848	115,698	127,374	128,848	109,645	133,295	124,648	126,540	134,086	1,472,312

Deep well

Unit:m³

Industry	1	2	3	4	5	6	7	8	9	10	11	12	Total
INDUSTRI BESAR	42,176	53,121	49,487	48,404	38,394	33,741	34,756	38,036	34,856	41,917	43,845	37,436	496,168
INDUSTRI KECIL	18,325	24,086	15,579	16,729	14,379	13,915	17,509	14,318	12,750	16,858	20,340	20,438	205,225
NIAGA BESAR	190,253	237,076	203,047	194,694	201,702	218,106	211,101	219,608	228,937	230,655	254,972	294,689	2,684,839
NIAGA KECIL	30,072	49,320	40,826	33,055	44,148	44,820	37,963	35,994	39,739	35,304	29,649	27,329	448,218
NON NIAGA	146,402	210,921	199,972	268,683	239,821	285,103	231,275	205,614	233,678	195,554	304,006	220,872	2,741,900
Total	427,227	574,524	508,910	561,565	538,444	595,685	532,604	513,571	549,960	520,288	652,812	600,762	6,576,349

Figure 2-118 Pumping volume by industry

b) Summary of pumping volume data (percentage of wells with no stated pumping volume)

【Breakdown of Pumping Well】

The average value is applied to wells with an annual pumping rate of 0m³.

	Pumping rate(m³/y)	Ratio	Number of well	Ratio (Number of well)
Shallow well:	1,472,312	18.3%	1252	40.8%
Deep well:	6,576,349	81.7%	1814	59.2%
Total:	8,048,661	100%	3066	100%

	Wells with no pumping rate description.		Wells with pumping volume described.	
	Number of well	Ratio (Number of well)	Number	Ratio (Number of well)
Shallow well:	304	9.92%	948	30.92%
Deep well:	549	17.91%	1265	41.26%
Total:	853	27.82%	2213	72.18%

Figure 2-119 Summary of pumping volume data

Table 2-49 Breakdown of pumping well

	Industry	Number of wells with data	Pumping volume (m³/y)	Pumping volume of 1 well (m³/y/well)	Number of well without data	Pumping volume (m³/y)	Total number of well	Total pumping volume (m³/y)
Shallow well	INDUSTRI BESAR	96	97,107	1,012	58	58,669	154	155,775
	INDUSTRI KECIL	50	93,377	1,868	5	9,338	55	102,715
	NIAGA BESAR	568	741,474	1,305	192	250,639	760	992,113
	NIAGA KECIL	163	287,016	1,761	29	51,064	192	338,080
	NON NIAGA	71	253,339	3,568	19	67,795	90	321,133
	PEMERINTAH	0	0	0	1	0	1	0
	合計	948	1,472,312		304	437,504	1,252	1,909,816

	Industry	Number of wells with data	Pumping volume (m³/y)	Pumping volume of 1 well (m³/y/well)	Number of well without data	Pumping volume (m³/y)	Total number of well	Total pumping volume (m³/y)
Deep well	INDUSTRI BESAR	171	496,168	2,902	105	304,664	276	800,832
	INDUSTRI KECIL	47	205,225	4,366	14	61,131	61	266,355
	NIAGA BESAR	766	2,684,839	3,505	351	1,230,259	1,117	3,915,098
	NIAGA KECIL	82	448,218	5,466	18	98,389	100	546,608
	NON NIAGA	199	2,741,900	13,778	61	840,482	260	3,582,382
	合計	1,265	6,576,349		549	2,534,925	1,814	9,111,274

Unit: m³

	Industry	1	2	3	4	5	6	7	8	9	10	11	12	total
Shallow well	INDUSTRI BESAR	10,017	10,444	9,813	8,922	28,084	13,957	16,482	11,053	10,886	12,098	11,809	12,481	155,775
	INDUSTRI KECIL	7,823	7,671	6,903	6,181	3,793	10,277	9,377	5,621	13,344	9,045	12,216	10,464	102,715
	NIAGA BESAR	71,827	75,557	87,163	81,450	78,831	88,220	83,169	79,838	88,868	87,157	84,430	86,688	992,113
	NIAGA KECIL	26,043	31,347	27,454	39,517	22,294	26,674	29,866	25,079	25,471	27,146	27,340	29,849	338,080
	NON NIAGA	26,769	32,834	25,945	24,238	18,955	24,705	26,462	25,015	32,245	25,661	27,204	31,105	321,133
	PEMERINTAH	0	0	0	0	0	0	0	0	0	0	0	0	0
	合計	142,577	157,852	157,278	160,307	152,157	163,833	165,306	146,103	169,754	161,107	162,999	170,545	1,909,816

Unit: m³

	Industry	1	2	3	4	5	6	7	8	9	10	11	12	total
Deep well	INDUSTRI BESAR	67,565	78,939	74,875	73,793	63,783	59,130	60,145	63,425	60,245	67,306	68,234	62,824	800,832
	INDUSTRI KECIL	23,419	29,180	20,873	21,823	19,479	19,009	22,603	19,412	17,844	21,952	25,434	25,532	266,355
	NIAGA BESAR	292,775	338,598	305,569	297,216	304,223	320,628	313,823	322,138	331,459	333,176	357,484	397,210	3,915,098
	NIAGA KECIL	38,271	57,519	49,025	41,254	52,347	53,019	46,162	44,193	47,938	43,503	37,848	35,529	546,608
	NON NIAGA	216,442	290,961	270,012	338,723	309,861	355,143	301,315	275,654	303,718	265,584	274,046	290,912	3,582,382
	合計	638,471	795,767	720,153	772,809	749,687	806,929	743,948	724,814	761,204	731,531	864,056	812,005	9,111,274

Figure 2-120 Pumping volume by industry (considering those without data)

3) Pumping intensity map (2015)

Annual pumping in 2015 was about 11 million m³/year, which is not necessarily consistent with previously reported land subsidence areas (Abidin et al. 2015). Number of registered deep wells and pumping volume is almost consistent with previously reported values (Hutabarat and Ilyas. 2017)

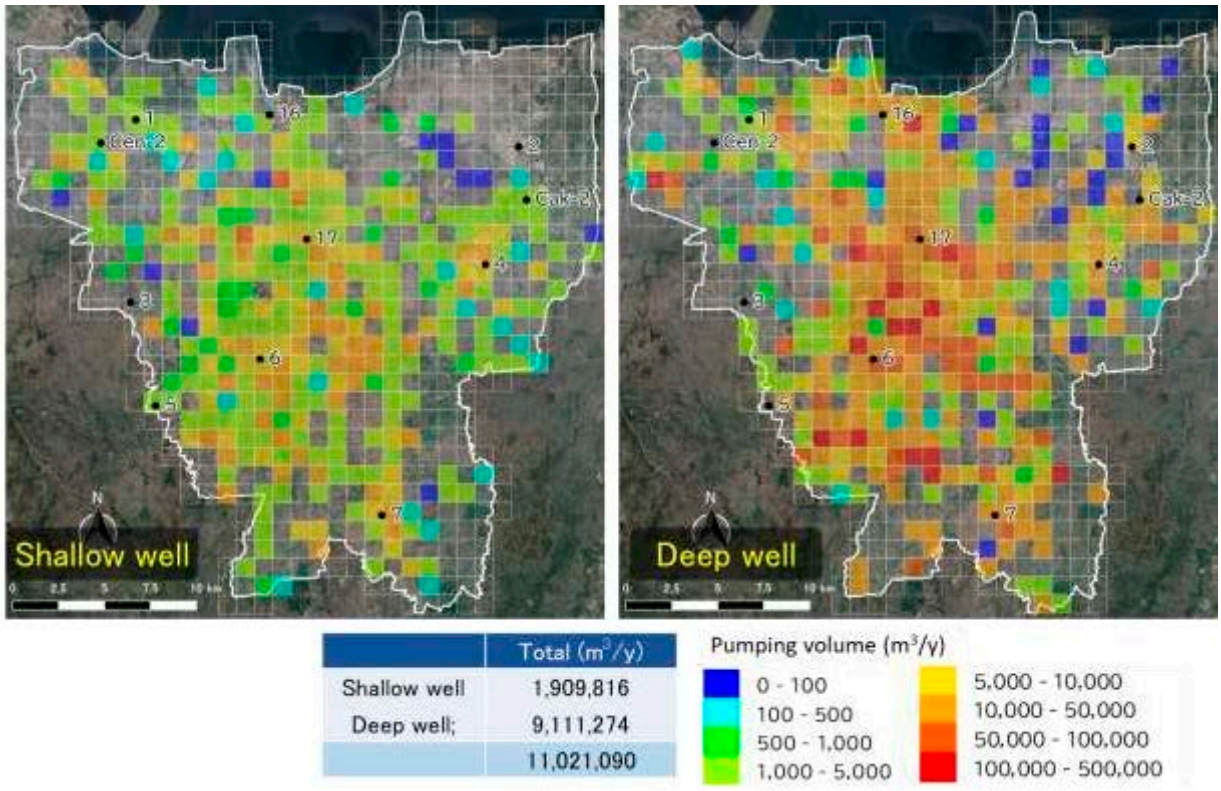


Figure 2-121 Pumping intensity map in 1m mesh (2015)

4) Setting the pumping volume for unregistered wells

As the groundwater pumping volume, the pumping volume for registered wells and unregistered wells are set. The method of setting the pumping volume for registered wells is as described above, but for unregistered wells, the pumping volume was set by the following method. (Groundwater pumping is modeled separately for registered and unregistered wells.)

Based on the pumping data of the wells obtained in this study and the actual condition of water use in DKI Jakarta, the pumping capacity of the registered and unregistered wells shown below was estimated.

■Registered wells

【Registered wells (shallow wells + deep wells)】

・Pumping volume (0.32 m^3/s ⇒ 27,648 m^3/day ⇒ 10,091,520 $m^3/year$)

■Unregistered wells

【Total groundwater volume pumped by unregistered wells】

Basically, shallow wells. However, since the depth is about 50 m, the water is pumped from the 2nd aquifer.

Pumping volume; (10.0 m^3/s ⇒ 864,000 m^3/day ⇒ 315,360,000 $m^3/year$)

■Calculation method

Approximately 300 million $m^3/year$ of the above unregistered wells will be allocated to each mesh.

In addition, if pumping is not possible due to the large pumping volume, it is necessary to increase the coefficient of permeability to create a condition where groundwater can be pumped easily.

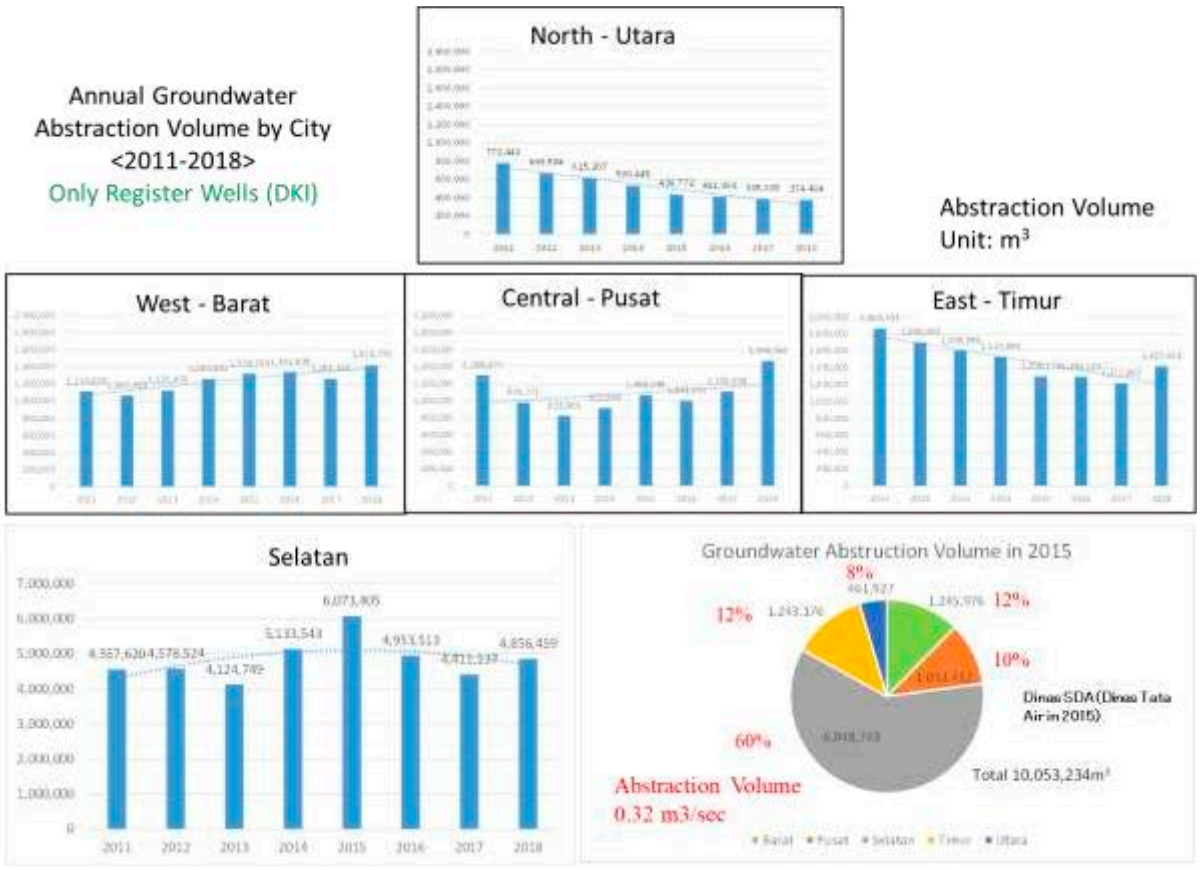
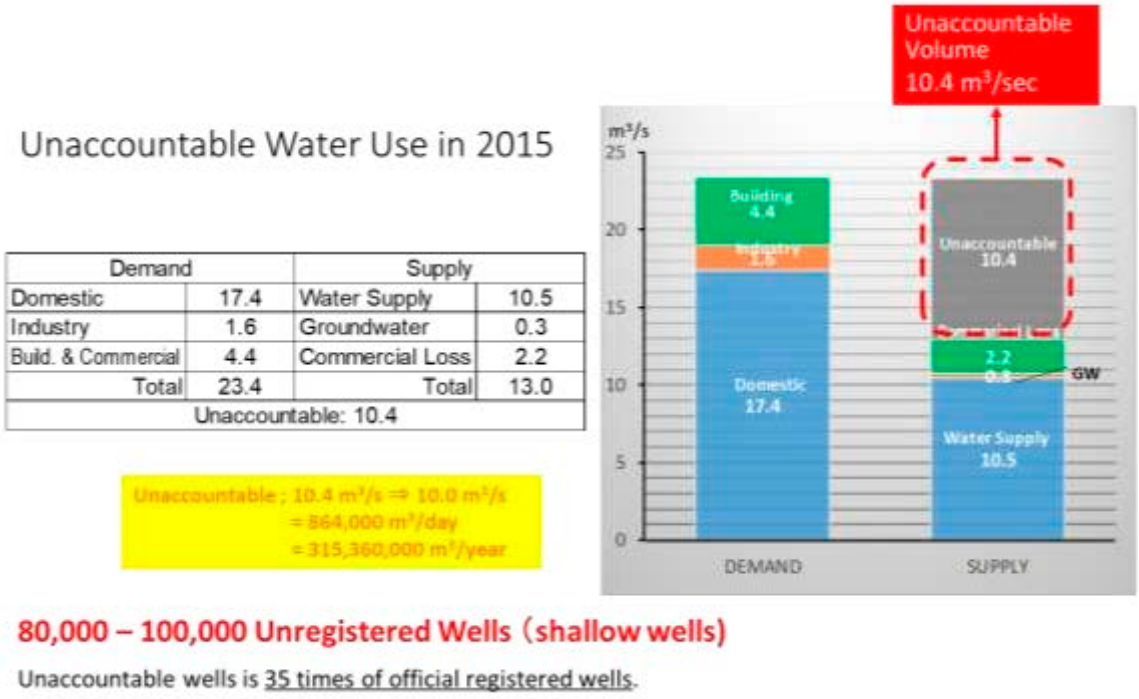


Figure 2-122 Pumping situation (registered well)



80,000 – 100,000 Unregistered Wells（shallow wells）

Unaccountable wells is 35 times of official registered wells.

Figure 2-123 Pumping situation (Unregistered well)

(3) Groundwater level monitoring data

There are 11 observation points for groundwater level as follows (irregular and continuous observation × 9 points (MONAS) and continuous observation × 2 points (Cengkareng, Cakung)). The observation period is from April 26, 2019 to March 22, 2021 (all measurements are in GL-m).

The height of the ground at each observation point is unknown except for Cengkareng and Cakung, so further investigation is required. As for the groundwater level observation data, the range of water level change and average water level were confirmed and utilized.

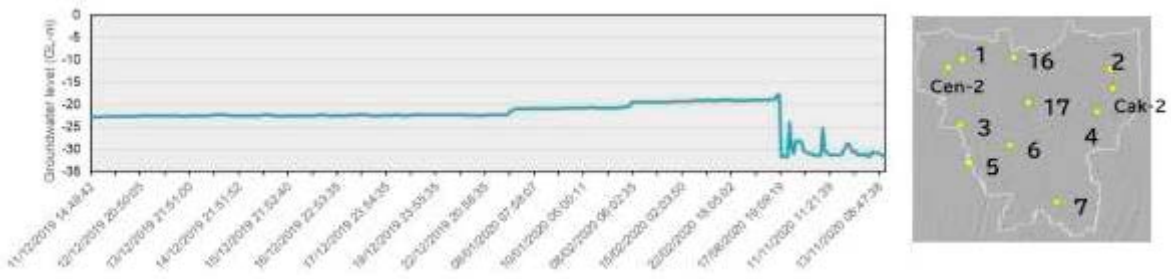
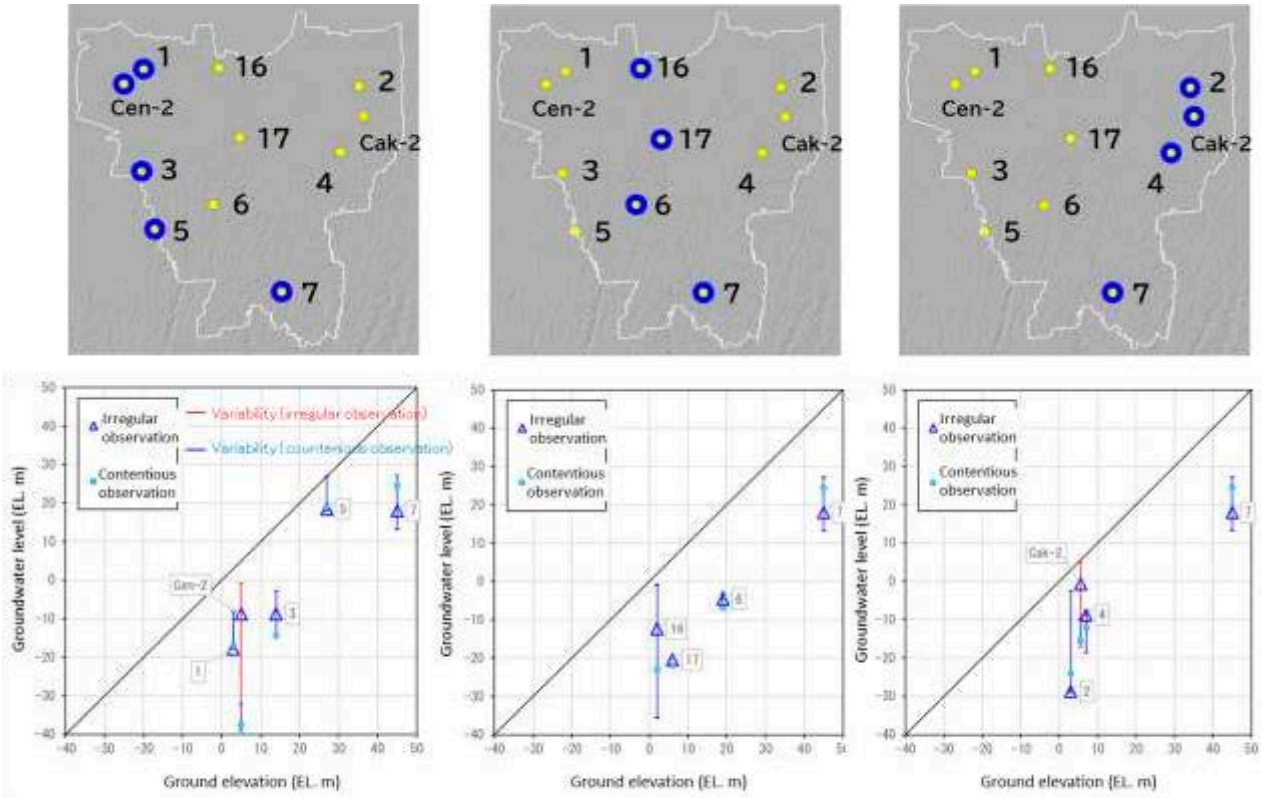


Figure 2-124 Example Continuous monitoring Data (monitoring Well-7 in MONAS)



※ The three sites on the north (seaward) side (Cen-2, No.16 and No.2) are characterized by large fluctuations in groundwater level.

Figure 2-125 Groundwater level monitoring Location and data

(4) Model Establishment for groundwater analysis

In this project, new geological and hydrogeological data were obtained from 10 AMT surveys and 2 subsidence observation wells in the Jakarta Special Region. Based on the results, geological and hydrogeological investigations were carried out. New geological and hydrogeological data were obtained from 10 AMT surveys and 2 subsidence observation wells in DKI Jakarta. Based on the results, geological and hydrogeological investigations were carried out.

① We found that the depth of distribution of the basement rock and the geological composition and structure from the ground surface to the basement rock differed from the previous geological study results. Our findings are consistent with the results of recent studies in Indonesia, and the hydrogeological structure was reviewed based on the newly obtained information.

② Since good boring cores were continuously collected during the construction of the subsidence monitoring wells, the parameters (permeability) of the stratum up to 300 m depth (drilling point) were estimated.

③ As a result of this survey, BKAT (ESDM) established a database called MONAS in collaboration with JICA. The database contains the data of previous groundwater level observation by BKAT, and the groundwater level data was utilized for groundwater analysis. The accuracy of the database will be improved by providing data on wells and groundwater (location, well structure, and groundwater level monitoring results) from related organizations (PU and DKI). In addition, technology transfer is necessary so that the Indonesian side can utilize this database continuously.

④ As for the investigation of land subsidence in Jakarta, PUSAIR has conducted a study on NCICD for the construction of embankments and seawalls. However, this study is now suspended, and JICA's support is required to conduct groundwater study (modeling and simulation) including new land subsidence study, and this groundwater analysis will continue the continuous groundwater analysis in the Indonesian side.

① and ② will be verified by new hydrogeological modeling and further verified by new data by ③. It is important that the model will be continuously revised by CP agencies after the completion of this project.

Based on the above new findings, a 3D groundwater flow model was developed considering the three major aquifers and the impermeable layers between the aquifers. (A total of 496,920 grids (200 m in planar grid and 30 layers in depth direction) were used.

The hydrogeological structure consists of three aquifers and four low-permeability layers, and the boundary conditions were modeled based on previous studies (literature values) to consider groundwater inflow from the southern end of the domain.

For the pumping volume of the registered wells, the groundwater pumping volume data of 2015 discussed above was used.

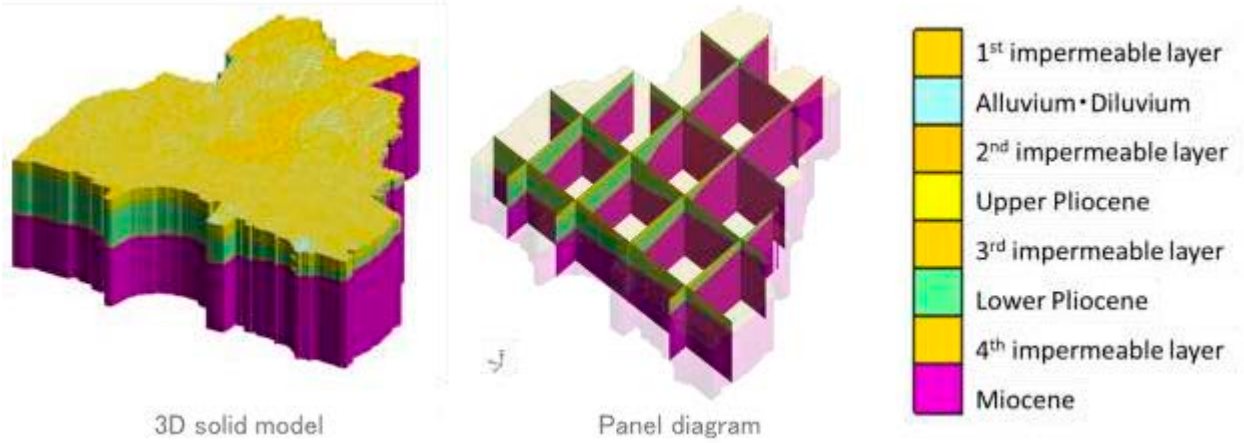
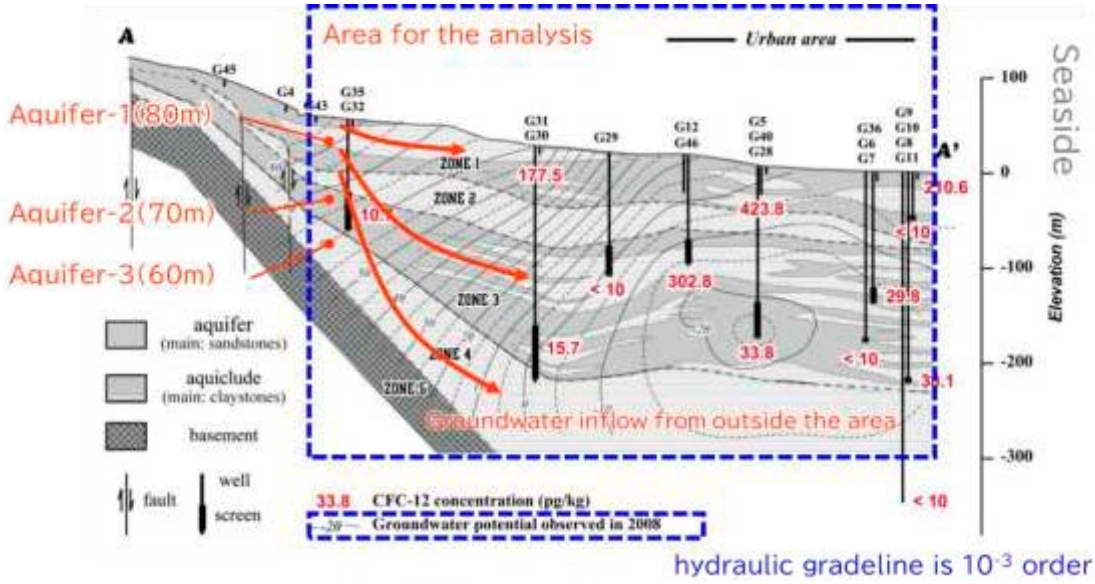


Figure 2-126 Model Establishment for groundwater analysis

*The groundwater level at the southern end of the target area was set based on previous study (reflected in the boundary conditions and modeled considering the groundwater inflow from inland).



Kagabu, et al. (2010). Groundwater Characteristics in Jakarta Area, Indonesia. *RISET Geologi dan Pertambangan*, *20*(2), 69-79.

Figure 2-127 Modelling of boundary condition

Table 2-50 Basic specifications

<table>
<tr><th>Items</th><th>Setting</th></tr>
<tr><td>Analysis program</td><td>MODFLOW-NWT</td></tr>
<tr><td>Package</td><td>Unsaturated flow (UZF), River (RIV)</td></tr>
<tr><td>Analysis type</td><td>Steady analysis</td></tr>
<tr><td>Grid model</td><td>496,920</td></tr>
<tr><td>coefficient of permeability (initial condition)</td><td>
<table>
<tr><td>Hydrogeology</td><td>Geology</td><td>coefficient of permeability (m/s)</td></tr>
<tr><td>Impermeable -1</td><td rowspan="3">Alluvium・Diluvium</td><td>1×10^{-11}</td></tr>
<tr><td>Aquifer-1</td><td>1×10^{-6}</td></tr>
<tr><td>Impermeable -2</td><td>1×10^{-11}</td></tr>
<tr><td>Aquifer -2</td><td rowspan="2">Upper Pliocene</td><td>1×10^{-7}</td></tr>
<tr><td>Impermeable -3</td><td>1×10^{-11}</td></tr>
<tr><td>Aquifer -3</td><td rowspan="2">Lower Pliocene</td><td>1×10^{-6}</td></tr>
<tr><td>Impermeable -4</td><td>1×10^{-11}</td></tr>
<tr><td>Base rock</td><td>Miocene</td><td>1×10^{-8}</td></tr>
</table>
</td></tr>
<tr><td>Groundwater extraction</td><td>200 m mesh pumping intensity map</td></tr>
<tr><td>Boundary condition</td><td>Surface : rainfall 6.42 mm/d, Leach surface boundary with evapotranspiration rate of 2.7 mm/d</td></tr>
<tr><td></td><td>Bottom : impermeable boundary</td></tr>
<tr><td></td><td>North end : Boundary with fixed water level at 0m elevation</td></tr>
<tr><td></td><td>South end : fixed pressure boundary based on literature values (80, 70, 60 m for each aquifer)</td></tr>
<tr><td></td><td>East and west ends : impermeable boundary</td></tr>
</table>

(5) Reproduction analysis (calibration of the model)

Considering the width of unregistered wells (200-300 million m^3/y), the range of coefficient of permeability that adequately reproduces the observed water level was identified.

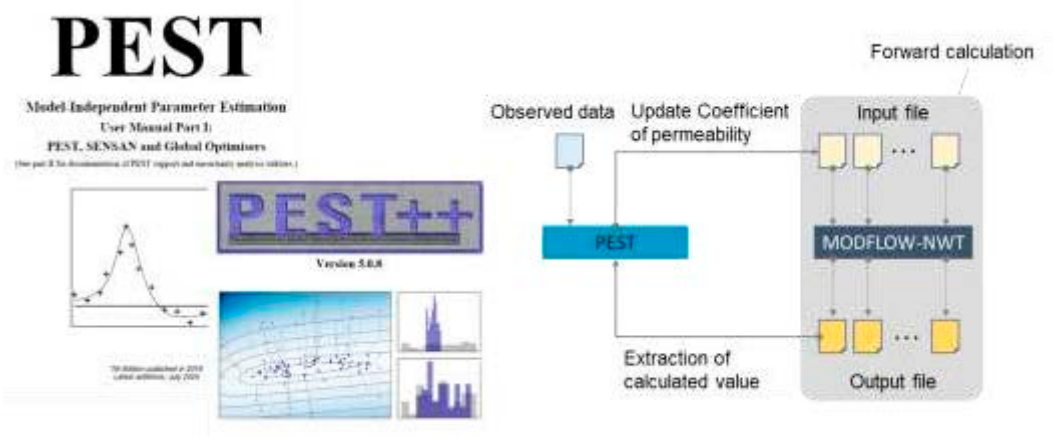
Table 2-51 Range of pumping volume

Case No.	Case	Unregistered well pumping volume (m^3/y)	Rainfall (mm/y)
1	Unregistered wells : about 3 million m^3/y	315 million	2,345
2	Unregistered wells : about 2 million m^3/y	315 million	2,345

For the identification of coefficient of permeability, PEST/PEST++ which enables automatic calibration by optimization algorithm was applied. PEST/PEST++ automates the inverse analysis only by manipulating the input and output files of the forward calculation without any modification to the groundwater flow simulation program (MODFLOW-NWT in this study).

The optimization algorithm is to find the combination of coefficient of permeability that minimizes the sum of squares of the residuals between the observed and calculated water levels.

In addition to automatic calibration (parameter identification), the software is equipped with practical functions for model validation and accuracy improvement (regularization, global sensitivity analysis, uncertainty analysis, and Pareto analysis).



Based on the calibration results, the optimum coefficient of permeability for each pumping volume (300 million or 200 million) for unregistered wells was calculated.

Table 2-52 Calibration result

Hydrogeology	Geology	Initial Coefficient of permeability (m/s)	Calculated Coefficient of permeability (m/s)		Remarks
			[Case-1] Pumping volume : about 300 million m^3	[Case-2] Pumping volume : about 300 million m^3	
Impermeable -1	Alluvium・Diluvium	1.0×10^{-11}	5.5×10^{-9}	$2.0x\ 10^{-9}$	Case 2 reproduces the same degree of groundwater level lowering with less pumping than Case 1, so a lower coefficient of permeability is identified.
Aquifer-1		1.0×10^{-6}	1.0×10^{-4}	$4.9x\ 10^{-6}$	
Impermeable -2		1.0×10^{-11}	2.0×10^{-9}	2.0×10^{-9}	
Aquifer -2	Upper Pliocene	1.0×10^{-7}	1.1×10^{-6}	2.0×10^{-7}	The coefficient of permeability of other aquifers and impermeable layers are almost the same in both cases.
Impermeable -3		1.0×10^{-11}	$1\ .2x\ 10^{-8}$	$9.7x\ 10^{-8}$	
Aquifer -3	Lower Pliocene	1.0×10^{-6}	5.8×10^{-6}	2.0×10^{-6}	
Impermeable -4		1.0×10^{-11}	2.0×10^{-7}	2.0×10^{-7}	
Base rock	Miocene	1.0×10^{-8}	2.6×10^{-5}	1.3×10^{-5}	

Based on the results of the above calibration, the coefficient of permeability of the first aquifer in Case 1 is 1.0×10^{-4} m/s. Compared to the measured (base value) coefficient of permeability (1.0×10^{-6} m/s), the situation was confirmed that pumping 300 million m^3/year is difficult even if the magnitude is given 100 times. In Case 2, the Coefficient of permeability of the first aquifer was 5.0×10^{-6} m/s. Compared to the coefficient of permeability (1.0×10^{-6} m/s) of the measured value (the base value), it was confirmed that pumping of 200 million m^3/year was possible when a magnitude of 5 times was given.

Based on the above results, judging from the comparison with the measured coefficient of permeability (validity), Case 2 (200 million m^3/year pumping) is adopted for unregistered pumping from shallow wells, and the value of Case 2 is also adopted for the basic Coefficient of permeability.

The analysis results of Case 1 & 2 are shown below.

1) Case-1（Unregistered well : 300 million m^3）

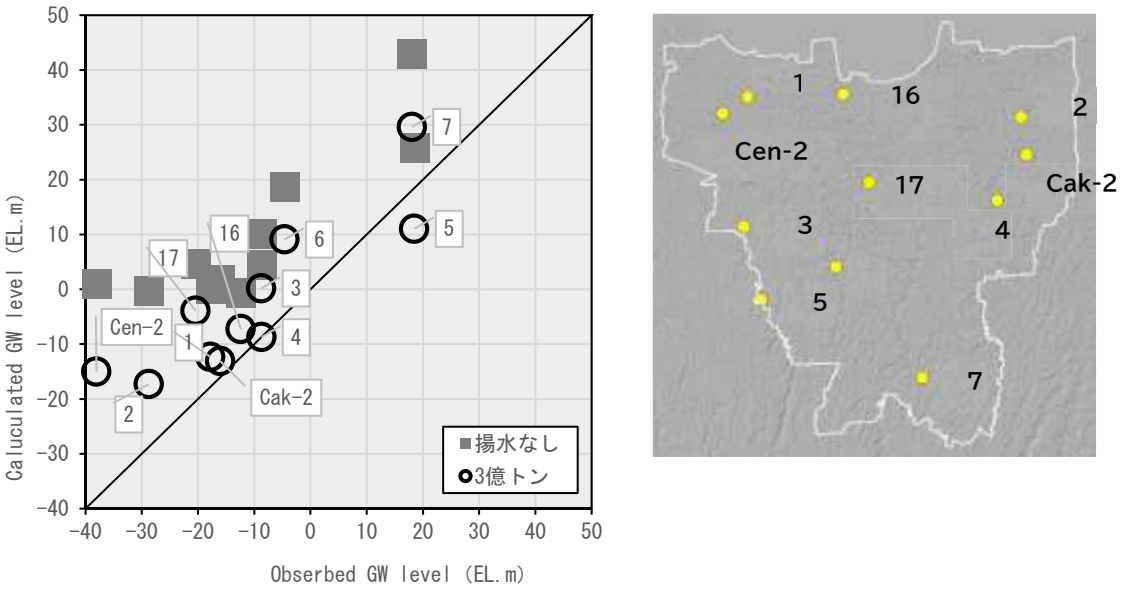


Figure 2-128 Coefficient between observed and calculated

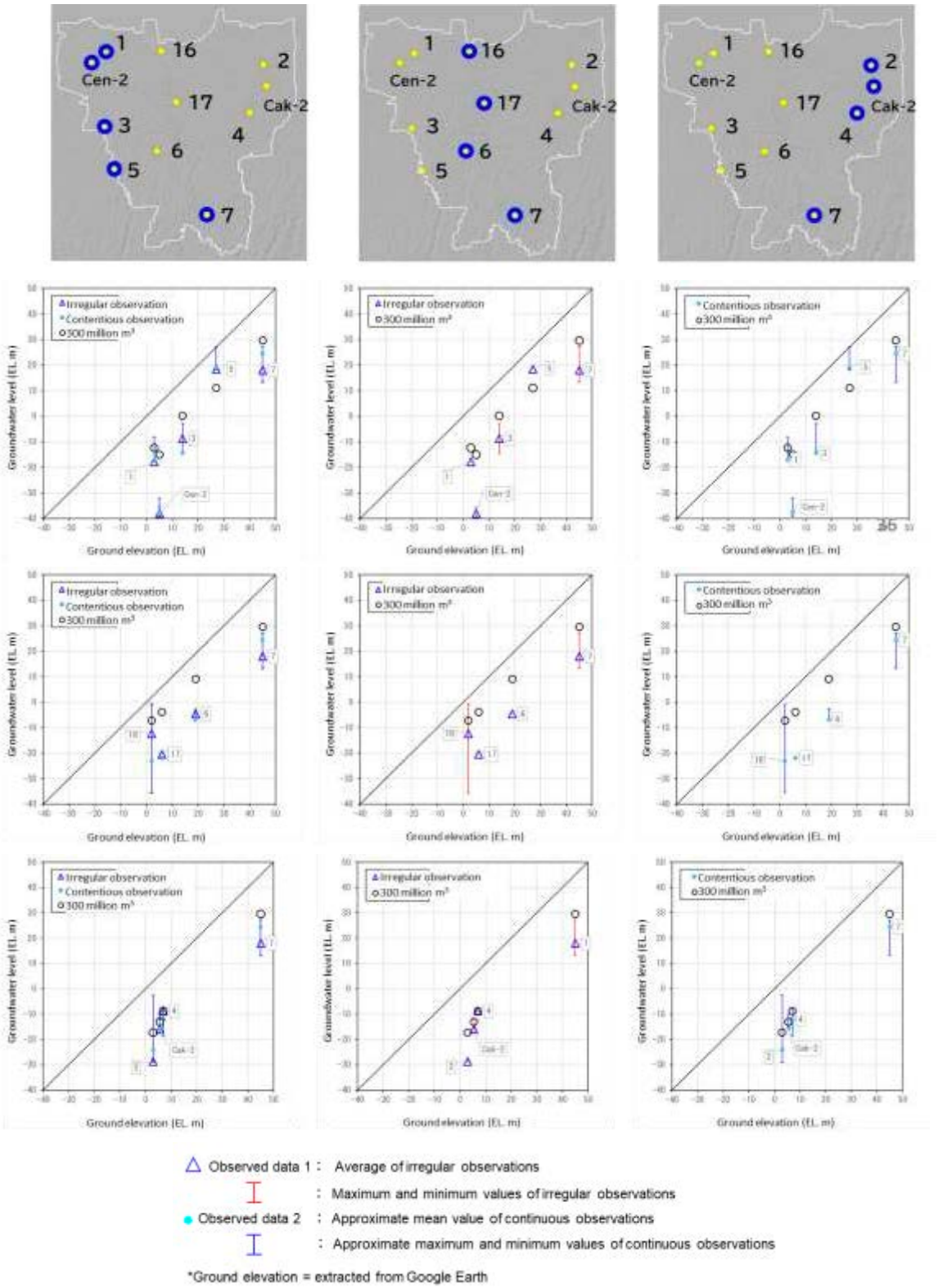


Figure 2-129 Ground height × groundwater level elevation values (upper : west side, middle : center, lower : east side)

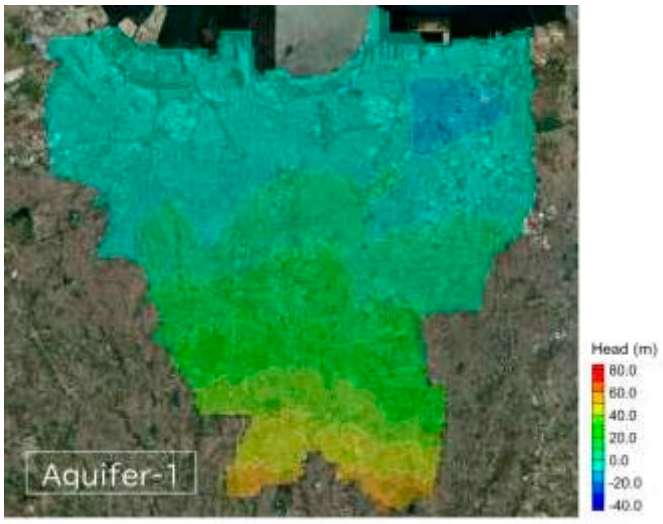


Figure 2-130 Groundwater level from analysis result (aquifer-1)

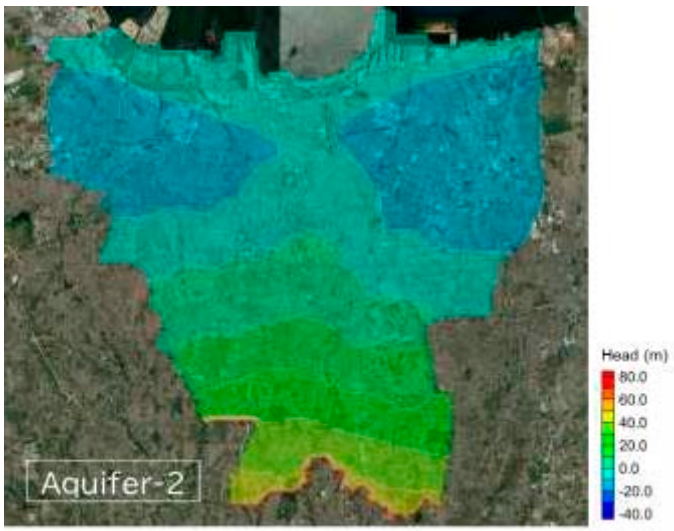


Figure 2-131 Groundwater level from analysis result (aquifer-2)



Figure 2-132 Groundwater level from analysis result (aquifer-3)

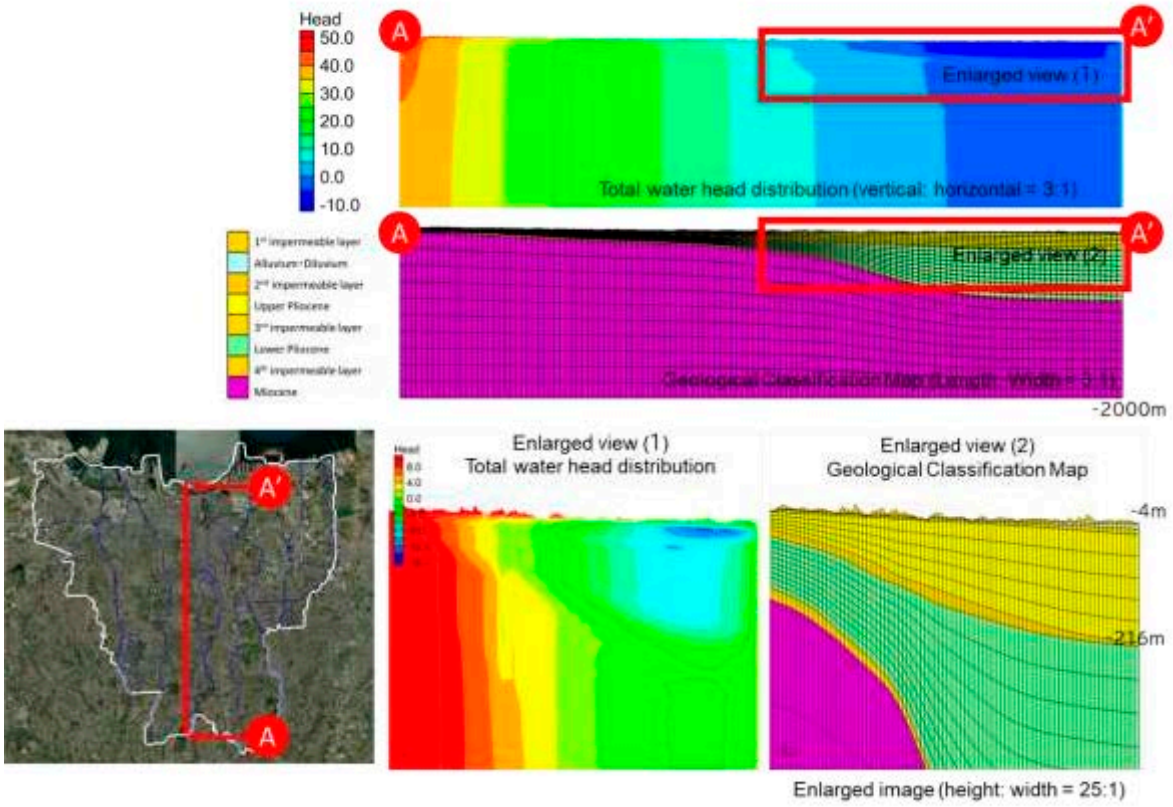


Figure 2-133 Calculated GW level 1 (cross section)

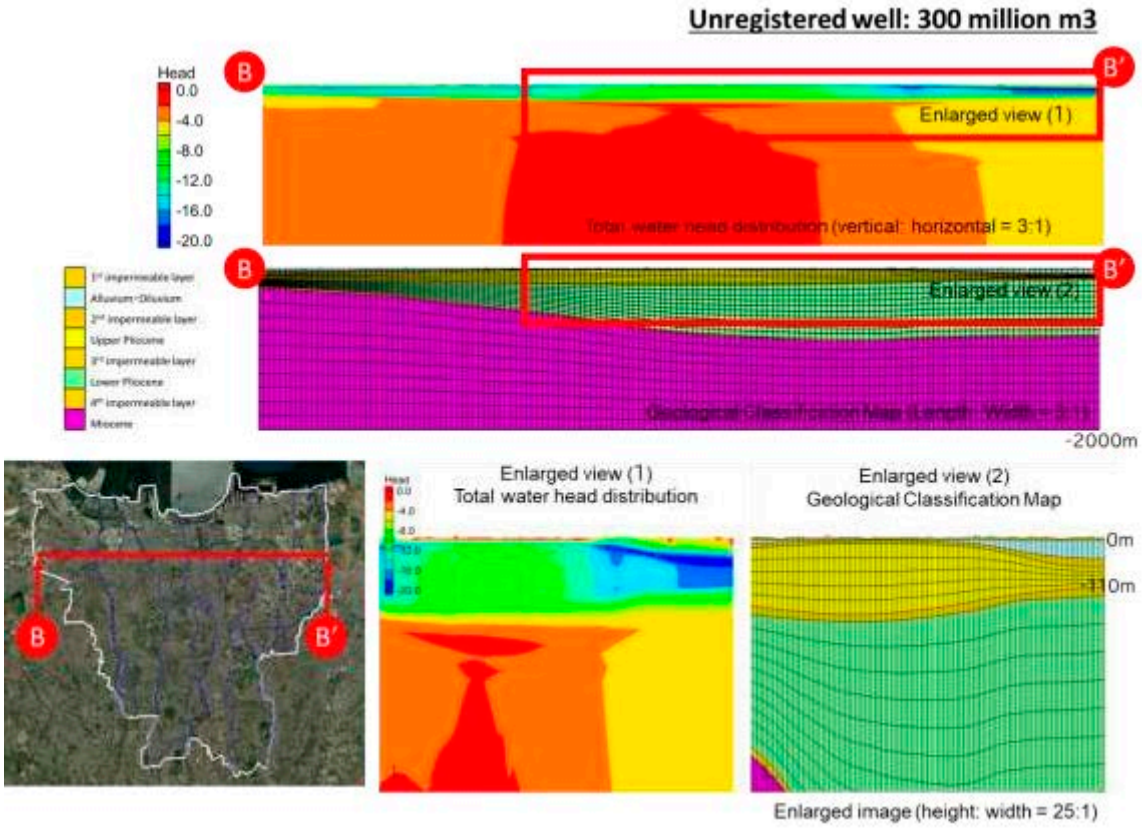


Figure 2-134 Calculated GW level 2 (cross section)

2) Case-2（Unregistered well : 200 million m3）

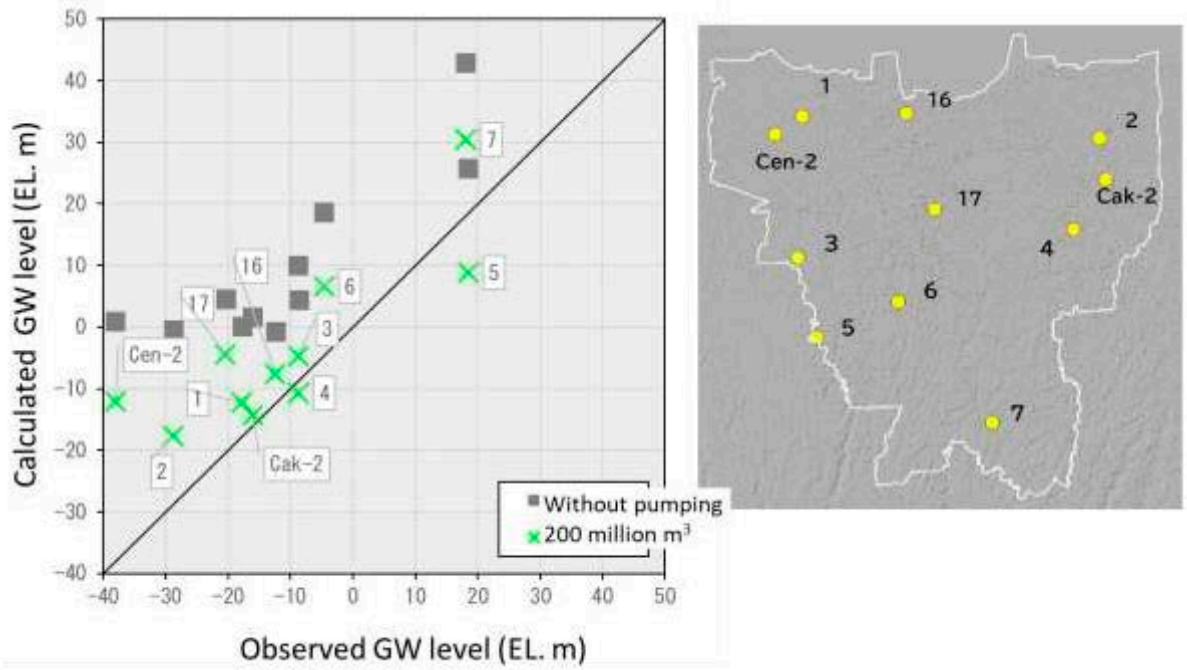


Figure 2-135 Coefficient between observed and calculated

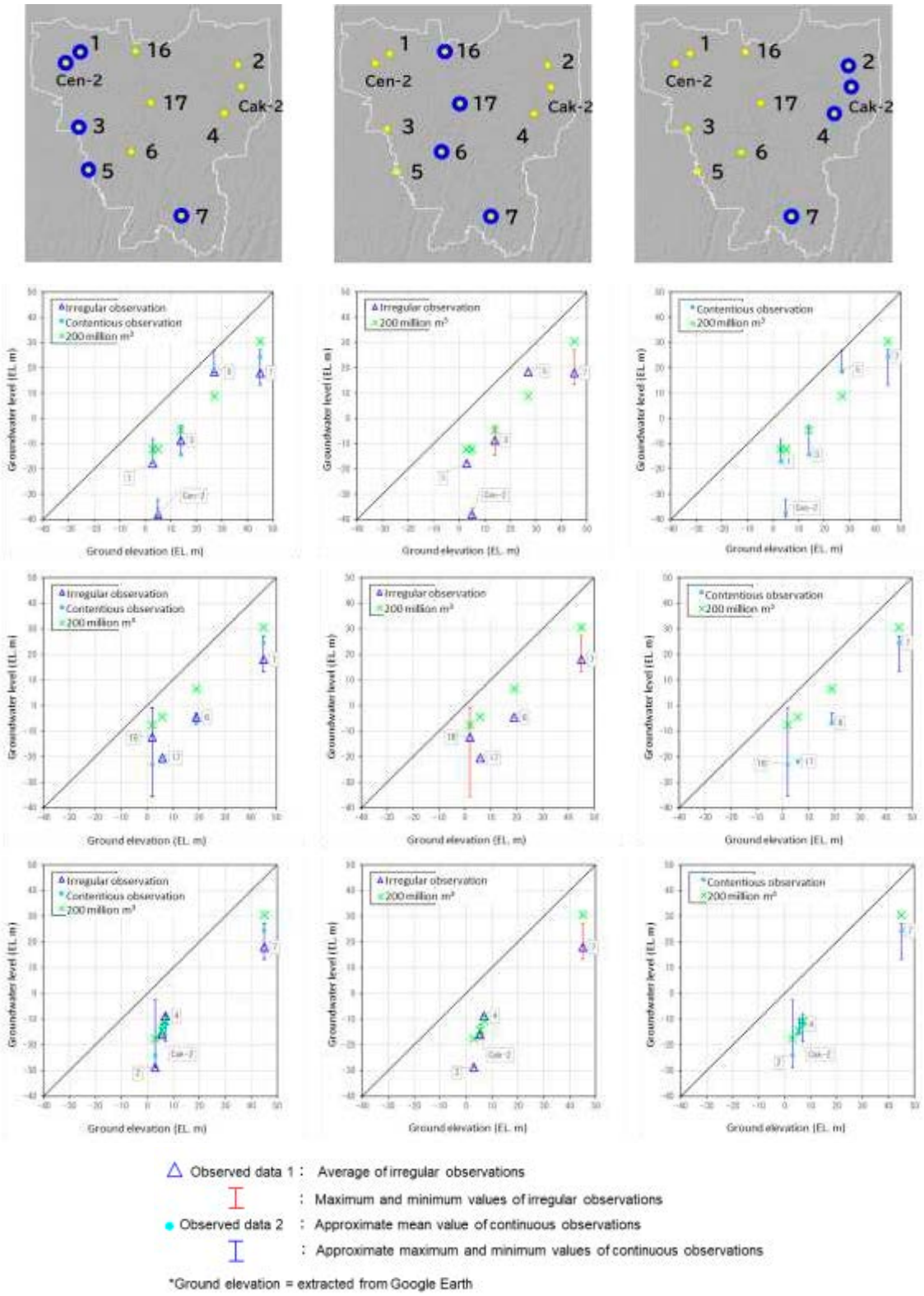


Figure 2-136 Ground height × groundwater level elevation values (upper : west side, middle : center, lower : east side)

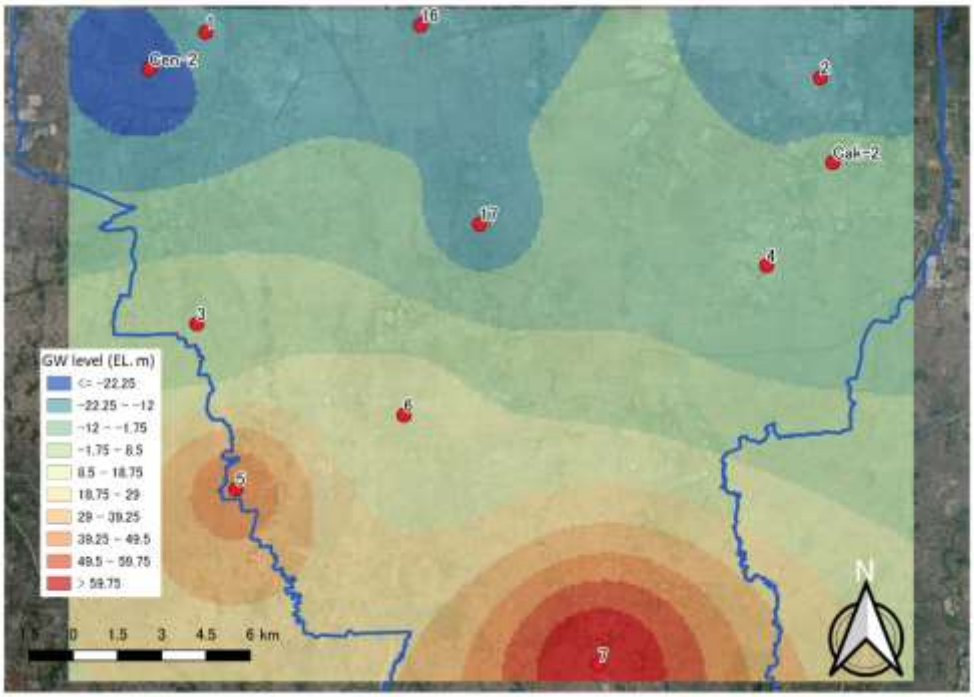


Figure 2-137 Groundwater level contour map of the second aquifer (Observation data)

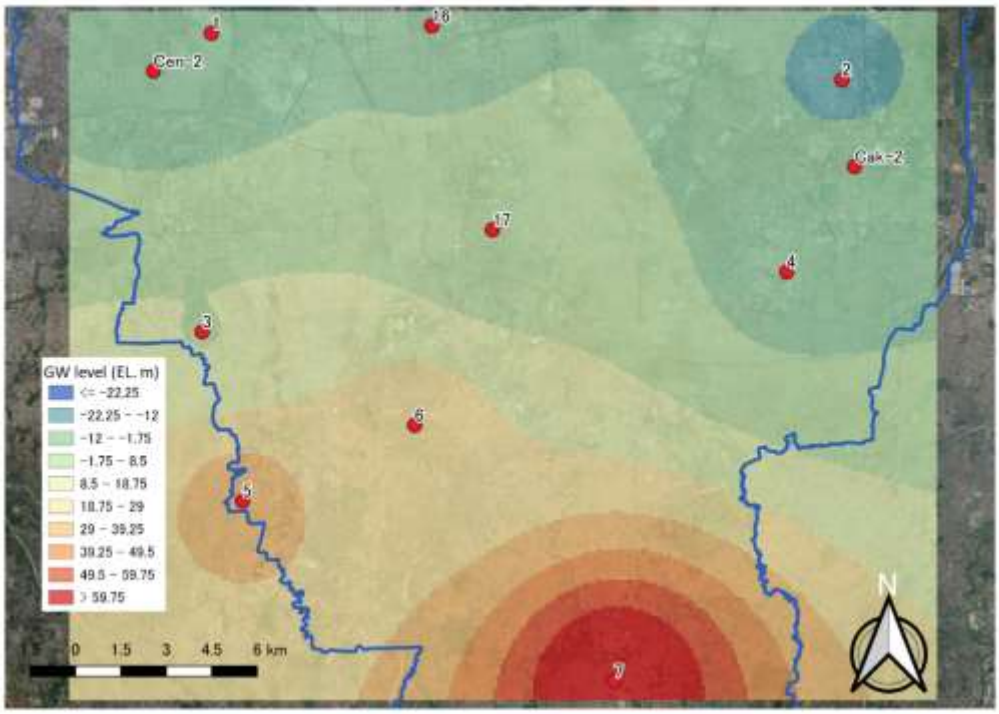


Figure 2-138 Groundwater level contour map of the second aquifer (Calculation data)

The groundwater level is calculated to be higher at Cen-2, 1, 16, and 17 on the north side of the site when the observed and calculated values are compared. For other points, the results are reproduced very accurately. From this result, it is assumed that the set amount of groundwater pumping may be low near the points where the groundwater level is estimated to be higher than the actual value.

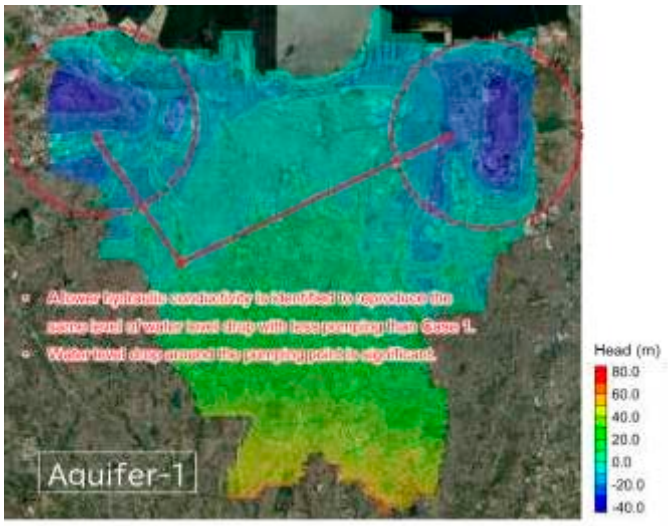


Figure 2-139 Groundwater level from analysis result (aquifer-1)

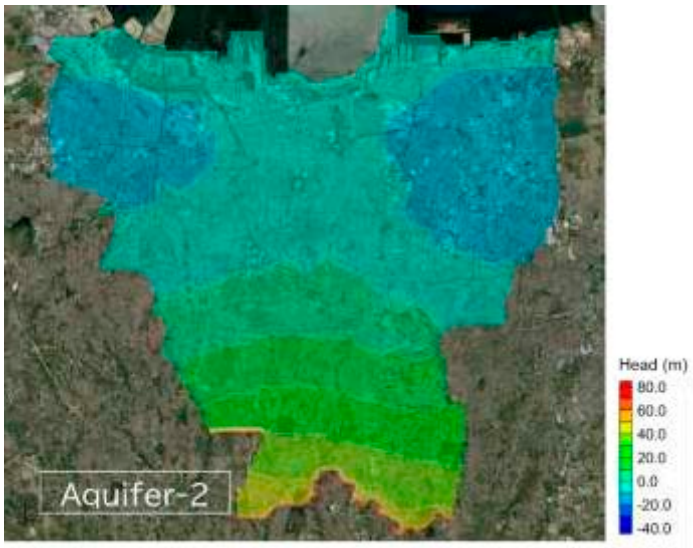


Figure 2-140 Groundwater level from analysis result (aquifer-2)

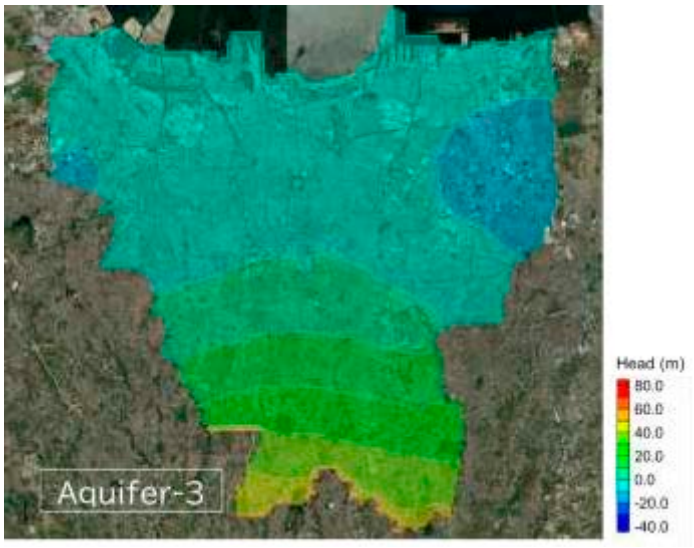


Figure 2-141 Groundwater level from analysis result (aquifer-3)

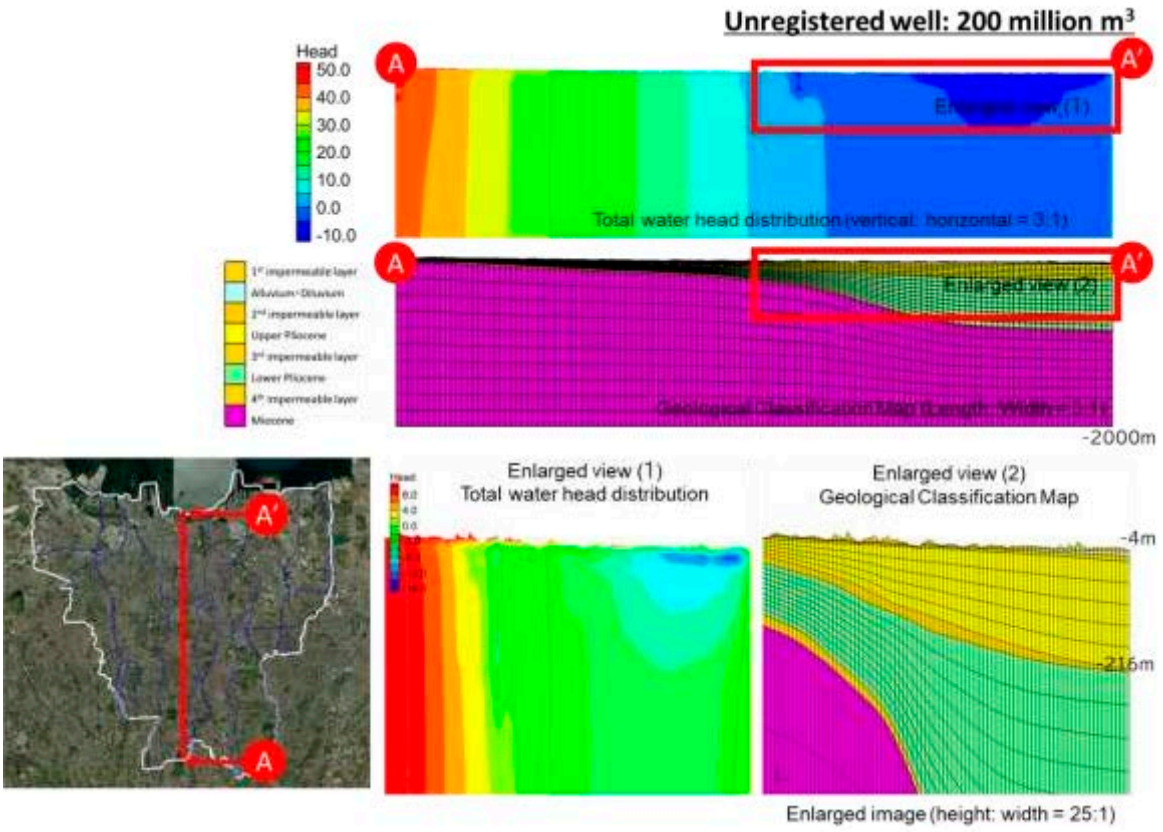


Figure 2-142 Calculated GW level 1 (cross section)

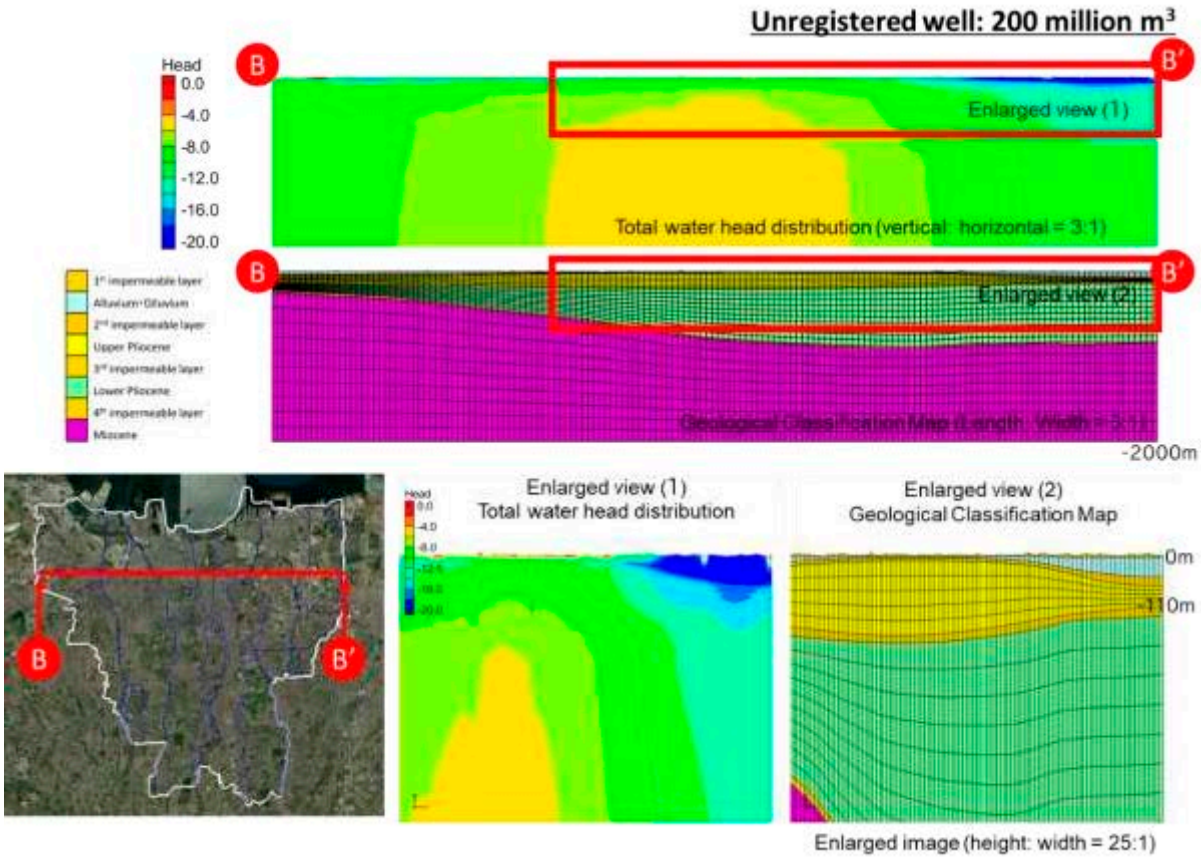


Figure 2-143 Calculated GW level 1 (cross section)

2.8.4 Evaluation of water balance and regional characteristics

(1) Relationship between water level lowering area and distribution of Alluvium

It is estimated that the alluvium is more thickly distributed on the east and west sides of the northern part of the area than near the center. Therefore, it is highly likely that the area where the Alluvium is thickly distributed will be the area where water level lowering is likely to occur during pumping because the flow rate (coefficient of permeability) is larger than the surrounding area.

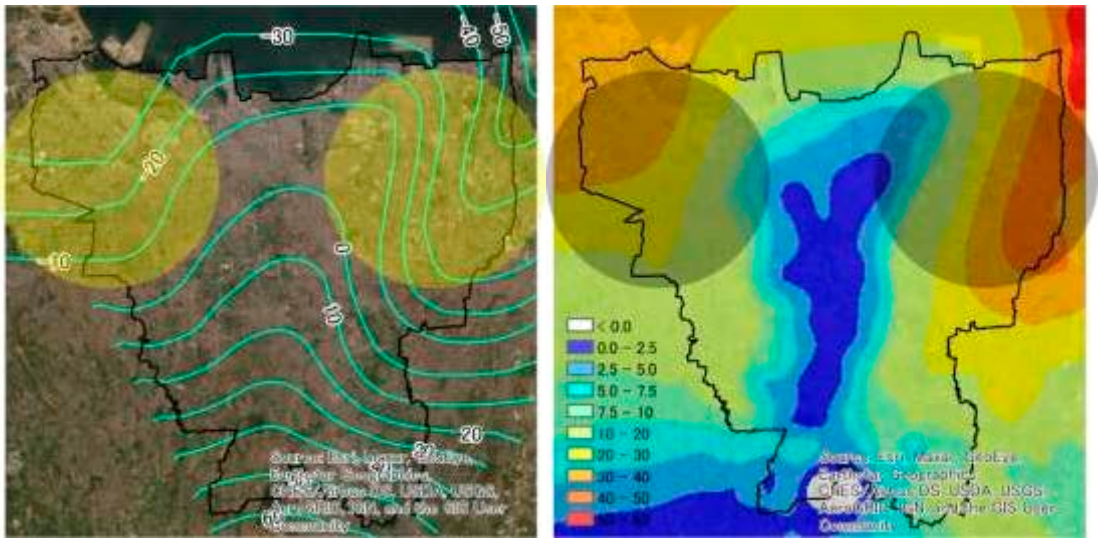
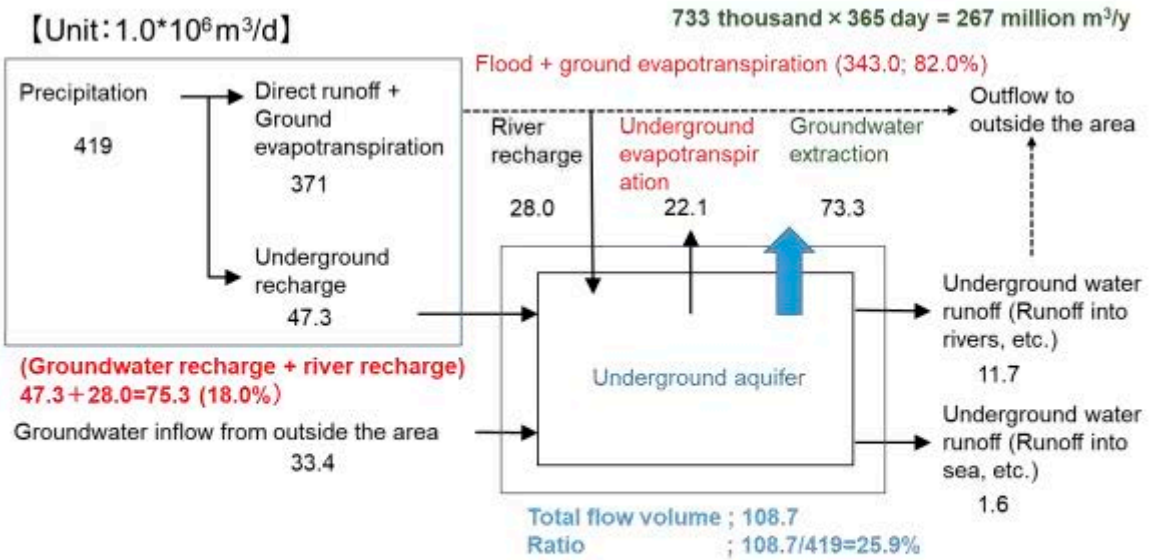


Figure 2-144 Counter map of the Alluvium bottom (m)

(2) Water balance in DKI Jakarta

1) Case-1 (Unregistered well : about 300 million m^3/y)



Considering that 40% of the total rainfall is evapotranspiration, the total amount of ground and underground evapotranspiration is 167.6. Evapotranspiration from the ground is 167.6-22.1=145.5
∴ Direct runoff = 343.0-145.5=197.5
Ratio of direct runoff; 197.5/419=47.1% (reasonable)

Figure 2-145 Water balance calculation (case-1)

2) Case-2 (Unregistered well : about 200 million m^3/y)

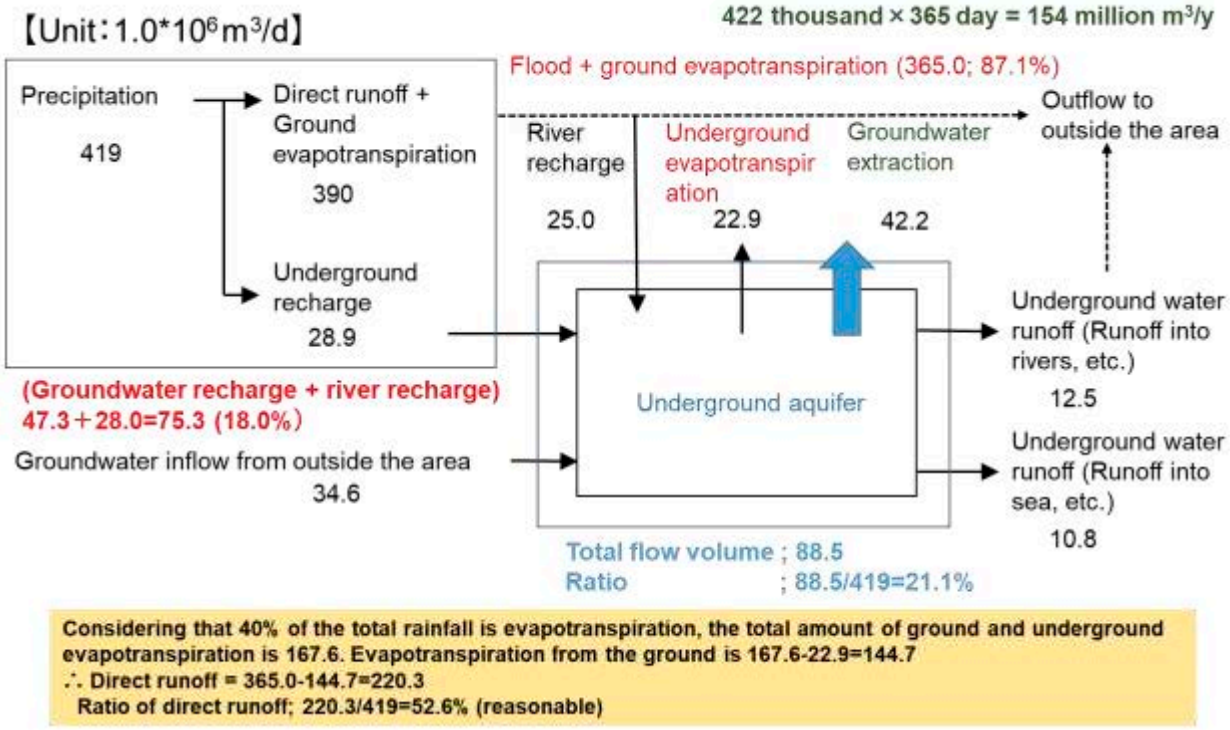


Figure 2-146 Water balance calculation (case-2)

From the above investigation results, we found that pumping 315 million m^3/y from shallow wells in Case 1 (the permeability of the first aquifer needs to be further increased to enable pumping) is difficult.

In Case 1 & 2, the recharge from groundwater and rivers is about 18% to 13% of the precipitation, which means that the amount of recharge to the underground space is likely to be small.

Based on these results, the following scenario prediction analysis is carried out.

2.8.5 Scenario Prediction Analysis

(1) Calculation condition

A scenario prediction analysis was conducted with the following calculation conditions.

■Steady state analysis
【Rainfall conditions】
Annual rainfall (average value)
Annual rainfall (drought year (about 1/2)
【Pumping conditions】
Pumping volume of unregistered wells; 300 million m^3/y or 200 million m^3/y
Pumping volume of registered wells; current registered volume
Pumping volume of registered wells; current registered volume × 2 times

■Unsteady analysis
【Rainfall conditions】
Annual rainfall use (monthly rainfall adopted)
【Pumping conditions】
Pumping capacity of unregistered wells; 200 million m^3/y)
Pumping capacity of registered wells; current registered volume × 2 times

(2) Senario-1

As the basic examination cases, Case 1 (pumping volume of unregistered wells (shallow wells) of 315 million m^3/year) and Case 2 (pumping volume of unregistered wells (shallow wells) of 200 million m^3/year) were conducted. As the pumping volume of the registered wells (deep wells), the value of this survey result (of about 9.11 million m /year) was adopted.

Table 2-53 Summary of the examination case (Senario-1)

Case ID	Pumping volume of unregistered well 【Shallow well】(m^3/y)	Pumping volume of registered well 【Deep well】(m^3/y)	Precipitation (mm/y)
1	315 million	9.11 million	2,345
2	200 million	9.11 million	2,345

Table 2-54 Summary of water balance in Jakarta (Case-1, 2)

Case		1	2	Ratio	Remarks
Pumping volume (m^3/y)	Unregistered shallow well	About 300 million	About 200 million	Same	An increase of 311,000 in groundwater pumping led to an increase in groundwater infiltration and recharge from rivers, resulting in an increase of 203,000 in total flow.
	Registered Deep well	About 9.11 million		Same	
Precipitation (mm/y)		2,345		Same	
【Water balance (m^3/d)】					
Total flow volume		1,087,000 (100.0%)	884,000 (100.0%)	1.23	Total flow volume increased by 203,000 due to groundwater infiltration and recharge from rivers
Inflow	Underground seepage volume	473,000 (43.6%)	289,000 (32.7%)	1.64	184,000 increase
	Recharge from river	280,000 (25.8%)	250,000 (28.3%)	1.12	30,000increase
	Inflow flow from outside	334,000 (30.7%)	346,000 (39.1%)	0.97	
Outflow	evapotranspiration	221,000 (20.3%)	229,000 (25.9%)	0.97	
	Pumping volume	733,000 (67.4%)	422,000 (47.7%)	1.74	311,000 increase
	Outflow into river, etc.	117,000 (10.8%)	125,000 (14.1%)	0.94	
	Outflow into ocean, etc.	16,000 (1.5%)	108,000 (12.2%)	0.15	92,000 decrease

(3) Senario-2

From the results of the above examination, we found that implementing pumping of 315 million m^3/y from shallow wells in Case 1 (the permeability of the first aquifer needs to be increased to enable pumping) is difficult.

Also, in Case 1 & 2, the recharge from groundwater and rivers is about 18% to 13% of the precipitation, which means that the amount of recharge to the underground space may be low.

Therefore, the cases (2B & 2C) are implemented here based on Case 2 where the permeability of the surface impermeable layer is increased by 10 and 100 times.

Based on the results of the above study, we assumed that Case 2B is a reasonable model (permeability) where the recharge from groundwater and rivers is about 30% of the precipitation as shown below.

Table 2-55 Summary of examination case (Senario-2)

Case ID	Pumping volume of unregistered well 【Shallow well】 (m^3/y)	Pumping volume of registered well 【Deep well】 (m^3/y)	Precipitation (mm/y)	remarks
2	200 million	9.11 million	2,345	
2B	200 million	9.11 million	2,345	Multiply the permeability of the surface layer (impermeable layer) by 10.
2C	200 million	9.11 million	2,345	Multiply the permeability of the surface layer (impermeable layer) by 100

1) Case 2B

The water balance results for Case 2B are as follows.

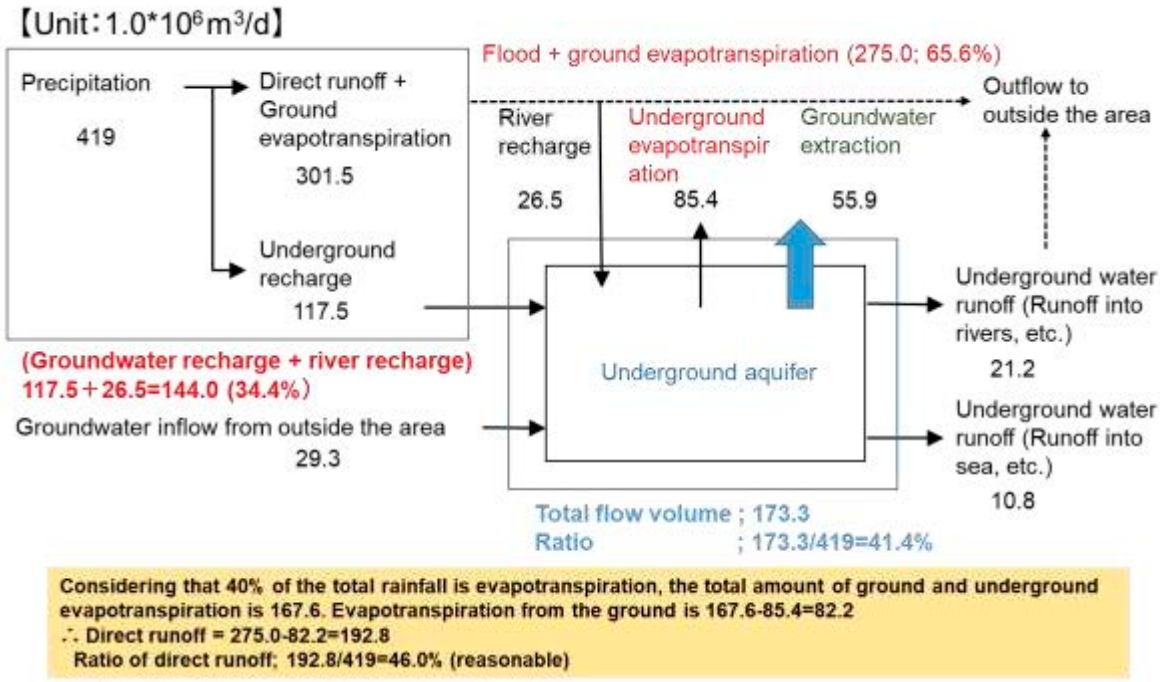


Figure 2-147 Water balance calculation (Case 2B)

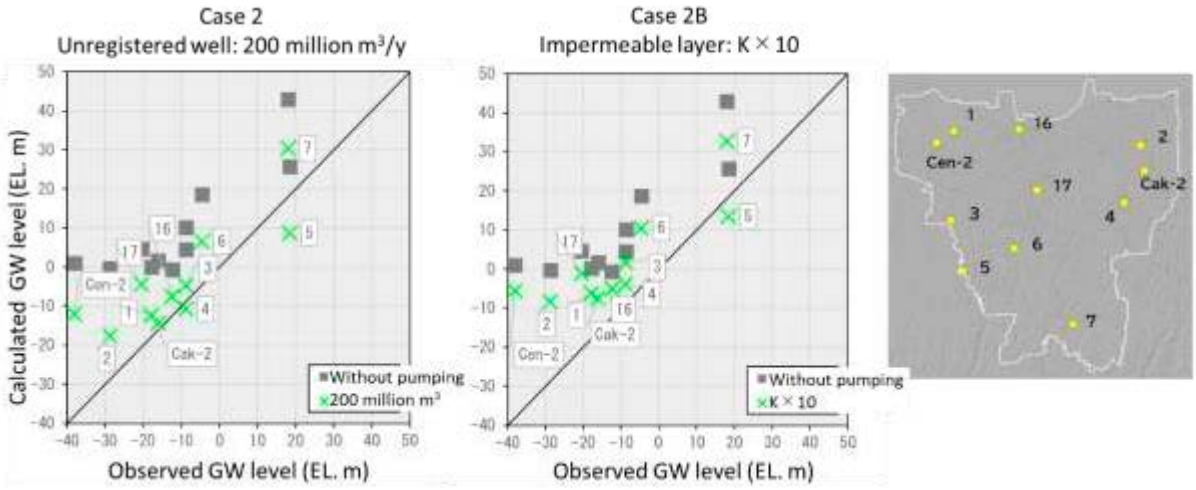


Figure 2-148 Coefficient between observed and calculated GW level (comparison with case 2)

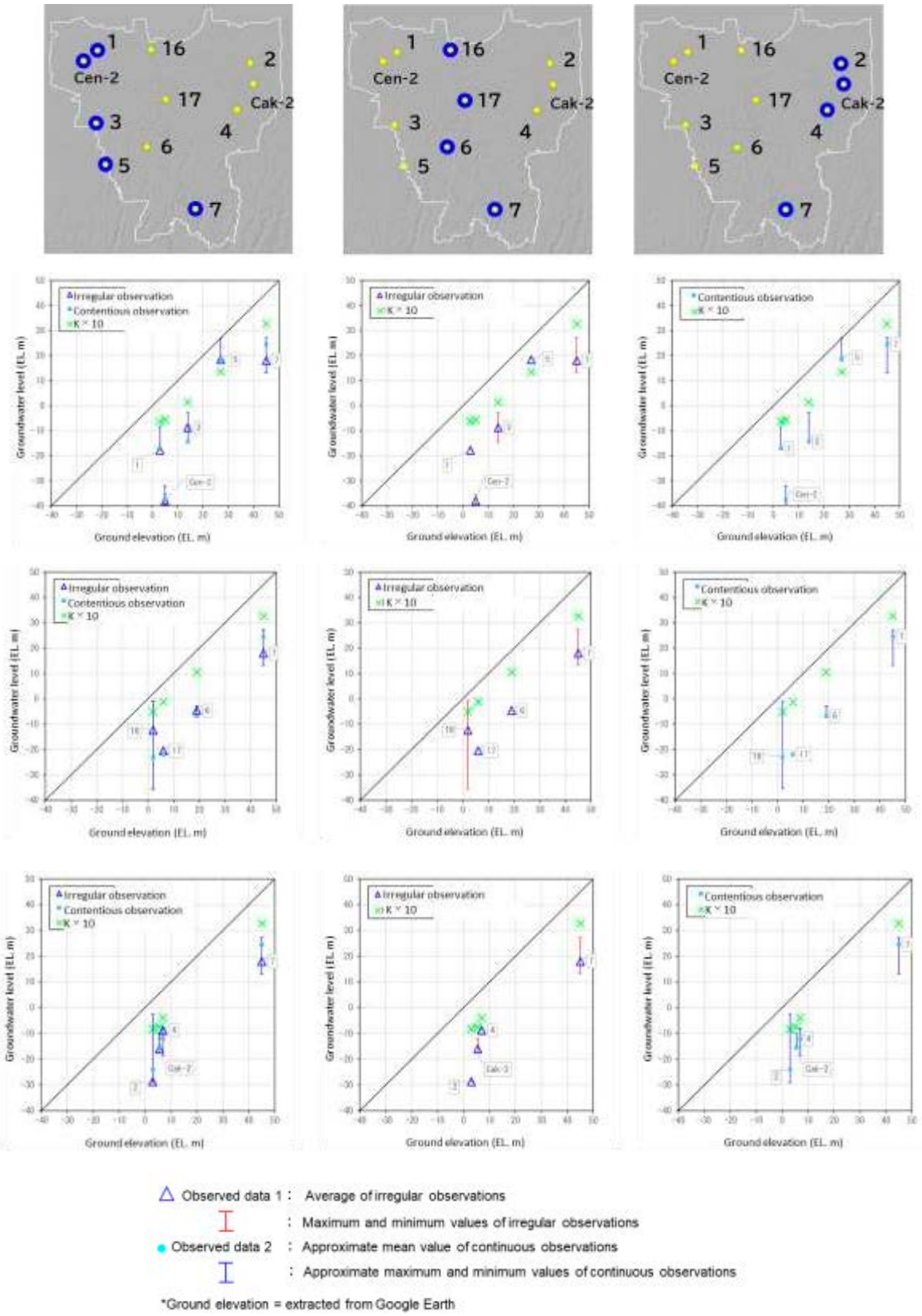


Figure 2-149 Ground height × groundwater level elevation values (upper : west side, middle : center, lower : east side)

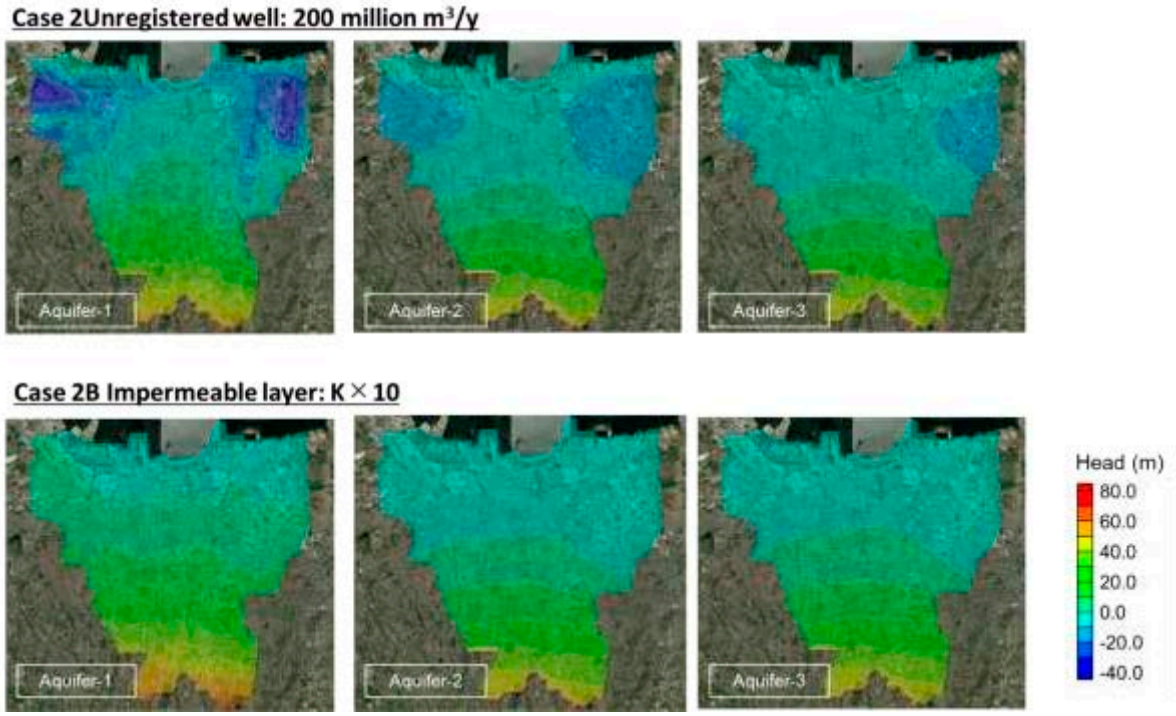


Figure 2-150 Case 2B Groundwater level from analysis result (Comparison with case 2)

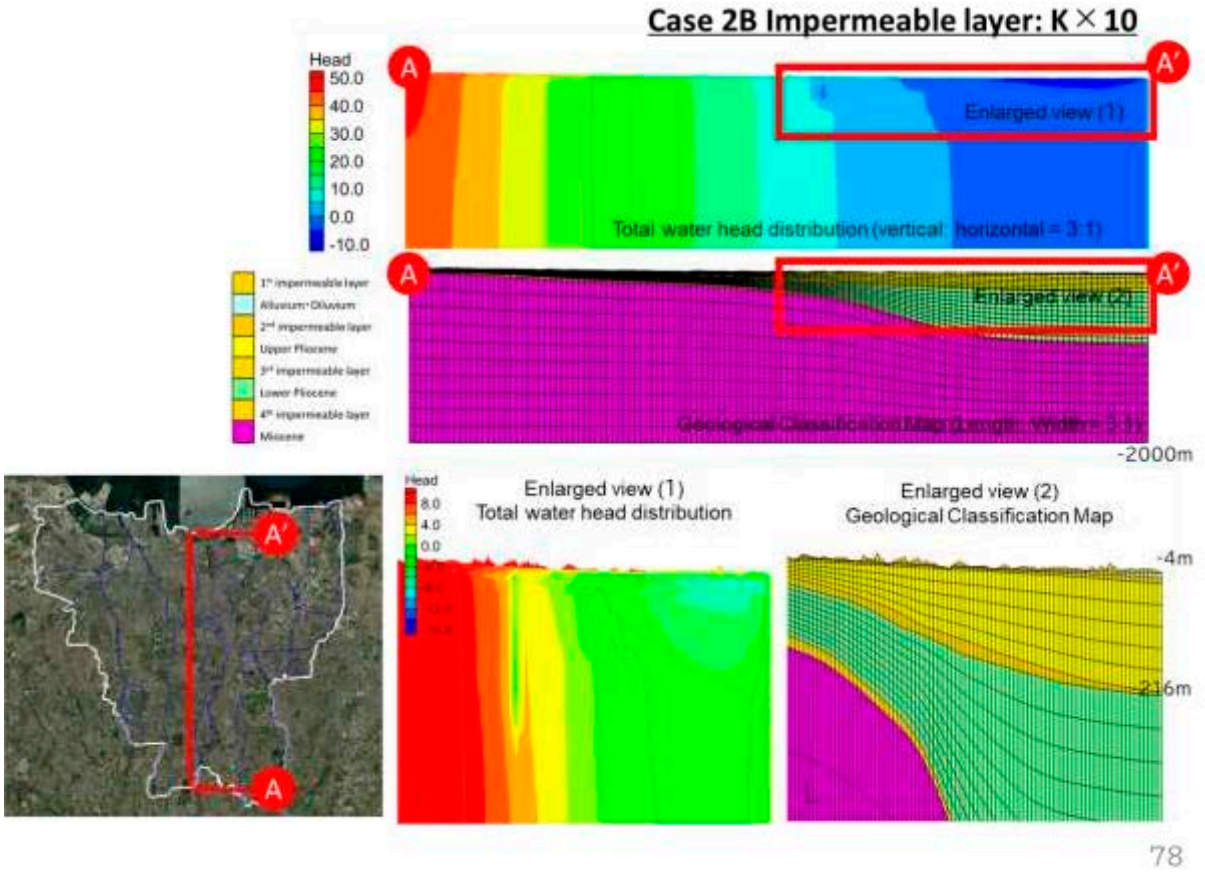


Figure 2-151 Case 2B : Calculated GW level 1 (cross section)

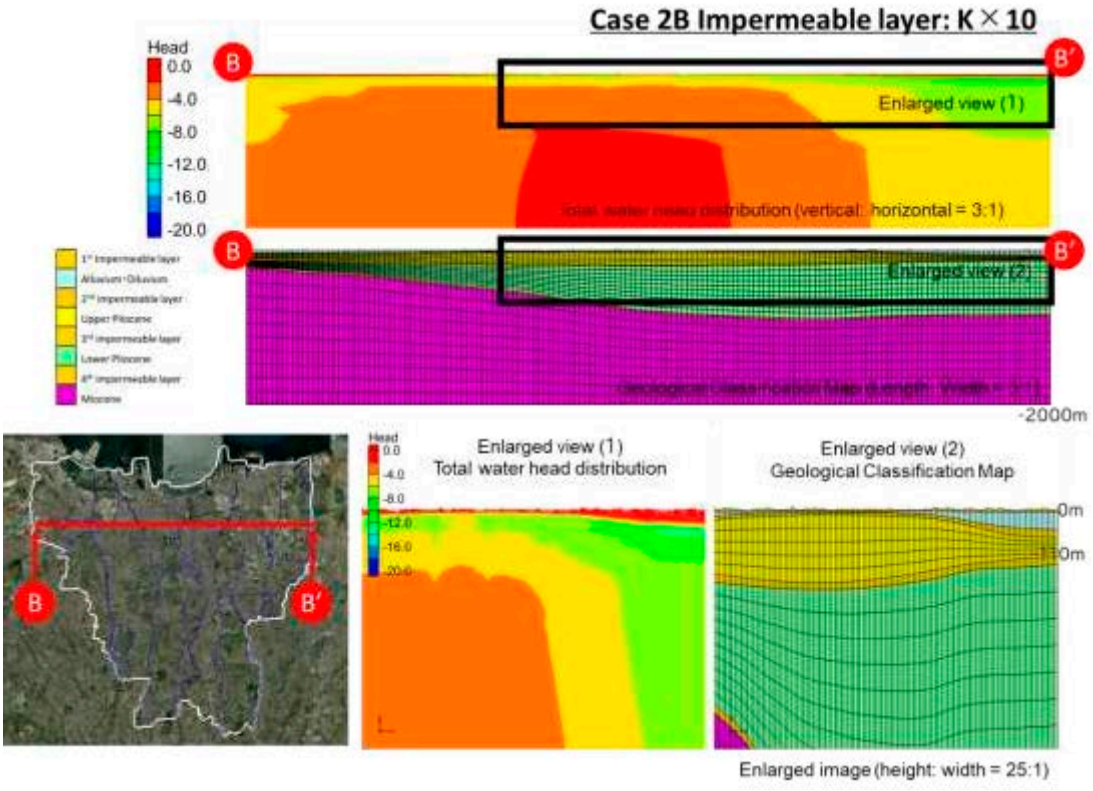


Figure 2-152 Case 2B : Calculated GW level 2 (cross section)

Table 2-56 Summary of water balance in Jakarta (Case 2B)

Case		2	2B	Ratio	Remarks
Pumping volume (m^3/y)	Unregistered shallow well	About 200 million	About 200 million	Same	By multiplying the coefficient of permeability of the surface layer (impermeable layer) by 10, the amount of subsurface infiltration increased and the total flow rate increased by 849,000.
	Registered Deep well	About 9.11 million		Same	
Precipitation (mm/y)				Same	
【Water balance (m^3/d)】					
Total flow volume			1,733,000 (100.0%)	1.96	Total flow rate increased by 849,000 due to increased groundwater infiltration
Inflow	Underground seepage volume	289,000 (32.7%)	1,175,000 (67.8%)	4.07	886,000 increase
	Recharge from river	250,000 (28.3%)	265,000 (15.3%)	1.06	15,000 increase
	Inflow flow from outside	346,000 (39.1%)	293,000 (16.9%)	0.85	53,000 decrease
Outflow	evapotranspiration	229,000 (25.9%)	854,000 (49.3%)	3.73	625,000 increase
	Pumping volume	422,000 (47.7%)	559,000 (32.3%)	1.32	137,000 increase
	Outflow into river, etc.	125,000 (14.1%)	212,000 (12.2%)	1.70	87,000 increase
	Outflow into ocean, etc.	108,000 (12.2%)	108,000 (6.2%)	1.00	

2) Case 2C

The water balance results for Case 2C are as follows.

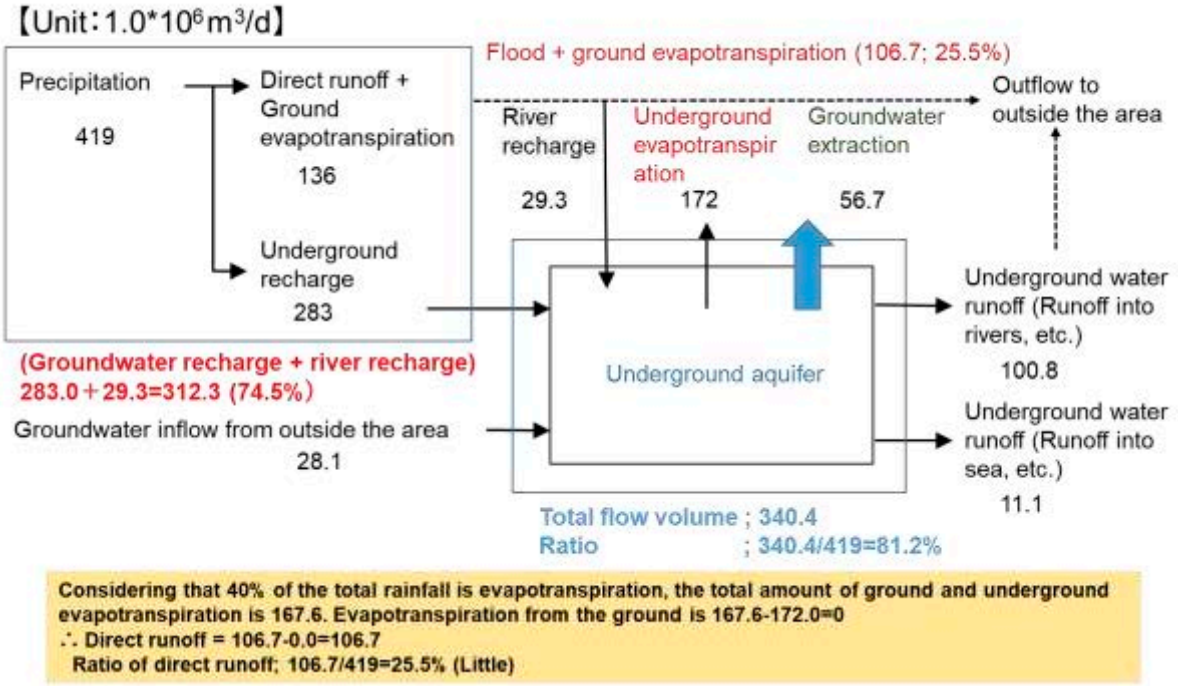


Figure 2-153 Water balance calculation (Case 2C)

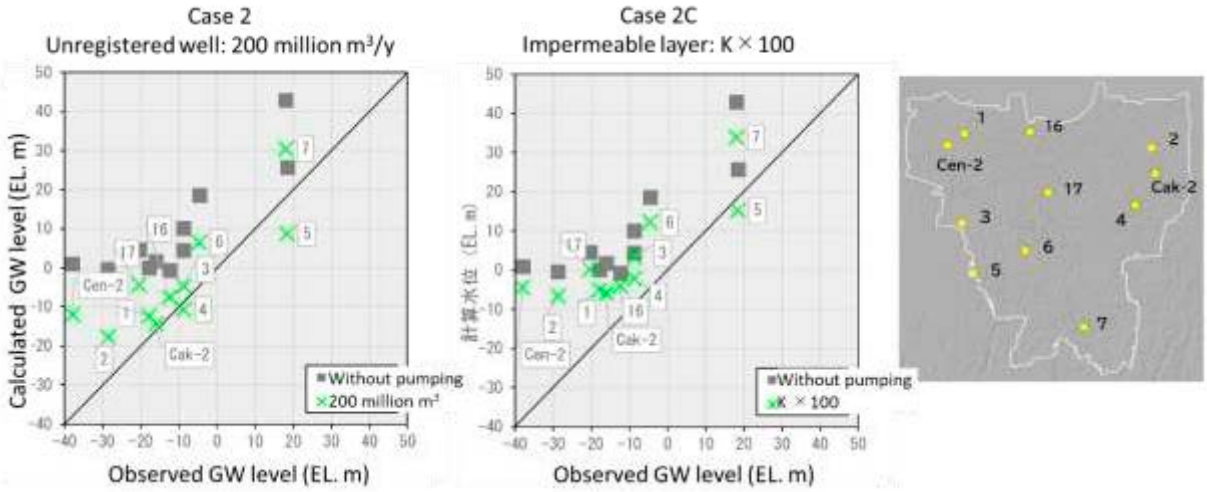


Figure 2-154 Coefficient between observed and calculated GW level (comparison with case 2)

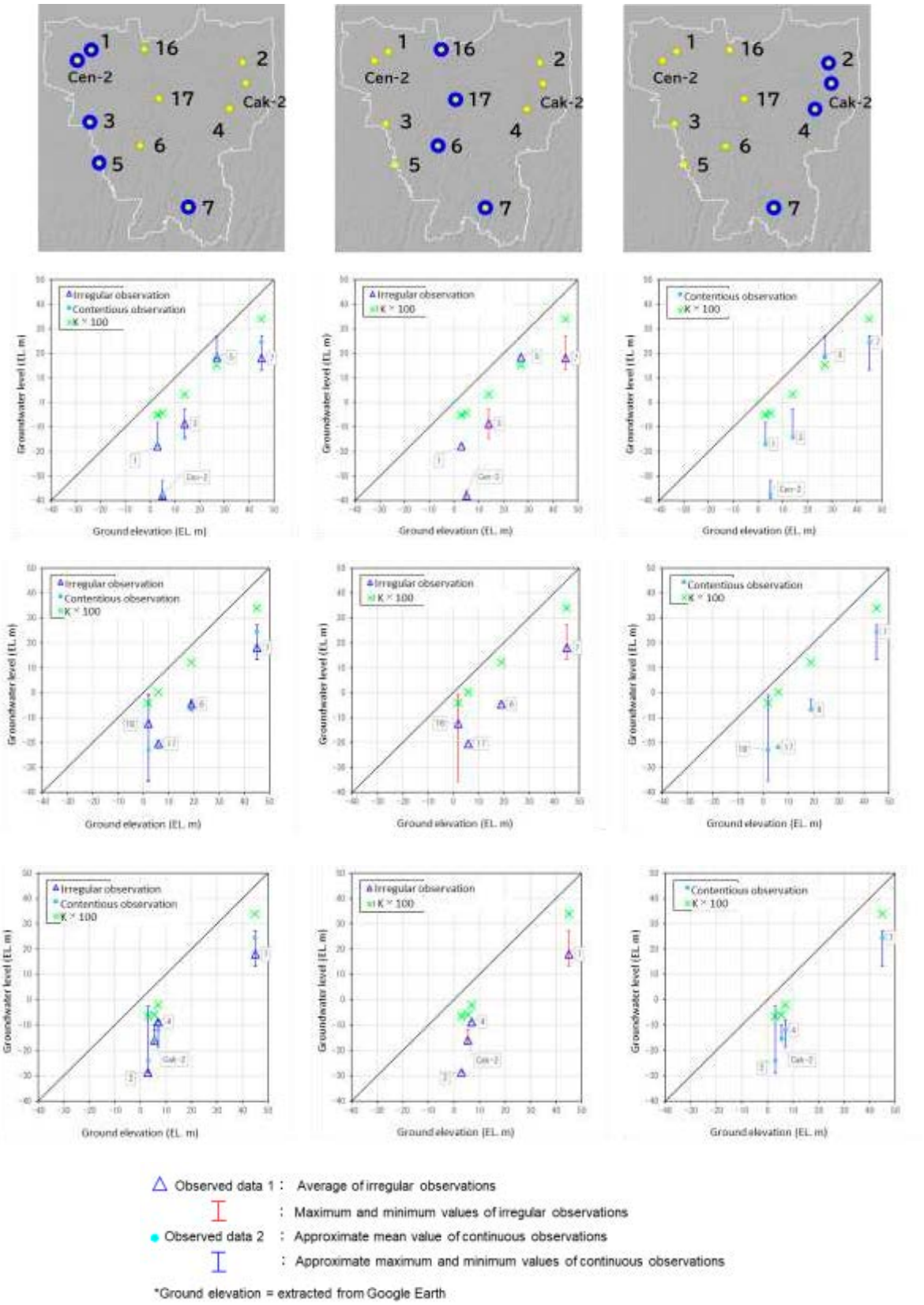


Figure 2-155 Ground height × groundwater level elevation values (upper : west side, middle : center, lower : east side)

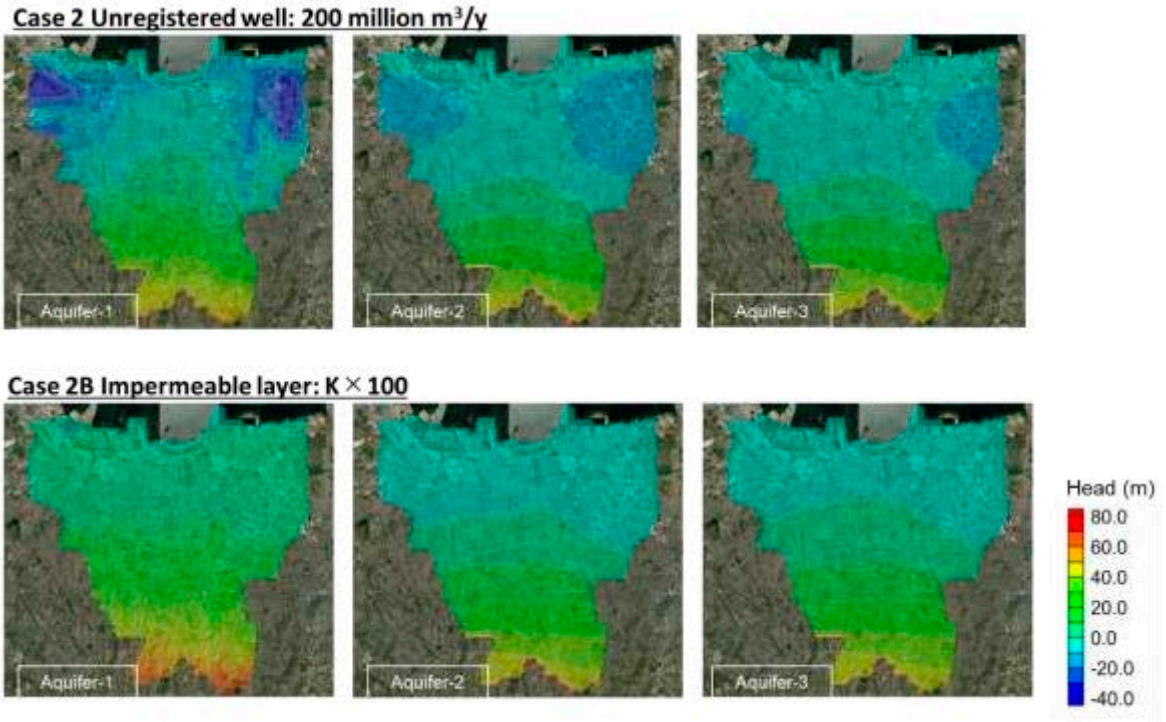


Figure 2-156 Case 2C Groundwater level from analysis result (Comparison with case 2)

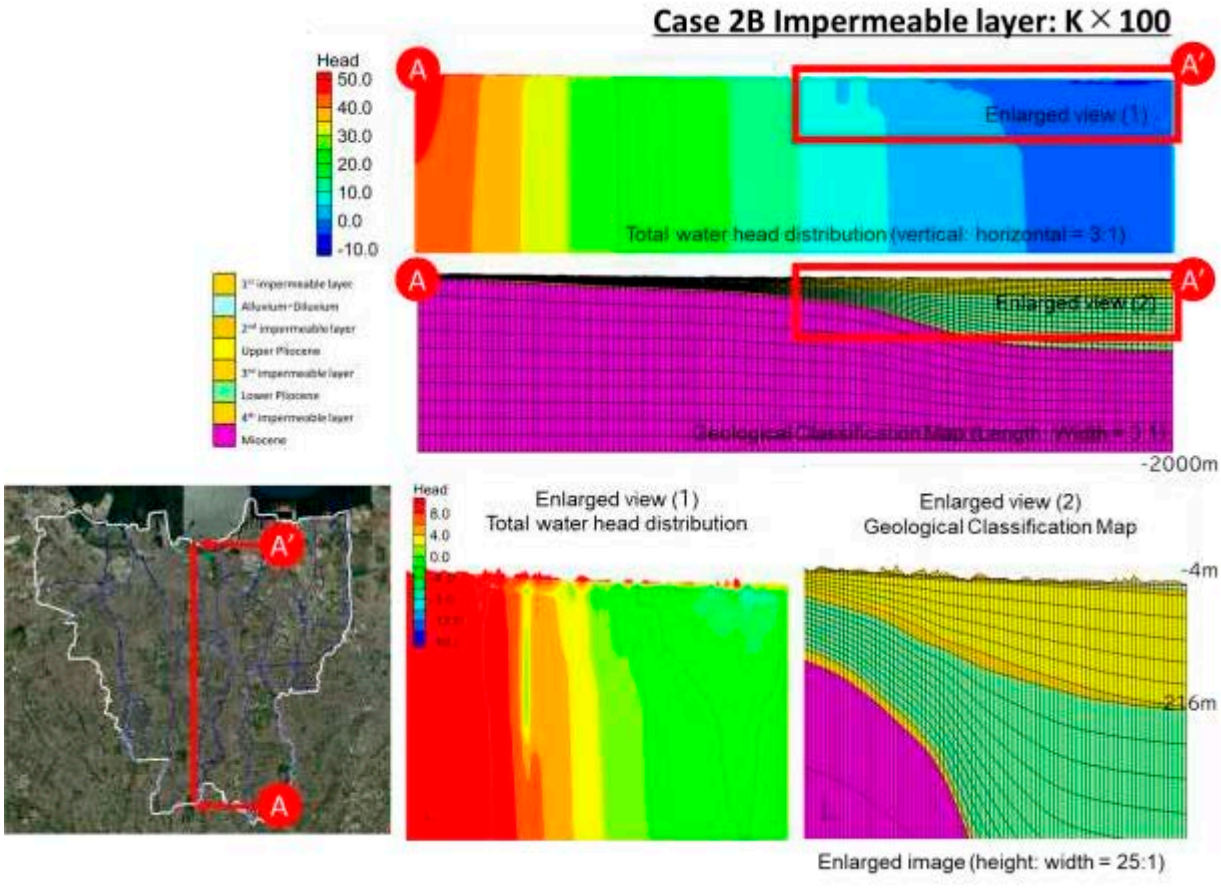


Figure 2-157 Case 2C : Calculated GW level 1 (cross section)

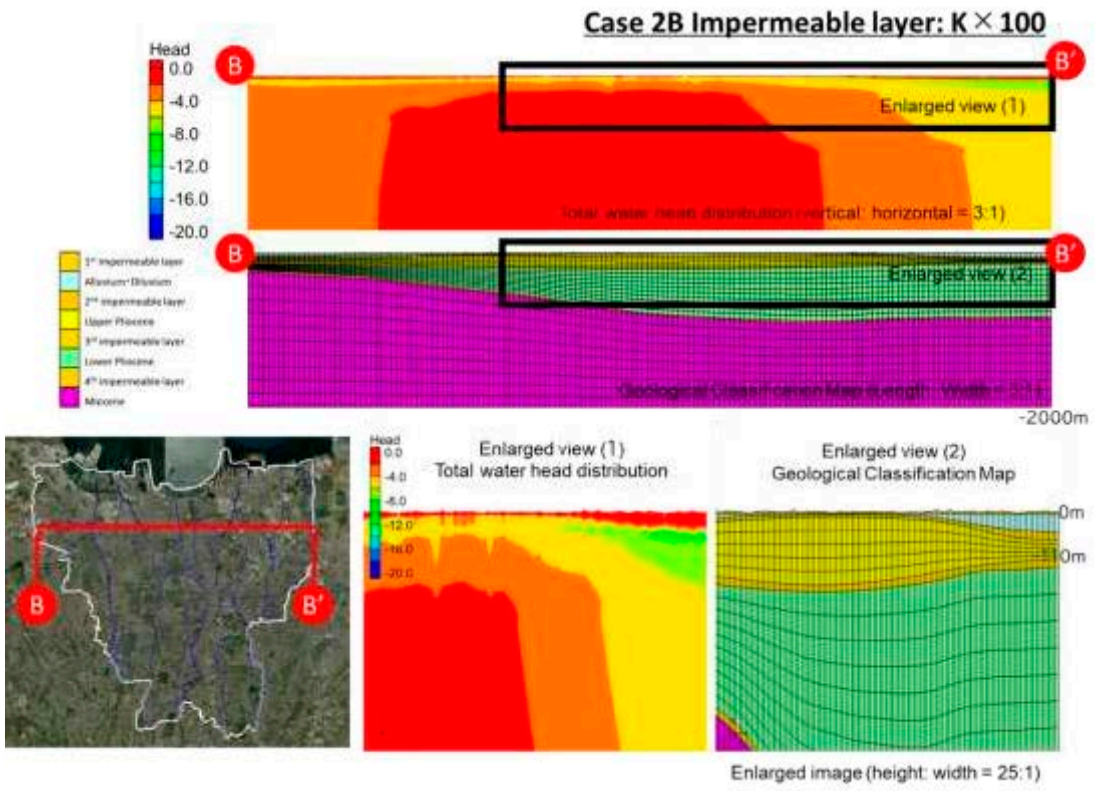


Figure 2-158 Case 2C : Calculated GW level 2 (cross section)

Table 2-57 Summary of water balance in Jakarta (Case 2C)

Case		2	2C	Ratio	Remarks
Pumping volume (m^3/y)	Unregistered shallow well	About 200 million	About 200 million	Same	By multiplying the coefficient of permeability of the surface layer (impermeable layer) by 100, the amount of subsurface infiltration increased and the total flow rate increased by 2,520,000
	Registered Deep well	About 9.11 million		Same	
Precipitation (mm/y)		2,345		Same	
【Water balance (m^3/d)】					
Total flow volume		884,000 (100.0%)	3,404,000 (100.0%)	3.85	Total flow rate increased by 2,520,000 due to increased groundwater infiltration
Inflow	Underground seepage volume	289,000 (32.7%)	2,830,000 (83.1%)	9.79	2,541,000 increase
	Recharge from river	250,000 (28.3%)	293,000 (8.6%)	1.17	43,000 increase
	Inflow flow from outside	346,000 (39.1%)	281,000 (8.3%)	0.81	65,000 decrease
Outflow	evapotranspiration	229,000 (25.9%)	1,720,000 (50.5%)	7.51	1,491,000 increase
	Pumping volume	422,000 (47.7%)	567,000 (16.7%)	1.34	145,000 increase
	Outflow into river, etc.	125,000 (14.1%)	1,008,000 (29.6%)	8.06	883,000 increase
	Outflow into ocean, etc.	108,000 (12.2%)	111,000 (3.3%)	1.03	

(4) Senario-3

Based on the results of the above examination, it is assumed that Case 2B, where the recharge from groundwater and river is about 30% of the rainfall, is a reasonable model (permeability).

Case 2 : Groundwater recharge + river recharge = 28.9 + 25.0 = 53.9 (12.9% of rainfall)

Case 2B : Groundwater recharge + river recharge = 117.5 + 26.5 = 144.0 (34.4% of rainfall)

Case 2C : Groundwater recharge + river recharge = 283.0 + 29.3 = 312.3 (74.5% of rainfall)

Therefore, the case where the coefficient of permeability of the impermeable layer at the surface is 10 times higher than the observed value (Case 2B) is examined here. Calculations are conducted by assuming that the pumping volume from the registered wells (deep wells) is doubled and the precipitation is increased by 1/2. The case of doubling the pumping volume was set based on past well pumping data and other factors.

Table 2-58 Setting of examination case

Case ID	Pumping volume of unregistered well 【Shallow well】 (m^3/y)	Pumping volume of registered well 【Deep well】 (m^3/y)	Additional pumping volume (m^3/y)	Precipitation (mm/y)	Coefficient of permeability of impermeable layer-1
2B-1	200 million	18 million[1)]	—	2,345	10 times
2B-2	200 million	9.11 million	—	1,172[2)]	10 times

1) Double the pumping volume (only for deep wells out of the registered well pumping volume)
2) Precipitation 1/2 times

1) Case 2B-1

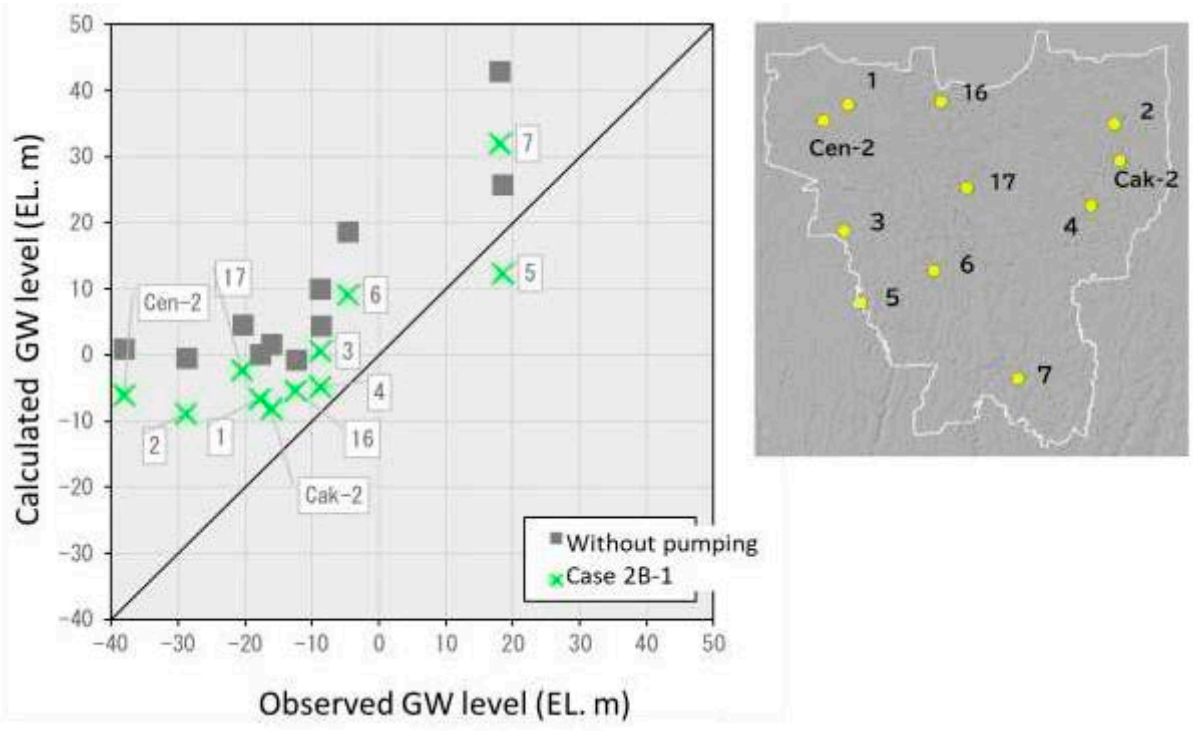


Figure 2-159 Coefficient between observed and calculated GW level (2B-1)

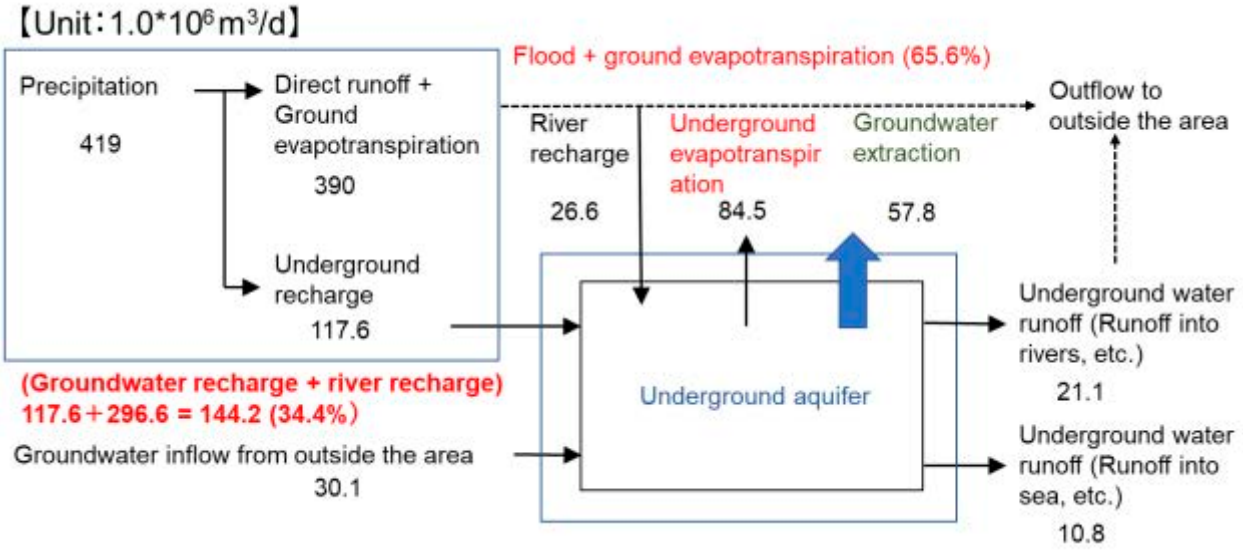


Figure 2-160 Water balance calculation (Case 2B-1)

Table 2-59 Summary of water balance in Jakarta (Case 2B-1)

Case		2	2B (×10)	2B-1 (×10)	Ratio	Remarks
Pumping volume (m^3/y)	Unregistered shallow well	About 200 million			Same	By multiplying the coefficient of permeability of the surface layer (impermeable layer) by 10 → 100, the amount of subsurface infiltration increased and the total flow rate increased by 1,671,000
	Registered Deep well	About 9.11 million		About 18 million	Same	
Precipitation (mm/y)		2,345			Same	
【Water balance (m^3/d)】						
Total flow volume		884,0 (100.0%)	1,733,000 (100.0%)	1,743,000 (100.0%)	1.96	Total flow rate increased by 1,671,000 due to increased groundwater infiltration
Inflow	Underground seepage volume	289,000 (32.7%)	1,175,000 (67.8%)	1,176,000 (64.5%)	2.41	1,655,000 increase
	Recharge from river	250,000 (28.3%)	265,000 (15.3%)	266,000 (15.3%)	1.11	28,000 increase
	Inflow flow from outside	346,000 (39.1%)	293,000 (16.9%)	301,000 (17.3%)	0.96	12,000 decrease
Outflow	evapotranspiration	229,000 (25.9%)	854,000 (49.3%)	845,000 (48.5%)	2.01	866,000 increase
	Pumping volume	422,000 (47.7%)	559,000 (32.3%)	578,000 (33.2%)	1.01	8,000 increase
	Outflow into river, etc.	125,000 (14.1%)	212,000 (12.2%)	211,000 (12.1%)	4.75	796,000 increase
	Outflow into ocean, etc.	108,000 (12.2%)	108,000 (6.2%)	108,000 (6.2%)	1.03	

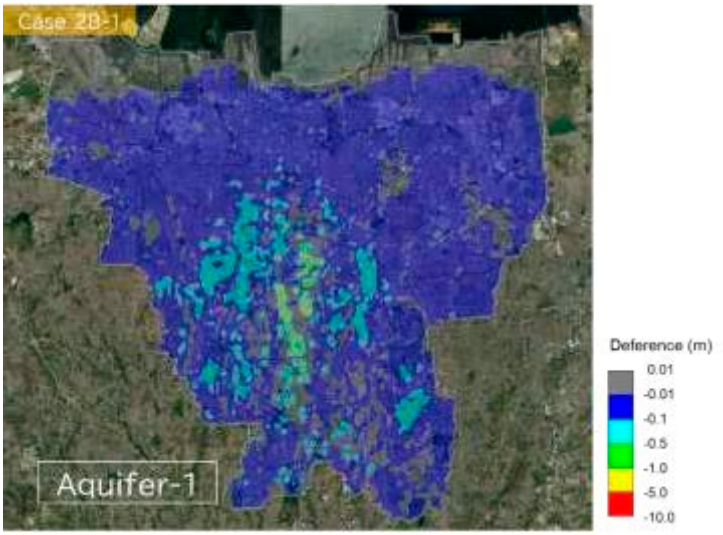


Figure 2-161 Case 2B-1 : Groundwater level analysis results (difference from Case 2B, aquifer 1)

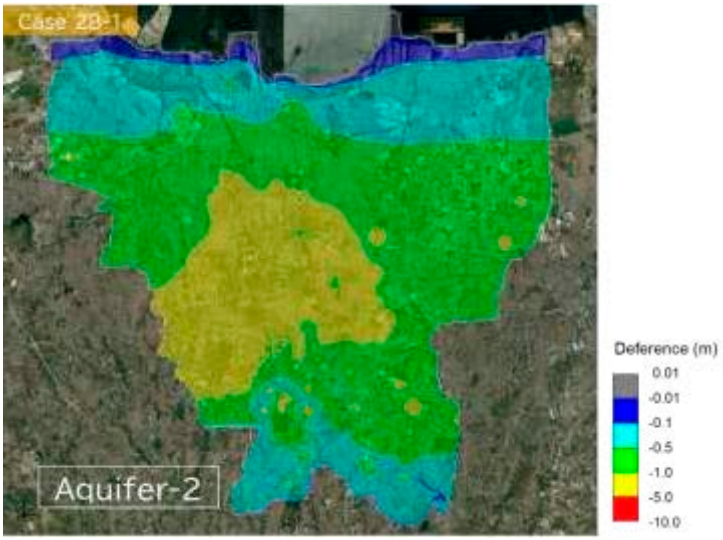


Figure 2-162 Case 2B-1 : Groundwater level analysis results (difference from Case 2B, aquifer 2)

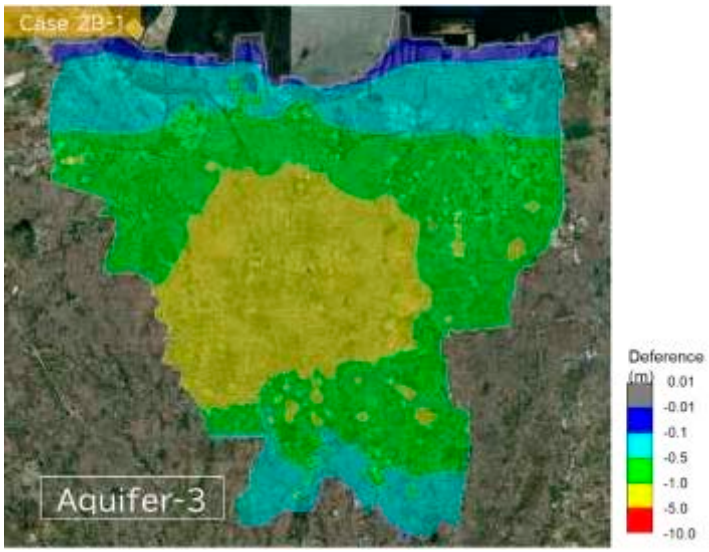


Figure 2-163 Case 2B-1 : Groundwater level analysis results (difference from Case 2B, aquifer 3)

2) Case 2B-2

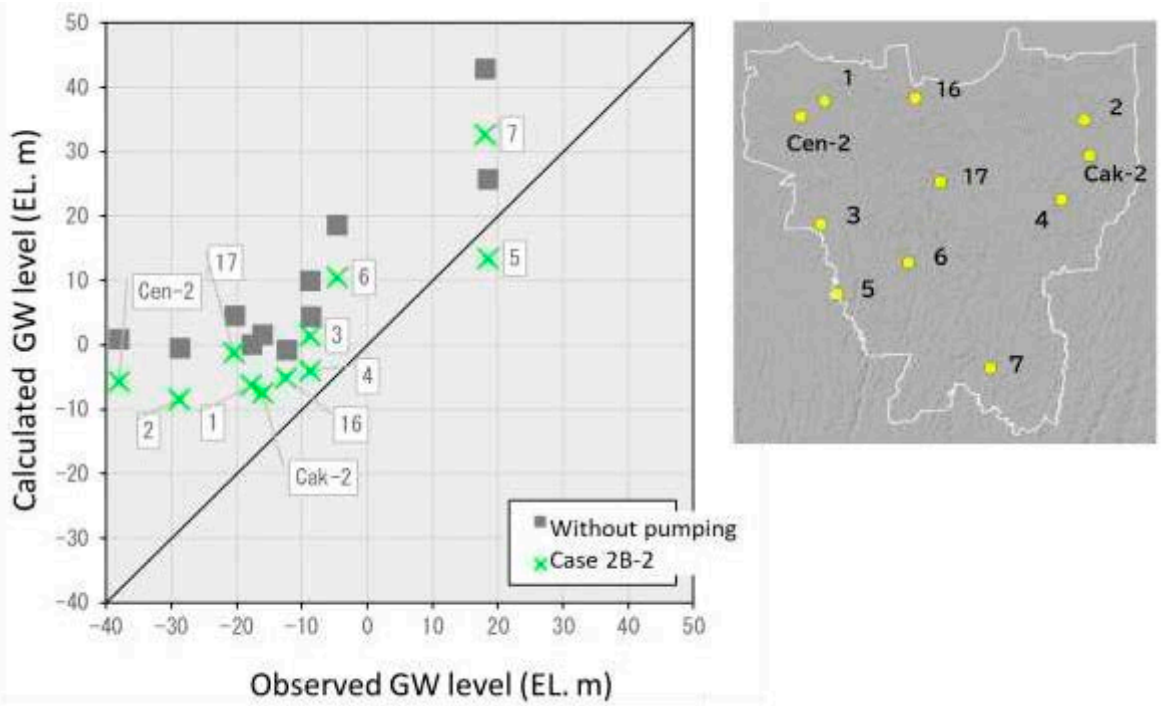


Figure 2-164 Coefficient between observed and calculated GW level (2B-2)

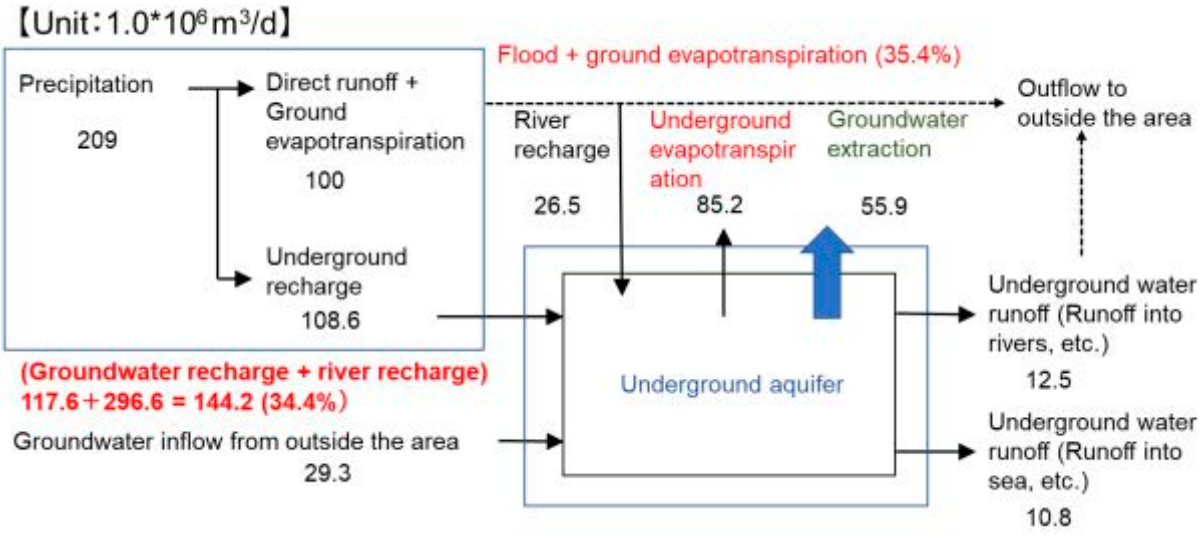


Figure 2-165 Water balance calculation (Case 2B-2)

Table 2-60 Summary of water balance in Jakarta (Case 2B-2)

Case		2	2B (×10)	2B-2 (×10)	Ratio	Remarks
Pumping volume (m^3/y)	Unregistered shallow well	About 200 million			Same	By multiplying the coefficient of permeability of the surface layer (impermeable layer) by 10 → 100, the amount of subsurface infiltration increased and the total flow rate increased by 1,671,000
	Registered Deep well	About 9.11 million			Same	
Precipitation (mm/y)		2,345		1,172	Same	
【Water balance (m^3/d)】						
Total flow volume		884,0 (100.0%)	1,733,000 (100.0%)	1,743,000 (100.0%)	1.96	Total flow rate increased by 1,671,000 due to increased groundwater infiltration
Inflow	Underground seepage volume	289,000 (32.7%)	1,175,000 (67.8%)	1,176,000 (64.5%)	2.41	1,655,000 increase
	Recharge from river	250,000 (28.3%)	265,000 (15.3%)	266,000 (15.3%)	1.11	28,000 increase
	Inflow flow from outside	346,000 (39.1%)	293,000 (16.9%)	301,000 (17.3%)	0.96	12,000 decrease
Outflow	evapotranspiration	229,000 (25.9%)	854,000 (49.3%)	845,000 (48.5%)	2.01	866,000 increase
	Pumping volume	422,000 (47.7%)	559,000 (32.3%)	578,000 (33.2%)	1.01	8,000 increase
	Outflow into river, etc.	125,000 (14.1%)	212,000 (12.2%)	211,000 (12.1%)	4.75	796,000 increase
	Outflow into ocean, etc.	108,000 (12.2%)	108,000 (6.2%)	108,000 (6.2%)	1.03	

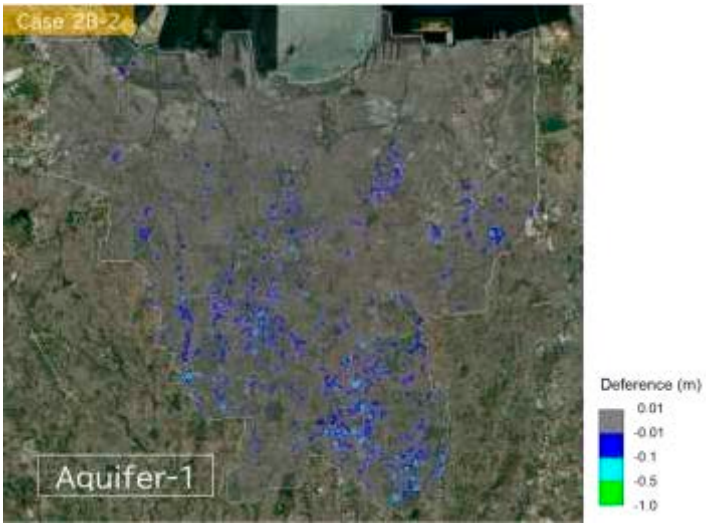


Figure 2-166 Case 2B-2 : Groundwater level analysis results (difference from Case 2B, aquifer 1)

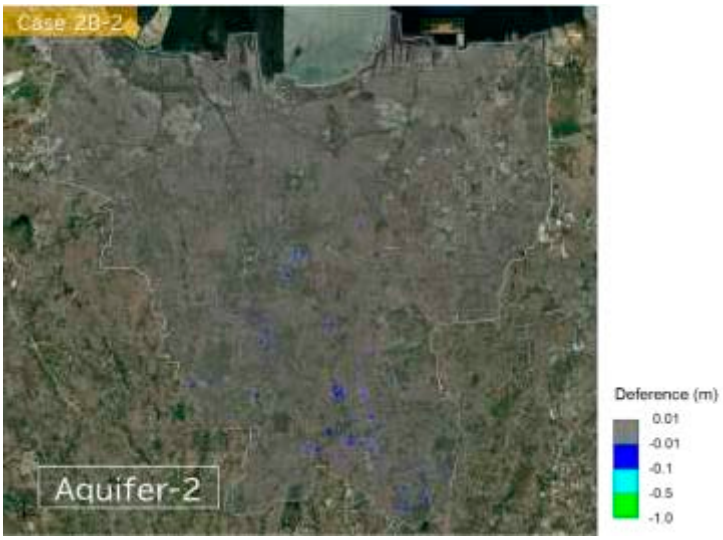


Figure 2-167 Case 2B-2 : Groundwater level analysis results (difference from Case 2B, aquifer 2)

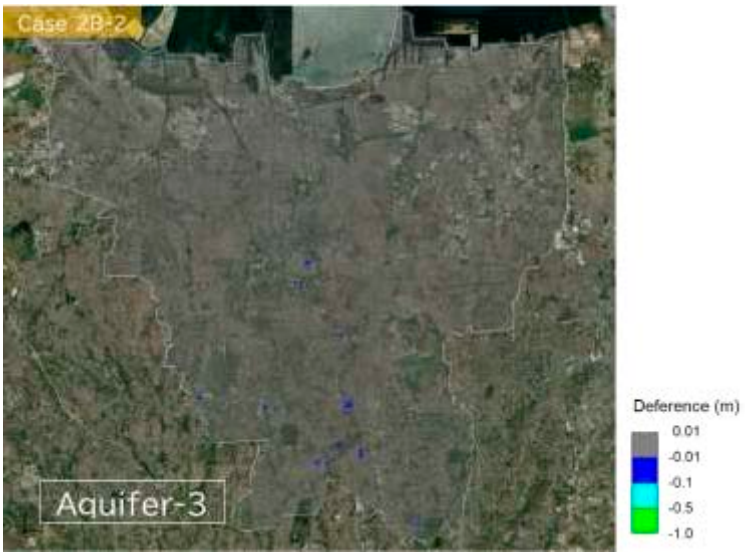


Figure 2-168 Case 2B-2 : Groundwater level analysis results (difference from Case 2B, aquifer 3)

(5) Senario-4

The calculation is carried out by assuming the case where the pumping volume at a specific point (Cen-2) increases, etc. In Case 2-1 shown above, the calculated groundwater level at Cen-2 is very high compared to the observed water level. For the other observed values, the calculated values and observed values are close. Around the Cen-2 point, the calculated groundwater level became closer to the observed value by raising the pumping volume to the maximum value around the point (about 300 m^3/d).

From the above, we found that the groundwater level was greatly affected by a slight change in the pumping volume of the well (deep well). Therefore, understanding the daily variation of the pumping volume of deep wells (not the average value but the daily variation; especially the maximum pumping volume) is important. The above calculation results and the coefficient of permeability around the deep wells suggest that the groundwater level decreases rapidly when the pumping rate increases even for a short period of time.

Table 2-61 Setting of examination case (scenario-4)

Case ID	Pumping volume of unregistered well 【Shallow well】 (m^3/y)	Pumping volume of registered well 【Deep well】 (m^3/y)	Additional pumping volume (m^3/y)	Precipitation (mm/y)	Coefficient of permeability of impermeable layer-1
2B-1	200 million	18 million[1)]	—	2,345	10 times
2B-1①	200 million	18 million[1)]	Deep well pumping from 4 meshes around Cen-2 (+200 m^3/d) 4 mesh × 200 × 365 = 300,000 m^3/year increase	2,345	10 times

1) Double the pumping capacity (only deep wells among the registered well pumping capacity)
*The pumping volumes of shallow wells and deep wells at Cen-2 site are as follows
Case 2B : 126 m^3/day (shallow wells : 71, deep wells : 55)
Case 2B-1 : 181 m^3/day (shallow wells : 71, deep wells : 110)
Case 2B-1① : 381 m^3/day (shallow wells : 71, deep wells : 110+200) only for 4 meshes near Can-2

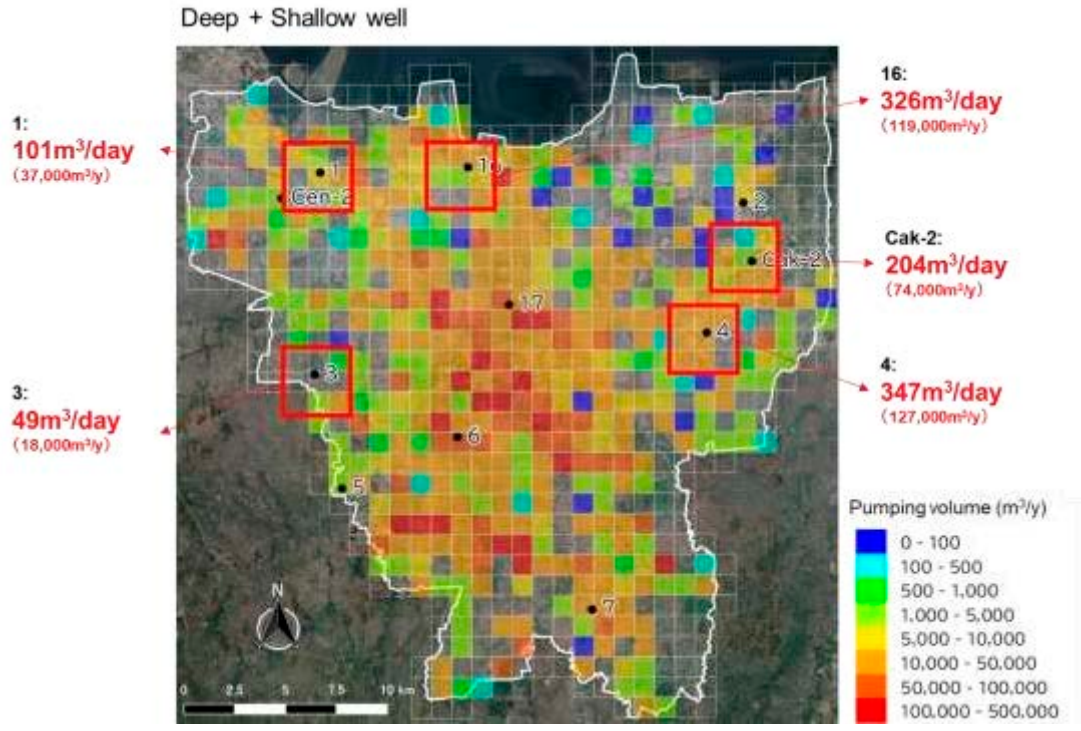


Figure 2-169 Pumping volume of registered well

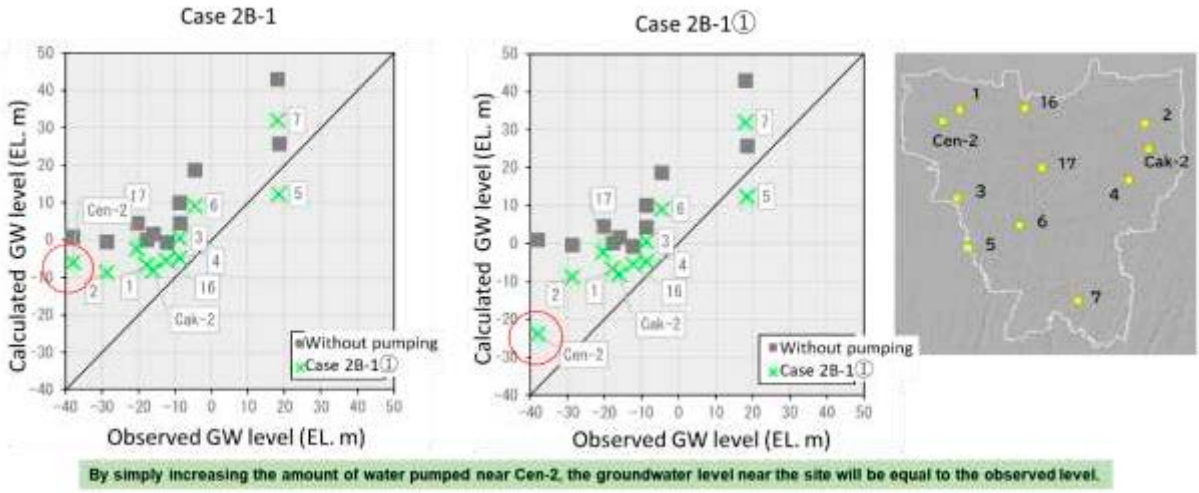


Figure 2-170 Coefficient between observed and calculated GW level (Senario-4)

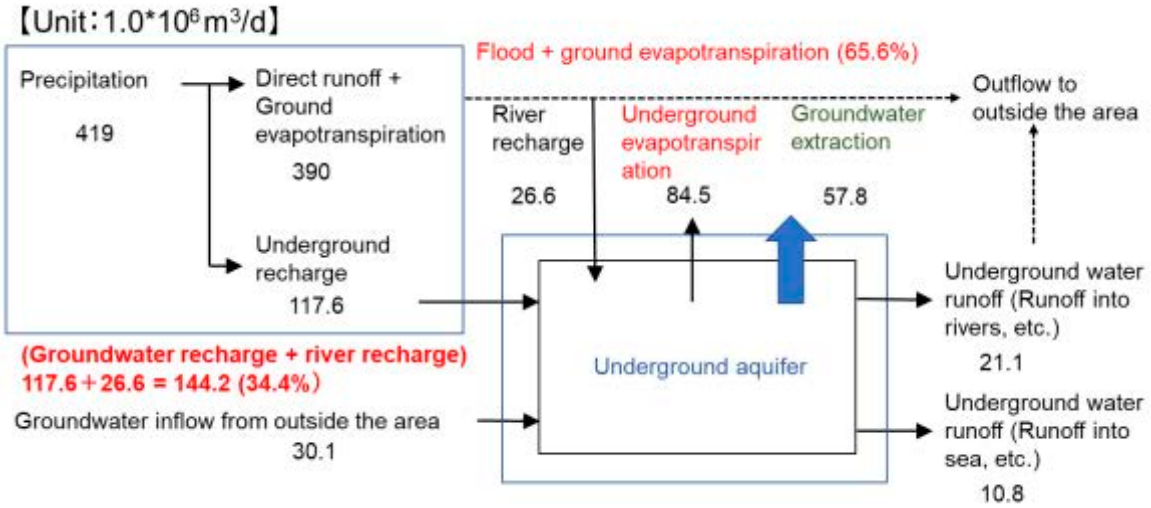


Figure 2-171 Water balance calculation (Case 2B-1①)

Table 2-62 Summary of water balance in Jakarta (Senario-4)

Case		2	2B (×10)	2B-1 (×10)	2B-1① (×10)	Ratio	Remarks
Pumping volume (m^3/y)	Unregistered shallow well	About 200 million				Same	Although the pumping volume from Cen-2 is increased, the total flow rate is almost the same. It is only a partial change (only near Cen).
	Registered Deep well	About 9.11 million		About 18 million		Same	
Precipitation (mm/y)		2,345				Same	
【Water balance (m^3/d)】							
Total flow volume		884,0 (100.0%)	1,733,000 (100.0%)	1,743,000 (100.0%)	1,744,000 (100.0%)		
Inflow	Underground seepage volume	289,000 (32.7%)	1,175,000 (67.8%)	1,176,000 (64.5%)	1,176,000 (64.5%)		
	Recharge from river	250,000 (28.3%)	265,000 (15.3%)	266,000 (15.3%)	266,000 (15.3%)		
	Inflow flow from outside	346,000 (39.1%)	293,000 (16.9%)	301,000 (17.3%)	302,000 (17.3%)		
Outflow	evapotranspiration	229,000 (25.9%)	854,000 (49.3%)	845,000 (48.5%)	845,000 (48.5%)		
	Pumping volume	422,000 (47.7%)	559,000 (32.3%)	578,000 (33.2%)	579,000 (33.2%)		
	Outflow into river, etc.	125,000 (14.1%)	212,000 (12.2%)	211,000 (12.1%)	212,000 (12.1%)		
	Outflow into ocean, etc.	108,000 (12.2%)	108,000 (6.2%)	108,000 (6.2%)	108,000 (6.2%)		

By changing the pumping volume of the deep well around the Cen-2 point from 100 m^3/d to 300 m^3/d, the calculated groundwater level at the Cen-2 point became almost the same as the observed value.

From the above, we found that if the maximum pumping volume (pumping intensity) of other areas was taken at the Cen-2 site, the calculated value and the observed value would be the same. Based on this result, it is necessary to reconfirm whether the pumping volume of deep wells is properly applied, especially for the points with low observed groundwater level. Similarly, in areas where the calculated groundwater level is higher than the observed value, it is considered necessary to reconfirm the ground constants and the pumping rate (especially the deep well pumping rate).

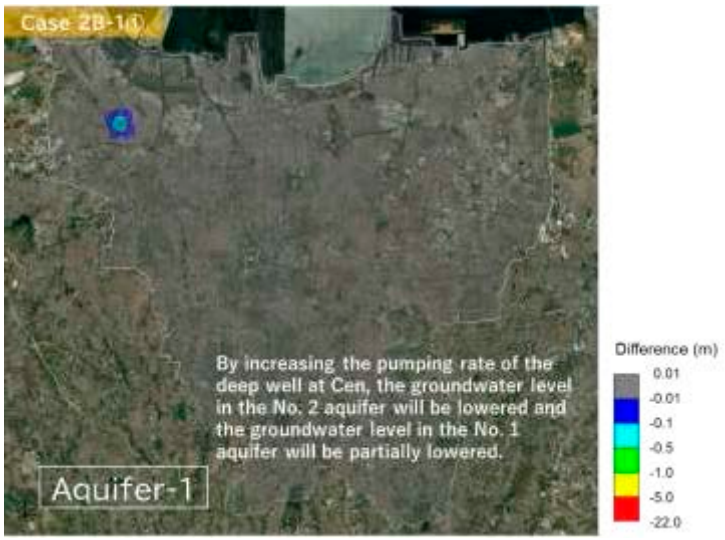


Figure 2-172 Case 2B-1① : Groundwater level analysis results (difference from Case 2B, aquifer 1)

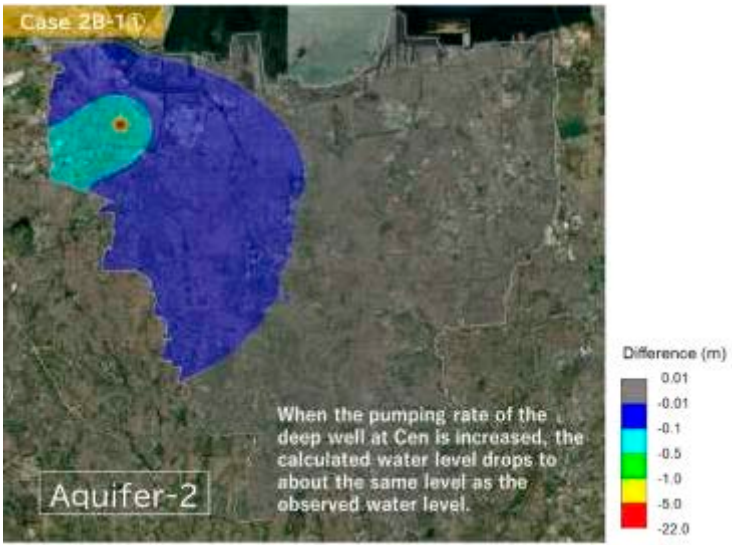


Figure 2-173 Case 2B-1① : Groundwater level analysis results (difference from Case 2B, aquifer 2)

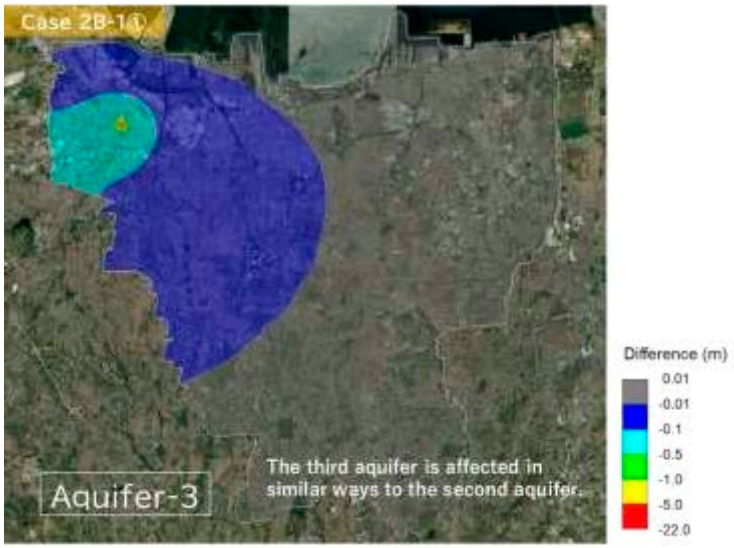


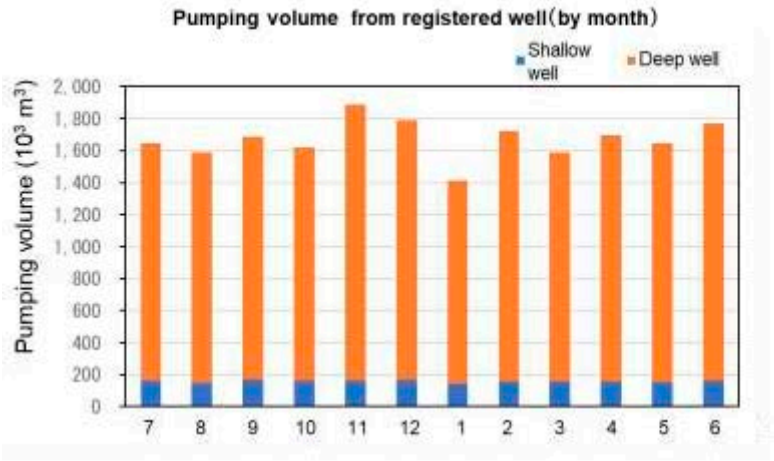
Figure 2-174 Case 2B-1① : Groundwater level analysis results (difference from Case 2B, aquifer 3)

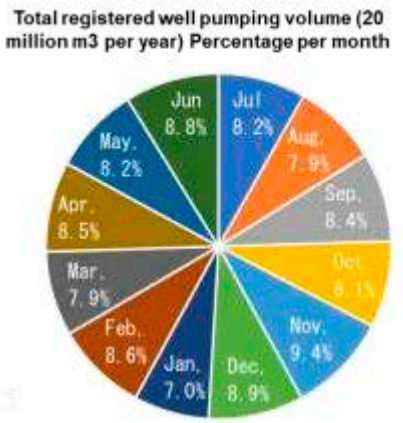
(6) Transient analysis

1) Transient analysis calculation conditions

Transient analysis was conducted under the following conditions

- Monthly precipitation and evapotranspiration from July 2020 to June 2021
- Unregistered well pumping : 200 million m^3/y
- Registered wells : approximately 18 million m^3/y for deep wells and approximately 2 million m^3/y for shallow wells, prorated according to the percentage of monthly observations
- Pumping of 290,000 m^3/y from 4 meshes around Cen-2, prorated according to the ratio of monthly observation values





Unit: million m^3

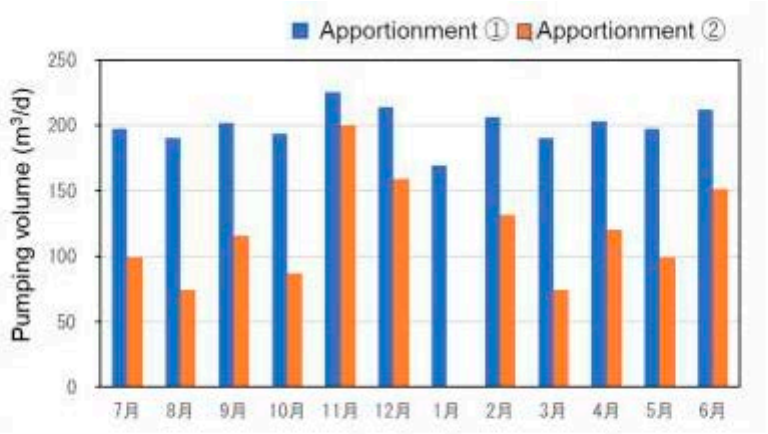
	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Shallow	0.16	0.14	0.17	0.16	0.16	0.17	0.14	0.16	0.16	0.16	0.15	0.16	1.89
Deep	1.48	1.45	1.52	1.46	1.73	1.62	1.27	1.57	1.43	1.54	1.50	1.61	18.18
Total	1.65	1.59	1.69	1.62	1.89	1.79	1.41	1.72	1.59	1.70	1.65	1.77	20.07
Ratio (W_i)*	0.0821	0.0792	0.0841	0.0807	0.0940	0.0892	0.0705	0.0859	0.0792	0.0846	0.0821	0.0883	1.000

* W_i is the ratio of the pumping rate in the target month to the total pumping rate

Figure 2-175 Pumping volume of registered well

At the Cen site, the calculated groundwater level is evaluated to be higher than the observed groundwater level.

We evaluated how the groundwater level would change by adding an additional pumping rate of about 200 m^3/day to the pumping rate (about 100 m^3/day) investigated in this study. (Transient analysis) The value of the additional pumping volume is described below.



Additional pumping volume around Cen-2 (per mesh)

Unit (m^3/d)

	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Apportionment①	193	187	205	190	229	210	166	224	187	206	193	215
Apportionment②	99	75	116	87	200	159	0	131	74	120	99	151

Unit (m^3/month)

	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Apportionment①	5,790	5,610	6,150	5,700	6,870	6,300	4,980	6,730	5,610	6,180	5,790	6,450
Apportionment②	2,970	2,250	3,480	2,610	6,000	4,770	0	3,930	2,220	3,600	2,970	4,530

Total of Apportionment① : 72,160 m3/y
Total of Apportionment② : 39,330 m3/y

Figure 2-176 Additional pumping around Cen-2 and apportionment method

In the case of the appropriation method (1), there is no significant difference in the amount of water pumped at the Cen point, so the annual difference in water level is contained at about 2 meters. The annual pumping volume at the Cen point has increased by about 72,000 m^3, which is about 0.36% of the total registered groundwater pumping volume (20 million m^3).

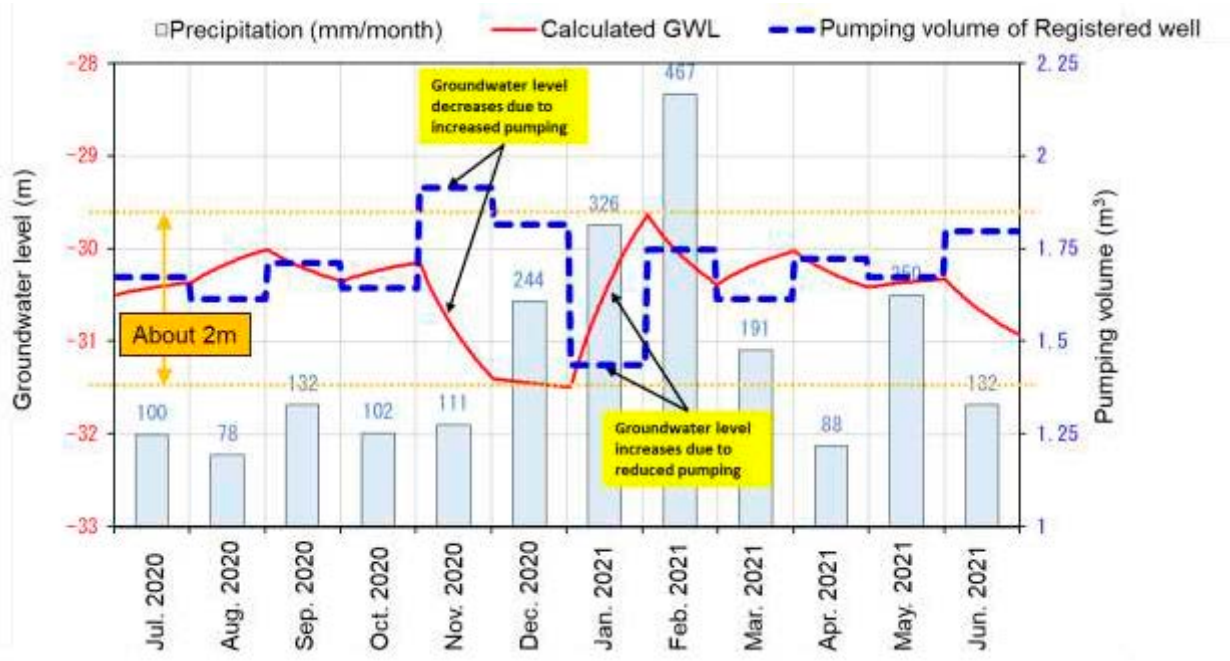


Figure 2-177 Fluctuation of Groundwater level (1)

In the case of the apportionment method (2), a large difference is set in the pumping volume at the Cen point, so the annual difference in water level has increased to about 10 meters. The annual pumping volume at the Cen point has increased by about 40,000 m^3, which is about 0.20% of the total registered groundwater pumping volume (20 million m^3).

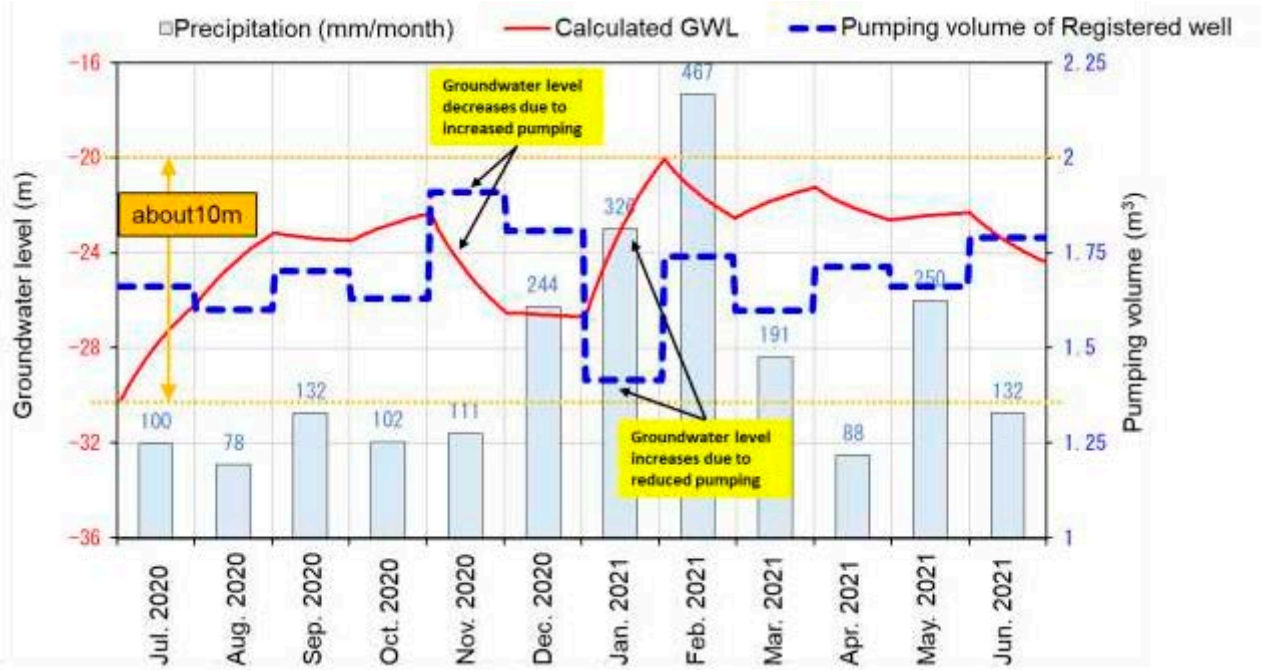


Figure 2-178 Fluctuation of Groundwater level (2)

2) Result of Transient analysis

From the table above, it is remarkable that when the amount of groundwater pumped from deep wells increased from the previous month, the groundwater level decreased. While when the amount of groundwater pumped decreased from the previous month, the groundwater level increased. This

indicates that the groundwater level changes remarkably with the increase or decrease of groundwater pumping.

In this calculation, the amount of water pumped from the deep well is calculated for the case where the amount of water pumped from Cen-2 is increased, as in Case 2B-1①. The value calculated here is about the same as the observed value of groundwater level in Cen-2. In the future, it is necessary to confirm how the groundwater level will change when the pumping rate is changed. In the steady state analysis, the increase or decrease of groundwater level by about 20 m is calculated by changing the pumping rate. (From the comparison between Case 2B-1 and 2B-1①)

2.8.6 Conclusion

(1) Groundwater Analysis

The groundwater analysis model was developed based on the range of observed groundwater levels, considering that it varies significantly from season to season. The geological and geotechnical conditions were set based on the results of this investigation and other factors. The pumping volume (shallow wells and deep wells) was set based on the information of more than 3,000 wells, but there are still a considerable number of unregistered pumping wells. In addition, pumping intensity diagrams for wells were created, but the amount of water pumped in areas where land subsidence is in progress was recorded less than expected, resulting in somewhat unnatural pumping intensity diagrams. In the future, it will be necessary to further understand the pumping volume.

In this study, groundwater analysis was conducted by considering various scenarios (varying the analysis conditions). As a result, a reliable analytical model (model based on water balance) was developed and the analytical results were obtained, and the model was generally consistent with the observed groundwater level.

1) Groundwater steady state analysis

The following figure shows a list of scenarios and setting conditions that lead to the optimal solution.

Scenario-1 (setting the pumping volume for unregistered wells) → Case 2 was selected as the optimal solution.

Case No.	Pumping rate of unregistered well (m^3/y)	Pumping rate of registered deep well (m^3/y)	Rainfall (mm/y)	Remarks
1	315 Million	About 9.11 million	2,345	Pumping volume for unregistered wells is based on the results of this survey.
2	200 Million	About 9.11 million	2,345	Set a pumping volume of about 60% of the above as the pumping volume for unregistered wells.

Scenario-2 (setting permeability of surface layer) → Case 2B was selected as the optimal solution.

Case No.	Pumping rate of unregistered well (m^3/y)	Pumping rate of registered deep well (m^3/y)	Rainfall (mm/y)	Remarks
2	200 Million	About 9.11 million	2,345	
2B	200 Million	About 9.11 million	2,345	x10 times the permeability of the surface layer (impermeable layer)
2C	200 Million	About 9.11 million	2,345	x100 times the permeability of the surface layer (impermeable layer)

Scenario-3 (Setting of pumping volume for registered wells) → Case 2B-1 was set as the optimal solution.

Case No.	Pumping rate of unregistered well (m^3/y)	Pumping rate of registered deep well (m^3/y)	Additional pumping rate (m^3/y)	Rainfall (mm/y)	Permeability of Impermeable Layer-1
2B-1	200 Million	About 18.00 million	—	2,345	10 times
2B-2	200 Million	About 9.11 million	—	1,172	10 times

Scenario-4 (setting of pumping around Cen-2) → Case 2B-1① was set as the optimal solution.

Case No.	Pumping rate of unregistered well (m^3/y)	Pumping rate of registered deep well (m^3/y)	Additional pumping rate (m^3/y)	Rainfall (mm/y)	Permeability of Impermeable Layer-1
2B-1	200 Million	About 18.00 million	—	2,345	10 times
2B-1①	200 Million	About 18.00 million	Deep well pumping from 4 meshes around Cen-2 (+200m3/d) 4 mesh x 200 x 365 = 300,000m3/year increase	2,345	10 times

Figure 2-179 List of scenarios and setting conditions leading to the optimal solution

【Result of Groundwater Steady State Analysis】

A comparison between the calculated and observed groundwater levels for Case 2B-1①, which was chosen as the optimal solution, is shown below. By changing the deep well pumping volume around the Cen-2 point from 100 m3/d to 300 m3/d, the calculated groundwater level at the Cen-2 point became almost the same level as the observed value.

From the above results, it was found that the calculated and observed groundwater levels were almost the same when the maximum pumping volume (pumping intensity) in other areas was pumped at the Cen-2 point.

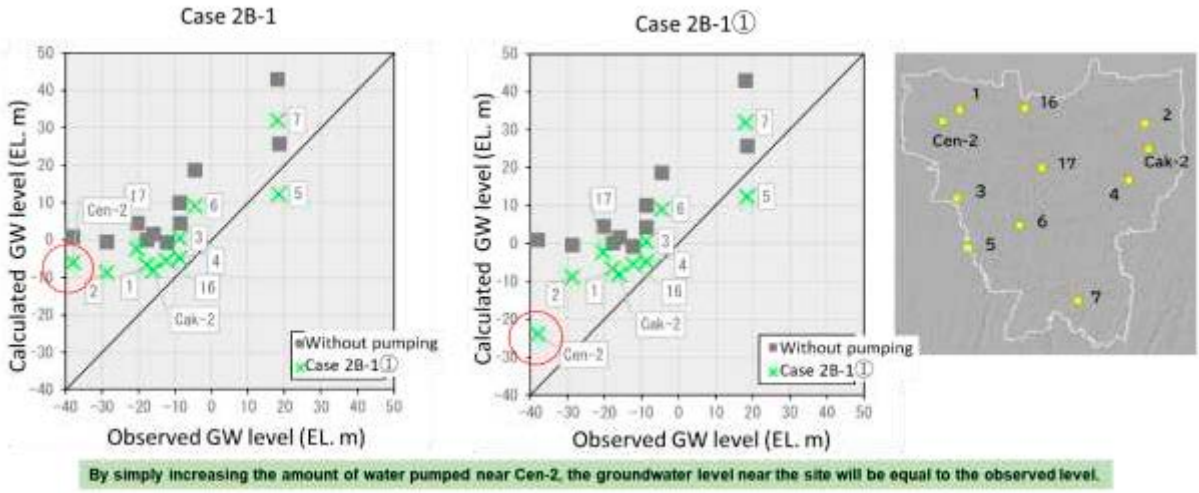


Figure 2-180 Coefficient between observed and calculated GW level (Senario-4, re-post)

The results of water balance calculation for case 2B-1① are shown below. The recharge from surface and river is 34.4% of the total precipitation, which can be judged as reasonable recharge.

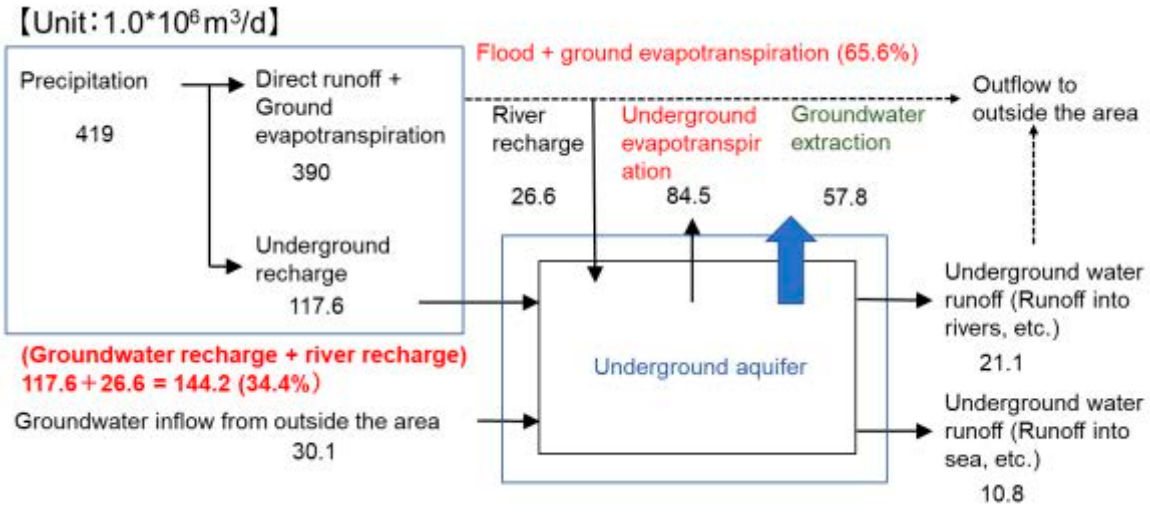


Figure 2-181 Water balance calculation (Case 2B-1①, re-post)

2) Groungwater transient analysis

In the results of the groundwater steady state analysis discussed above, a groundwater model (Case 2B-1①) was developed in which the observed groundwater level and calculated groundwater level were generally consistent. However, the actual phenomena are not in steady state but in unsteady state. Therefore, the unsteady groundwater analysis was conducted here assuming monthly changes in groundwater pumping (registered wells) based on the knowledge obtained from the steady-state analysis (monthly changes in groundwater pumping).

Since the calculated groundwater level at the Cen-2 site is evaluated higher than the observed groundwater level in the pumping volume of the surveyed registered wells, the groundwater pumping volume is added here by referring to the groundwater pumping volume in other districts, considering that the groundwater pumping volume at this site may have been calculated less than other districts.

In the same way as Case 2B-1① where the additional pumping rate (m3/day) was considered in the four meshes around Cen-2, we evaluated how the groundwater level would change by adding the pumping rate of about 200 m3/day to the pumping rate (about 100 m3/day) investigated this time around the Cen-2 point (Transient analysis). The value of the added pumping rate is described below. The prorating method (1) allocates 200 m3/s in proportion to the monthly pumping rate, and the prorating method (2) allocates the maximum 200 m3/s. The amount of groundwater pumping after allocation (after addition; about 300m3/day) is the amount that is also pumped in other districts.

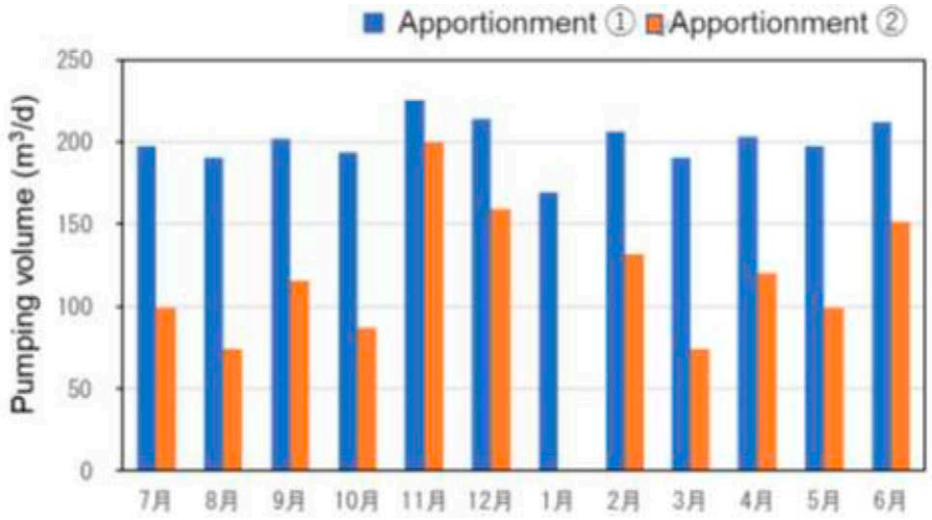


Figure 2-182 Additional pumping around Cen-2 and apportionment method (re-post)

In the case of the appropriation method (1), there is no significant difference in the amount of water pumped at the Cen point, so the annual difference in water level is contained at about 2 meters. The annual pumping volume at the Cen point has increased by about 72,000 m^3, which is about 0.36% of the total registered groundwater pumping volume (20 million m^3).

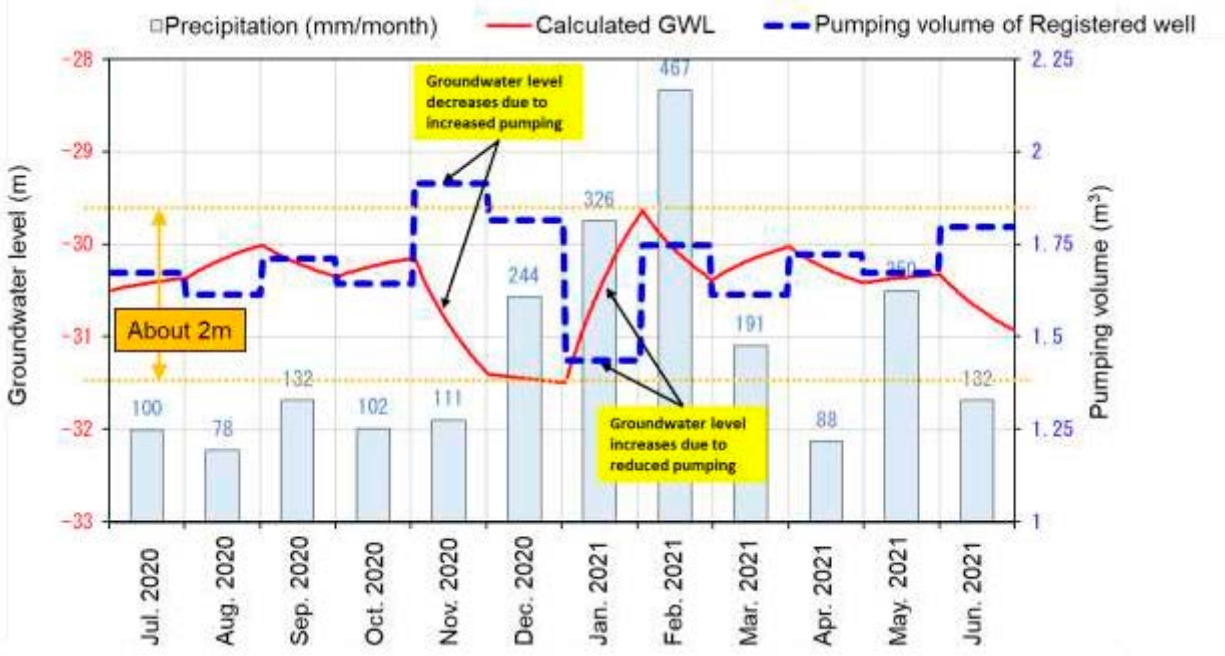


Figure 2-183 Fluctuation of Groundwater level (Apportionment①, re-post)

In the case of the apportionment method (2), a large difference is set in the pumping volume at the Cen point, so the annual difference in water level has increased to about 10 meters. The annual pumping volume at the Cen point has increased by about 40,000 m3, which is about 0.20% of the total registered groundwater pumping volume (20 million m3).

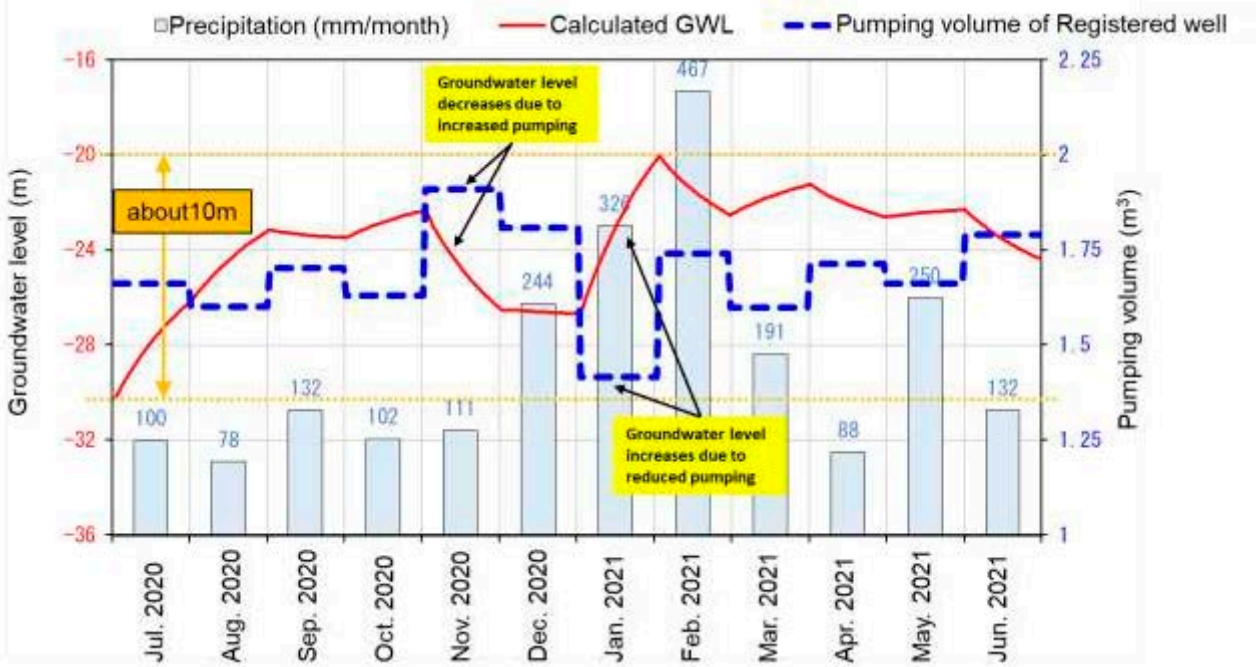


Figure 2-184 Fluctuation of Groundwater level (Apportionment②, re-post)

【Result of Transient analysis】

From the result above, it is remarkable that when the amount of groundwater pumped from deep wells increased from the previous month, the groundwater level decreased, and when the amount of groundwater pumped decreased from the previous month, the groundwater level increased. It can be said that the groundwater level changes remarkably with the increase or decrease of groundwater pumping and its deference.

In this calculation, the amount of water pumped from the deep well is calculated for the case where the amount of water pumped from Cen-2 is increased, as in Case 2B-1①. The value calculated here is about the same as the observed value of groundwater level in Cen-2.

In the steady state analysis, the increase or decrease of groundwater level by about 20m is calculated by changing the pumping rate. (From the comparison between Case 2B-1 and 2B-1①). In transient analysis, Increase or decrease of groundwater level by about 10m (in the case of proportional method (2)) has been analyzed.

(2) Future issues based on the results of groundwater analysis

Based on the results of the groundwater analysis, it is necessary to monitor whether the pumping rate of deep wells in the vicinity of the points with particularly low observed groundwater levels is appropriately applied in the future, and if necessary, to construct a detailed (region-specific) groundwater analysis model (steady-state or transient model) to further clarify the relationship between

groundwater pumping rate and groundwater level. In the groundwater analysis model developed in this study, there are some areas where the calculated groundwater level differs from the observed level. Since it is assumed that the amount of groundwater pumping is also high at the points where the observed groundwater level is low, it is desirable to increase the number of observation points (groundwater monitoring points), establish a groundwater observation network for the entire Jakarta Special Region, and further improve the accuracy of the groundwater model.

In the future, it is necessary to confirm how the groundwater level will change (comparison of analytical results and measured groundwater level data) based on the results of continued groundwater pumping and groundwater level monitoring (daily groundwater pumping and groundwater level).

In this study, the characteristics of groundwater in the Jakarta area (water balance, groundwater level, etc.) were summarized by examining various phenomena (scenario analysis) under different geological and geotechnical conditions, pumping conditions, and rainfall conditions. In addition, the importance of groundwater management (e.g., lowering of groundwater level in case of extreme groundwater pumping in a narrow area) was clarified.

In order to further improve the accuracy of the groundwater analysis in the future, it is desirable to further improve the quality and quantity of the data that will be the conditions for the analysis described below. For this purpose, **it is necessary to create a database of groundwater-related information as soon as possible.**

- Improvement of the quality of topographic and geological data (understanding of spatial distribution of hydraulic conductivity, etc.; detailed setting of hydraulic conductivity of aquifers and impermeable layers)
- Improvement of the quality of groundwater level observation data (observation location, installation height of wells, observed water level aquifers, proper arrangement and distribution of observation wells, and securing the minimum number of observation wells required)
- Improving the accuracy of pumping data (pumping location, installation height, pumping volume, pumping aquifer, pumping volume of unregistered wells, etc.

In order to analyze groundwater, it is necessary to set **[geological ground conditions]** × **[pumping conditions]** × **[rainfall conditions]** for each. How much the accuracy of these condition settings can be improved is important.

(3) Appropriate groundwater use

Based on the results of the above study, an appropriate method of groundwater utilization has been summarized.

- Even a temporary increase in groundwater pumping (shallow and deep wells) due to population growth (regional increase), etc., may lead to a rapid decline in groundwater, resulting in progressive land subsidence.
- For example, if intensive pumping is carried out in a small area when there is little rainfall (drought year), there is a high possibility that the ground will sink due to an extreme drop in the groundwater level around the area.
- However, there are some areas where groundwater pumping is not a major problem. In such cases, groundwater pumping needs to be allowed to some extent.

- Especially at the present stage when the progress of the water supply project is lagging behind, we think that we have no choice but to allow appropriate groundwater pumping. In the case of allowing groundwater pumping, it is necessary to set the threshold level of groundwater level (the lowest level that can be used as a standard) properly and stop groundwater pumping if the groundwater level drops below the threshold level.
- In particular, it is necessary to assure large pumping companies that they will abide by the regulations and rules.



- **In order to properly manage groundwater, a database to manage groundwater levels and pumping rates is necessary.**
- **The database will make it possible to provide detailed data on the daily groundwater level and pumping volume, land subsidence, and rainfall to managers and local stakeholders in real time.**
- **In addition, due to the effects of climate change, the possibility of large-scale droughts is increasing. When a major drought occurs, the possibility of active groundwater use increases, resulting in a temporary drop in the groundwater level and an increase in the possibility of land subsidence. Therefore, prediction of drought occurrence and groundwater management in case of occurrence will be very important.**

In particular, since the results of this study confirmed that the groundwater level changes significantly with changes in groundwater pumping from deep wells (based transient analysis), it is important to monitor the changes (daily changes) in the pumping rate of wells (especially deep wells) with high accuracy in the vicinity of the area where land subsidence is still in progress (the northern coastal area of Jakarta Province) to further clarify the relationship between groundwater pumping rate, groundwater level, and land subsidence.

In the area around the three newly installed wells in this study, i) further detailed geological data should be investigated and collected, and then a groundwater analysis model (detailed model focusing on the area) should be prepared considering the results of groundwater pumping and groundwater level monitoring in the area, ii) various scenarios should be compared and examined, and iii) the amount of groundwater that can be pumped (acceptable amount) and the control level of groundwater level (threshold level) in the area should be set more precisely.

CHAPTER 3 MITIGATION MEASURES AGAINST LAND SUBSIDENCE

3.1 Legal Framework for Groundwater Abstraction Control

3.1.1 Current Situation of Legal Framework

(1) Legal Framework for Groundwater Abstraction Control

The authority of water resources management is separated into surface water and groundwater. The Ministry of Public Works and Housing is responsible for surface water management, while the Ministry of Energy and Mineral Resources is engaged in groundwater management at the national level. The management unit of water resources is divided to river basin for surface water and groundwater basin for groundwater. DKI Jakarta belongs to Ciliwung-Cisadane river basin for surface water and Jakarta groundwater basin for groundwater. Jakarta groundwater basin covers Kabupaten Tangerang and Kota Tangerang of Banten Province, and Kabupaten Bogor, Kabupaten Bekasi, Kota Depok, and Kota Bekasi of West Java Province. The state has the right to control all the water resources including groundwater. Therefore, groundwater can be considered as a public resource. Permits for commercial, industrial, and domestic use are given to groundwater users based on application process. Groundwater use is controlled at the regional level and the governors have authority to issue permits for drilling and groundwater use. Therefore, application to use groundwater within DKI Jakarta should be submitted to DKI Jakarta, while technical recommendations on the applications are made by the Geological Agency (Badan Geologi), the Ministry of Energy and Mineral Resources. As shown in Figure 3-1, the legal system on water resources management including groundwater, is changing in line with the progress of decentralization and with repeal of the Water Resource Law (No. 7 No. 2004) based on the Constitutional Court Decision in 2013. The new Water Resources Law was promulgated in 2019. Table 3-1 shows the existing legal framework related to the land subsidence at the national and regional levels.

Of the laws and regulations listed in Table 3-1, the main ones are “the Law No. 17 Year 2019 concerning Water Resources", “the Government Regulation No. 121 Year 2015 concerning Utilization of Water Resources, and "the Regional Regulation No. 17 Year 2010 concerning Groundwater Tax". The Government of DKI Jakarta has promoted the “Zero Deep Well” activities and promulgated “the Governor of Special Capital Province of Jakarta Regulation No. 93 Year 2021 concerning Groundwater Free Zone” which controls the groundwater use in the designated zones. The outline of each law/regulation is shown below.

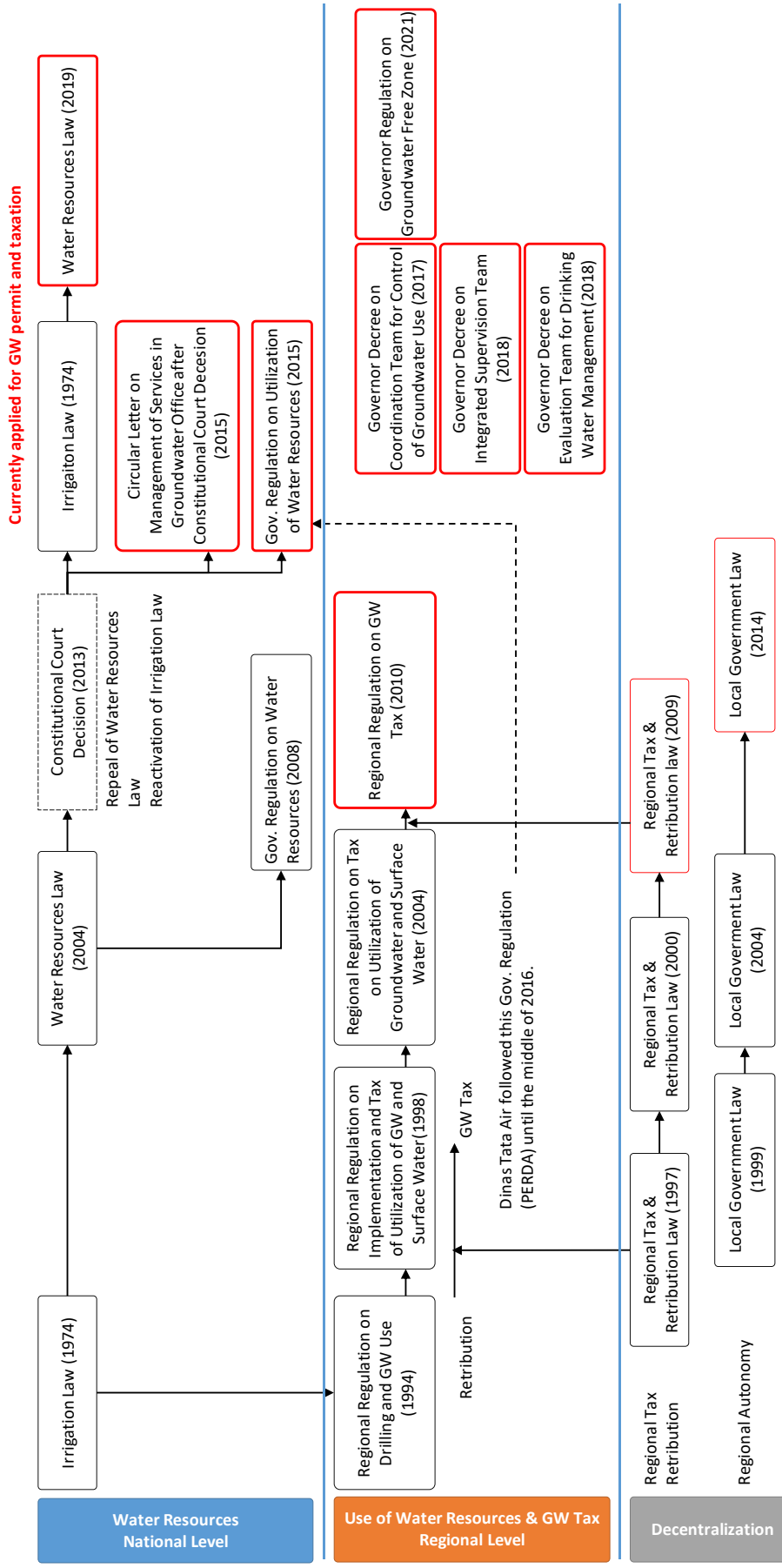


Figure 3-1 History of Legal Framework related to Water Resources management

Source: The Project Team

Table 3-1 Legal Framework related to Land Subsidence at the National and Regional Levels

Field	Legislation
Water Resources Management	< National Level >
	Law No. 17 Year 2019 concerning Water Resources
	Minister of Public Works and Housing Regulation No. 04/PRT/M/2015 concerning Criteria and Determination of River Basin
	Minister of Public Works Regulation No. 09/PRT/M/2015 concerning Water Resources Utilization
	Minister of Public Works and Housing Regulation No. 01/PRT/M/2016 concerning Procedure for Licensing of Exploitation and Use of Water Resources
	Minister of Energy and Mineral Resources Regulation No. 2 Year 2017 concerning Groundwater Basin
Groundwater Use	< National Level >
	Government Regulation No. 121 Year 2015 concerning Utilization of Water Resources
	Minister of Energy and Mineral Resources Circular Letter No. 01 E/40/MEM/2015 concerning Service Provision in the Field of Groundwater after the Court Ruling No. 85/PUU-XI/2013
	< Regional Level >
	Governor of Special Capital Province of Jakarta Regulation No. 93 Year 2021 concerning Groundwater Free Zone
	Governor of Special Capital Province of Jakarta Decree No. 2388 Year 2017 concerning Coordination Team for Control of Groundwater Use
	Governor of Special Capital Province of Jakarta Decree No. 279 Year 2018 concerning Integrated Supervision Team for Infiltration Wells and Wastewater Treatment Plants as well as Utilization of Groundwater in Buildings and Housing
	Governor of Special Capital Province of Jakarta Circular Letter No. 37/SE/2011 concerning Use of Groundwater as Standby
Taxation on Groundwater Use	< National Level >
	Law No. 28 Year 2009 concerning Regional Tax
	< Regional Level >
	Regional Regulation No. 76 Year 2005 concerning Mechanisms of Tax Collection for Making Use of Groundwater
	Regional Regulation No. 17 Year 2010 concerning Groundwater Tax
	Governor of Special Capital Province of Jakarta Regulation No. 86 Year 2012 concerning Extraction Volume of Groundwater as the Basis for Imposition of Groundwater Tax
	Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2017 concerning Collection of Groundwater Tax
	Governor of Special Capital Province of Jakarta Instruction No. 10 Year 2014 concerning Collection of Penalty on Taking and/or Using Groundwater in Excess of Allowed Volume
Water Supply	< National Level >
	Government Regulation No. 122 Year 2015 concerning Water Supply System
	Minister of Public Works and Housing Regulation No. 19/PRT/M/2016 concerning Provision of Support by the Central and/or Regional Government Partnership in Implementation of Water Supply System
	Minister of Public Works and Housing Regulation No. 25/PRT/M/2016 concerning Operation of Water Supply Systems by only Enterprises to Meet Needs
	< Regional Level >
	Governor of Special Capital Province of Jakarta Decree Number 1149 Year 2018 concerning Evaluation Team for Drinking Water Management

Source: Prepared by the Project Team

Law No. 17 Year 2019 concerning Water Resources

A major regulatory change related to land subsidence is the ratification of the new Water Resources Act by the Indonesia Parliament in September 2019. The Constitutional Court annulled Water Resources Law No. 7 Year 2004 in 2015. This has led to the formulation of revised bill centered on the management of water resources by the state for the benefit of the people. Matters related to countermeasures against land subsidence and water use are as follows:

- Water resources is controlled by state and is used as much for people's prosperity. (Article 5)
- State ensures citizens' right over water, in order to fulfil basic daily needs. (Article 6)
- State will prioritize citizens' right over water as such; a. daily needs, b. citizens' agriculture, and c. Water resources usage for business needs in order to fulfil daily needs through drinking water supply system. (Paragraph 2, Article 8)
- The central government has an authority to establish groundwater conservation zone on groundwater basin on river area between countries, between provinces and national strategic river area. (Article 11)
- Water resources usage permit for business activities using water and water power as material that produce products, such as drinking water, is issued for state-owned enterprises, regional-owned enterprises, or village-owned enterprises; implementers of drinking water supply system. (Article 50)
- Permission to use water resources for business needs to the private sector can be granted if the water resources is still available after fulfilling the requirements for other uses

With the enactment of the new Water Resources Law, related regulations are expected to be revised in the future to be based on its contents. (Article 51)

Government Regulation No. 121 Year 2015 concerning Utilization of Water Resources

Details of application for the permit is provided by the Government Regulation No. 121 Year 2015 concerning Utilization of Water Resources. Governors have authority to issue permits and those who want to use groundwater should submit applications with some technical documents.

The permit is given to the following users:

- State-owned enterprises, Regional owned enterprises, Village-owned business entities
- Private business entities
- Cooperatives
- Individual

The target groups that need the permit for groundwater use are private entities and individuals aiming for business use, while government agencies are not required to obtain the permit for groundwater use under the provision of the Government Regulation. Domestic use of groundwater by individual households is also allowed without permit.

Regional Regulation No. 17 Year 2010 concerning Groundwater Tax

In Article 3 of Chapter 3, it is stipulated that the use of groundwater by central and regional governments should be excluded from taxable objects. In addition, groundwater uses which is not subject to taxation are basic household needs, irrigation, small-scale fisheries, and worship. The groundwater tax is charged on individuals or entities that use groundwater other than those prescribed in Article 3 every month when they use groundwater.

The groundwater tax was one of the retributions before 1999, but restrictions on regional taxes were relaxed after the Soeharto regime. The groundwater tax was categorized as regional tax at the provincial level in the Law No. 38 Year 2000 concerning Amendment of Law No. 18 Year 1997 concerning Regional Tax and Retribution. Subsequently, depending on the situation of the social economy, division of responsibilities between the central government and regional governments, the contents of regional taxes and retributions have been continuously reviewed, but there is no particular change in handling of groundwater tax. Detailed procedures for collecting groundwater tax are described in the Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2017 concerning Collection of Groundwater Tax. Groundwater users are classified into "non-commercial (non niaga)", "small commercial (niaga kecil)", "small and medium industrial (industri kecil dan menengah)", "big commercial (niaga besar)", and "big industrial (industri besar)". In case the maximum abstraction volume allowed in the permit is exceeded, additional 50% will be imposed as penalty for the exceeded volume of abstraction. However, the permit holders can use beyond the allowed maximum volume under the prevailing regulation and they just pay a penalty. Table 3-2 and Table 3-3 show the unit price of groundwater tax by user category and the classification of groundwater users, respectively. The unit price of pipe water by PAM JAYA is fixed by the Regional Regulation No. 91 Year 2017, ranging from Rp.1,050 to 14,650/m^3. Groundwater tax on the use within the PAM Jaya's service area is higher, and the tariff-setting for non-commercial use is lower than other categories.

Table 3-2 Tariff Table of Groundwater Tax by Category

No.	Category	Usage (m^3)					
		0-50	51-250	251-500	501-750	751-1000	> 1000
Within PAM Jaya's Service Coverage Area (unit: IDR)							
1	Non-commercial (Non Niaga)	44,332	44,332	44,916	44,916	44,916	44,916
2	Small Commercial (Niaga Kecil)	49,582	50,749	51,915	53,082	54,249	55,415
3	Small/Medium Industrial (Industri Kecil/Menengah)	72,915	74,665	76,415	78,165	79,915	81,665
4	Large Commercial (Niaga Besar)	84,581	86,915	89,248	91,581	93,915	96,248
5	Large Industrial (Industri Besar)	102,081	104,998	107,914	110,631	113,747	116,664
Outside of PAM Jaya's Service Coverage Area (Unit: IDR)							
1	Non-commercial (Non Niaga)	26,833	26,833	27,416	27,416	27,416	27,416
2	Small Commercial (Niaga Kecil)	32,083	33,249	34,416	35,583	36,749	37,916
3	Small/Medium Industrial (Industri Kecil/Menengah)	55,415	57,165	58,915	60,665	62,415	64,165
4	Large Commercial (Niaga Besar)	67,082	69,415	71,748	74,082	76,415	78,748
5	Large Industrial (Industri Besar)	84,581	87,498	90,415	93,331	96,248	99,164

Source: Governor of Special Capital Province of Jakarta Regulation No. 86 Year 2012 concerning Abstraction Volume of Groundwater as the Basis for Imposition of Groundwater Tax

Table 3-3 Classification of Groundwater Users

No.	Category	User Group	Example of User
1	Non Commercial (Non Niaga)	Educational institutes, NPOs, luxury houses with deep wells, other non-commercial institutions	Embassies, consulates, dewatering works, guesthouses, social institutions
2	Small Commercial (Niaga Kecil)	Household commerce, inns, small restaurants, private clinics, non-star hotels, other small commerce	Cooperatives, car wash, sports centres, barbers, fitness centres
3	Small/Medium Industrial (Industri Kecil/Menengah)	Fisheries, star hotels (1, 2, 3), simple flats, other small and medium industries	Home furniture industry, laundry, fabric dyeing, cottage industry, industries with a number of employees of 5 to 99
4	Large Commercial (Niaga Besar)	Star hotels (4, 5), apartments, banks, large café/restaurants, real estate, other large commerce	Golf courses, supermarkets, car wash and workshops, sauna and spa
5	Large Industrial (Industri Besar)	Ice factories, food/beverage factories, chemical factories, cold storage, textile factories, steel mills, other large industries	Automotive assembly factories, Pharmaceutical factories, concrete plants, factories with 100 employees or more

Source: Governor of Special Capital Province of Jakarta Regulation No. 86 Year 2012 concerning Abstraction Volume of Groundwater as the Basis for Imposition of Groundwater Tax

Governor of Special Capital Province of Jakarta Regulation No. 93 Year 2021 concerning Groundwater Free Zone

This regulation was enacted to strengthen measures to ban groundwater abstraction in areas where water supply is already available, with the aim of improving groundwater abstraction control and land subsidence conditions in DKI Jakarta. The outline of the regulation is as follows:

Target building: floor are of 5,000 m^2 or more, 8 stories or more

Target zones: see Figure 3-2

Control measures:

a. Strengthening groundwater abstraction monitoring (water balance report and water balance information system)
   - Installing a recording device for water intake and use at the water intake
   - Installing an automatic water consumption recording device at the outlet
   - Integrating the recording devices into the information system of Dinas SDA (by January 30, 2022)
   - Getting access to information on the groundwater use by the Provincial Government
   - Submitting monthly water balance report (user to Dinas SDA by the 10th of every month, from January 2022)

b. Prohibiting groundwater abstraction and use

Penalties for violating building owners and managers:

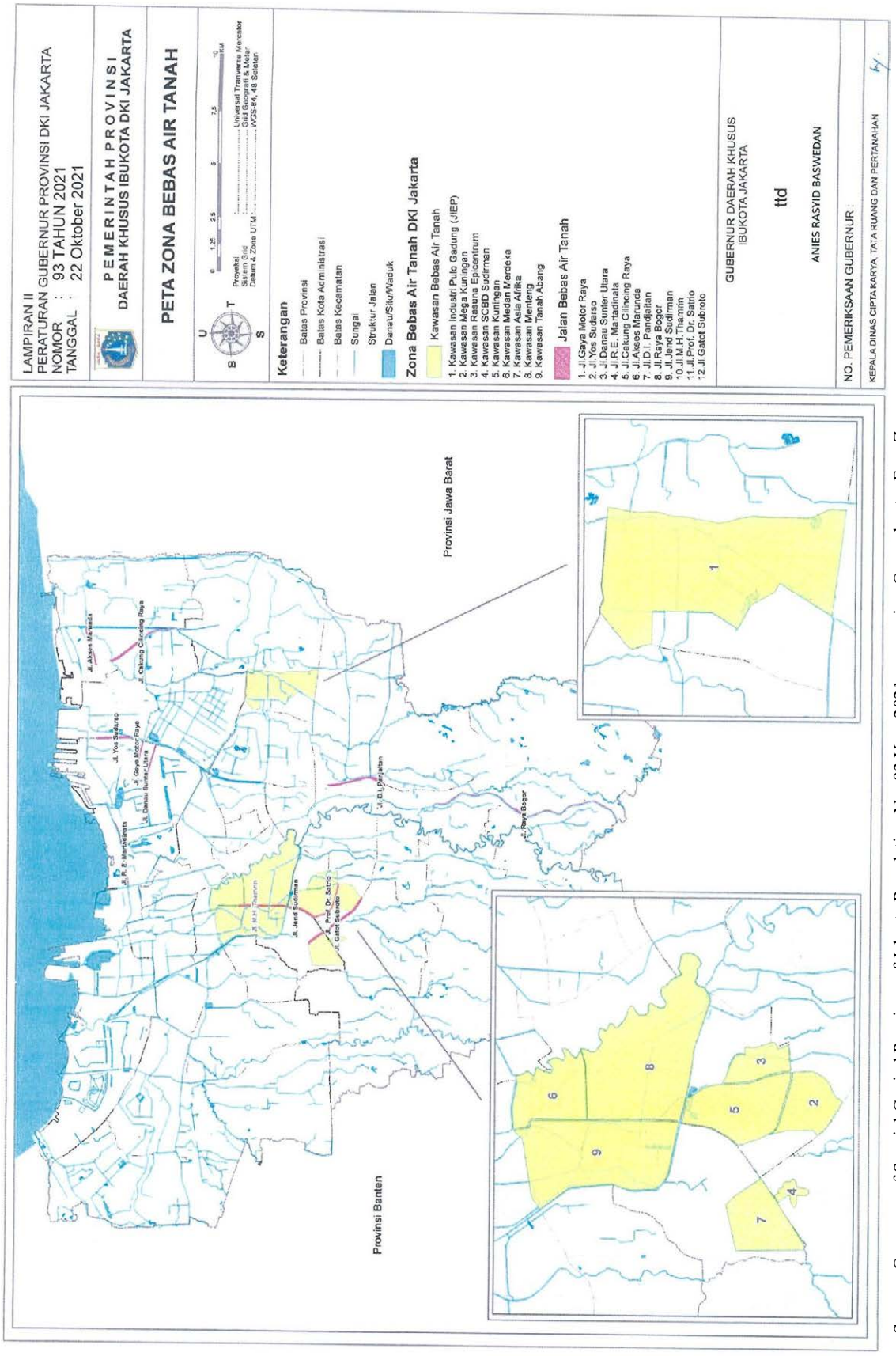
- Administrative sanctions
  - Written warning by Dinas SDA
  - If the owners and managers do not follow the warning within 7 days, the activity will be suspended (well closure).
  - In addition, if the warning is not fulfilled within 7 days after the suspension, the license will be suspended and revoked by DMPPTSP (after receiving technical recommendations from CITATA and Dinas SDA).
- Sanctions by taxations (fine based on the provisions of laws and regulations regarding groundwater tax)

The following are the current situation of preparation for the enforcement as of January 2022:

- There is no specific socialization program to target building's owners.
- Several socialization activities had been conducted by each agency in accordance with their respective task & responsibilities, such as extension of permits to building owners.
- There is no plan to conduct site inspection/investigation to target buildings.
- The Government of DKI Jakarta is carrying out the work to determine the exact target buildings. For the category Floor ≥ 8, around 500 buildings were identified, while no official number has been identified for the category Floor Area ≥ 5,000 m^2 and the total estimated number is around 1,000 buildings.
- The Water Balance Information System is under development by Dinas SDA.

The following are the expected issues:

- Identification of exact target buildings in all Jakarta
- Additional cost for installing automatic water recorders in private buildings



Source: Governor of Special Capital Province of Jakarta Regulation No. 93 Year 2021 concerning Groundwater Free Zone

Figure 3-2 Groundwater Fee Zone

The "installation of recording devices (water intake and use)", "storage of purified water from other water sources to replace groundwater (with a capacity to meet at least 2 (two) days need of clean water for emergency situations", and "use of other water sources to replace groundwater" applies to the owners and managers of the target buildings after August 1, 2023. Dinas SDA is the main agency for the enforcement in the Government of DKI Jakarta.

(2) Legal Framework for Alternative Water Sources (Rainwater and Recycled Water)

Rain water and recycled water can be considered as alternative water sources for groundwater use, other than water supply services and surface water development which will be described later. Table 3-4 shows the legal framework related to the use of alternative water sources.

Table 3-4 Legal Framework related to Utilization of Alternative Water Sources

Field	Legislation
Utilization of Rain Water	< National Level >
	Minister of Public Works Regulation No. 11/PRT/M/2014 concerning Rainwater Management in Buildings
	< Regional Level >
	Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2012 concerning Green Building
Overall Water Use	< National Level >
	Minister of Public Works Regulation No. 09/PRT/M/2015 concerning Water Resources Utilization

Source: The Project Team

"The Minister of Public Works Regulation No. 11/PRT/M/2014 concerning Rainwater Management in Buildings" mainly intends to maintain the water cycle and to use rainwater in the building. The regulation explains how to choose measures for rainwater utilization in buildings and types of them. Districts and cities are responsible for giving information for the implementation of rainwater utilization, such as local characteristics of geology and groundwater level. The provincial government plays the role in DKI Jakarta. As for infiltration wells, four types (different materials and applicable locations) are shown in the regulation as typical ones.

"The Minister of Public Works Regulation No. 09/PRT/M/2015 concerning Water Resources Utilization" aims at showing materials on measures of water resource utilization for organizations and people who use water resources towards achieving sustainable usage. The regulation shows an example of rainwater utilization (recharge well and rainwater storage). Article 58 provides that large water consumers such as hotels, hospitals and industries have to utilize rain water and recycled water by latest two years after this regulation is established and regional governments have to create a regional regulation which requires the large water consumers to implement the terms on this Minister Regulation according to right, condition and necessity. The Government of DKI Jakarta has established the regional regulation related to utilization of rainwater and recycled water ("Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2012 concerning Green Building") before the enactment of this Minister Regulation.

"The Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2012 concerning Green Building" stipulates measures of environmental conservation in specific types and sizes of buildings. The followings are the target buildings of the regulation:

- Apartments with the total floor area of 50,000 m^2
- Office buildings with the total floor area of 50,000 m^2
- Commercial buildings with the total floor area of 50,000 m^2
- Multipurpose buildings (one building with multiple functions) with the total floor area of 50,000 m^2

- Hotels with the total floor area of 20,000 m^2
- Medical facilities with the total floor area of 20,000 m^2
- Educational facilities with the total floor area of 10,000 m^2

The following are required for water use in the target buildings under the regulations.

- ✓ Installing devices to measure the volume of water used (water supply from PAM Jaya, groundwater, recycled water and others)
- ✓ Setting wastewater treatment facility for secondary water use
- ✓ Setting facilities for utilization of secondary water (treated water can be used for cooling, flushing, watering to planting about reuse of treated water)
- ✓ Using water other than groundwater and clean water for watering plants
- ✓ Installing rainwater storage systems (installation capacity: 0.05 m × site area (m^2))
- ✓ Reporting water consumption and water quality by building managers

(3) Legal Framework for Groundwater Infiltration

The following regional regulations stipulate the groundwater infiltration in DKI Jakarta:

- Governor of Special Capital Province of Jakarta Instruction No. 47 Year 2018 concerning Supervision and Optimization of Infiltration Well Function
- Governor of Special Capital Province of Jakarta Regulation No.20 Year 2013 concerning Infiltration Wells
- Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2012 concerning Green Building

The Governor Instruction No. 47 Year 2018 gives instructions to related offices within the Government of DKI Jakarta to enhance implementation of the Governor Regulation No.20 Year 2013. Table 3-5 shows the contents of the instructions and target offices.

Table 3-5 Outline of the Governor Instruction No. 47 Year 2018

Target Offices	Instructions
Industry and Energy Office (DPE) *The function has been transferred to Dinas SDA since 2020.*	• Guiding installation of groundwater infiltration wells in communities • Giving technical advice about geological conditions • Monitoring and evaluating installation of groundwater infiltration wells required for permit of groundwater use for communities and private companies
Forestry Office	• Installing and managing groundwater infiltration wells in parks and cemeteries
Human Settlements, Spatial Planning and Land Office	• Coordinating management of groundwater infiltration wells in provincial government buildings

Source: Governor of Special Capital Province of Jakarta Instruction No. 47 Year 2018 concerning Supervision and Optimization of Infiltration Well Function

The Governor Regulation No. 20/2013 provides the following target groups and main requirements for installation of groundwater infiltration wells. As for buildings that are considered as existing at the time of promulgation of the regulation, trial of measures stipulated by the regulation and execution of conservation programs are required. However, the regulation does not provide any penalty for the

existing buildings. Table 3-6 shows the volume of infiltration wells required for each building size.

Target groups (facilities):	• Building owners and buildings that cover the land area • Applicants of groundwater use
Specific requirements:	• Individuals and legal entities that build on land area of 5,000 m^2 or more are required to allocate 1% of the land to be used for constructing an infiltration pond in addition to infiltration wells. • For building owners who do not have land are to construct infiltration wells, the regional government facilitate to make communal infiltration wells. • Infiltration wells should be installed with a minimum distance of 5 m from the location of landfill, used landfill, septic tank or soil containing pollutants • Infiltration wells should be installed with a minimum distance of 1 m from the foundation of building. • Minimum groundwater level 1.5 m during rainy season
Water applicable to the infiltration systems	• Rainwater coming from the roof of building • Rainwater coming from land surface covered by municipal infrastructure and facilities and other buildings • Ablution water, condenser water or other water which have been processed according to the water quality standards required by legislation.
Penalties	• Issuing warning letter, suspending permit and revoking permit

Table 3-6 Volume of Infiltration Wells set in the Governor Regulation No. 20/2013

No.	Cross-section Area of Building (m^2)	Volume (m^3)
1	= 50	2
2	51 – 99	4
3	100 – 149	6
4	150 – 199	8
5	200 – 299	12
6	300 – 399	16
7	400 – 499	20
8	500 – 599	24
9	600 – 699	28
10	700 – 799	32
11	800 – 899	36
12	900 – 999	40

Source: Governor Regulation No. 20/2013

3.1.2 Suggestions for Strengthening the Groundwater Management and its Rolling out to Other Areas

The control of groundwater abstraction from deep wells by enacting a Governor Regulation has been considered since 2018 in DKI Jakarta. The Project Team made the following suggestions to the draft Governor Regulation in the Project during the preparation period of the regulation.

- Introducing the concept of critical zones where the groundwater abstraction needs to be banned/regulated, based on the satellite images and the groundwater conservation map prepared by BKAT
- Introducing reporting/registration system of wells for all the purposes to grasp the whole picture of groundwater abstraction and water balance within Jakarta

In addition, the Project Team also suggested that the shift of water source from groundwater to alternative water sources such as piped water from PDAM must be started from the government buildings. These recommendations were explained to the offices of the Government of DKI Jakarta related to the well registration and groundwater management, and were conveyed in the form of a suggestion letter to Biro PKLH (Spatial Planning and Environment Department), which was in charge of drafting the Governor's Regulation.

Of the above suggestions, the introduction of critical zones into groundwater abstraction control is conditional on the ability to switch from groundwater to alternative water sources. Therefore, the Government of DKI Jakarta can update the target area in the future, taking into account the availability of alternative water sources and critical zones. A reporting/registration system of wells for all the purposes has not yet been considered at this time. Since the initial draft of the Governor's Regulation only covered private facilities, but it eventually included government buildings. Therefore, it is considered that the Government of DKI Jakarta recognized the need to regulate groundwater abstraction without distinction for government buildings.

3.1.3 Suggestions for Strengthening the Groundwater Management and its Rolling out to Other Areas

(1) Registration of All the Groundwater Users and Abstraction Control

1) Current Situation

Under the prevailing laws and regulations, individuals and private business entities need permit to use groundwater, while central and regional government agencies do not need permit. In addition to the permit for groundwater use, the central and regional government agencies are not subject to collection of groundwater tax. The uses for household basic needs, irrigation, small-scaled fishery, and worship services are also not subject to collection of groundwater tax in DKI Jakarta. As stated above, the groundwater tax collection database includes some central and regional government agencies and religious facilities as groundwater users, while their tax payment amount is zero in the database. An effort to grasp relatively large-scaled use of groundwater can be seen.

As mentioned above, according to the groundwater abstraction volume from January 2015 to June 2018 (except for the South Jakarta where the PAM Jaya’s service coverage area is very limited), about one quarter of the groundwater abstraction for the top 20 entities is used by the government agencies. The central and regional government agencies are not required to get permit or pay groundwater tax under the existing regulations. Therefore, controlling the groundwater use through requesting permit application and charging regional tax does not work for some users directly. There are also groundwater users who do not understand the necessity of getting permit even if they are subject to permit application.

Furthermore, as mentioned in "4.2.2 Current Status of Groundwater Use", about 80% of the registered wells that are the status of in use or standby are located within the service area of PAM Jaya in three cities, North Jakarta, West Jakarta, and East Jakarta, where the land subsidence is progressing in DKI Jakarta. In particular, in order to grasp the existence of such wells located within the service area of PAM Jaya and the abstraction volume from the wells, identification of the actual conditions of the groundwater utilization that is not subject to permission and taxation under the existing laws and regulations is necessary.

2) Improvement Method

In order to solve such misunderstandings or lack of understanding and to grasp the overall picture of the groundwater abstraction in Jakarta, a measure to be taken is to oblige all the groundwater users to register

their wells without exceptions. Improvement methods of the existing legal framework for groundwater abstraction control through the registration of all the groundwater users is shown in Table 3-7. In particular, central and local government offices, which are not subject to use permission and taxation under the existing laws and regulations yet use a large amount of groundwater, are required to take initiative in registering existing wells and switching the water sources. Therefore, the central and local governments should set the upper limit of abstraction volume for each well as private users, and when it exceeds the upper limit, they are obliged to pay the ground water tax like private users.

Making registration obligations for all users means that the registration itself is not subject to taxation. Therefore, explanation that a permit application and tax payment are necessary for those who are willing to use groundwater for business purposes according to the existing system of application is necessary. Examining a registration system that can be used in combination with the existing permit application system, making a new regulation stipulating the registration system (enactment of a regional regulation), and organizing registration promotion campaigns are required to realize this improvement.

Table 3-7 Improvement of Existing Legal Framework for Groundwater Abstraction Control

Target Law/Regulation	Applicable Part and Its Improvement
< National Level >	
Government Regulation No. 121 Year 2015 concerning Utilization of Water Resources	Article 32, Paragraph 1, Part 3, Chapter 4 Original: No Item (3) in Article 32 Improvement: Adding Item (3) in Article 32, "In addition, the groundwater users including the persons subject to permission described in Item (1) needs submission of notification (registration) in line with rules which the governor establishes".
< Regional Level >	
Regional Regulation No. 17 Year 2010 concerning Groundwater Tax	Article 3, Part 1, Chapter 3 Original: No Sub-item d in Item 2 of Article 3 Improvement: Adding Sub-item d in Item 2 of Article, "However, central and local governments are required to set the upper limit of groundwater abstraction for each well like private users, and when it exceeds the upper limit, they are obligated to pay the groundwater tax like private users."

Source: prepared by the Project Team

(2) Setting Critical Zones and Prohibiting Groundwater Abstraction

1) Current Situation

Some deep wells within the PAM Jaya's service area have been closed down and the permit for the second and subsequent wells for one company was not given are the current measures for control of groundwater use in DKI Jakarta. Such operational rules were decided and implemented by the responsible department depending on the occasion and interest. However, steps to grasp the tendency of land subsidence based on observation results and legislate the designation of abstraction-prohibited areas and operational rules have not been taken. As for the groundwater use in DKI Jakarta, technical recommendations are given by the Geological Agency, the Ministry of Energy and Mineral Resources based on the groundwater conservation map. But the groundwater abstraction control linked with the groundwater conservation map prepared by the Geological Agency has not been clarified by DKI Jakarta. For this reason, procedures to not issuing a permit according to technical recommendations based on such operational rules and groundwater conservation maps are taken from time to time after submitting application from users.

2) Improvement Method

To promote the groundwater abstraction control as a countermeasure against land subsidence, the Government of DKI Jakarta should have a clear vision and measures for realizing the vision should be legislated. In particular, regulations that designate critical zones where land subsidence is remarkable and the water source needs to be promptly changed and prohibit groundwater abstraction in the zones should be enacted. More appropriate method for groundwater conservation is to designate which aquifer should be prohibited from abstraction as well. In conjunction with this regulation, prioritized supply of alternative water sources to the critical zones should also be implemented. Improvement methods concerning setting of the critical zones and prohibition of groundwater abstraction is shown in Table 3-8.

A new regional (or governor) regulation concerning setting of critical zones and prohibition of groundwater abstraction that provide setting the critical zones based on the groundwater conservation map, analysis of water supply situation within the designated critical zones, examination of alternative water source supply plan to the critical zones needs to be enacted to realize this improvement method.

Table 3-8 Improvement of Existing Legal Framework for Setting Critical Zones and Prohibiting Groundwater Abstraction

Target Law/Regulation	Applicable Part and Its Improvement
< National Level >	
Government Regulation No. 121 Year 2015 concerning Utilization of Water Resources	Article 44, Section 6, Part 3, Chapter 4 Original: No Item (3) in Article 44 Improvement: Adding Section (3), "The governor designates critical zones to prohibit or limit groundwater abstraction for the purpose of groundwater resources preservation and countermeasures against land subsidence on the issuance of permission based on the status of groundwater conservation and land subsidence, and establishes rules for water resources utilization including supply of alternative water sources in the designated critical zones."
< Regional Level >	
Enactment of a new regional (or governor) regulation	Original: None Improvement: Enacting a new regional (or governor) regulation which provides designation of critical zones to prohibit or limit groundwater abstraction for the purpose of groundwater resources preservation and countermeasures against land subsidence on the issuance of permission based on the status of groundwater conservation and land subsidence, and establishment of rules for water resources utilization including supply of alternative water sources in the designated critical zones

Source: prepared by the Project Team

(3) Collaboration for Enhancing Countermeasures against Land Subsidence such as Designation of Critical Zones

The Government of DKI Jakarta has been carrying out analysis by sharing information with ITB etc. about observation results of land subsidence and groundwater level. However, such efforts have not reached to the

point where the analysis result is linked to control of groundwater abstraction. In designating the critical zones, it is necessary to use data on land subsidence and groundwater level observed by the Government of DKI Jakarta and information on groundwater conservation maps regularly updated by the Geological Agency of ESDM. The Government of DKI Jakarta should continuously accumulate observation data of land subsidence and groundwater level, share the information with related organizations such as the Geological Agency and BKAT, and understand the situation of land subsidence from the observation results.

In accordance with the situation identified, the Government of DKI Jakarta is required to designate areas where the control of groundwater abstraction should be made strict, groundwater infiltration and alternative water sources development and utilization should be promoted. In addition, Dinas SDA should lead the related organizations in the Government of DKI Jakarta to take necessary actions and initiate the countermeasures against land subsidence.

The Government of DKI Jakarta is in the process of preparing for the implementation of the Governor's Regulation on Groundwater Free Zone, as mentioned in Section 3.1.1. The actual implementation of the regulation is expected to take about one year. Of the above suggestions, "(2) Setting critical zones" and "(3) Collaboration for enhancing countermeasures against land subsidence" such as designation of critical zones" need to be implemented with securing alternative water sources in the regulated areas. However, those will be the basis for considering the expansion of regulated area in future.

Since Dinas SDA is the agency primarily responsible for enforcing the Governor's Regulation and the content of the regulation is under the jurisdiction of several related agencies, an implementation system is being established in which Dinas SDA will take the lead in executing the countermeasures against land subsidence. As for (1) Registration of all the groundwater users and abstraction control, the Government of DKI Jakarta recognizes the necessity of understanding whole picture of water demand, but is cautious about that because such registration may be confused with regional tax collection. The effort made by the Government of DKI Jakarta is to establish a system to manage water intake and usage at facilities of a scale that are considered to have high water use, rather than to capture the overall demand through reporting and registration.

(4) Collaboration and Rolling-out of Activities towards Groundwater Basin Management

DKI Jakarta belongs to Jakarta groundwater basin. If the groundwater abstraction is very active in recharge areas, groundwater conservation efforts will not work sufficiently even though groundwater abstraction control is carried out within DKI Jakarta. Groundwater abstraction in DKI Jakarta could also affect land subsidence in the surrounding area.

The results of satellite image analysis shows the tendency in recent years that land subsidence has also been seen in areas close to DKI Jakarta such as Bekasi City and Tangerang City. This indicates that not only measures within DKI Jakarta, but also management in coordination with other local governments belonging to the same groundwater basin will be necessary. Actions to be taken towards the groundwater management in one groundwater basin includes establishment of a liaison council on management of groundwater basin with neighboring local governments, examination and institutionalization of joint management methods, sharing of monitoring results of joint management, and examination of improvement measures.

Land subsidence is widely seen in Java Island, not only in DKI Jakarta but also in Bandung and Semarang. Revising the existing laws and regulations on the management method introduced in DKI Jakarta must be rolled out to the nationwide. The rolling-out of the countermeasures against land subsidence covers a wide range of activities, not only the groundwater management, but also supply of alternative water sources and planning and implementation of adaptation measures. Therefore, it would be appropriate for the Ministry of Public Works and Housing to play a role in the initiative and coordination of activities in the areas where countermeasures against land subsidence are needed, such as forming a project implementation committee that involves relevant parties such as the provincial government, district and city governments, and regional water utilities, compiling action plans, and monitoring implementation after task allocation among the committee members. Since the permission for well drilling and groundwater use is the authority of the provincial governor, the provincial government is required to prepare and implement an action plan referring to activities such as those implemented by the Government of DKI Jakarta in this project. The provincial government will participate in the project implementation committee together with the district and city governments, and regional water utilities in charge of water supply services in the area, and will implement groundwater management based on the action plan prepared.

3.2 Current Water Consumption Volume

3.2.1 Water Supply Volume

(1) Current Situation of Water Supply Services

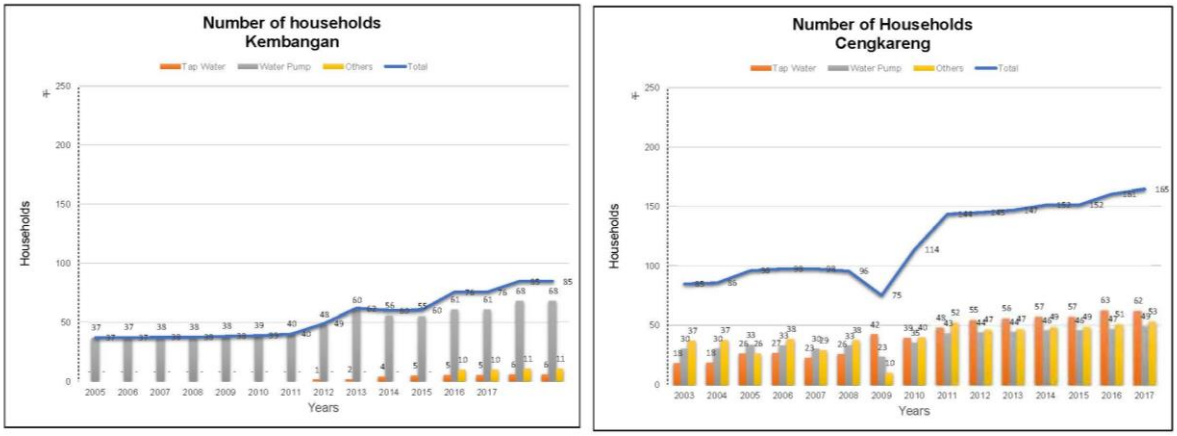
Table 3-9 shows the number of customers and the consumption volume by customer category in the past three years. Households account for 84% of the total number of customers and 55% in consumption, followed by commercial and industrial users which account for 14% in the number of customers and 20% in consumption. Both the number of customers and the consumption volume shows an increasing trend.

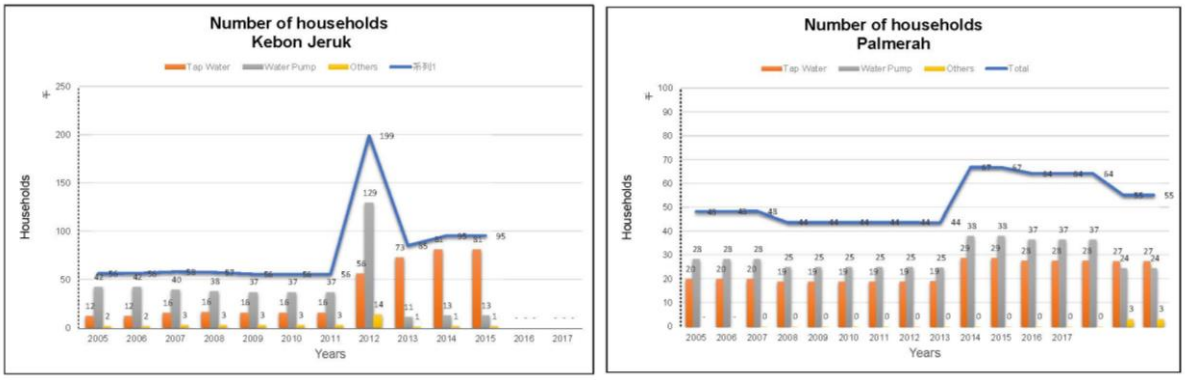
Table 3-9 Number of Customers and Consumption by Customer Classification

No.	Category	Nomber of Customers					Consumption Volume (million m^3)				
		2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
1	Household	703,556	708,167	717,048	726,391	739,944	185.44	188.64	189.21	191.87	
2	Hotel	1,374	1,412	1,437	1,469	1,504	31.94	32.35	32.63	34.38	
3	Hospital	1,734	1,716	1,715	1,684	1,684	8.77	9.86	10.07	10.05	
4	House for Worship	4,413	4,415	4,421	4,435	4,493	3.55	3.54	3.54	3.60	
5	Public Services	1,294	1,034	1,025	1,021	1,021	3.13	1.75	0.50	0.54	
6	Establishment Industry	113,049	117,089	119,788	122,070	123,385	67.65	69.16	71.80	74.2	
7	Government Office	3,905	4,003	4,164	4,234	4,411	20.21	21.4	22.62	24.92	
8	Others	1,532	1,555	1,557	1,861	1,541	9.8	10.43	11.24	12.45	
9	Losses	-	-	-	-	-	-	-	-	-	-
	Total	830,857	839,391	851,155	863,165	877983	330.49	337.13	341.61	352.01	362.62

Source: prepared by the Project Team based on the data of Jakarta Provincial Statistics Office

According to the 2014 Master Plan, the consumption per capita per day in DKI Jakarta was 108 liters in 2014. In the master plan, the unit volume of consumption for the target year is set at 131 liters in 2018 and 130 liters in 2035. The daily consumption amount of household for four (4) cities excluding North Jakarta where the usage data by customer category is not available in the statistical data, is 137 liters for East Jakarta (2015), 112 liters for West Jakarta (2016), 107 liters for Central Jakarta (2016), and 90 liters for South Jakarta (2015). The daily consumption is less in South Jakarta compared to other cities because the area covered by the public water service is narrow in South Jakarta and combination use of groundwater and piped water due to problems of water volume and quality. In West Jakarta, some areas where land subsidence is remarkable can be found. There are areas where the distribution of pipe network is not well developed. In Kalideres, western part of West Jakarta, receiving bulk water from PDAM Tangerang and some districts close to Central Jakarta, the piped water usage rate is relatively high, but wells are still the main water source in other places (see Figure 3-3).



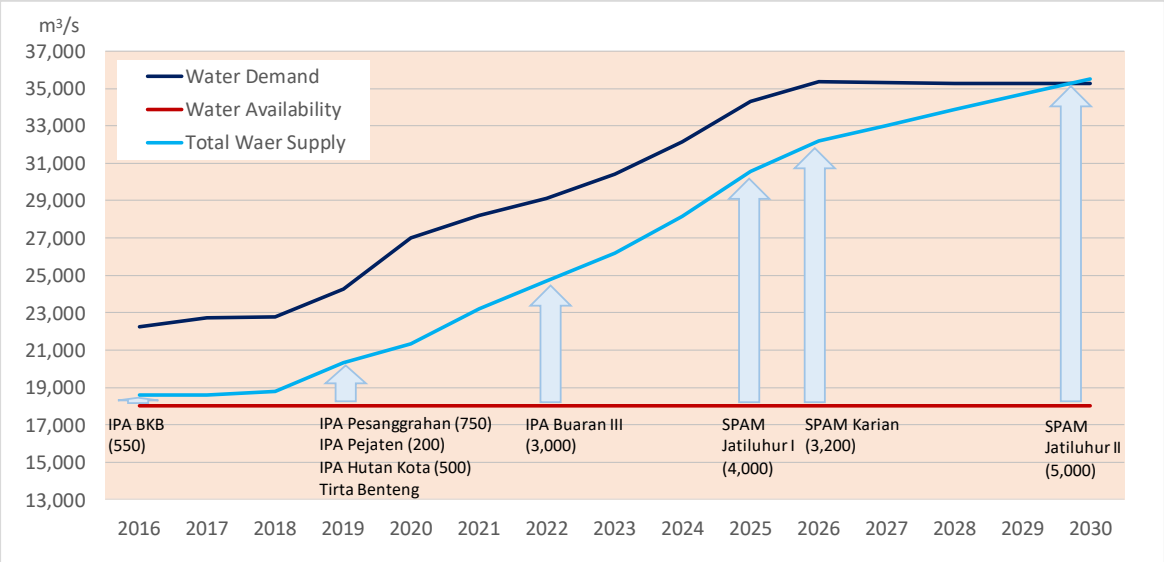


Source: prepared by the JICA Team based on the data of each District Statistics Office

Figure 3-3 Water Sources in Districts with Higher Well Utilization in West Jakarta

(2) Demand Forecast

Table 3-4 shows the water supply demand forecast in DKI Jakarta until 2030. With the development of new water treatment plants and raw water, the gap between demand and available amount is gradually eliminated and the water supply is expected to meet the demand in 2030. However, actual facility and raw water developments are behind this plan. Even if the demand growth is as expected, the demand will be able to be satisfied after 2030.



	2016	2020	2025	2030
Demand (m^3/s)	22,246	26,984	34,322	35,278
Existing Available Water (m^3/s)	18,025	18,025	18,025	18,025
Water Supply Volume (m^3/s)	18,575	21,325	30,558	35,525

Source: PAM Jaya

Figure 3-4 Demand Forecast of Water Supply in DKI Jakarta

As for investment trends from 2013 to the third quarter of 2018 summarized by the Investment Coordinating Board of the Republic of Indonesia (BKPM), the investment in manufacturing industry accounts for 40-50%, followed by 30-40% for service industry. By region of investment, West Java Province accounts for about 20%, followed by 10-15% in DKI Jakarta and East Java Province. Concentration of investment in Java Island is remarkable. Regarding the gross regional domestic product (GRDP) by city in DKI Jakarta from 2015 onwards, each city has grown at around 6% per year. However, the growth rate in North Jakarta and East Jakarta was lower than the previous year (2019), and the growth rate was negative in all cities due to the impact of COVID-19 in 2020 (see Table 3-10). Each city has a feature of the GRDP composition. East Jakarta and North Jakarta have a higher ratio of manufacturing industry than other cities. West Jakarta and South Jakarta have a higher ratio of information and communications, while Central Jakarta and South Jakarta shows higher ratio in financial and insurance activities (see Table 3-11). These results imply that the demand for industrial water is particularly high in East Jakarta and North Jakarta. However, since the minimum wage is increasing in DKI Jakarta, the manufacturing industry tends to move out from DKI Jakarta in search of lower wages. According to the interview results with the related organizations, major relocation destinations include Tangerang Regency in Banten Province, Bekasi Regency in Wes Java Province, and Semarang City in Central Java Province (see Figure 3-5). Meanwhile, the logistics businesses tend to increase in DKI Jakarta. Development of real estate such as high-rise buildings and apartments and shopping malls is active in DKI Jakarta.

Figure 3-6 shows the demographic dynamics by city and district from 2010 onwards. In South Jakarta, the population increase in Jagakarsa, which is located in the southern part of the city, is remarkable. But in this region, PAM Jaya's water distribution network is not well developed. In East Jakarta, Cakung shows the rapid population increase. The population growth in this area is due to the progress of development in JAKARTA Garden City including residential and commercial areas. In Central Jakarta, especially in Kemayoran, the population increase is remarkable. It seems to be due to redevelopment of the former Kemayoran Airport area. In West Jakarta, the population is increasing in Kalideres and Cengkareng. As these districts are close to Soekarno-Hatta Airport, the population increase seems to be due to the urban development in recent years and construction of public housing by DKI Jakarta.

However, the PAM Jaya's distribution network has not been fully developed in these areas. In North Jakarta, population increase is seen especially in Penjaringan in the west end and Cilincing in the east end in which urbanization had not been progressing compared to other districts. From these situations, it is expected that the water demand will continue to increase continuously, mainly for commercial and domestic use.

Table 3-10 Gross Regional Domestic Product (GRDP) by City in DKI Jakarta

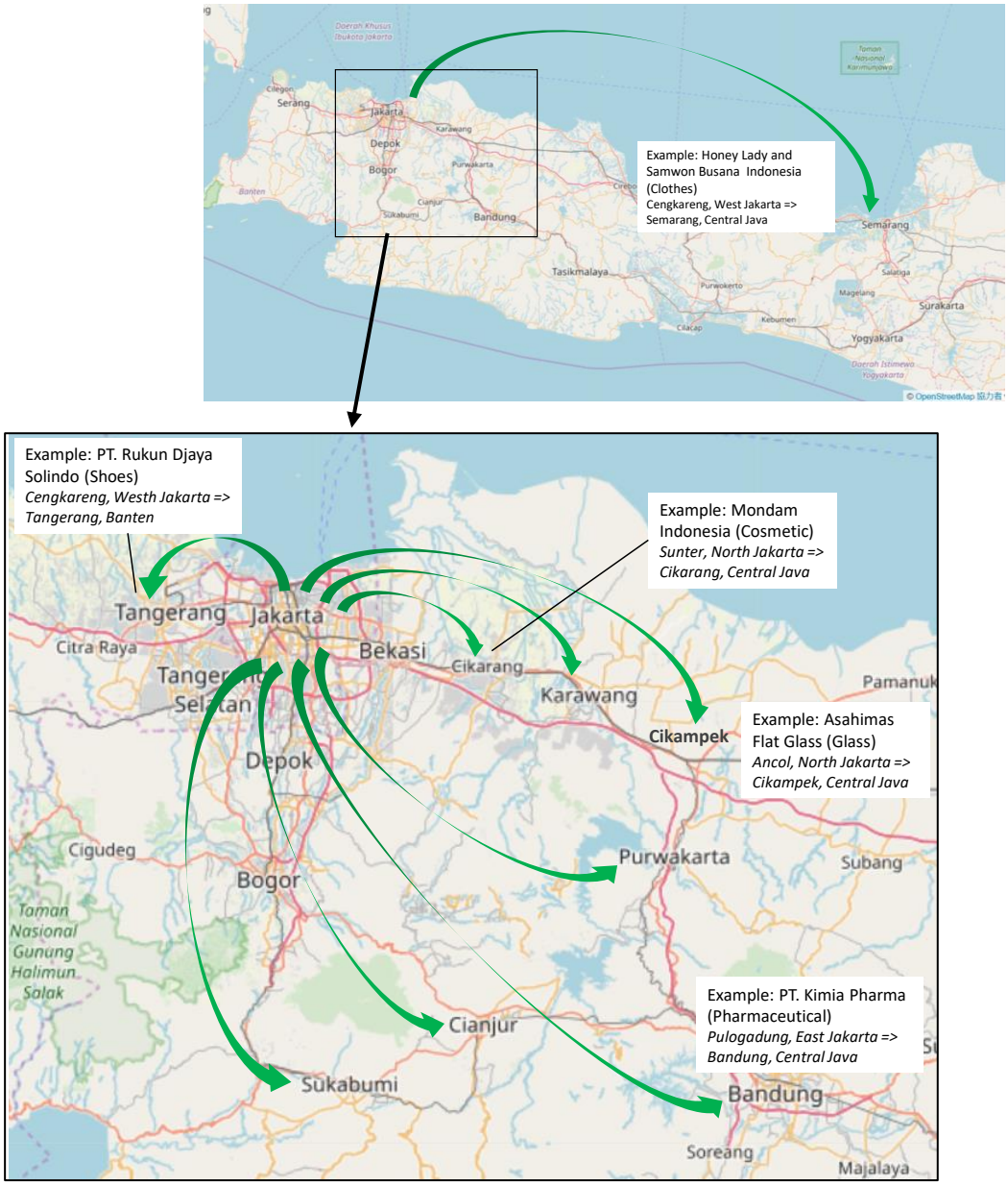
	2015	2016	2017	2018	2019	2020
North Jakarta (Utara)						
GRDP (Billion Rupiah)	271,156	283,654	301,779	320,658	332,844	312,332
GRDP Growth Rate (%)	5.59	4.61	6.39	6.26	3.8	-6.16
East Jakarta (Timur)						
GRDP (Billion Rupiah)	249,477	264,810	281,363	298,531	313,551	299,705
GRDP Growth Rate (%)	5.5	6.15	6.25	6.1	5.03	-4.42
West Jakarta (Barat)						
GRDP (Billion Rupiah)	249,329	264,435	281,570	299,452	318,892	316,204
GRDP Growth Rate (%)	6.01	6.06	6.48	6.35	6.49	-0.84
Central Jakarta (Pusat)						
GRDP (Billion Rupiah)	355,093	377,782	400,475	424,204	452,519	449,615
GRDP Growth Rate (%)	6.67	6.39	6.01	5.93	6.67	-0.64
South Jakarta (Selatan)						
GRDP (Billion Rupiah)	329,155	349,252	371,254	394,430	421,291	419,330
GRDP Growth Rate (%)	6.12	6.11	6.3	6.24	6.81	-0.47
Total (Billion Rupiah)	1,454,209	1,539,933	1,636,441	1,737,276	1,839,096	1,797,185

Source: prepared by the Project Team based on the data of Jakarta Provincial Statistics Office

Table 3-11 Top Three Sectors in Gross Regional Domestic Product (GRDP) by City

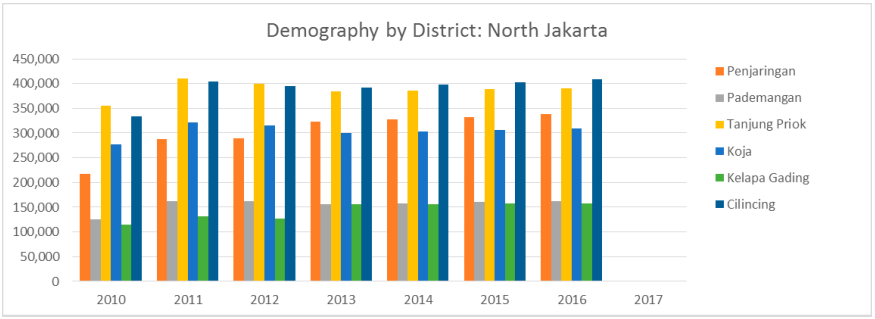
	1st	2nd	3rd
North Jakarta (Utara)	35.1%	16.9%	15.2%
	Manufacturing	Motor/Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Construction
East Jakarta (Timur)	29.0%	15.6%	11.8%
	Manufacturing	Motor/Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Construction
West Jakarta (Barat)	19.7%	17.3%	15.5%
	Information and Communication	Motor/Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Construction
Central Jakarta (Pusat)	22.8%	16.7%	10.1%
	Financial and Insurance Activities	Motor/Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Construction
South Jakarta (Selatan)	15.1%	14.5%	12.8%
	Motor/Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Information and Communication	Construction

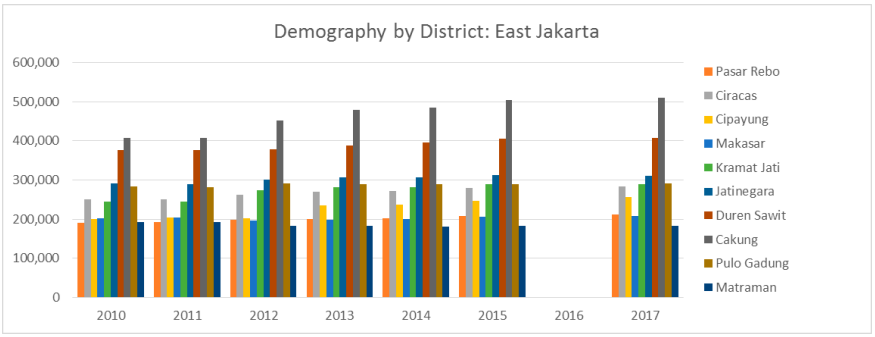
Source: prepared by the Project Team based on the data of Jakarta Provincial Statistics Office

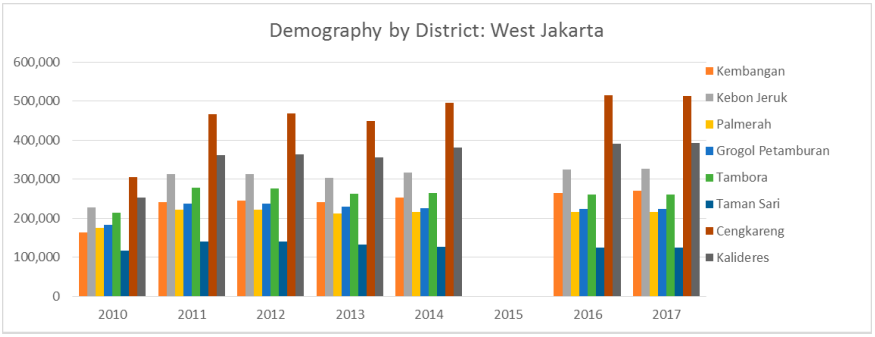


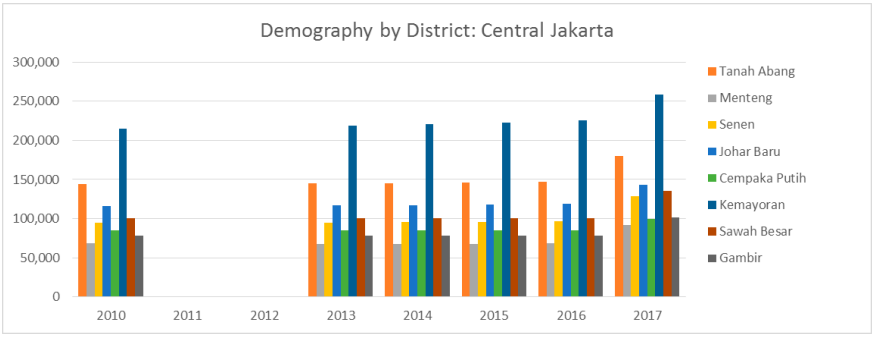
Source: prepared by the Project Team based on Open Street Map

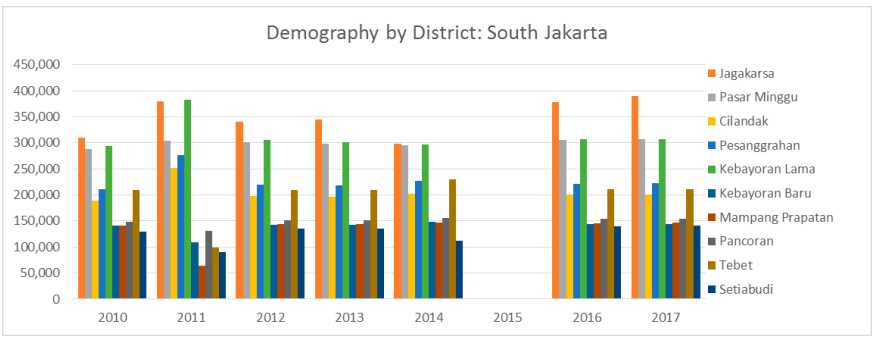
Figure 3-5 Major Relocation Destinations of Manufacturing Industry











Source: prepared by the Project Team based on the data of Jakarta Provincial Statistics Office

Figure 3-6 Population Dynamics by City and District

3.2.2 Current Situation of Groundwater Use

(1) Summary by Region

Table 3-12 shows the amount of groundwater used in DKI Jakarta in 2015. The groundwater abstraction in South Jakarta, where the pipeline development of water supply is delayed, accounts for 56% of total abstraction volume from the registered wells in DKI Jakarta. On the other hand, the groundwater abstraction in North Jakarta, where the pipeline development of water supply is also delayed, accounts for 5%. When it comes to the groundwater abstraction by type of use, non-commercial use (social facilities such as hospitals, schools, religious institutions, central and regional government agencies) accounts for 44%, followed by large-scale commercial use (4 stars and 5 stars hotels, apartments, large-scale commercial facilities, etc.). The industrial use accounts for 9% of the total abstraction volume in DKI Jakarta. Although there is an error between the data of the statistics office and the groundwater abstraction data of the Water Resources Office, the water consumption in 2015 for PAM Jaya and groundwater abstraction is 330.49 million m^3 and 9.04 million m^3, respectively. The groundwater abstraction accounts for only 3% of the consumption of PAM Jaya water supply. It can be assumed that there are also wells that are used without permission, or continues to be used without extension of permits, as well as shallow wells that are used by households to meet basic needs. Therefore, in reality, more groundwater is being consumed in Jakarta.

Table 3-12 Groundwater Abstraction from Registered Wells by Purpose of Use (2015)

	Large Industrial (industri besar)	Small Industrial (industri kecil)	Large Commercial (niaga besar)	Small Commercial (niaga kecil)	Non Commercial (non niaga)	Total (Ratio)
North Jakarta (Utara)	82,030	26,070	278,673	48,552	32,724	468,049 (5%)
West Jakarta (Barat)	230,729	23,288	531,724	264,944	199,392	1,250,077 (14%)
East Jakarta (Timur)	258,173	32,360	186,673	45,678	724,120	1,247,004 (14%)
Central Jakarta (Pusat)	4,941	59,876	530,024	117,876	326,128	1,038,845 (11%)
South Jakarta (Selatan)	37,251	175,150	2,336,080	391,468	2,099,893	5,039,842 (56%)
Total (Ratio)	613,124 (7%)	316,744 (4%)	3,863,174 (43%)	868,518 (10%)	3,382,257 (37%)	9,043,817

Source: prepared by the Project Team based on the data of Water Resources Office, DKI Jakarta

Based on the data obtained from Water Resources Office of DKI Jakarta (DSDA), monthly abstraction volume by city is summarized in Table 3-13 and comparison between rainfall data at Kemayoran rain-gauge station is shown in Figure 3-7. In 2015, heavy rainfall was recorded in February and rainfall in dry season after March was much less than the average. Data accuracy might not be high since monthly variation of abstraction volume is large in every city. Regardless, abstraction volume increases in April or May in all city excluding East Jakarta. Abstraction volume also increases at the end of rainy season. It can be said that groundwater abstraction increases by decreasing of rainfall. The followings are possible causes of this phenomena.

- By decreasing of rainfall, groundwater utilization for watering increases.
- By decreasing groundwater recharge to unconfined aquifer, unregistered shallow well users change to registered deep well use.

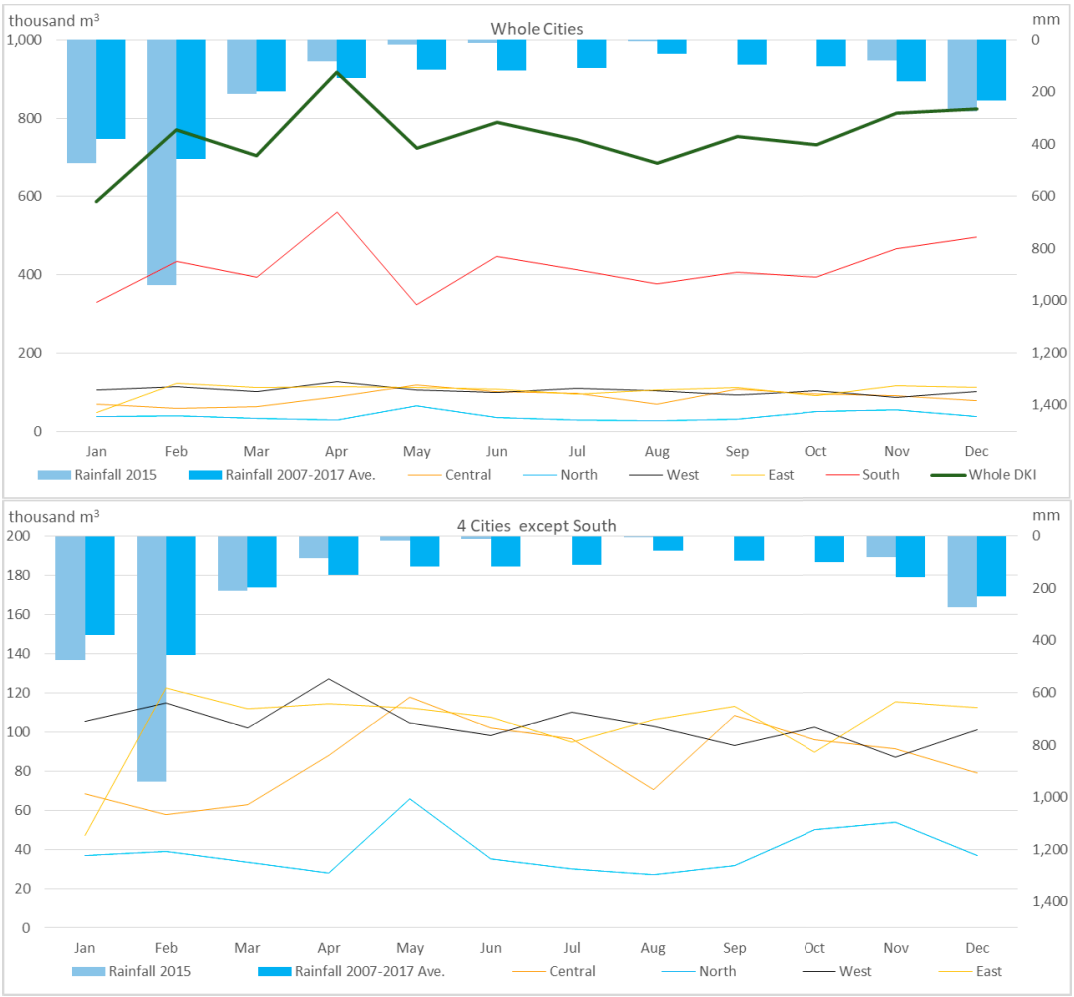
Improvement of analysis accuracy is required by further examination of abstraction data, application of basin rainfall and so on.

Table 3-13 Monthly Groundwater Abstraction Volume from Registered Wells by City in 2015

Unit: m^3

City	Jan.	Feb.	Mar.	Apr.	May	Jun.	1st Half	
North	36,987	39,127	33,461	27,768	65,957	35,184	238,484	
West	105,482	114,983	102,023	127,231	104,676	98,290	652,685	
East	46,987	122,659	111,847	114,276	112,118	107,482	615,369	
Central	68,516	57,891	63,052	87,977	117,641	101,893	496,970	
South	328,775	434,842	392,986	559,606	322,722	447,353	2,486,284	
Total	586,747	769,502	703,369	916,858	723,114	790,202	4,489,792	
City	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	2nd Half	Total
North	29,865	27,143	31,889	50,131	53,811	36,726	229,565	468,049
West	110,325	102,867	93,277	102,537	87,174	101,212	597,392	1,250,077
East	94,998	106,274	112,998	89,806	115,313	112,246	631,635	1,247,004
Central	96,729	70,437	108,435	95,952	91,431	78,891	541,875	1,038,845
South	412,654	377,658	407,523	394,300	466,105	495,318	2,553,558	5,039,842
Total	744,571	684,379	754,122	732,726	813,834	824,393	4,554,025	9,043,817

Source: prepared by the Project Team based on DSDA data



Source: prepared by the Project Team based on DSDA and Agency for Meteorology, Climatology and Geophysics (BMKG) data

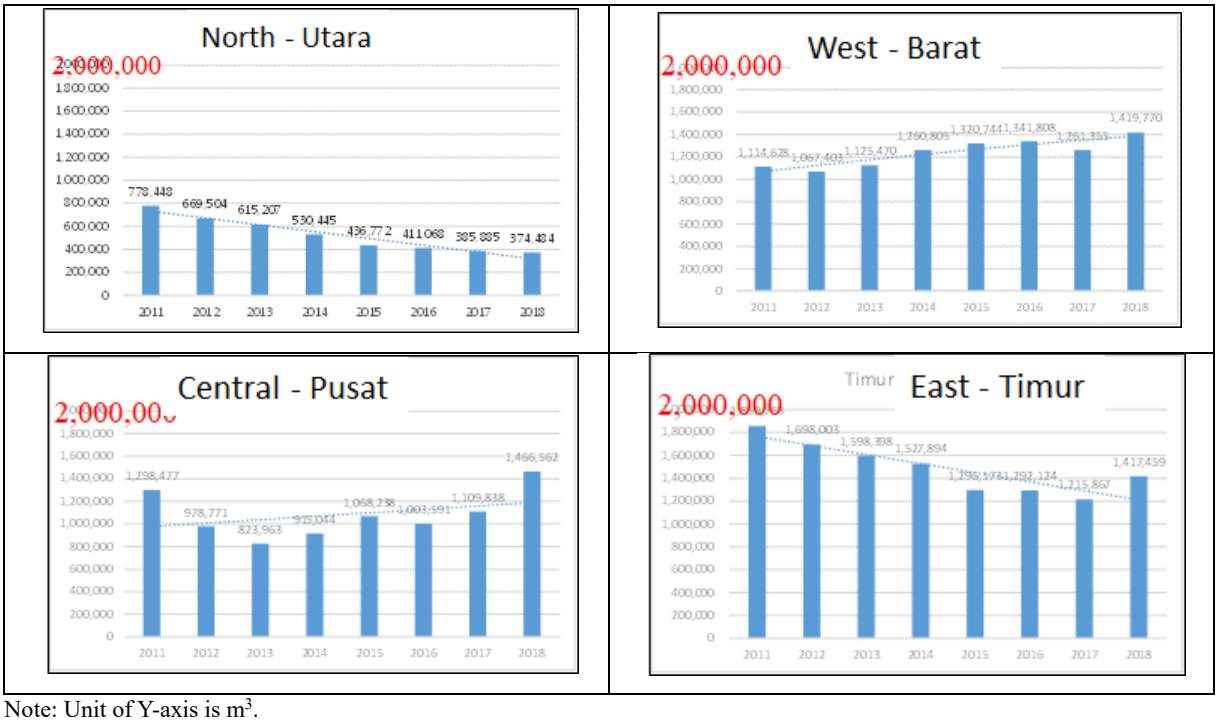
Figure 3-7 Groundwater Abstraction from Registered Wells and Rainfall in 2015

(2) Groundwater Abstraction of each Kecamatan and KOTA

The current status of groundwater use in DKI Jakarta was analyzed for North Jakarta, West Jakarta, East Jakarta, and Central Jakarta. South Jakarta was excluded from this analysis because the groundwater conservation map shows that most of the area is covered by the zone where the groundwater abstraction is permissible. Figure 3-8 shows the changes in groundwater use based on the groundwater abstraction data for each city (Kota) and district (Kecamatan) from 2011 to 2018 obtained from the DKI Jakarta Tax Office. The following features of the groundwater use in those four cities can be found:

- The highest total volume of groundwater abstraction is in East Jakarta, followed by West Jakarta.
- North Jakarta, where the land subsidence is remarkable, shows less groundwater abstraction among these four cities.
- North Jakarta and East Jakarta shows the tendency of decrease in the groundwater abstraction volume. On the other hand, an increasing trend is observed in West Jakarta and Central Jakarta.

The trend of decrease or increase in groundwater abstraction volume is considered to indicate social changes such as urbanization and usage of groundwater in the area.



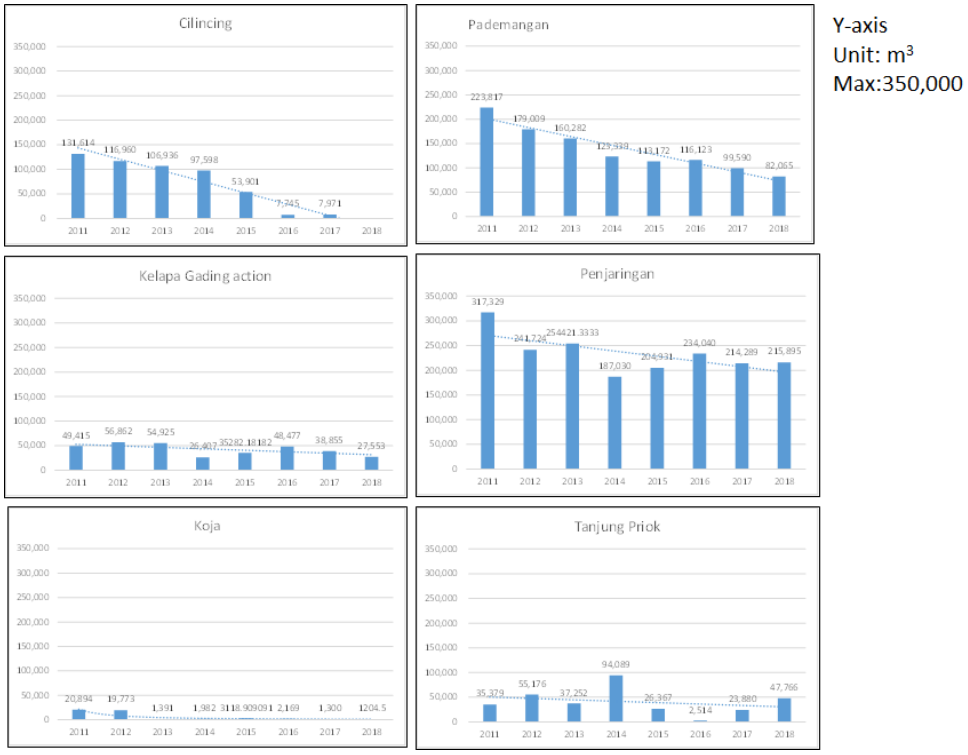
Note: Unit of Y-axis is m^3.
Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-8 Changes in Groundwater Abstraction Volume in 4 Kota (2011 – 2018)

The following part describes the situation of groundwater abstraction by city. In addition, groundwater use in Kecamatan with large volume of consumption and/or no decreasing trend in three cities that covers the pilot areas of the Project (i.e. North Jakarta, West Jakarta, and East Jakarta) was analyzed to capture the business type and actual consumption volume. The groundwater abstraction data for 2015, which has more organized data than other years was used for the analysis.

1) North Jakarta

Figure 3-9 shows the changes in the groundwater abstraction volume in Kecamatan in North Jakarta. Kecamatan other than Kelapa Gading, Koja, and Tanjung Priok, which have relatively small groundwater abstraction volume, shows a general tendency of decrease in the groundwater abstraction volume during the period. Penjaringan has the highest groundwater abstraction volume in North Jakarta with annual average volume is about 234,000 m^3.



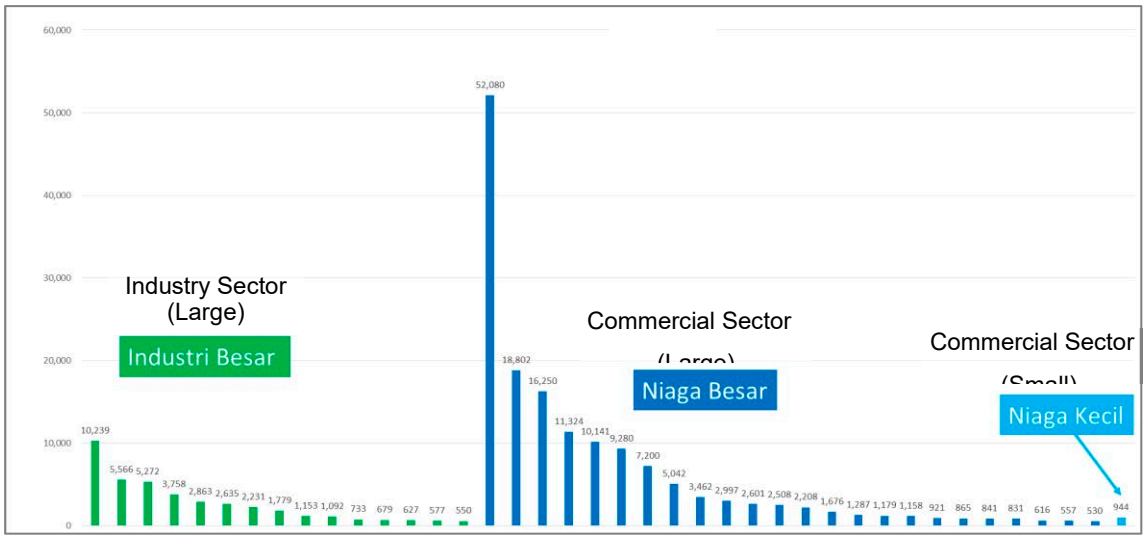
Source: prepared by the Project Team based on data of DKI Jakarta

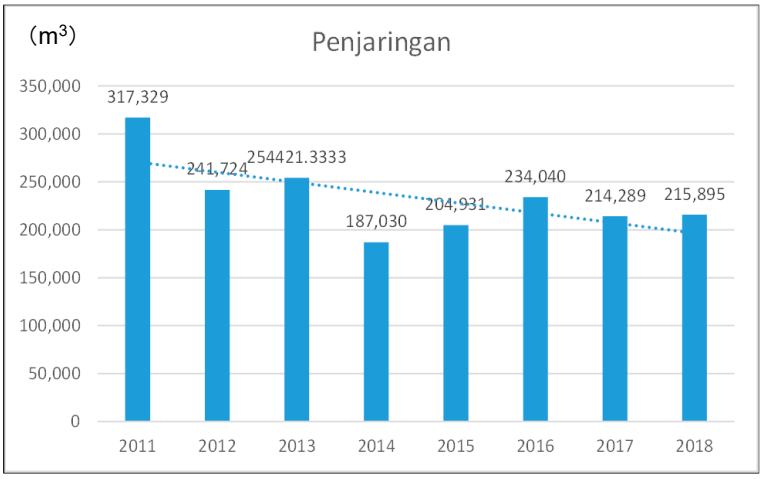
Figure 3-9 Groundwater Abstraction Volume from 2011 to 2018 of Kecamatan in North Jakarta

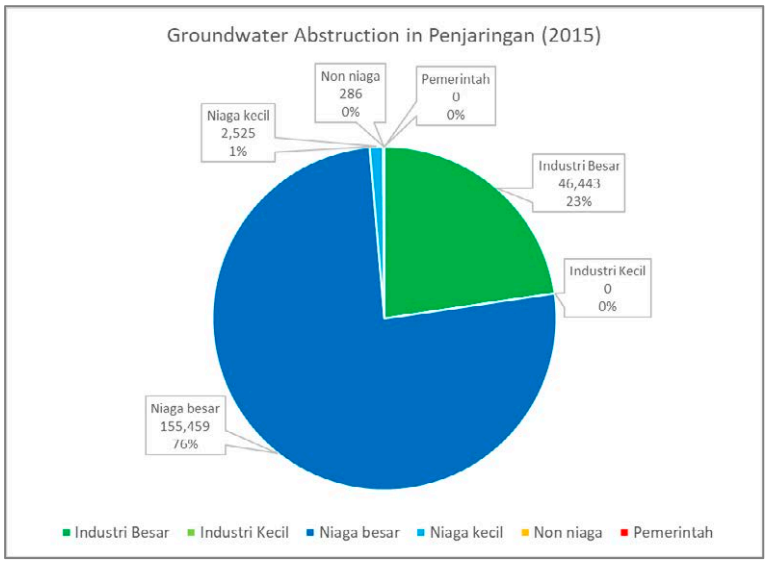
The district (Kecamatan) selected for the detailed analysis in North Jakarta is Penjaringan.

The sector which use the largest volume of groundwater in Penjaringan was the commercial sector (large), which accounted for 76% of the total, followed by 23 % for the industrial sector (large).

The types of businesses with the large consumption were real estate development, manufacturing and sale of curtains, wallpaper, and mosquito nets, and sale of corrugated cardboard products for the commercial sector (large), and manufacturing and sale of writing materials for the industrial sector (large). Outstanding volume of groundwater is abstracted by real estate development, compared to other types of businesses in this area (see Figure 3-10).





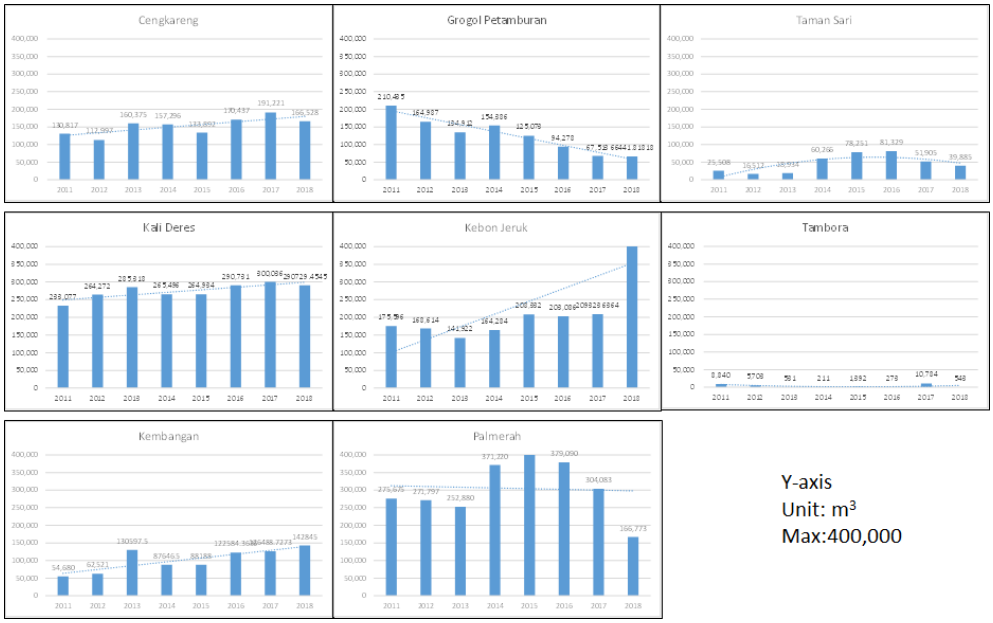


Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-10 Analysis Result for Penjaringan in North Jakarta

2) West Jakarta

Figure 3-11 shows the changes in the amount of groundwater abstraction volume in Kecamatan in West Jakarta. There is a tendency that the amount of abstraction volume and its change are different for each Kecamatan. Palmerah and Kalideres have highest average annual groundwater abstraction volume of about 305,000 m^3 and 274,000 m^3, respectively.



Source: prepared by the Project Team based on data of DKI Jakarta

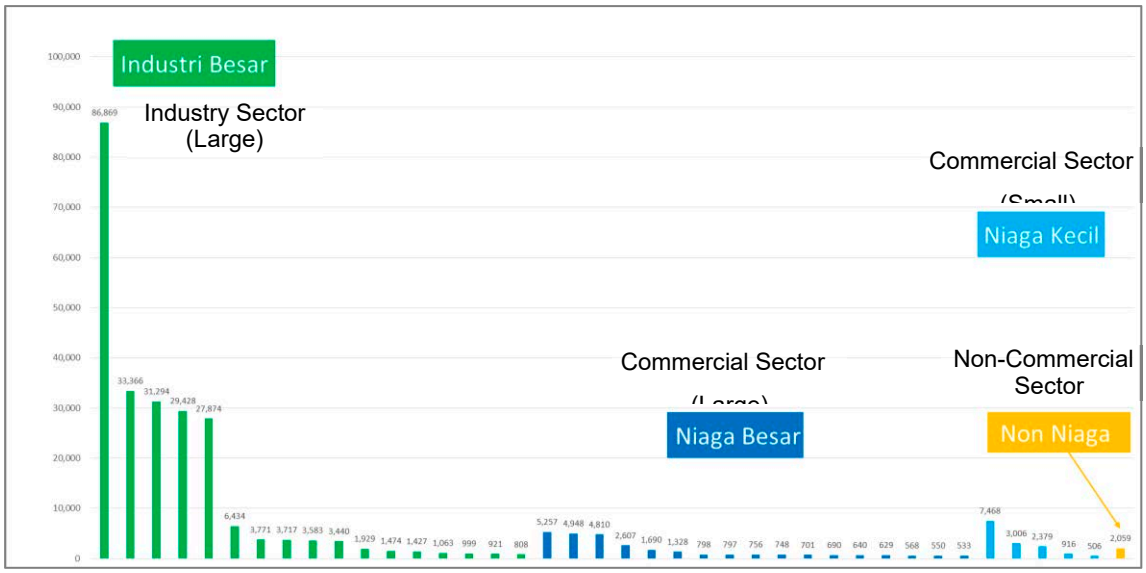
Figure 3-11 Groundwater Abstraction Volume from 2011 to 2018 of Kecamatan in West Jakarta

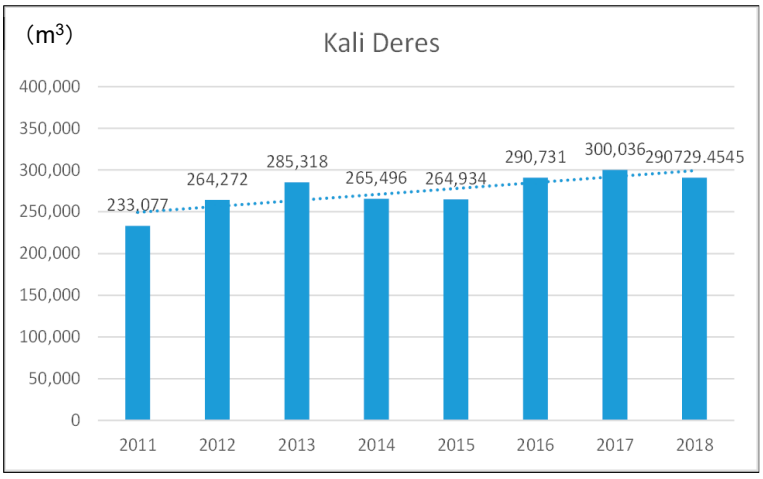
The districts (Kecamatan) selected for the detailed analysis in West Jakarta is Kali Deres, Kebon Jeruk, and Palemerah.

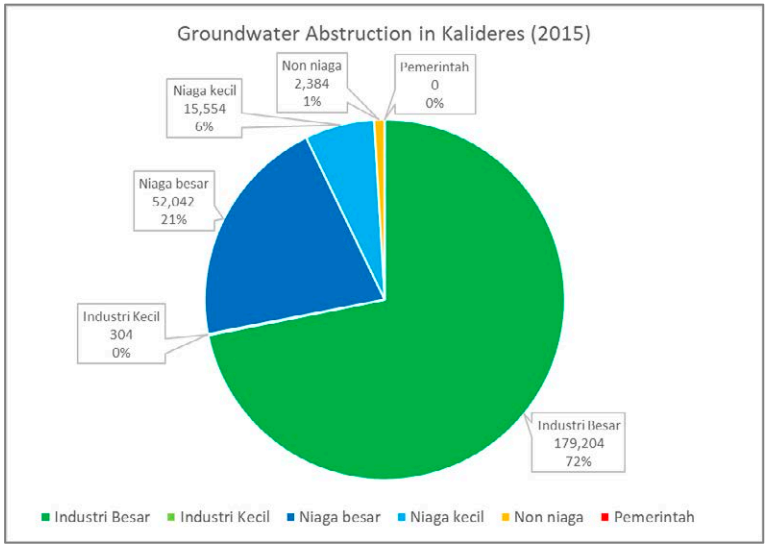
The sector which use the largest amount of groundwater in Kali Deres was the industrial sector (large) which accounted for 72% of the total, followed by 21% for the commercial sector (large). Especially, the groundwater abstraction by five companies categorized as the industrial sector (large) was outstandingly high. Business categories of large users included the manufacturing and sale of building materials, hard metal products (such as cans for food), and clothing (see Figure 3-12).

The sector which use the largest amount of groundwater in Kebon Jeruk was the commercial sector (large) which accounted for 51% of the total, followed by 24% for the non-commercial sector and 23% for the commercial sector (small). Business categories of large users included the TV stations and real estate development for the commercial sector (large), hospitals for the commercial sector (small), and social facilities for the non-commercial sector (see Figure 3-13).

The sector which use the largest amount of groundwater in Palmerah was the commercial sector (small), which accounted for 53% of the total, followed by 30% for the commercial sector (large), and 14% for the non-commercial sector. Business categories of large users included the private hospitals for the commercial sector (small), manufacturing and sale of urea fertilizer and clove cigarettes for the commercial sector (large), and public hospitals for the non-commercial sector (see Figure 3-14).

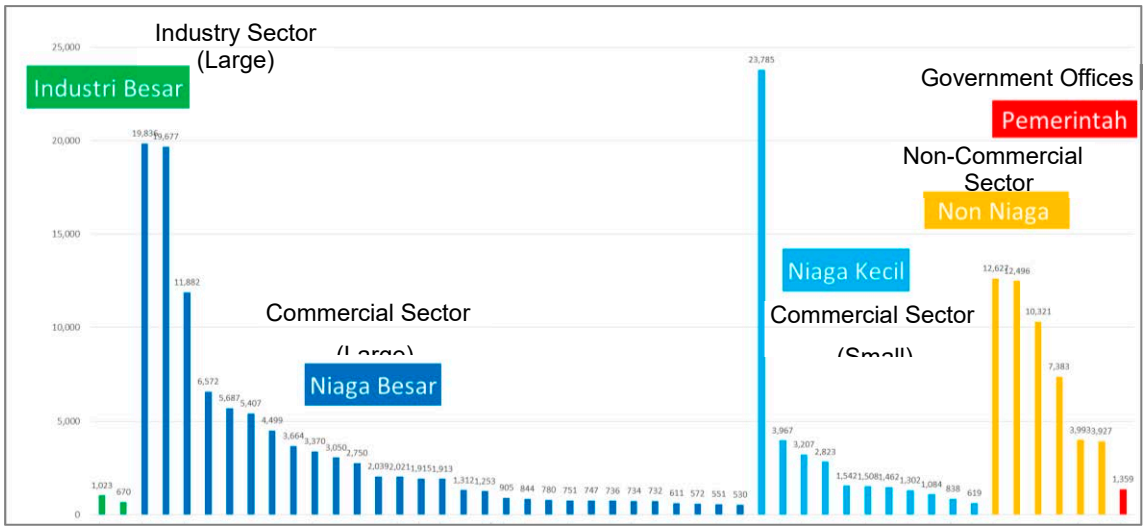


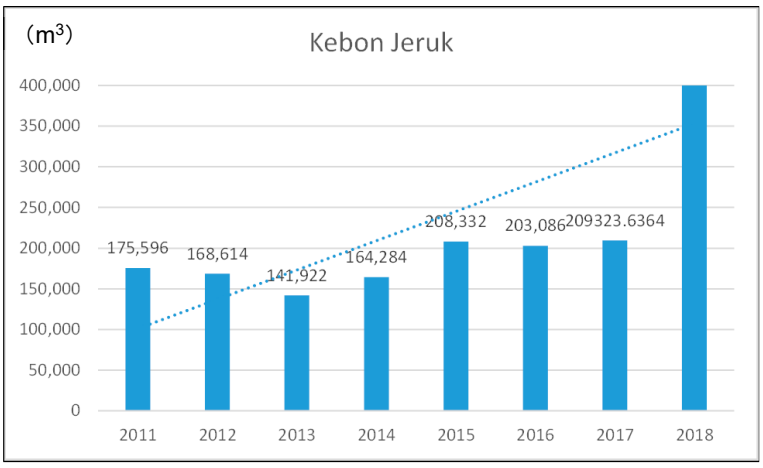


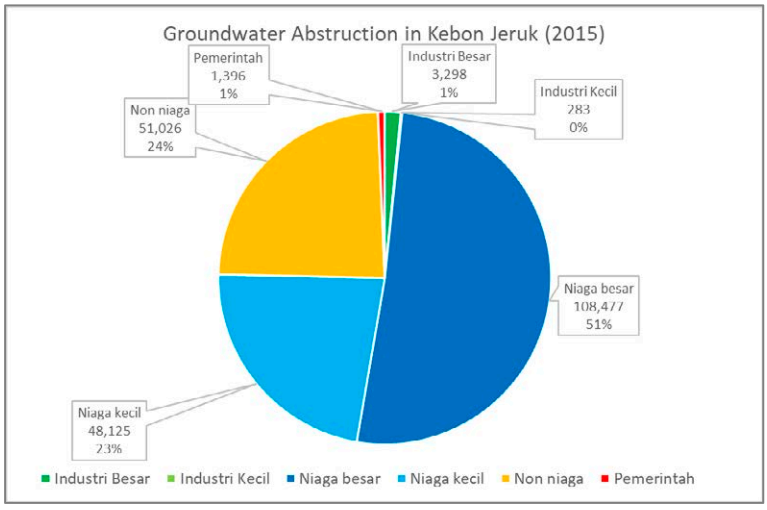


Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-12 Analysis Result for Kali Deres in West Jakarta

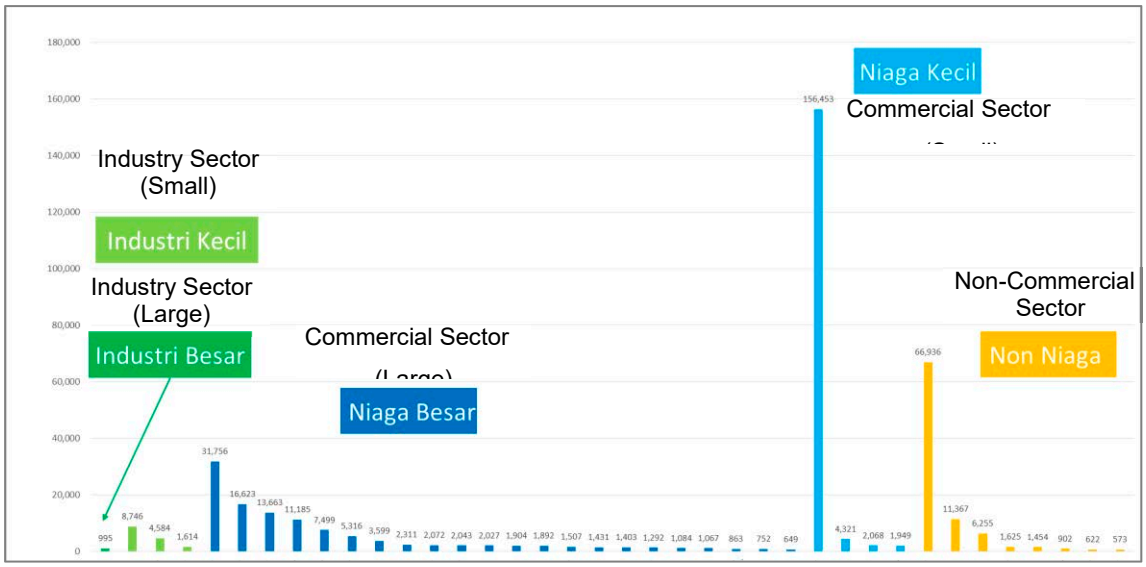


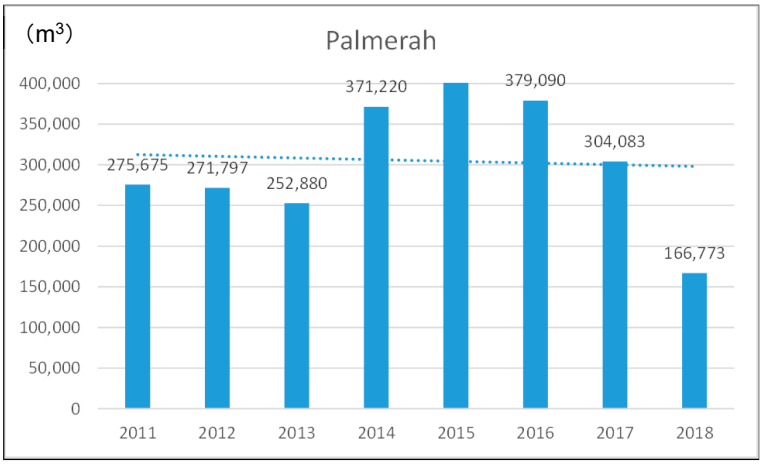


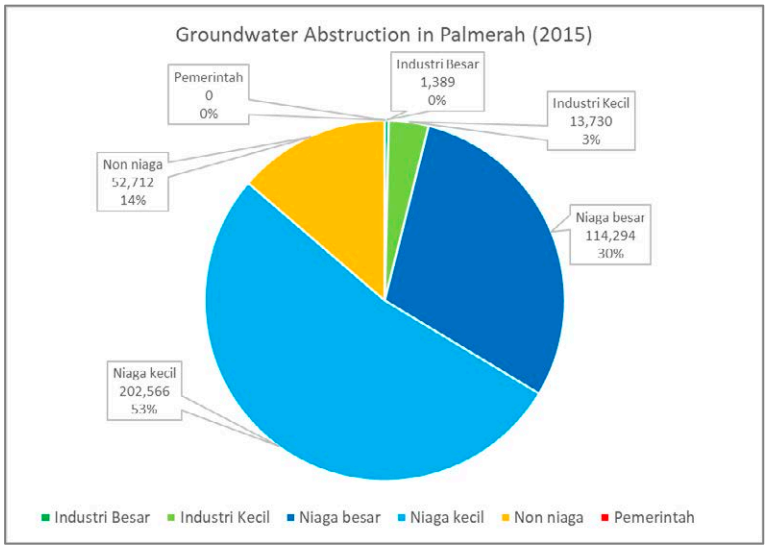


Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-13 Analysis Result for Kebon Jeruk in West Jakarta







Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-14 Analysis Result for Palmerah in West Jakarta

3) East Jakarta

Figure 3-15 shows the changes in the amount of groundwater abstraction volume in Kecamatan in East Jakarta. In East Jakarta, Kecamatan with the smaller abstraction volume shows small annual change in annual abstraction volume. In contrast, while Kecamatan with the larger abstraction volume shows remarkable change in annual abstraction volume. Ciracas shows the trend of decrease in the abstraction volume during the period. Makasar has the largest groundwater abstraction volume in East Jakarta with average annual volume of about 449,000 m^3.



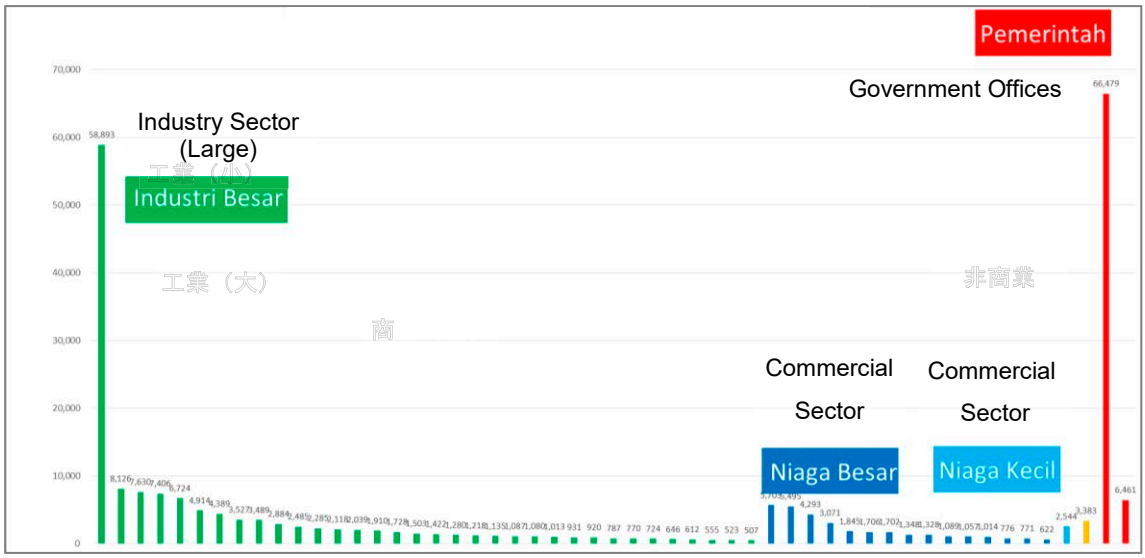
Source: prepared by the Project Team based on data of DKI Jakarta

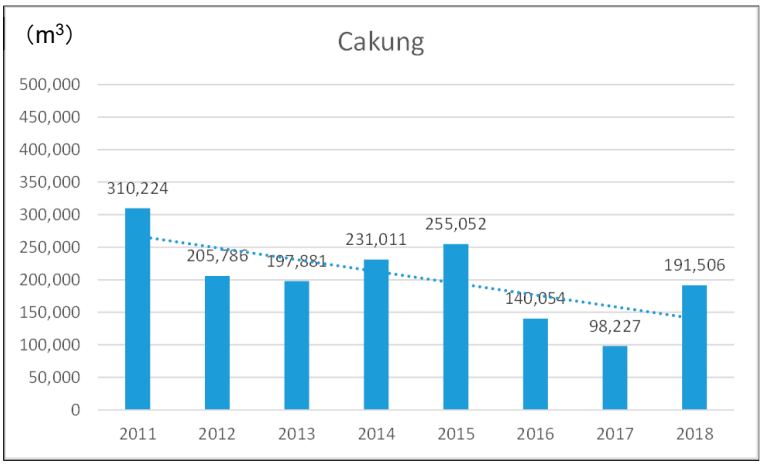
Figure 3-15 Groundwater Abstraction Volume from 2011 to 2018 of Kecamatan in the East Jakarta

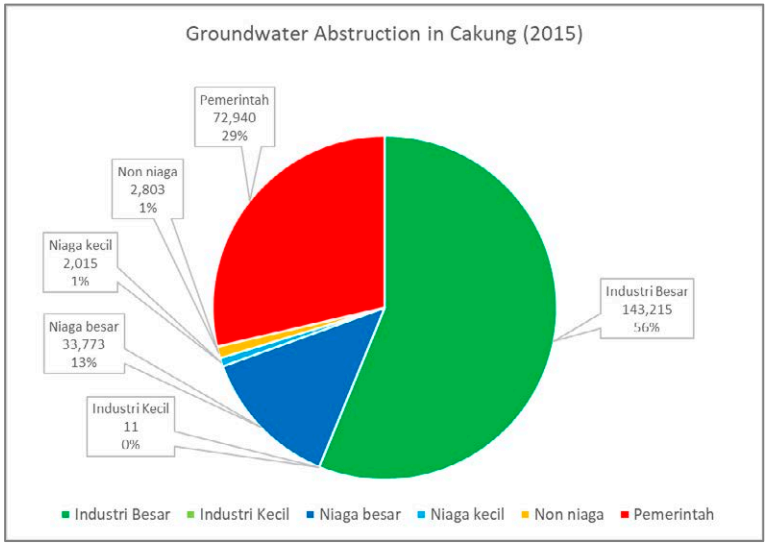
The districts (Kecamatan) selected for the detailed analysis in East Jakarta is Cakung and Makasar.

The sector which use the largest amount of groundwater in Cakung was the industrial sector (large), which accounted for 56% of the total, followed by 29% for the government offices (categorized as "non-commercial" in the records of groundwater abstraction from registered wells), and 11% for the industrial sector (small). Especially, the groundwater abstraction by one company (manufacturing and sale of negative films and photographic papers) categorized as the industrial sector (large) and one government office (public transportation) was outstandingly high (see Figure 3-16).

The sector which use the largest amount of groundwater in Makasar was the government offices, which accounted for 47% of the total, followed by 45% for the non-commercial sector, and 7% for the commercial sector (large). Business categories of large users included the religious buildings and public facilities (sports complex) for the non-commercial sector, and national and provincial government buildings for the government offices (see Figure 3-17).

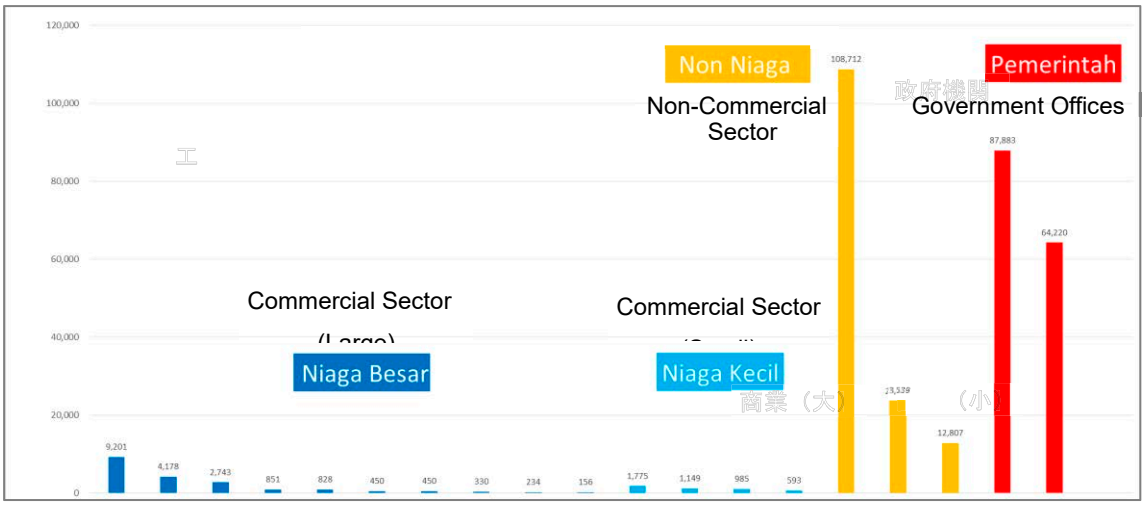


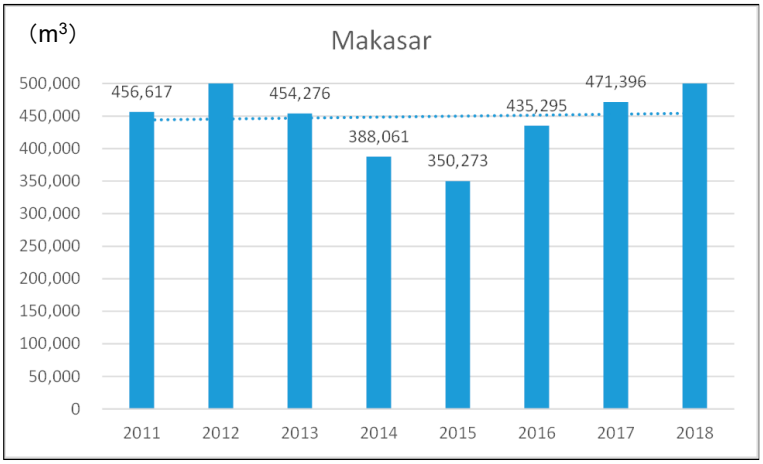


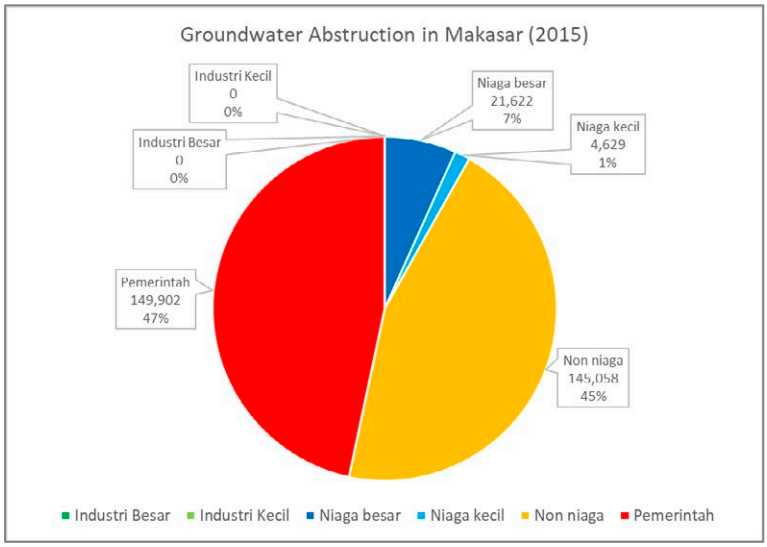


Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-16 Analysis Result for Cakung in East Jakarta







Source: prepared by the Project Team based on data of DKI Jakarta

Figure 3-17 Analysis Result for Makasar in East Jakarta

4) Central Jakarta

Figure 3-18 shows the changes in the groundwater abstraction volume in Kecamatan in Central Jakarta. Similar to East Jakarta, Kecamatan with the smaller abstraction volume shows small annual change in annual abstraction volume. In contrast, Kecamatan with the larger abstraction volume shows remarkable

change in annual abstraction volume. Tanah Abang has the largest groundwater abstraction volume in Central Jakarta with annual average volume is about 389,000 m^3.

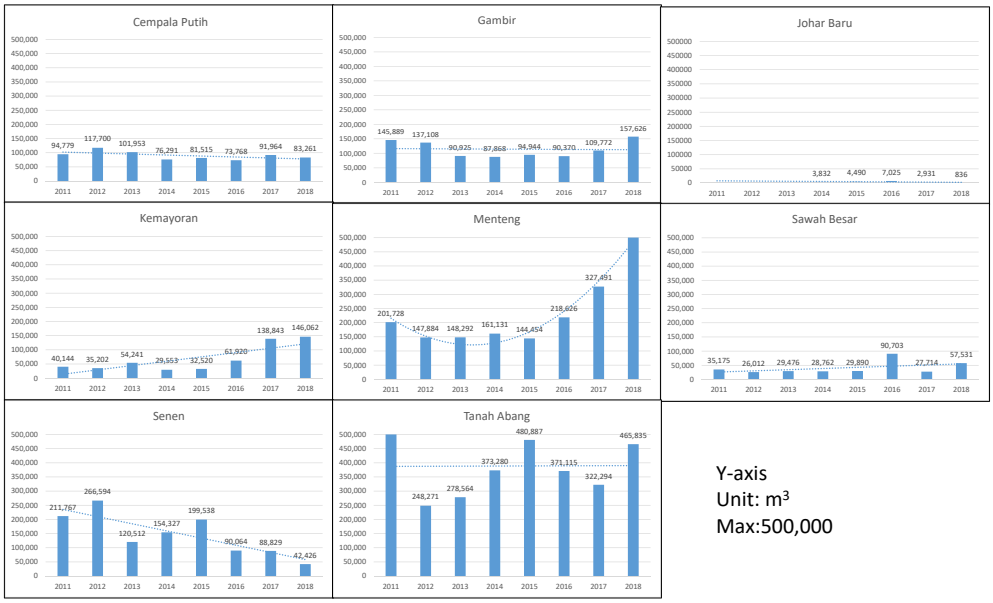


Figure 3-18 Groundwater Abstraction Volume from 2011 to 2018 of Kecamatan in Central Jakarta

3.2.3 Estimation of Volumes of Groundwater Abstraction by Unregistered Wells

The wells except "registered well" can be categorized as follows.

"Illegal Well" : A well which fails to meet the regulation such as location, depth, diameter and pump capacity

"Unregistered Well" : A well which is not registered by intention or accident

"Non-renewed Well" : A well registered but not renewed its registration within each 3 years

In this section, above mentioned wells are generally called "Unregistered Wells".

(1) Estimation Methods

Based on statistical data, total water consumption is estimated including domestic, industrial, commercial, and building water use. And the groundwater abstraction volume by illegal wells is estimated by deducting PAM Jaya water supply volume, groundwater abstraction volume by registered wells, and commercial loss (water theft, error on meter reading or processing, etc.) of NRW by PAM Jaya.

Domestic use: estimation by income groups

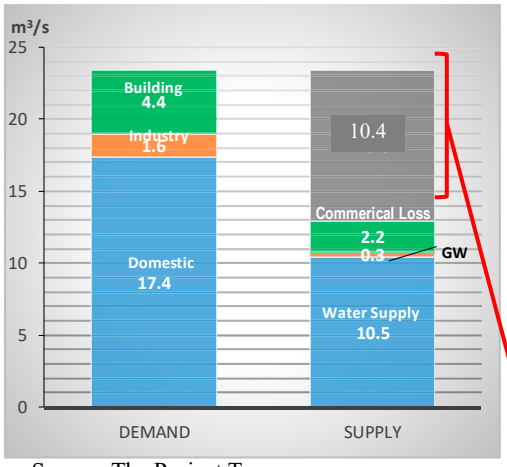
Industrial use: estimation by types of industries

Commercial and building use: buildings, schools, hospitals, mosques, hotels, restaurants, and shopping malls

Considering the data availability, statistical data in 2015 is principally used and neighboring year is used when the data in 2015 is not available. Since the statistical data by City (Kota) is not reliable, water volume in whole DKI Jakarta is estimated.

(2) Estimation of Volumes of Groundwater Abstraction by Unregistered Wells

Water balance in 2015 is calculated based on the water demand described above, water supply service volume, groundwater abstraction volume by registered wells and commercial loss out of NRW (30% of NRW). As shown in Figure 3-19, total water demand is estimated at 23.4 m^3/s while total water supply is at 13.0 m^3/s (55% of the total demand). Deficit is estimated at 10.4 m^3/s, equivalent to about 45% of total demand. Most of them are supplied by unregistered wells, others are water supply from Tangerang or buying from tank waters. The majority of demand is for domestic use, and in areas not affected by groundwater salinization, it is assumed that the shortfall in supply is being utilized from shallow groundwater. Therefore, the consumption of shallow groundwater by households is estimated in the next section.



Demand (m^3/s)		Supply (m^3/s)	
Domestic	17.4	Piped water	10.5
Industrial	1.6	Groundwater	0.3
Building & commercial	4.4	Commercial loss	2.2
Total	23.4	Total	13.0
23.4 – 13.0 = 10.4 <- deficit			

Sources for deficit
- Groundwater abstraction from unregistered wells <= used for most of the deficit
- Others (purchasing rom water tankers, distribution from Tangerang

Source: The Project Team

Figure 3-19 Water Balance of DKI Jakarta in 2015

(3) Procedure of Estimation

The following are the steps to estimate the whole demand of water in DKI Jakarta.

Setting the unit water consumption volume:

Set the basic unit water consumption volume based on existing data for each type of demand (domestic, industrial, and commercial/building water).

Estimating the water demand:

Estimate the water consumption by type of demand based on the set basic unit water consumption volume.

1) Unit Water Consumption

Based on the interview survey and data collection, the following unit water consumption rates are applied.

a) Governor Decree No. 122 in 2005 on Wastewater Management

This decree stipulates the standards for waste water management and treatment by building and facilities, and unit water supply volume by building/facility type is also stipulated as a reference for waste water treatment facility design (see Table 3-14). Data sources of the values are Indonesian National Standards (SNI), JICA Study (it is assumed to be "The Study on Urban Drainage and Wastewater Disposal Project in the City of Jakarta" by issuing year), and "Design and Maintenance of Plumbing Systems" (Perencangan dan Pemeliharaan Sistem Plambing) by Soufyan-M-Noerbambang-Morimura.

Table 3-14 Unit Water Consumption by Governor Decree No. 122 in 2005 on Waste Water Management

No.	Type	Water Supply	Waste Water	Unit	Reference
1	High-Class houses	250	200	l/person/day	*1
2	Medium houses	150	120	l/person/day	JICA Study 1990(2000 estimation)
3	Apartment	250	200	l/person/day	*1
4	Flats	100	80	l/person/day	
5	Dormitory	120	96	l/person/day	
6	Clinic/Health Center	3	2,7	l/person/day	*1
7	High-class hospital	1000	800	l/bed/day	*1
	Medium hospital	750	600	l/bed/day	*1
	Public hospital	425	340	l/bed/day	*1
8	Elementary School	40	32	l/student/day	SNI 03-7065-2005
9	Junior High School	50	40	l/student/day	SNI 03-7065-2005
10	High School	80	64	l/student/day	SNI 03-7065-2005
11	University	80	64	l/student/day	SNI 03-7065-2005
12	Shop /Workhouse	100	80	l/person/day	SNI 03-7065-2005
13	Building	50	40	l/worker/day	SNI 03-7065-2005
14	Department Store	5	4,5	l/floor/day	SNI 03-7065-2005
15	Factory / Industry	50	40	l/worker/day	SNI 03-7065-2005
16	Station / Bus Shelter	3	2,7	l/passenger/day	SNI 03-7065-2005
17	Airport	3	2,7	l/passenger/day	*1
18	Restaurant	15	13,5	l/seat/day	SNI 03-7065-2005
19	Showroom	10	9	l/seat/day	SNI 03-7065-2005
20	Movie Theatre	10	9	l/seat/day	SNI 03-7065-2005
21	Hotel until Two-Star	150	120	l/bed/day	SNI 03-7065-2005
22	Three-Star Hotel and more	250	200	l/bed/day	SNI 03-7065-2005
23	Religious Building	5	4,5	l/visitor/day*2	SNI 03-7065-2005
24	Library	25	22,5	l/visitor/day	*1
25	Bar	30	24	l/visitor/day	*1
26	Social Gathering / Club	30	27	l/visitor/day	*1
27	Night Club	235	188	l/seat/day	*1
28	Meeting Hall	25	20	l/seat/day	*1
29	Laboratory	150	120	l/worker/day	*1
30	Market	40	36	l/shop/day	*1

Notes: *1 : Perencangan dan Pemeliharaan Sistem Plambing(Design and Maintenance of Plumbing Systems), Soufyan M/Noerbambang/Takeo Morimura, 1985

*2 : Excluding ablution water (*air wudhu*)

Source : Peraturan Gubernur Provinsi Daerah Khusus Ibukota Jakarta No. 122 Tahun 2005 Tentang Pengelolaan Air Limbah Domestik di Provinsi Daerah Khusus Ibukota Jakarta

For evaluation, the values are compared with the standard values in the Handbook by the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan (ver. 11) (1985), and reasons are considered for large differences as shown in Table 3-15. It is judged that the unit consumption volumes by the degree is reasonable.

Table 3-15 Comparison of Unit Water Consumption

NO	Type	Indonesia	Japan	Remarks
1	High-Class houses	250	200-400	-
2	Medium houses	150		
3	Apartment	250	200-300	-
4	Flats	100		
5	Dormitory	120	400-600	Difference of lifestyle of single household such as bathing and washing
6	Clinic/Health Center	3	-	-
7	High-class hospital	1,000	1,500-3,000	Difference of medical and sanitary standards
	Medium hospital	750		
	Public hospital	425		
8	Elementary School	40	70-100	-
9	Junior High School	50		
10	High School	80		
11	University	80	-	-
12	Shop /Workhouse	100	60-100	-
13	Building	50		
14	Department Store	5	15-30	Due to including restaurants (refer to Restaurant)
15	Factory / Industry	50	60-300	Examined below
16	Station / Bus Shelter	3	0.003-0.01	Difference of number of passenger (larger by far in Japan)
17	Airport	3	-	-
18	Restaurant	15	55-130	Difference of sanitary standards and much water consumed in noodle restaurants in Japan
19	Showroom	10	-	-
20	Movie Theatre	10	-	-
21	2-Star & less	150	350-450 (room only)	Difference of bath facilities and its utilization
22	3-Star Hotel & more	250		
23	Religious Building	5	10	Difference of number of visitor (larger by far in Indonesia)
24	Library	25	25	-
25	Bar	30	-	-
26	Social Gathering / Club	30	-	-
27	Night Club	235	-	-
28	Meeting Hall	25	-	-
29	Laboratory	150	-	-
30	Market	40	-	-

Source : The Project Team based on Peraturan Gubernur Provinsi Daerah Khusus Ibukota Jakarta No. 122 Tahun 2005 Tentang Pengelolaan Air Limbah Domestik di Provinsi Daerah Khusus Ibukota Jakarta, and Handbook by the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan (ver. 11) (1985)

b) Inventory Survey on Water Resources in Industrial Sector

The Ministry of Industry conducted the survey named “Inventory Survey on Availability, Needs, and Efforts to Manage Water Resources in the Industrial Sector” (Inventarisasi Ketersediaan, Kebutuhan, dan Upaya Pengelolaan Sumber Daya Air di Sektor Industri) in 2015 (hereinafter referred to as the “MOI Study”) with the objective to grasp current situation, issue, and potential of water resources in industrial sector. The study areas were 9 cities namely Bekasi, Bogor, and Cirebon in West Java Province, Semarang, Magelang, and Madiun in Central Java Province, and Malang, Pasuruan, and Madiun in East Java Province. Inventory survey was conducted for 129 companies in these 6 cities and production volume by ton, number of workers, water resources, and consumption volumes in 2014 were collected. Table 3-16 and Table 3-17 shows the survey results.

Table 3-16 Inventory of Water Resources and Consumption by MOI Study (1/2)

No	Code	Product	Product Vol.	No. Worker	Water Source (m^3/year)					Water Consumption (m^3/year)			
					SW	GD	PDAM	Others	Total	Process	Utility	Domestic	Total
1	22111	Tires	23,200	994	345,000		44,000		389,000		345,073	44,653	389,726
2	10621	corn flour	455	26		600	400		1,000		130	512	642
3	22293	electronic component	1,103	118		2,300			2,300			2,039	2,039
4	13113	sewing thread	3,636	419	3,470	187,016	25,398		215,884	167	205,005	7,240	212,413
5	13121	fabric and thread	1,316	871	126,000	84,000			210,000	130,810	35,200	15,051	181,061
6	14111	jacket	150	60			1,200		1,200			1,037	1,037
7	15201	shoe sholes	5,231	103		1,700			1,700			1,700	1,700
8	10773	coconut extract	87	24		1,500	200		1,700	300	700	500	1,500
9	10314	fruit extract	6,225	1,010		67,300	28,700		96,000	27,160	50,440	17,000	94,600
10	21012	medicine	693	106					17,170	4,510	10,860	1,800	17,170
11	11040	powder drink	558	62	2,000	3,000	1,000		6,000	1,324	2,530	1,200	5,054
12	14111	apparels	112	251		1,560			1,560			1,560	1,560
13	22220	pertamina bottle packaging	2,285	150		2,592			2,592			2,592	2,592
14	15201	footwear	705	1,488		6,578			6,578		255	4,845	5,100
15	14111	men underwear	764	810		8,858			8,858		972	8,748	9,720
16	10799	flavoring	148	64		1,419			1,419	129	1,032	258	1,419
17	10431	cooking iol	96,870	278		32,000	28,000		60,000		50,400	5,840	56,240
18	10801	animal food	3,349	311		2,200	2,500		4,700	200		4,500	4,700
19	11050	bottled water	339,982	267						5,707,000	156,400	5,500	5,868,900
20	13133	printing, screen printing, embroidery	740	893		130,000			130,000		104,700	15,400	120,100
21	14111	apparels	334	60		2,090			2,090		890	1,200	2,090
22	15201	shoes component	1,599	41		708			708			708	708
23	20222	paint	71	40		480			480			480	480
24	20231	washing sponge from polyester	4,373	190		16,050	24,150		40,200	15,500	20,325	3,280	39,105
25	22291	plastic pipe	766	166		1,700	750		2,450			2,450	2,450
26	17099	cardboard manufacturing	9,719	275					5,100			4,900	4,900
27	15202	exercise shoes	74	52		550			550			550	550
28	13930	carpets	766	154							5,630	2,500	8,130
29	20232	cosmetics	25	118		1,500			1,500		120	1,200	1,320
30	22111	vehicle tires	297,618	1,519					200,000		156,000	28,670	184,670
31	10740	vermicelli	150	45		2,400	3,000		5,400	1,269	2,961	770	5,000
32	10729	rock sugar	112	30			1,000		1,000	147	343	510	1,000
33	22192	equipments from plastic	577	41		1,500	120		1,620		912	708	1,620
34	11040	packaging tea, bottled water	352	80		1,750	2,600		4,350	1,870	980	1,307	4,157
35	10213	frozen fish	890	150		1,230	2,870		4,100		980	2,590	3,570
36	10213	frozen fish	995	51		1,220	1,480		2,700		1,300	890	2,190
37	20119	chitosan and chifarm	29	81					1,200	100	200	900	1,200
38	13942	fishing nets	2,593	2,389					37,100			37,100	37,100
39	10801	cattle fooder	316,458	261						50,320	23,930	4,500	78,750
40	10771	sweet ketchup	95	26		11,400	1,200		12,600	540	335	320	1,195
41	22199	rubber clutch	14	20		270			270			270	270
42	10721	sugar	573	1,378					60,000	15,120	18,480	23,800	57,400
43	22220	plastic bag	103,966	1,050					18,440			18,440	18,440
44	20292	fireworks	5000	206		3,200	1,030		4,230		500	3,560	4,060
45	17099	big envolopes	48	21		120			120			120	120
46	10130	chicken meat	230	20		1,500	1,100		2,600	500	1,570	350	2,420
47	10392	tofu	288	23		1,230			1,230	150	850	230	1,230
48	22220	plastic bag	11784	1,088		13,500	4,000		17,500			17,500	17,500
49	22220	plastic bag	515	63		1,000	100		1,100			970	970
50	20231	detergent	1231	66		6,000	4,000		10,000	2,520	5,880	1,100	9,500
51	10710	dry bread	270	94					2,500	302	572	1,300	2,174
52	10794	eggplant crackers	21	26		580			580	30	150	400	580
53	13121	hand-woven sarong	1	24		465			465	85	60	320	465
54	22220	plastic bag	7251	461		6,250	2,100		8,350			8,120	8,120
55	14111	garment (convection)	373	282		2,400	3,600		6,000			4,870	4,870
56	21012	medicine	865	21		8,190	4,410		12,600	3,650	8,170	363	12,183
57	10621	cassava	999	46		800	200		1,000		200	790	990
58	10794	snacks	78	70		1,170	280		1,450	78	182	950	1,210
59	17091	wet tissue	2637	112		3,688			3,688	2,950		738	3,688
60	10710	wafer	600	100		6,000			6,000	3,000	1,200	1,800	6,000
61	15112	shoe soles	54	60		36,000			36,000	18,295	14,968	1,037	34,300
62	15201	shoes component	175	120		180	240		421			421	421
63	10732	candies	1440	175		2,808			2,808	259	1,440	3,024	4,723

Source：Inventory/Ketersediaan, Kebutuhan dan Upaya Pengelolaan Sumber Daya Air di Sektor Industri, the Ministry of Industry, the Republic of Indonesia, 2015

Table 3-17 Inventory of Water Resources and Consumption by MOI Study (2/2)

No	Code	Product	Product Vol.	No. Worker	Water Source (m^3/year)					Water Consumption (m^3/year)			
					SW	GD	PDAM	Others	Total	Process	Utility	Domestic	Total
64	14111	men formal shirt	164	100		1,400	600		2,000			1,700	1,700
65	10792	shangai nuts	85	45		4,200	120		4,320	432	129	770	1,331
66	10110	slaughterhouse services	2190	40		2,920			2,920		2,920	691	3,611
67	14111	jacket	46	40		850			850			691	691
68	15112	wet blue	5762	120		135,600	300		135,900	711,364	550,670	2,074	1,264,108
69	14111	garment (convection)	92	75		1,100			1,100			1,100	1,100
70	14111	trousers	255	154		2,500			2,500			2,000	2,000
71	17021	duplec sheet	2900	160		2,700			2,700			2,700	2,700
72	10312	tomato sauce	1200	40		2,500	700		3,200	720	1,420	600	2,740
73	20232	shampoo	16	25		650			650		80	450	530
74	14111	shirt	60	38		500			500			500	500
75	22123	raw rubber	810	50					0	13,608	9,072	860	23,540
76	14111	men's hem	18	895		5,800	2,000		7,800			7,800	7,800
77	10710	sweet bread	7	25		1,000			1,000	87	350	400	837
78	10731	candies	135	100		2,000	1,000		3,000		340	1,900	2,240
79	14111	jeans	18	48		370			370			370	370
80	14111	apparels	425	574		3,228			3,228			3,100	3,100
81	10774	bricket salt	224	20		975	525		1,500		750	350	1,100
82	10740	dry noodle	2100	70	1,900		1,000		2,900	600	1,900	400	2,900
83	10739	confectionery, 'Ting-Ting'	394	260		5,640	3,660		9,300				2,040
84	22220	plastic bag	1081	53		1,200			1,200			916	916
85	10392	tofu	138	38		950			950	298	350	300	948
86	15112	goat skin	1484	61		69,400	128,600		198,000	105,800	85,630	1,054	192,484
87	10774	bricket salt	2014	78		2,000	3,000		5,000		3,800	1,200	5,000
88	10392	tofu	58	25		550			550	150	150	250	550
89	10794	fish crackers	38	25		585			585	30	123	432	585
90	21022	attached	2495	3,000		215,139	78,840		293,979	11,590	181,814	100,575	293,979
91	21022	herbal medicine	382	1,500		12,000			12,000	4,540	7,390	25,920	37,850
92	21022	tensilon, healthy womb	12	80		1,700			1,700	110	230	900	1,240
93	15122	meat, goat meat	268	60		38,400	2,400		40,800	23,055	15,650	1,037	39,742
94	14111	garment (apparels)	2773	1,794		23,130			23,130			23,130	23,130
95	10314	wasabi, okra, nutmeg	5731	291		72,000			72,000	22,740	42,231	5,028	70,000
96	10219	frozen fish	2183	200		12,000			12,000	1,240	4,808	3,508	9,556
97	17021	cardboard	313	20		500			500			340	340
98	22123	Sir 20 / rubber	4721	130		7,800			7,800			2,246	74,000
99	10392	white tofu	257	29		3,600			3,600	605	950	289	1,844
100	22210	flexible container bag	1735	390		840	144		984		120	720	840
101	21012	injection and tablet ('Antimo')	713	1,300		61,800		1,200	63,000	10,483	14,345	30,345	55,173
102	10392	tofu	180	40		1,800	600		2,400	330	480	380	1,190
103	11090	powder drink	560	1,085		18,500	240		18,740	2,765	1,185	14,500	18,450
104	22291	plastic sheet (PVC)	5739	654		73,902	36,967	3,600	114,469			12,050	12,050
105	22121	rubber	431	445		16,500	5,000	500	22,000	5,040	3,360	7,600	16,000
106	10723	vinegar	187	284		4,500	3,000		7,500	900	2,100	4,500	7,500
107	13112	thread	2586	2,235					0	29,875	89,625	37,500	157,000
108	20231	cosmetics	7963	156		105,000	45,000	15,000	165,000	29,490	68,810	2,700	101,000
109	15112	leather (cow)	73	51		9,200	1,000	400	10,600	4,320	2,880	850	8,050
110	10314	frozen vegetables	60	26		480			480		240	240	480
111	10293	frozen shrimp	207	40		2,000			2,000		1,430	734	2,164
112	10710	bread	462	116		6,000	1,500		7,500	900	4,340	1,900	7,140
113	10801	cattle fooder	518	36		600	150		750	150		600	750
114	10740	dry noodle	123	47		880	440		1,320	75	120	810	1,005
115	13111	yarn	170628	2,323					398,752	145,002	210,350	43,400	398,752
116	13121	grey fabric	49	83		4,100	1,780		5,880	980	3,560	1,340	5,880
117	14111	baby's clothes	88	58		460			460			430	430
118	20231	soap	1545	55					8,230	2,300	4,530	950	7,780
119	22220	plastic bag	3884	150		2,300			2,300			2,300	2,300
120	10213	fish fillet	556	56		4,700			4,700	870	2,700	960	4,530
121	20231	cream soap and powder	220	50		720	480		1,200	50	97	860	1,007
122	10219	fish fillet	754	30		4,330			4,330	620	3,100	610	4,330
123	10219	fermented bran	108	49		1,575			1,575	125	720	730	1,575
124	13121	woven sarong ATBM	5	60		855			855	90	65	700	855
125	10761	dry tea 'Wangi'	2597	300		5,700	3,800		9,500	1,750	1,230	5,580	8,560
126	21022	herbal medicine	718	24		10,399	3,467		13,866	5,700	7,566	600	13,866
127	21022	herbal medicine	500	22		6,500	1,700		8,200	1,560	5,120	350	7,030
128	13121	woven sarong ATBM	17	89		1,500			1,500		95	1,200	1,295
129	10219	fish nugget	71	44		780			780	80	400	300	780

Source：Inventory/Ketersediaan, Kebutuhan dan Upaya Pengelolaan Sumber Daya Air di Sektor Industri, the Ministry of Industry, the Republic of Indonesia, 2015

Based on the interview surveys to related organizations such as Central and Regional Statistic Office, MOI and Chamber of Commerce (*KADIN*) in DKI Jakarta, data on production volume are not available. Thus, water consumption volume is estimated by correlation to the number of workers. The correlation coefficient by industry type is confirmed as shown in Table 3-18. For categorization of industry type, the Indonesian Industrial Code (*KBLI*) in 2014 is applied.

Table 3-18 Correlation between Number of Worker and Water Consumption

Code	Type	Workers	Water Consumption (m^3/worker/year)	Correlation Coefficient
10	Food	6,562	472,819	0.73
11	Beverage	1,494	5,896,561	-0.15
12	Tobacco	-	-	-
13	Textiles	9,540	1,123,051	0.60
14	Wearing Apparel	5,239	60,098	0.97
15	Tanning and Dressing of Leather	2,156	1,547,163	-0.10
16	Wood and Wood Products	-	-	-
17	Paper and Paper Products	588	11,748	0.92
18	Printing and Recorded Media	-	-	-
19	Oil and Coals	-	-	-
20	Chemical and Chemical Products	987	165,982	0.48
21	Pharmacy Medical Chemistry	6,053	438,491	0.91
22	Rubber and Plastic Products	7,542	758,043	0.56
23	Non-metal Mineral Products	-	-	-
24	Basic Metals	-	-	-
25	Fabricated Metal Products	-	-	-
26	Computers, Electric Equipment	-	-	-
27	Electrical Equipment	-	-	-
28	Machinery Equipment	-	-	-
29	Motor Vehicle	-	-	-
30	Other Transport Equipment	-	-	-
31	Furniture	-	-	-
32	Others	-	-	-
33	Service, Repair and Installation of Machinery and Equipment	-	-	-

Source: The Project Team

For the industry types of which correlation coefficient is less than 6.0, data was examined and the following modifications were applied.

<11: Beverage>

The original data contains a large mineral water production factory. On the other hand, there is no such mineral water production factory in DKI Jakarta. By omitting this data, correlation coefficient becomes 1.00.

<15: Tanning and Dressing of Leather>

The Code 15 is divided into the sub-type, 151: Tanning and 152: Dressing of Leather such as shoes manufacturing. Since water consumptions might be much different by these industry types, correlations are calculated. The results are 0.99 for tanning and 0.97 for dressing of leather.

Currently, number of workers by sub-type in 2015 is not obtained. However, tentative figures of 2017 statistics are available. Thus, ratio calculated by 2017 statistics is used for estimation of number of workers by sub-type in 2015.

<20: Chemical and Chemical Products>

The original data contains fireworks manufacturing. Water consumption of fireworks manufacturing is estimated to be different from other chemical products. By omitting this data, correlation

coefficient becomes 0.70.

<22: Rubber and Plastic Products>

The Code 22 is divided into the sub-type, 221: Rubber such as tire production and 222: Plastic Products such as plastic bag. The correlation coefficients of these sub-types are 0.73 for rubber and 0.96 for plastic products.

After the above mentioned modification, the unit water consumption per worker is calculated as shown in Table 3-19. According to the Handbook by the Society of Heating, Air-Conditioning, and Sanitary Engineers of Japan (ver. 11) (1985), unit water consumption volume by industrial sector varies between 60-300 liter/worker/day, which is equivalent to 22-110 m^3/worker/year. Therefore, as the minimum value, 22 m^3/worker/year is applied for the industry types of which unit water consumption is calculated less than it.

Table 3-19 Calculation of Unit Water Consumption based on MOI Study

Code	Type	Correlation Coefficient	No. Worker	Water Con. (m^3/year)	Unit Water Con (m^3/worker/year)
10	Food	0.73	6,562	472,819	73
11	Beverage	1.00	1,227	27,661	23
12	Tobacco	-	-	-	
13	Textiles	0.60	9,540	1,123,051	118
14	Wearing Apparel	0.97	5,239	60,098	12
15	Tanning and Dressing of Leather				
151	Tanning	0.99	352	1,538,684	4,372
152	Dressing of Leather	0.97	1,804	8,479	5
16	Wood and Wood Products	-	-	-	22
17	Paper and Paper Products	0.92	588	11,748	20
18	Printing and Recorded Media	-	-	-	22
19	Oil and Coals	-	-	-	110
20	Chemical and Chemical Products	0.70	781	161,922	208
21	Pharmacy Medical Chemistry	0.91	6,053	438,491	73
22	Rubber and Plastic Products				
221	Rubber	0.73	3,199	689,826	216
222	Plastic Products	0.96	4,343	68,217	16
23	Non-metal Mineral Products	-	-	-	
24	Basic Metals	-	-	-	
25	Fabricated Metal Products	-	-	-	
26	Computers, Electric Equipment	-	-	-	
27	Electrical Equipment	-	-	-	
28	Machinery Equipment	-	-	-	
29	Motor Vehicle	-	-	-	
30	Other Transport Equipment	-	-	-	
31	Furniture	-	-	-	
32	Others	-	-	-	
33	Service, Repair and Installation of Machinery and Equipment	-	-	-	

Source: The Project Team

For the industry types of which unit water consumption is not available by the MOI Study, the unit water consumption shown in Table 3-20 is applied by considering expected water consumption by industry type based on the Handbook by the Society of Heating, Air-Conditioning, and Sanitary Engineers of Japan (ver. 11) (1985).

Table 3-20 Unit Water Consumption by Industry Type

Category	Criteria	Unit Water Con (m^3/worker/year)	Applied Industrial Code
Large	Water is required as a material	300	23：Non-metal Mineral Products
Middle	Water is required during process such as cooling and washing	180	19：Oil and Coals, 29：Motor Vehicle, 30：Other Transport Equipment, 32 Others (Coal refined petroleum product is included.)
Small	Almost no water is required during process.	60	Others

Source: The Project Team

As a result, the unit water consumption shown in Table 3-21 is applied in the Study. Unit water consumption is not set for tobacco industry because no tobacco factory exists in DKI Jakarta.

Table 3-21 Unit Water Consumption for Industrial Sector

Code	Type	Correlation Coefficient	No. Worker	Water Con. (m^3/year)	Unit Water Con. (m^3/worker/year)
		①	②	③	④ = ③ / ②
10	Food	0.73	6,562	472,819	73
11	Beverage	1.00	1,227	27,661	23
12	Tobacco	-	-	-	0
13	Textiles	0.60	9,540	1,123,051	118
14	Wearing Apparel	0.97	5,239	60,098	22
15	Tanning and Dressing of Leather				
151	Tanning	0.99	352	1,538,684	4,372
152	Dressing of Leather	0.97	1,804	8,479	22
16	Wood and Wood Products	-	-	-	22
17	Paper and Paper Products	0.92	588	11,748	22
18	Printing and Recorded Media	-	-	-	22
19	Oil and Coals	-	-	-	66
20	Chemical and Chemical Products	0.70	781	161,922	208
21	Pharmacy Medical Chemistry	0.91	6,053	438,491	73
22	Rubber and Plastic Products				
221	Rubber	0.73	3,199	689,826	216
222	Plastic Products	0.96	4,343	68,217	22
23	Non-metal Mineral Products	-	-	-	110
24	Basic Metals	-	-	-	22
25	Fabricated Metal Products	-	-	-	22
26	Computers, Electric Equipment	-	-	-	22
27	Electrical Equipment	-	-	-	22
28	Machinery Equipment	-	-	-	22
29	Motor Vehicle	-	-	-	66
30	Other Transport Equipment	-	-	-	66
31	Furniture	-	-	-	22
32	Others	-	-	-	66
33	Service, Repair and Installation of Machinery and Equipment	-	-	-	22

Source: The Project Team

2) Estimation of Water Demand in DKI Jakarta

a) Domestic Water

Unit water consumption for domestic water varies between 100-250 liter/person/day depending on type of house. The Boston Consulting Group analyzed population composition by economic class in 2012 based on BPS statistic data and estimated it in 2020. In general, population composition by economic class in DKI Jakarta shows higher in middle-high classes than country average. Thus, projected composition in 2020 is applied for allocation of the total population in 2015 into classes. And the water consumption by domestic water is estimated as 17.4 m^3/s by applying the unit water consumption for each class as shown in Table 3-22.

Table 3-22 Estimated Domestic Water Consumption in 2015

	Indonesian Pop. Projection in 2020*1		Jakarta Population in 2015*2	Unit Water Cons.	Water Cons.
	(million)	(ratio)	(person)	(l/person/day)	(m^3/s)
Elite	6.9	3%	304,638	250	0.881
Rich	16.5	6%	609,275	250	1.763
High-middle	49.3	18%	1,827,825	150	3.173
Mid-middle	68.2	25%	2,538,646	150	4.407
Low-middle	50.5	19%	1,929,371	150	3.350
Vulnerability	47.9	18%	1,827,825	120	2.539
Poor	28.3	11%	1,117,004	100	1.293
Total	267.6	100%	10,154,584	-	17.406

Notes: *1): The Boston Consulting Group, 2013
*2): Estimated based on BPS data. Pulau Selibu District is excluded.
Source: The Project Team

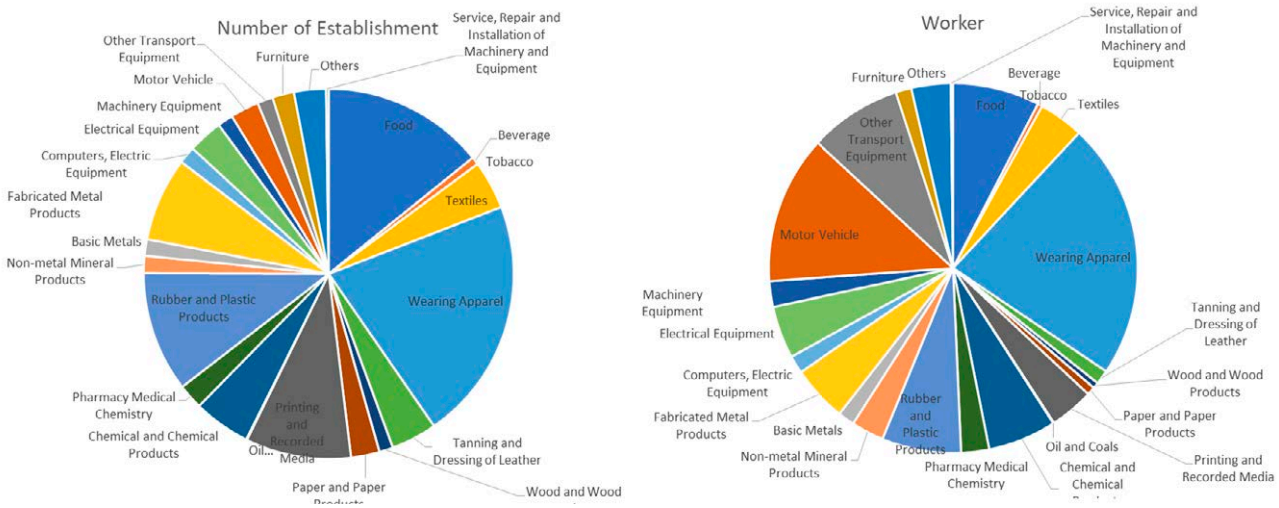
b) Industrial Water

The industrial water consumption is estimated based on the Jakarta in Figures 2017 (*Jakarta Dalam Angka 2017*). The number of establishment and workers in 2015 are shown in Table 3-23 and their compositions by industry type are shown in Figure 3-20. The numbers of worker by sub-types (151: Tanning, 152: Dressing of Leather, 221: Rubber, 222: Plastic Products) are estimated based on the ratios calculated tentative numbers in 2017.

Table 3-23 Number of Establishment and Worker in DKI Jakarta in 2015

Code	Type	No. of Establishment	No. of Worker
10	Food	188	21,143
11	Beverage	9	1,142
12	Tobacco	0	0
13	Textiles	56	10,928
14	Wearing Apparel	281	62,564
15	Tanning and Dressing of Leather	53	3,500
151	Tanning		(1,311)
152	Dressing of Leather		(2,189)
16	Wood and Wood Products	16	1,438
17	Paper and Paper Products	33	2,010
18	Printing and Recorded Media	122	10,752
19	Oil and Coals	1	185
20	Chemical and Chemical Products	66	16,643
21	Pharmacy Medical Chemistry	29	6,808
22	Rubber and Plastic Products	139	19,294
221	Rubber		(1,446)
222	Plastic Products		(17,848)
23	Non-metal Mineral Products	20	7,952
24	Basic Metals	19	4,026
25	Fabricated Metal Products	97	13,748
26	Computers, Electric Equipment	20	4,342
27	Electrical Equipment	40	12,693
28	Machinery Equipment	18	6,281
29	Motor Vehicle	33	36,143
30	Other Transport Equipment	18	22,577
31	Furniture	25	3,829
32	Others	37	9,582
33	Service, Repair and Installation of Machinery and Equipment	3	522
	Total	1,323	278,102

Source: Jakarta Dalam Angka 2017



Source: Jakarta Dalam Angka 2017

Figure 3-20 Compositions of Number of Establishments and Workers

There are 1,323 establishments and 278,102 workers in industrial sector in DKI Jakarta. Food, wearing apparel, printing and recorded media, and rubber and plastic products industries are large in number of establishments. Wearing apparel and motor vehicle industries are large in number of workers. However, the number of workers accounts for only 2.7% of population and 5.5% of working population. The reasons are assumed to be (a) this statistic does not include small establishment of which worker is 10 or less, and (b) the definition of worker in this statistic. Since the number of worker in industrial sector is 436,969 in the National Labor Force Survey in August 2015 (*Survey Angkatan Kerja Nasional August 2015*), this number is applied by allocating the ratio of each industry type in 2015. The estimated water consumption is summarized in Table 3-24.

Table 3-24 Water Consumption by Industrial Sector

Code	Type	No. of Est.	No. of Worker	No. of Working Pop.*	Unit Water Con. (m^3/worker/year)	Water Con.	
						(thousand m^3/year)	(m^3/sec)
10	Food	188	21,143	50,261	73	3,669	0.116
11	Beverage	9	1,142	2,715	23	62	0.002
12	Tobacco	0	0	0	0	0	0.000
13	Textiles	56	10,928	25,977	118	3,065	0.097
14	Wearing Apparel	281	62,564	148,724	22	3,272	0.104
15	Tanning and Dressing of Leather	53	3,500			0	0.000
151	Tanning		1,311	3,115	4,372	13,619	0.432
152	Dressing of Leather		2,189	5,205	22	115	0.004
16	Wood and Wood Products	16	1,438	3,418	22	75	0.002
17	Paper and Paper Products	33	2,010	4,778	22	105	0.003
18	Printing and Recorded Media	122	10,752	25,559	22	562	0.018
19	Oil and Coals	1	185	440	66	29	0.001
20	Chemical and Chemical Products	66	16,643	39,563	208	8,229	0.261
21	Pharmacy Medical Chemistry	29	6,808	16,184	73	1,181	0.037
22	Rubber and Plastic Products	139	19,294			0	0.000
221	Rubber		1,446	3,438	216	743	0.024
222	Plastic Products		17,848	42,427	22	933	0.030
23	Non-metal Mineral Products	20	7,952	18,903	110	2,079	0.066
24	Basic Metals	19	4,026	9,570	22	211	0.007
25	Fabricated Metal Products	97	13,748	32,681	22	719	0.023
26	Computers, Electric Equipment	20	4,342	10,322	22	227	0.007
27	Electrical Equipment	40	12,693	30,173	22	664	0.021
28	Machinery Equipment	18	6,281	14,931	22	328	0.010
29	Motor Vehicle	33	36,143	85,917	66	5,671	0.180
30	Other Transport Equipment	18	22,577	53,669	66	3,542	0.112
31	Furniture	25	3,829	9,102	22	200	0.006
32	Others	37	9,582	22,778	66	1,503	0.048
33	Service, Repair and Installation of Machinery and Equipment	3	522	1,241	22	27	0.001
	Total	1,323	278,102	661,088		50,832	1.612

Note: * Estimated by "Survey Angkatan Kerja Nasional August 2015"
Source: The Project Team

As shown in Table 3-24, the water consumption by industrial sector in DKI Jakarta in 2015 is estimated at 50.8 million m^3/year or 1.61 m^3/s. However, several assumptions are applied for setting of unit water consumption and number of workers which contains uncertainty. Improvement of accuracy in estimation is required by further examination of available data and interview survey to large users.

c) Commercial and Building Water

Commercial and building water including major social and public infrastructure is estimated at 4.4 m^3/s in total as follows.

Buildings:	1.27 m^3/s	
Schools:	2.09 m^3/s	
Hospitals:	0.17 m^3/s	
Mosques:	0.23 m^3/s	
Hotels:	0.17 m^3/s	
Restaurants:	0.04 m^3/s	
Shopping malls:	0.42 m^3/s	Total 4.4 m^3/s

Building Water

Building water is estimated at 1.27 m^3/s using the number of business workers and civil servants based on the National Labor Force Survey and the Provincial Statistical Year Book 2016 as shown in Table 3-25.

Table 3-25 Water Consumption by Building

Job Type	No. of Employee	Unit Water Con. (l/person/day)	Water Con.	
			(thousand m^3/year)	(m^3/s)
Transportation, Warehousing and Communication	424,498			
Financial, Insurance, Real Estate and Business Service	520,543			
Community, Social and Personal Service	1,159,508			
Local Civil Servant	72,743			
National Civil Servant	22,624			
Total	2,199,916	50	40,148	1.273

Source: The Project Team

School

Water consumption by schools is estimated at 2.09 m^3/s using the number of pupils/students from kindergarten to university based on the Provincial Statistical Year Book 2017 as shown in Table 3-26.

Table 3-26 Water Consumption by Schools

Category	No. of Student	Unit Water Con. (l/person/day)	Water Con.	
			(thousand m^3/year)	(m^3/s)
Kindergarten and Primary School	903,070	40	13,185	0.418
Junior High School	358,795	50	6,548	0.208
High School	150,835	80	4,404	0.140
University/Collage（2014）	1,427,407	80	41,680	1.322
Total	2,840,107		65,817	2.087

Source: The Project Team

Hospital

Based on the Provincial Statistical Year Book 2017, the number of hospitals and beds are as shown in Table 3-27.

Table 3-27 Number of Hospital and Bed

Operating Body	No. of Hospital	No. of Bed
Private	126	13,546
Public	19	7,033
Military	11	2,297
Total	145	22,876

Source: Jakarta Dalam Angka 2017

Since data on medical level is not available, the water consumption by a hospital is estimated at 0.17 m^3/s as shown in Table 3-28, assuming that the 20% of private hospitals are categorized to high class hospital and military hospitals are categorized to public hospital.

Table 3-28 Water Consumption by Hospital

Category	No. of Bed	Unit Water Con. (l/bed/day)	Water Con.	
			(thousand m^3/year)	(m^3/s)
High-class Hospital	2,709	1,000	989	0.031
Middle-class Hospital	10,837	750	2,967	0.094
Public Hospital	9,330	425	1,447	0.046
Total	22,876		5,403	0.171

Source: The Project Team

Mosque

According to the Provincial Statistical Year Book 2016, 8,627 mosques exist in DKI Jakarta. Unit water consumption per unit of mosque is estimated at 837 m^3/year based on the number of customer and water consumption shown in Table 3-29, water consumption by mosque is estimated at 0.23 m^3/s as shown in Table 3-29.

Table 3-29 Water Consumption by Mosque

City	Mosque	Private Mosque	Unit Water Con. (m^3/unit/year)	Water Con.	
				(thousand m^3/year)	(m^3/s)
South Jakarta	748	1,285			
East Jakarta	921	1,657			
Central Jakarta	427	452			
West Jakarta	506	1,287			
North Jakarta	434	910			
Sub-total	3,036	5,591			
Total	8,627		837	7.22	0.229

Source: The Project Team

Hotel

Based on the Hotel Statistics and Hotel Occupancy Rate 2015 (*Statistik Hotel dan Tingkat Penghunian Kamar Hotel Jakarta 2015*), the number of hotels and beds by class is as shown in Table 3-30.

Table 3-30 Number of Hotel and Bed

Category	No. of Hotel	No. of Bed
With Stars	224	53,656
Without Stars	181	9,880
Others	12	1,101
Total	417	64,637

Source: Statistik Hotel dan Tingkat Penghunian Kamar Hotel Jakarta 2015

Although the category is different from that of unit water consumption by the governor decree, water consumption by hotel is estimated at 0.17 m^3/s as shown in Table 3-31, assuming that all the star hotels are categorized as "3-Stars and more" and the non-star hotels and others are "2-Stars and less".

Table 3-31 Water Consumption by Hotel

Category	No. of Hotel	No. of Bed	Unit Water Con. (l/bed/day)	Water Con.	
				(thousand m^3/year)	(m^3/s)
3-stars & more	224	53,656	250	4,896	0.155
2 stars & less	193	10,575	150	579	0.018
Total	417	64,231		5,475	0.174

Source: The Project Team

Restaurant

According to the Restaurant and Buffet Statistics 2011 (*Statistik Restoran/ Rumah Makan 2011*), there are 1,361 restaurants and buffets in DKI Jakarta and the number of customers are 177/day. Thus, the water consumption is estimated at 0.04 m^3/s as shown in Table 3-32.

Table 3-32 Water Consumption by Restaurant

No. of Restaurant	No. of Customer (No. of Seat)	Unit Water Con. (l/seat/day)	Water Con.	
			(thousand m^3/year)	(m^3/s)
1,361	177	15	1,319	0.042

Source: The Project Team

Shopping Mall

According to the website of DKI Jakarta named "Jakarta Open Data" (http://data.jakarta.go.id/), there are 83 shopping malls in the Province. The floor area of each mall, which is disclosed in the internet is averaged at 87,057 m^2 and water consumption is estimated at 0.42 m^3/s as shown in Table 3-33.

Table 3-33 Water Consumption by Shopping Mall

Name of Shopping Mall	Floor Area (m^2)	No. of Shopping Mall	Unit Water Con. (l/m^2/day)	Water Con.	
				(thousand m^3/year)	(m^3/s)
Grand Indonesia	250,000				
Plaza Indonesia	38,050				
Senayan City	76,000				
Emporium Pluit Mall	61,243				
Mall Of Indonesia	50,000				
Mall Kelapa Gading	150,000				
La Piazza	20,000				
MPI	55,000				
Pejaten Village	56,000				
Lippo	130,000				
Kasabranka	60,000				
Gandaria	98,388				
Average	87,057	83	5	13,187	0.418

Source: The Project Team

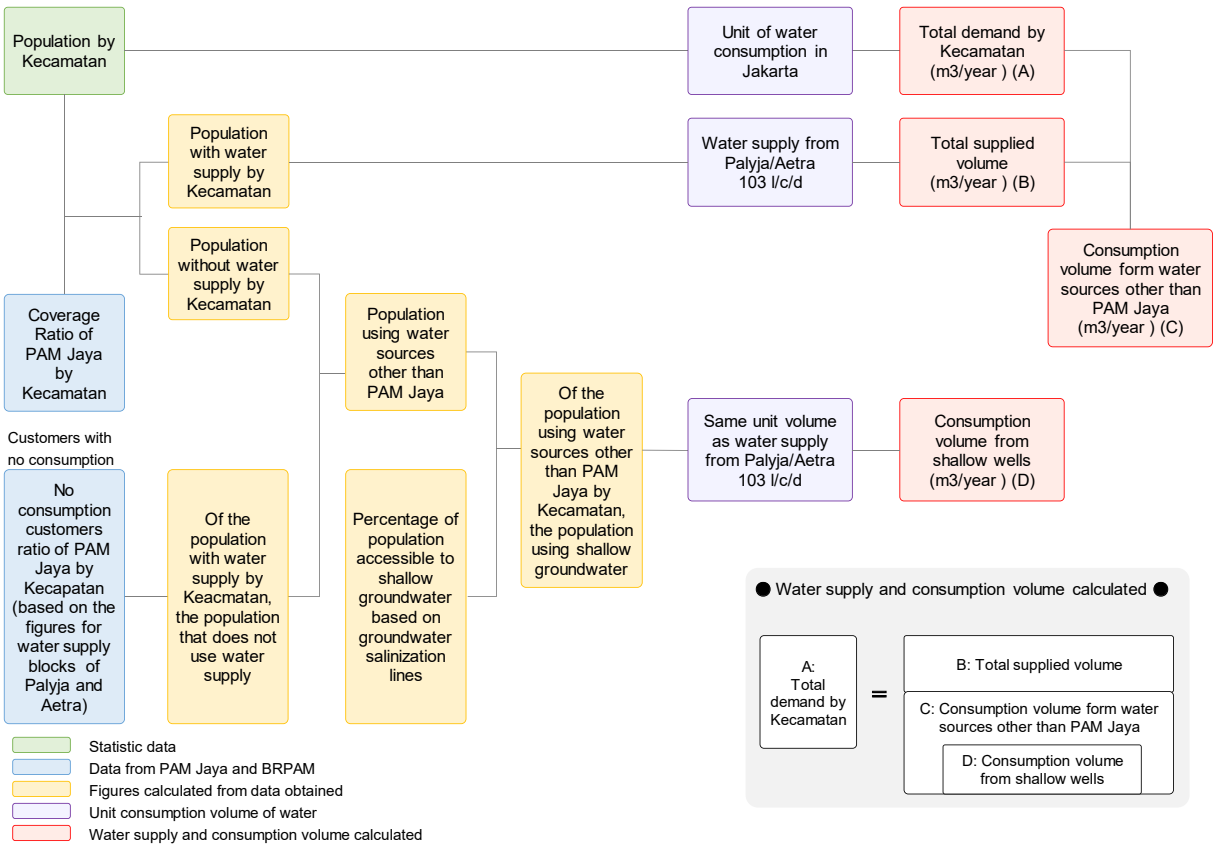
3.2.4 Estimation of Groundwater Abstraction from Shallow Wells by Households

Water balance (demand by type of use and supply by water source) in DKI Jakarta as of 2015 was estimated in the Project. Furthermore, groundwater use for domestic use from shallow wells (0 to 40 m) which is the main source of water other than piped water was estimated (as of 2018).

(1) Estimation Method

The following conditions were set for the estimation, and calculations were made according to the flow shown in Figure 3 14.

- Applying the unit water demand volume at 150 l/capita/day to the estimation
- Calculating the rate of access to groundwater based on coverage rate of water supply and groundwater salinization data by Kecamatan (assuming that all households in non-saline areas have access to shallow groundwater)
- Considering the existence of households that are connected to piped water but do not consume it (using data of Jakarta PAM Regulatory Body (BRPAM))
- Applying unit consumption volume 103 l/capita/day to the estimation based on the figure from statistics
- Applying the same unit consumption volume (103 l/capita/day) to that of groundwater use from shallow wells

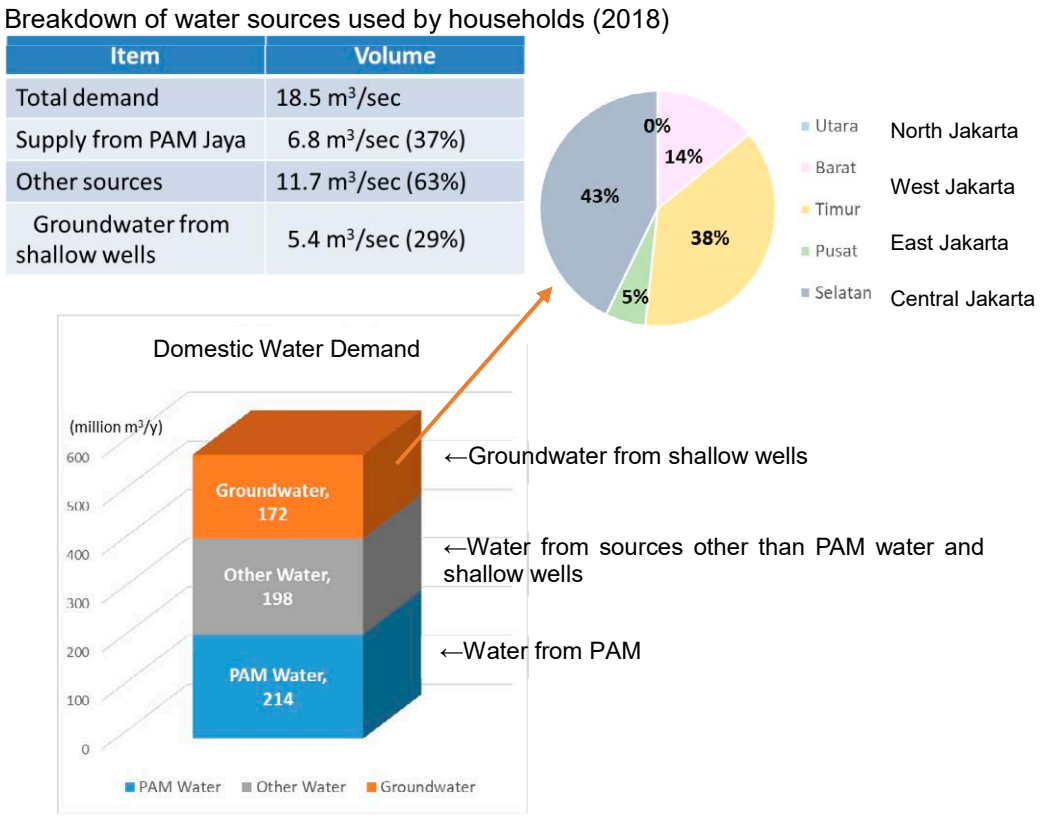


Source: The Project Team

Figure 3-21 Flow to Estimate the Groundwater Abstraction from Shallow Wells by Households

(2) Result of Estimation

The estimation result shows that 37% of the domestic water demand was supplied by drinking water, while the remaining 63% was from other water sources. Among all demand 29% was the use of groundwater from shallow wells (see Figure 3-22). In particular, the use of shallow groundwater in East Jakarta and South Jakarta is remarkable. These two cities have lower water supply rates than other cities, and many consumers do not use the piped water even though they are connected to the water supply systems.



Source: The Project Team

Figure 3-22 Estimation Result of Groundwater Abstraction from Shallow Wells by Households

3.3 Surface Water Development – Current Situation and Issues

The urbanization of DKI Jakarta is already at its limit and the urban area is expanding to the surrounding area of JABODETABEK (Jakarta-Bogor-Demak-Tangerang-Bekasi). The factories in the DKI Jakarta are starting to be relocated outside of the DKI Jakarta, under the influence of the current regulation on restriction of groundwater extraction. However, in the newly developed area in JABODETABEK, development of water sources to meet the increase in water demand and maintenance of existing water supply facilities do not follow the increase in water demand, and the shortage of water source depends on groundwater. For example, in Bekasi City, 56% of the water source is dependent on groundwater, and land subsidence is progressing. In addition to these facts, the raw water supply plan by PUPR is also formulated for the entire JABODETABEK, so that in this chapter, surface water development for the entire JABODETABEK was discussed.

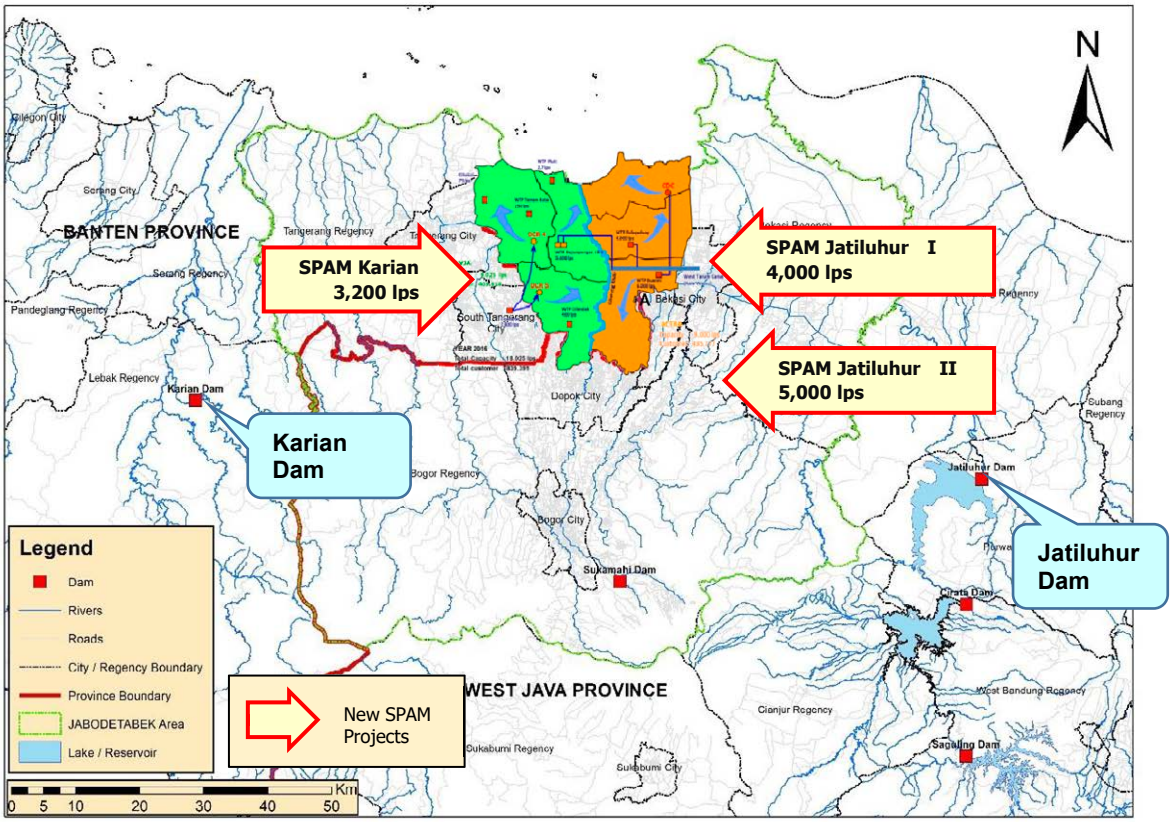


Figure 3.23 Existing Water Supply System & New Surface Water Development Plan at DKI Jakarta

3.3.1 Current Situation and Future Forecast of Water Balance in DKI Jakarta

(1) Water Resources and Water Use in JABODETABEK

The amount of available water resources in JABODETABEK (6 River Basins: Ciujung River, Cidurian River, Cidanau River, Cidanau River, Ciliwung River, Cisadane River, Citarum River) and their water use are shown in the table below.

Table 3-34 Available Water Resources in JABODETABEK

Catchment Area	5,569 km^2
Maximum Annual Rainfall	3,500 mm/year
Minimum Annual Rainfall	1,500 mm/year
Average Annual Rainfall	2,500 mm/year
Average Annual Discharge	13,922,650,000 m^3/year

Source: Data Sheets of Rencana BBWS CiliCis

Table 3-35 Water Use depend on Purpose in JABODETABEK

Description	m^3/sec	m^3/year	Utilization ratio (%)
Municipal Water	14.46	456,105,168	31.7
Irrigation	31.10	980,690,760	68.3
Total	45.56	1,436,795,928	100.00

Source: Data Sheets of Rencana BBWS CiliCis

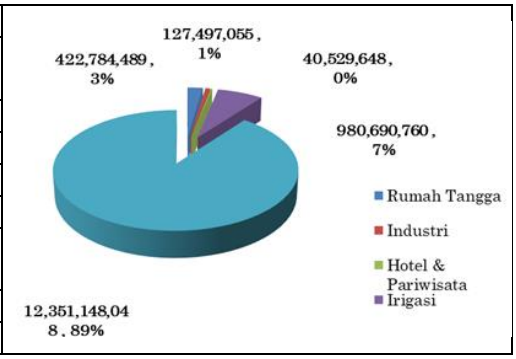
Table 3-36 Use of Water Resources

Purpose	Amount Used Water (m3/year)	Ratio (%)
Municipal Water	326,388,858	23%
Industry	98,427,495	7%
Hotel-Tourism	31,288,815	2%
Irrigation	980,690,760	68%
Total	1,436,795,928	100%

Source: Data Sheets of Rencana BBWS CiliCis

Table 3-37 Water Use Ratio in Ciliwung Cisadane River Basin

Water Use of SDA WS Ciliwung Cisadane		
Purpose	Amount of Annual Use (m3/year)	Ratio (%)
Municipal Water	326,388,858	2.34
Industry	98,427,495	0.71
Hotel-Tourism	31,288,815	0.22
Irrigation	980,690,760	7.04
Annual River Discharge	13,922,650,000	100.00
Used Water	1,436,795,928	10.32
Nonuse Water	12,485,854,072	89.68



Source: Data Sheets of Rencana BBWS CiliCis

Water sources by region are as shown in Figure 3.24 and Table 3-38, and they show that the proportion of water from Tarm Barat Canal (Citarum River) is large. About 45% of JABODETABEK's raw water and 80% of DKI Jakarta's rely on the Citarum River. On the other hand, the dependency rate of Deep Well (groundwater) is about 30%. Especially in Bekasi district where new factory complexes are scattered, about 60% of the raw water is dependent on groundwater.

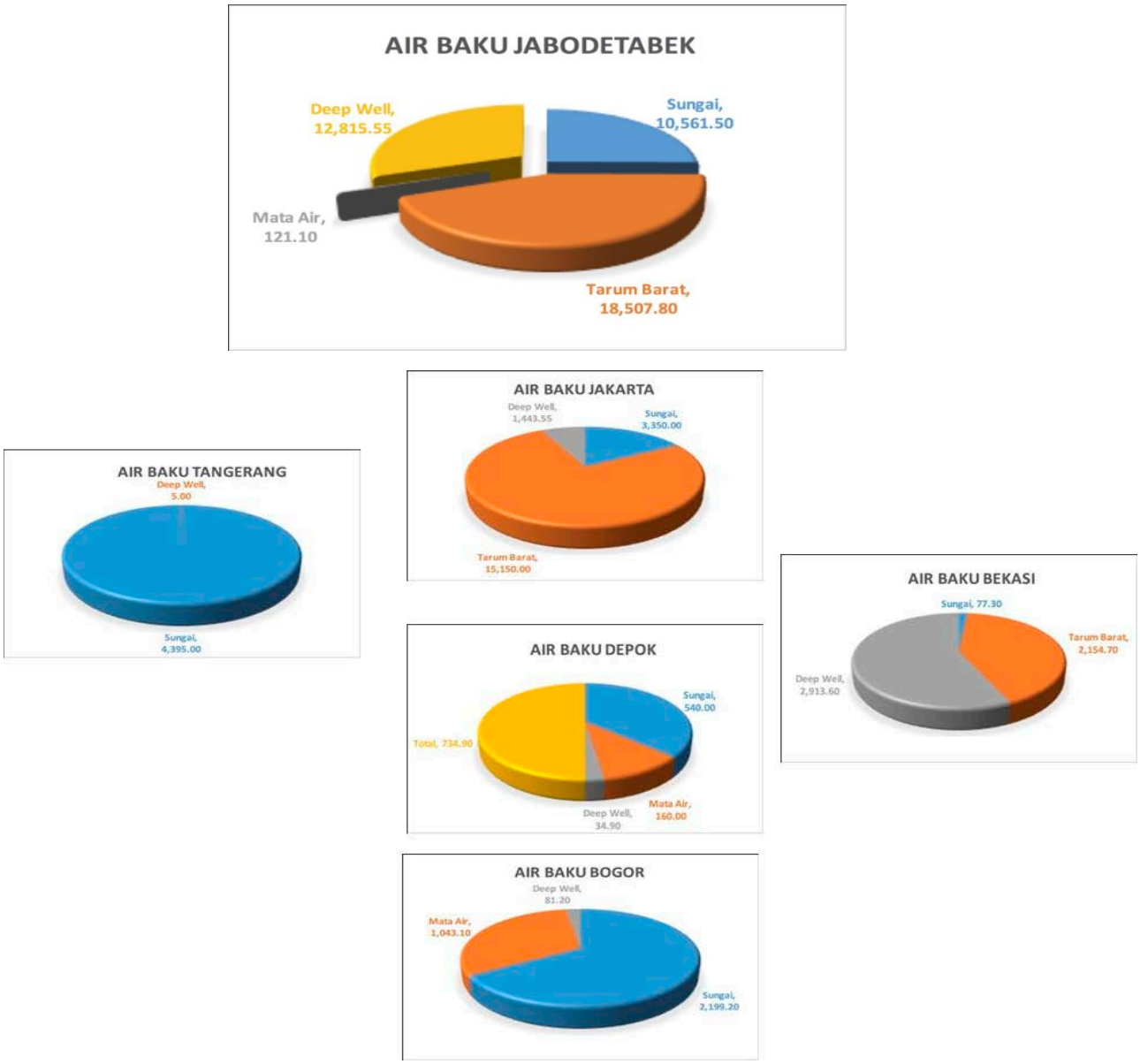


Figure 3.24 Water Source in JABODETABEK

Source : RENCANA AIR MINUM (Version 1), BBWS CiliCis

Table 3-38 Water Sources in JABODETABEK

No	Kab/Kota	Satuan	Prod PDAM (sumber dari PDAM)							Sumber Data	Prod PDAM (Kab/Kota Dlm Angka)	
	Nama PDAM		IPA dan Sumber2 Air Baku						Jumlah Prod		m3/th	Pelanggan
1	Kota Tangerang	m3/th	IPA Mitra	IPA Benda	IPA Ciledug					Perpamsi	44,939,403	
	Tirta Benteng		S.Cisadane	S.Cisadane	Air Tanah					Banten 2015		
		m3/dt	0.01	0.37	0.005				0.385		1.43	107,195
2	Kab. Tangerang	m3/th	IPA Serpong	IPA Cikokol (Bd.10)	IPA Perumnas	IPA Lainnya				PDAM Tangerang	133,150,508	
	Tirta Kerta Raharja		S.Cisadane	S.Cisadane	S.Cisadane	S.Cisadane	Cidurian					
		m3/dt	3.00	1.58	0.13	0.15			1.85		4.22	
			Catatan: PDAM Tangerang mensuplai air bersih=			3.00	m3/dt ke Palyja				0.00	132,057
3	Kota Tangerang Sel.	m3/th	Catatan: Pelayanan air bersih dari PDAM Kab.Tangerang				S.Cisadane				11,205,947	
		m3/dt					0.36		0.36		0.36	11,117
								Jumlah Prod PDAM Seluruh Tangerang	5.24		1.78	
4	Jakarta Barat	m3/th	IPA Taman Kota	IPA Pjompongn 1	IPA Pjompongn 2	IPA Cilandak	IPA BKB	PDAM Tangerang			74,350,552	
	Palyja		Cengkarng Drain	Sal.Tarum Barat	Sal.Tarum Barat	S.Krukut	Sal.BKB					
		m3/dt									2.36	252,676
5	Jakarta Pusat	m3/th									55,732,165	
	PAM Jaya											
		m3/dt									1.77	2,058
6	Jakarta Selatan	m3/th									45,781,298	
	Palyja											
		m3/dt	0.15	3.00	3.10	0.40	0.50	3.00	10.15		1.45	669,683
								Jumlah Prod PALYJA	10.15		5.58	
7	Jakarta Timur	m3/th	IPA Buaran	IPA Pulogadung							89,858,739	
	Aetra		Sal.Tarum Barat	Sal.Tarum Barat								
		m3/dt									2.85	426,088
8	Jakarta Utara	m3/th									5,692,456	137,388
	Aetra											
		m3/dt	6.00	4.00					10.00		0.18	
								Jumlah Prod AETRA	10.00		3.03	
9	Kab. Bekasi	m3/th	IPA Sungai	IPA Sungai							23,518,724	
	Tirta Bhagasasi		S.Bekasi	Sal.Tarum Barat								
		m3/dt	1.02	1.24					2.26		0.75	84,322
10	Kab. Bogor	m3/th	IPA Ciburial Cs	IPA Sumur Bor	IPA Sungai	IPA Sungai	IPA Sungai	IPA Sungai			61,425,282	
	Tirta Kahuripan		Mata Air	Air Tanah	Cisadane	Ciliwung	S. Bekasi	S.Cipamingkis				
		m3/dt	0.721	0.129	0.50	0.49	0.25	0.14	2.23		1.95	119,950
11	Kota. Depok	m3/th	IPA Sungai								1,172,883	
	Tirta Asasta		S.Ciliwung									
		m3/dt	1.10						1.10		0.04	52,255
12	Kota Bekasi	m3/th	IPA S.Bekasi	SPAM Jatuluhur I							18,438,570	
	Tirta Patriot		S.Bekasi	Sal.Tarum Barat								
		m3/dt	0.45	0.35					0.80		0.58	
13	Kota Bogor	m3/th	IPA Mata Air	IPA Sungai							37,278,542	
	Tirta Pakuan		Mata Air	Ciliwung								
		m3/dt	0.355	2.797					3.15		1.18	139,412
									32.287		12.94	

Source : RENCANA AIR MINUM Calculation Sheet, BBWS CiliCis

(2) Water Demand Projection of Jakarta and JABODETABEK

Figure 3.25 shows the water sources in Jakarta as of 2017. As shown in the figure, the water demand in the service coverage area (pipe water distribution) which is 60% of total area of DKI Jakarta, is 26.94m^3/sec, while the suppliable amount is estimated at 29.9m^3/sec applying the non-revenue water rate (NRW) of 38.5%. However, the actual supplied water was 19.9 m^3/sec in 2017.

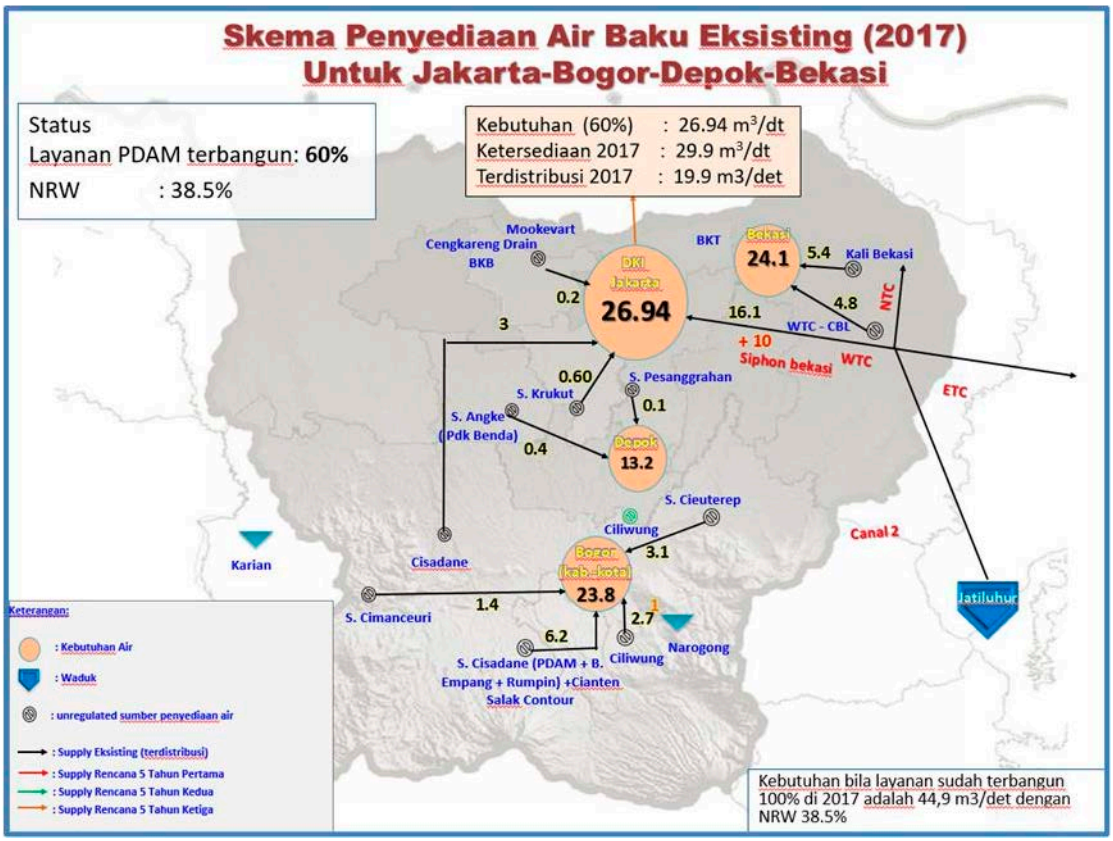


Figure 3.25 Water Balance of DKI Jakarta in 2017

Source : NCICD Road Map Water Supply, 7 May 2018

As shown in Fig. 3-4 and Table 3-6, Palyja in charge of the west and Aetra in charge of the east each have a water supply capacity (water treatment plant capacities) of about 9 m^3/sec, so the total water supply capacity is about 18 m^3/sec. Therefore, at present, the supply amount of raw water (29.9m^3/sec) exceeds the treatment capacity (18.26 m^3/sec).

Table 3-39 Present Condition of Water Supply in DKI Jakarta

OPERATOR									
PT. PALYJA					PT. AETRA				
No	IPA	Sumber Air	Kapasitas produksi tersedia*) (liter/det)	Kapasitas Produksi tahun 2007**) (m^3)	No	IPA	Sumber Air	Kapasitas produksi tersedia*) (liter/det)	Kapasitas Produksi tahun 2007**) (m^3)
1.	Pejompongan I	Saluran Tarum Barat,BKB	2.000	57.004.060	1.	Buaran I dan II	Saluran Tarum Barat	2.500 dan 2.500	143.312.580
2.	Pejompongan I	Saluran Tarum Barat, BKB	3.600	96.881.970	2.	Pulogadung	Saluran Tarum Barat	4.000	117.895.810
3.	Cilandak	S. Krukut	400	9.849.416	**Pembelian air curah**				
4.	Taman Kota	S.Pasanggraha	200	273.422	3.	Ciburial	MA Ciburial	185	78.202
5.	DW Rawa		N/A	13.596					
Pembelian air curah									
6.	Cisadane (DCR-	S. Cisadane	1.200	55.892.063					
7.	Cisadane (DCR-	S. Cisadane	1.600	25.726.597					
8.	Cikokol/Cengkare	S. Cisadane	75	2.413.972					
Jumlah			9075	**248,055,096**	Jumlah			9185	**261,286,592**
Total Kapasitas Produksi Tersedia : 18.260 l/det atau 575.847.360 m^3									
Total Kapasitas Produksi tahun 2007 : 509.341.688 m^3									

Source : NCICD Road Map Water Supply, 7 May 2018

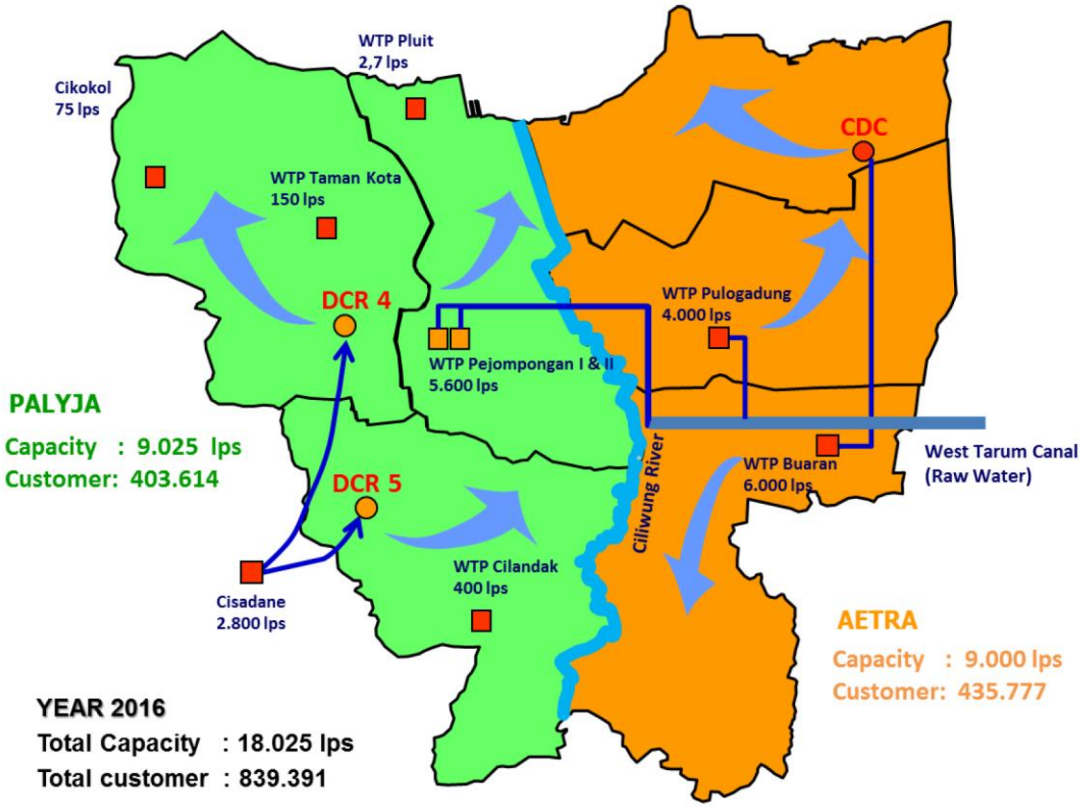


Figure 3.26 Service Area, WTP and Capacities of Plyja & Aetra

Source : NCICD Road Map Water Supply, 7 May 2018

(3) Projection of Water Demand in JABODETABEK

The current and future water demand in Jakarta is officially estimated applying the figures published by the Governor of DKI Jakarta, shown below. The estimation of water demand is conducted by BBWS CiliCis.

Projection of Population Growth

The population growth rate of JABODETABEK for 20 years up to 2035 is estimated at 151% , while that of DKI Jakarta is 116%. This fact indicates that the urban area has rapidly been extending to the suburbs.

Table 3-40 Population Projection of JABODETABEK

No.	Kabupaten/Kota	2015	2020	2025	2030	2035	2015-2035
	Tangerang						
1	Kabupaten Tangerang	3,171,018	3,490,775	3,760,556	4,011,431	4,230,685	133%
2	Kota Tangerang	2,012,223	2,215,130	2,386,324	2,545,521	2,684,652	133%
3	Kota Tangerang Selatan	1,543,209	1,829,309	2,168,450	2,570,466	3,047,012	197%
	Sub-Total	**6,726,450**	**7,535,214**	**8,315,330**	**9,127,418**	**9,962,349**	**148%**
	DKI Jakarta						
4	Jakarta Selatan	2,161,477	2,259,950	2,351,222	2,434,071	2,507,352	116%
5	Jakarta Timur	2,812,229	2,928,710	3,034,920	3,129,398	3,210,815	114%
6	Jakarta Pusat	909,268	919,773	930,399	941,148	952,021	105%
7	Jakarta Barat	2,438,058	2,595,575	2,749,652	2,898,506	3,040,331	125%
8	Jakarta Utara	1,731,809	1,811,156	1,877,303	1,924,708	1,949,859	113%
	Sub-Total	**10,052,841**	**10,515,164**	**10,943,496**	**11,327,831**	**11,660,378**	**116%**
	Jawa Barat						
9	Bogor	5,572,376	6,444,247	7,380,424	8,370,659	9,401,537	169%
10	Bekasi	3,123,337	3,655,208	4,215,833	4,791,974	5,367,678	172%
11	Kota Bogor	1,069,981	1,192,973	1,317,138	1,440,026	1,558,974	146%
12	Kota Bekasi	2,770,416	3,255,563	3,788,770	4,366,696	4,984,049	180%
13	Kota Depok	2,147,979	2,628,457	3,185,639	3,823,923	4,546,010	212%
	Sub-Total	**14,684,089**	**17,176,448**	**19,887,804**	**22,793,278**	**25,858,248**	**176%**
	Total	**31,463,380**	**35,226,826**	**39,146,630**	**43,248,527**	**47,480,975**	**151%**

Source : RENCANA AIR MINUM (Version 1), BBWS CiliCis

Projection of Water Demand

Water demand is calculated based on the conditions shown in Table 3-41, Indonesian standard (SNI 19-6728.1-2002: PENYUSUNAN NERACA SUMBER DAYA AIR SPASIAL (SNI: Indonesia National Standard)).

Table 3-41 Water demand calculation standard values in Indonesia

No.	Description	Standard	Applied	Unit
A	DOMESTIC--> House connection			
	1 City with population > 1 Million	250		lt/person/day
	2 City with population = 1Million	150		lt/person/day
	3 Village	100		lt/person/day
	4 Public hydrant	30		lt/person/day
B	NON-DOMESTIC			
	1 Fire hydrant	5		% Domestic demand
	2 Leakage	20		% Domestic demand
	3 School	10		lt/student/day
	4 Office	10		1t/staff/day
	5 Praying facility	2		??
C	INDUSTRY	0,4-1	0.7	lt/ha/sec
D	COMMERCIAL			
	1 Airport	10.00-20.00	10	1t/passenger/day
	2 Bus station	3		lt/passenger/day
	Seaport	10		lt/passenger/day
E	HEALTH FACILITY			
	Hospital	300		lt/l/day
F	TOURISM			
	Hotel	90		lt/l/day
G	FARMER	1		lt/l/day
H	FISHERIES POND	3.91 - 5.91	4.91	lt/l/day
I	LIVESTOCK			
	Horse	37.85		1t/life/day
	Cow	40		1t/life/day
	Buffalo	40		1t/life/day

Note : Especially for DKI Jakarta, Domestic water requirements are calculated = 195 ltr/person/day or 0.00000226 m^3/sec/person

Source: SNI 19-6728.1-2002: PENYUSUNAN NERACA SUMBER DAYA AIR SPASIAL

The water demand for 2015-2035 is projected as shown in Table 3-42 applying the SNI standard value.

Table 3-42 Water Demand Projection to 2035[1]

(Unit: m^3/sec)

No	Region/ City	2015	2020	2025	2030	2035
1	Tangerang Region	8.81	9.70	10.45	11.14	11.75
2	Tangerang City	5.59	6.15	6.63	7.07	7.46
3	South Tangerang City	4.29	5.08	6.02	7.14	8.46
		18.68	20.93	23.10	25.35	27.67
4	South Jakarta	7.81	8.16	8.49	8.79	9.05
5	East Jakarta	10.16	10.58	10.96	11.30	11.59
6	Central Jakarta	3.28	3.32	3.36	3.40	3.44
7	West Jakarta	8.80	9.37	9.93	10.47	10.98
8	North Jakarta	6.25	6.54	6.78	6.95	7.04
	Domestic water demand DKI Jakarta	36.30	37.97	39.52	40.91	**42.11**
9	Bogor Region	15.48	17.90	20.50	23.25	26.12
10	Bekasi Region	8.68	10.15	11.71	13.31	14.91
11	Bogor City	2.97	3.31	3.66	4.00	4.33
12	Bekasi City	7.70	9.04	10.52	12.13	13.84
13	Depok City	5.97	7.30	8.85	10.62	12.63
		40.79	47.71	55.24	63.31	71.83
		95.78	106.61	117.86	129.57	141.61

Source : RENCANA AIR MINUM (Version 1), BBWS CiliCis

Based on this projected demand, DKI-Jakarta has formulated a water supply plan of 2033, under the condition of service coverage area 100% and NRW rate 30%, as shown in Figure 3.27 DKI Jakarta Water Supply Plan by 2033.

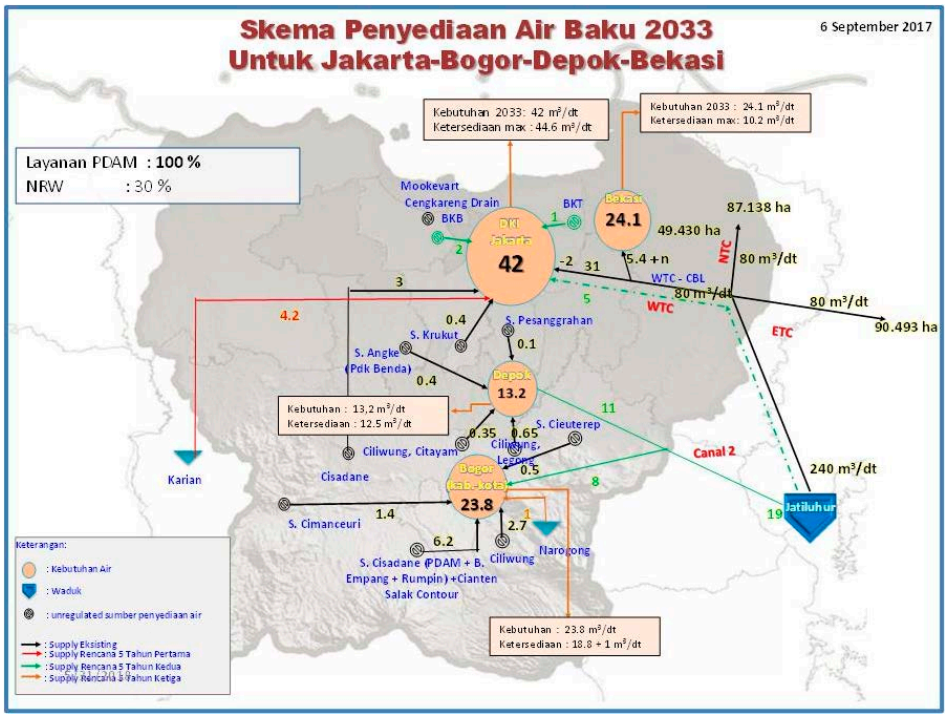


Figure 3.27 DKI Jakarta Water Supply Plan by 2033

[1] The demand calculated by PamJaya (Table 3-4) does not include commercial water or industrial water, so it differs from the value calculated by BBWS CiliCis.

Source : NCICD Road Map Water Supply, 7 May 2018

3.3.2 Plans and Issues of Surface Water Development

Water development plan of DKI Jakarta is summarized in Table 3-43 and the water supply plan of JABODETABEK is shown in Figure 3.28.

In the surface water development plan up to 2035, the most of the raw water will rely on the Citarum and Ciujung rivers, which are more than 60 km east to west respectively. The raw water dependence on both rivers is 80% as of 2015 and it will increase to 87% as planned for 2035.

In addition, more than 90% of newly developing raw water rely on the Citarum and Ciujung rivers. Three proposed SPAM[2] projects will supply a 90% of new raw water; namely SPAM Jatiluhur I ($4m^3$/sec among total supply of $5m^3$/sec will be supplied to DKI Jakarta), SPAM Jatiluhur II[3] ($5m^3$/sec), and SPAM Karian (among the total supply of $10m^3$/sec, only $3.2m^3$/sec will be supplied to DKI Jakarta).

Table 3-43 DKI Jakarta Surface Water Development Plan

(Unit: m^3/sec)

		2015	2020	2025	2030	2035	New Development
Demand		36.30	37.97	39.52	40.91	42.11	5.81
West Tarm	Citarum R.	16.10	21.10	26.10	26.10	26.10	10.00
Serpon	Cisadane R.	3.00	3.00	3.00	3.00	3.00	-
Cenkareng	Cenkareng D.	0.15	0.30	0.45	0.60	0.60	0.45
Kurkut	Kurkut D.	0.40	0.55	0.70	0.85	1.00	0.60
BKB	West Floodway	0.50	0.65	0.80	0.80	0.80	0.30
BKT	East Floodway		0.25	0.50	0.75	1.00	1.00
Mookevart	Mookevart D.		0.15	0.30	0.45	0.60	0.60
Karian	Ciujung R.			3.20	6.40	10.60	10.60
Pipa Curug	Citarum R.				5.00	9.00	9.00
Total		20.15	26.00	35.05	43.95	52.70	32.55
Balance		-16.15	-11.97	-4.47	3.04	10.59	26.74
Sources	Citarum/Ciujung	16.10	21.10	29.30	37.50	45.70	29.60
	Others	4.05	4.90	5.75	6.45	7.00	2.95
Dependence Rate to Citarum/Ciujung		80%	81%	84%	85%	87%	**91%**

[2] SPAM : Sistem Penyediaan Air Minum (Drinking Water Supply System)

[3] Currently, the official document states Regional SPAM Jatiluhur II/Djuanda (Section 3.3.7 MOU) or SPAM Ir. H. Djuanda. Here, it is decided to call it uniformly in Jatiluhur II.

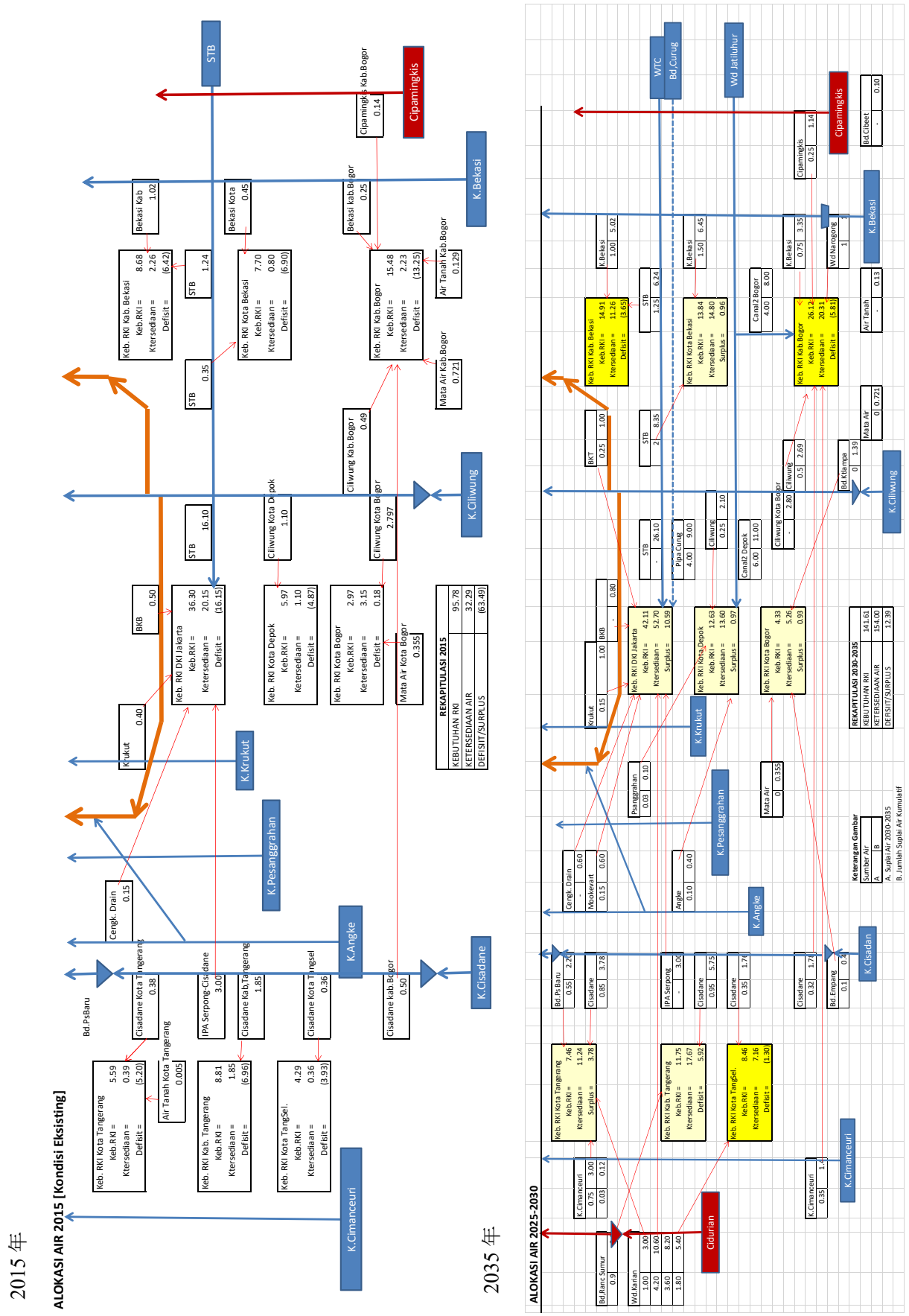


Figure 3.28 Water Supply Plan for JABODETABEK

While the current service coverage area of drinking water supply in DKI Jakarta is about 60% (Figure 3-3), it is expected that the service coverage area will be expanded to 100% by 2030 (Figure 3 5). The development works of expansion area of 40% will be allocated to be responsibly constructed by each related organization as table below (see 3.3.8 MOU on Regional SPAM among MoHA, PUPR and DKI-Jakarta).

- PUPR (Central Government) will supply an additional 30% of raw water by means of three Regional SPAMs (Jatrhur I & II (Djuanda), Karian-Serpong).
- The remaining 10% will be covered by DKI Jakarta projects such as WTP Buaran III, Cilandak, Hutan Kota and Pesanggarahan.

Table 3-44 Plan of 3 Regional SPAM Projects

	Jatiluhur-I	Karian Serpong	Jatiluhur-II / Djuanda
Construction (target)	Q1 : 2022 –2024	Q2 : 2022 –2024	Q3 : 2023 – 2025/2027
Increasing water supply in DKI	13%	10%	7%
	4,000 lps	3,200 lps	2,000 lps

The house connection of pipe will be made by DKI Jakarta/PAM Jaya.

3.3.3 Large-Scale Surface Water Development Projects

Three large-scale surface water development projects, which supply a 90% of new raw water resources for DKI Jakarta, are ongoing, namely SPAM Jatiluhur I (among 5 m^3/sec, 1 m^3/sec will be diverted to Bekasi and remaining 4m^3/sec will be delivered to DKI Jakarta), SPAM Jatiluhur II (5m^3/sec, may be changed to 10m^3/sec in the future) and Karian Project (Total 14.6m^3/sec, 3.2 m^3/sec for DKI Jakarta).

These large scale projects will be implemented as middle-long term action plan, however, in this study the following activities are conducted to accelerate their implementation.

- Recommendation of Water Resources Development by Improving the Dam Operation of the Citarum River 3 Cascade Dams(refer Section 3.3.5)
- Proposal of Pumped Storage Scheme for Three Cascade Dams on the Citarum River (see Section 3.3.5 (5))
- Consensus Building for Acceleration of SPAM Projects through WG Meetings and Workshops

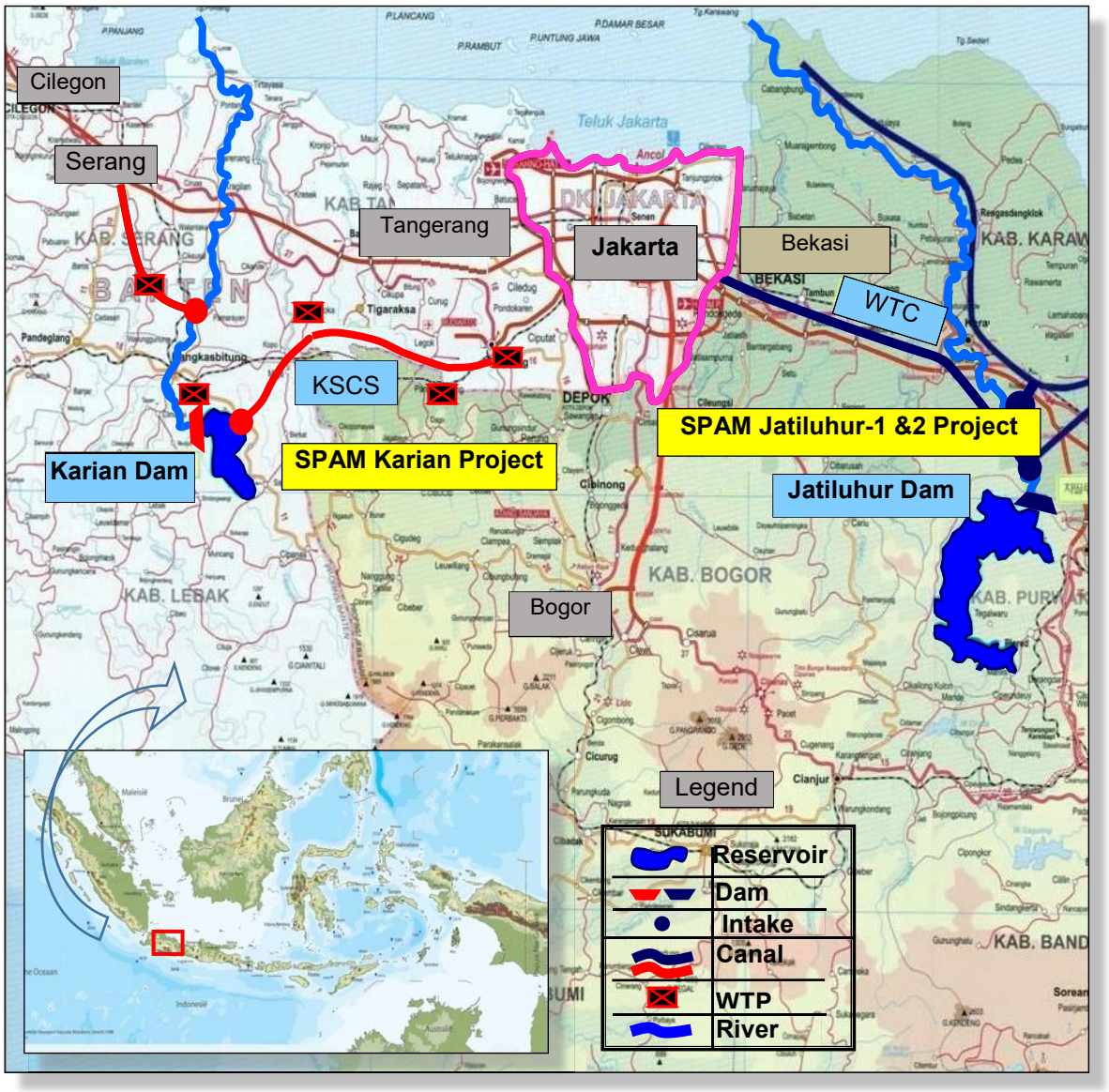


Figure 3.29 SPAM Jatiluhur Project and SPAM Karian Project

Source: PROGRES PEMBANGUNAN PROYEK STRATEGIS NASIONAL DI PROVINSI BANTEN BENDUNGAN KARIAN DAN BENDUNGAN SINDANG HEULA, MEI 2018

(1) Regional SPAM Jatilufur I & Jatiluhur II (currently renamed as SPAM Ir. H. Djuanda)

The SPAM Jatiluhur Project was proposed by INDII (Indonesia Infrastructure Initiative, AusAID, Semi-grant Fund implemented by the Government of Australia). The project was composed of three water conveyance pipes (diameter: 2000 mm, 68 km, 5 m^3/sec per pipe) and will supply 15 m^3/sec of raw water from the Jatiluhur Dam on the Citarum River to DKI Jakarta, Bekasi City and Karawan regency. The Government of Indonesia divided the project into three phases in consideration of the scale of the project cost, and two of them will be implemented as SPAM Jatiluhur I & II. SPAM Jatiluhur I plans to use the existing West Tarum Canal to convey raw water to Bekasi water treatment plant and the treated water will be transferred to DKI Jakarta through pipe system.

The water source will be an impounding water in the existing Jatiluhur Dam. To secure the additional water, it is proposed to improve the irrigation efficiency to 80%, thus 14m^3/sec of raw water can be newly secured. The water right of 10 m^3/sec to be used in SPAM Jatiluhur I and II had already agreed with farmers in the Jatiluhur irrigation area. The remaining 4m^3/sec has not been agreed yet. Currently, BBWS Citarum has proposed a construction of new dam in the eastern

part of the irrigated area, repairing irrigation channels and to implement several measures to reduce the burden on farmers.

Available Raw Water for SPAM Jatiluhur I and II

In the Study Report of "Water Allocation Practices and Water Balance Jatiluhur, October 2010TA 7189-INO Package B (2010, ADB)", it is concluded that it is possible to secure the required volume of raw water from the Jatiluhur Dam in 2025 for the project, under the conditions of the improving operation of irrigation system and irrigation facilities of the system. The Feasibility Study of SPAM Jatiluhur (2016), however, discussed on the necessity of the advanced use of water of the Citarum River because shortage of water has been observed at many locations of command area of Jatiluhur Irrigation area at present and the farmers are forced to use groundwater or to decrease of planting area or to change of cropping pattern/intensity. This means the former study result did not cover the all actual conditions and the concreted one:

- A negative trend in water releases of Jatiluhur dam has observed and it is considered that this trend has a correlation with decreasing of rainfall in the upper watershed of the Citarum. However, the study results did not refer this fact;
- New developments in the upper watershed of the Citarum are not accounted in the water balance study;
- The monthly discharge variations, in particular for the period of May-July, of water supply from Jatiluhur dam and interception rivers crossing West Tarm Channel can be a critical bottle-neck, but it is not considered in the estimation;
- In the water balance does not take into account the potential negative effects of climate change on water availability.

In the review of ADB's estimation, it was found that the water supply from Jatiluhur Dam (municipal water supply to DKI Jakarta and irrigation water supply) may not be performed as expected, therefore, further study stipulated below will be required.

- A more detailed analysis focusing on water fluctuations (demand and supply) considering time (seasonal fluctuations) and space (upstream basins, irrigation canal systems).
- Formulation of irrigation efficiency improvement plan in the Jatirufur irrigation area by PJT II, BBWS Citarum and Dynas PSDA.

Currently, PUPR/PJT II propose a plan to secure the required amount of raw water by improving the use of existing water sources. For the advanced use of water, consensus and cooperation of water users is indispensable. PUPR/PJT II, therefore, has been making efforts to gather stakeholders, hold coordination meetings, exchange opinions and discuss on water use, and obtain consensus on this policy for the smooth implementation of the project.

Regional SPAM Jatiluhur I

The SPAM Jatiluhur 1 Project is a system that sends 5 m^3/sec of raw water from Curug weir to Bekasi and Cibeet water treatment plants through West Tarum Cannel. At Cibeet and Bekasi, 0.5 m^3/sec each of water will be used and remaining 4 m^3/sec water supply to DKI Jakarta. The total project cost is estimated at $ 663 million. Project cost of water intake facilities and WTP are estimated at $ 122 million, expected to be implemented with PPP. The project will be implemented by a consortium that includes PJT-II, Cipta Karya, DKI Jakarta and others.

The implementation schedule as of December 2018 is shown in Figure 3.30. As shown in the schedule, a bid process (Proses Pelelangan) was scheduled to start in March 2019. However, approval for the Government Contracting Agency (GCA) had not been given because a financial arrangement with the consortium could not be concluded. As of January 2022, the implementation schedule was revised, and the project has been proceeding with the target date of starting operation in 2028 (see Chapter 3.3.7 MOU on Regional SPAM (MoHA, PUPR, DKI-Jakarta).

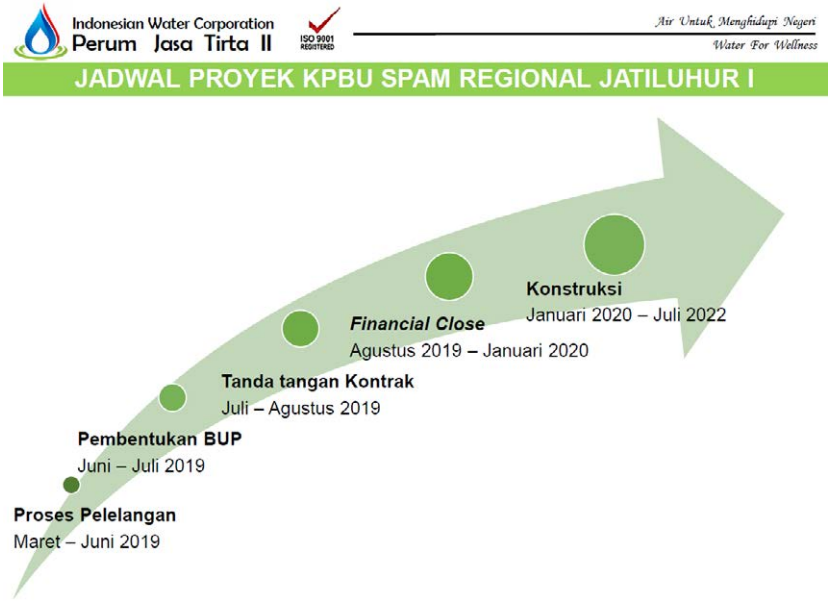


Figure 3.30 Implementation Plan of SPAM Jatiluhur I (as of 2017)

Source: PJT II

As for the project management, Cipta Karya (PUPR) will be in charge of water channel construction from Jatiluhur Dam to Bekasi, and DKI Jakarta and Pam-Jaya will be in charge of construction of water channels, water treatment plant and Pipe Connection.

The design flow capacity of Cikarang-Bekasi section of West Tarum Canal has already been improved to 31 m^3/sec with the assistance of ADB (Asian Development Bank) to meet the requirements of SPAM Jatiluhur I project. The section between Bekasi-Cawang (Jakarta) downstream of Bekasi is 15 to 17 m^3/sec without any modification. Since SPAM Jatiluhur I plans to convey purified water directly from Bekasi to DKI Jakarta via a pipe, the flow capacity of the west Tarum canal of this section does not matter.

The destination of the newly supplied water is planned to be the pipe non-connecting area in the northwestern part of Jakarta and the western part where the land subsidence is severe, and it is expected to function reducing land subsidence.

The overall plan and water distribution plan of SPAM Jatiluhur I are shown in Figure 3.31 and Figure 3.32.

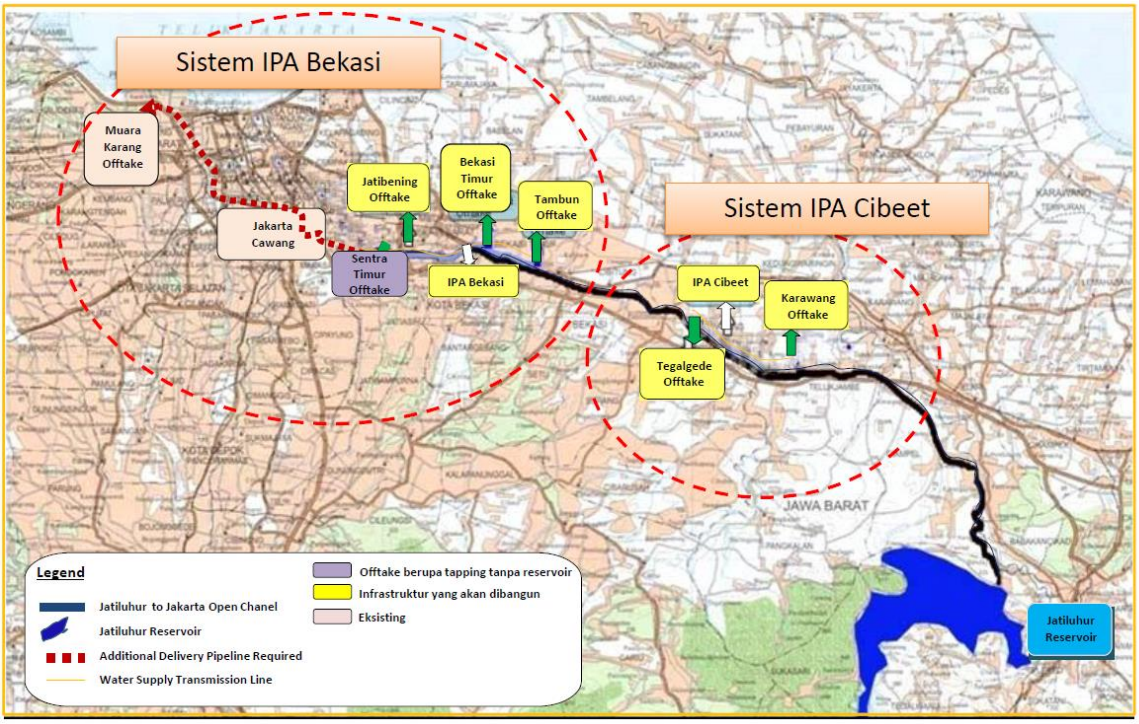


Figure 3.31 Overall Plan of SPAM Jatiluhur I Project

Source: Profil SPAM Regional JATILUHUR 1 dan 2_Januari 2017_update 20

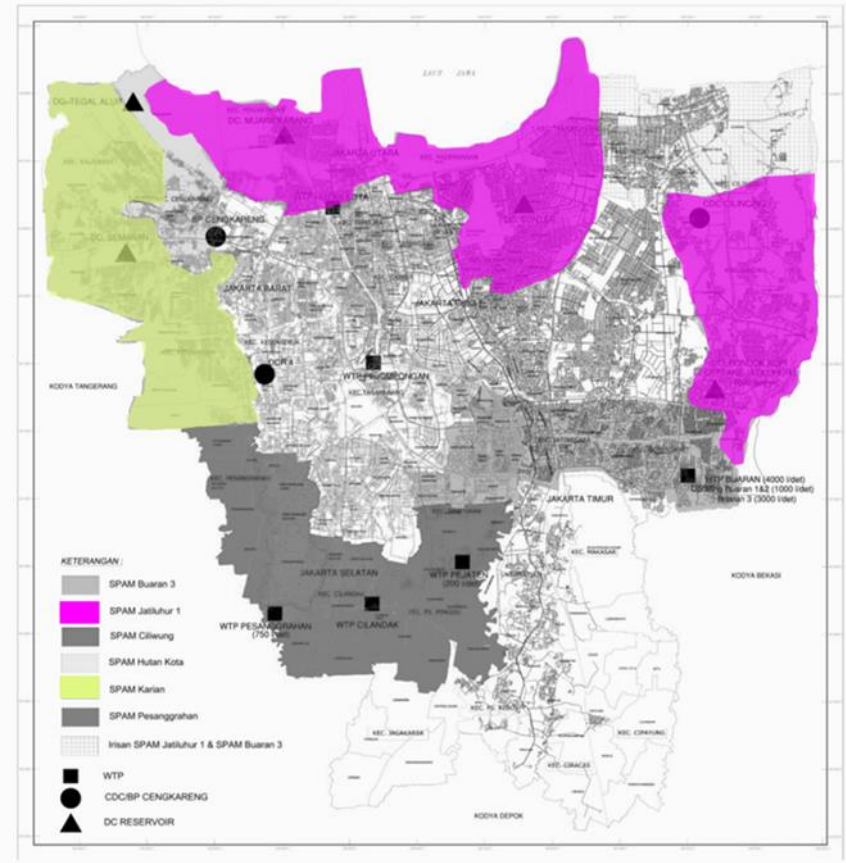


Figure 3.32 Water Distribution Plan

Source: Rencana Penyerapan Air Minum Curah dan Pembiayaan Hilir Proyek KPBU SPAM Regional Jatiluhur I dan Proyek KPBU SPAM Regional Karian-Serpong, Cipta Karya

Regional SPAM Jatiluhur II

At Regional SPAM Jatilufur II, 7m^3/sec of raw water is pumped up directly from the Jatiluhur Reservoir and purified it at the intake point. The purified water of 5m^3/sec will be conveyed to Jakarta through a new pipeline to be constructed at south of West Tarum Cannal and remaining 2m^3/sec will be used in the surrounding city (Bekasi, Karawan, and Bogor). The Indonesian government planed to procure this project as PPP in 2027 and to complete it in 2030. However, the project itself will be re-examined including the increase of water demand after the completion of the SPAM Karian Project and the SPAM Jatiluhur I Project.

The project outline of SPAM Jatilhur II is as follows (refer to Figure 3.33).

- Pumping up a 7 m^3/sec of raw water from Jatiluhur reservoir, and conveying the water to a proposed water treatment plant at 1.5 km downstream from the dam. The purified water of 7m^3/sec is directly sent to Pondok Copi in Jakarta by pipe with 68 km long and 2000 mm diameter (there is no water supply to Bekasi and Karawang).
- Among the purified Water of 7 m^3/sec, 2 m^3/sec will be transferred to Sunter Reservoir and Cilincing Distribution Center (CDC) Reservoir in East Jakarta, and 5 m^3/sec to Hutan Kota Reservoir and Perdana Reservoir in West Jakarta.
- Water transmission from Jatiluhur dam to WTP and construction of water treatment plant will be conducted by public corporation (PJT II) participating as Private Sector. Construction of water transmission pipe with 68km long will be APBN (National Budget) and water transmission facility from Pondok Copi to each reservoir will be constructed applying a budget of DKI Jakarta.
- The total project cost is estimated at 3,347,197 million IDR (approx. ¥ 30 billion, including taxes and administrative expenses).
- This project is applied VGF (validity gap funding, one of the incentives for PPP projects that can be regarded as a subsidy) from the government. The amount of subsidy will be varied depending on the water rate. If the water rate is set at 4,500 IDR/Ltr, VGF of 620,030 million IDR (approximately 5.6 billion yen) is expected, but if set to 5,324 IDR/Ltr, there is no subsidy. It is still under negotiation between GOI and investor.
- The construction period is one year for site acquisition and two years for construction.
- Currently, there is a Pre-F/S implemented by INDII: Indonesian Infrastructure Initiative, Australian AID in 2012.
- Construction will start in 2025, aiming to start operation in 2027 (see Chapter 3.3.7)

Water source of SPAM Jatiluhur II is expecting to use water below EL 87.5m which is the restricted water level for maintaining the stability of spillway (morning-glory type) and dam body, so that it is necessary to reexamine the original plan including water resources development.

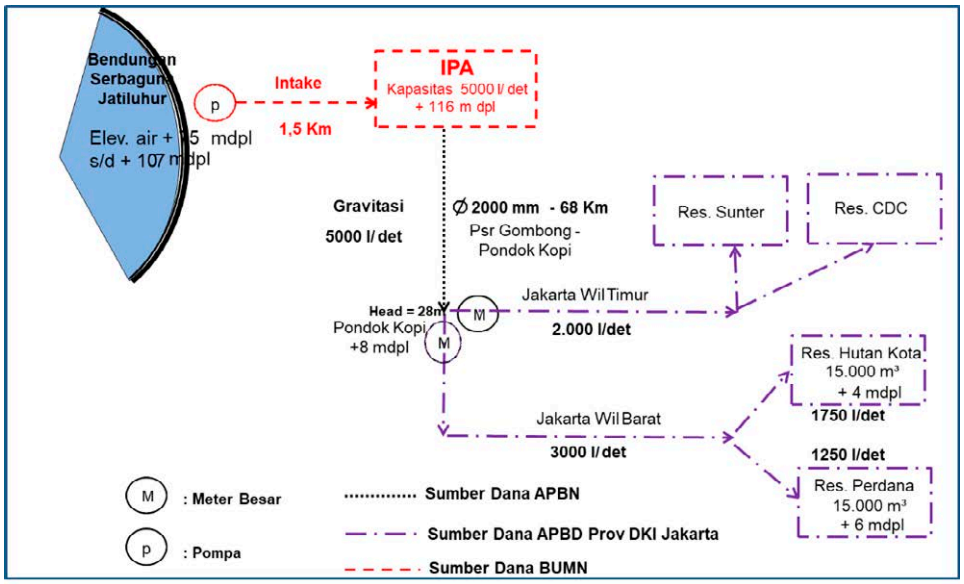


Figure 3.33 General Map of SPAM Jatiluhur II

Source: PROFIL SPAM REGIONAL, Status: Maret 2017, Cipta Karya

Table 3-45 Implementation Schedule of SPAM Jatiluhur II Project

No	Uraian Kegiatan	Penanggung Jawab	Estimasi Waktu	2015	2016	2017	2018	2019
A. TAHAP PERENCANAAN PROYEK KERJA SAMA				1 2 3 4	1 2 3 4	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4	1 2 3 4
1	Penyusunan Rencana dan Anggaran Dana KPBU	Menteri PUPR	3 bulan					
2	Identifikasi dan Penyusunan Usulan Rencana KPBU	Menteri PUPR, PJT II	3 bulan					
3	Penganggaran Dana Tahap Perencanaan	Menteri PUPR, PJT II	3 bulan					
4	Konsultasi Publik	Menteri PUPR, PJT II	4 Juni 2013					
5	Pengambilan Keputusan Lanjut/Tidak Lanjut Rencana KPBU	Menteri PUPR, Menteri Bappenas	3 bulan					
6	Pengajuan Daftar Rencana KPBU	Menteri PPN Bappenas	3 bulan					
7	Pengkategorian KPBU	Menteri PPN Bappenas	3 bulan					
B. PENYIAPAN PROYEK KERJASAMA								
1	Prastudi Kelayakan							
a	Penyiapan Kajian Prastudi Kelayakan KPBU	PJPK, Badan Penyiapan (bila perlu)						
b	Konsultasi Publik	PJPK						
c	Penjaringan Minat Pasar Pada Tahap Penyiapan	PJPK						
d	Pengajuan Dukungan Pemerintah							
	- Perolehan Dukungan Teknis dari Kemen PUPR	PJPK, KemenPUPR						
	- Proses Pengajuan dan Persetujuan Prinsip Dukungan Pemerintah/Viability Gap Fund (VGF)	PJPK, KemenKeu						
e	Pengajuan Jaminan Pemerintah							
	- Proses Perolehan Confirmation to Proceed (CTP) dari PT.PII	PJPK, PT.PII						
2	Kajian Lingkungan Hidup							
	- Proses AMDAL (KA ANDAL, ANDAL, RKL-RPL, Izin Lingkungan)	PJPK, Pemkot Semarang,Kemen.LHK						
	- Penerbitan SIPA	PJPK, Kemen.PUPR						
C. TRANSAKSI PROYEK KERJASAMA								
1	Penjajakan Minat Pasar (*Market Sounding*)	PJPK						
2	Penetapan Lokasi KPBU	PJPK						
3	Pengadaan Badan Usaha Pelaksana KPBU	PJPK, Tim KPBU, Panitia Pengadaan						
a	Prakualifikasi							
b	Penyampaian Aplikasi Penjaminan							
c	Persetujuan Besaran Dukungan Pemerintah/VGF							
d	Dokumen Permintaan Proposal/Request For Proposal (RFP)							
e	Adendum RfP (*Request for Proposal*)							
f	Pemasukan Proposal							
g	Evaluasi							
h	Penetapan Pemenang							
i	Pembentukan Badan Usaha Pelaksana/*Special Purpose Vehicle* (SPV)							
4	Penandatanganan Perjanjian KPBU	PJPK, BUP						
5	Persetujuan Final VGF	PJPK, BUP						
6	Pemenuhan Pembiayaan (*Financial Close*)	PJPK, BUP						
7	Izin Lingkungan	KemenLHK, Kemen Agraria dan Tata Ruang, PJPK						
D. TAHAP KONSTRUKSI								
Ket								
	Rencana							
	Realisasi							

Source: PROFIL SPAM REGIONAL, Status: Maret 2017, Cipta Karya

(2) Regional SPAM Karian-Serpon

The construction of Karian Dam was commenced on June 2015 with a four-year construction period applying a financial assistance by South Korea. Completion date in original schedule was June 2019, but the works has been delayed and rescheduled that the completion is March 2022 and filling reservoir is 2023. As of December 2021, the progress of civil works is 93.7% and that of Hydromechanical works is 89.3%.

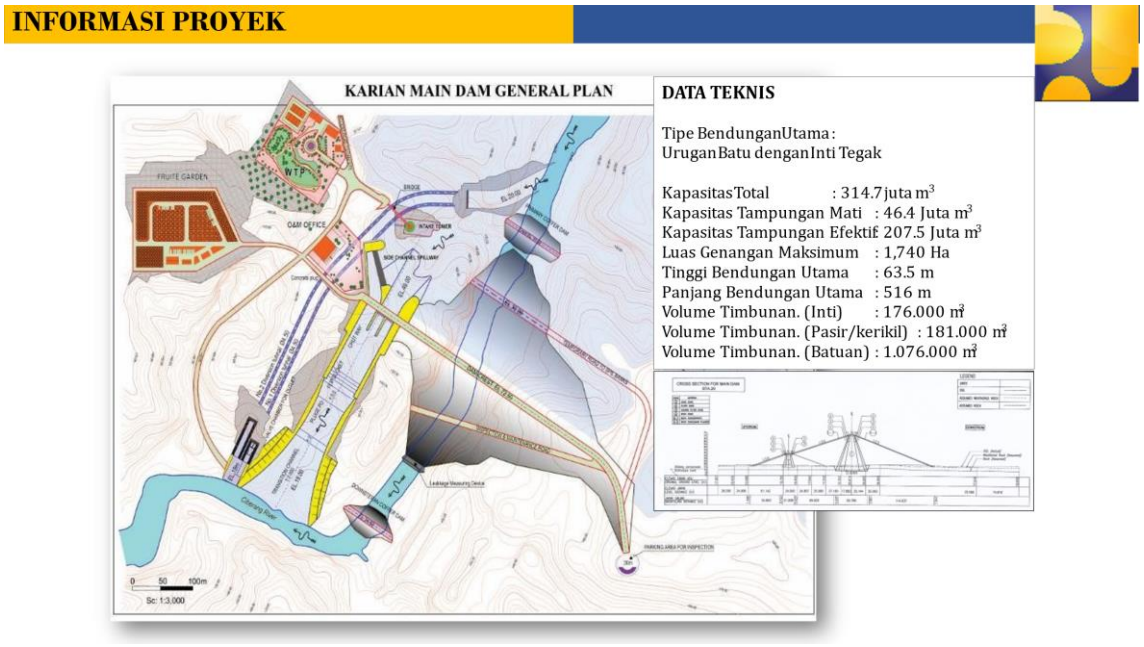


Figure 3.34 Feature of **Karian** Dam

Source : PROGRESS PEMBANGUNAN BENDUNGAN KARIAN DI KABUPATEN LEBAK, PROVINSI BANTEN, BAHAN INFORMASI, Lebak, 27 Desember 2021



Figure 3.35 Air-scape of Construction Site on September 2022

Source : PROGRESS PEMBANGUNAN BENDUNGAN KARIAN DI KABUPATEN LEBAK, PROVINSI BANTEN, BAHAN INFORMASI, Lebak, 19 September 2022

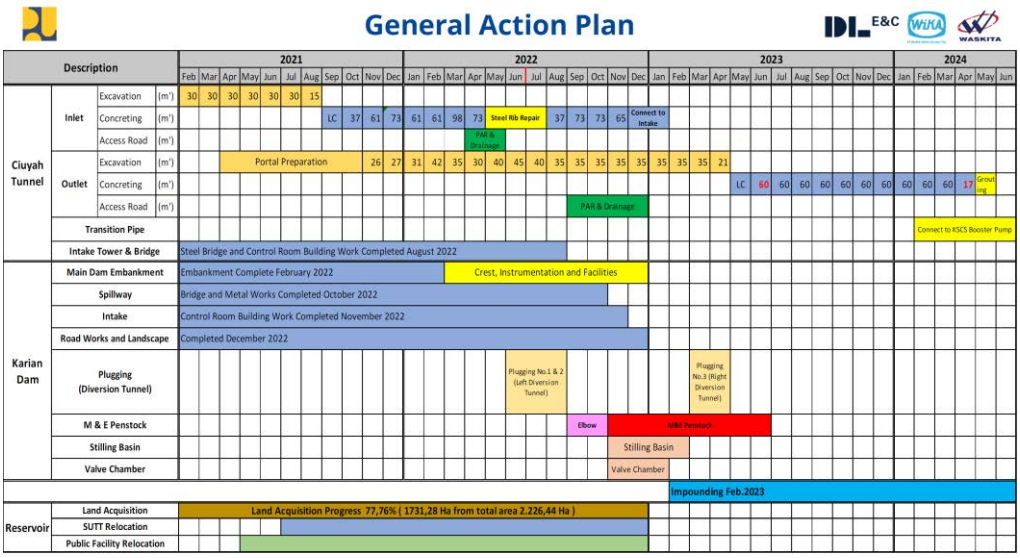
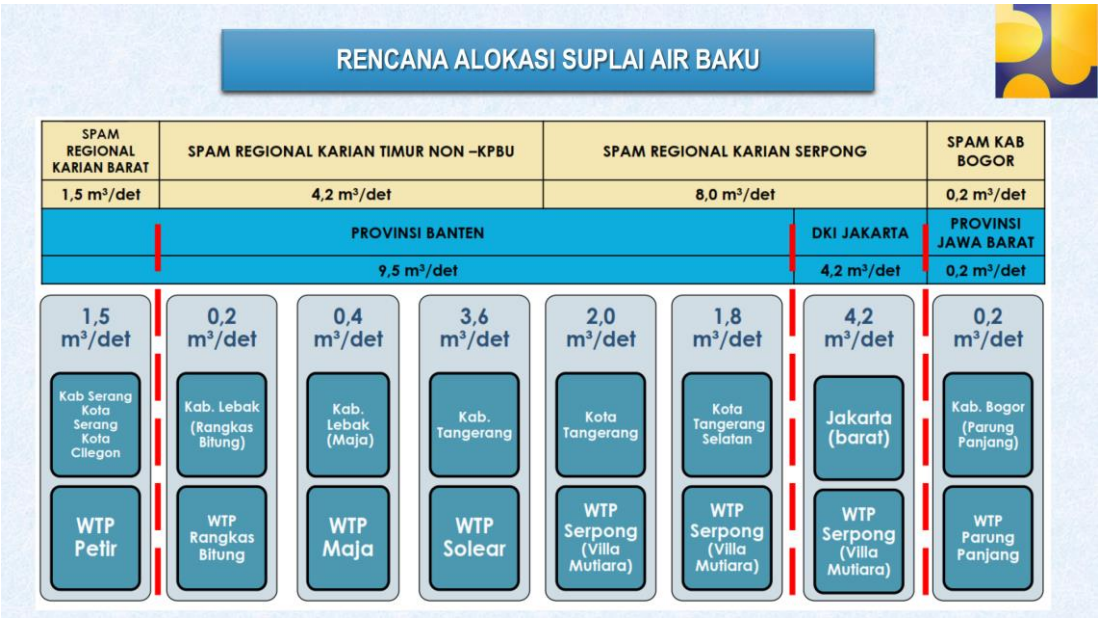


Figure 3.36 Implementation Schedule (General Action Plan)

Source : PROGRESS PEMBANGUNAN BENDUNGAN KARIAN DI KABUPATEN LEBAK, PROVINSI BANTEN, BAHAN INFORMASI, Lebak, 19 September 2022

Karian Dam plans to supply 14.6 m^3/sec of raw water (Municipal Water: 13.9m^3/sec, Irrigation: 0.7m^3/sec), of which 3.2 m^3/sec will be supplied to DKI Jakarta. The water conduit KSCS (Karian-Serpon Conveyance System) will be implemented in two phases. Figure 5-6 shows the raw water allocation plan of Karian Dam.



Total water : 14.6m^3/sec
Municipal Water: 13.9m^3/sec、Irrigation: 0.7m^3/sec
Distribution of Municipal Water:
Banten Province 9.7m^3/sec, Kota Tangerang 1.0m^3/sec, DKI Jakarta 3.2m^3/sec

Figure 3.37 Karian Dam Raw Water Allocation Plan

Source: PROGRESS PEMBANGUNAN BENDUNGAN KARIAN DI KABUPATEN LEBAK, PROVINSI BANTEN, BAHAN INFORMASI, Lebak, 19 September 2022

GOI signed on a Loan MoD for KSWCS with government of South Korea in December 2020. The Loan Agreement will be signed after approval of Environmental Impact Assessment

(AMDAL). Currently, BBWS 3C[4] is selecting a consultant for supervison of construction works.

Since KSWCS's original plan of pipe alignment could not solve the land acquisition problem, so the plan was changed drastically, and the plan to use the Serpon water treatment plant (PDAM Kab Tangerang's office) was changed to the Karian water treatment plant (South Tangerang, about 60km from Karian Dam). BBWS 3C will be responsible for the construction of the water pipes to Serpong.

The plan for the water pipeline from the Karian water treatment plant to the water supply area (DKI Jakarta downstream section public-private partnership project) has not yet been prepared.

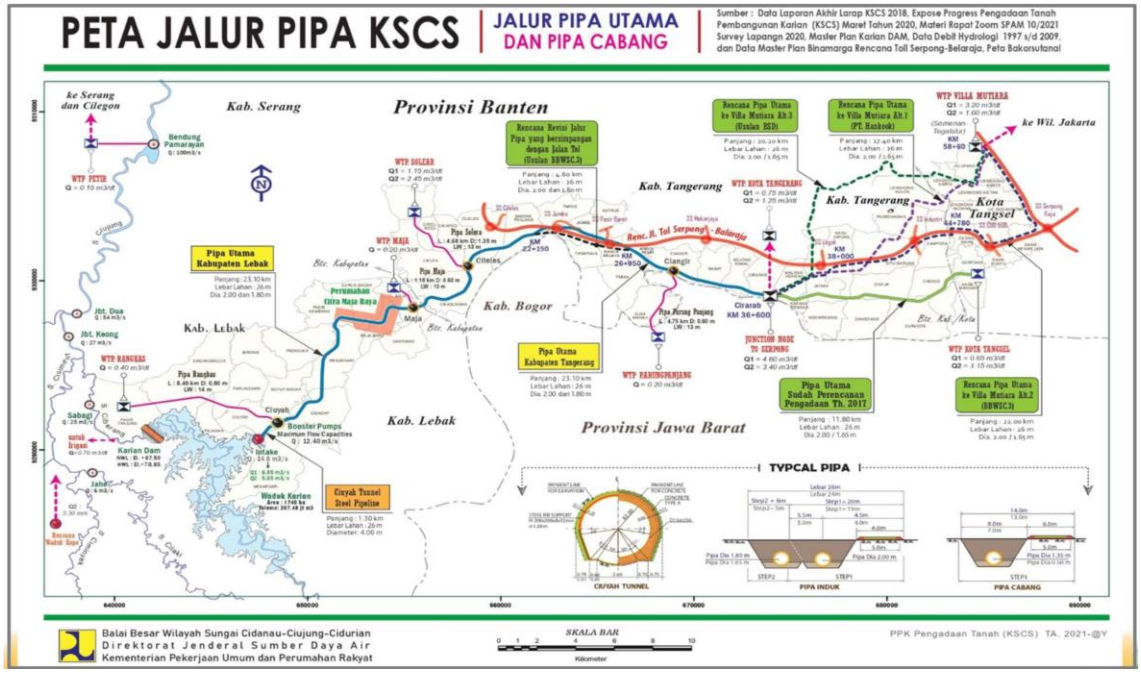


Figure 3.38 Plan of KSWCS as of September 2022

Source: PROGRESS PEMBANGUNAN BENDUNGAN KARIAN DI KABUPATEN LEBAK, PROVINSI BANTEN, BAHAN INFORMASI, Lebak, 19 September 2022

[4] Balai Besar Wilayah Sungai Cidanau Ciujung Cidurian



Figure 3.39 Location of Karian WTP and Pipe Networks

出典 : Rencana Penyerapan Air Minum Curah dan Pembiayaan Hilir Proyek KPBU SPAM Regional Jatiluhur I dan Proyek KPBU SPAM Regional Karian-Serpong, Cipta Karya

(3) SPAM Buaran III

Regional SPAM Buaran III is a project to treat and supply water. Raw water is taken from the Citarum River and transfer to the Buaran III water purification plant (treatment amount: 3.0 m³ / sec) in the eastern part of Jakarta through the West Tarum Canal, an irrigation canal. Since West Tarum Canal is used, there is an advantage that a new raw water pipe is not required, and the land for WTP is already secured, so early implementation is expected. A rehabilitation and expansion plan to increase the capacity, adding 5 m^3/sec, of the West Tarum Canal with a view to the Buarang III project, had completed (construction cost $ 229 million, APBN (National budget) was applied).

The DKI Jakarta Water Department (Pam Jaya) has been preparing a master plan, which includes the construction of the Buaran III WTP as well as water pipe networks and facility rehabilitation. The supply area is south-eastern Jakarta. It is planned that the construction works will start from 2023 and the plant operation will be commenced from 2025. BOT scheme may be applied to Buaran III project.

At present, SDA PUPR has already agreed the water use (3,000 lps) from the Citarum river. DGPI[5] PUPR, however, is still evaluating the water intake position and the design has not been completed yet, so no water use permit (water use of 3 m^3/s of the Citarum river) has been issued by SDA.

3.3.4 Other Types of Alternative Water Sources

The alternative water sources proposed in NCICD and their implementation plans are as shown in Table 5-4, i.e., 1. Improvement of NRW, 2. Rainwater utilization, 3. It is three items of reclaimed water use. The improvement of NRW will be discussed in the next chapter “Improvement of Water Supply Services”.

[5] DGPI：Ditjen Pembiayaan Infrastruktur Pekerjaan Umum dan Perumahan：DG for Infrastructure Financing,

Table 3-46 Implementation Schedule of Alternative Water Source Development Plan proposed by NCICD

Nr	Project		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	NRW reduction	PAM Jaya		2%	2%	2%	2%	2%	2%	2%	2%	2%	2%			
2	Rainwater Harvesting Jakarta (~4% savings)															
	- New Regulation	DKI														
	- Implementation North Jakarta															
	- Implementation (Rest) DKI Jakarta															
	- Law enforcement															
3	Water Reuse in Jakarta (?? m3)															
	- New Regulation	DKI														
	- Implementation North Jakarta															
	- Implementation (Rest) DKI Jakarta															
	- Law enforcement															

Source: NCICD Roadmap

The DGWR, PUPR has been proposing the following new raw water source as an emergency measures:

(1) Use of Situ (irrigation pond), Waduk and

(2) Construction of Long Storage (Utilization of river course or channel as storage during dry seasons by installation of movable weir).

Existing Situ and low wetlands in the northern part of DKI Jakarta, where land subsidence is significant, are mostly registered as private land, and the owner wants to convert a residential area, so that it is supposed that utilization as reservoir is quite difficult. On the other hand, in southern Jakarta, Depok City and Bogor Province, Situ usage plans have already been formulated by BBWS CiliCis.

(1) Situ and Waduk

There are many unused Situ (irrigation pond) remaining in DKI Jakarta and suburbs, and retarding basins (Waduk) included in the Polder Plan also proposed, and their use is also effective as alternative water sources.

Especially, many Situ, which was constructed for irrigation in the 1870's, are in un-use because of the continues reducing of existing agricultural land and the converting to residential area, trade center, etc. together with the development of the Jabodetabek area.

They can be expected as a water regulating facilities of the Ciliwung River and the Cisadane River and alternative water sources during dry season.

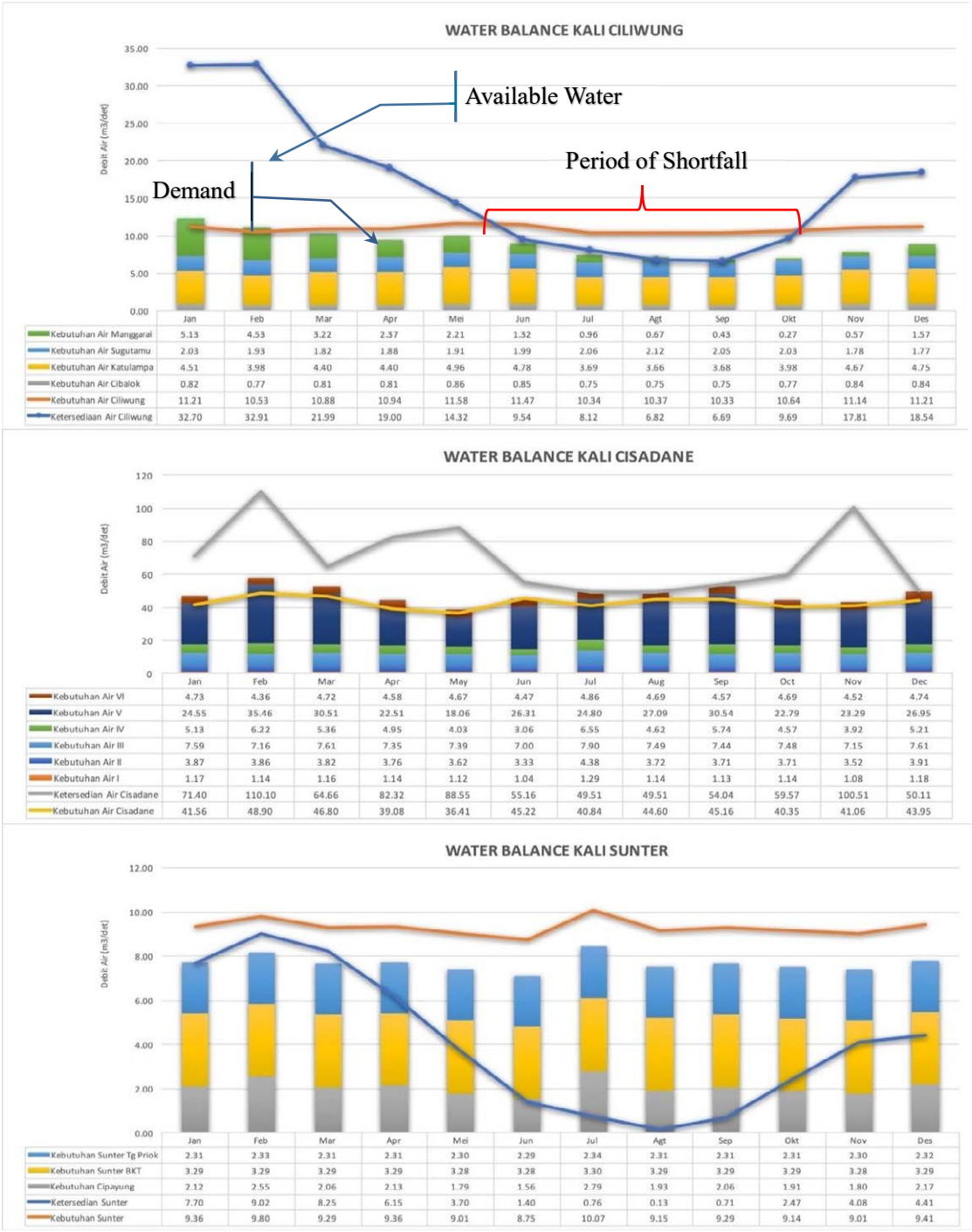
BBWS CiliCis is proposing the reutilization of these Situ. Since the Situs in the urban area of Jakarta are already owned by the private sector and difficult to use, it is planned the use of Situ in suburb.

The current development plan is limited to regional water use, but the system, to develop raw water at the Situ in suburbs and return the water to the river once during dry season and pump it up at downstream water treatment plant, can be an alternative water source of ground water.

The water balance of the main rivers of DKI Jakarta, namely Ciliung River, Cisadane River and Sunter River, is as follows. The figure shows that at the water treatment plant of DKI Jakarta, water shortage of up to 3.5 m^3/sec during the dry season, from June to October, in the Ciliwung River. On the other hand, since the Sunter River at eastern Jakarta has no basin, there is a shortage

of water throughout the year.

A water supply plan to compensate for these shortfalls of water will be a future issue.



	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Agt	Sep	Okt	Nov	Des
Kebutuhan Air Manggarai	5.13	4.53	3.22	2.37	2.21	1.32	0.96	0.67	0.43	0.27	0.57	1.57
Kebutuhan Air Sugutamu	2.03	1.93	1.82	1.88	1.91	1.99	2.06	2.12	2.05	2.03	1.78	1.77
Kebutuhan Air Katulampa	4.51	3.98	4.40	4.40	4.96	4.78	3.69	3.66	3.68	3.98	4.67	4.75
Kebutuhan Air Cibalok	0.82	0.77	0.81	0.81	0.86	0.85	0.75	0.75	0.75	0.77	0.84	0.84
Kebutuhan Air Ciliwung	11.21	10.53	10.88	10.94	11.58	11.47	10.34	10.37	10.33	10.64	11.14	11.21
Ketersediaan Air Ciliwung	32.70	32.91	21.99	19.00	14.32	9.54	8.12	6.82	6.69	9.69	17.81	18.54

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kebutuhan Air VI	4.73	4.36	4.72	4.58	4.67	4.47	4.86	4.69	4.57	4.69	4.52	4.74
Kebutuhan Air V	24.55	35.46	30.51	22.51	18.06	26.31	24.80	27.09	30.54	22.79	23.29	26.95
Kebutuhan Air IV	5.13	6.22	5.36	4.95	4.03	3.06	6.55	4.62	5.74	4.57	3.92	5.21
Kebutuhan Air III	7.59	7.16	7.61	7.35	7.39	7.00	7.90	7.49	7.44	7.48	7.15	7.61
Kebutuhan Air II	3.87	3.86	3.82	3.76	3.62	3.33	4.38	3.72	3.71	3.71	3.52	3.91
Kebutuhan Air I	1.17	1.14	1.16	1.14	1.12	1.04	1.29	1.14	1.13	1.14	1.08	1.18
Ketersedian Air Cisadane	71.40	110.10	64.66	82.32	88.55	55.16	49.51	49.51	54.04	59.57	100.51	50.11
Kebutuhan Air Cisadane	41.56	48.90	46.80	39.08	36.41	45.22	40.84	44.60	45.16	40.35	41.06	43.95

	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Agt	Sep	Okt	Nov	Des
Kebutuhan Sunter Tg Priok	2.31	2.33	2.31	2.31	2.30	2.29	2.34	2.31	2.31	2.31	2.30	2.32
Kebutuhan Sunter BKT	3.29	3.29	3.29	3.29	3.28	3.28	3.30	3.29	3.29	3.29	3.28	3.29
Kebutuhan Cipayung	2.12	2.55	2.06	2.13	1.79	1.56	2.79	1.93	2.06	1.91	1.80	2.17
Ketersedian Sunter	7.70	9.02	8.25	6.15	3.70	1.40	0.76	0.13	0.71	2.47	4.08	4.41
Kebutuhan Sunter	9.36	9.80	9.29	9.36	9.01	8.75	10.07	9.15	9.29	9.14	9.01	9.41

Source: POTENSI PENYEDIAAN AIR BAKU JABODETABEK、BBWS CiliCis

Figure 3.40 Monthly Water Balance of Rivers in DKI Jakarta

(2) Effective Use of Existing Situ

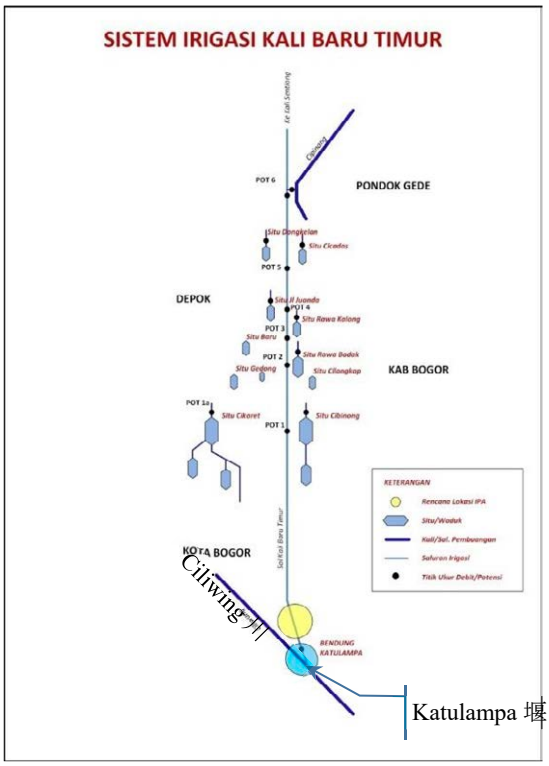
BBWS CiliCis established a plan of utilization of Situ for water supply to Bogor & Depok including the southern part of DKI Jakarta. The water also can be utilized as the water sources of

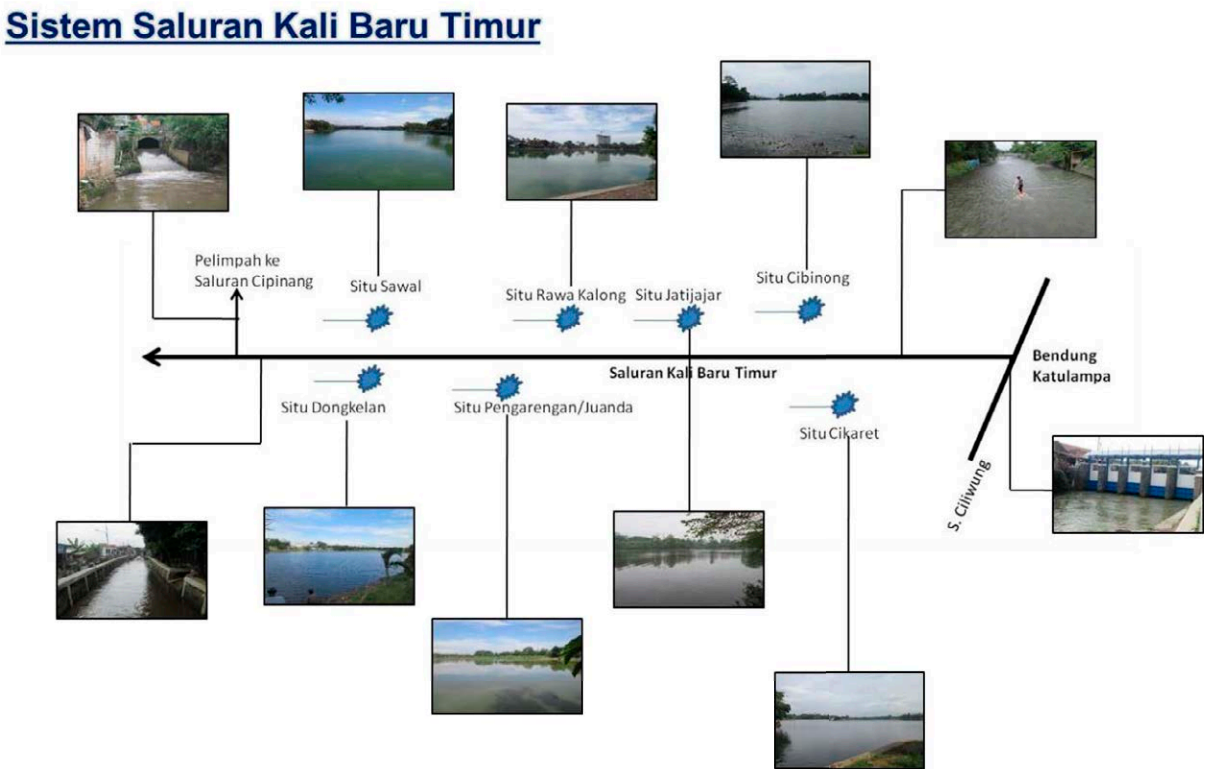
the Chiwung-Cisadane Rivers.

Ciliwung River Basin (Kali Baru Timur)

The Katulampa Weir in Bogor is a dam that was constructed in 1911 after a heavy flood in Jakarta in 1872 and was built to irrigate an area of approximately 5000 ha on the left and right banks of the weir. The irrigation channel has a capacity of up to 6,000 ltr per second. In 1990, there were 2,414 ha of paddy fields in Ciliwung river basin at Bogor and DKI Jakarta, but it decreased rapidly, and the irrigated area (DI Katulampa / Ciliwung) of Ciliwung river basin is currently set at 449 ha (Kepmen PU 390/2007).

In cosideration of the future irrigation water demand of Kali Baru Timur, the regurating capacities of the weir and the surrounding Situ will be utilized as a source of water supply.



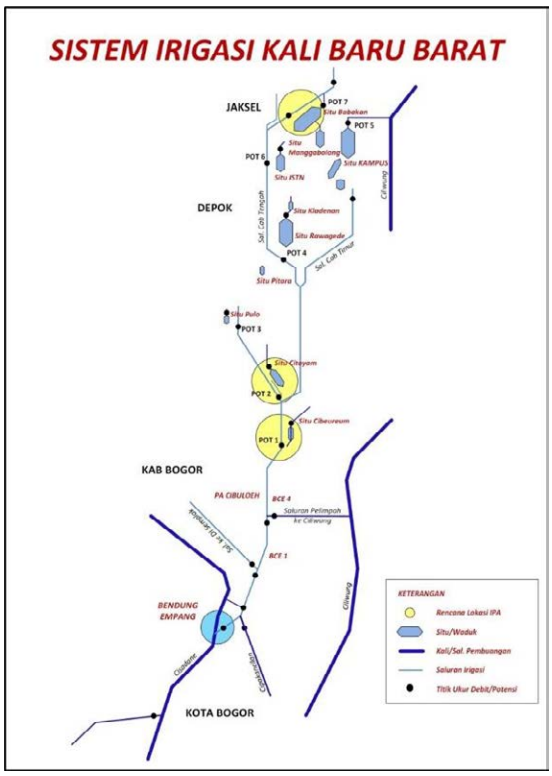


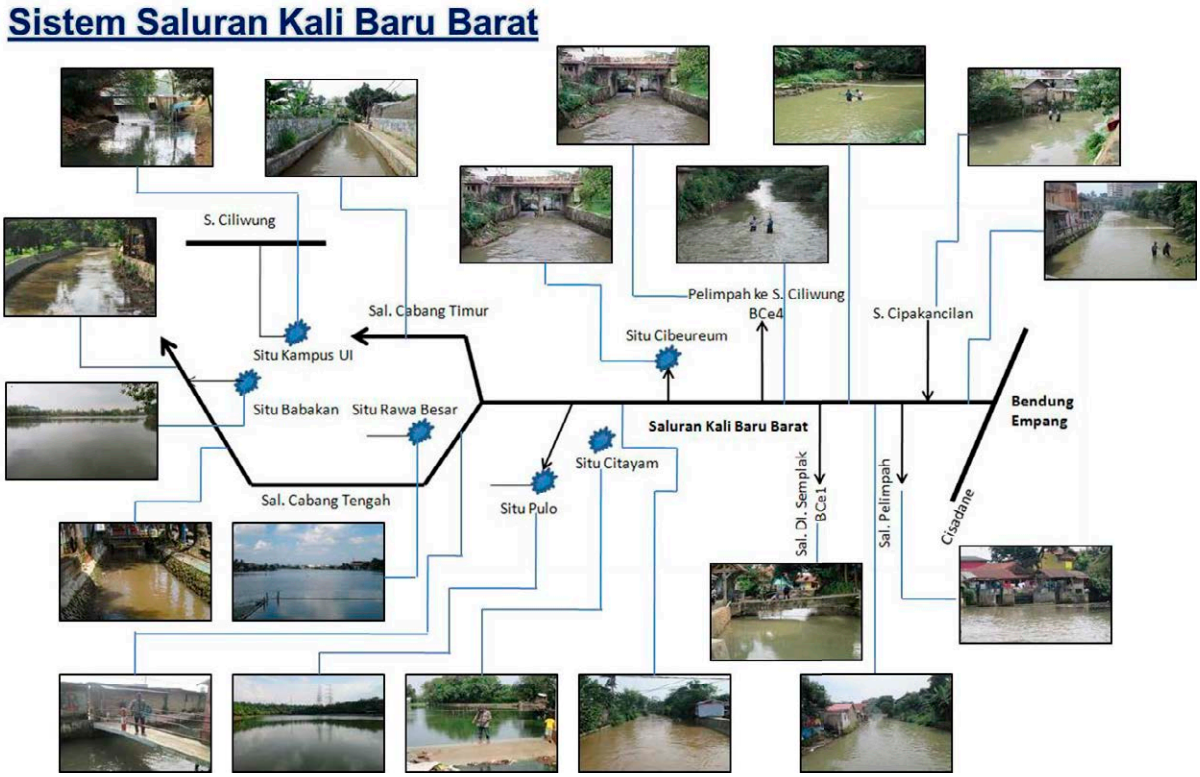
Source: POTENSI PENYEDIAAN AIR BAKU JABODETABEK, BBWS CiliCis

Figure 3.41 Potential of Development of Situ in Ciliwung River Basin

Cisadane River Basin (Kali Baru Barat)

Empang Weir, which was constructed in 1872, had taken water from the Cisadane River and irrigated 1,500 hectares of farmland through Kali Baru Barat river. However, due to the development of the Jabodetabek area, existing agricultural land continues to decrease and is being diverted to residential areas and trade centers.





Source: POTENSI PENYEDIAAN AIR BAKU JABODETABEK, BBWS CiliCis

Figure 3.42 Potential of Development of Situ in Cisadane River Basin

(3) Utilization of River Water

A planning and design of raw water supply from Kali Baru Timur and Kali Baru Barat were conducted on the potential raw water sources, and the following projects were proposed.

a. Construction of Raw Water Supply Facility (200 ltr / sec) in Situ Cibeureum, Bogor District
b. Construction of Raw Water Supply Facility (200 ltr / sec) in Situ Citayam, Depok City
c. Construction of Situ Babakan Raw Water Supply Facility (200 ltr / sec) in South Jakarta City
d. Construction of raw water supply facility (500 ltr / sec) of Kali Baru Timur in Bogor City (Katulampa weir)

For the implementation, BBWS CiliCis commented on the projects as below.

- Residents agree to the construction of raw water facilities (no need to secure land). The residents are expected to be involved in the maintenance of the river environment, especially in the improvement of water pollution.
- In the dry season, there are many residents who complain of the lack of clean water, and the residents strongly desire PDAM (pipe water supply), and want to construct a raw water supply facilities to secure daily living water.
- Water sources used for raw water supply of Kali Baru Barat and Kali Baru Timur come from Bogor Depok's Situ group and Katulampa weir, and expect a continuous and optimal supply for their water supply capacity.
- It is necessary to monitor the safety of raw water supply facilities to be constructed. In particular, since Situ has been over 100 years old, it is necessary to check the water leakage from the reservoir regularly. Therefore, it is important to carry out routine and periodic maintenance activities so that existing problems can be identified as soon as possible.

(4) Long Storage

For the maximum use of the water developed by the reuse of Situ, Long Storage will be required, which is to provide a weir at the river mouth and reserve water and use it from the end of the rainy season to the dry season. In consultation with BBWS CiliCis, the following rivers were suggested as candidates for Long Storage by the person in charge (see figure 5-10). These rivers are expected to be used as a retarding basins for the Polder Plan in the future and also as a water source, and can be expected as a facility that combines raw water storage during dry season and flood storage during rainy season (included in future plans). However, at present, there is no plan for raw water storage.

- Mookervart
- Cengkareng Drain
- Cakung Drain
- East Canal (BKT)

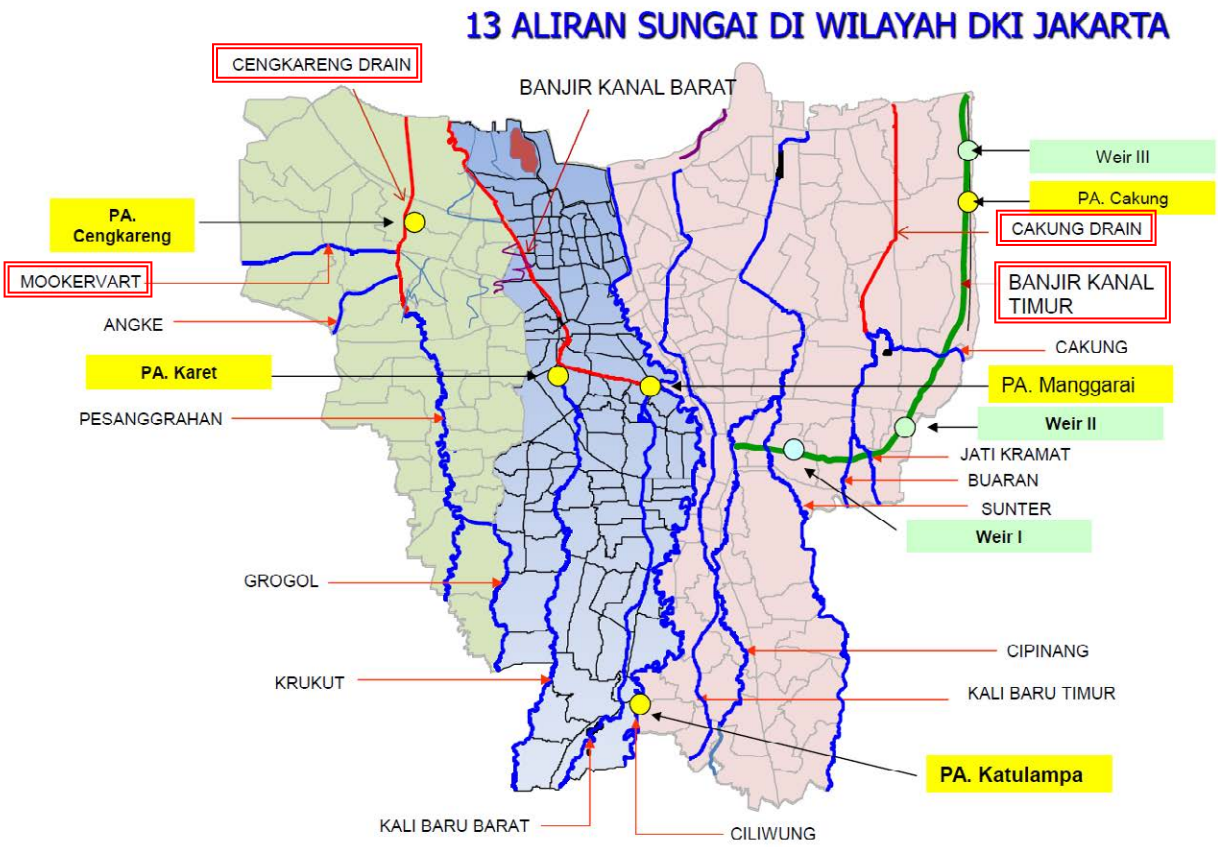


Figure 3.43 Candidate Locations of Long Storage

(5) Recycled Water

Proper treatment and use of sewage is focused and promoted as an important measure of global water and sanitation improvement and sustainable water resource securing. The UN's Sustainable Development Goals (SDGs) also set SDG6: Ensuring availability and sustainability management of water and sanitation for all as one of 17 areas. According to it, by 2030, it is decided to plan expansion of the approach to the reclaimed water use for water and sanitation improvement.

Global trend

Figure 3.44 shows the rate of reuse of treated sewage water. It can be seen that the proportion of agricultural use (32%), watering to green areas and plants (20%), and industrial use (19%) is large.

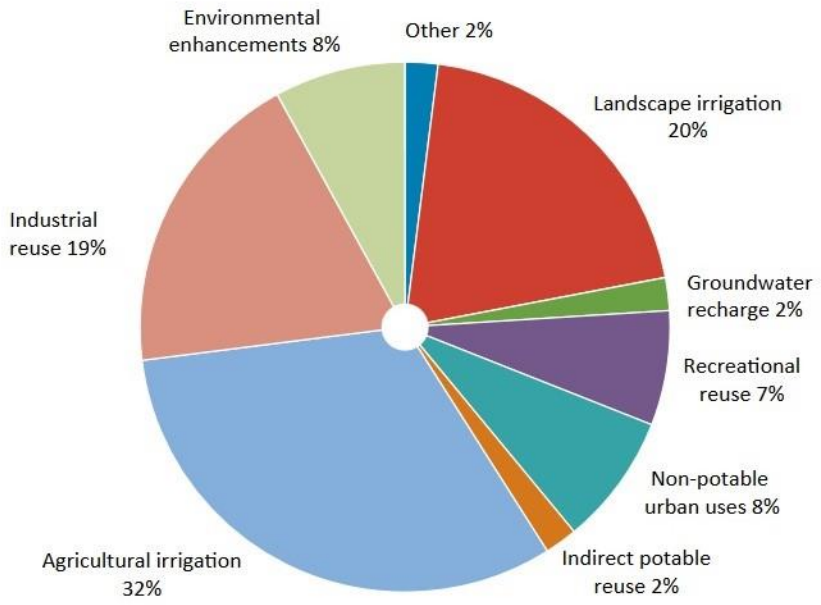


Figure 3.44 Global reclaimed water usage

Source：World water development report 2017
https://unesdoc.unesco.org/ark:/48223/pf0000247153

Status in Japan

One of the start times of reclaimed water use for treated sewage in Japan is the start of full-scale urban use in Fukuoka City in 1980 triggered by a drought in 1978. According to the sewerage statistics, 190 million m^3 per year was used for landscape water, river maintenance water, snow melting water, etc. in 2013.

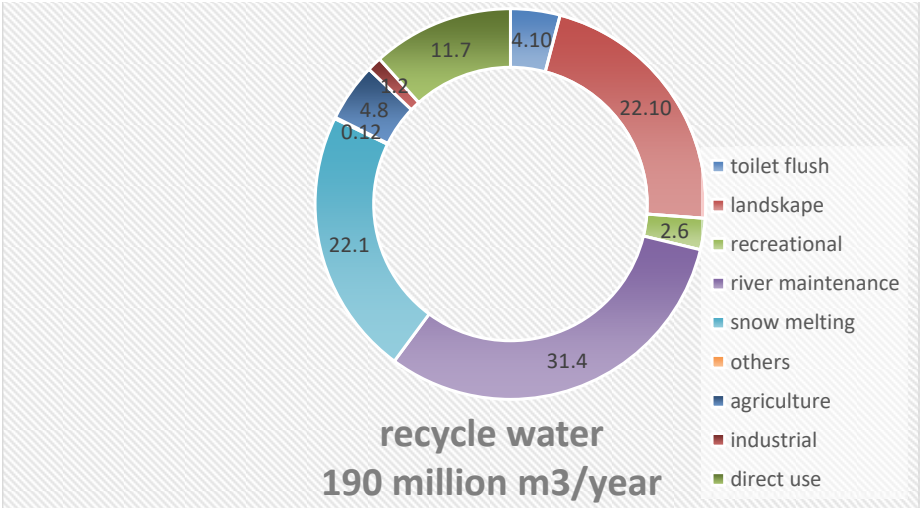


Figure 3.45 Reclaimed water in Japan (2013)

Source：Sewerage statistics in Japan(2013)

Status in Indonesia

There are few examples of sewerage in Indonesia as shown in Table 3-47, and recycling is not yet implemented.

Table 3-47 Existing Sewerage Systems in Indonesia

No.	City	Units	System	Capacity (m3/day)	House Connection (unit)
1	Medan	1	UASB	10,000	20,480
2	Parapat	1	Aerated Ponds	2,000	253
3	Batam	1	Oxidation Ditch	2,852	300
4	Jakarta Zone 0	1	MBBR	3,880	1,852
5	Tangerang	1	Aerated Ponds	2,800	300
6	Bandung	1	Lagoons	80,835	114,444
7	Cirebon	4	Lagoons	20,500	8,136
8	Surakarta	3	Biofilter & Lagoons	14,000	10,039
9	DI Yogyakarta	1	Aerated Ponds	15,500	20,158
10	Denpasar & Badung	1	Aerated Ponds	51,000	14,546
11	Balikpapan	1	Aerated Ponds	800	1,385
12	Banjarmasin	7	RBC	18,000	6,722
13	Manado	1	RBC	2,000	100

Source: Indonesia Towards SDG'S 2030
http://www.mlit.go.jp/common/001219586.pdf

Status in Jakarta

At present, the Governor Regulation on Green Building (No. 38 Year 2012) is being prepared as a project for using reclaimed water, and this regulation stipulates the proper use of water in the building. By 2020, it will be applied to 300 large-scale buildings by targeting commercial and office buildings with a floor area of 50,000 m^2 or more, hotels of 20,000 m^2 or more, and educational facilities of 10,000 m^2 or more. At the time of building construction, we recommend the installation of a system for water reuse in the building, and it is thought that rainwater use will be promoted in the future. In South Jakarta's Points Square Shopping Mall (built in 2005, consists shopping center in 1st to 6th Floor and apartments with 323 rooms, approximately 600 inhabitants, in 7th to 25th Floor) uses 600 m^3 / day of water throughout the building Out of 600m^3/day about 400 m^3 / day are filled with recycled water. The conceptual diagram of the Green Building proposed in the Governor's Regulations is shown in Figure 3.46.

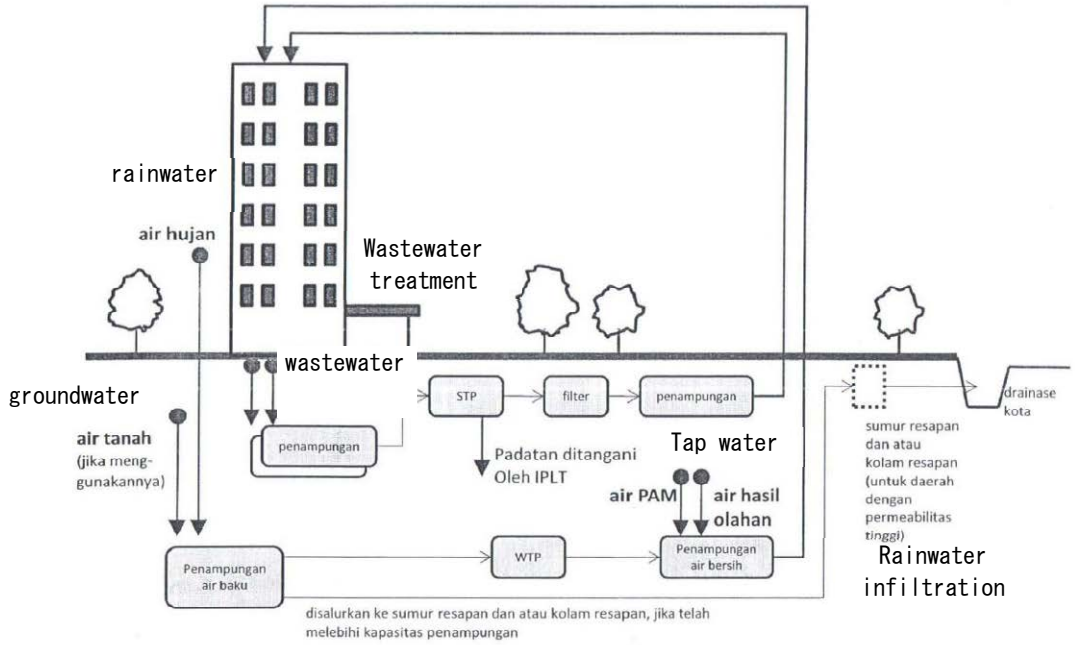


Figure 3.46 The conceptual diagram of the Green Building proposed in the Governor's Regulations

Source：Governor of Special Capital Province of Jakarta Regulation No. 38 Year 2012 concerning Green Building

At present, sewage treatment is being implemented in the area called Zone 0 in Jakarta as shown in Table 3-47. In addition, the design of sewers in Zone 1 and Zone 6 is in progress by the JICA loan project. Since the sewage treatment plant in Zone 1 is adjacent to the Pluit area where ground subsidence is severe, the use of treated water can be expected. However, the start of operation of the treatment plant is several years later. Furthermore, since the inflow to the sewage treatment plant is expected when the connection from the source of sewage (actually, the waterway to actually adopt the interceptor method) is finished, the inflow volume is considered to be small at the first stage.

Apart from this, there are a large number of small treatment plants in Jakarta. The following table is a list of small-scale treatment plants installed in the Zone 1 in Jakarta.

With regard to the availability of these treated waters, there is a problem such as securing the location in case a separate treatment device is required and securing the installation of water pipes and storage tanks from the treatment facility to the users.

Table 3-48 Small-scale treatment plants installed in the Zone 1 in Jakarta

No.	Treatment plant location	Capacity m3/day
1	Waduk Melati	800
2	Muara Angke	140
3	Kantor Dinas Teknis Jatibaru	125
4	Kantor Kecamatan Tambora	10
5	Dinas Pemadam Kebakaran	90
6	Kantor Gubemur	100
7	RT06,RT07,RW01 KSM Menteng	63.75
8	RT08,RT09,RW01 KSM Delima	65
9	RT13,RT14,RW01 KSM Glamour	45
10	RPTRA Penjaringan	2*150
11	Kosasih	N.A.

Discussion points of water recycle

Challenges of reclaimed water use include cost sharing, water quality, and cultural tolerance.

With regard to the cost burden, in principle, the user is responsible for the cost. However, when the distance from the treatment facility to the user is long, attention must be paid to the need for a water supply facility, the need for advanced treatment facilities depending on the application, and the increase in maintenance costs. As a means of cost reduction, cost allocation by sharing with public use such as landscape water, etc., and in the case of use in a commercial building, it is conceivable to pass on tenant fees as part of CSR-Corporate social responsibility.

As for water quality, there is no standard for reclaimed water in Indonesia at present, so it is necessary to consider the standard according to application.

Table 3-49 show the reference for cultural tolerance. These interviews were conducted when the demand for reclaimed water was investigated for power stations, port facilities, large-scale hotels, golf courses, shopping malls, etc. in order to understand the demand for reclaimed water in the study area of South Bali.

Table 3-49 Interview results on cultural tolerance of reclaimed water

Level of reclaimed water	Interview result
Level 1: Reclaimed water as drinking water	Although there were no problems with water quality, all the opinions were that they did not want to use reclaimed water that uses sewage as raw water for drinking and cooking.
Level 2: Reclaimed water for all purposes except beverages and cooking	This reclaimed water has a quality that causes no problem even if it touches the skin directly, or immediately after accidental ingestion. Regarding the use of reclaimed water at this level, many water supply facilities managers interviewed say that it will be difficult, but some water supply facilities managers have no problem if the quality of the reclaimed water meets the criteria. It is noted that they answered with the image of toilet flush water, the main use of conventional reclaimed water as the level 2.
Level 3: Reclaimed water as landscape water and water for greenary etc.	The use of BTDC's (Bali Tourism Development Center) reclaimed water as irrigation water is known, and the treated water from the sewage treatment facility in the hotel facility has already been used, so it is easy for the interviewed water supply facility manager to understand the reclaimed water.

Source：Preparatory survey on South Bali reclaimed water utilization project in Indonesia
http://open_jicareport.jica.go.jp/pdf/12080073.pdf

In addition to the cultural tolerance of reclaimed water, according to the religious view (No. 02/2010) by the Indonesia Ulama Council (Islamic Leadership Council), the promotion of reclaimed water use and the minimum necessary use of reclaimed water It is admired and needs consideration from a religious point of view.

Proposal of water recycle

Here, the use of reclaimed water is proposed for the Jakarta fishing port in Pluit district. In the fishing port, there are many processing plants for fishery products landed there. The current water supply within the fishing port is estimated as shown in Figure 3.46 .

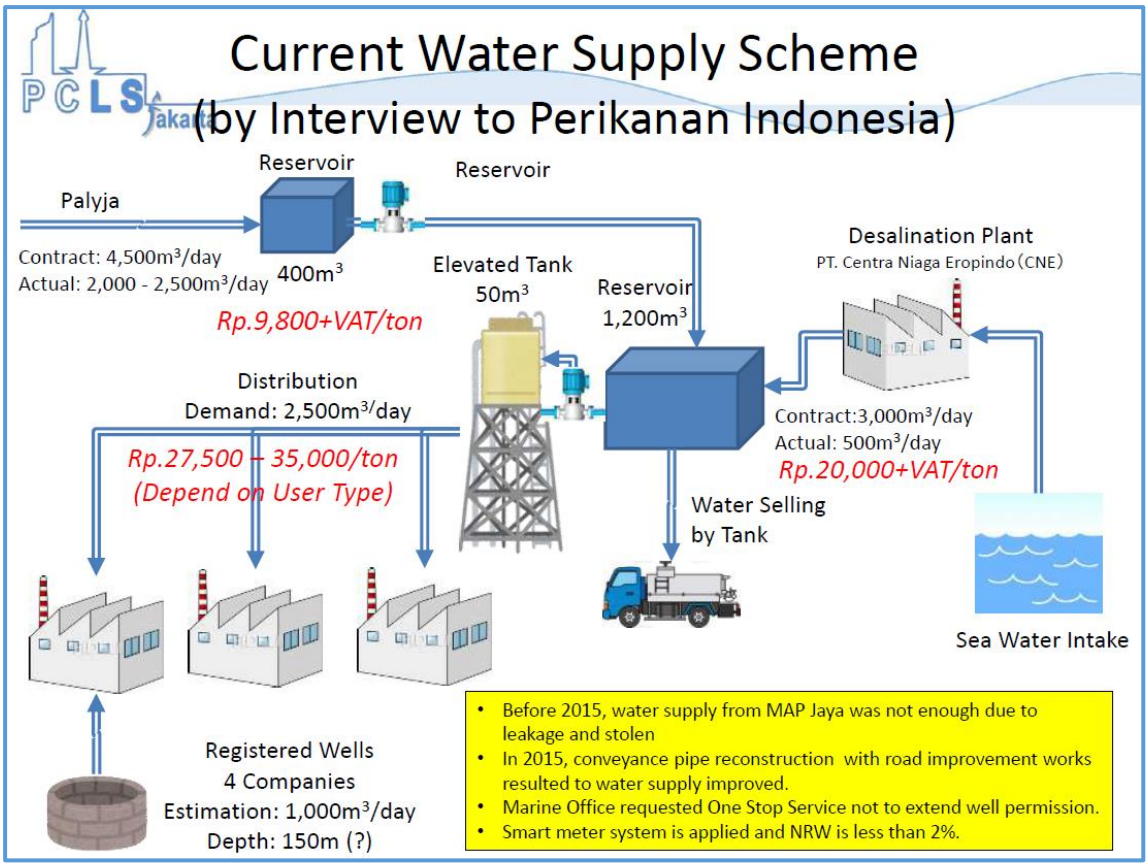


Figure 3.47 Estimated water supply scheme in Jakarta fishing port Pluit

At present, the water supply through deep wells is estimated at 1,000 m3/day. By substituting all of this with reclaimed water, land subsidence due to groundwater pumping is mitigated. The supply of reclaimed water shall be as shown in Table below. The reason for requesting raw water from nearby Waduk Pluit is that there is already precedent by JAKPRO, a local government corporation in the Special Region of Jakarta. In addition, as mentioned in the previous section, the reuse of sewage treatment water derived from human waste is not acceptable from the viewpoint of cultural tolerance.

Table 3-50 Proposed outline of recycle water distribution in Jakarta fishing port Pluit

No	Item	description
1	Water source	Waduk Pluit
2	Water volume	1,000m3/day
3	Treatment process	Raw water intake—grid removal by screen—pre-treatment(pre aeration) —sedimentation—sand filtration—Ultra filtration—Transmission to Jakarta fishing port Pluit
4	Location of treatment facilities	East side of Waduk Pluit
5	Water quality	Raw water Treated water
6	Operational body	JAKPRO or Jakarta fishing port Corporation

In Figure below, Site A and Site B shows the candidate location site of water recycle plant



Figure 3.48 Candidate location site of water recycle plant

<u>Proposal of water recycle Feasibility of water recycle in wastewater treatment facilities in DKI Jakarta</u>

As mentioned above, in DKI Jakarta, a sewage treatment plant installed in Zone 0 is currently operating as an off-site sewage treatment plant. The Zone 1 sewage treatment plant is scheduled to start operation around 2024. As on-site facilities, the facilities shown in Table below are in operation.

Among these, the feasibility of reclaimed water is summarized in Table below for Zone 0 and Zone 1 of off-site sewage treatment plants and Waduk Melati treatment facility of on-site facilities.

Table 3-51 Feasibility of water recycle in wastewater treatment facilities in DKI Jakarta

Wastewater treatment facility	Description	Feasibility
Zone 0 （Photo from east to west） 	Location:Setia Budi, South side of West Ciliun Channel Capacity:20,000m3/day 5,000m3/day for MBBR	MBBR for water recycle was already installed.
Zone 1 （perspective image） 	Location:West side of Waduk Pluit Start of Operation:2024 Capacity:240,000m3/day（Full scale, maximum daily）	The effluent water is discharged directly to Waduk Pluit. In oerder to direct water to Jakarta fishing port Pluit, pump station is needed.
Waduk Melati Photo: 29Sep2019 	Location:West side of Waduk Melati Start of Operation 2004 Capacity 800m3/day	Aeration is working but sedimentation and disinfection seemed not working. Need area to install additional water recycle plant.

Note: According to World Bank, the capacity of Zone 0 is 18,116m3/day for West Pond and 10,167m3/day for East Pond.

3.3.5 Pilot project (Rainwater harvesting facility)

(1) Background

Since the first phase of this project, the research team has been discussing with the C/P on how to promote rainwater harvesting as a short-term alternative water source, and has been examining the possibility of installing underground rainwater harvesting facilities. In the process, the DKI Housing Department provided information on the current situation of the new public housing in Daan Magot district, where deep wells are being used due to the lack of water supply, and the plan to build a reservoir on the site and introduce a reuse system that treats and uses rainwater,

sewage, and river water drawn from nearby rivers. This information was provided by DKI Housing Department and advice was requested to the survey team.



Figure 3.49 Public Housing Plan in Daan Magot District

In response, the survey team conducted a joint survey with the Housing Department and DSDA, and based on the survey, proposed the improvement of the reservoir and the rainwater harvesting facility using Japanese products. Initially, the rainwater harvesting facility was planned to be two 20m x 20m x 1m cisterns installed beside a mosque on the site, collecting rainwater from the roof of the mosque and connecting it to the water supply system of the reuse system. As of January 2022, the construction of the reservoir was completed, but the water purification system was not yet in place and the reuse system was not yet operational.

(2) Objective

The purpose of this project is to construct a rainwater harvesting facility as part of the mitigation measures against land subsidence and as a pilot project for a short-term alternative water source.

(3) Planning and construction

The planning and construction of the rainwater harvesting facility was carried out according to the flow chart below.

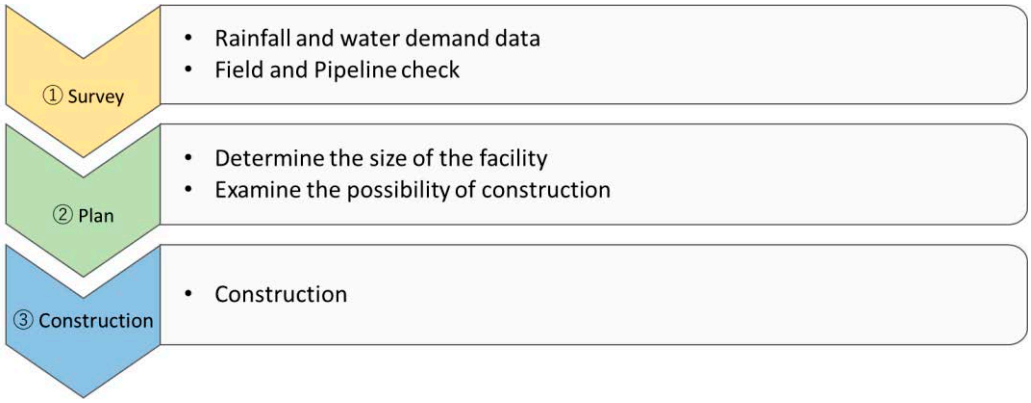


Figure 3.50 Planning flow of the rainwater harvesting facility

1) Survey

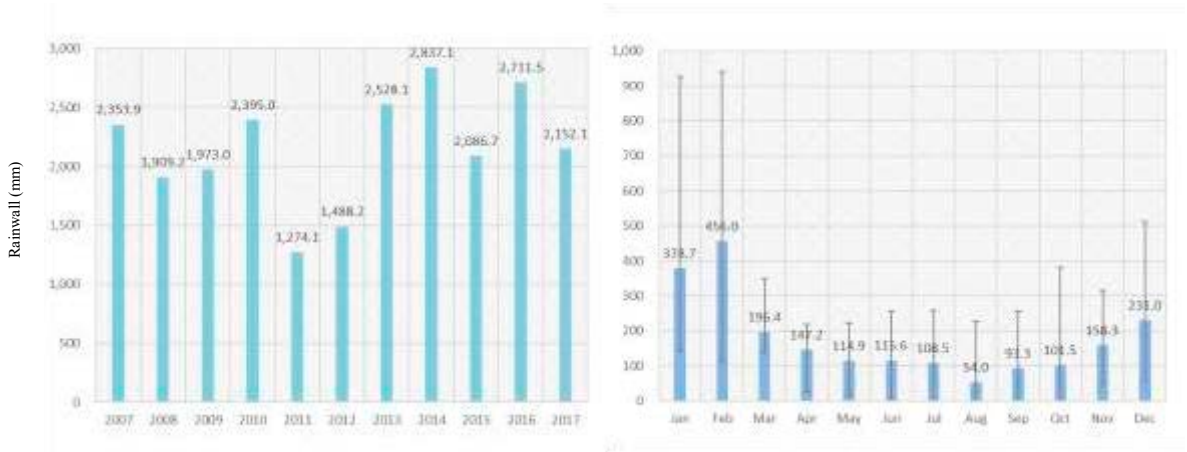
a) Rainfall survey

BMKG observation data at Kemayoran point were used for rainfall survey. The figure below shows the variation of annual and monthly rainfall in the area from 1/1/2007 to 31/12/2017. The annual precipitation average is 2155.4 mm. An average monthly precipitation on February is 456.0 mm and it is 54.0 mm on August.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2007	211.3	674.9	178.3	165.5	188.5	100.7	34.5	66.6	59.7	75.6	85.5	512.8	2,353.9
2008	226.5	677.6	212.4	218.4	25.9	51.4	9.5	36.4	97.3	85.8	113.8	154.2	1,909.2
2009	547.9	231.9	141.4	92.7	223.4	74.4	10.4	6.5	88.3	63.3	303.7	189.1	1,973.0
2010	377.0	223.3	242.5	26.7	87.7	133.8	249.6	150.6	256.1	380.9	142.8	124.0	2,395.0
2011	145.6	230.7	147.7	106.8	198.9	70.5	18.1	1.5	52.6	80.1	44.6	177.0	1,274.1
2012	259.2	110.5	177.5	195.7	78.9	66.9	21.0	0.0	19.5	20.2	314.7	224.1	1,488.2
2013	621.9	146.6	184.4	204.3	101.0	256.7	256.7	61.4	49.5	110.1	196.6	338.9	2,528.1
2014	925.6	743.6	179.8	165.5	52.0	166.8	214.1	38.1	0.1	50.8	65.1	235.6	2,837.1
2015	472.6	939.5	207.1	82.9	16.6	10.1	0.0	5.2	0.0	0.0	79.5	273.2	2,086.7
2016	163.8	516.5	350.1	204.0	156.3	202.1	259.3	227.2	237.4	136.8	199.9	58.1	2,711.5
2017	214.2	520.8	138.7	156.5	135.0	138.5	119.9	0.8	165.8	112.4	195.4	254.1	2,152.1
Average	378.7	456.0	196.4	147.2	114.9	115.6	108.5	54.0	93.3	101.5	158.3	231.0	2,155.4

Light blue indicates the monthly minimum value, and red indicates the monthly maximum value.

Figure 3.51 Rainfall data at Kemayoran observation point (2007~2017)



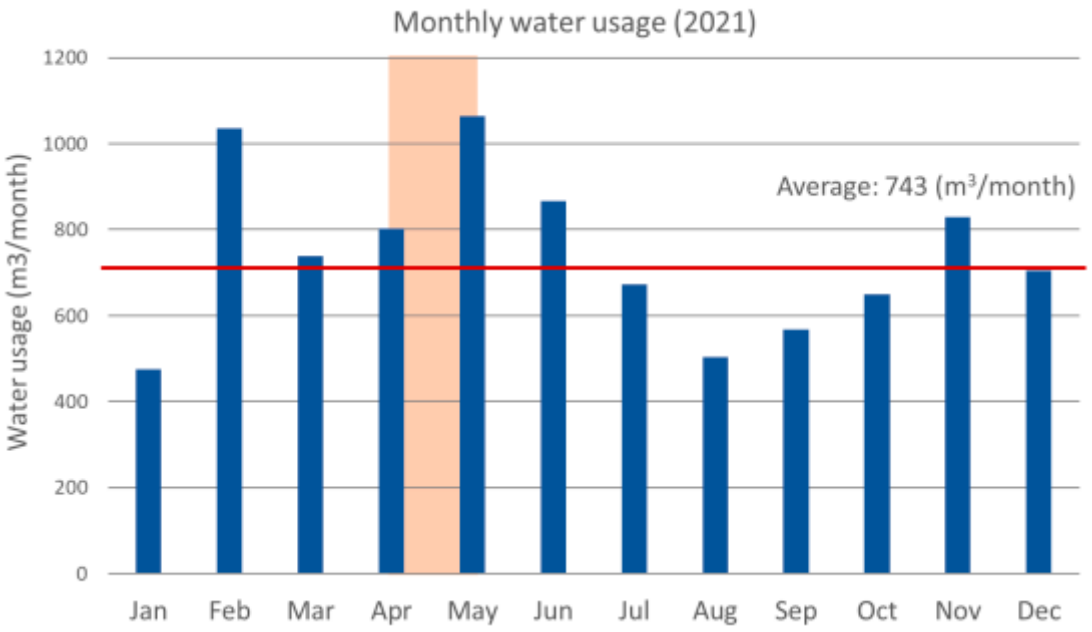
(Left) Variation of annual rainfall, (Right) Vriation of monthly rainfall (bars indicate maximum and minimum values from 2007 to 2017)

Figure 3.52 Rainfall graph of 18 Kemayoran stations (2007~2017)

b) Water Demand Survey

The water consumption of the mosque was calculated using the invoice submitted by Pam Jaya every month (see the figure below). The mosque has been using purified water from Pam Jaya for both wudhu and toilet use since before the Corona disaster. As a result, it was found that an average of 24.4m3/month was used. It is highly likely that these data are strongly influenced by COVID-19, and the mosque management reported that the water consumption before the Corona disaster was about double that of the 2021 data.

Date	2021												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Water Usage (m3/month)	475	1036	738	802	1064	866	673	504	568	649	830	705	743
Average Usage (m3/day)	15.3	37.0	23.8	26.7	34.3	28.9	21.7	16.3	18.9	20.9	27.7	22.7	24.4



The orange bar indicates Ramadan period

Figure 3.53 Water consumption in the mosque (2021)

c) Pipeline survey

In order to collect precipitation on the mosque roof, a survey of the existing pipelines was conducted. The results showed that the pipeline was divided into three major systems, each connecting to an existing seepage well.

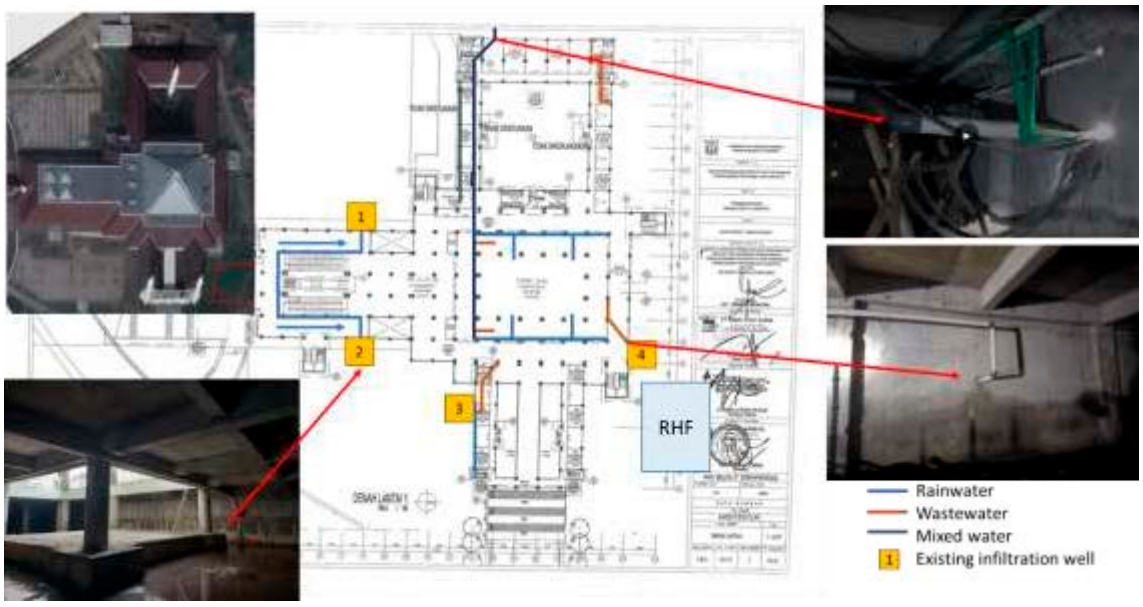


Figure 3.54 Results of existing pipeline survey

2) Planning

Based on the above survey, a detailed plan for the rainwater harvesting facilities was developed.

a) Outline of the rainwater harvesting system

In order to ensure efficient operation of rainwater, this facility is planned to be integrated into the existing water harvesting system. The outline and plan view of the whole system are shown below. The rainwater stored in the rainwater harvesting facility will be temporarily stored in a exisiting tank No.3 in the backyard of the mosque through a water treatment plant. After that, the rainwater can be used for toilet or wudhu by exisiting operation.

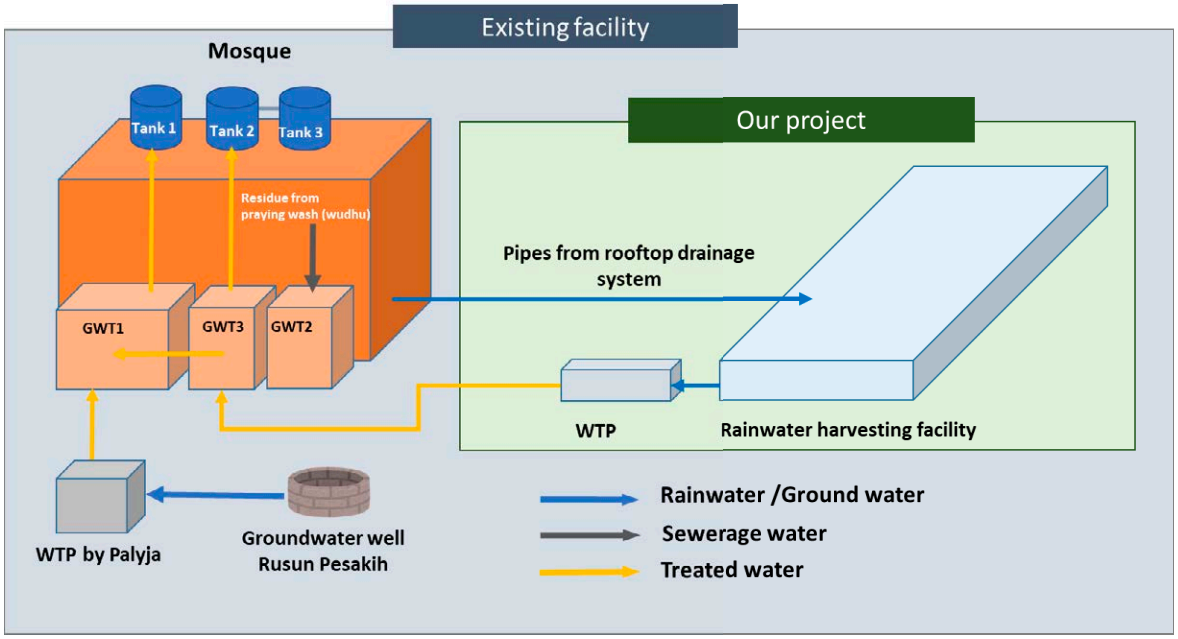


Figure 3.55 Integration of the rainwater harvesting system into the existing system



Figure 3.56 Overall view of the whole rainwater harvesting system (plan view)

b) Determination of storage tank size

The size of the rainwater harvesting facility was determined based on the potential rainwater amount on the roof of the mosque (3,500m2). The formula and results of the calculation are shown in the figure below. As a result, it was found that the potential amount is 507m3/month in the rainy season (November to April) and 277m3/month in the dry season (May to October).





2007~2017	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum Amount (m3)	473.3	359.2	450.8	86.8	54.0	32.8	0.0	0.0	0.0	0.0	145.0	188.8
Maximun Amount (m3)	3,008.6	3,053.8	1,138.0	709.9	726.1	834.4	842.8	738.5	832.4	1,238.1	1,022.9	1,666.8
Average Amount (m3)	1,230.9	1,482.2	638.2	478.4	373.6	375.8	352.6	175.6	303.3	329.8	514.6	750.9
*Average date	24.6	29.6	12.8	9.6	7.5	7.5	7.1	3.5	6.1	6.6	10.3	15.0

***Average date, average rainfall from 2007 to 2017, the number of days the facility can provide for the mosque's water demand of 50m3/day (double the amount in the 2021 data).**

Potential amount = roof area (m2) × precipitation (mm/day) × (1 - evapotranspiration rate) × 0.001
Roof area = 3,530 m2 and evapotranspiration rate = 0.2

Figure 3.57 Potential rainwater amount calculation

The potential rainwater amount during the rainy season is a minimum of 75 m^3/month, a maximum of 2613 m^3 /month, and an average of 738 m^3 /month based on the rainfall data from 2007~2017. Therefore, the size of the reservoir was set to **800m^3** (actual storage capacity of 764m^3), which is the maximum storage capacity within the budget and land area limitations (). The overflow from rainwater harvesting facility is expected to be dealt with in the following two ways: 1) to create an efficient operation manual, and 2) to install infiltration wells and return the overflow into the ground through infiltration wells.

The figure also shows the number of days that water demant in th mosque can be covered by the rainwater harvesting facility, assuming that the water demand at the mosque is 50 m3/day. As a calculation result, 20-30 days/month can be covered during the rainy season, and 3-8 days/month during the dry season.

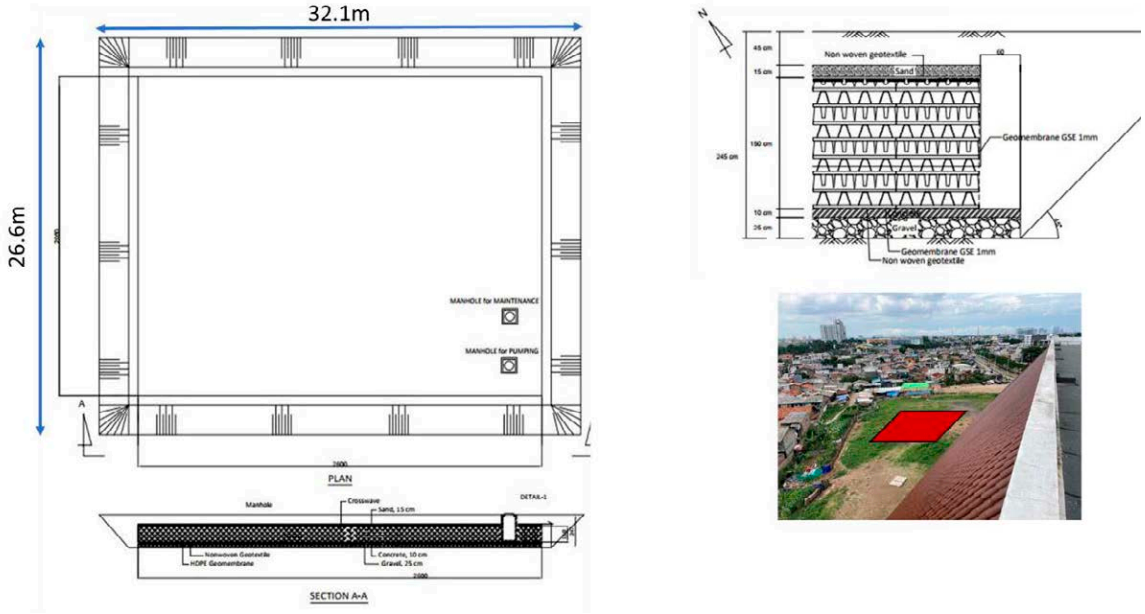


Figure 3.58 Rainwater harvesting facility design

c) Plumbing

In order to connect the rainwater on the rooftop to the rainwater harvesting facility, a piping work will be carried out as shown below.

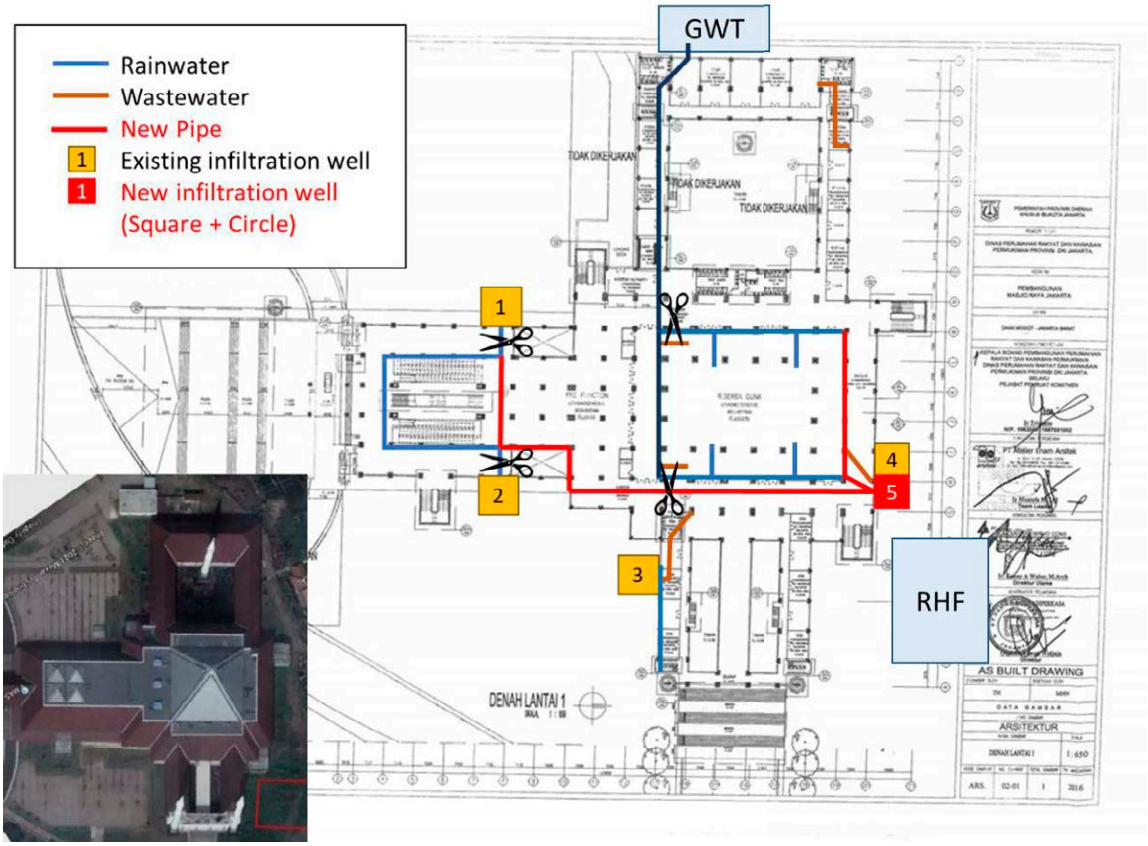


Figure 3.59 Outline of piping work

d) Installation of water treatment plant

In order to make rainwater available for domestic use, a water treatment plant is going to be constructed before rainwater is transfered to the existing tank in the backyard of the mosque. The

water treatment plant will meet the Indonesian water quality standard Class 2 (Health Minister Regulation No. 3212017), and the water quality will be checked after installation.

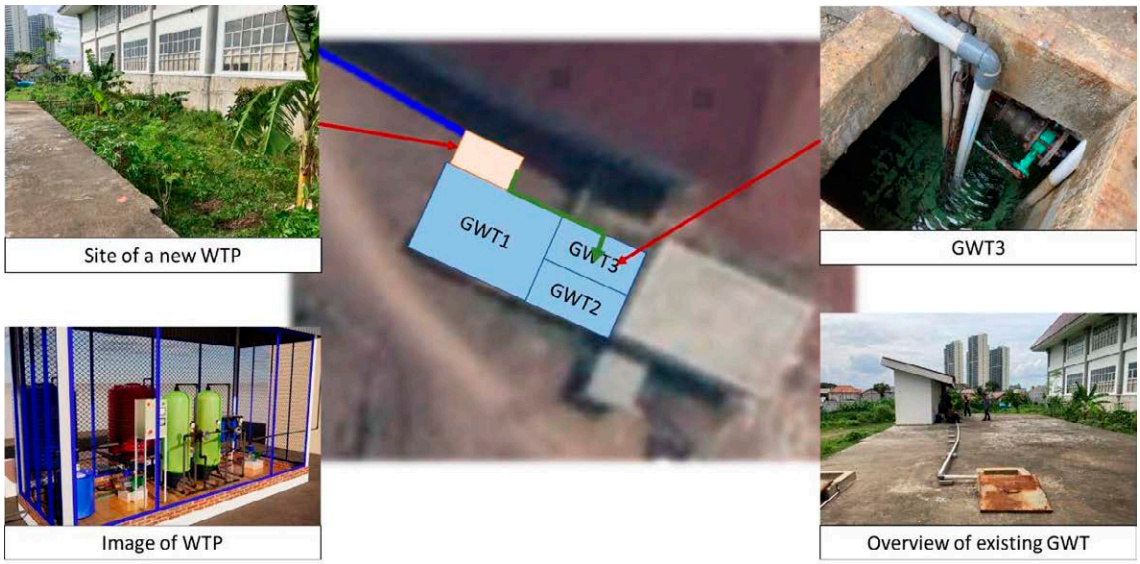


Figure 3.60 Image of the existing water storage tank and water purification facility

3) Construction

As of the end of January 2022, the project is still in the process of importing storage materials and has not yet reached the construction stage. A kick-off meeting for construction will be held in early February, and piping work, installation of water purification facilities, etc. will be carried out during the import procedures for storage materials. The mosque administrator and DKI have already approved for the construction work.

a) Piping work

The pipework was installed according to the pipework plan shown in Figure 3 69. As a result, precipitation to the mosque roof was collected to one location.

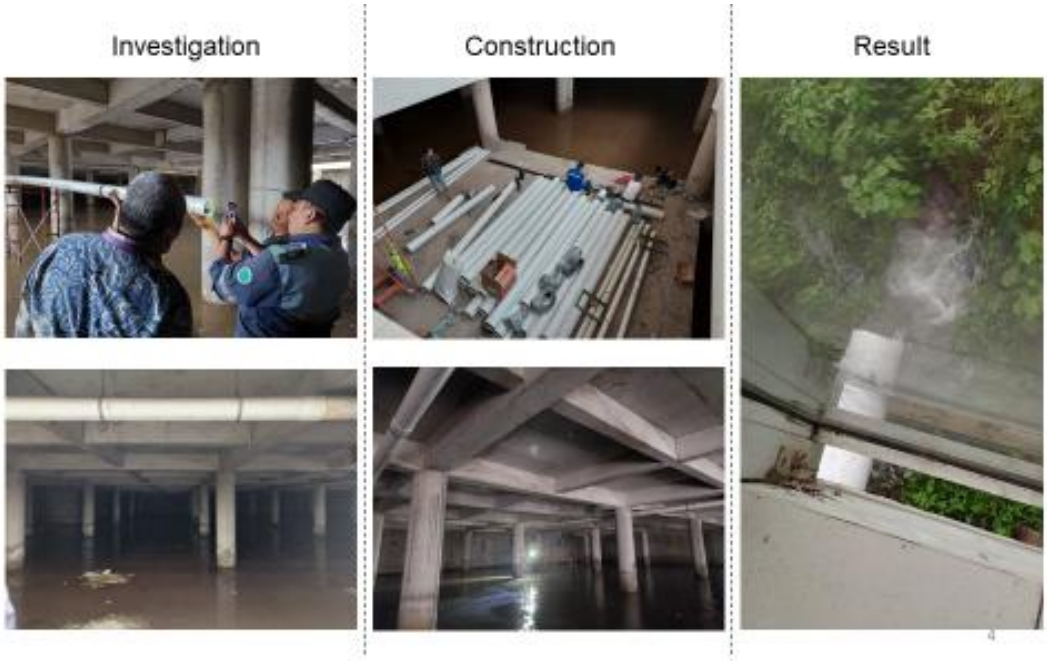


Figure 3.61 the result of piping

b) Water treatment plant

The water treatment plant was constructed according to the plan shown in Figure 3 70. The appearance is shown in the figure below, and it was confirmed that precipitation to the mosque roof automatically accumulates in the existing tank through the water treatment plant. The quality of the water after treatment was tested and found to meet the Indonesian water quality standard Class 2 (Health Minister Regulation No. 3212017).



Figure 3.62 appearance of the water treatment plant



**Temporary tanks have been installed underground to store rainwater until the reservoir is constructed*

Figure 3.63 The process by which precipitation to the rooftop accumulates in the existing tanks through the water treatment plant.

c) Storage tank

The construction process of the storage tank is shown in the figure below. Although this construction was not difficult, the joints of the impervious sheets and other parts of the construction work had a significant bearing on the functionality of the storage tank. Therefore, a manufacturer of the storage tank was invited from Japan to provide technical guidance while construction was carried out.

	
Before construction	excavation
	
Covering with crushed stone	Placing concrete
	
Installation of impervious sheets	Installation of reservoirs
	
Installation of manholes	After installation

Figure 3.64 Construction process for rainwater harvesting facilities

(4) Technology Transfer

1) Planning of new rainwater harvesting facilities

The Consultant has been continuously discussing with C/Ps led by DKI departments, including PUPR, in the above-mentioned study and planning. At the same time, starting in 2020, the relevant DKI departments have asked the Consultant to advise on potential sites for new rainwater harvesting facilities. The Consultant proposed the following criteria for construction, and the DKI, led by the Department of Social Affairs, is currently collecting information on potential sites for new rainwater harvesting facilities.

- Densely populated buildings and commercial facilities
- There is enough space on rooftops and yards to construct a storage tank.

2) Maintenance and management

Since rainwater stored in the rainwater harvesting facility is automatically transferred to one of the three existing water storage tanks, there is no need to make major changes in the operation of the rainwater harvesting facility, but it is necessary to perform periodic maintenance on the water purification facility, such as its operation and filter replacement. Therefore, we prepared rainwater harvesting facility maintenance materials and invited mosque managers and DKI to share their maintenance and management methods.



Figure 3.65 Maintenance materials (excerpts)

3) On-line/on-site briefings

The Consultant has conducted a number of online and on-site technical transfers on the above studies and construction methods. The technical transfer was targeted at the DKI Social Affairs Department, which manages the mosque where the rainwater storage facility was constructed this time, as well as DSDA and PUPR. In addition, in August 2022, a manufacturer of storage materials was invited to the site to introduce Japanese technology, including storage materials.



Figure 3.66 Technology transfer inviting manufacturers of storage materials

3.3.6 Water Resources Development by Improving the Dam Operation of the Citarum River 3 Cascade Dams

(1) Necessity of New Water Development on the Citarum River and Improvement of Dam Operation

BBWS CiliCis plans to supply a new 19m^3/s from the Citarum River, while the water use capacity of the Jatiluhur Dam is not sufficient at present. According to PJT-II, operater of the Jatiluhur dam, the additional water will be secured by reduction of irrigation water based on the policy of prioritization of water utilization (first priolity is municipal water supply) and alredy got a concensus with farmers. But there is still a lot of opposition from P3A (water users association), so countermeasure plan to solve this problem are proposing such as improvement of irrigation efficiency by efficient operating irrigation water and rehabilitation of irrigation canals/facilities, and dams construction. According to this countermeasure plan, By increasing the irrigation efficiency to 80%, a new raw water of 14 m^3/sec can be secured (details are not shared at the time). The main measures are considered to be the repair of irrigation canals and the improvement of operational efficiency of irrigation water by the Real Time Operation System (RTOS)[6] (verbally explained at PJT II). RTOS is one of technique for effective use of irrigation water applied to small-scale irrigation but it is supposed that it is difficult to apply in the large irrigation areas such as Jatiluhur irrigation system.

As long as the current dam operation method is applying as it is, it can not be to cope with the expected five-year drought of irrigation. It is supposed, therefore, that the water shortage cannot be solved (refer to the following chapter "(2) Citarum River Basin".

Furthermore, PUPR has proposed the additional water supply of 3m^3/s by development of Buaran III beside the 3 SPAM projects for DKI Jakarta as an alternative water source for subsidence in Jakarta, but this water source also depends on the Citarum River (water use permit has not been issued yet) .

The raw water supply balance of DKI Jakarta as a whole is shown in the table below, and the expected amount of new raw water development in the Citarum River will be 14.81 m^3/s even if water supply from Karian Dam and small-scale development progress.

Table 3-52 Raw Water Development Plan

2035 Water demand	42.11m^3/sec	
2015 water supply	20.15m^3/sec	
Required raw water development		
Citarum River	14.81m^3/sec (21.96 --4.20 --2.95)	Diversion from irrigation water, Securing irrigation water by improving dam operation
Supply from Ciujung River	4.20m^3/sec	supply from Karian dam
Others	2.95m^3/sec	
Total	21.96m^3/sec	

(2) Citarum River Basin

The Citarum River Basin (1,200km2) is the largest catchment area among the six river basins

[6] Real-time operating system (RTOS): Processing daily rainfall in real time by a decision support system to estimate the required dam release. A system that can be expected to rationalize the use of irrigation water because the results are reflected in the daily operation plan.

around Jakarta called 6Ci. As shown in Figure 3.50, there are three dams in the basin namely Saguling, Cirata, Jatiluhur and irrigation area with 240,000ha. Also, the Jakarta Capital Special Region (Jakarta) has problems such as chronic water shortage, land subsidence due to excessive pumping of groundwater, flood damage caused by land subsidence, and water pollution due to delay in sewerage maintenance, etc. Improvement of basic social capital and function to solve the water related problems, and improvement of urban water supply including industrial water are urgent issues. On the other hand, when looking at the operation of the Citarum River Cascade Dams, there is a release that seems to be more than the water demand from each dam to satisfy the condition of "Equal Sharing", especially in the first half of each year. It would be possible to develop new water resources by storing these discharges without depending on "Equal Sharing" and operating them efficiently.

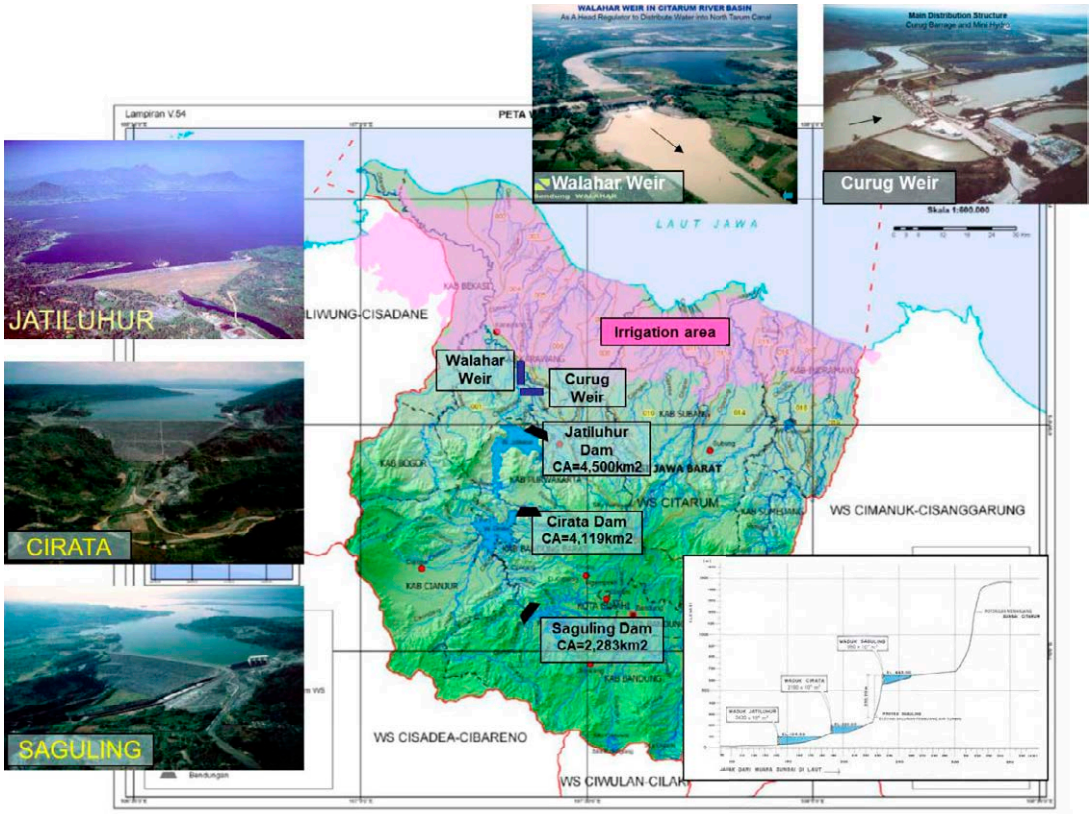


Figure 3.67 Location Map of Citarum 3 Cascade Dams

Table 3-53 Features of Citarum 3 Cascade Dams

Name of Dam	Saguling	Cirata	Jatiluhur
Completion Year	1984	1988	1962
Owner of Dam	PT Indonesia Power	PT Pembangkitan Jawa Bali (PJB)	Jasa Tirta II Public Corporation (PJT-II)
Type of Dam	Rookfill with impervious Core	Concrete Faced Rockfill Dam	Embankment Rockfill clay core
Dam Height (m)	99	126.5	105
Crest Length (m)	301.4	451.5	1,220
Purpose	Hydropower Additional function: DMI water supply and irrigation	Hydropower Additional function: DMI water supply and irrigation	Multipurpose (Irrigation, DMI water supply, Flood control and hydropower generation)

Catchment Area (km^2)	228.3	4,119	4,500
Total Capacity (MCM)	881	2,165	3,000
Effective Capacity (MCM)	609	796	2,100
Capacity of Spillway (m^3/sec)	2,400	2,600	3,000
Power Output (GWh)	2,156	1,426	790

Source : PJT-II

(3) Water Resource of SPAM Jatiluhur I, Djuanda & Buanan III — Necessity of new water resource development by improving dam operation

The water sources for SPAM Jatiluhur I, Jatluhur II and Buanan III are secured by changing the reservoir water use capacity allocation of the Jatiluhur Dam, with plans to limit existing irrigation water and divert it to municipal water rather than developing new water resources. This applies the idea of prioritizing municipal water over irrigation in water utilization priority criteria.

The figure below shows the operation status of the reservoir of the Jatiluhur Dam over the past 20 years. During this period, the water storage level has reached the minimum water level of 6 degrees (drought once every three years), so it is clear that the water utilization capacity is insufficient at present.

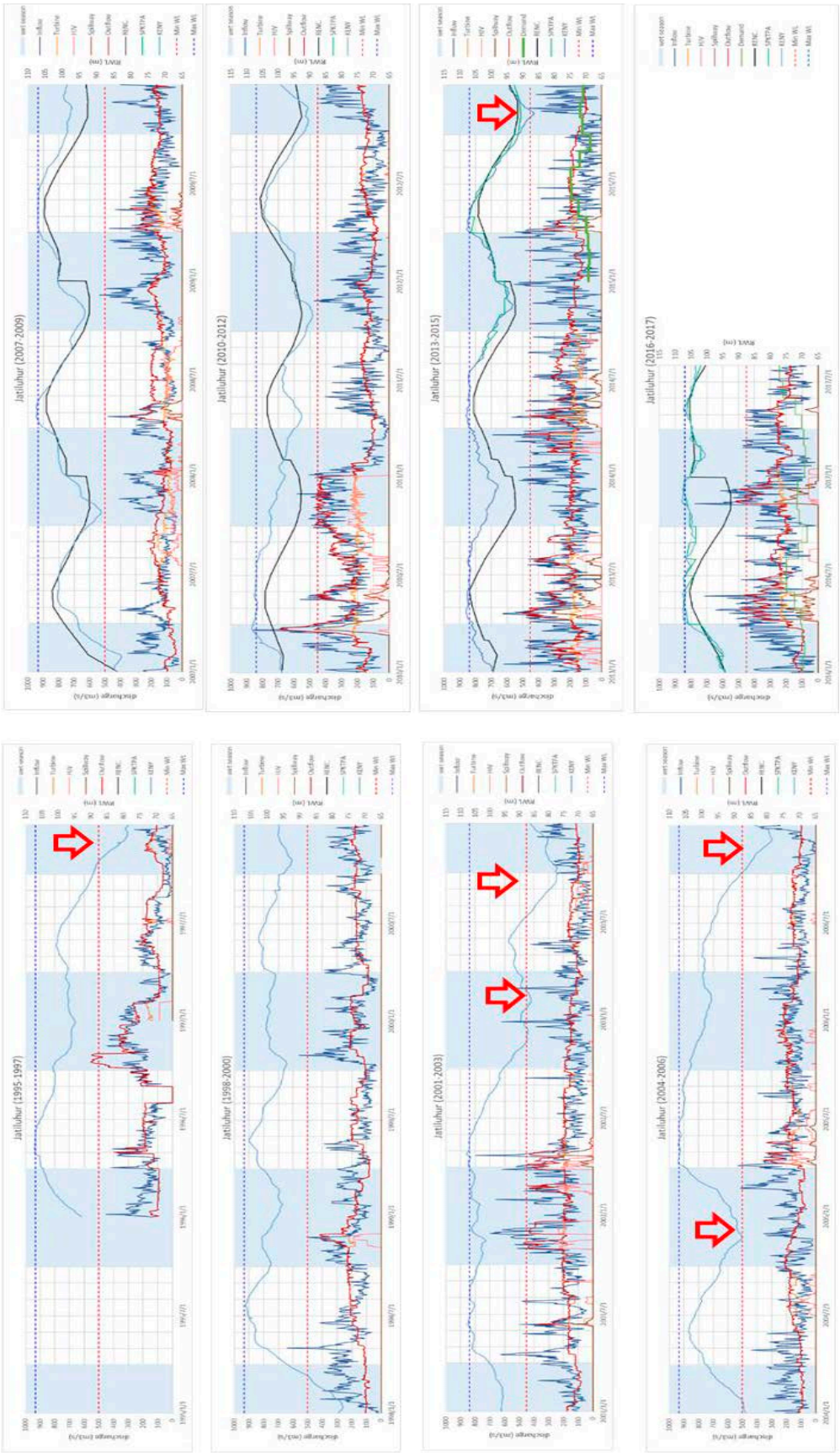


Figure 3.68 **Jatiluhur Reservoir Operation Record: 1995 to 2017**

The table below shows the operation results of the Jatiluhur Dam from 2001 to 2014 by month. The brown colored areas represent the months when the discharge from the dam does not meet the water demand. The table also shows that the Jatiluhur dam was unable to supply sufficient water for demand, especially between March-July and October-December.

Table 3-54 Ratio of Water Discharge to Water Demand from 2001 to 2014。

MONTH / YEAR	JAN %	FEB %	MAR %	APR %	MAY %	JUN %	JUL %	AUG %	SEP %	OCT %	NOV %	DEC %	MINIMUM RWL (m.asl)
2001	172.31	144.37	123.89	117.89	97.40	107.95	92.11	173.07	401.21	174.43	179.91	251.75	95.43
2002	151.10	264.54	211.19	267.55	127.00	95.87	107.88	138.32	157.71	117.45	86.83	101.70	87.11
2003	173.68	157.62	120.31	97.11	81.54	80.56	83.22	124.95	171.29	76.77	61.06	83.75	77.05
2004	111.43	112.92	113.54	104.61	73.66	78.76	102.82	158.10	276.83	127.24	105.07	108.68	86.61
2005	102.44	113.84	94.93	227.48	119.49	96.02	80.78	127.48	271.39	114.23	109.53	160.32	90.71
2006	217.82	173.53	134.07	109.87	77.48	75.14	86.49	111.90	199.94	94.34	69.20	69.35	78.39
2007	108.28	55.41	81.74	81.36	80.58	78.32	89.40	147.14	258.22	144.51	98.07	104.83	82.73
2008	112.76	115.83	91.96	187.58	135.00	107.71	108.19	146.00	199.97	118.83	122.83	175.66	93.34
2009	151.76	133.49	150.36	222.52	149.69	111.79	105.81	147.80	267.96	128.31	113.44	151.52	97.23
2010	172.44	197.71	451.52	289.44	216.81	142.67	129.53	278.70	685.30	343.39	328.19	424.93	97.99
2011	242.51	155.68	117.86	104.28	74.94	79.45	89.66	143.11	273.12	112.25	103.98	153.87	89.14
2012	124.98	112.07	96.54	86.82	86.91	81.23	92.74	128.42	245.03	99.92	107.15	128.65	90.51
2013	261.31	412.93	202.48	433.24	259.66	135.22	171.47	246.02	470.27	222.63	198.55	196.27	97.92
2014	225.23	296.47	301.08	243.22	156.94	104.26	145.18	194.72	297.57	160.81	135.33	146.34	93.19

(4) Operation Improvement Plan for Cisadane Cascade Dams

The method of improving the operation of the Citarum River Cascade Dams and its simulation are examined in detail in the "FY2017 Overseas Disaster Prevention/Water Infrastructure, Basic Information Collection and Cooperation Possibility Study Work, MLIT" based on past operational results. Its effectiveness was confirmed during the study work.

The outline is shown below.

*** Current Status and Issues of Operational Rules**

There are three large dams on the Citarum River (from the downstream, Jatiluhur Dam, Cirata Dam, and Saguling Dam). The three dams are operated based on the operation rule "Equal Sharing". The water storage level of the 3 dams is controlled within the upper and lower limits. The water storage rate of the effective water storage capacity is set, and the water is discharged to maintain this water storage rate.

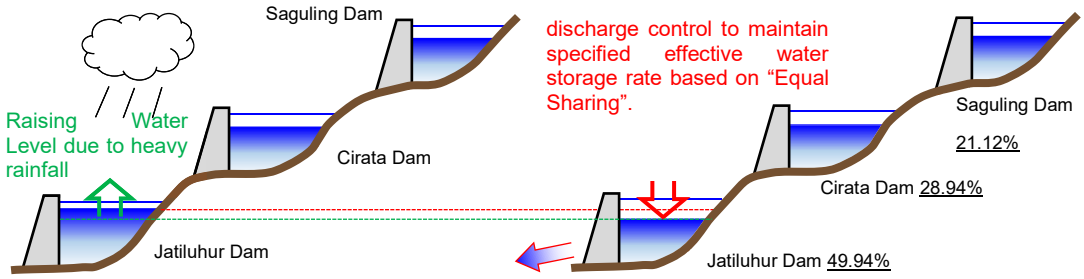
Table 3-55 Reservoir Operation Rule of 3 Cascade dams on the Citarum River (Equal Sharing)

No.	Description	Dam		
		Jatiluhur	Cirata	Saguling
1	Reservoir WL (lower Limit)	87.5 m	206 m	625 m
2	Reservoir WL (upper Limit)	106.5 m	219.5 m	642.5 m
3	Initial WL (required WL on Jan 1)	105.31 m	216.88 m	639.02 m
4	Reservoir Volume Rate	49.94 %	28.94 %	21.12 %

"Equal Sharing" has the advantage of equalizing the interests of dam managers by maintaining a defined water storage rate, but there are many inefficiencies from the vie point of water resource development.

For example, even if heavy rain occurs at the most downstream Jatiluhur dam and the water storage capacity of the Jatiluhur dam increases, valuable water resources must be released based

on Equal Sharing.



* **Improvement of Operation Rules**

In the preliminary survey conducted by MLIT, the following conditions are set as the rules for developing and operating new water resources at the 3 dams.

- Reserve water from the upstream Saguling dam (fill it up).
- If the effective storage capacity of Jatiluhur Dam is insufficient, supply water to Jatiluhur Dam from the Cirata Dam and Saguling Dam located at upstream.

The effectiveness of the above new operation rule was verified by analysis.

- Calculation period: 1997-2016 (20 years)
- Analytical model: Water balance calculation (based on actual dam inflow and water demand)
- Examination case: (i) Maximum amount of development water that can be produced, (ii) The amount of developed water (+ flood control) that takes into account the reservoir operation curve which is being separately examined by the Indonesian side.

The results of the analysis are as follows.

- There is a possibility of additional water supply to DKI Jakarta (i) 7m^3/sec and (ii) 5.5m^3/sec.
- It was estimated that there was no big difference in the amount of power generation before and after the change in the operation rules, but it is necessary to verify it in consideration of the actual power generation flow rate.
- In order to consider the optimal operation rules that balance the amount of developed water, flood control, and power generation, it is desirable to carry out technical cooperation (development survey) / basic information gathering survey for the purpose of operational improvement.

(5) Pumped Storage Hydropower Scheme for Three Cascade Dams on the Citarum River

When the proposed Citarum 3 Cascade Dams operation focusing on the supply of raw water to Jakarta, has been implemented, new restrictions will be imposed on the power generation of Saguling and Cirata Dams. It is anticipated that the proposed operation will affect the power supply plan of Java-Bali grid. To clarify this outstanding issue, we would like to confirm the actual potential of generated power under the proposed dam operation and compare with the previous record of power generation (need detail data of power generation at Saguling and Cirata dams). Furthermore, to obtain the incentives of hydro-power sector, a pumped-storage power generation using the Cirata or Saguling Reservoirs as upper reservoir and the Jatilufur or Cirata Reservoirs as the lower reservoir will be proposed. Power generation can be performed without any restriction by water use of irrigation and municipal purposes (Equal Shearing). This system will

have a potential generating the more and stable power.

The outline of the plan is as follows.

- Generate and supply electricity during peak power demand time, from 5:00 pm to 9:00 pm.
- Return the water discharged into the Jatilufur Reservoir to the Cirata Reservoir or Cirata reservoir to Saguling reservoir using the surplus electricity at night.
- The required new facility is a pumping facility at lower reservoir and a water conduit, which are for returning water to upper reservoir.
- When the pumped-storage system between Saguling dam and Cirata dam, the existing Rajamandala power station (run-of-river type power station) also can enjoy the generating power using water from Saguling.

It should be noted that this plan focuses on efficient water supply to Jakarta, economic efficiency should be evaluated together with water supply to Jakarta, and power generation should be considered as ancillary. Therefore, it is necessary to judge the adoption of a business from the following viewpoints in addition to the economic efficiency of the business.

- The need for pumped storage power plants from the perspective of electricity demand
- Need for water supply as a countermeasure against water shortage and land subsidence in Jakarta

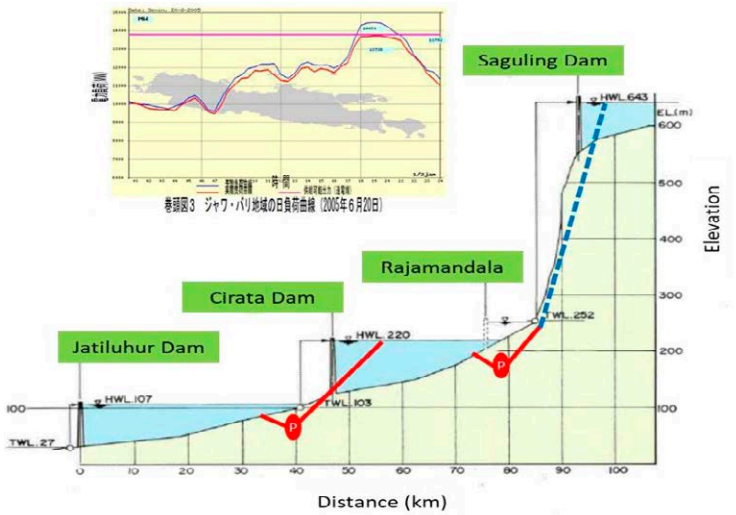


Figure 3.69 Pumped Storage Scheme for Three Cascade Dams on the Citarum River

1) **Cirata-Jatiluhur Pumped Storage Project**

Cirata-Jatiluhur Pumped Storage Project is;

i) Water of Cilata reservoir will flow down to Jatiluhur Reservoir through Cirata hydropower plants during peak load time (maybe 5pm to 10pm);

ii) The discharged water is pumped up at Jatiluhur reservoir and return to Cirata reservoir through waterway tunnel using surplus electricity during off-peak load time (nighttime) for pump operation;

By implementing this project, it will be possible to generate electricity as needed (at peak load) without following the rules of Equal Shearing, which is a great advantage for the Cirata power plant.

Required Facilities

- Pumping station (or powerhouse) at upstream end of Jatiluhur Reservoir
- Waterway tunnel with 13 km long

Issues

- Despite the need for a 13km waterway, the water head can only secure 100 m, so it cannot be expected as a commercial power generation project.
- This plan focuses on efficient water supply to Jakarta (Economic efficiency should be evaluated together with water supply to Jakarta and Power generation may be ancillary).

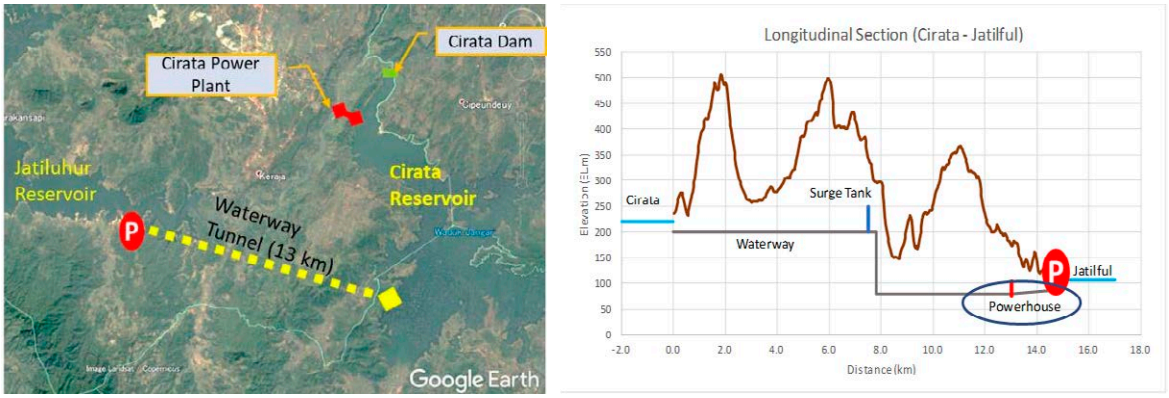


Figure 3.70 Jatiluhur–Cirata pumped storage

2) **Saguling-Cirata Pumped Storage Project**

Saguling-Cirata Pumped Storage Project is;

i) Water of Saguling reservoir will flow down to Cirata Reservoir through two hydropower plants (Saguling and Rajamandala) during peak load time (maybe 5pm to 10pm);

ii) The discharged water is pumped up at Cirata reservoir and conveyed to Saguling power plant using surplus electricity during off-peak load time (nighttime) for pump operation;

iii) The water is pumped up again using surplus electricity from Saguling power plant to Saguling reservoir through existing penstock.

Required Facilities

- Water intake facility (pumping station) at Cirata reservoir,
- Water conduit from intake facility to Saguling power plant connecting to penstock of Saguling.。

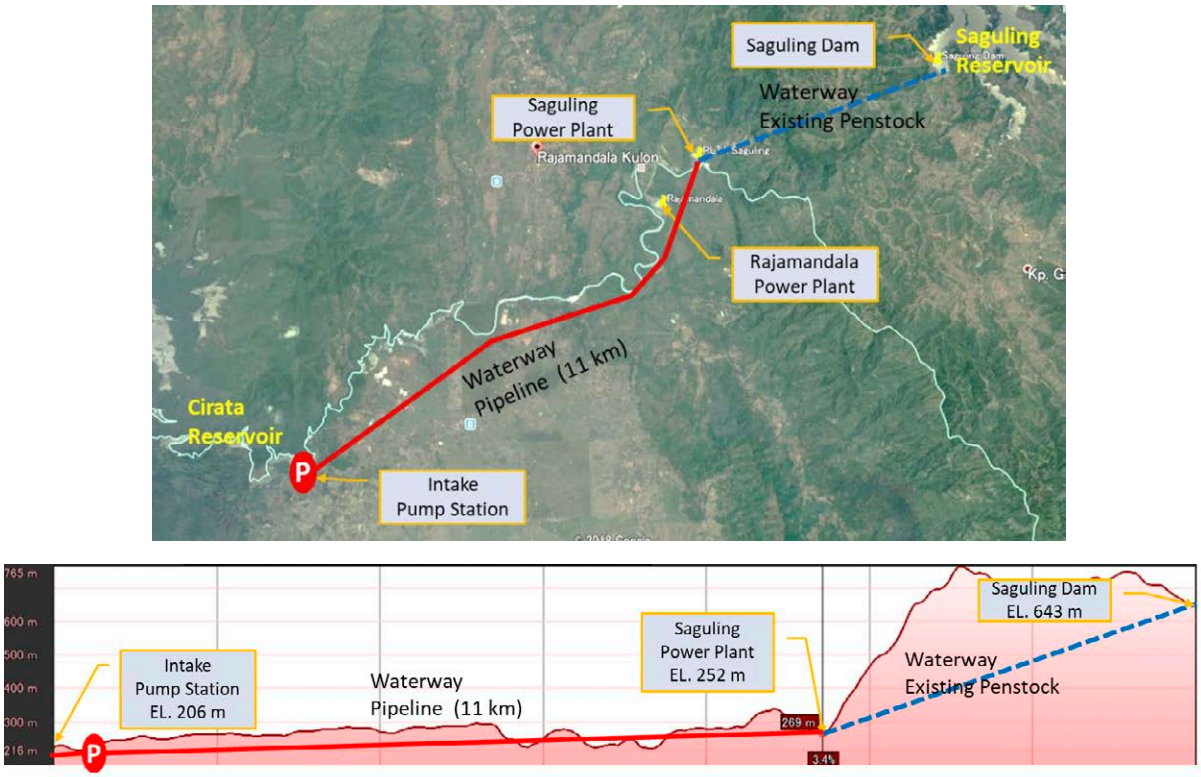


Figure 3.71 Cirata-Saguling pumped storage

3.3.7 MOU on Regional SPAM

Since there is possibility to be changed the Governor of DKI Jakarta due to the election of the governor and the local council in October 2022, among the parties involved in SPAM of DKI-Jakarta (Ministry of Interior, Ministry of Public Works and Housing and DKI Jakarta), MOU on Implementation of DKI Jakarta Regional SPAM was signed on January 3, 2022 for the purpose of confirming the agreement on the issues. In the MOU, the implementation projects in Regional SPAM projects for DKI-Jakarta and the responsibilities of each organization are described. All these processes are stated to be carried out in accordance with PUPR's existing regulations. Therefore, the large-scale water resources development plan described in the MOU will proceed in accordance with this MOU.

Also, on the MOU signing date, The Governor of DKI Jakarta announced a policy that the use of pumped groundwater within service area of PAM JAYA will be limitted or prohibited in line with the progress of these SPAM projects, as described in Governor Regulation No. 93 of 2021.

MOU on Regional SPAM

NOTA KESEPAKATAN

ANTARA

KEMENTERIAN DALAM NEGERI REPUBLIK INDONESIA

DENGAN

KEMENTERIAN PEKERJAAN UMUM DAN PERUMAHAN RAKYAT
REPUBLIK INDONESIA

DAN

PEMERINTAH PROVINSI DAERAH KHUSUS IBUKOTA JAKARTA

TENTANG

SINERGI DAN DUKUNGAN PENYELENGGARAAN SISTEM PENYEDIAAN AIR MINUM
DI PROVINSI DAERAH KHUSUS IBUKOTA JAKARTA

NOMOR 119/10/SJ
NOMOR 01/PKS/M/2022
NOMOR 1 TAHUN 2022

Pada hari ini senin tanggal tiga bulan Januari tahun Dua Ribu Dua Puluh Dua, kami yang bertanda tangan di bawah ini:

1. MUHAMMAD TITO KARNAVIAN : Menteri Dalam Negeri, dalam hal ini bertindak untuk dan atas nama Kementerian Dalam Negeri Republik Indonesia berdasarkan Keputusan Presiden Nomor 113/P Tahun 2019, yang berkedudukan di Jalan Medan Merdeka Utara Nomor 7, Jakarta Pusat. Untuk selanjutnya disebut PIHAK KESATU.

2. M. BASUKI HADIMULJONO : Menteri Pekerjaan Umum dan Perumahan Rakyat, dalam hal ini bertindak untuk dan atas nama Kementerian Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia berdasarkan Keputusan Presiden Nomor 113/P Tahun 2019, yang berkedudukan di Jalan Pattimura Nomor 20, Jakarta Selatan. Untuk selanjutnya disebut PIHAK KEDUA.

3. ANIES RASYID BASWEDAN : Gubernur Daerah Khusus Ibukota Jakarta, dalam hal ini bertindak untuk dan atas nama Pemerintah Provinsi Daerah Khusus Ibukota Jakarta berdasarkan Pasal 65 ayat (1) Undang-Undang Nomor 23 Tahun 2014 tentang Pemerintahan Daerah sebagaimana telah beberapa kali diubah terakhir dengan Undang-Undang Nomor 11 Tahun 2020 tentang Cipta Kerja yang berkedudukan di Jalan Medan Merdeka Selatan Nomor 8-9, Jakarta Pusat. Untuk selanjutnya disebut PIHAK KETIGA.

PIHAK KESATU dengan PIHAK KEDUA dan PIHAK KETIGA, selanjutnya secara bersama-sama disebut PARA PIHAK, terlebih dahulu menerangkan hal sebagai berikut:

(1) Procurement Program

As a joint responsibility efforts, planning and implementation of a piped water services will be conducted among the three parties, including regulation, technology, financing, asset optimization, and management including tariffs and subsidy policies on both regional and state scales.

Projects listed in the table below, presented in the MOU, will be procured under APBN (national budget)/APBD (local government budget) and other sources of funding.

Table 3-56 Procurement programs listed in MOU

No	Plan	Capacity (lps[7]) / Length of Pipe (km)	Construction and Absorption Time
	Regional Program		
1	SPAM Jatiluhur I - Upstream	4,000 lps	2022 - 2028
	SPAM Karian Serpong – Upstream	3,200 lps	2022 - 2028
	DKI Jakarta Province Plan		
1	SPAM Jatiluhur I – Downstream*	1,910 km	2023 - 2028
2	SPAM Karian Serpong – Downstream*	660 km	2023 - 2028
3	SPAM Buaran III	3,000 lps	2022 – 2025
	Upgrade (increasing the capacity) of SPAM Buaran I & II (In accordance with available water balance)	1,000 lps	2023 – 2025
4	Province SPAM (i.e., Pesanggrahan, Ciliwung, communal, Cilandak)	1,350 lps	2022 – 2025
5	Decrease of NRW (Non-Revenue Water)		2023 – 2030
6	Cyclical Maintenance		2023 – 2030
7	(Direct) Connection		2023 – 2030
8	Others and Building (supporting infrastructues)		2023 – 2030
	Sub Total	12,550 lps 2,570 km	
	Integrated Regional Program		
1	Regional SPAM Jatiluhur II/ Djuanda Integrated (upstream)	2,054 lps	2023 – 2027
2	Regional SPAM Jatiluhur II/ Djuanda Integrated (downstream)		2025 – 2029

Notes: *) including financial support

(2) Missions and Responsibilities

The missions and responsibilities of MoHA, PUPR, and DKI-Jakarta are are as below and summarized in Table below.

1) Ministory of Internal (MoHA)

- Promote and prepare the policy and regulatory supports that DKI-Jakarta needs to implement SPAM. This includes the preparation of regional planning documents, financial assistance, tariff adjustments, regulatory coordination between relevant authorities, and other issues related to public services required through the implementation of SPAM.
- Coordinate, guide and supervise the missions of relevant authorities within the scope of SPAM management.
- Work with PUPR to suport DKI-Jakarta reduce the burden of implementing Regional SPAM and solve problems.
- Cooperate with PUPR / DKI-Jakarta on the principles of information disclosure, business transparency, accountability and anti-corruption in accordance with regulatory provisions.

2) Ministry of Public Works and Public Works (PUPR)

- Support the preparation of policies and regulations necessary for the implementation of SPAM.
- Provide technical and other assistance at all stages of SPAM implementation, as required by law.
- Propose and issue approvals under the authority of PUPR.
  - Allocation of raw water to the following water purification plants (IPA)

[7] Liter per Second

(including confirmation of water balance and preparation of administrative documents) in accordance with the provisions of laws and regulations.

- IPA Buaran III;
- IPA Pesanggarahan;
- IPA Ciliwung;
- IPA Cilandak;
- IPA Hutan Kota;

▪ Determining the location of the intake.

▪ Install a pipe on a national road registered as an asset of PUPR.

▪ Construction of other supporting facilities

o Provide financial assistance to improve the feasibility of SPAM implementation through APBN or other sources (Rp2.1 trillion for SPAM Jatiluhur 1 and SPAM Karian-Serpong's terminal facilities (Phase 1)).

o Assist DKI-Jakarta in considering solutions in case there are signs that the goal will not be significantly achieved.

o Discuss with DKI-Jakarta if subsidies are needed to implement SPAM.

o Regularly discuss the implementation of the entire SPAM plan with DKI-Jakarta.

o Work with MoHA to help DKI-Jakarta reduce the burden and solve problems for SPAM implementation.

o Cooperate with MoHA and DKI-Jakarta in accordance with legislation on the principles of cooperation, public information, transparency, accountability and anti-corruption.

3) DKI-Jakarta

o Establish and operate policies for implementation of SPAM under the roles, responsibilities and authorities of DKI-Jakarta.

o Promote technical support and authorization under DKI-Jakarta's responsibilities, functions, and authority regarding the implementation of SPAM in accordance with legislation.

o Propose recommendations (advise) and apply for permits necessary for the implementation of water resources development projects (water businesses).

o Propose SPAM prioritized plans and budgets based on SPM (Minimum Standard Service), taking into account financial capacity.

o If necessary, allocate budget through APBD in accordance with legislation to increase the feasibility of implementing SPAM, such as by providing subsidies and other support, taking into account financial capacity.

o Discuss with PUPR if there are any issues that the goal will not be achieved significantly.

o Discuss with MoHA and PUPR if subsidies are needed to operate SPAM.

o Assign PAMJAYA as an Offtaker.

o Allocate SPAM operation items that can be implemented jointly to PAMJAYA in accordance with laws and regulations.

o Adjust water tariffs, including tariff restructuring, customer reclassification, and tariff increases.

o Regularly discuss the implementation of the entire SPAM plan with DKI-Jakarta.

- Prepare and implement mitigation measures for problems in implementing SPAM.
- Cooperate with MoHA and PUPR in accordance with legislation on the principles of cooperation, public information, transparency, accountability and anti-corruption.

Table 3-57 Division of roles for water-related projects

	Description	Organization		
		MoHA	PUPR	DKI Jakarta
1	Preparation of additional contract for approval of buyer of supplied raw water (here, DKI Jakarta), one year after Issuance of MoU		○	○
2	Prepare a policy to support the revision of water charges	○	○	○
3	Land acquisition for SPAM Jatilfur-I and Karian Serpong (downstream) among water services projects			○
4	Construction of a network and water tank to execute the 5% budget in 2024, the first year of the budget		○	
5	Advance financial planning in Stage 1 for Jatilfur-I and Karian Serpong among water-related projects (downstream)		○	
6	Preparation of materials necessary for PUPR to submit a financial plan			○

(3) Change of SPAM Project Plan in MOU

Prior to concluding the MOU, plan of Regional SPAM in DKI Jakarta has been significantly changed by examining the feasibility. The specific changes are as follows.

- Changed the target year from 2035 to 2030.
- Due to the change of target year, the target water demand of DKI Jakarta was changed from 42.11 m3 / s (2035) to 31.875 m3 / s (2030) (calculation basis is not available. Water demand in 2030 was estimated at 40.91 m^3/sec by BBWS CiliCis in 2017).
- The improvement targets by 2030 are : Service area expanding from current 60% to 100% and the non-revenue water rate (NRW) from current 44% to 26% (in estimation in 2017, applying 38.5% of current NRW rate and 30% of target NRW rate).
- The name of SPAM Jatiluhur II was changed to Regional SPAM Ir. H. Djuanda, and the initial raw water supply of 10 m^3/sec was changed to 7 m^3/sec. The supply to DKI Jakarta will be reduced from 5 m^3/sec to 2.054 m^3/sec, and the remaining 3 m^3/sec will be used for the Buaran III water source (3 m^3/sec, which was included in the original plan, is no longer be in the new plan).
- The water intake point of Buaran III, which was initially taken directly from West Tarum Canal at the WTP, was changed to 5 km upstream of the Bekasi siphon in consideration of the lack of flow capacity of the siphon and send to Buaran WTP through pipe.
- For SPAM Karian Serpong project, the pipe alignment of KSWCS and location of WTP is changed. In the original plan, it is planned to use the existing Serpon WTP but replaced to new Karian WTP which located about 8.5km downstream from Serpong WTP.
- In SPAM Jatiluhur I and Spam Karian-Separate, the water supply from the WTP to the Distribution Center is separated from the contracts as KPBU Hilir DKI Jakarta (PPP project of downstream of DKI Jakarta).



Figure 3.72 Target of Water Supply System Improvement

Source : Rapat Koordinasi Terbatas Dalam Rangka Pemenuhan Air Minum Wilayah DKI Jakarta, M. Baski Hadimuljono、December 2021

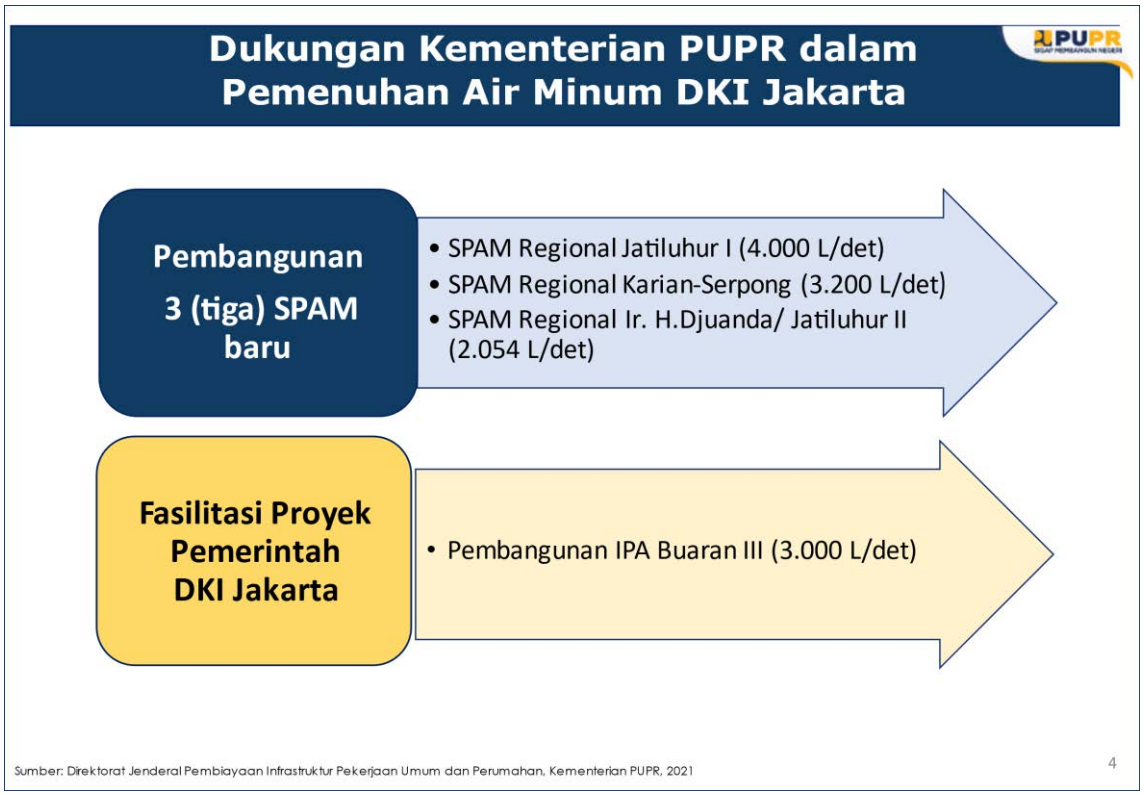


Figure 3.73 Capacity of Raw Water Supply of SPAM 4 Projects

Source : PEMENUHAN AIR MINUM WILAYAH DKI JAKARTA, Herry Trisaputra Zuna, Direktur Jenderal Pembiayaan Infrastruktur Pekerjaan Umum dan Perumahan, 17 Desember 2021

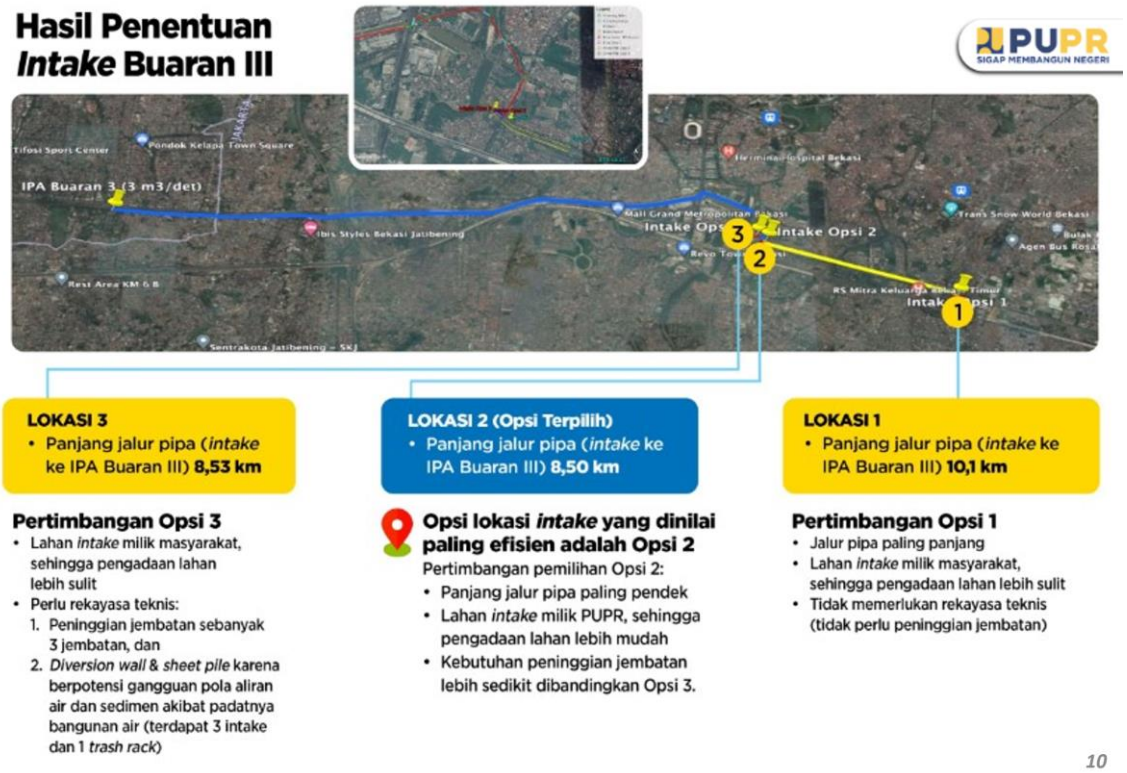


Figure 3.74 Comparison of Buaran III Intake Location (to be selected Lokasi 2)

Source : Rapat Koordinasi Terbatas Dalam Rangka Pemenuhan Air Minum Wilayah DKI Jakarta, M. Baski Hadimuljono、December 2021

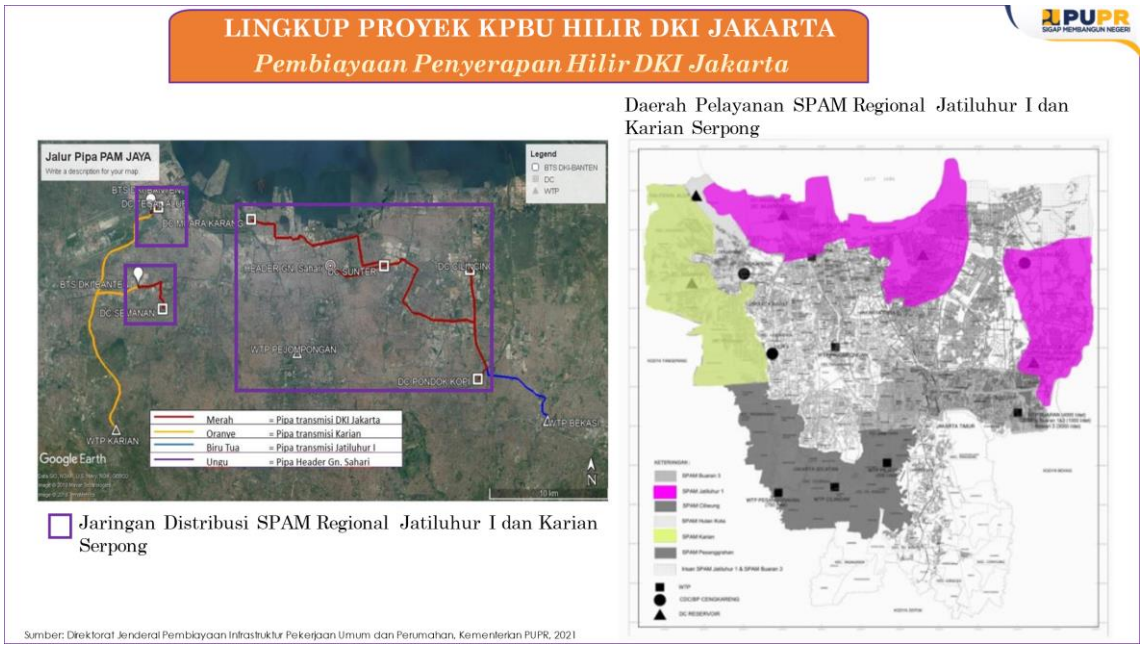


Figure 3.75 WTP Karian and SPAM Jatilhulu I/Spam Karian Serpon Downstream Project

Source : Rencana Penyerapan Air Minum Curah dan Pembiayaan Hilir Proyek KPBU SPAM Regional Jatiluhur I dan Proyek KPBU SPAM Regional Karian-Serpong, Cipta Karya 資料

(4) Implementation Plan of SPAM Projects

As of Dec. 2022, The implementation plan for SPAM projects is as shown in the figure below.

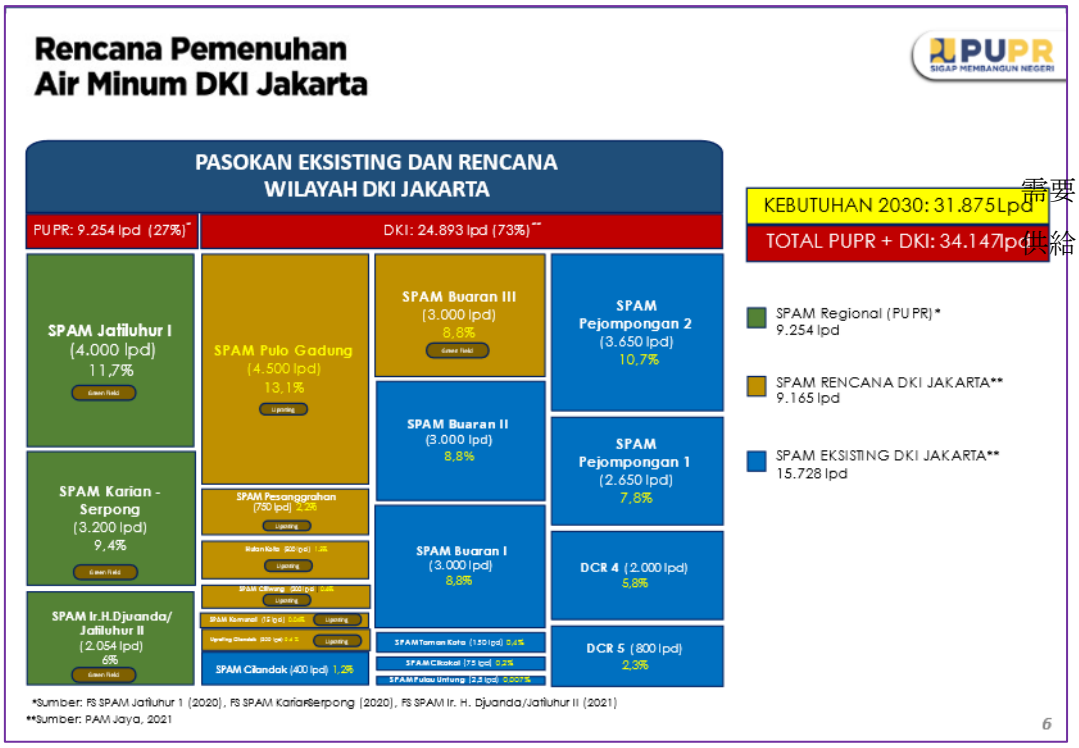


Figure 3.76 Component of SPAM Projects in DKI Jakarta

Source : Rapat Koordinasi Terbatas Dalam Rangka Pemenuhan Air Minum Wilayah DKI Jakarta, M. Baski Hadimuljono、December 2021

Implementation Schedule and scope of works for PUPR、DKI Jakarta are as shown in Figure ____ and Table____ respectively。

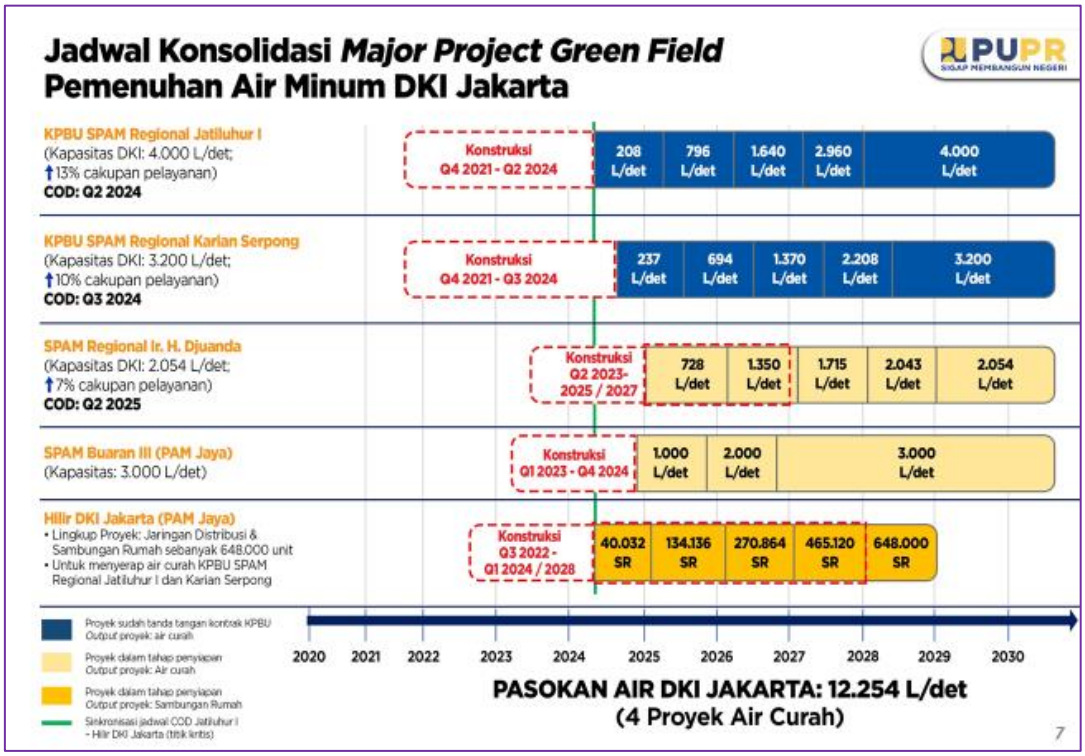


Figure 3.77 Implementation Schedule of Regional SPAM Projects in DKI Jakarta

Source : Rapat Koordinasi Terbatas Dalam Rangka Pemenuhan Air Minum Wilayah DKI Jakarta, M. Baski Hadimuljono、December 2021

Table 3-58 Follow Up Activities under PUPR and DKI Jakarta

No	Activities	Executer	Target Day
1	SPAM Jatiluhur I and Karian-Serpong Process of financing downstream infrastructure development Project (Phase I) proposed by the Regional SPAM.	Kementerian PUPR	Januari 2022
2	Facility planning criteria to support the Phase I funding proposal process	Provinsi DKI Jakarta	s/d September 2022
3	Consensus building on raw water sales contract (SPAM Karian Serpong)	Kementerian PUPR & Provinsi DKI Jakarta	s/d Maret 2022
4	Approval of FS study report for downstream development projects to determine the initiater of SPAM Ir H Djuanda	Provinsi DKI Jakarta	s/d Maret 2022
5	Downstream Infrastructure Development Phase II, SPAM Jatiluhur I SPAM Karian-Serpong and the preparation of an integrated financing scheme for existing assets (bundling)	Provinsi DKI Jakarta	s/d Maret 2022
6	Providing land for downstream infrastructure development of SPAM Jatiluhur I, SPAM Karian Serpong and SPAM Ir H Djuanda	Provinsi DKI Jakarta	s/d September 2022

Sources : Rapat Koordinasi Terbatas Dalam Rangka Pemenuhan Air Minum Wilayah DKI Jakarta, M. Baski Hadimuljono、December 2021

(5) Possibility of JICA Support for SPAM Project

At the Regional SPAM MOU signed in January 2022, as the division of roles of PUPR, "To proceed the financial plan for the downstream water transmission facility and for the water distribution center (DC) project (Stage 1) of Jatilfur-I and Karian Serpong among water supply related projects (downstream side) "is stated. For this reason, CIPTA Karya, PUPR, was requested the JICA Team to consider the possibility of JICA's support, including time restrictions in its national strategy.

The upstream part of the Regional SPAM of Jatiluhur I and Karian-Serpong (raw water conduction project) is already funded under the PPP scheme, but the investment of 12.1 trillion rupiah is additionaly required for the construction of the downstream part (Stage 1). PUPR plans to raise 2.1 trillion in APBN, but the remaining 10 trillion has not yet been decided. Furthermore, for Karian Serpong (downstream), additional $ 2 trillion should be invested.

According to the current implementation plan, the start of construction is scheduled in 2023, so that it is unlikely that it will be in time for the implementation schedule if normal procedures are taken for the conclusion of the Loan. According to the interview at Cipta Karya, KSWCS is expected to be delayed by at least one year, but construction of SPAM Jatiluhur I has already started, therefore Stage 1 must start as scheduled and it is important issue to avoid changing the process.

At this time, the plan is not included in the blue book, but according to Cipta Karya's SPAM representative, the blue book could be revised immediately.

Table 3-59 Expect Loan Project and Required Amount

JATILUHUR 1

Phase 1 (2022-2023)	Total (IDR billion)
I. Transmission Unit	
Package 1: Offtake Building - DC Pondok Kopi	60.6
Package 2: Offtake - Raya Bekasi	550.3
Package 3: Raya Bekasi - DC Cilincing	132.2
DC Pondok Kopi	194.2
DC Cilincing	206.2
II Distribution Unit	
DC Pondok Kopi - Pondok Kelapa	103.8
DC Cilincing	201.8
Sub Total Phase 1	**1,449.0**

Phase 2 (2024-2029)	Total (IDR billion)
I. Transmission Unit	
Package 4: Raya Bekasi - Danau Sunter Selatan	1,941.7
Package 5: DC Sunter - Gunung Sahari	204.4
Package 6: Danau Sunter Selatan - DC Muara Karang	621.7
DC Sunter	392.6
DC Muara Karang	259.0
II Distribution Unit	
DC Pondok Kopi - Pondok Kelapa	474.1
DC Cilicing	765.6
DCR Muara Karang	1,113.4
DCR Sunter	1,396.2
Feeder Gunung Sahari	781.4
Sub Total Phase 2	7,950.0

KARIAN - SERPONG

Phase 1 (2022-2023)	Total (IDR billion)
Supervision Transmission /Reservoir	7.7
Supervision Distribution	1.2
Preparation Work	12.1
Construction Transmission /Reservoir	545.8
Construction Distribution	40.6
Others work	3.7
Sub Total Phase 1	**611.1**

Phase 2 (2024-2029)	Total (IDR billion)
Supervision Transmission /Reservoir	3.3
Supervision Distribution	12.0
Preparation Work	11.4
Construction Transmission /Reservoir	124.6
Construction Distribution	1,925.2
Others work	11.1
Sub Total Phase 2	**2,087.6**

3.3.8 Long-term, Mid-term and Short-term Vision for Water Resources Development in DKI Jakarta

The basic idea of water resource development at DKI Jakarta is stated in the Water Supply Road Map, which is to realize a stable water supply while implementing the above-mentioned large-scale water resource development and local water resource development. Implementation of the detailed master plan of the Jakarta water supply plan. These plans have many issues for implementation, and it is extremely difficult to realize them as planned.

The three SPAMs (large-scale water resource development projects) currently underway by PUPR are planned to enable sufficient supply of raw water in the long term by 2030. Toward this implementation, an MOU was signed between MoHA, PUPR and DKI Jakarta in January 2022 and measures to achieve sufficient water supply throughout DKI Jakarta by 2030 were clarified.

Based on the contents of this MOU, the long-term, mid-term and short-term visons for DKI Jakarta's water source development to be promoted in the future are summarized below.

(1) Long-term Vison

The water transmission facility for DKI Jakarta will be completed in 2030 by implementing the SPAM projects as schedul shown in the MOU connected by MoHA-PUPR-DKI Jakarta. However, the amount of raw water sources from the Jatiluhur Dam is not sufficient, and there is concern that the dam will be exhausted after the project is completed. In this study, "Operation Improvement Plan for Citarum Three Cascade Dams" was proposed in order to secure water in the Jatiluhur reservoir reliably and effectively. It is essential to take measures to secure raw water in parallel with the implementation of the SPAM project.

(2) Mid-term Vison

In the mid term vison, it will be important to extend and construct a pipe network and water treatment plants in order to expand the service area, which is currently 60%, to 100%. Furthermore, it is essential to achieve the NRW reduction as planed, which included in the water

supply plan. In addition, it is expected that effective use of Situ (irrigation pond) scattered in DKI Jakarta and construction of Long Storage will be used as emergency water souces until the long-term plan is completed.

1) Utilization of Situ and Construction of Long Storage

Around DKI Jakarta, agricultural land (paddy field) has decreased due to the expantion of residential and industrial area, leaving many unused Situ. These reservoirs are usually reclaimed for land development, but they will be able to use as reservoir for municipal water and as flood mitigation facilities. BBWS CiliCis has a plan to utilize these Situs as potential raw water resources, and it is easy to take action toward implementation.

In addition, long storage plan also effective for securing water provisonally and complementary during the dry season. Many drainage channels had been constructed in DKI Jakarta and they are not used during dry season. At the bigining of dry season, channel is closed and reserve water in the channel. Since it is not necessary to secure land, construction can be started easily.

As a method of delivering raw water and purified water, it is conceivable to construct water treatment plant near Situ or Long Storage and to use a water truck until water pipe networks are completed. If there is an existing water treatment plant nearby, directly connected water pipe and use this.

2) Reduction of NRW

The reduction of NRW is a countermeasure included in future plans and is a measure for an effective use of limited resources that must be implemented, while it is limited to the pipe distribution area.

Although it is difficult to see the effects of new water resources development project, it is an extremely important and effective measure to use water. At present, the loss of water is about 40% of 8m^3/sec or more, and if this is reduced to 20%, the same effect as the development of new water resources of 4 m3 / s or more can be expected. It will be a steady work and it will take time, but it is a measure that must be gradually advanced. This includes the replacement of aging pipes and the introduction of small blocks (DMA : Distrct Meter Area or LCZ : Leakage Control Zone).

(3) Short Term Vision

In order to secure an alternative water source for groundwater in the short term, the effective use of local water by using rainwater and desalination of seawater has been be implemented at large-scale commercial or industrial facilities.

Desalination of seawater has already been carried out at Tanjung Priok Port and Purit Reservoir. In this project, therefore, the "rainwater storage facility" described in the next chapter is implemented as a pilot project.

In addition, as a NRW reduction plan that can be implemented in a short term, it is conceivable to reduce the amount of water leakage by pressure adjusting (decompression) during times when water usage is low.

The most effective measure against water leakage from pipe is the renewal of pipelines. Especially in Jakarta, more than 30 years have passed since the water distribution pipes and water supply pipes were installed, and it is considered that most of them have exceeded their useful lives. However, renewal of all pipelines requires enormous cost and time, and short-term implementation is difficult. Therefore, it must be carried out sequentially in the medium to long term vision.

When considering short-term countermeasures for reduction of water leakage, it is effective to pay attention to "leakage due to high water pressure", which is one of the causes of water leakage.

Generally, the higher the water pressure, the larger the amount of water leakage. During times when water usage is low, such as at night, the water pressure in the distribution pipe network tends to rise and the amount of water leakage tends to increase. Therefore, it is possible to reduce the amount of water leakage by appropriately controlling the water pressure in distribution pipe network. For implementation, it is necessary to verify the actual daily fluctuation of pipe pressure

and the effect of reducing the amount of water leakage by pressure control in the current water distribution pipe network in advance.

3.4 Current Situation and Issues of Water Supply Services

3.4.1 Mandate of Water Supply Services

The Ministry of Public Works and Housing Regulation No. 15/PRT/M/2015 concerning "Organizing and Working Procedures for the Ministry of Public Works and Housing" gives job description for the Ministry of Public Works and Housing. However, detailed task allocation for surface water development and water supply service is not clearly mentioned. According to the interview with the Directorate of Water Resources Management, the Directorate General of Water Resources, development of dam and intake facilities is the responsibility of the Directorate of Water Resources Management. While the Directorate of Water Supply System Development, the Directorate General of Human Settlements is made responsible for development of water supply systems such as water conveyance facilities and water treatment plants.

Surface Water Development (Dams, intake facilities, etc.):	Directorate General of Water Resources
Water Supply Systems (Water conveyance facilities, water treatment plants, etc.):	Directorate General of Human Settlements

3.4.2 History of Water Supply Services Development

(1) General

Table 3.60 shows the history of water supply services in DKI Jakarta.

Table 3.60 The history of water supply in DKI Jakarta

Year	Item
1843	To meet the need for water of Jakarta (Batavia), the Dutch East Indies Government supplied clean water from wells/artesian groundwater wells
1918-1920	Spring water source was found at Ciburial in Ciomas, Bogor by the Dutch East Indies Government with 484 l/s capacity. This is the moment of the establishment of Gementeestaat waterleidengen van Batavia
1922	On December, for the first time water from Ciburial Bogor distributed to Batavia (Jakarta), and the date was then commenced as the anniversary of PAM JAYA
1945-1963	Drinking water service was carried out by Municipal Office of Drinking Water Supply under the Municipal Public works Unit
1972	*Formulation Master plan by France*
1977	On 30 April 1977, PAM JAYA was legitimized under DKI Jakarta Regional Regulation No. 3/1977. On November 2nd, 1977 PAM JAYA was confirmed under the Decree of the Minister of Home Affairs No. PEM/10/53/13350 and announced in DKI Jakarta Gazette No. 74/1977
1985	*Formulation of Water supply Master plan(JICA)*
1997	*Amendment of Water supply Master plan(JICA)*
1997	On 6 June 1997, Cooperation Agreement for a period of 25 years was signed between PAM JAYA and 2 Private Parties, i.e. PT.Garuda Dipta Semesta which at present has become PT.PAM LYONNAISE JAYA (PT. PALYJA) and PT.Kekar Pola Airindo which at present has become PT.THAMES PAM JAYA (PT. TPJ)
1998	On 1 February 1998, fully operation of drinking water supply for Jakarta was carried out by the 2 Private Parties
2001	After renegotiations, the Cooperation Agreement was revised and restated (Amended & Restated) and has become effective since 22 October 2001
2004-2005	On 24 December 2004, Addendum Cooperation Agreement 2001 was signed for west region (PT. PALYJA). While on7 October 2005 Addendum Cooperation Agreement 2001 was signed for east region (PT. TPJ)
2008-2009	On 20 October 2008 Addendum Cooperation Agreement 2001 was signed for west region (PT. PALYJA). Whil e on 8 January 2009 Addendum Cooperation Agreement 2001 was signed for east region (PT. AETRA)
2014	*Proposal of Master plan by DKI*
2017	*The Supreme Court ordered termination of water privatization and restoration of public management to ensure human right to water.*
2023 (TBD)	Termination of privatization, re-municipalization (TBD)

Source: The Project Team based on PAMJAYA Website (http: //pamjaya.co.id/en/profile/history)

(2) 1985 Master plan

1) Outline

Table 3.61 shows a summary of the Water Supply Master Plan (hereinafter referred to as the 1985 JICA MP), which was developed with JICA assistance in 1985. The planning period of this master plan is 20 years from 1985 to 2005.

Table 3.61 Outline of the 1985 JICA Master Plan

Item	1980	1985	1990	1995	2000	2005
Population (thousand, A)	6,469	7,630	8,873	9,950	11,005	11,999
Population in water supply area (thousand, B)	4,949	5,372	6,538	8,002	9,092	10,496
Water supply area (km^2)	283	283	338	383	414	454
Population of water distribution (C)	4,024	4,419	5,357	6,523	7,497	8,784
Average water supply volume (l/sec)	5,500	7,800	15,900	20,300	25,300	31,500
Average water supply volume per capita (l/capita/day)	118	153	257	268	291	309
Planned water supply volume (l/sec)	5,500	7,800	12,800	23,300	29,300	36,300
NRW (%)	77(1977) 53(1983)	49	40	33	29	25
Water source	Spring Ciliwung Sunter	Spring Ciliwung Sunter	Spring WTC*1 Cisadane	TJC*2 WTC Cisadane	TJC WTC Cisadane	TJC WTC Cisadane

*1 WTC: West Tarum Canal, *2 TJC: Tarum Jaya Canal

The planned scale of JICA MP in 1985 is summarized by item as follows, based on the current status.

- The future projected population shows generally the same trend as the current situation.
- The reason for this is that there is a certain number of people who depend on groundwater use and will not be able to use the water supply even if it is built.
- The projected water supply area does not cover the entire Jakarta Special Region (661 km^2). The reason for this is that the population density of the surrounding areas in the east and west regions is low, and it is assumed that the maintenance efficiency is low.
- The large increase in the daily water supply per capita from the current 100-150 liters to about 300 liters is presumably due to the anticipation of increased water consumption due to changes in lifestyle and to the consideration of commercial use.
- The planned water volume is 36.3 m^3/sec, which is almost the same as the current plan of about 35 m^3/sec in 2030.
- As for the water source, the current source is Ciburial (Spring) in Bogor, and Ciliwung and Sunter in the city. But in the future, the source will be WTC and TJC, which are fed by Jatiluhur Dam and the Cisadane River, which borders the west side of Jakarta Special Region. In the future, the water will be diverted to WTC, TJC, and the Cisadane River, which borders the Jakarta Special Region. Of these, the TJC is a water pipeline planned to be constructed on the northern border of the WTC, using the Cirata and Saguling dams located in the southern part of the Jatiluhur Dam as its water source. This pipeline was planned to provide 30 m^3/second of water supply, but due to the difficulty of land expropriation and the possibility of contaminated water from the surrounding rivers, it has not yet been constructed.

2) Water treatment plant construction project and water source

The 1985 JICA Master Plan planned to upgrade the water treatment plant in stages. The contents of the plan are shown in Table 3.62 along with the water source and water treatment capacity.

Table 3.62 Water treatment plant construction plan- Water treatment plant and its water source, water treatment capacity

unit: m^3/sec

Water treatment plant	1985	1991	1995	2000	2005
Pejompongan	Ciliwung 5.6	WTC 5.6	WTC 5.6	WTC 5.6	WTC 5.6
Pulogadung	Sunter 1.0	WTC 4.0	TJC 4.0	TJC 4.0	TJC 4.0
Buaran I		WTC 2.0	TJC 2.0	TJC 2.0	TJC 2.0
Buaran II		WTC 3.0	TJC 3.0	TJC 3.0	TJC 3.0
Lebakbulus I		Cisadane3.0	Cisadane3.0	Cisadane3.0	Cisadane3.0
Cakung I			TJC 5.0	TJC 5.0	TJC 5.0
Cakung II				TJC 1.0	TJC 3.0
Lebakbulus II				Cisadane5.0	Cisadane10.0
Mini plant/Spring	1.2	1.2	0.7	0.7	0.7
Total	7.8	18.8	23.3	29.3	36.3

Source: 1985 Master Plan

As of 1985, with the exception of the Mini plant/Spring, water supply relied on the two water treatment plants of Pejompongan and Pulogadung, and the two city rivers of Ciliwung and Sunter which were very fragile sources of water. On the other hand, three water treatment plants, Buaran I, Buaran II and Lebakbulus I, were installed by 1991 to meet the growing demand. The plans after 1995 was also to add Cakung I, Cakung II and Lebakbulus II. These were preconditions for securing two new large scale water sources i.e. Jatiluhur Dam and Cisadane, and developing water conduits (WTC, TJC, etc.) from them.

3) Extension program of Master plan period

In the Master Plan of 1985, the ongoing project period was designated as Phase 1, and the planning period of the Master Plan was divided into Phase 2 (1986-1997) and Phase 3 (1998-2005). Phase 2 was divided into the first stage (until 1990) and the second stage (until 1995). It should be noted that the target year in the plan does not necessarily coincide with the construction period.

Table 3.63 Extension program of Master plan period

Item	Phase 2 (first stage)	Phase 2 (second stage)	Phase 3
Target year	1990	1995	2005
Volume (m^3/sec)	6.0	5.0	13.0
Water sources	WTC, Cisadane	TJC	Cisadane, TJC
Water treatment plant and capacity (m^3/sec)	Buaran 3.0 Lebakblus 3.0	Cakung 5.0	Lebakblus 10.0 Cakung 3.0
Details	In-take from Cisadane conduit/conveyance, water treatment plant, trunk main/transmission reservoir, distribution pipe	Conduit/conveyance from Canal I, conduit/conveyance from Cakung to Buaran, water treatment plant, trunk main/transmission reservoir, distribution pipe	In-take and conduit/conveyance from the waterway by Directorate of Water Resources, water treatment plant, trunk main/transmission reservoir, distribution pipe
Budget (million dollar)	Construction 222 Reserve 143 Total 365	Construction 169 Reserve 187 Total 356	Construction 335 Reserve 764 Total 1,099
Construction period	1986-1993	1991-1997	1998-2005

Source: 1985 Master Plan

Time trend of the capacity of 17 water treatment plants is summarized in Table 3.64.

Table 3.64 Time trend of the capacity of 17 water treatment plants

No.	Water treatment plant	Location	Water source	Capacity (l/sec)	Start year	Incremented capacity (l/sec)	Completed year
1	Pejompongan I	Tanah Abang Central JKT	Banjir Canal	2,000	1957		
2	Pejompongan II	Tanah Abang Central JKT	Banjir Canal	1,000 3,000	1970 1973	 600	 1984
3	Pulogadung	Kramt Jati East JKT	Sunter	1,000	1982	3,000	1985
4	Cilandak	Cilandak South JKT	Krukut	200	1977	250	1984
5	Pesing	Taman Sari North JKT	Banjir Canal	5	1980		
6	Muara karang	Penjaringan North JKT	Banjir Canal	100	1982	100	1984
7	Cenkareng	Taman Sari North JKT	Pasanggarahan	50	1982		
8	Sunter	Tanjun Priok North JKT	Sunter	50	1982		
9	Cakung	Cakung East JKT	Irrigation Canal	25	1982		
10	Pajaten	Pasar Minggu South JKT	Ciliwung	5	1976		
11	Condet	Pasar Rebo East JKT	Ciliwung			100	1983
12	Tarogong	Kebayoran Lama South JKT	Grogol			100	1984
13	Bogor Spring	Ciburial, Bogor	Ciburial Spring	300	1922		
14	Deep Well *1	Various locations	Groundwater	120			
15	Buaran I *2		WTC	2,000	1992		
16	Buaran II *2		WTC	3,000	1995		
17	Lebak bulus		Cisadane		?		

*1 Deep Well: total 43 sites, daily 250 m^3 per site
*2 Pejompongan by French project, Pulogadung and Buaran by JICA project (*3)
Source: 1985 Master plan
http: //pamjaya.co.id/en/profile/history
*2 Source: Nihon Suido Consultants website ”Buaran water treatment plant project in Indonesia”
https: //www.nissuicon.co.jp/jigyou/kaigai/indonesia/
*3 Kubota Corporation website “Jakarta water supply project”
https: //www.kubota.co.jp/globalindex/backnumber/back_number/vol_4/vol4_14.html
https: //www.kubota.co.jp/globalindex/backnumber/back_number/vol_4/vol4_15.html

(3) 1997 Master plan

The outline of the 1997 Master Plan (hereinafter referred to as the 1997 JICA MP) is shown in Table 3.65. In this table, for the purpose of comparison with the 1985 Master Plan, the population, population in the water supply area, water supply population, and average daily water supply, excluding the planned water volume, are shown only within DKI Jakarta.

Table 3.65 Outline of the 1997 JICA Master Plan

Item	1995	2000	2005	2010	2015	2019
Population (thousand)	8,800	9,400	10,097	10,795	11,492	11,950
Population in water supply area (thousand)	5,500	7,100	8,397	10,126	11,492	11,950
Water supply area (km^2)	316	435	505	715	837	871
Population of water supply (thousand)	3,000	4,700	6,497	8,195	9,692	10,150
Daily average water supply volume (m^3/sec)	13.2	16.6	21.3	28.7	37.4	40.1
Daily average water supply volume per capita (l/capita/day)	156	162	168	174	180	185
Planned water supply volume (m^3/sec)	16.1	18.9	23.9	36.0	44.8	51.5
NRW (%)	53.5	40.0	30.0	28.0	26.0	25.0
Water quality improvement		Treated water from WTP is drinkable		Transmissioned water is drinkable		Distributed water is drinkable
Water treatment plant (unit: m3/sec)		2005 Buaran III 5.0	2008 Cipayung I 5.0	2011 Cisadane II 5.0	2015 Cipayung II 9.3	2019 Cisadane III 5.0
Budget (million JPY)		101,952	95,409	67,617	76,579	47,756

Source: 1997 Master Plan

The 1997 JICA MP is summarized item by item as follows.

- The years covered by the plan are 24 years from 1995 to 2019.
- The following two items were added to the 1995 JICA MP.
  - The plan covers not only Jakarta Special Province but also its surrounding areas.
  - New target of water quality improvement.
- The actual figures at the time of the formulation of the 1997 Master Plan compared to the planned figures in the 1985 Master Plan are as follows: population (planned 9,950,000, actual 8,800,000), population within the water supply area (planned 8,002,000, actual 5,500,000), and water supply area (planned 383 km^2, actual 5,500,000).
- Water supply area (planned 383 km^2, actual 316 km^2), water supply population (planned 6,523,000, actual 3,000,000)
- Average daily water supply rate (planned 20.3 m^3/second, actual 13.2 m^3/second)
- Daily water supply per capita (planned 268 l/person/day, actual 156 l/person/day), and planned water volume (planned 23.3 m^3/second, actual 16.1 m^3/second).

- Even discounting the difference between the planned and actual water supply area, the difference in the population within the water supply area is large. The reasons for this are i) the delay in the construction of water distribution pipes, and ii) the non-revenue water ratio of 53.5%, which has hardly improved compared to 53% in 1983 and 57% in 1977.
- Regarding the development of water purification plants, Buaran I and Buaran II were constructed with Japanese assistance and secured 5.0 m^3/sec. In addition, the Lebak Bulus water treatment plant (3.0 m^3/sec) which takes water from the Cisadane River, was also constructed.
- The planned Cakung I (5.0 m^3/sec) has not been constructed and a new Cipayung water treatment plant and Cisadane II and III are planned as alternative facilities.
- As TJC has not been constructed, Pulogadung and Buaran use WTC as their water intake source.

3.4.3 Current Situation and Issues of Water Supply Services

(1) Operational History of Water Utilities

The following is an overview of the history of the operation of water utilities in DKI Jakarta.

＜The transition to operation by private entities＞

Since the establishment of the Water Supply Corporation in 1977 as the Local Government Corporation (BUMD), the water supply service has been provided by PAM Jaya. However, due to the financial constraints of the BUMD, in 1998, the water supply area was divided into two districts i.e. east and west. Further, a 25-year concession contract was signed in each district with a private entity i.e. PT PAM Lyonnaise Jaya (PALYJA) for the western district and PT Aetra Air Jakarta (Aetra) for the eastern district. Figure 3-78 shows the service areas of the private entities and the layout of the main water supply facilities.

＜Transition to re-publication＞

The operation by the private entity is supposed to last until January 2023 under the concession contract. However in October 2017, the Indonesian Supreme Court ordered to halt the privatization of the water supply and have it re-publicized in order to guarantee water as a human right. The water supply rate at the start of the privatization in 1998 was 44.5%, but by 2018 it had increased to about 60%. As a result, the target water supply rate of 82% for 2023 has not been achieved.

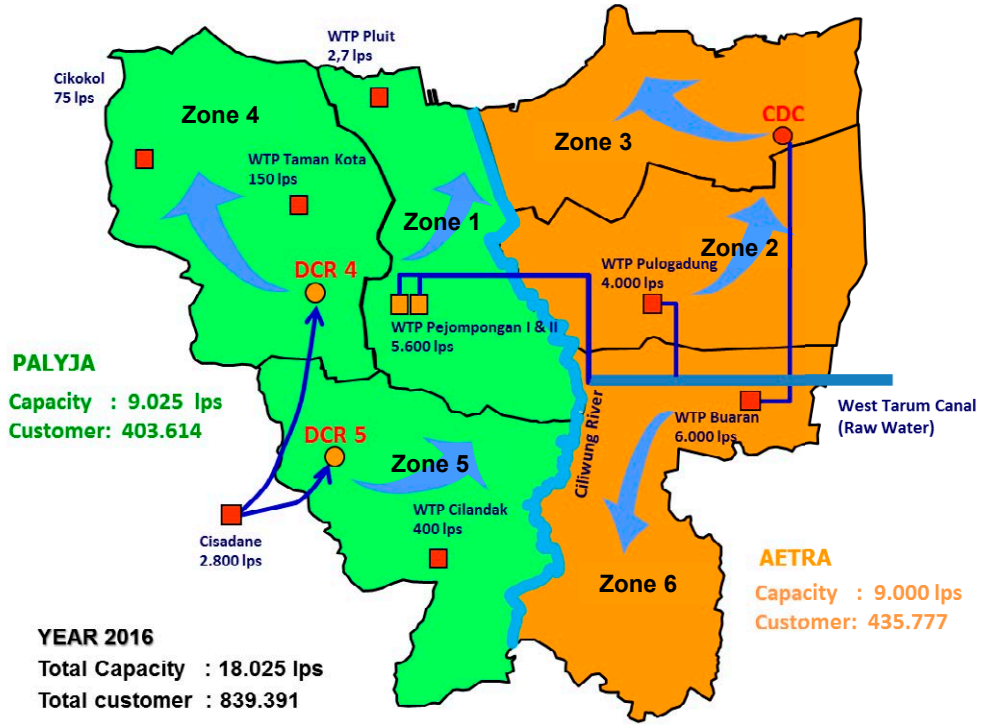
＜Transition measures for re-publication＞

The transition process for re-publication includes stock purchase, contract cancellation, and partial business transfer. If the contract is cancelled, the state government will have to pay a penalty of 1 trillion rupiah (US$71.4 million) to the two companies. For this reason, measures for re-publicizing the project have not yet been finalized. The coverage ratio of water supply services in 1998, at the start of privatization, was 44.5%. It rose to about 60% in 2018. However, it is far from the "82% in 2023" target figure which was set for the privatization. This was the reason for the decision to re-publicize the water supply services.

＜PAM Jaya's Organizational Capacity Issues＞

Since 20 years have already passed since the privatization, PAM Jaya has no remaining technology and know-how in water business operation. Therefore, it is necessary to strengthen the capacity of PAM Jaya. It is also necessary to consider optimization of the water distribution system within the region

when the water supply system, which has been operated by two entities in two districts i.e. East and West, is integrated into one.



Source: PAM Jaya

Figure 3-78 Service Areas of Private Water Supply Enterprises and Location of Major Facilities

(2) Capacity of Water Supply Facilities and Supplied Volume

Table 3.66 shows capacity of the water supply facilities operated in DKI Jakarta and the production amount in the past three years at each facility. Although there is a tendency to increase the production volume in the overall water treatment plants, DCR 4 and DCR 5 that are distribution facilities receiving bulk water from Tangerang Regency show the tendency of decrease. The capacity of water treatment plants (WTPs) is 18,025 l/s in total. This volume corresponds to 70 % of the planned capacity 25,528 l/s in 2020 in the Final Report for Preparation of Master Plan for Water Supply Service Improvement in DKI Jakarta 2015-2035 compiled in 2014 by PT Arkonin Engineering Manggala Pratama (hereinafter referred to as the "2014 Master Plan"). For that reason, several facilities have already exceeded the planned capacity. In 2017, WTP Pejompongan I and WTP Pejompongan II were operated at 126% and 101% of the designed capacity, respectively. While WTP Pulogadung was operated at 105%, and both Buaran I & II were operated at 119%. Decrease in the physical leakage rate and efficient water distribution will be the immediate issues to reduce the overload operation of existing facilities.

Figure 3-79 shows the planned facilities in the water supply master plan formulated in 1997 JICA Master Plan and the 2014 Master Plan. The construction of water purification facilities that were planned in the 1997 JICA MP and 2014 MP has not been realized. Therefore, it is an urgent issue not only to secure raw water but also to develop water purification facilities and expand and improve the water distribution network in the DKI Jakarta.

Table 3.66 Capacity and Production of Facilities in DKI Jakarta

Zone	Area	Name of WTP/ Bulk Water	Capacity		Reservoir Volume (m3)	Production Volume (m3/year)		
			l/s	m3/day		2015	2016	2017
1	W	Pejompongan I	2,000	172,800	32,000	48,107,045	56,445,718	79,244,300
		Pejompongan II	3,600	311,040	28,000	118,860,926	121,276,920	114,960,838
		Sub-total	5,600	483,840	60,000	166,967,971	177,722,638	194,205,138
2	E	Pulogadung	4,000	345,600	67,200	118,752,390	127,945,340	132,504,860
3	E	CDC/DCR3 (Buaran II)	3,000	259,200	33,600			
4	W	Taman Kota	150	12,960	509	3,749,102	4,500,755	4,531,913
		DCR4	2,000	172,800	22,500	63,053,431	61,246,605	58,729,151
		Cikokol (Tanggeran)	75					
		Sub-total	2,225	185,760	23,009	66,802,533	65,747,360	63,261,064
5	W	Cilandak	400	34,560	2,000	11,156,565	12,120,978	12,509,147
		DCR5	800	69,120	22,500	22,854,437	24,165,761	19,829,306
		Sub-total	1,200	103,680	24,500	34,011,002	36,286,739	32,338,453
6	E	Buaran I	2,000	172,800	27,000	171,106,349	184,337,510	188,268,292

Note: The production volume for Buaran I is total amount of Buaran I and CDC/DCR3 (Buaran II).
Source: prepared by the Project Team based on the data of Jakarta Provincial Statistics Office and the 2014 Master Plan

[1997 JICA Master Plan]

Proposed Facility	Capacity (l/sec)	Proposed Facility	Capacity (l/sec)
Buaran III TP	5,000	R3 II DC	1,250
Cipayung I TP	5,000	R4 II DC	2,600
Cipayung II TP	10,000	R4 III DC	1,300
Cisadane II TP	5,000	R4 IV DC	1,300
Cisadane III TP	5,000	R5 II DC	1,600
R1 II DC	2,000	R6 1 DC	4,400
R3 I DC	1,250	-	-

[Existing Facilities in 2014]

Proposed Facility	Capacity (l/sec)	Proposed Facility	Capacity (l/sec)
Pejompongan I WTP	2,000	Taman Kota WTP	150
Pejompongan II WTP	3,600	Cikokol WTP	75
Pulogadung WTP	4,000	Cilandak WTP	400
Buaran I WTP	2,000	DCR4	2,000
Buaran II WTP	3,000	DCR5	800

[2014 Master Plan]

Proposed Facility	Capacity (l/sec)	Proposed Facility	Capacity (l/sec)
A. Uprating Existing WTP		Pluit Dam	100
Pejompongan WTP	500	Waduk Sentar Selatan	50
Cilandak WTP	100	C. Bulk Water Addition	
B. New WTP		Cikokol WTP	325
Pejatan WTP	200	Jatilhur/WTP Bekasi	4,000
Pesanggrahan WTP	800	Jatlhur/WTP Buaran	4,000
Jembatan Besi WTP	400	Karian Dam/Ciawi Dam	10,500
Kali Banjir Timur WTP	400	-	-

Source: prepared by the Project Team based on 1997 Master Plan and 2014 Master Plan

Figure 3-79 Development Plan of Water Treatment Plants in the Water Supply Master Plans

Table 3.67 shows the number of customers, production, sales, and non-revenue water volumes for the past three years, and the planned values as of 2020, as planned in the 2014 MP. All of them are increasing, but the non-revenue water volume is also increasing along with the production volume, which accounts for more than 40% of the production volume.

According to the results of the interviews at PAM Jaya, 70% of the non-revenue water volume was reported to be due to leakage and the remaining 30% due to uncollected fees. The planned leakage rate as of 2020 is 22%, but as of 2017 it was 44%, and it is increasing every year.

Excessive leakage not only overloads the existing facilities, but also leads to a decrease in the amount of water from alternative sources to control groundwater pumping and affects the income of the water utility, so urgent measures are needed.

Table 3.67 Number of Customers, Production, Sold Volume, and Non-revenue Water

Item	2015	2016	2017	Planned Figures in 2020	Achievement of the 2020 target as of 2017
Population	10,177,924	10,277,628	10,374,235	11,036,867	-
Customers	830,857	839,391	851,155	1,249,439	68%
Production (m^3)	560,382,856	594,182,530	613,254,707	783,325,571	78%
Water Volume Sold (m^3)	330,498,664	337,140,611	341,601,198	610,993,945	56%
Non-revenuw Water (m^3)	229,884,192	257,041,919	271,653,509	172,331,626	63%
Non-revenie Water (%)	41%	43%	44%	22%	50%

Notes: Non-revenue water is the difference between production and water volume sold.
Planned figures in 2020 are the target figures set in the 2014 Master Plan.
Source: prepared by the Project Team based on the data of Jakarta Provincial Statistics Office and the 2014 Master Plan

(3) Groundwater Use in the Service Area of Piped Water

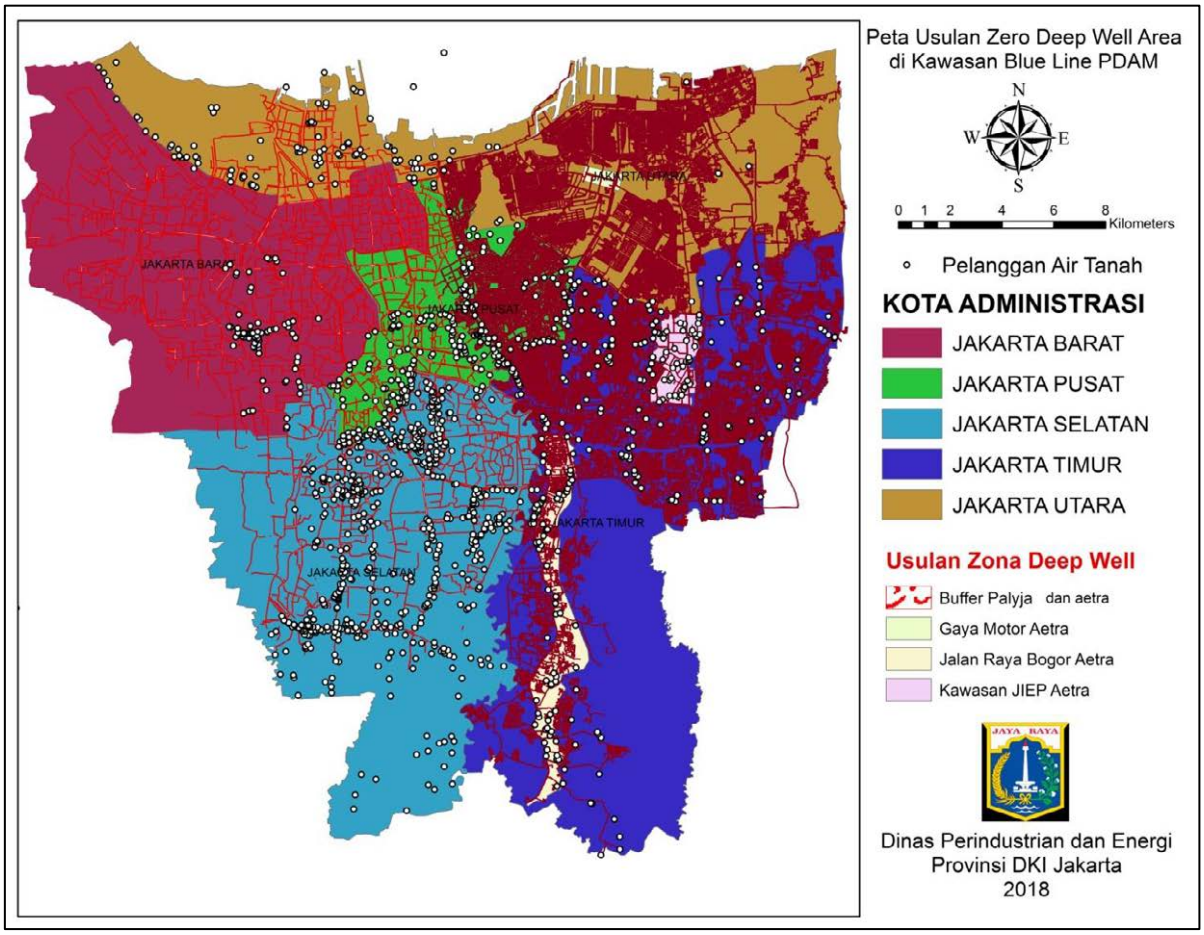
Figure 3-80 shows the water supply network and the location of deep wells prepared by the Jakarta Special Municipality to study the restriction and suspension of deep well use in the water supply area of PAM Jaya.

Figure 3-81 shows the water supply rate per district (Kecamatan) as of 2019. This figure indicated many deep wells in the water supply area of PAM Jaya. The reasons for groundwater utilization in the supply area of PAM Jaya are (i) the water pressure is weak in the areas located at the end of the pipe network and the volume is not sufficient, and (ii) the pipe water supply is not good compared to groundwater because the pressure is weak and the quality of water is not good. For these reasons, general public and households in South Jakarta tend to use groundwater. In addition, facilities that require large amounts of water such as hotels and hospitals, cannot rely solely on public water supply.

The inspection team formed by the Governor Decree of the Special Capital Province of Jakarta No. 279 Year 2018 regarding the “Integrated Supervision Team for Infiltration Wells and Wastewater Treatment Plants as well as Utilization of Groundwater in Buildings and Housing”. In the first inspection (March 2018), the team inspected office buildings along Thamrin and Sudirman Streets in the center of Jakarta. The survey also uncovered unregistered wells, which were found to be used to evade payment of water bills or groundwater tax.

In DKI Jakarta, groundwater use from deep wells is basically to be installed on standby (backup in case of drinking water supply problems). Pumping itself is not prohibited. Therefore, in addition to the supply

of alternative water sources, implementation of pumping regulations and establishment of pumping regulation zones and the laws and regulations that indicate the conditions for such zones are necessary.



Source: DPE, DKI Jakarta

Figure 3-80 Piped Water Network and Locations of Deep Wells in DKI Jakarta



Source: Pelayanan Air Bersih di Kawasan Daerah Rawan Kekurangan Air Bersih Jakarta Utara dan Barat

Figure 3-81 Piped Water Supply Ratio by District (*kecamatan*)

3.4.4 Improvement of Water Supply Services

(1) Water Supply Services Improvement

2014 Master plan is regarded as the latest plan for water supply. In this master plan, total planning area for water supply was confined again to DKI Jakarta area, whereas neighboring area of DKI Jakarta was included as the planning area in 1997 JICA Master Plan. The summary of 2104 Master Plan is described below.

1) Outline of 2014 Master plan

The outline of the 2014 Master Plan is shown in Table 3.68.

Table 3.68 Outline of 2014 Master plan

Item	2015	2020	2025	2030	2035
Water supply service coverage ratio (%)	62	92	98	98	98
Number of connections	880,072	1,249,439	1,337,646	1,397,644	1,510,945
Production volume in WTP (m^3/sec)	17.9	24.8	25.1	26.2	27.3
NRW (%)	35	22	16	14	12
Effective served water volume (m^3/sec)	11.6	19.3	21.1	22.5	24.0

Source: 2014 Master Plan

As shown in this summary, the following items are necessary to be carried out to achieve the final target in 2035, i.e. 98% of water distribution rate, approximately 1.5 million connections, 27.3 m^3/sec of production at the water treatment plant, and 12% of NRW. Each of these items is discussed below.

- Extension of water treatment plant
- Extension of distribution reservoir and installation of water transmission pipe
- Expansion of water supply area and extension of water distribution pipe
- Improvement of NRW and rehabilitation/renewal of old pipes

2) Extension of water treatment plant

The expansion of the water treatment plant is planned in Table 3.69. According to the 2014 Master Plan, the planned value of Buaran III/Jatiluhur II is 4,000 l/sec in its final form as of 2016. In comparison to this, the planned value according to the PAM Jaya plan is 3,000 l/sec for Buaran III and Jatiluhur II.The main difference is that Karian's planned capacity is 3,200 l/s instead of 1,500 l/s. Jatiluhur I, Jatiluhur II, and Karian are classified as bulk water, but all of them require the installation of new water treatment plants.

Table 3.69 Extension Plan of water treatment plant in 2014 Master plan

	item	unit	2015	2016	2017	2018	2019	2020	2022	2025	2030	2035
	DKI Population		10,317,800	10,461,613	10,605,427	10,749,240	10,893,053	11,036,867	11,348,533	11,755,933	12,475,000	13,194,067
	Population in service area		6,397,036	7,323,129	8,272,233	8,858,449	9,585,887	10,153,917	11,008,077	11,520,815	12,225,500	12,930,185
	ratio		0.62	0.70	0.78	0.82	0.88	0.92	0.97	0.98	0.98	0.98
	unit water supply	lpcd	120	129	129	131	133	135	132	130	130	130
	average water demand	l/sec	16,813	19,491	20,980	22,206	23,955	25,258	25,355	25,314	26,337	27,361
	maximum water demand	l/sec	18,494	21,440	23,078	24,427	26,350	27,783	27,891	27,845	28,971	30,097
	water supply	l/sec	18,525	21,450	23,100	24,700	26,700	27,900	27,900	27,900	29,900	30,400
Existing												
WTP West	Pejompongan I,II	l/sec	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600
	Cilandak	l/sec	400	400	400	400	400	400	400	400	400	400
	Taman Kota	l/sec	150	150	150	150	150	150	150	150	150	150
	sub total A	*l/sec*	*6,150*	*6,150*	*6,150*	*6,150*	*6,150*	*6,150*	*6,150*	*6,150*	*6,150*	*6,150*
WTP East	Pulo Gadung	l/sec	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
	Buaran I,II	l/sec	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	sub total B	*l/sec*	*9,000*	*9,000*	*9,000*	*9,000*	*9,000*	*9,000*	*9,000*	*9,000*	*9,000*	*9,000*
Bulk water	DCR4	l/sec	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	DCR5	l/sec	800	800	800	800	800	800	800	800	800	800
	Cikokol	l/sec	75	75	75	75	75	75	75	75	75	75
	sub total C	*l/sec*	*2,875*	*2,875*	*2,875*	*2,875*	*2,875*	*2,875*	*2,875*	*2,875*	*2,875*	*2,875*
	Total A+B+C	**l/sec**	**18,025**	**18,025**	**18,025**	**18,025**	**18,025**	**18,025**	**18,025**	**18,025**	**18,025**	**18,025**
Planning												
WTP	Pejaten	l/sec	0	200	200	200	200	200	200	200	200	200
	Pesanggrahan DCR4	l/sec	0	400	400	600	600	600	600	600	600	600
	Pesanggrahan DCR5	l/sec	0	0	0	200	200	200	200	200	200	200
	Cikokol	l/sec	0	325	325	325	325	325	325	325	325	325
	Pluit	l/sec	0	100	100	100	100	100	100	100	100	100
	Cilandak (uprating)	l/sec	0	100	100	100	100	100	100	100	100	100
	Waduk Sunter Selatan	l/sec	0	0	50	50	50	50	50	50	50	50
	subtotal D	*l/sec*	*0*	*1,125*	*1,175*	*1,575*	*1,575*	*1,575*	*1,575*	*1,575*	*1,575*	*1,575*
Bulk water	Jembatan Besi	l/sec	0	400	400	400	400	400	400	400	400	400
	Jatilfur I	l/sec	0	1,200	2,800	4,000	4,000	4,000	4,000	4,000	4,000	4,000
	Buaran III/Jatilufur II	l/sec	0	0	0	0	2,000	2,000	2,000	2,000	4,000	4,000
	uprating Pejompongan	l/sec	500	500	500	500	500	500	500	500	500	500
	Kali Baru Timur	l/sec	0	200	200	200	200	400	400	400	400	400
	Karian	l/sec	0	0	0	0	0	1,000	1,000	1,000	1,000	1,500
	subtotal E	*l/sec*	*500*	*2,300*	*3,900*	*5,100*	*7,100*	*8,300*	*8,300*	*8,300*	*10,300*	*10,800*
	Total D+E	**l/sec**	**500**	**3,425**	**5,075**	**6,675**	**8,675**	**9,875**	**9,875**	**9,875**	**11,875**	**12,375**
	Grand total A+B+C+D+E	**l/sec**	**18,525**	**21,450**	**23,100**	**24,700**	**26,700**	**27,900**	**27,900**	**27,900**	**29,900**	**30,400**

Source: 2014 Master Plan

3) Expansion of distribution reservoirs and installation of water pipes

The capacity of the distribution ponds is 20% of the daily water distribution volume. Accordingly, additional distribution reservoirs will be required as shown in Table 3.70. In addition, Table 3.71 shows the plan for the water pipes from the water treatment plant to the distribution ponds.

Table 3.70 Distribution reservoirs and their volume in 2014 Master plan

Zone	Reservoir	Location	Volume m3
Zone1	Harmoni	Jl. Batu Ceper, Gambir	32,000
	Uprating Pejompongan	Jl. Jembatan Gambang I, Penjaringan	32,000
Zone2	Pulogadung	Pulogadung	5,000
Zone3	Perdana	Jl. Balai Pustaka, Pulogadung	37,000
Zone4	Chengkareng	Jl. Kayu Besar 3, Cengkareng	13,500
Zone5	Pesanggrahan	Jl. Persatuan Amal Mulia, Pesanggrahan	36,000
	T.B.Simatupang	Jl. T.B. Simatupang, Cilandak	36,000
Zone6	Kampung Baru Raya	Jl. Mampung Baru Raya, Ciracas	35,000
	D.I. Panjaitan	Jl. D.I. Panjaitan, Jatinegara	35,000

Source: 2014 Master Plan

Table 3.71 Transmission pipe planned in the 2014 Master plan

No.	Transmission pipe	capacity l/sec	length m	diameter mm	Water head m
1	Lane1 (PJT2-Bekasi WTP) Lane 1 (PJT2- Bekasi)	4,000	15,015	1,600	35
2	Lane1 (PJT2-Bekasi WTP) 1a (Reservoir Perdana)	350	9,366	600	29
3	Lane1 (PJT2-Bekasi WTP) 1b	3,650	3,701	1,500	10
4	Lane1 (PJT2-Bekasi WTP) 1c (Reservoir Harmoni)	720	1,319	500	36
5	Lane1 (PJT2-Bekasi WTP) 1d	2,930	3,765	1,200	20
6	Lane1 (PJT2-Bekasi WTP) 1e (Reservoir updating Pejompongan)	380	6,469	700	11
7	Lane1 (PJT2-Bekasi WTP) 1f (Reservoir Pesanggrahan)	2,550	14,178	1,300	40
8	Lane1 (PJT2-Bekasi WTP) 1g (reservoir T.B. Simatupang)	1,275	3,540	1,000	10
9	Lane 2 (PJT2- Buaran III) Lane 2 (PJT2- Buaran III)	4,000	3,476	1,400	16
10	Lane 2 (PJT2- Buaran III) 2a	885	6,839	800	29
11	Lane 2 (PJT2- Buaran III) 2b (Reservoir Pulogadung)	200	2,623	400	21
12	Lane 2 (PJT2- Buaran III) 2c (Reservoir Perdana)	685	7,885	700	40
13	Lane 2 (PJT2- Buaran III) 2d (Reservoir D.I. Panjaitan)	3,115	1,866	1,200	11
14	Lane 2 (PJT2- Buaran III) 2e (Reservoir Kampung Baru Raya)	1,557.5	13,244	1,100	34
15	Lane 3 (Waduk Sunter Selatan) Reservoir Perdana	50	4,860	250	29
16	Lane 4 (Uprating Pejompongan) Reservoir uprating Pejompongan	500	7,950	700	22
17	Lane 5 Waduk Pluit Reservoir Harmoni	50	6,147	250	36
18	Lane 6 (Pesanggrahan) DCR 5	140	5,954	400	24
19	Lane 6 (Pesanggrahan) DCR 4	660	10,348	800	25
20	Lane 7 (Pajaten) Reservoir T.B. Simatupang	200	7,258	500	19
21	Lane 8 (Cilandak) Reservoir T.B. Simatupang	100	2,751	300	24
22	Lane 9 (Waduk Karian) Reservoir Pesanggrahan	1,500	30,577	1,300	32
23	Lane 10 (Cikokol) Reservoir Cengkareng	325	18,668	540	34
24	Lane11 (Jembatan Besi) Reservoir Cengkareng	400	10,106	600	40

Source: 2014 Master Plan

4) Extension of water supply area and water distribution pipe

2014 Master Plan indicates the required extension of distribution mains by pipe diameter (⌀300 to ⌀1,800). While the preconditions for calculation are i) flow velocity is 0.6 m/s to 3.0 m/s, and ii) water pressure at the end of distribution main pipe is 17.5 m (0.175 MPa) or more. With regard to distribution main and distribution branches, the necessary pipe extension is calculated as follows, under the assumption that the end water pressure is 10 m (0.1 MPa) and the pipe length per connection is 12 m.

Table 3.72 Extension plan of water distribution pipe

Item		Pipe Extension Length
Total pipe length	A	18,131 km
Existing pipe length	B	11,530 km
Planned pipe length	C=A-B	6,601 km
Primary pipe		321 km
Secondary pipe		1,425 km
Tertiary pipe		4,855 km

Source: 2014 Master Plan

5) Improvement of NRW and renewal of old pipes

The NRW is planned as shown in Table 3.73 and the measures shown in Table 3.74 are planned to improve the NRW.

Table 3.73 Target of NRW in 2014 Master Plan

item	unit	2015	2016	2017	2018	2019
NRW	%	35	31	27	25	23

item	unit	2020	2022	2025	2030	2035
NRW	%	22	18	16	14	12

Source: 2014 Master Plan

In addition, the following measures were planned to improve NRW.

Table 3.74 Outline of NRW measures in 2014 Master Plan

No.	measures	description
1	**Introduction of small block system (*)** * DMA (District Meter Area), CZ (Leakage Control Zone) are also used	By dividing the distribution network area into small blocks and monitoring the amount of water for each block, the amount of water leakage for each block can be clarified.
2	**Renewal of primary pipe**	Primary pipe installed before 1930 of approximately 115 km in total length, has high priority for replacement. Next step is to replace pipe installed after 1930 of about 692 km in total length, with 1% per year.
3	**Renewal of secondary and tertiary pipe**	GIP (Galvanized Iron Pipe) and pipes installed before 1930 are regarded as high priority to replace. For rest of the pipe, secondary pipe replacement is conducted 2% per year and 4% per year for tertiary pipes. The pipe material is HDPE (High Density Polyethylene Pipe)
4	**Renewal of service pipe**	Service pipe will be replaced by GIP made of HDPE.
5	**Water meter replacement**	Water meter are replaced every 5 years. (Note: According to Measurement Act in Japan, mandated replacement frequency is 8 years)
6	**Introduction of water loss detection devices**	

Source: 2014 Master Plan

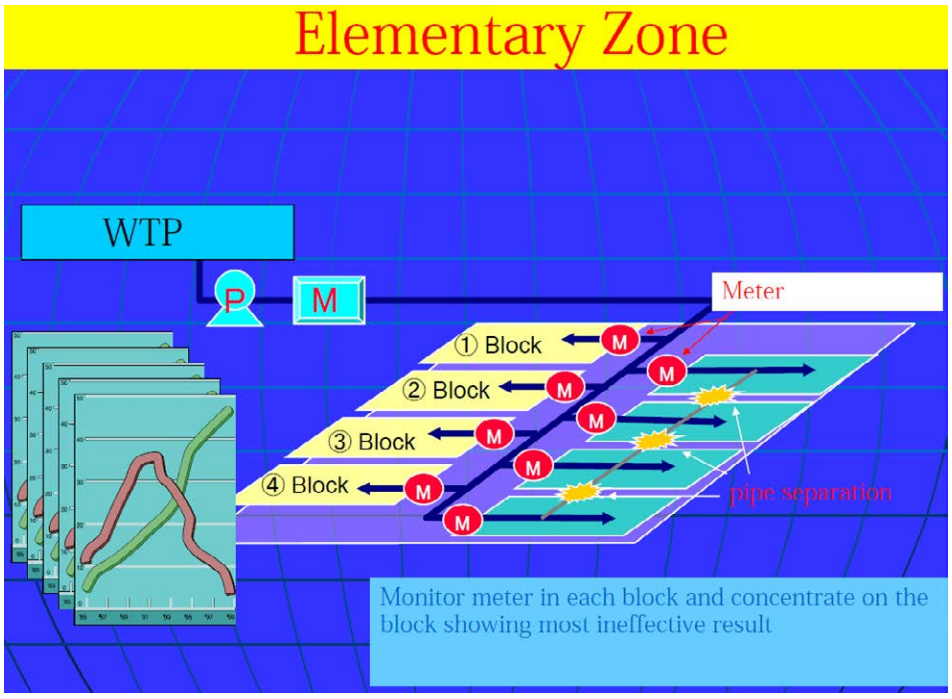


Figure 3-82 Scheme of small block and control

Note: As illustrated above, water valve in each block controls the water
Source: Kitakyushu City
https: //www.mhlw.go.jp/seisakunitsuite/bunya/topics/bukyoku/kenkou/suido/newvision/senshinjirei/10-kokusai-01.pdf

6) Implemented NRW measures

According to 2014 Master Plan, the investment shown in the Table 3.75 was implemented. Total amount was estimated approximately Rp1.3 trillion from 2008 to 2012.

Table 3.75 Investment from 2008 to 2012 by Palyja and Aetra

unit: 1 billion Rupiah

No.	Item	Palyja	Aetra	Total
1	Building innovation	9.56	29.33	38.89
2	Production plant rehabilitation	76.73	133.08	209.81
3	Pipeline rehabilitation and expansion	325.67	483.45	909.12
4	Water meter replacement and installation/NRW	78.96	112.37	191.33
5	Supporting works/others	53.63	59.16	112.79
	Total	544.56	817.39	1,361.95

Source: 2014 Master Plan

This resulted in the improvements shown in Table 3.76. The increase of sold water volume, number of connections, water production, and the decrease of NRW were achieved. On the other hand, the service coverage ratio decreased. The reason of this decrease is considered to be that the population of DKI Jakarta has increased more than the rate of increase of the service coverage ratio.

Table 3.76 Achievement indicators from 2009 to 2012

No.	Indicator	unit	2009	2010	2011	2012	Increase/Decrease from 2009 to 2012
1	Sold water volume	Million m^3	267.14	283.87	297.82	310.25	43.11
2	Connections		795,149	805,153	802,636	799,699	4,550
3	Water production	Million m^3	423.21	442.66	439.47	447.11	23.90
4	NRW	%	47.55	45.75	43.46	43.03	-4.52
5	Service coverage	%	61.80	62.31	61.58	60.27	-1.53

Source: 2014 Master Plan

The investment was mainly by ADB, where according to the ADB report, Rp 455 billion was loaned to Palyja and Rp 430 billion to Aetra.

Source:
West Jakarta water supply development project
https: //www.adb.org/sites/default/files/project-document/79157/41913-014-ino-xarr.pdf
East Jakarta water supply development project
https: //www.adb.org/sites/default/files/project-document/75724/46936-014-ino-rrp-0.pdf

(2) Current Status of the Water Supply Remunicipalisation in Jakarta

Since the privatization of water supply started in February 1998, PAM Jaya's main business activities include operation and management of water treatment plants, laying and renewal of pipelines, repair of defective sections including leakage control, and customer service.

1) Current Status of Water Supply Remunicipalisation in Jakarta

Current status of water supply remunicipalisation in Jakarta is summarized in Table 3.77.

Table 3.77 Current Status of Water Supply Remunicipalisation in Jakarta

Year/Month	Item
1998	Two operating companies started concession until 2023
2013	Court case against privatization
Oct 2017	Supreme Court ordered termination of privatization
Sep 2018	DKI Governor Anies Baswedan established the Water Management Evaluation Team
Feb 2019	**Recommendations of the Special Evaluation Team**
Apr 2019	Basic Agreement between PAM Jaya and Aetra
Nov 2021	**DKI issued Regulation on changing of legal form of PAM Jaya into Perunda Air Minum Jaya**
Jan 2022	**MoU between PUPR Cipta Karya and DKI was issued**

The following sections detail the "Recommendations of the Special Evaluation Team", the "Issuance of the Decree of Jakarta Special Province to the effect that PAM Jaya will be changed to Perumda Air Minum Jaya", and the "Memorandum of Understanding (MoU) between the Ministry of Public Works and Housing of Indonesia and Jakarta Special Province" in February and April 2019 as shown in the table above.

a) Recommendations of the Special Evaluation Team

The Drinking Water Management Evaluation Team, which examines the remunicipalisation of PAM Jaya, was established in September 2018. In February 2019, the team presented the following three recommendation shown in Table 3.78.

Table 3.78 Three Recommendation Issued in Feb 2019

Recommendation	Remarks
1: To continue the contract until 2023	
2: To terminate the contract by PAM Jaya	PAM Jaya should pay Rp 1 trillion to two private companies as penalty
3: To take over the services from private companies to PAM Jaya	To take over the services includes the transfer the stocks by two private companies. Aetra’s stock is Rp 1.2 trillion and Palyja’s stock is Rp 0.65 trillion. Also Aetra has Rp 2 trillion debt and it shall be transferred to PAM Jaya.

Comparing the monetary value, Plan 2 is advantageous to PAM Jaya than Plan 3. However, considering the response from the Jakarta business community when implementing Plan 2, Plan 3 is considered to be the most appropriate on the Jakarta Special Province side.

b) Regulation by DKI

In December 2021, DKI issued Regulation (Perda DKI No.4_2021) on changing of legal form of PAM Jaya into Perumda Air Minum Jaya (Public Company). The summary of the Regulation is as follows:

Table 3.79 Summary of Perda DKI No.4_2021

No.	Item	content
1	Name, location	The entire capital is owned by the DKI provincial government and is not divided into shares
2	Objective of the establishment of PAM Jaya	• To provide drinking water services in order to fulfil the people's right to drinking water • To increase the coverage area of drinking water services. • Good management & services quality with affordable price. • To provide benefits for economic development and the potential of DKI
3	Business Activity	• Build, operate and develop SPAM through pipeline and non-pipeline network • Other businesses in drinking water sector as well as other services that support the main business In addition, PAM Jaya can conduct: • Join cooperation with state/local government owned companies, private companies, etc. • Business diversification as part of business development • Create subsidiary company and/or own shares in other company → feasibility study should be prepared with approval from Governor.
4	Basic Capital	• Basic Capital is 24.4 trillion IDR • Issued and paid capital is 1.3 trillion IDR • Fulfilling the basic capital will be provided by: company's net profit, general reserve fund allocation and regional capital participation • Capital and source of funding (for project/investment): PMD, Loan, Grant and others
5	Income	Customer of drinking water and other legal income from other business
6	Cooperation	PAM Jaya will be the main responsible party in SPAM operation and development
7	Utilization of Profit	As general reserve fund, business spending, divided for DKI, bonus, etc.

c) MoU between PUPR Cipta Karya and DKI

This MoU was signed in January 2022 PUPR and DKI Jakarta. The contents are the specifications, period, and division of roles between PUPR and DKI Jakarta related to SPAM. The contents are summarized in the Table below.

Table 3.80 SPAM for DKI

No	Plan	Capacity (lps) / Length of Pipe (km)	Construction and Absorption Time
	A. Regional Plan		
1	SPAM Jatiluhur I - Upstream	4,000 lps	2022-2028
	SPAM Karian Serpong – Upstream	3,200 lps	2022-2028
	B. DKI Jakarta Province Plan		
1	SPAM Jatiluhur – Downstream*	1,910 km	2023-2028
2	SPAM Karian Serpong – Downstream*	660 km	2023-2028
3	SPAM Buaran III and	3,000 lps	2022-2025
	Uprating of SPAM Buaran I – II (In accordance with available water balance)	1,000 lps	2023-2025
4	Province SPAM (i.e., Pesanggrahan, Ciliwung, communal, Cilandak)	1,350 lps	2022-2025
5	Decrease of NRW		2023-2030
6	Cyclical Maintenance		2023-2030
7	(Direct) Connection		2023-2030
8	Others and Building		2023-2030
	Sub Total	12,550 lps 2,570 km	
	C. Integrated Regional Program		
1	Regional SPAM Jatiluhur II/Djuanda Integrated (upstream)	2,054 lps	2023-2027
2	Regional SPAM Jatiluhur II/Djuanda Integrated (downstream)		2025-2029

Table 3.81 SPAM and responsibilities

No	Description	Implementer		
		Ministry of Home Affairs	PUPR	DKI Jakarta
1	Prepare addendum contract of Off taker agreement on the absorption of Bulk Drinking Water, one year after the effectiveness of the agreement		○	○
2	Policy to support the adjustment of Drinking Water Tariff in DKI Jakarta	○	○	○
3	Provision of Land for construction of infrastructure for SPAM Jatiluhur I & Karian Serpong (Downstream)			○
4	Development of network & DCR Pondok Kopi, Cilincing and Semanan Phase-1 to make sure that the spending of first year fiscal budget (2024) reach 5%.		○	
5	To process the financial proposal for Stage-1 of SPAM Jatiluhur I & SPAM Karian Serpong (Downstream)		○	
6	Prepare the completeness of readiness criteria, which are required for the submission of financial support by the 2nd Party (PUPR)			○

If the water-related projects shown here are implemented, water will be supplied to areas where water is not currently widespread and depends on the use of groundwater, and the amount of groundwater pumped will decrease and the ground subsidence will accompany it. Is expected to decrease.

2) Current Press Issues

Current press issues are summarized in Table 3.82.

Table 3.82 Current Press Issues on PAM Jaya Remunicipalisation

Year/Month	Item
May 2019	Komisi Pemberantasan Korupsi, KPK is cooperating for remunicipalisation
Nov 2019	PAM Jaya and Aetra agreed to carry out Due Diligence, to transfer water supply system after concession and to achieve 82% access by 2023.
Dec 2020	DKI Jakarta announced 100% water service coverage until 2030

In December 2020, PAM Jaya President Director Bambang Hernowo announced that he would aim for 100% coverage of water supply service in Jakarta by 2030. This press report also shows the current water supply situation in Jakarta, so the main points are summarized in Table 3.83.

Table 3.83 Current Status of Water Supply in DKI Jakarta

Item	Status	Item	Status
Total length of water distribution pipe	11,900 km	Existing/Future Project	・Ciliwung 200 lps ・Pesanggrahan 750 lps ・Hutan Kota WTP 500 lps ・Buaran WTP 4,000 lps ・Jatiluhur Dam 4,000 lps ・Karian Dam 3,200 lps
Amount of total water distribution	20,727 lps (litres per second)	Other topics	・Renewal of aged pipes and water meters and prevention of illegal connection were carried out. ・Public awareness was carried out for water saving, conversion from groundwater use to tap water to prevent land subsidence. ・Due to Covid-19, financial support from DKI Jakarta was reduced. Need to find alternative financial source. ・Rp 27-28 trillion is needed for 100% water service coverage
Number of connection	888,342		
Service coverage ratio	65%		
Water resource share	Jatiluhur Dam: 82% PDAM in Tangerang Regency: 12% Pesanggrahan, and Krukut : 6%		

Source: Jakarta Post 2020-12-27

https://www.thejakartapost.com/news/2020/12/27/pam-jaya-aims-to-reach-100-percent-tap-water-coverage-in-jakarta-by-2030.html

According to the press information in January 2022, the Figures shown above was changed as under:

a. Coverage ratio 64%

b. Amount of water distribution 20,725 lps

c. Number of connection 908,324

3) Discussion with PUPR Cipta Karya

An opinion exchange was conducted between Cipta Karya of PUPR and JICA team on January 17, 2022. The following is a summary of the discussion.

- DKI aims to achieve 100% water supply penetration rate by 2030 (current rate is around 60%).
- Of these projects, PUPR is involved in Jatiluhur-I, Jatiluhur-II, and Karian Serpong. Of these projects, PUPR is involved in Jatiluhur-I, Jatiluhur-II, and Karian Serpong which aim to increase penetration by 13%, 7%, and 10% respectively. The remaining 10% will be covered by the expansion of Buaran water treatment plant (Buaran III) to be implemented by DKI.
- Jatiluhur-I and Karian Serpong will be implemented under PPP scheme.
- The total investment for the project downstream of the dam is estimated at 12.1 trillion Indonesian rupiah, of which 2.1 trillion Indonesian rupiah will be provided by the Ministry of Public Works and the remaining 10 trillion Indonesian rupiah is yet to be determined.

(3) Support policy for PAM Jaya

Based on the above, the support policy for PAM Jaya is summarized in the table below. It should be noted that although these have already been proposed to PAM Jaya, no answers have been obtained.

Table 3.84 Support Policy for PAM Jaya

No.	Items	Current Status	Proposal of support and ooperation
1	Technical cooperation for water resource development project	Among the water-related projects to be implemented in the future, the water conveyance project and the distribution reservoir construction project scheduled to be implemented by the Special Province of Jakarta need to be implemented based on the management status of the existing facilities. The existing facility is currently managed by two operating companies and will be taken over by PAM Jaya after the remunicipalisation in 2023. After the transfer, it is necessary to fully understand the operation management status of waterworks and distribution reservoir facilities. But now he lacks that experience.	From the standpoint of PAM Jaya, we will provide advice on water pipes and distribution reservoirs to be constructed in future water supply-related projects, taking into consideration the operational management status of water purification plants and distribution reservoirs.
2	Technical cooperation for Non Revenue Water	The current Non Revenue Water rate of Jakarta water supply is about 40%, which has not improved in recent years. The reason is that the efforts of the two operating companies are not sufficient. If it is taken over by PAM Jaya as it is, the situation	To advise PAM Jaya to develop a plan to reduce the non-revenue water rate. At the same time, support the execution of the plan and provide necessary technical cooperation.

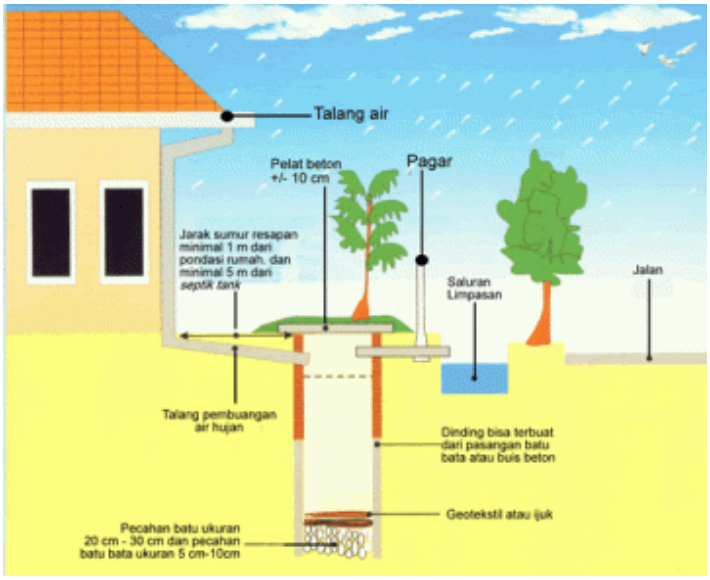
		may not be improved regarding measures against non-revenue water.	
3	Technical cooperation for expansion of coverage area	The current water supply business plan is based on a plan that targets a limited area rather than the entire city area. Therefore, in order to implement future area expansion, it is not possible to respond with the idea of expanding the conventional facilities, and it is necessary to create a completely new water supply plan for the expanded area.	To advise PAM Jaya to create a new plan for expansion. At the same time, support the execution of the plan and provide necessary technical cooperation.
4	Technical cooperation for aged facilities	The current policies regarding the renewal of aging facilities of the two operating companies are symptomatic treatments to deal with problems, and no planned renewal of aging facilities has been implemented.	To advise on the formulation of renewal plans for aging facilities. At the same time, support the execution of the plan and provide necessary technical cooperation.
5	Technical cooperation for raw water quality improvement	Currently, the raw water quality of the water purification plants managed by the two operating companies is not good due to the mixing of sewage into the raw water. Consequently there is a fact that measures (biological treatment) added to the normal water treatment process are being implemented.	To advise on raw water quality improvement plans. At the same time, support the execution of the plan and provide necessary technical cooperation.
6	Management support for due diligence of two operating entities	At the time of remunicipalisation in 2023, the assets managed by the two operating companies will be transffered, but the management status has not been clarified, and there is a risk that it will have a significant impact on management after remunicipalisation.	To advise on the valuation of managed assets of the operating company. At the same time, support the execution of evaluation.
7	Management support for the revision of water tariff	It is indispensable to review the water tariff in order to carry out systematic renovation and renewal and to implement sound water supply business management in the future. However, the water tariffs have not been reviewed for the past 10 years, and the necessary maintenance and renovations have not been implemented.	To advise on reviewing water rates. At the same time, support its execution.
8	Management support for asset management plan	The introduction of asset management is indispensable for the effective use of limited assets and the supply of safe and	To advise on the formulation of asset management plans and support their implementation.

		inexpensive water services, but it has not been introduced at present and systematic maintenance and renewal have not been implemented.	
9	Management support for introduction of DX/ICT	In order to carry out efficient water supply business management with a limited number of personnel, it is necessary to introduce DX or ICT such as automation of water supply inspection by introducing smart meters, but PAM Jaya lacks experience in these matters.	To advise on the formulation of DX or ICT introduction plans for smart meters, etc., and support their implementation.
10	Management support for human resources development	After the remunicipalisation in 2023, PAM Jaya will run the water business. However, PAM Jaya lacks experience and knowledge in both business operation and technical management, as two operating companies have traditionally implemented water services.	It is necessary to create a group that specializes in training, and that department prepares a training plan and implements systematic training. We will support the human resources development program on the teaching side for that purpose.

3.5 Current Situation of Groundwater Infiltration

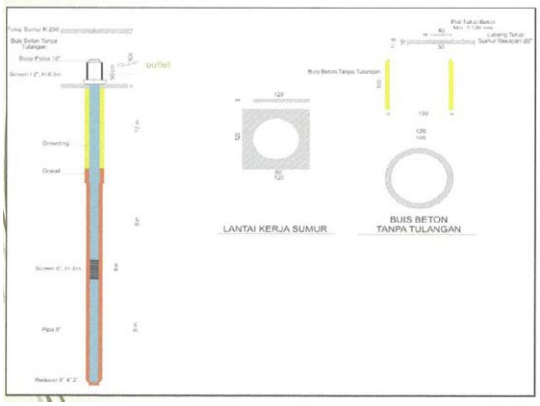
3.5.1 Overview and results of rainwater infiltration facilities

In DKI Jakarta, the type and standard structure of rainwater infiltration facilities were indicated in the former Governor's Regulation (No. 68 of 2005). In addition, the construction of storage infiltration facilities using plastic modules and infiltration wells with a depth of 30 meters has been tried in recent years, but has not been widely adopted. Figure 3-83 and Figure 3-84 show the structure of seepage wells and module type seepage facilities and seepage wells (30 m depth) for general houses recommended in Jakarta Special Region. The infiltration facility was managed by the DKI Jakarta Water Resources Department until 2014, but was transferred to the DPE in January 2017. According to the DPE, 7,540 seepage wells have been constructed in the province so far (see Table 3.85 Existing Number of Infiltration Facilities (2015-2016).



Source: Industry and Energy Office, DKI Jakarta

Figure 3-83 Standard Structure of Infiltration Wells



Source: Industry and Energy Office, DKI Jakarta

Figure 3-84 Module Type Infiltration Facilities and Infiltration Wells with a Depth of 30m

Table 3.85 Existing Number of Infiltration Facilities (2015-2016)

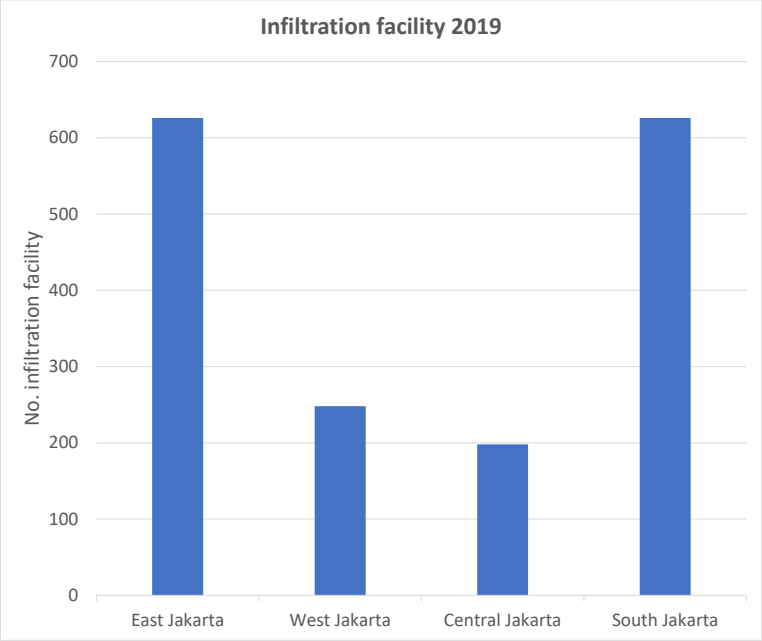
No.	City	Handover from Water Resources Office 2014	Construction from 2015-2016		
			Water Resources Office	District of Water Resources Office	Pertamina
1	South	2,555	1,481	12	50
2	East	1,974	-	327	-
3	West	543	-	-	-
4	Central	512	-	-	-
5	North	86	-	-	-
Total		5,670	1,870		
		7,540			

Source: Industry and Energy Office, DKI Jakarta

3.5.2 Recent development of rainwater infiltration facilities

By 2019, 1,698 rainwater infiltration facilities are planned to be installed in DKI Jakarta. As shown in Figure 3-85, these rainwater infiltration facilities consist of 626 units in East Jakarta, 248 units in West Jakarta, 198 units in Central Jakarta, and 626 units in South Jakarta. According to these number, infiltration facilities are concentrated in East Jakarta and South Jakarta, where many residential areas exist. The main installation sites are in offices, hospitals, places of worship, schools, etc. Similar to 2019, 1,300 units are planned to be installed in 2020.

Cross-section of the infiltration facilities being installed under this plan is shown in Figure 3-87. The locations of the rainwater infiltration facilities in Jakarta are not entirely clear, but a database of the locations will be developed in the future.



Source: DPE

Figure 3-85 Number of infiltration facilities to be installed in 2019

3.5.3 Groundwater Infiltration

Based on the current situation of groundwater recharge, the following three points are proposed.

(1) Policy on rainwater infiltration and groundwater recharge

As a result of hearing to DKI Cipta Karya, it was confirmed that the department examined the construction for rainwater penetration at the time of construction application (including renewal every 5 years). In addition, it was confirmed that guidance was given to buildings for which establishment of infiltration facilities is required as an activity of the illegal building detection team.

The department only grasps the installation situation of rainwater infiltration facilities in each building. However the department is no responsible for the overall goal of installation of infiltration facilities-for example, install rainwater infiltration facilities by 20xx and secure xx m3 for recharge amount.

There is no department in the country or DKI that currently comprehensively understands measures for

rainwater penetration.

Therefore, it is proposed for both the country and DKI to carry out goal setting and progress management in the department implementing comprehensive policy.

(2) Expansion to basin area water management

According to the distribution system diagram released by the water supplier (Tirta Asasta) of Depok City, which is south of Jakarta Special Region, the city's water supply volume is 605 l / sec. Assuming that the water supply rate per person per day is 100 liters, it corresponds to about 500,000 people. Comparing this with the city's total population (1.87 million), it is estimated that over 1 million people depend on wells.

As the city is located upstream of the Jakarta Special Region, groundwater management in the city has a major impact on the groundwater management in Jakarta.

Therefore, we will call on the city and Bogor, which is located further upstream, to participate in and cooperate with this project, and will appeal the importance of appropriate groundwater management in the basin area.

Specifically, while introducing the regulation on groundwater use implemented by DKI for the entire basin and the aim of this project and the results so far, each city or prefecture can be used for the sound use and maintenance of groundwater Induce them to propose their own policies.

(3) Proposal for maintenance of infiltration facilities

As a result of the field survey of the rainwater storage facility tested and constructed by the JICA model project in the BAPEDDA government office parking lot in Bogor City, maintenance manuals are prepared in English and Indonesian for each set up facility. On the other hand, through the interview of DPE, it was revealed that DPE was the department in charge of technical standards (structure, capacity, etc.) of rainwater infiltration facilities. Based on this, we propose a general maintenance manual that can be applied elsewhere

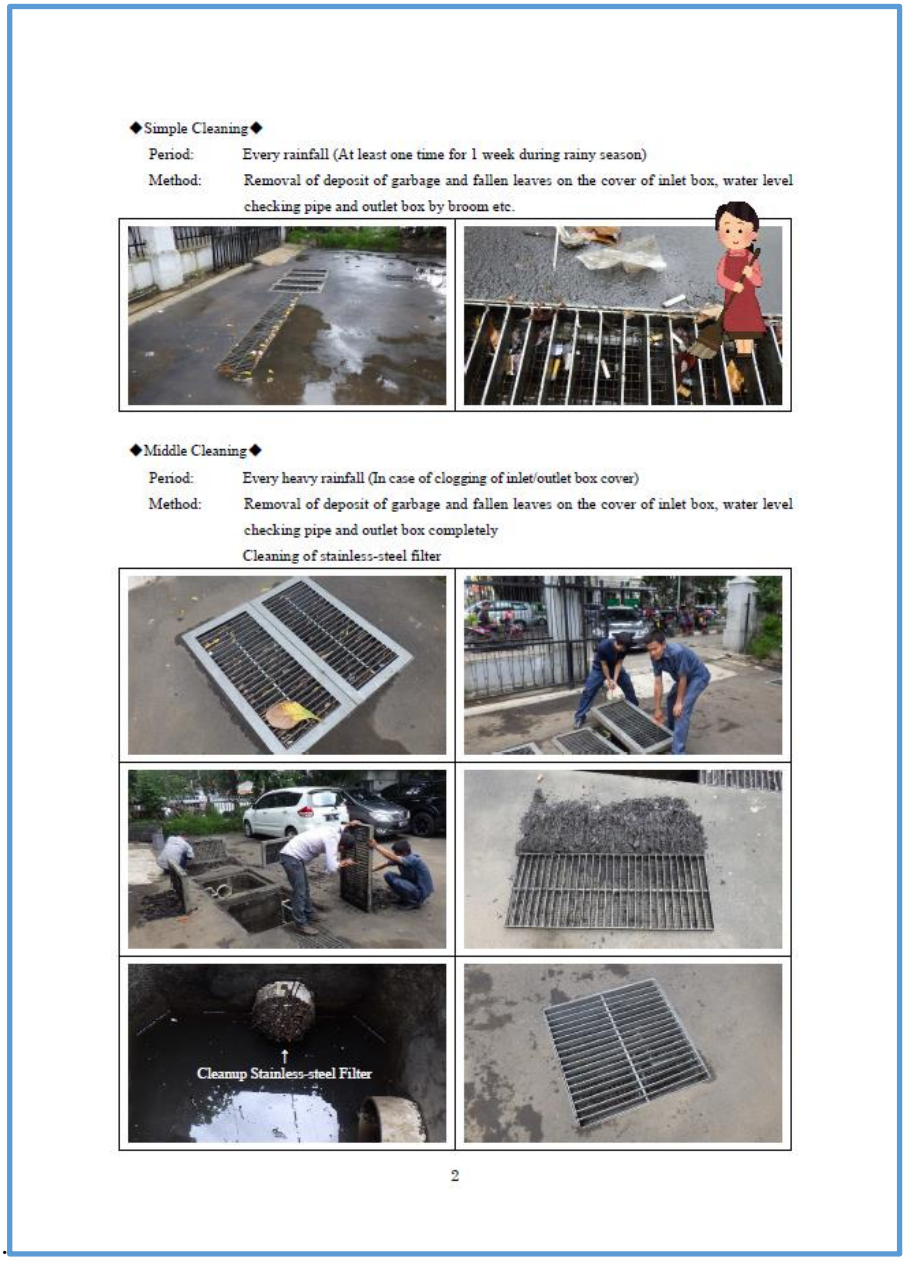
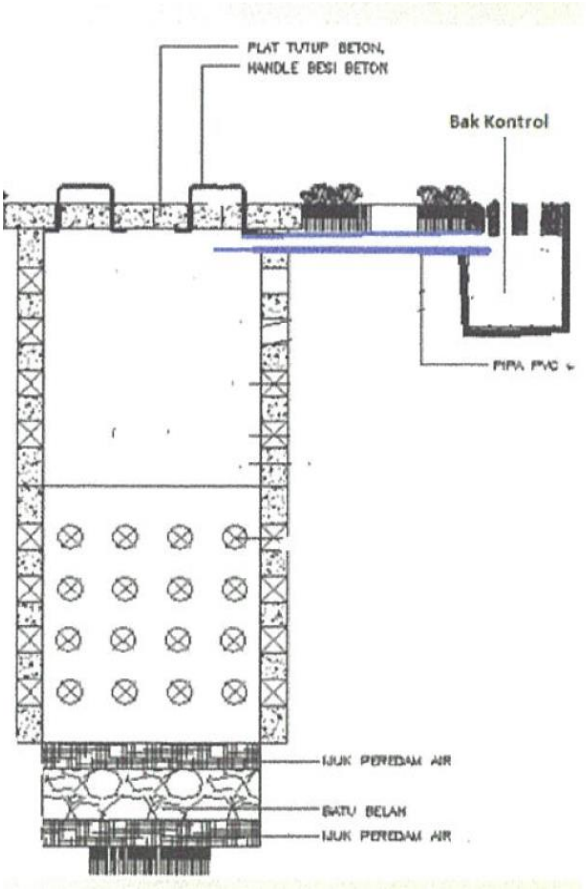


Figure 3.86 Maintenance and management of rainwater storage and infiltration facilities installed in BAPPEDA in Bogor City, Manual excerpt

Source: Chichibu Chemical Co., Ltd.



Source: DPE

Figure 3-87 Cross section of infiltration facilities implemented in DKI Jakarta

CHAPTER 4 ADAPTATION MEASURES AGAINST LAND SUBSIDENCE

4.1 Overview of Flood and High Tide Disaster

4.1.1 Flood Disaster

Flood disaster in the Ciliwung River and West Banjir Canal flow through DKI Jakarta is described below.

A large scale of river water floods has occurred approximately once every five years in the Ciliwung River Basin, such as the floods in 1996, 2002, 2007, 2013, and 2020. It is identified that the river water flood will occur in case that the rainfall at the upstream area continues for approximately 4 to 13 days intermittently.

Table 4.1 Major Flood Disaster in Recent Years

Year of Occurrence	Duration of Rainfall (hr)	Average Rainfall in Basin at Manggarai Gate Point					Manggarai Gate Point Peak WL (m)	Disaster Condition	Inundatioin Area (km2)	Casualty (person)
		1hour (mm)	6hour (mm)	24hour (mm)	48hour (mm)	168hour (mm)				
1-6 Jan. 1996	102	31.8	64.6	130.5	156.9	296.7	9.70	Overflow, Inland Water	–	–
26 Jan..-2.Feb.2002	164	16.6	59.9	132.4	194.9	397.8	10.50	Overflow, Inland Water	87	25
30 Jan. - 6 Feb. 2007	153	21.5	86.6	179.5	254.6	445.6	10.61	Overflow, Inland Water	300	80
8-20. Jan. 2013	305	21.6	54.4	90.7	161.6	334.5	10.00	Dike Break, Overflow, Inland Water	140	20
31 Dec.2019 - 1 Jan.2020	approx. 48	–	–	90 (provisional)	133 (provisional)	–	9.65	Dike Break, Overflow, Inland Water	142	61

* Duration of rainfall is the duration of average rainfall at Manggarai including non-rain time for less than 6 hours.

* Inundation area is a record in DKI Jakarta.

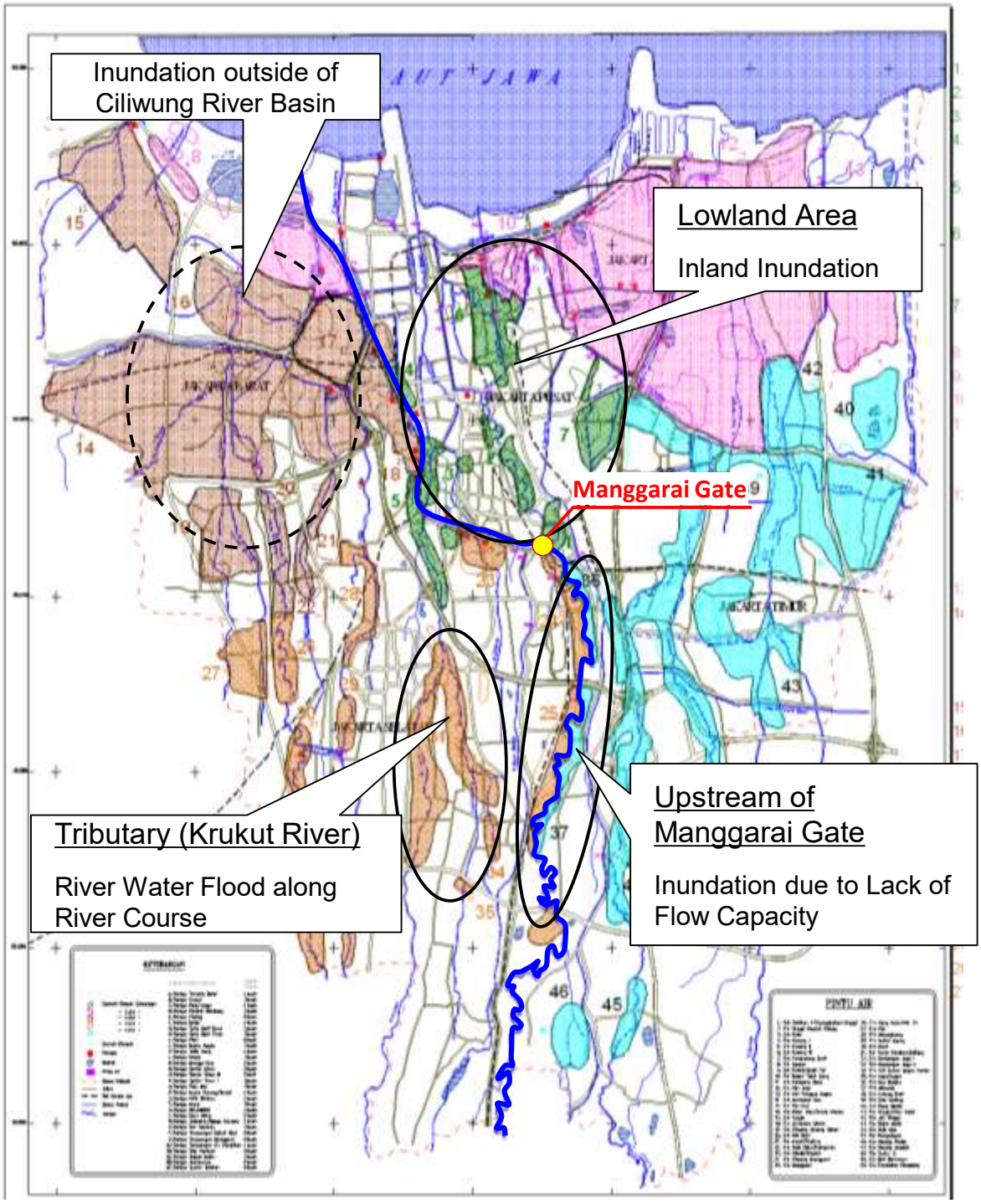
* Inundation area in January, 2013 is estimated based on field survey by JCFM (JICA, 2013).

*Casualty is a record in websites

Source: The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia Comprehensive Flood Management Plan（JICA, 2013）

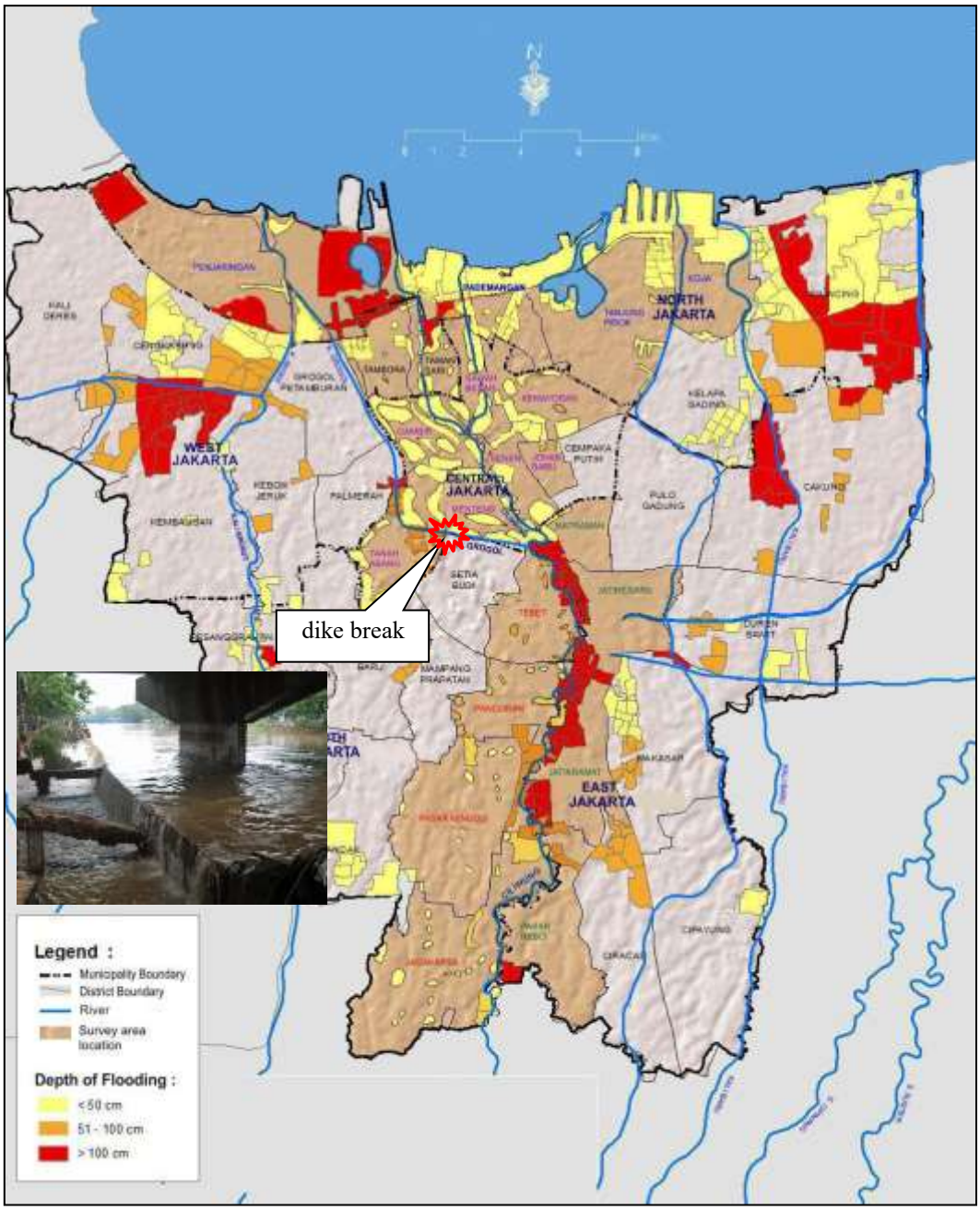
The flood disaster in February 2007 caused a large-scale inundation in approximately 45% of the DKI Jakarta area. At this time, the peak water level at Manggarai Gate was EL. 10.61 m, which is the most extensive record, exceeding dangerous water level for approximately 1.5 days. Moreover, at the time of the January 2013 flood, the water flowed into the central area of DKI Jakarta, where the embassy and presidential palace are located, up to the lowland areas along the coast due to the dike break at Jl. Latuharhari.

Furthermore, the flood disaster from December 31 to January 1, 2020 caused extensive damage from DKI Jakarta to neighboring local governments such as KOTA Bekasi, KOTA Tangerang, and KOTA Tangerang Selatan. KOTA Bekasi had the largest impact, with about 370,000 evacuees among the surrounding local governments.



Source: DKI Jakarta

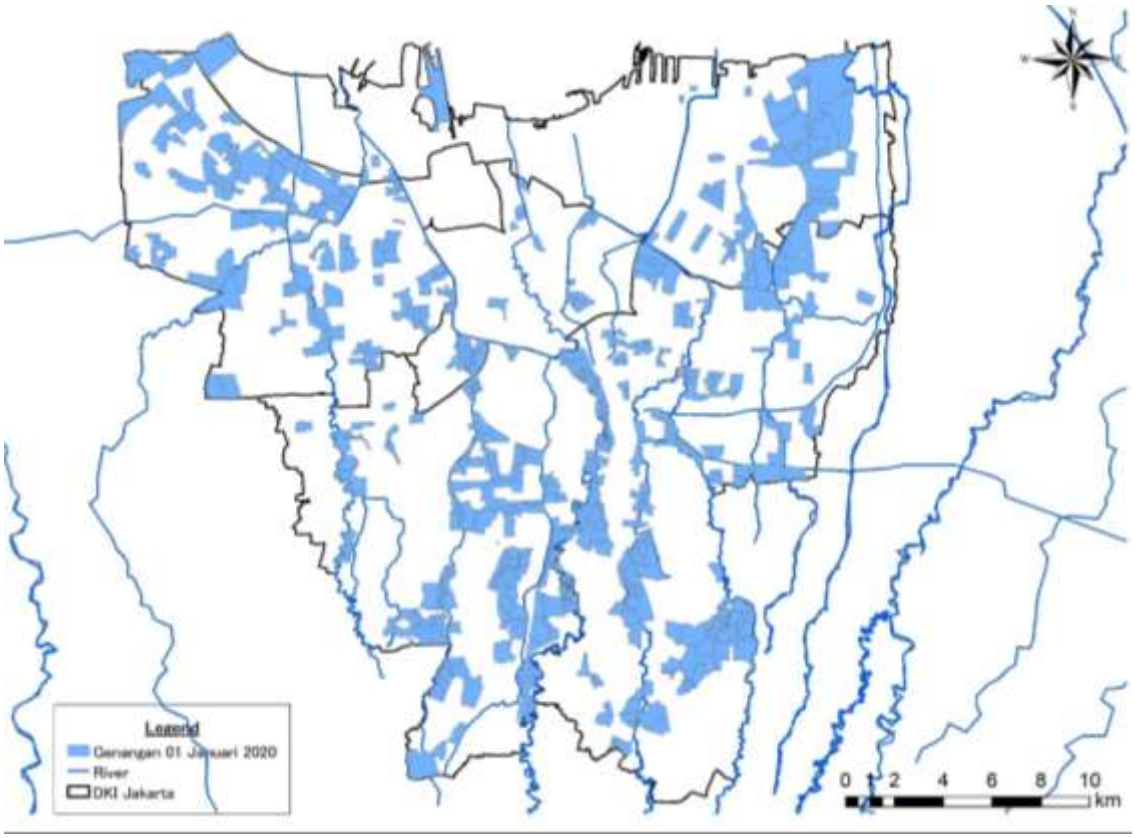
Figure 4.1 Inundation Area in February 2007 Flood



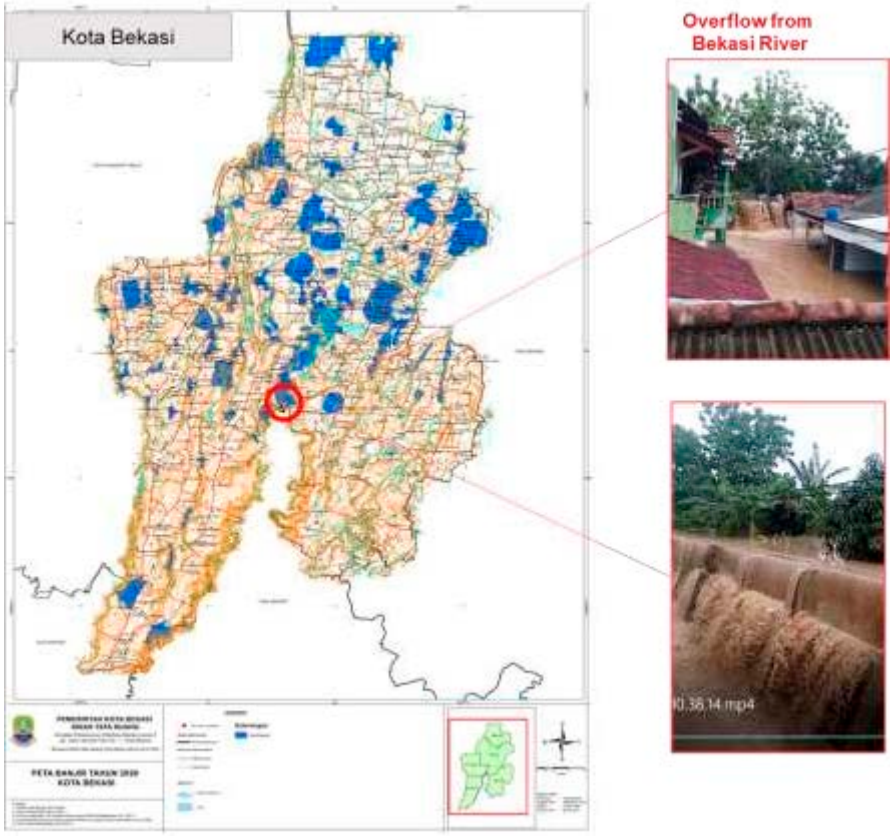
Note: Inundation area is estimated based on site survey conducted by JICA Project Team.

Source: The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia Comprehensive Flood Management Plan (JICA, 2013)

Figure 4.2 Inundation Area and Dike Break at West Banjir Canal in January 2013 Flood

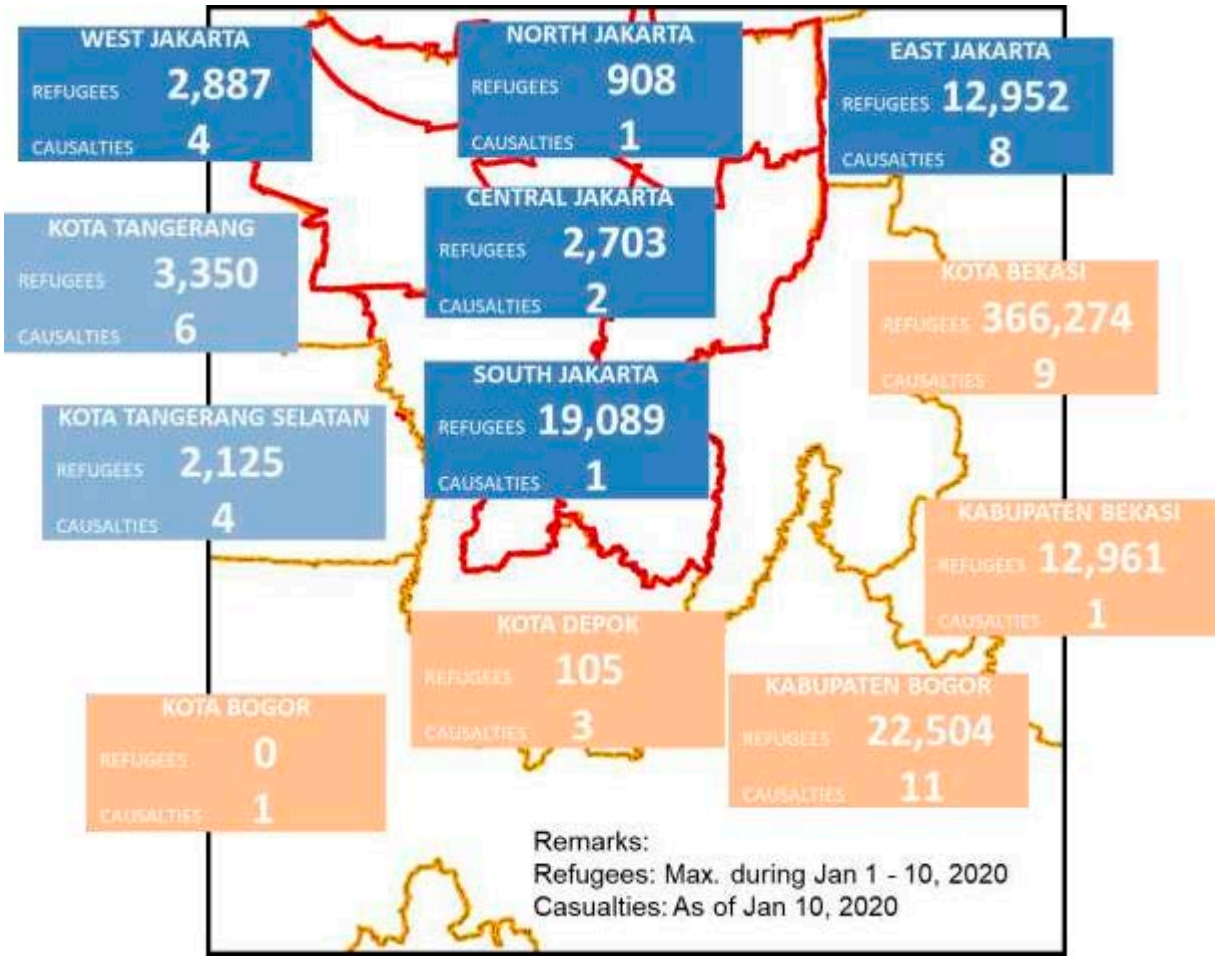


Source: DKI Jakarta



Source: KOTA Bekasi

Figure 4.3 Inundation Area in January 2020 Flood (upper: DKI Jakarta, lower: KOTA Bekasi)



Source: BNPB

Figure 4.4 Damage distribution in January 2020 Flood (refugees and causalities)

(1) Relationship between land subsidence areas and flood damage

1) Subsidence distribution map

Figure 4.5 GNSS surveyed land subsidence distribution and recent major flood inundation results shows the distribution of land subsidence based on GNSS surveying over a period of about 40 years from 1974 to 2014. The maximum subsidence in each city is 4.1m or more in North Jakarta and 2.1m or more in West Jakarta, and the percentage of land subsidence is larger than in other cities.

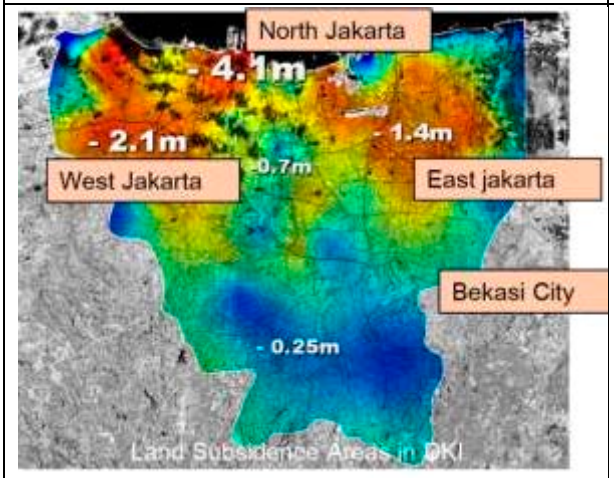
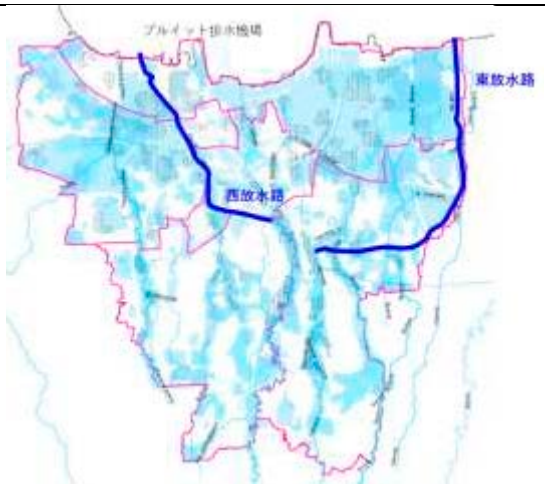
Subsidence distribution based on GNSS survey (1974-2014, 40 years)	Overlaid map of flooding results for the four recent floods
	
・In North Jakarta, the maximum sinking is more than 4.1 m. ・In West Jakarta, the maximum sinking is 2.1 meters or more. ・East Jakarta sank a maximum of 1.4 meters or more ・Central Jakarta sank a maximum of 0.7 m or more ・South Jakarta sank by a maximum of 0.25m or more	Overlaid map of flooding results for the 2002.2, 2007.2, 2013.1, and 2020.1 floods, with darker colored areas in the figure indicating areas where more flooding is likely to occur.

Figure 4.5 GNSS surveyed land subsidence distribution and recent major flood inundation results

2) Percentage of each city's area inundated by major floods in recent years

The percentage of inundated area of each city in Jakarta SAR is summarized in Table 4.2 and Figure 4.6 based on the inundation performance maps for the four major floods in recent years. The following characteristics are noted.

- In the 2002 flood, about 10-20% area was inundated in all areas.
- The 2007 flood inundated the entire area, with 50% area inundated in the north and west.
- The 2013 flood was concentrated in the Central area due to the breach of the right bank of the West Spillway.
- The January 2020 flood had more flooding due to rainfall to the south.

3) Relationship between land subsidence areas and flood damage

Based on (a) and (b) above, the areas inundated by major floods in recent years are mostly located in North Jakarta and West Jakarta, which coincide with areas where the rate of land subsidence is high, and land subsidence tends to increase the damage caused by flooding.

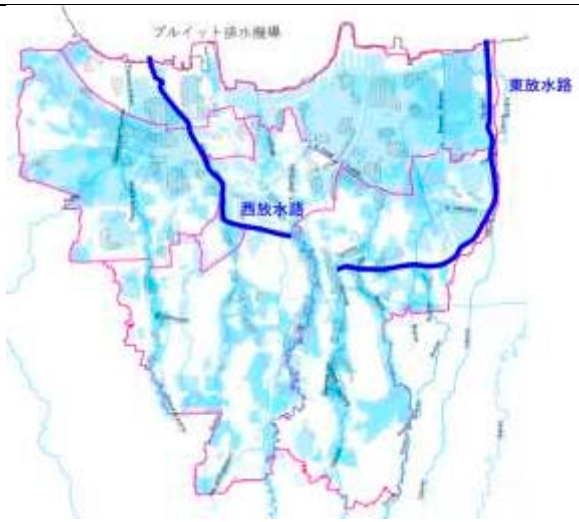
Table 4.2 Percentage of each city's area inundated by major floods in recent years

YEAR	Area	2002		2007		2013		2020	
		Flood	Rate	Flood	Rate	Flood	Rate	Flood	Rate
WEST	125.2	22.4	18%	65.5	52%	27.6	22%	49.9	40%
EAST	185.3	19.6	11%	57.6	31%	23.9	13%	63.6	34%
NORTH	146.7	22.3	15%	78.4	53%	59.4	41%	35.1	24%
CENTRAL	50.5	7.3	14%	14.6	29%	16.1	32%	8.3	17%
SOUTH	144.8	13.6	9%	30.2	21%	15.7	11%	57.7	40%
Total	**652.3**	**85.1**	**13%**	**246.3**	**38%**	**142.7**	**22%**	**214.6**	**33%**



Source: Consultants

Figure 4.6 Percentage of each city's area inundated by major floods in recent years



4Flood overlay diagram

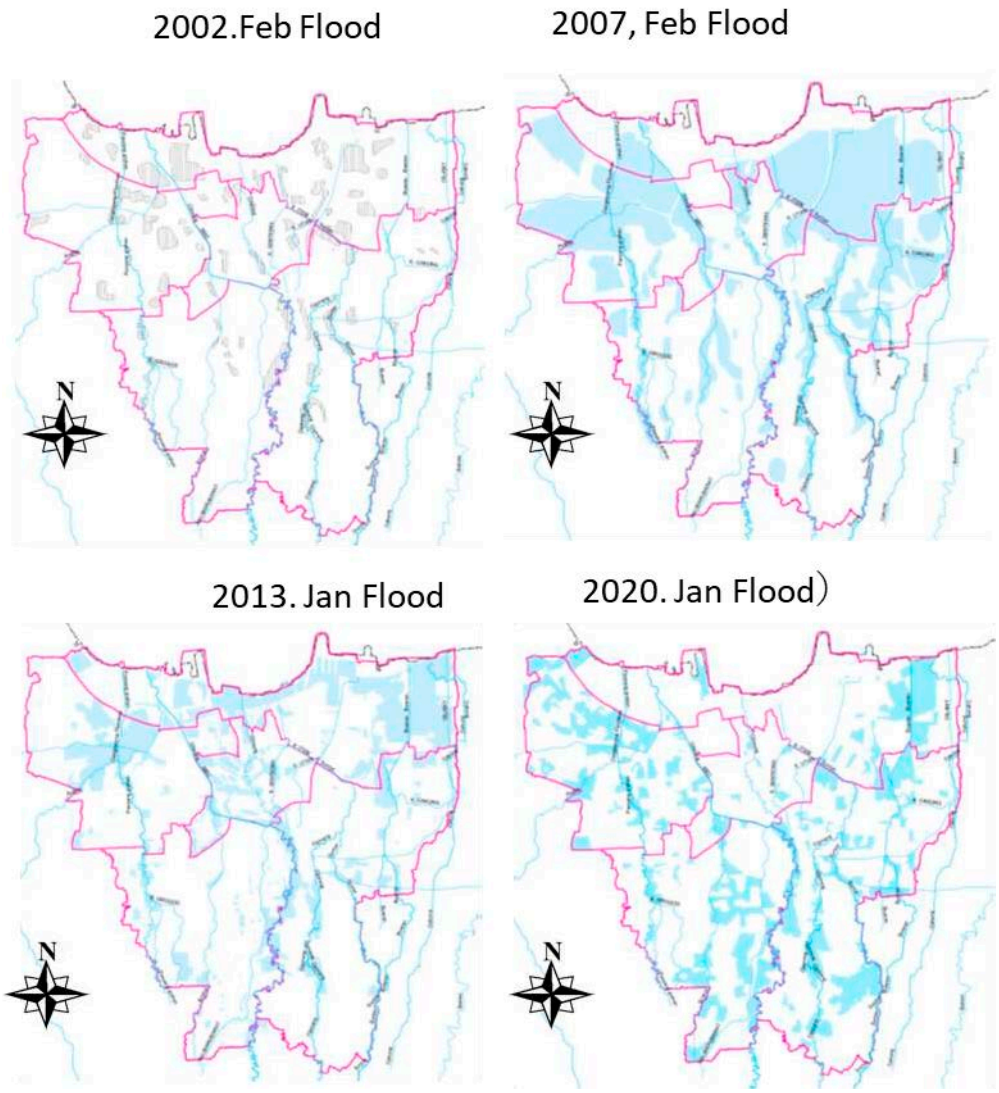


Figure 4.7 Inundation results map of major floods in recent years (Jakarta Special Province)

4.1.2 High Tide Disaster

The lowland areas under sea level, existing due to land subsidence, spread in the northern coastal area of Jakarta. Therefore, inundation disasters often occur during high tide in this area.

Lately, in the Pluit area, during high tide, overflowing of seawater from the crest of existing coastal dike and flowing into the inland area occur a few times per year.

Comparison of ground elevation and sea level, overflow condition, and inundation situation is shown below.



Comparison of seawall and sea level (Pluit)

The height under the eaves of the first floor of the building matches the height of the top of the existing seawall. (Pluit) Photo by yec



Comparison of ground elevation and sea level

Current condition from the top of the existing seawall. The ground is about 2m below sea level. （Photo by yec



Overflow due to high tide

Overflow beyond the existing seawall. Such overtopping occurs several times a year (Pluit) Courtesy of JICA expert



Flooding of overflowing seawater

Overflowing seawater flooded by high tide (Pluit)

Photo by yec

Figure 4.8 Overtopping and flooding in the Pruitt area

4.2 Understanding of Damage of Land Subsidence in Infrastructure and Building

4.2.1 Summary of land subsidence impact survey

(1) Background and Objectives

It is possible that the impact of land subsidence on public infrastructure, private buildings, and etc. has been apparent due to serious land subsidence in Jakarta in the past years. Given the possibility of the impact of land subsidence, the survey aimed to understand the impact of land subsidence in Jakarta. This survey consists of two activities as follows.

- Site survey of remarkable cases where land subsidence impact is apparent
- Interview survey to the related government agencies/property owners

The outcomes of this survey will be useful information on the following activities.

- Verification of inundation simulation
- Estimation of social cost due to land subsidence and consequent floods
- Public awareness raising with the use of easy-to-understand visual materials

(2) Target of Survey

Table 4.3 lists the target structures in this survey.

Table 4.3 Target structures in this survey

Target category	Target object
Infrastructures	- Land - Road - Bridge - Railway - Train station - Bus station - Dyke - Canal - Pumping stations - Water supply system - Sewerage systems - Seaport/Airport - Park
Public buildings	- Government building/complex - School/University - Hospital - Social facility - Religious facility - Public dormitory/Apartment
Private buildings and complexes	- Condominium/Apartment - Hotel - Business building - School/University - Hospital - Multi-purpose building - Factory

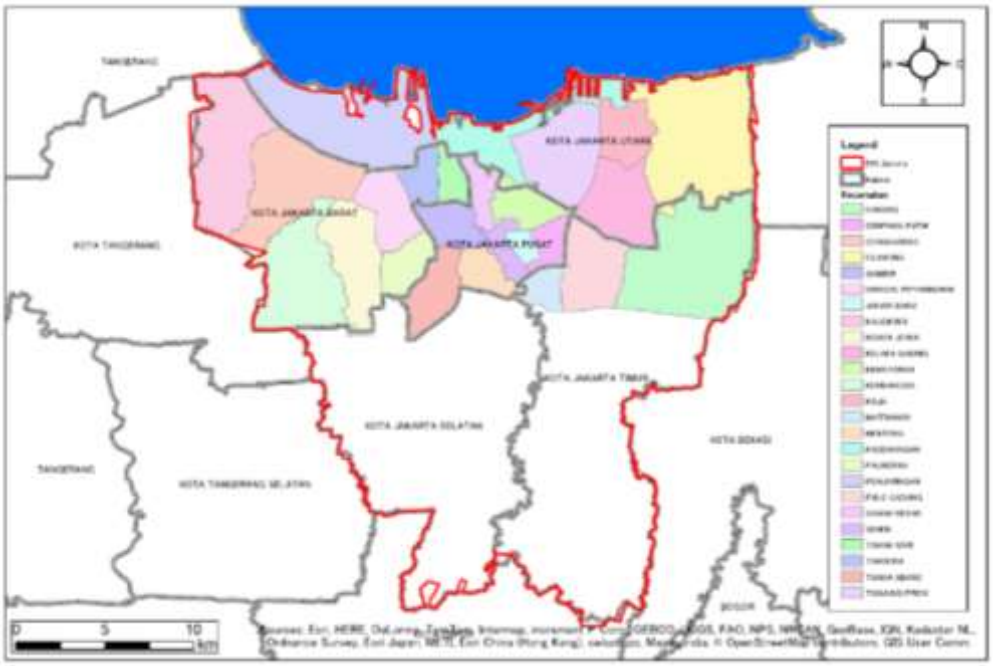
Source: The Project Team

This survey targets the area experiencing serious land subsidence. Table 4.4 lists the target 24 Kecamatan in the survey. Figure 4.9 shows the location map of the 24 Kecamatan.

Table 4.4 Target area in this survey (24 Kecamatan)

Kota	Kecamatan
Jakarta Pusat	Gambir, Tanah Abang, Menteng, Senen, Cempaka Putih, Johor Baru, Kemayoran, Sawah Besar
Jakarta Timur	Matraman, Pulo Gadung, Cakung
Jakarta Barat	Cengkareng, Grogol Petamburan Kalideres, Kebon Jeruk, Kembangan, Palmerah, Taman Sari, Tambora
Jakarta Utara	Koja, Kelapa Gading, Tanjung Priok, Pademangan, Penjaringan, Cilincing,

Source: The Project Team



Source: The Project Team

Figure 4.9 Target area (24 Kecamatan)

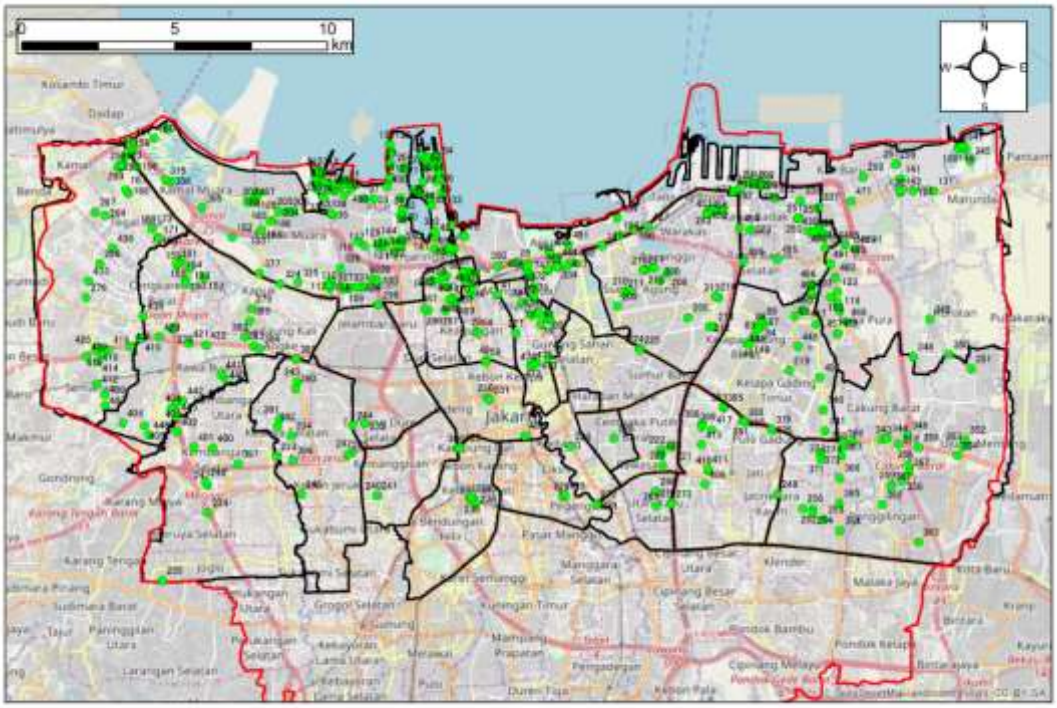
4.2.2 Result of land subsidence impact survey

(1) Survey locations and overall properties

1) Summary

This survey collected a total of 481 samples within sixteen days of survey, starting from October 21 to November 5, 2018. Figure 4.10 describes the locations of the survey, indicating that the surveyed locations are carefully selected to be evenly distributed to the target 24 Kecamatan.

Table 4.5 shows the summary of the surveys, namely, 1) site survey and 2) interview survey.



Source: The Project Team

Figure 4.10 Surveyed locations and locations' ID

Table 4.5 Summary of Overall Survey

Type of Survey	Result
Site survey and Interview survey	● Result indicates 370 locations of "site survey" and 111 locations of "interview survey", out of 481 surveyed locations. ● Result indicates 171 locations of "infrastructure", 121 locations of "public building and public property", and 161 locations of "private building and property", out of 481 surveyed locations. ● Among "infrastructure", the number of "road" is the highest, followed by "bridge", "canal", "land", and "pumping station". ● Among "public building and public property", the number of "governmental building and complex" is the highest, followed by "school and university", "religious facility", and "hospital". ● Among "private building and private property", the number of "business building" is the highest, followed by "multi-purpose building", and "factory".

Source: The Project Team

2) Results

a) Type of Survey

Figure 4.11 depicts the result of "Type of survey", indicating 370 locations of "site survey" and 111 locations of "interview survey", out of 481 surveyed locations.

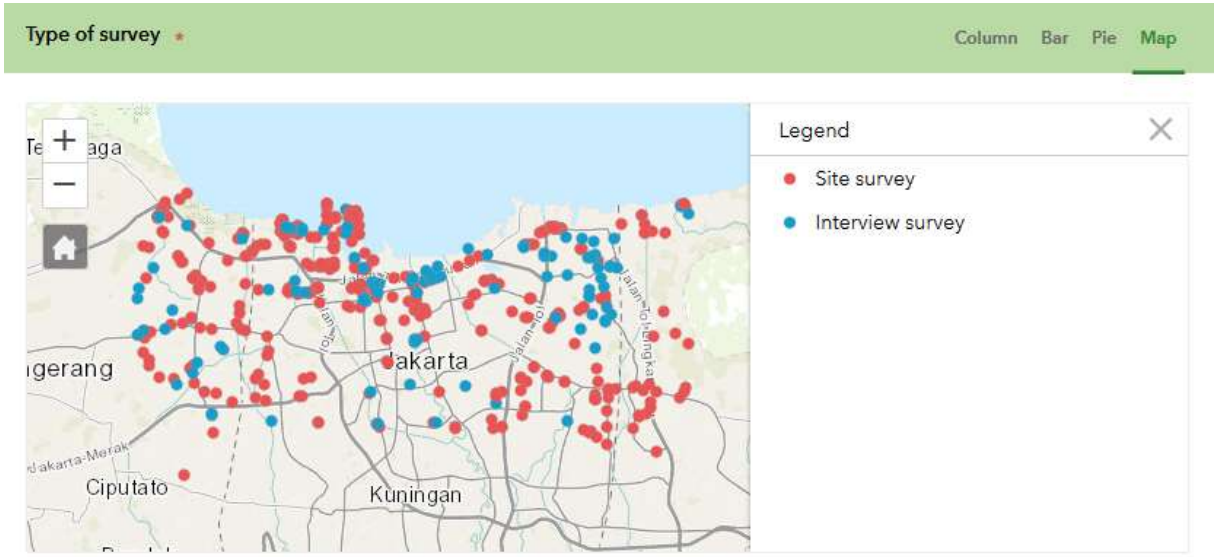


Figure 4.11 Result of "Type of Survey"

b) Type of Property

Figure 4.12 depicts the result of "Type of property", indicating 171 locations of "infrastructure", 121 locations of "public building and public property", and 161 locations of "private building and property", out of 481 surveyed locations. The figure shows scattered points and does not show any specific spatial characteristic. Figure 4.13, Figure 4.14, and Figure 4.15 show details of the result of "Type of property". Among "infrastructure", the number of "road" is the highest, followed by "bridge", "canal", "land", and "pumping station". Among "public building and public property", the number of "governmental building and complex" is the highest, followed by "school and university", "religious facility", and "hospital". Among "private building and private property", the number of "business building" is the highest, followed by "multi-purpose building", and "factory".

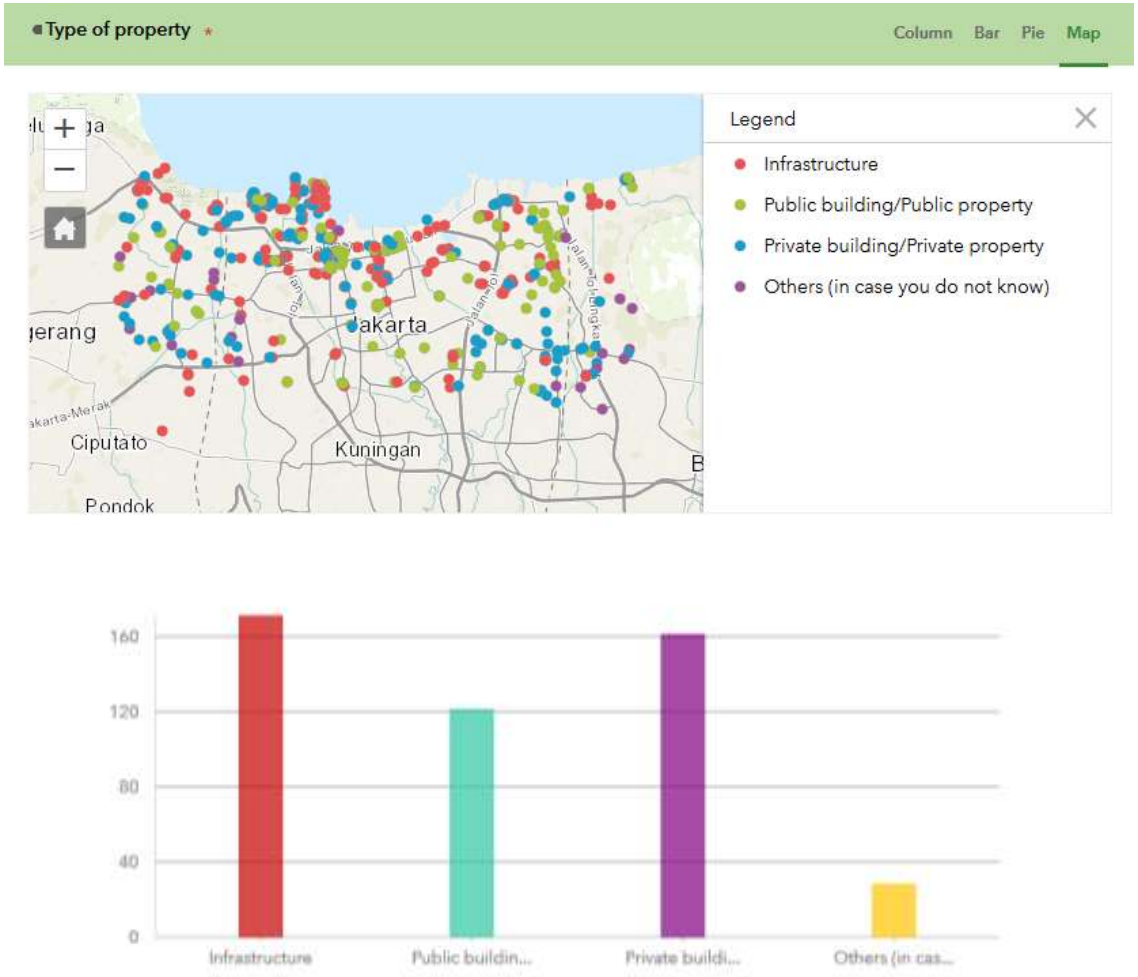
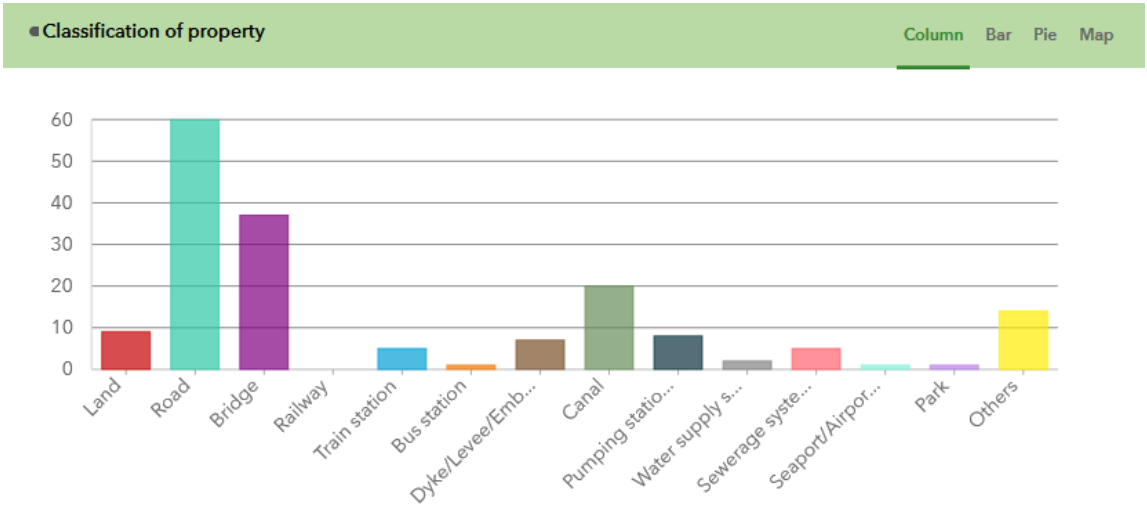
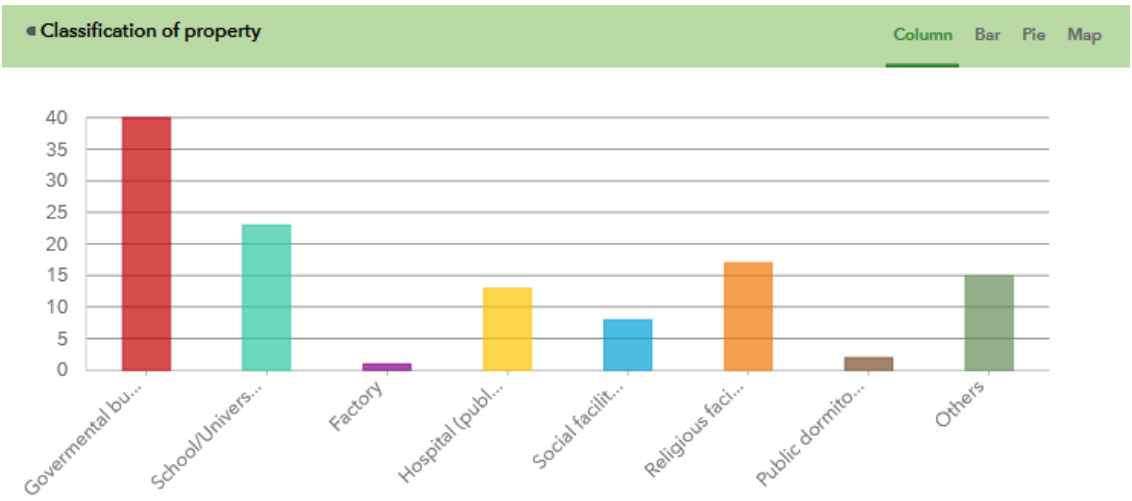


Figure 4.12 Result of "Type of Property"



Answers	Count	Percentage
Land	9	1.87%
Road	60	12.47%
Bridge	37	7.69%
Railway	0	0.00%
Train station	5	1.04%
Bus station	1	0.21%
Dyke/Levee/Embankment	7	1.46%
Canal	20	4.16%
Pumping station	8	1.66%
Water supply system	2	0.42%
Sewerage system	5	1.04%
Seaport/Airport	1	0.21%
Park	1	0.21%
Others	14	2.91%

Figure 4.13 Details of the result of "Type of Property" (Infrastructure)

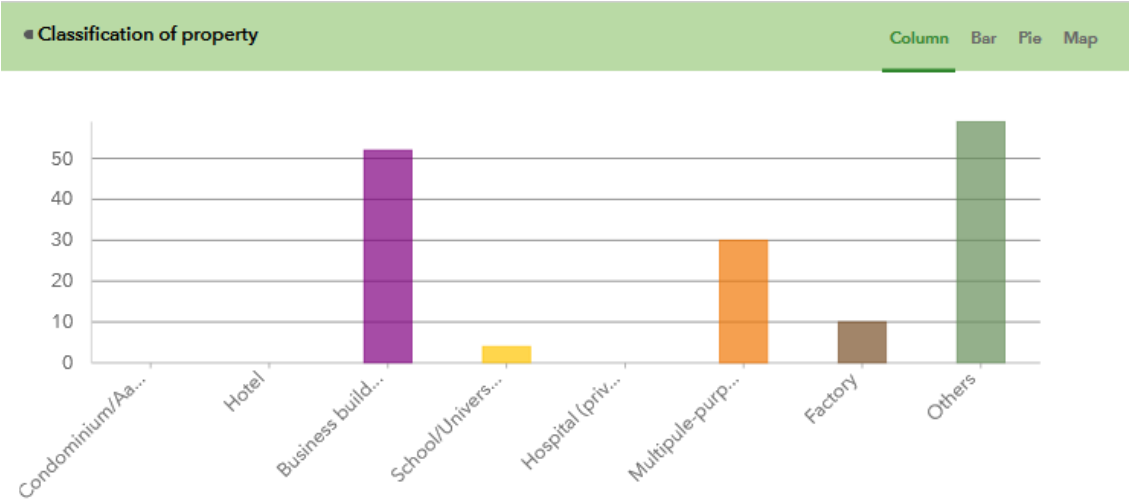


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Empty Categories Sort

Answers	Count	Percentage
Govermental building/complex	40	8.32%
School/University (public)	23	4.78%
Factory	1	0.21%
Hospital (public)	13	2.70%
Social facility (museum, city hall, etc)	8	1.66%
Religious facility (Mosque/Church/others)	17	3.53%
Public dormitory/apartment	2	0.42%
Others	15	3.12%

Figure 4.14 Details of the result of "Type of property" (Public building and property)



Hide Table

Empty Categories Sort

Answers	Count	Percentage
Condominium/Aartment	0	0.00%
Hotel	0	0.00%
Business building	52	10.81%
School/University (private)	4	0.83%
Hospital (private)	0	0.00%
Multipule-purpose building (residential & business & etc)	30	6.24%
Factory	10	2.08%
Others	59	12.27%

Figure 4.15 Details of the result of "Type of property" (Private building and property)

(2) Site survey

1) Summary

Site survey targets remarkable cases where land subsidence impact is apparent. Table 4.6 lists the contents of site survey. Table 4.7 shows a summary of site survey.

Table 4.6 Contents of site survey

No	Question
1	Survey date and time
2	Latitude/Longitude
3	Object name
4	Have you experienced the land subsidence at the property?
5	How much is the maximum depth of the land subsidence at the property? (cm)

Source: The Project Team

Table 4.7 Summary of Site Survey

Question	Summary of result
Have you experienced the land subsidence at the property?	● Result indicates 340 locations of "Yes, experienced" and 30 locations of "No, have not experienced", out of 370 surveyed locations. ● Result also indicates that the land subsidence impact covers most of the surveyed area. ● As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence impact is more significant in the north, northwest, and mid-east areas, while the impact is less in the central area of Jakarta.
How much is the maximum depth of the land subsidence at the property? (cm)	● Result indicates the maximum depth of 200 cm among 340 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence is more significant in the north (e.g., Pluit) and east, while the impact is minor in some other areas of Jakarta. ● Degree of land subsidence depends on the area, indicating its large spatial variability in Jakarta.

Source: The Project Team

2) Result in detail

a) Have you experienced the land subsidence at the property?

Figure 4.16 depicts the result of "Have you experienced the land subsidence at the property?", indicating 340 locations of "Yes, experienced" and 30 locations of "No, have not experienced", out of 370 surveyed locations in total. The result indicates that a majority of surveyed locations shows the existence of land subsidence impact because the site survey targets infrastructure, buildings, and property of remarkable cases where land subsidence impact is apparent. The result also indicates that the land subsidence impact covers most of the surveyed area. As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence impact is more significant in the north, northwest, and mid-east areas, while the impact is less in the central area of Jakarta.



Figure 4.16 Result of "Have you experienced the land subsidence at the property?"

b) How much is the maximum depth of the land subsidence at the property? (cm)

Figure 4.17 depicts the result of "How much is the maximum depth of the land subsidence at the property?", indicating the maximum depth of 200 cm among 340 surveyed locations. As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence is more significant in the north (e.g., Pluit) and east, while the impact is minor in some other areas of Jakarta. In another word, the degree of land subsidence depends on the areas, indicating its large spatial variability in Jakarta.

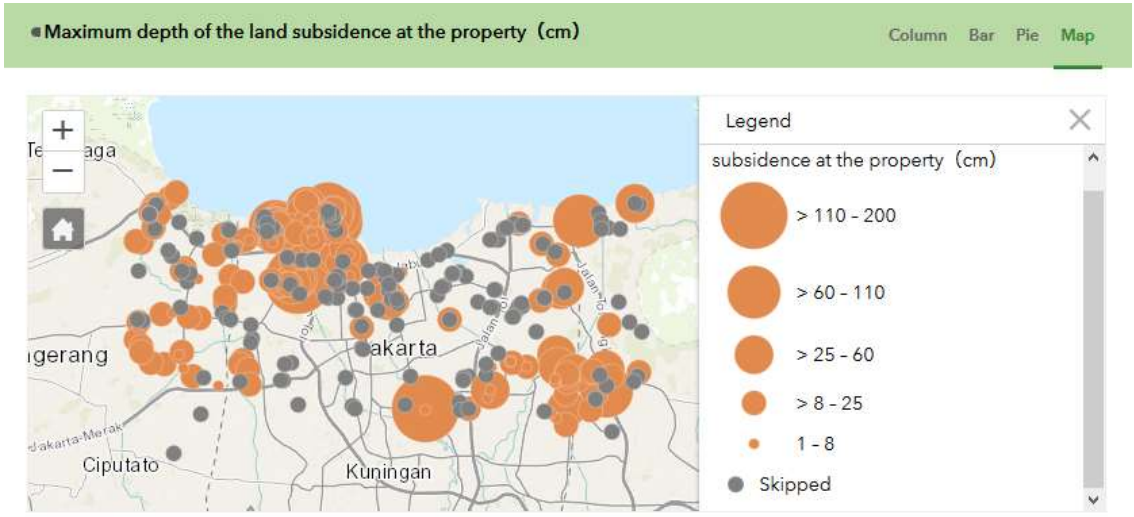


Figure 4.17 Result of "How much is the maximum depth of the land subsidence at the property?"

(3) Interview survey

1) Summary

Interview survey targets the related government agencies/property owners whose properties are facing serious land subsidence impacts. Table 4.8 lists the contents of interview survey. Table 4.9 shows a summary of site survey.

Table 4.8 Contents of interview survey

No	Question
1	Survey date and time
2	Latitude/Longitude
3	Object name
4	Have you experienced the land subsidence at the property?
5	How serious is the impact of land subsidence?
6	How much is the maximum depth of the land subsidence at the property? (cm)
7	Have you experienced any direct impact to your property from the subsidence? (e.g., Subsided land, subsided building structures, prolonged flood, and etc.)
8	Where is the location of land subsidence impact?
9	Have you inspected the land subsidence impact?
10	What is the method of inspection?
11	Have you repaired your property after the subsidence impact?
12	What is the method of repairing?
13	How much was the financial cost of repairing?
14	Have you experienced floods at your property?
15	Do you feel that floods get more frequent after the land subsidence at your property?
16	How many times have you experienced floods?
17	How much was the depth of flood inundation at your property?
18	How long was the maximum flood duration at your property? (hr)
19	When was the latest flood at your property?
20	How much was damage cost of the flood?

Source: The Project Team

Table 4.9 Summary of interview survey

Question	Summary of result
Have you experienced land subsidence at the property?	● Result indicates 59 locations of "Yes, experienced" and 52 locations of "No, have not experienced", out of 111 surveyed locations in total. ● As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence impact is more significant in the north and northeast, while the impact is less in the west area of Jakarta.
How serious is the impact of land subsidence?	● Result indicates 12 locations of "Severe", 18 locations of "Moderate", and 23 locations of "Minor", out of 53 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence impact is more significant in the north (e.g., Pluit), while the impact is less in the central area of Jakarta. ● Degree of land subsidence depends on the location, indicating its large spatial variability of seriousness in Jakarta.
How much is the maximum depth of the land subsidence at the property? (cm)	● Result indicates the maximum depth of 200 cm among 59 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence is more significant in the north (e.g., Pluit) and northeast, while the impact is minor in the south and west areas in Jakarta. ● Result revealed a spatial pattern of land subsidence in Jakarta.
Have you experienced any direct impact to your property from the subsidence? (e.g., Subsided land, subsided building structures, prolonged flood, and etc.)	● Result indicates 36 locations of "Yes, experienced" and 17 locations of "No, have not experienced", out of 53 surveyed locations in total. ● As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence direct impact is more significant in the north (e.g., Pluit) and northeast, while the direct impact is minor in the south and west areas in Jakarta. ● The next statements explains detailed locations of the impact
Where is the location of land subsidence impact?	● Result indicates that majority of the direct impacts appear as forms of "land" or "sinking of whole structure". ● While, the direct impacts on segments of structure (e.g., gate, wall, and etc.) are not common. ● It is likely that the direct impact as forms of "land" and "sinking of whole house" commonly appear in the result.
Have you inspected the land subsidence impact?	● Result indicates 11 locations of "Yes, inspected" and 42 locations of "No, have not inspected", out of 53 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies that there is no spatial tendency where the impact was inspected or not. ● Inspection of land subsidence impact is not common in Jakarta.
What is the method of inspection?	● Result indicates 8 locations conducted a visual inspection out of 11 surveyed locations in total. ● Result indicates that any specific method of inspection has not been decided in Jakarta and most of the inspections utilized a simple method although it was hard to be concluded due to a limitation of number of surveyed

Question	Summary of result
	locations.
Have you repaired your property after the subsidence impact?	● Result indicates 15 locations of "Yes, repaired" and 38 locations of "No, have not repaired", out of 53 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies that there is no spatial tendency where the property was repaired or not. ● Repairing of property after the subsidence impact is not common in Jakarta.
What is the method of repairing?	● Result indicates 7 locations conducted a land raising/basement raising out of 15 surveyed locations. ● Result indicates that the land raising/basement raising is the most common method for repairing.
How much was the financial cost of repairing?	● Result indicates maximum cost was 85,171,168,115IDR and average cost was 14,312,516,811IDR out of 10 surveyed locations. ● Result indicates that the cost of repairing might become very high although it was hard to be concluded due to the limitation of number of surveyed locations.
Have you experienced floods at your property?	● Result of "Have you experienced floods at your property?" indicates 84 locations of "Yes, experienced" and 26 locations of "No, have not experienced", out of 110 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure revealed that the experience of flood is common all over the surveyed area.
Do you feel that floods get more frequent after the land subsidence at your property?	● Result indicates 15 locations of "Yes" and 44 locations of "No", out of 59 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies that there is no spatial tendency in people's perception of the relationship between land subsidence and flood. ● Result suggests that people in Jakarta are likely not to recognize the relationship between land subsidence and flood.
How many times have you experienced floods?	● Result indicates 22 locations of "Only once", 35 locations of "More than twice", and 19 locations of "Almost every year", out of 76 surveyed locations in total. ● As a broad understanding of the spatial characteristic of the result, the figure revealed that the experience of flood is quite common in Jakarta, suggesting that flood damage is significant in the area.
How much was the depth of flood inundation at your property?	● Result indicates the maximum inundation depth of 240 cm among 73 surveyed locations. ● As a broad understanding of the spatial characteristic of the result, the figure implies the inundation is deeper in the north (e.g., Pluit) and northeast where land subsidence is significant, while the inundation is shallower in the western areas in Jakarta. ● Result revealed a spatial pattern of flood inundation depth as well as its correlation to land subsidence in Jakarta.

Question	Summary of result
How long was the maximum flood duration at your property? (hr)	● Result indicates that the maximum flood duration is less than 96 hours in 54 locations out of 64 surveyed locations and average duration is about 34 hours. ● As a broad understanding of the spatial characteristic of the result, the figure implies the duration is longer in the north (e.g., Pluit) and northeast where land subsidence is significant, while shorter in the west areas in Jakarta. ● Result revealed a spatial pattern of flood duration as well as its correlation to land subsidence in Jakarta.
When was the latest flood at your property?	● Result indicates 15 locations in 2017, 13 locations in 2013 and 2016, and 6 locations in 2014 out of 72 surveyed locations. ● It is likely that Jakarta faced significant floods in these years.
How much was damage cost of the flood?	● Result indicates maximum cost was 280,000,000,000 IDR and average cost was 21,556,230,769 IDR out of 13 surveyed locations in total. ● Result indicates that the flood damage was likely to be very high but it was hard to conclude due to limited number of surveyed locations.

Source: The Project Team

2) Result in detail

a) Have you experienced the land subsidence at the property?

Figure 4.18 depicts the result of "Have you experienced the land subsidence at the property?", indicating 59 locations of "Yes, experienced" and 52 locations of "No, have not experienced", out of 111 surveyed locations in total. Interview survey targets the related government agencies/property owners after site survey suggested that their properties are likely to be facing a serious land subsidence impact. In another word, interview survey is aimed at understanding the situation of land subsidence impact as much as possible rather than visiting many locations of subsidence. This is the reason why the result shows almost nearly the same numbers of "Yes, experienced" and "No, have not experienced", not resulting in a much higher number of "Yes, experienced" as site survey shows. As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence impact is more significant in the north and northeast, while the impact is less in the west area of Jakarta.

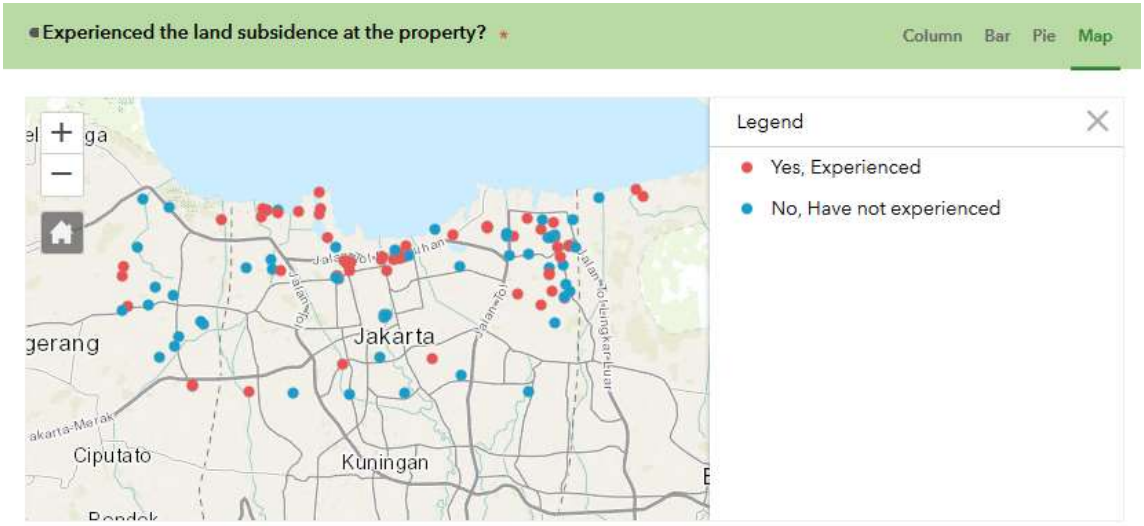


Figure 4.18 Result of "Have you experienced the land subsidence at the property?"

b) How much is the maximum depth of the land subsidence at the property?

Figure 4.19 depicts the result of "How much is the maximum depth of the land subsidence at the property?", indicating the maximum depth of 200 cm among 59 surveyed locations. As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence is more significant in the north (e.g., Pluit) and northeast, while the impact is minor in the south and west areas in Jakarta. The result revealed a spatial pattern of land subsidence in Jakarta.

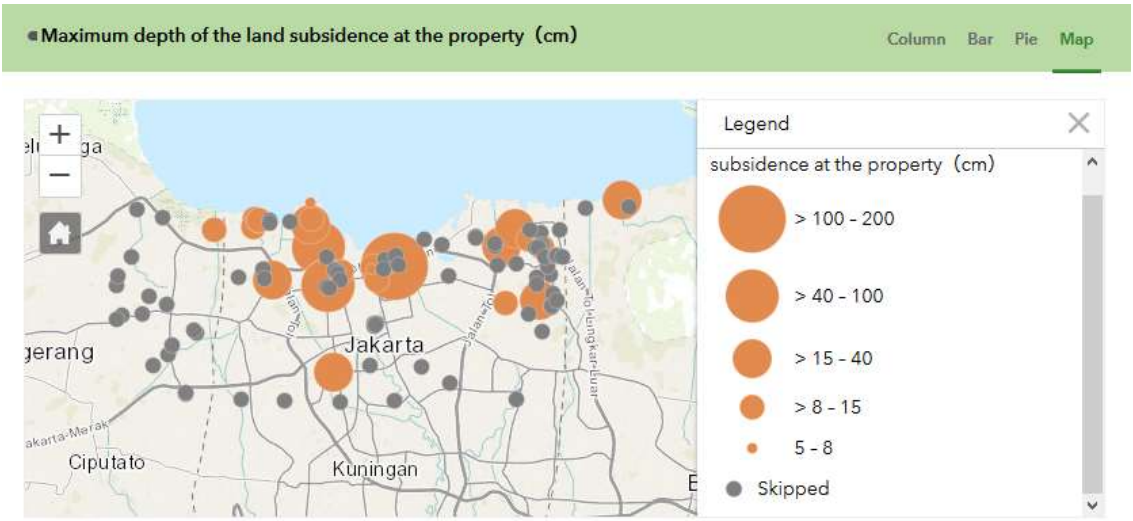


Figure 4.19 Result of "How much is the maximum depth of the land subsidence at the property?"



Figure 4.20 Comparison of results of land subsidence between InSAR analysis (within 11 years from 2007 to 2018) and interview survey

c) Have you experienced any direct impact to your property from the subsidence?

Figure 4.21 depicts the result of "Have you experienced any direct impact to your property from the subsidence?", indicating 36 locations of "Yes, experienced" and 17 locations of "No, have not experienced", out of 53 surveyed locations. As a broad understanding of the spatial characteristic of the result, the figure implies the land subsidence direct impact is more significant in the north (e.g., Pluit) and northeast, while the direct impact is minor in the south and west areas in Jakarta.

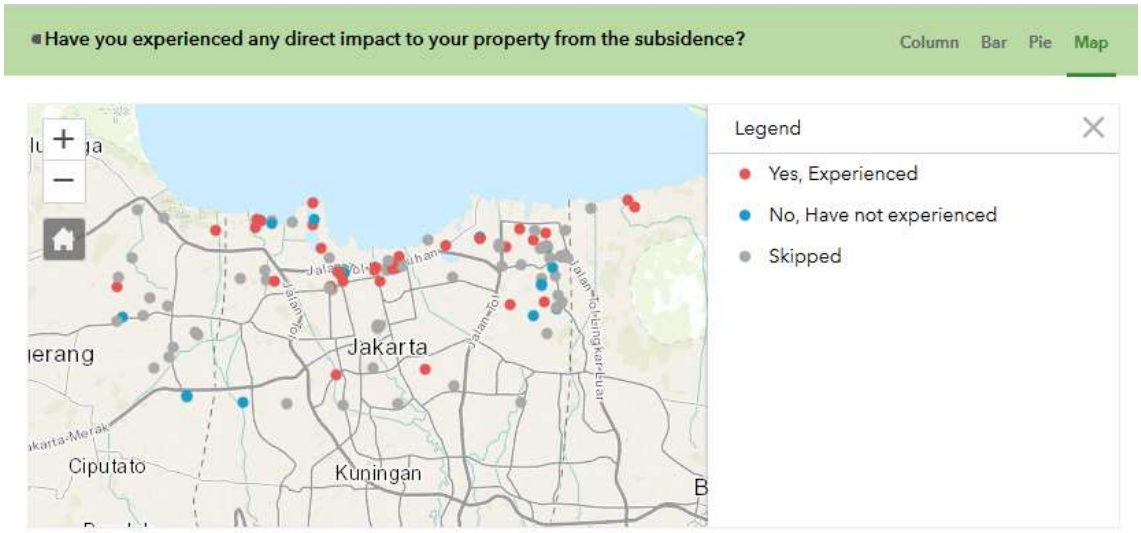
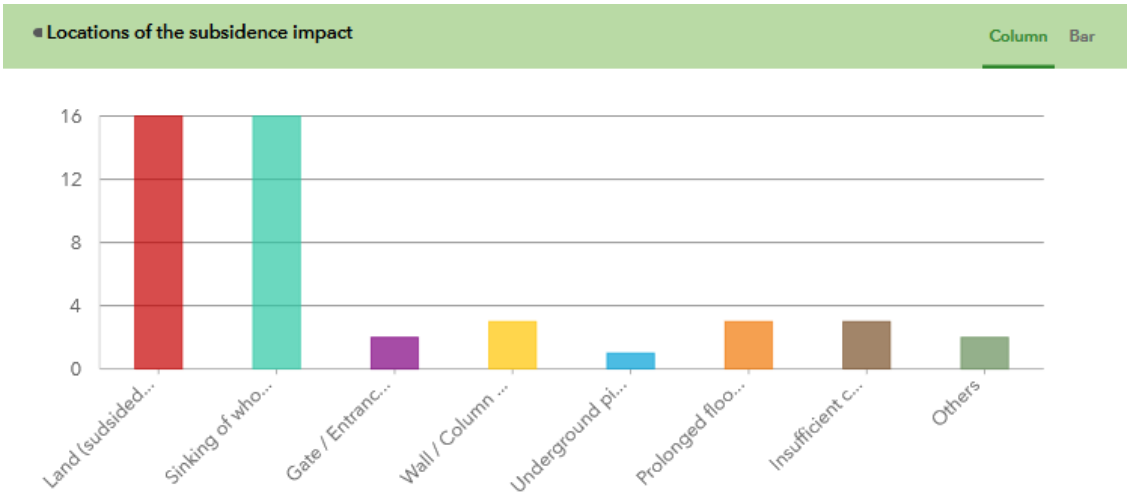


Figure 4.21 Result of "Have you experienced any direct impact to your property from the subsidence?"

d) Where is the location of land subsidence impact?

Figure 4.22 depicts the result of "Where is the location of land subsidence impact?", indicating that majority of the direct impacts appear as forms of "land" or "sinking of whole structure". While, the direct impacts on segments of structure (e.g., gate, wall, and etc.) are not common. In general, land subsidence appears in a spatially uniform manner so that the direct impacts on segments of the structure is rarely seen. Therefore, it is likely that the direct impact as forms of "land" and "sinking of whole house" commonly appear in the result.



Hide Table Empty Categories Sort

Answers	Count	Percentage
Land (sudsided land, crack, dent, etc)	16	14.41%
Sinking of whole structure	16	14.41%
Gate / Entrance (crack, gap between ground surface, etc)	2	1.80%
Wall / Column / Beam (crack, etc)	3	2.70%
Underground pipe (crack, leakage, etc)	1	0.90%
Prolonged flood/ Frequent flood (e.g., ROB (permanent flood))	3	2.70%
Insufficient clearance from water surface (bridge / dyke)	3	2.70%
Others	2	1.80%

Answered: 36 Skipped: 75

Figure 4.22 Result of "Where is the location of land subsidence impact?"



Subsided entrance of a building (Dinas Pariwisata Kota Tua)



Gap between building and its basement due to land subsidence (Kecamatan Pademangan)



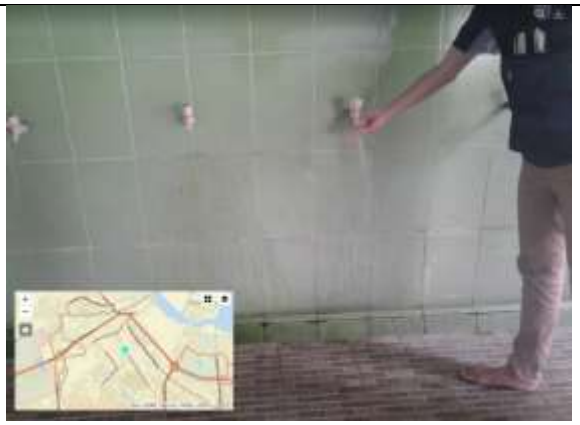
Inundation at seaport (Sunda Kalapa Port)



Subsided entrance of a building



Bridge suffered from land subsidence

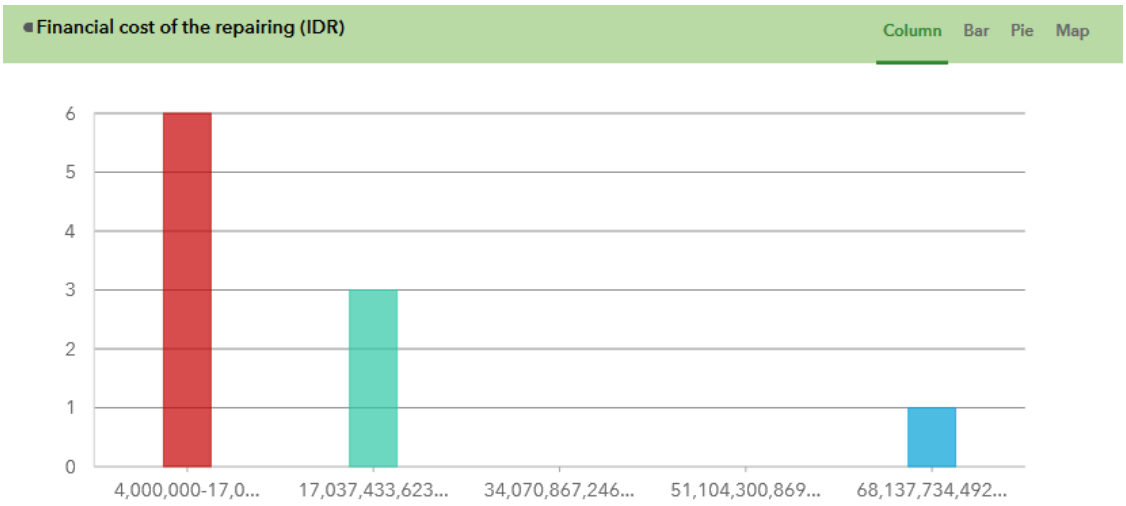


Contamination of tap water caused by seawater intrusion (mosque jami attaqwa)

Figure 4.23 Example of building damage due to land subsidence

e) How much was the financial cost of repairing?

Figure 4.24 depicts the result of "How much was the financial cost of repairing?", indicating maximum cost was 85,171,168,115IDR and average cost was 14,312,516,811IDR out of 10 surveyed locations in total. The result indicates that the cost of repairing might become very high although it was hard to be concluded due to a limitation of number of surveyed locations.



Hide Table Empty Categories Sort

Stats	Value
Min.	4,000,000
Max.	85,171,168,115
Avg.	14,312,516,811.5
Sum.	143,125,168,115

Figure 4.24 Result of "How much was the financial cost of repairing?"

Table 4.10 Examples of financial cost of repairing

Locations	Costs (IDR)	Contents
Pluit Fishery Port	85,171,168,115	Pumping facilities, Land raising, revetment improvement, pier improvement, dyke improvement
SMA 19 JAKARTA (Public High School)	18,000,000,000	Basement raising of building
Wilhara Property (Business Building)	2,000,000,000	Repairing of building
Museum Rumah Si Pitung	700,000,000	Management of ROB
Harapan Mulya	600,000,000	Basement raising of building
Singapore International School (SIS)	500,000,000	Basement raising of building

f) Have you experienced floods at your property?

Figure 4.25 depicts the result of "Have you experienced floods at your property?", indicating 84 locations of "Yes, experienced" and 26 locations of "No, have not experienced", out of 110 surveyed locations. As a broad understanding of the spatial characteristic of the result, the figure revealed that the experience of flood is common all over the surveyed area.

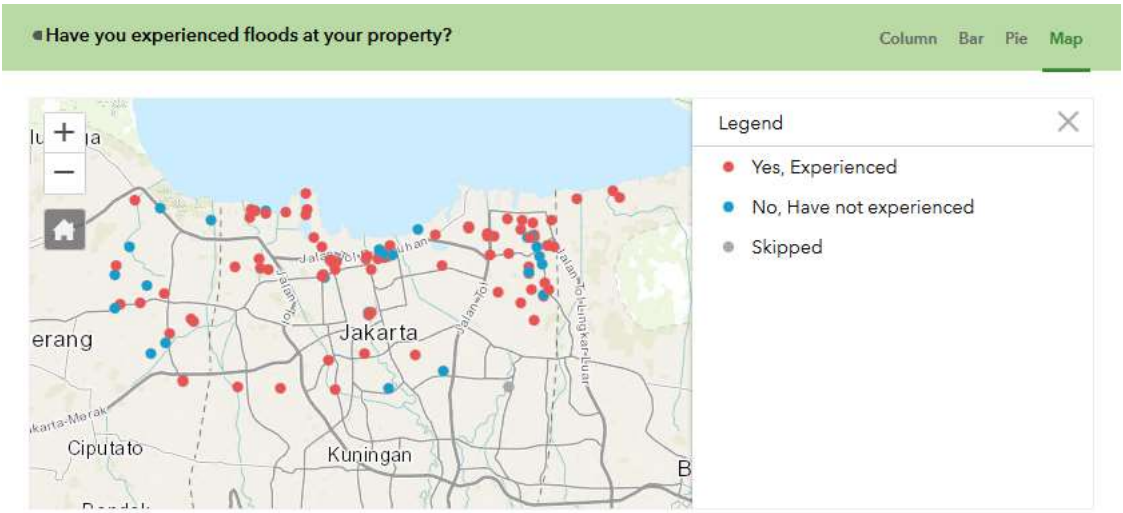


Figure 4.25 Result of "Have you experienced floods at your property?"

g) Do you feel that floods get more frequent after the land subsidence at your propert?

Figure 4.26 shows the results regarding the presence or absence of flooding experience. 15 of the 59 valid responses show a relationship between flooding and land subsidence, while 44 show no relationship between flooding and land subsidence. Taken at a macroscopic level, there is no regional trend regarding the existence of a relationship between flooding and land subsidence. Many survey respondents indicated that they perceive little relationship between flooding and land subsidence.

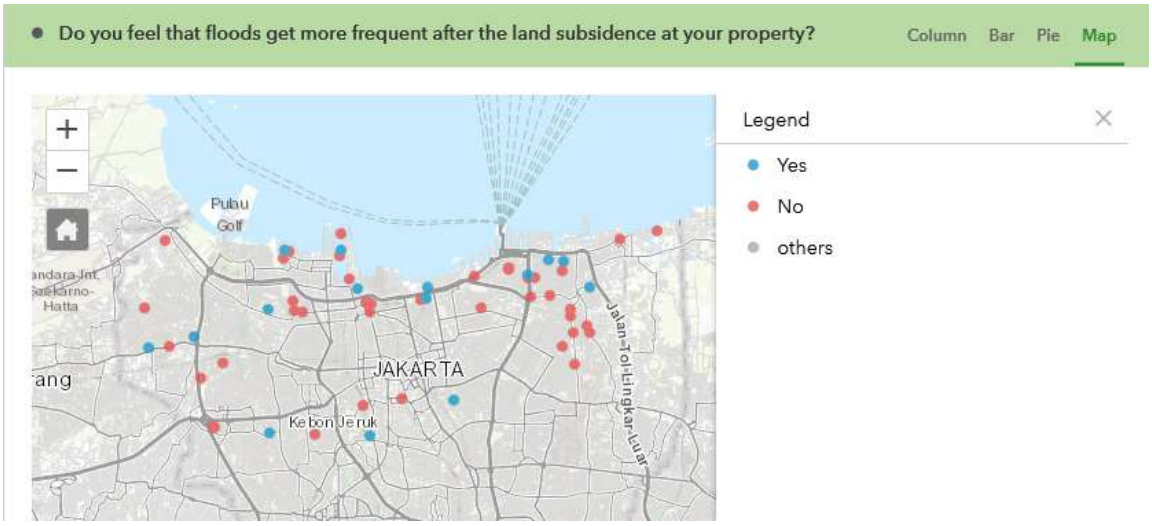


Figure 4.26 Result of "Do you feel that floods get more frequent after the land subsidence at your propert?"

h) Do you feel that floods get more frequent after the land subsidence at your property?

Figure 4.27 depicts the result of "Do you feel that floods get more frequent after the land subsidence at your property?", indicating 15 locations of "Yes" and 44 locations of "No", out of 59 surveyed locations in total. As a broad understanding of the spatial characteristic of the result, the figure implies that there is no spatial tendency in people's perception of the relationship between land subsidence and flood.

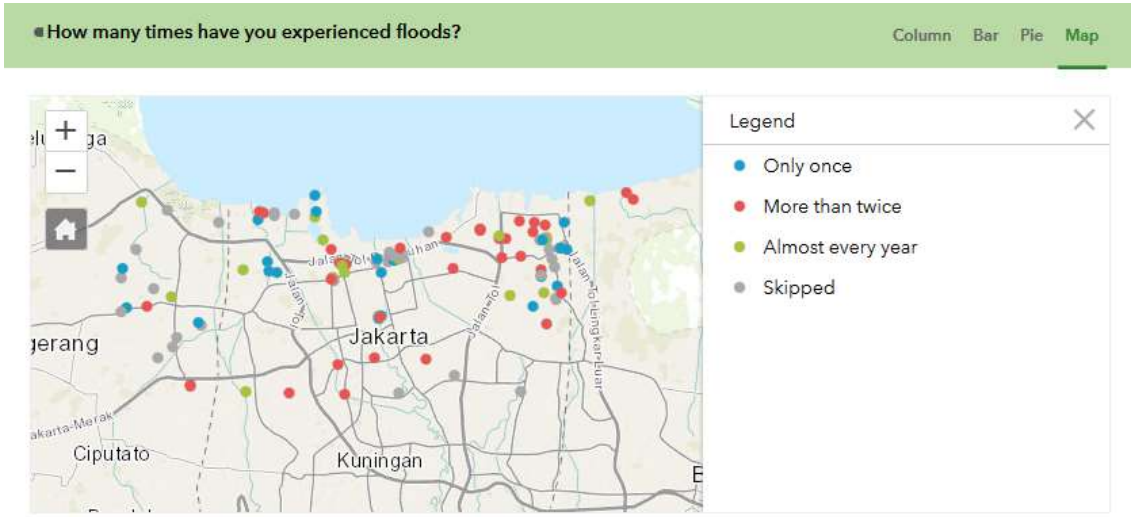


Figure 4.27 Result of "Do you feel that floods get more frequent after the land subsidence at your property?"

i) How much was the depth of flood inundation at your property?

Figure 4.28 depicts the result of "How much was the depth of flood inundation at your property?", indicating the maximum inundation depth of 240 cm among 73 surveyed locations. As a broad understanding of the spatial characteristic of the result, the figure implies the inundation is deeper in the north (e.g., Pluit) and northeast where land subsidence is significant, while the inundation is shallower in the western areas in Jakarta. The result revealed a spatial pattern of flood inundation depth as well as its correlation to land subsidence in Jakarta.

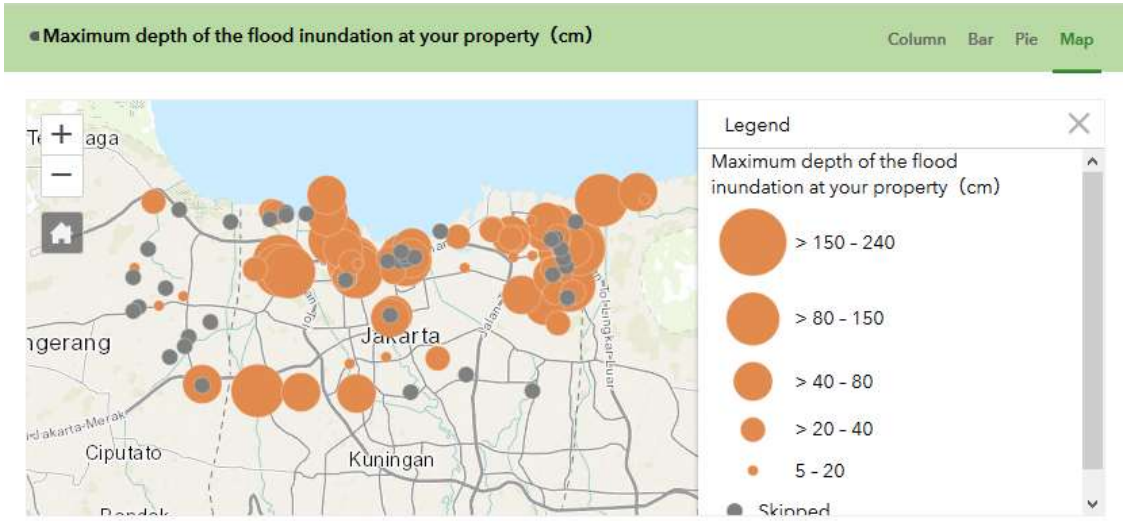


Figure 4.28 Result of "How much was the depth of flood inundation at your property?"

j) How long was the maximum flood duration at your property?

Figure 4.29 depicts the result of "How long was the maximum flood duration at your property?", indicating that the duration is less than 96 hours in 54 locations out of 64 surveyed locations and average duration is about 34 hours. As a broad understanding of the spatial characteristic of the result, the figure implies the duration is longer in the north (e.g., Pluit) and northeast where land subsidence is significant, while shorter in the west areas in Jakarta. The result revealed a spatial pattern of flood duration as well as its correlation to land subsidence in Jakarta.

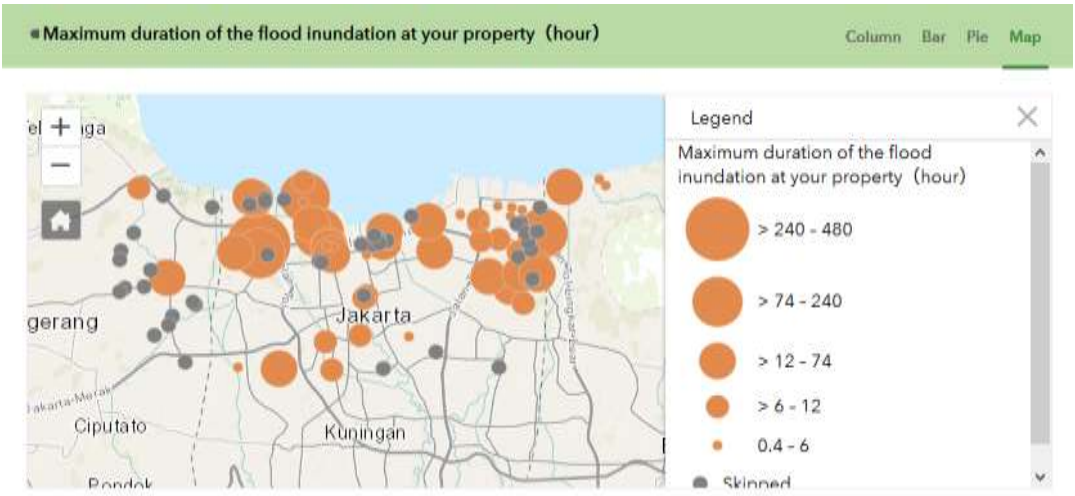


Figure 4.29 Result of "How long was the maximum flood duration at your property?"

k) When was the latest flood at your property?

Figure 4.30 depicts the result of "When was the latest flood at your property?", indicating 15 locations in 2017, 13 locations in 2013 and 2016, and 6 locations in 2014 out of 72 surveyed locations. It is likely that Jakarta faced significant floods in these years.

Year	Count
2002	1
2005	3
2007	5
2011	1
2012	5
2013	13
2014	6
2015	5
2016	13
2017	15
2018	5

Figure 4.30 Result of the year of last flood experience

l) How much was damage cost of the flood?

Figure 4.31 depicts the result of "How much was damage cost of the flood?", indicating maximum cost was 280,000,000,000 IDR and average cost was 21,556,230,769 IDR out of 13 surveyed locations in total. The result indicates that the flood damage might become very high although it was hard to be concluded due to a limitation of number of surveyed locations.

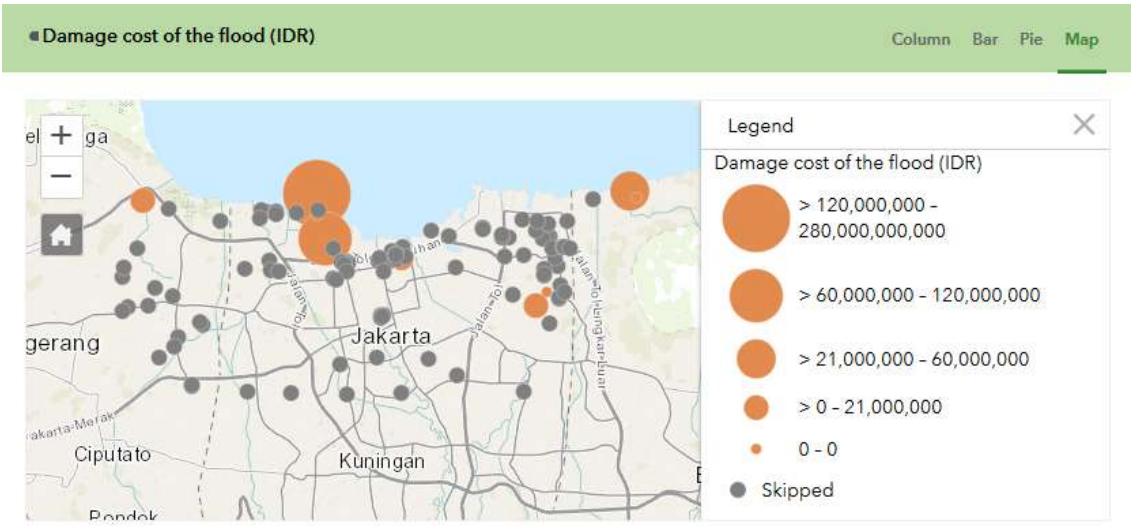


Figure 4.31 Result of "How much was damage cost of the flood?"

Table 4.11 Examples of flood cost

Locations	Costs (IDR)	Contents
Pluit Fishery Port	280,000,000,000	Direct damage and indirect damage
Yayasan pendidikan salahudin (Educational Foundation)	120,000,000	Direct damage
Al Musyarawah (Religious facility)	21,000,000	Direct damage

Table 4.12 Summary results on economic damage related to land subsidence and flooding

<table>
<tr><th>About land subsidence and its cost</th><th>About floods and its cost</th></tr>
<tr><td>

- Have you experienced the land subsidence at the property?

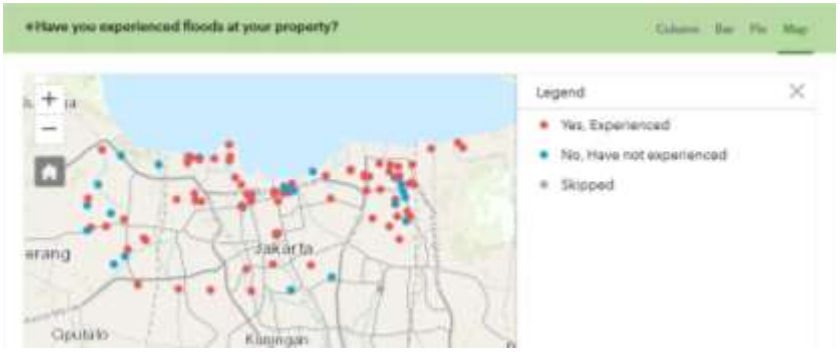


- Examples of financial cost of repairing

Locations	Costs (IDR)	Contents
Pluit Fishery Port	85,171,168,115	Pumping facilities, Land raising, revetment improvement, pier improvement, dyke improvement
SMA 19 JAKARTA (Public High School)	18,000,000,000	Basement raising of building
Wilhara Property (Business Building)	2,000,000,000	Repairing of building
Museum Rumah Si Pitung	700,000,000	Management of ROB
Harapan Mulya	600,000,000	Basement raising of building
Singapore International School (SIS)	500,000,000	Basement raising of building

</td><td>

- Have you experienced floods at your property?



- Examples of flood cost

Locations	Costs (IDR)	Contents
Pluit Fishery Port	280,000,000,000	Direct damage and indirect damage
Yayasan pendidikan salahudin (Educational Foundation)	120,000,000	Direct damage
Al Musyarawah (Religious facility)	21,000,000	Direct damage

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4.3 Condition on Land Subsidence and Climate Change

4.3.1 Condition on Land Subsidence

The land subsidence conditions used in estimating the extent of the flood damage are described below.

(1) Examination Policy

In NCICD, land subsidence prediction for coastal and river dike design was set based on the result of InSAR Analysis (2007-2010) in the Master Plan of 2014.

In February 2018, a land subsidence projection using a one-dimensional geological model at three locations with three different land subsidence scenarios has been conducted.

In this project, land subsidence projection using a one-dimensional geological model was carried out at nine sites, including Cenkareng and Cakung as described in section 2.7.1.

Based on the above situation, the following subsidence projection results are summarized in this study, which will also be used in this project:

a) NCICD's coastal and river dike design subsidence

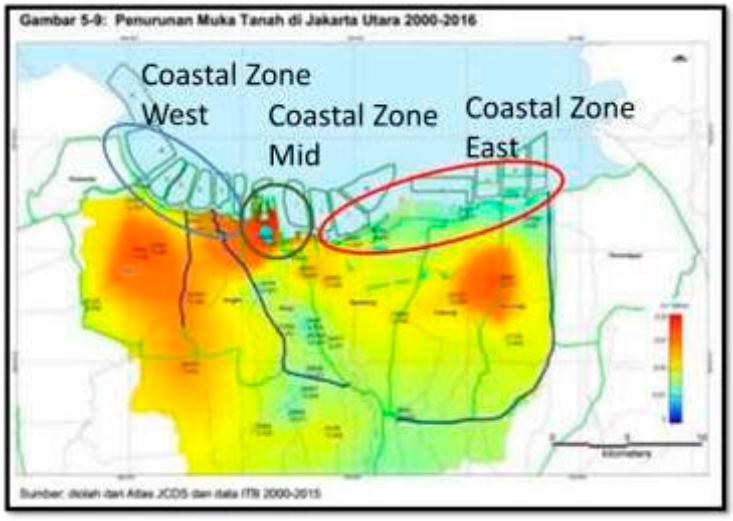
b) NCICD's subsidence projection

c) This project's subsidence projection

(2) Coastal and River Dike Design Subsidence by NCICD

NCICD's Coastal and River Dike Design Subsidence is set based on the result of InSAR Analysis (2007-2010), taking the safety side of design into consideration. The design value is set at three coastal zones and along the river. (Refer to Table 4.13)

Construction of Coastal dike in the northern coastal area is ongoing with this design value.



Source: IFSP Presentation Material (NCICD, 2019 Jan)

Figure 4.32 Zone on Land subsidence rates

Table 4.13 Land subsidence rates for design (Stage A/E and OSD)

Coastal zone (200m) Land Subsidence West

	m/y	years	total
until 2030	0.13	12	1.56
2030-2034	0.13	4	0.52
2034-2040	0.065	6	0.39
2040-2050	0.025	10	0.25
2050-2080	0.025	30	0.75
total		62	**3.47**

Coastal zone (200m) Land Subsidence Mid (around Pluit)

	m/y	years	total
until 2030	0.18	12	2.16
2030-2034	0.18	4	0.72
2034-2040	0.09	6	0.54
2040-2050	0.025	10	0.25
2050-2080	0.025	30	0.75
total		62	**4.42**

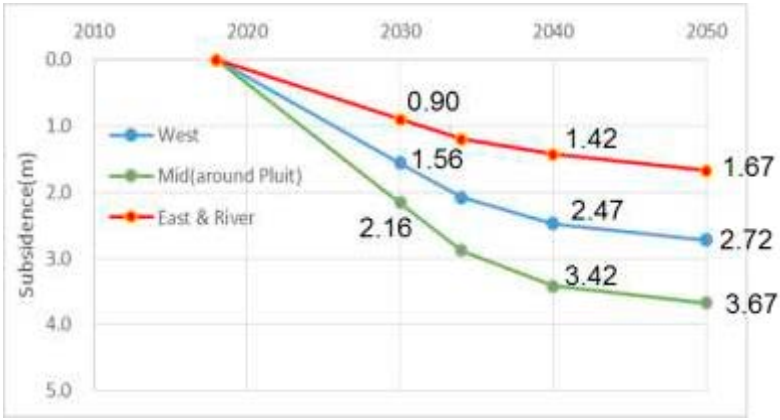
Land Subsidence along all rivers (west)

	m/y	years	total
until 2030	0.075	12	0.9
2030-2034	0.075	4	0.3
2034-2040	0.037	6	0.22
2040-2050	0.025	10	0.25
2050-2080	0.025	30	0.75
total		62	**2.42**

Coastal zone(200m) Land Subsidence East

	m/y	years	total
until 2030	0.075	12	0.9
2030-2034	0.075	4	0.3
2034-2040	0.037	6	0.2
2040-2050	0.025	10	0.25
2050-2080	0.025	30	0.75
total		62	**2.42**

Source：Road Map Mitigation Land Subsidence (NCICD, 2018 Feb)



Source：The Project Team based on Road Map Mitigation Land Subsidence（NCICD, 2018 Feb）

Figure 4.33 Land Subsidence Rates for Coastal and River Dike

(3) Land subsidence projection by NCICD

1) Scenario for groundwater use and drawdown

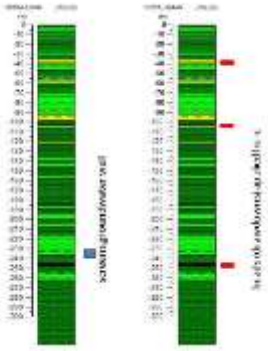
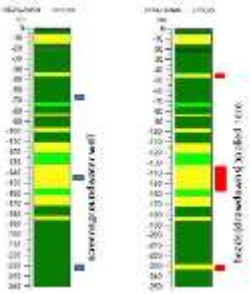
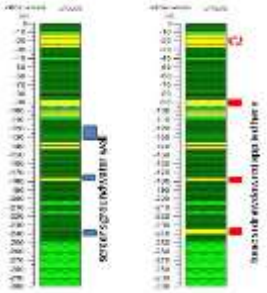
In the Roadmap Study of Land Subsidence mitigation measures in NCICD, the estimation of land subsidence is carried out at three representative sites (Daan Mogot, Sunter and Marunda) by setting drawdown time series depending on three groundwater utilization scenarios shown below.

A one-dimensional geological layer model by the SUB-CR Land Subsidence Package of Modflow (Deltales 2017) was applied for the land subsidence projection.

-Scenario 1: continuous use for business purposes (continuous decrease in groundwater level)

-Scenario 2: reduced/controlled deep groundwater use (groundwater level is maintained)

-Scenario 3: stopped deep groundwater use (groundwater level recovery cases, 3a: slow, 3b: fast)

Location Map	Marunda
	
Daan Mogot	**Sunter**
	

Source：Road Map Mitigation Land Subsidence（NCICD, 2018 Feb）

Figure 4.34 Predicted land subsidence locations and stratigraphic models

2) Drawdown Trend

The drawdown trend used for the subsidence projection is shown below.

It should be noted that groundwater abstraction volume based on the drawdown in scenario 1 is unknown and varies spatially.

- The time to suspend and control the use of deep groundwater is set at 2025. This is supposed to be the time when tap water covers the northern area. (Scenarios 2 & 3)
- The drawdown rate for Scenario 1 is 1 m/year, and will continue until 2100 in the three aquifers. The depth of the aquifer where groundwater abstraction is possible was considered.
- The recovery rate after the stop of groundwater abstraction in Scenario 3 presents an exponential rev rather than linear at 1 m/year.

3) Outline of the Projection Results

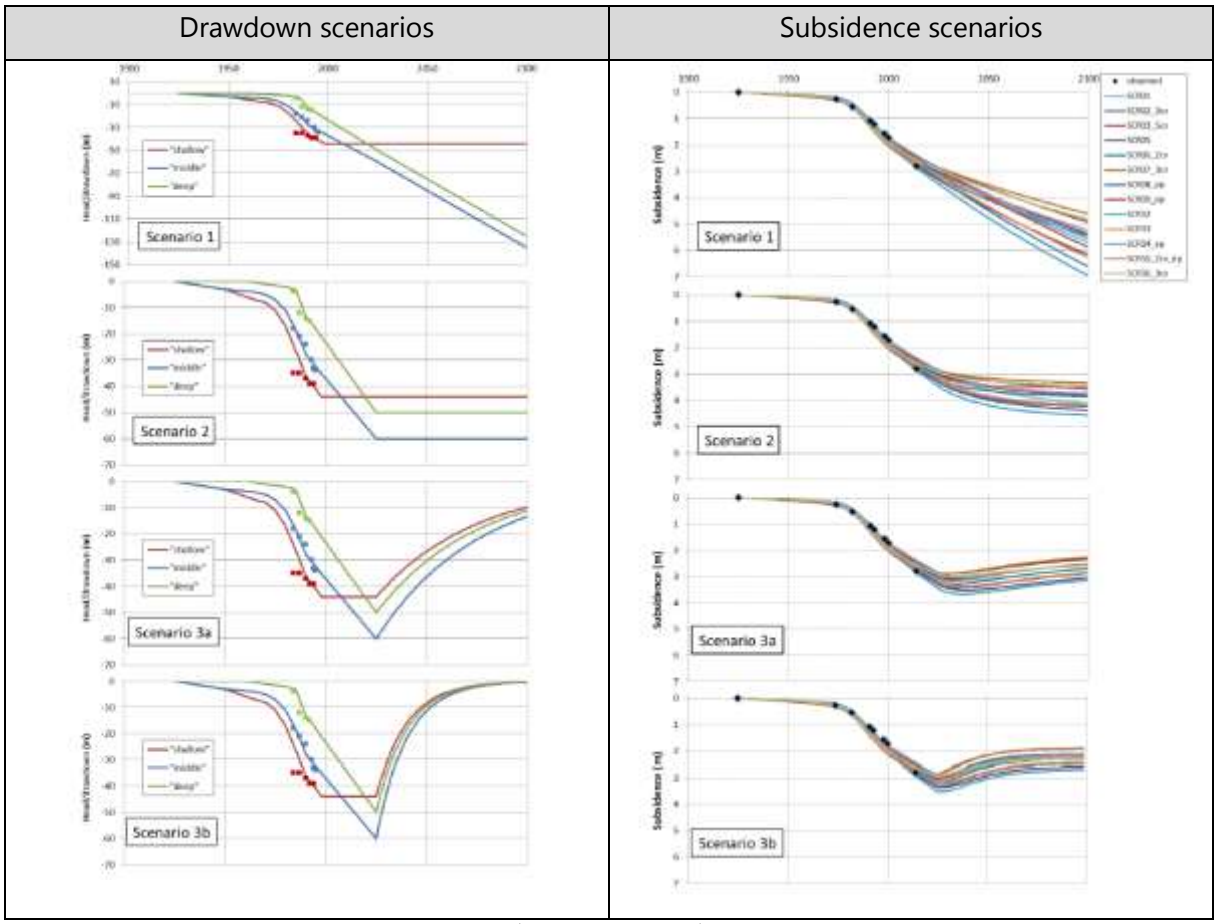
Seventeen combinations of soil parameters have been set and estimated to predict subsidence based on the groundwater use and groundwater lowering scenarios described above, resulting in an analysis with a range of maximum and minimum values. The soil parameters used in the calculations were parameterized to be consistent with available soil engineering data. The results are shown in Table 4.14. Figure 4.35 shows the predicted groundwater lowering and subsidence at the DaanMogot site.

Table 4.14 Summary of the Analysis Results: Subsidence Rate

	Subsidence rate 2018 (cm/yr)	Subsidence rate 2028 (cm/yr)	Subsidence rate 2050 (cm/yr)	Subsidence 2018-2028 (cm)	Subsidence 2018-2050 (cm)
			DAAN MOGOT		
Scenario 1 business as usual	3.2 / 5.6	2.8 / 5.4	2.5 / 4.9	30 / 55	87 / 168
Scenario 2 reduced abstraction	3.2 / 5.6	2.0 / 4.1	0.5 / 1.7	28 / 53	52 / 111
Scenario 3a stopped deep abstraction (slow recovery)	3.2 / 5.6	0.5 / 2.5	-1.2 / -0.7	25 / 49	6 / 52
Scenario 3b stopped deep abstraction (fast recovery)	3.2 / 5.6	-3.0 / 0.1	-2.0 / -1.2	19 / 44	-46 / -3
			SUNTER		
Scenario 1 business a.u.	1.3 / 2.7	2.7 / 4.7	5.0 / 9.5	16 / 29	109 / 196
Scenario 2 reduced abstraction	1.3 / 2.7	0.7 / 2.1	0.1 / 1.1	10 / 24	17 / 58
Scenario 3a stopped deep abstraction (slow recovery)	1.3 / 2.7	-0.5 / 1.3	-0.8 / -0.2	8 / 23	-11 / 28
Scenario 3b stopped deep abstraction (fast recovery)	1.3 / 2.7	-2.3 / 0.3	-1.1 / -0.7	4 / 20	-40 / 2
			MARUNDA		
Scenario 1 business a.u.	2.8 / 4.4	3.0 / 5.9	3.7 / 7.6	28 / 49	104 / 202
Scenario 2 reduced abstraction	2.8 / 4.4	2.3 / 3.4	0.8 / 1.5	27 / 44	61 / 85
Scenario 3a stopped deep abstraction (slow recovery)	2.8 / 4.4	1.0 / 2.3	-0.7 / -0.2	26 / 41	23 / 48
Scenario 3b stopped deep abstraction (fast recovery)	2.8 / 4.4	-1.6 / 0.5	-1.1 / -0.7	23 / 36	-17 / 18

* reported figures are min. / max. values, respectively

Source: Road Map Mitigation Land Subsidence（NCICD, 2018 Feb）



Source：Road Map Mitigation Land Subsidence（NCICD, 2018 Feb）

Figure 4.35 Groundwater level lowering and subsidence prediction scenario (Daan Mogot site)

(4) This Project Subsidence Projection

As described in section 2.7, subsidence projections from 2019 to 2050 were carried out using a one-dimensional land subsidence model at nine locations, where the geological conditions are clear.

The groundwater abstraction and the groundwater level conditions for the subsidence projection are shown in Table 4.15.

① Western part of Jakarta: Kamal Muara, Cengkareng, Daan Mogot

② Central part of Jakarta: Jakarta fish port, Tongkol, Sunter

③ Eastern part of Jakarta: Rawa Badak Stadium, Cakung, Marunda

By 2030, in Case C, if groundwater pumping is not regulated and groundwater pumping increases, there will be about 22-49 cm sinkage in the west, 13-38 cm sinkage in the center, and 6-45 cm sinkage in the east; by 2050, there will be about 77-154 cm sinkage in the west, 49-118 cm sinkage in the center, and 20-140 cm sinkage in the east; by 2050, there will be about 20-140 cm sinkage in the west, 49-118 cm sinkage in the center, and 20-140 cm sinkage in the east. 140 cm in the eastern part.

Table 4.15 Predicted case of primary settlement

Case	Groundwater abstraction condition after Sep. 2019	Groundwater level corresponding to groundwater abstraction conditions after Sep. 2019
Case A	If the current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and reach the original level in Dec. 2030.
Case A-1	If the current groundwater abstraction volume will be reduced by 50% by Dec. 2030	The groundwater levels will recover from October 2019 and reach groundwater level corresponding to the groundwater abstraction condition in Dec. 2030.
Case B	If the groundwater abstraction exceeding the current groundwater abstraction volume will be regulated	The same groundwater levels as of Sep. 2019 will remain.
Case C	If the groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

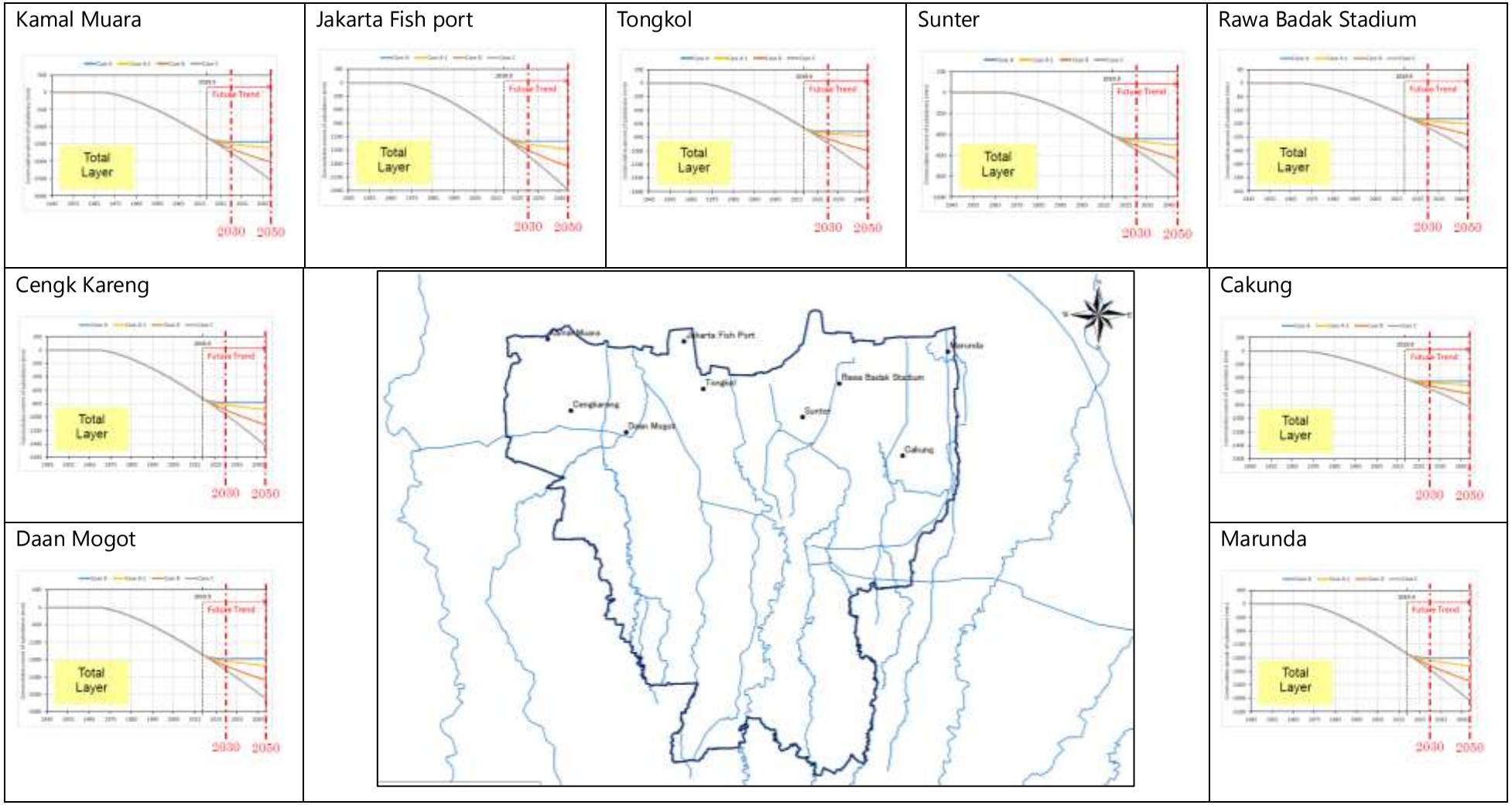


Figure 4.36 Settlement Prediction Points and Settlement Prediction Calculation Results

(5) Assumed Land Subsidence Conditions

In this project, the inundation simulation is based on the following land subsidence conditions.

LS	Case	Groundwater abstraction condition after Sep. 2019	Groundwater level corresponding to groundwater abstraction conditions after Sep. 2019
LS(A)	Case A	If the current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and reach the original level in Dec. 2030.
LS(A1)	Case A-1	If the current groundwater abstraction volume will be reduced by 50% by Dec. 2030	The groundwater levels will recover from October 2019 and reach groundwater level corresponding to the groundwater abstraction condition in Dec. 2030.
LS(B)	Case B	If the groundwater abstraction exceeding the current groundwater abstraction volume will be regulated	The same groundwater levels as of Sep. 2019 will remain.
LS(C)	Case C	If the groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

The projected land subsidence values in each site is organized in Figure 4.37. The maps of the land subsidence distribution and the average ground level are shown in to Figure 4.38 to Figure 4.40.

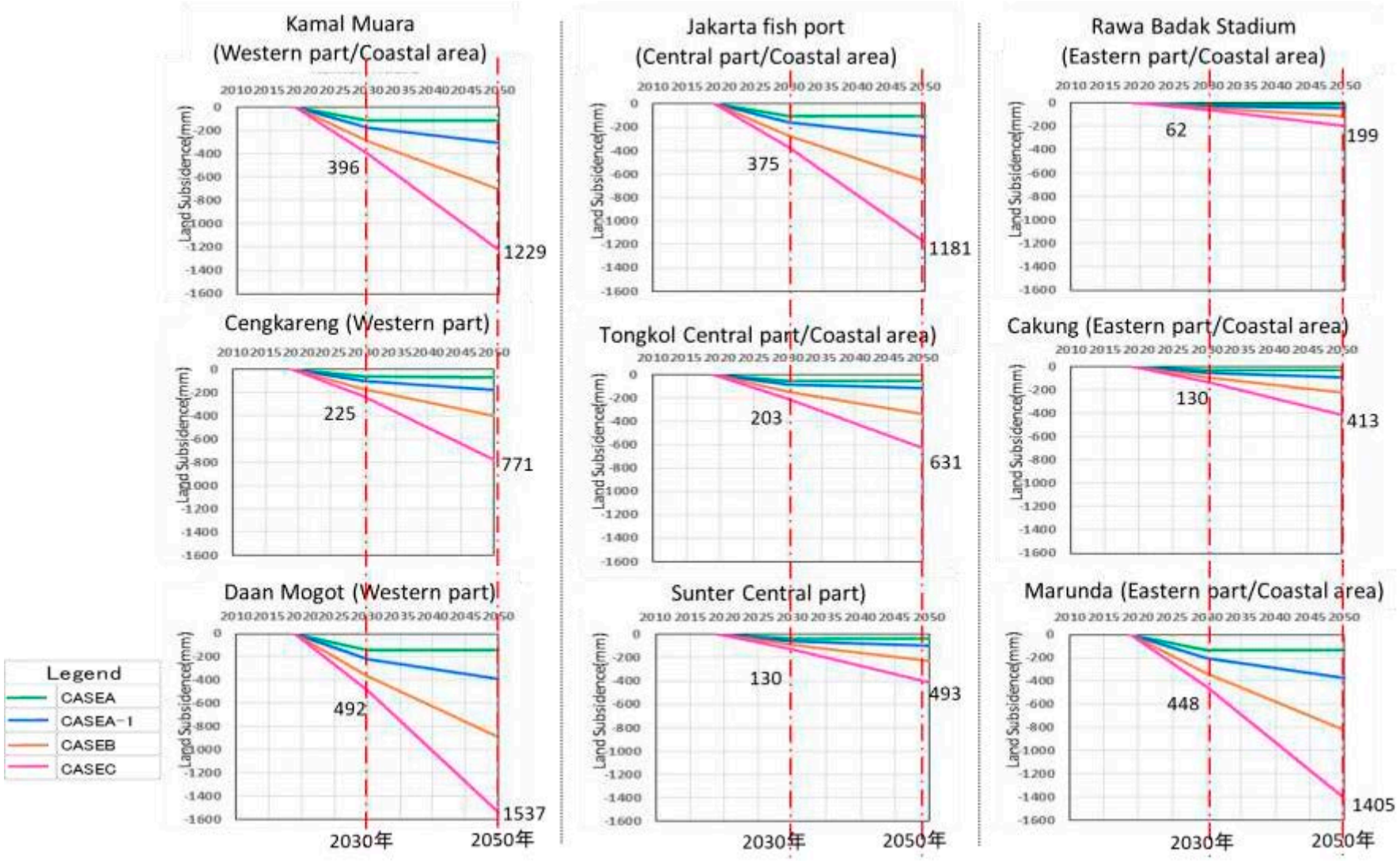
The area less or equal to 2 m (nearly equal to existing maximum high tide) on each prediction scenario are summarized in below. It is found that the area less or equal to 2 m in Case C with large subsidence increase by approximately 15 % in 2030 and about 41 % in 2050 compared to 2018.

Table 4.16 Inundation Area Results for Each Case, which may be flooded during high tide

Year	Land Subsidence Scenario	Inundated Area with depth ≤ 2m (km²)	Percentage of Area to the Total DKI Jakarta Area (%)	Increase ratio from 2018 (%)
2018	-	134.67	20.33%	100
2030	Case A	139.88	21.12%	104
	Case A-1	143.33	21.64%	106
	Case B	149.02	22.50%	111
	Case C	154.28	23.29%	115
2050	Case A	139.88	21.12%	104
	Case A-1	149.45	22.56%	111
	Case B	168.58	25.45%	125
	Case C	189.89	28.67%	141

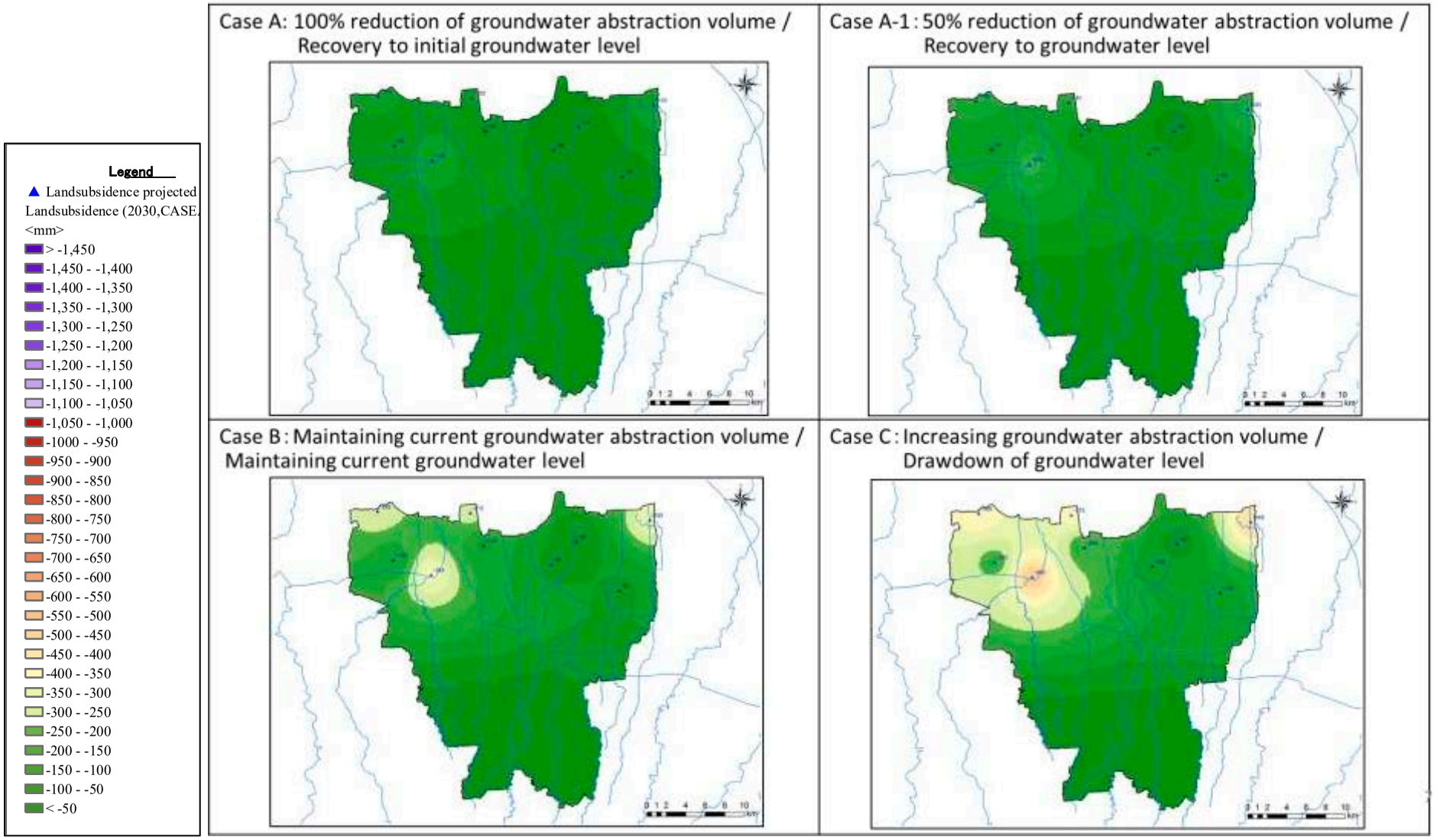
**Note: Total DKI Jakarta area is approximately 662.33 km².*

Source：The Project Team



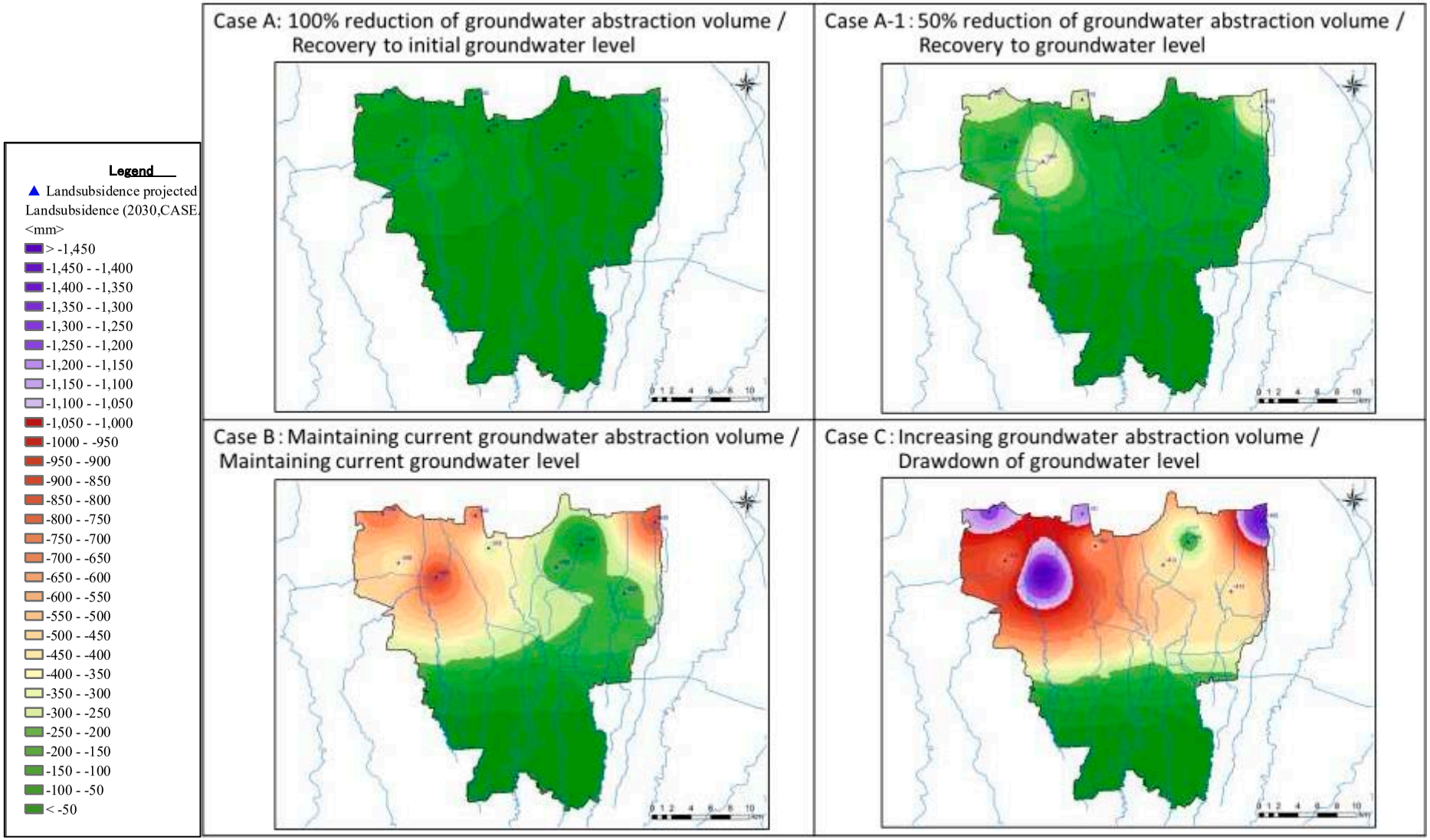
Source：The Project Team

Figure 4.37 Subsidence Projection on Each Case



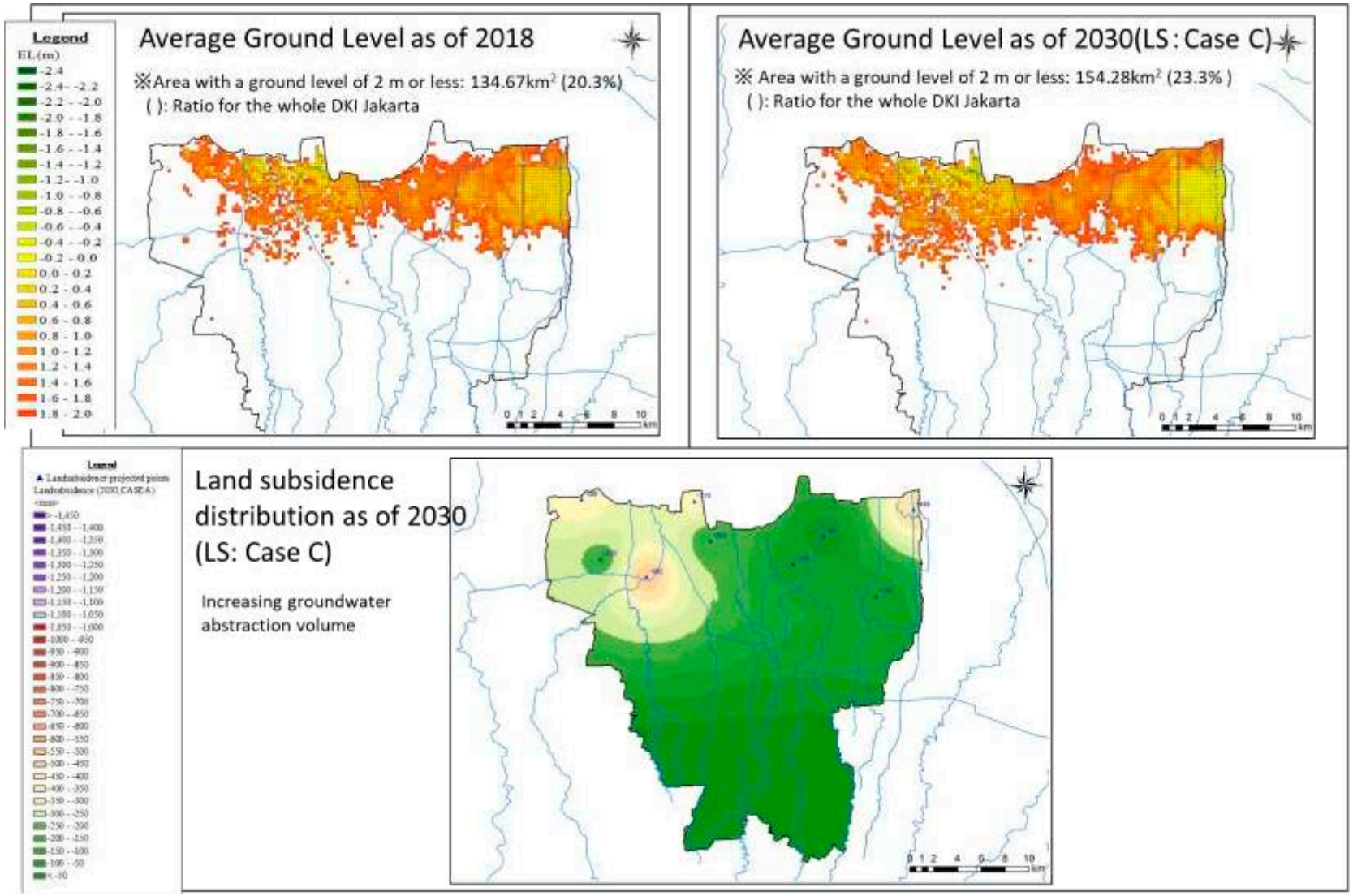
Source : The Project Team

Figure 4.38 Distribution of Land Subsidence (2030)



Source : The Project Team

Figure 4.39 Distribution of Land Subsidence (2050)



Source : The Project Team

Figure 4.40 Average Ground Level (upper left: 2018, upper right: Case C; 2030)

4.3.2 Climate Change Conditions

The climate change scenarios, RCP2.6 (low-level stabilization scenario) and RCP8.5 (high-level reference scenario) were adopted with reference to the IPCC Fifth Assessment Report. The amount of sea level rise and the rate of rainfall increase are set as shown in Table 4.17.

Table 4.17 Condition on Climate Change

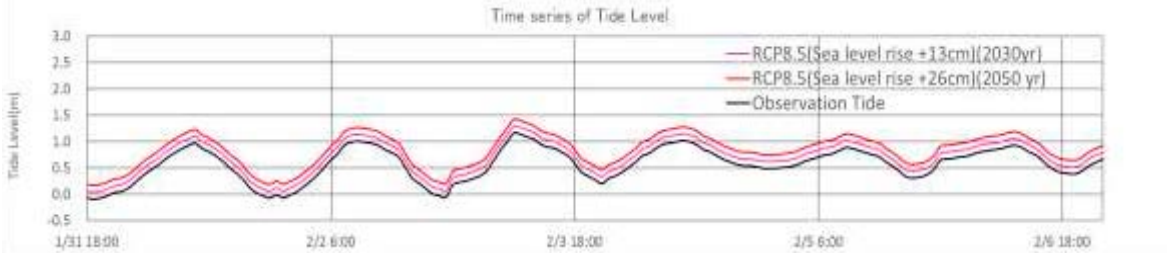
Climate Change Scenario	Year	Sea Level Rise:	Rainfall Increase Rate
RCP 2.6	2030	12 cm (10 mm/year)	1.10
	2050	22 cm (7mm/year)	1.15
RCP 8.5	2030	13 cm (11 mm/year)	1.11
	2050	26 cm (8 mm/year)	1.18

Source：The Project Team

The tidal level and hyetograph used for inundation simulation described later are shown below.

(1) Tidal level for simulation

The tidal level used for simulation is shown in Figure 4.41. This figure shows the case of RCP 8.5.

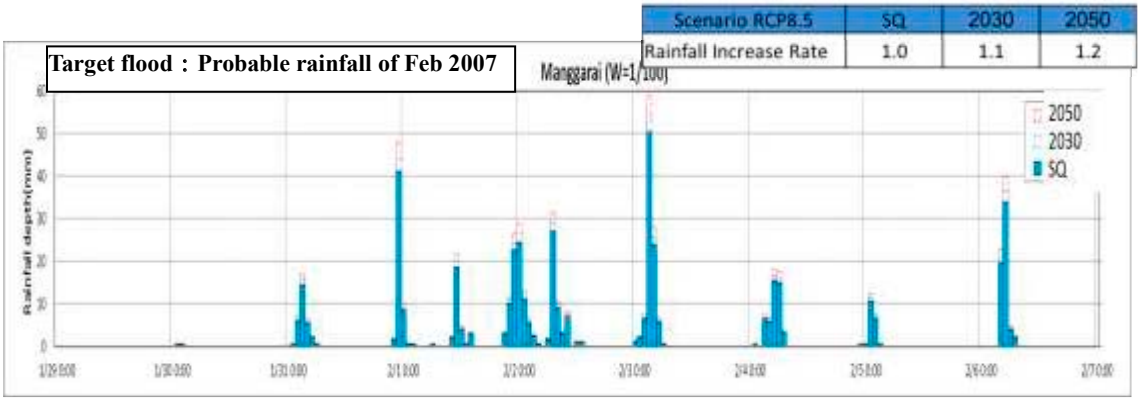


Source：The Project Team

Figure 4.41 Tidal Level at River Mouth

(2) Hyetograph for simulation

The hyetograph used for simulation is shown in below. This figure shows the basin average hyetograph at Maranggai Station on Ciliwung River.



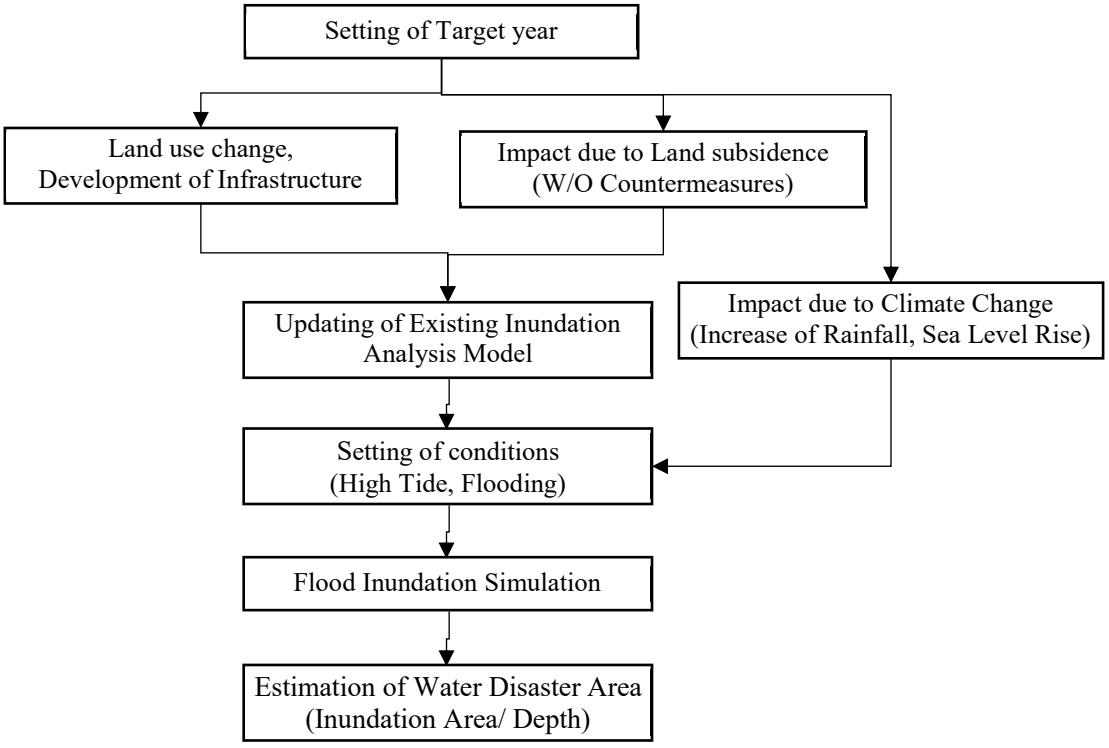
Source：The Project Team

Figure 4.42 Basin Average Rainfall Hyetograph (Manggarai Station, 1/100)

4.4 Estimation of Water Disaster Area

4.4.1 Method and contents of the simulation

Based on the land subsidence and climate change scenarios discussed in section 4.1.3, the extent of the inundation damage caused by high tide and flood (river and inland flooding) were simulated. The simulation was conducted using the model developed by Yachiyo Engineering Co., Ltd. for the Simulation Study on Climate Change in Jakarta, Indonesia (JICA, 2012). The study flow is shown in Figure 4.43.



Source：The Project Team

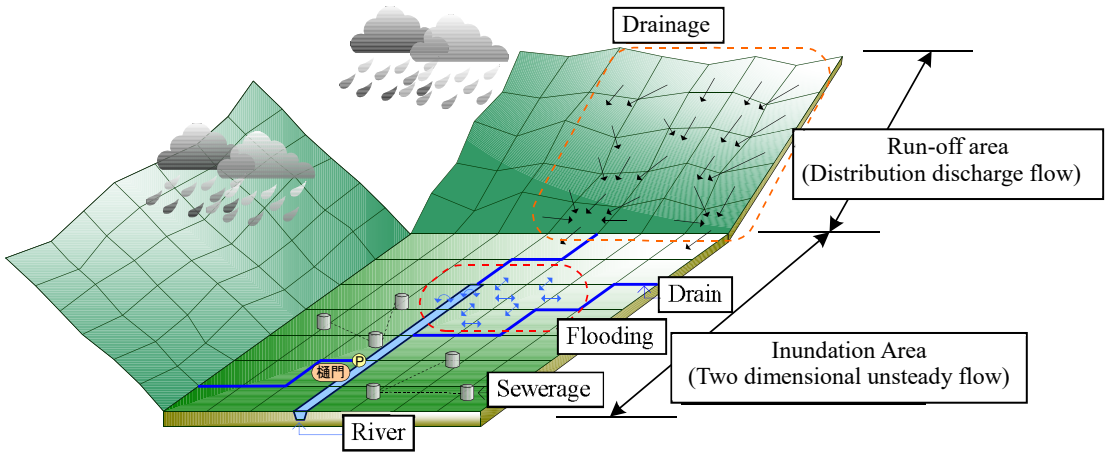
Figure 4.43 Study Flow for the Estimation of the Extent of the Inundation Damage

4.4.2 Outline of the Inundation Analysis Model

(1) Model Overview

Simulation of the extent of the flood damage due to high tide and floods (combination of inland and river flooding) shall be conducted using the updated data and inundation analysis model developed by Yachiyo Engineering Co., Ltd. for the previous study entitled, Simulation Study on Climate Change in Jakarta, Indonesia (JICA, 2012).

For the inundation simulation model, two models are applied depending on the inundation characteristics in the Target Basin: Distribution Design Flow Model (for consideration of discharge flow by the topographic gradient in mountainous and hilly areas in discharge basin) and Two-Dimensional Unsteady Flow Model (describing the distribution of floodwater flow in the inundation basin).



Source：The Project Team

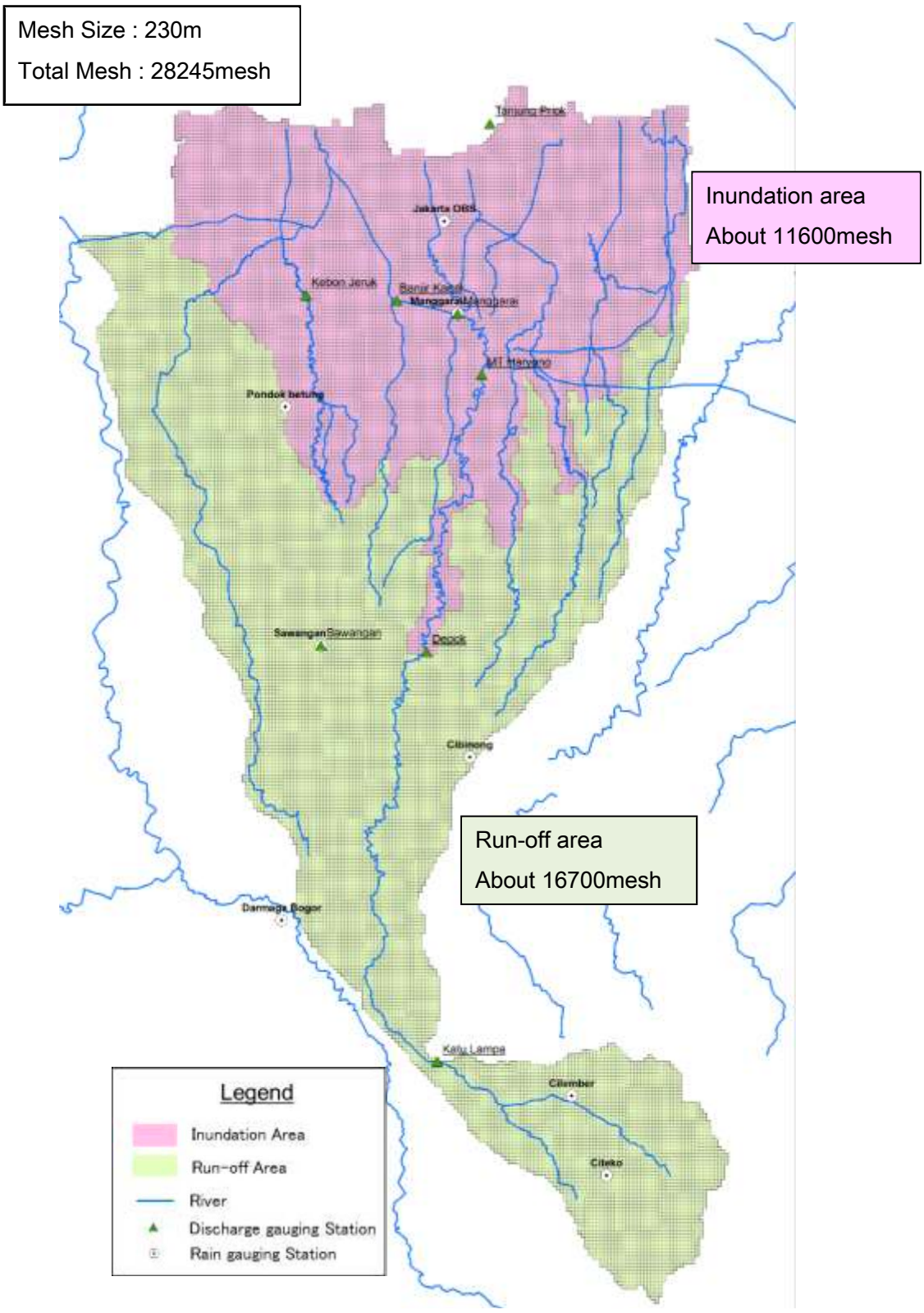
Figure 4.44 Outline of the Distributed Run-off Inundation Analysis Model

The summary of the inundation analysis model is shown in Table 4.18 . The whole area, where the model was applied, is shown with a mesh size of 230 m x 230 m in Figure 4.45. Further details of the model are given in Appendix-4.

Table 4.18 List of Flood Inundation Analysis Model

Items		Conditions	Remarks
Land Feature	Basic mesh	Run-off area 230m (7.5"), inundation area 230m (7.5")	
	Inundation area land feature	Formulated based on 1/5000 Topographic map (2008) and GPS data	
	Run-off area land feature	Formulated based on 1/25000 Topographic map (2008)	
	Land use (inundation area)	Formulated based on DKI land use map (2008)	
	Land use (run-off area)	Formulated based on Jabodetabekpunjur land use map (2009)	
Analysis Model	River	One dimensional unsteady flow model (Dynamic Wave)	
	Inundation area	Two-dimensional unsteady flow model (Dynamic Wave)	
	Run-off area	Distributed run-off model (Kinematic Wave)	
Built-in Model	Condition on the river	Bridges, gates, pumps	
	Inundation land feature mesh	Drainage canals, banks, culvert	
	Intervals of river and floodplain land feature mesh	Overflows, gates, pumps	
River	Cross-sectional surface	Current river in 2011, identify 100m and 200m pitch in 2008	
	The water level of the downstream end	Junction point with the Java Sea: Tide level data of Tanjung Priok	
	Upstream end/inflow volume	Run-off volume of distributed run-off model (Kinematic Wave)	
Facilities	Banks	Main local roads and railways over 50cm	
	Drainage canals	Secondary affluent	
	Others		
Overflow	Coefficient of overflow	Settled considering the side overflow by formula	
	Overflow Height	Current dike height	
	Overflow point	All intervals are targeted	
Pump operating condition		Follow the operation rules of each pump station	
Rainfall distribution		Hyetograph of the flood in Feb. 2007 (provided dimensionally by Thiessen method)	

Source：The Project Team



Source：The Project Team

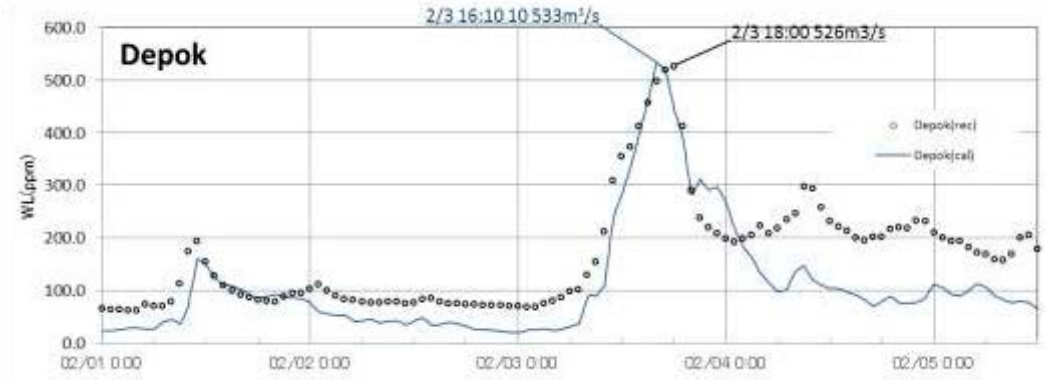
Figure 4.45 Mesh partitioning diagram of runoff inundation analysis model

(2) Reproducibility of the Model

The reproducibility of the model was based on the February 2007 flood, which is the largest flood in recent years. The model validity was verified using the actual flow rate (HQ adjusted value) at Depok Station for run-off area model and the actual water level and inundation area at Manggarai Station for inundation area model.

1) River Flow Rate

The simulated flow rate results at Depok Station is shown in Figure 4.46.

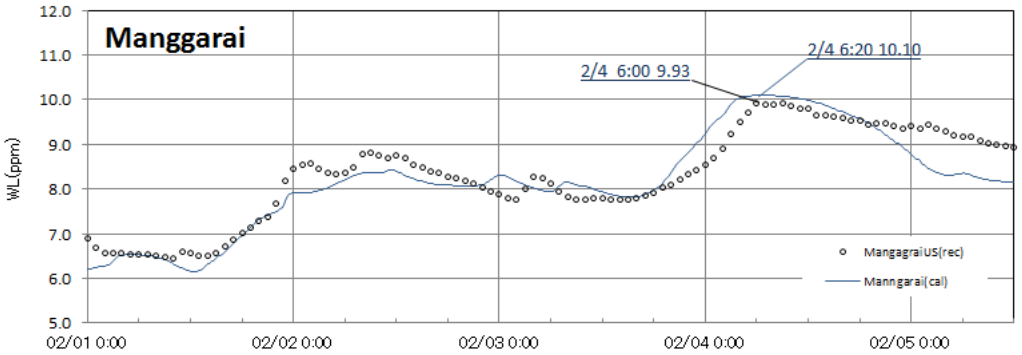


Source：The Project Team

Figure 4.46 Discharge Hydrograph (Depok)

2) River Water Level

The simulated water level results at Manggarai Station is shown in Figure 4.47.

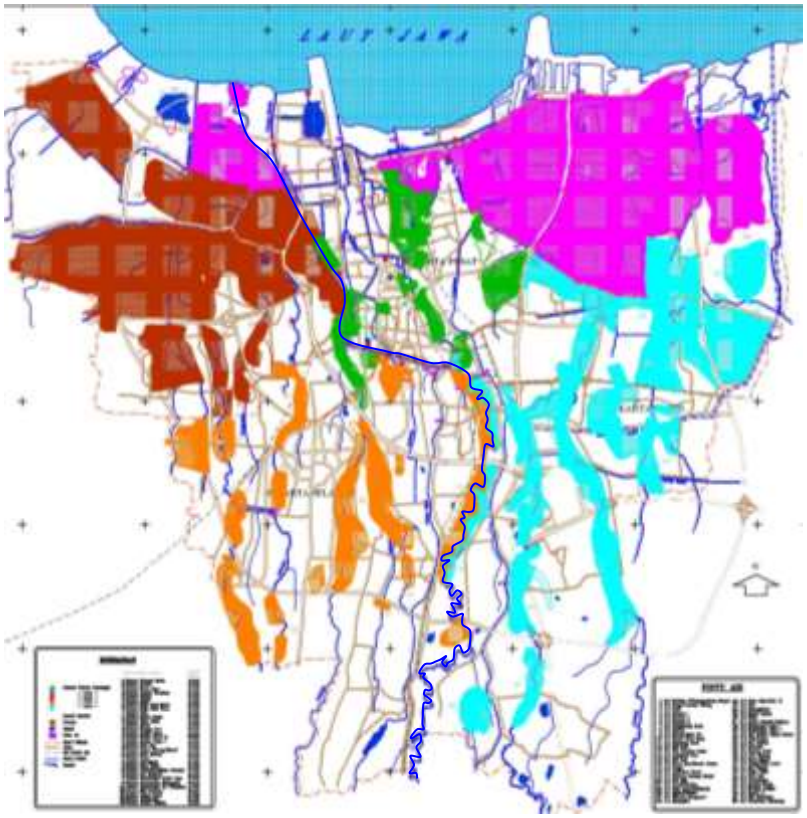
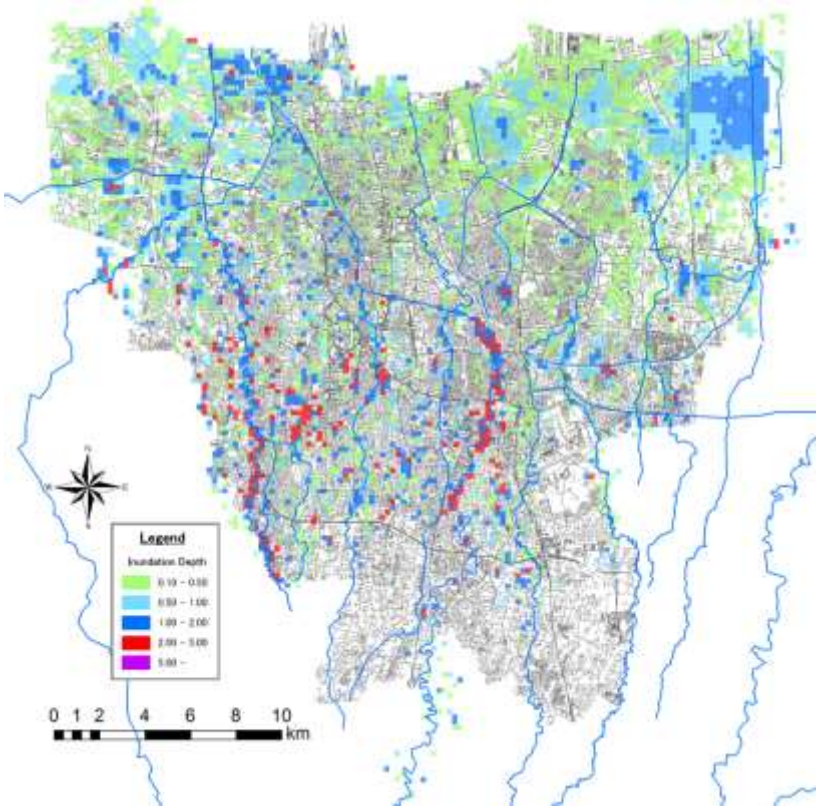


Source：The Project Team

Figure 4.47 Water Level Hydrograph (Manggarai)

3) Inundation Area

The simulated inundation area results are shown in the next page.

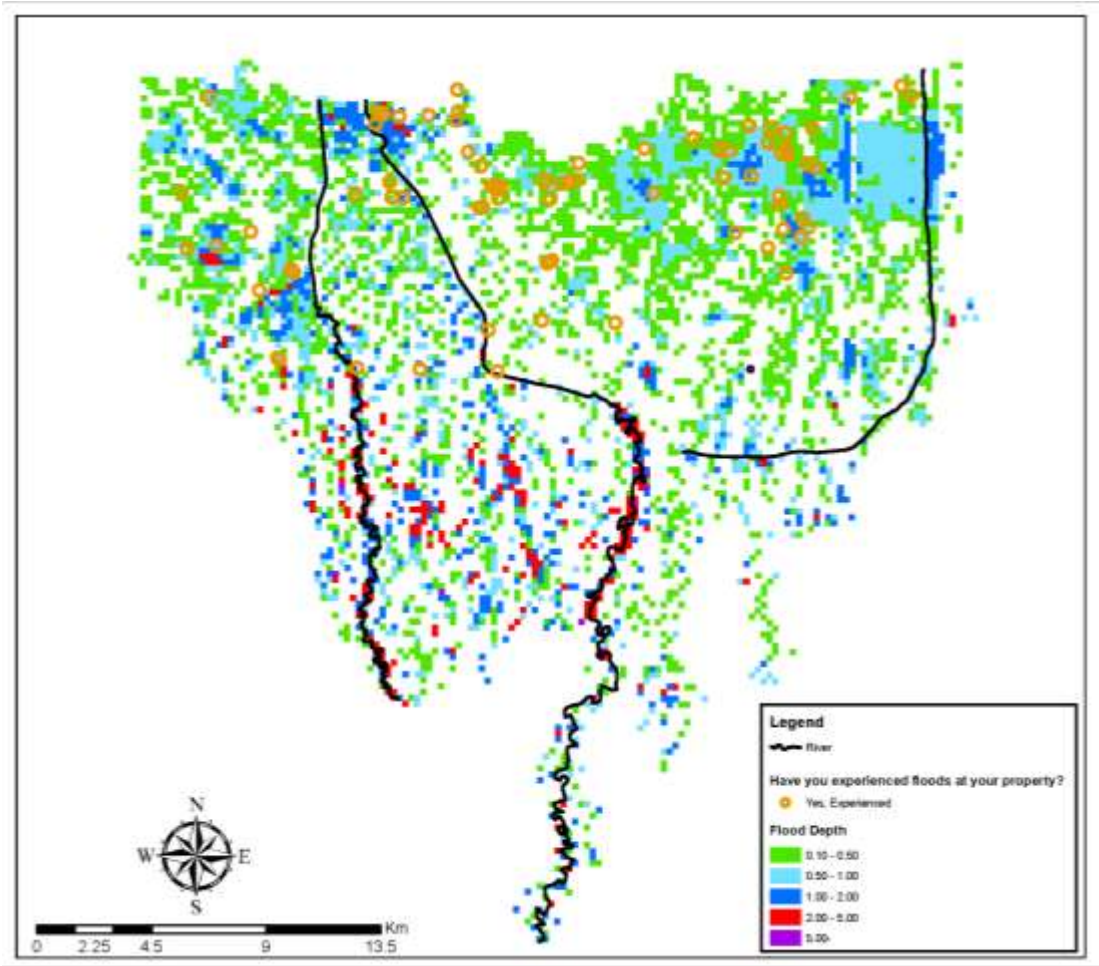
Record	Computation
 Inundation Area: 300.35 km^2	 Inundation Area: 262.3 km^2

Source：The Project Team

Figure 4.48 Maximum Inundation Depth

4) Comparison of the simulated results with field survey results

A comparison of the simulated inundation area and the flood experience obtained from the field survey is shown below. It is worth noting that there is a considerable correlation between the flood depth and experience of the flood, although the result of inundation analysis has a certain degree of uncertainty due to a limitation of numerical analysis in a large spatial resolution.



Source：The Project Team

Figure 4.49 Comparison of simulated inundation results with the field survey results

4.4.3 Setting of External Forces

The external forces for the inundation simulation is set at the Master Plan Level with reference to the existing plan and NCICD design scale as shown in Table 4.19.

Table 4.19 External Force for disaster type for inundation simulation

Type	Assumed Scale	Applied value	Remarks
High Tide	MP Level	Design high tide level PP＋1.90m	Recorded maximum high tide PP＋1.90m
		Spring Tide(H.H.W) PP+1.15m	Set by tidal data in 1925
		Mean Sea level (MSL)PP+0.60m	ditto
		Spring Tide(L.L.W) PP+0.00m	ditto
Flooding	MP Level	Return Period: 1/100	Design scale in 1997 MP, Flood protection level by NCICD
		Feb 2007 Flood Hydrograph	JCFM 2013
		Rainfall Duration: 48 hr	

Source：The Project Team

The design scale of the existing plan and NCICD are shown in the following.

(1) The Master Plan for Drainage and Flood Control of Jakarta in 1973

The outline of The Master Plan for Drainage and Flood Control of Jakarta in 1973 is below.

- Expansion of West Banjir Canal (WBC) (constructed in 1924) intercepting Ciliwung and Krukut rivers and East Banjir Canal (EBC) intercepting rivers in eastern Jakarta area with a 100-year return period.
- Construction of Cengkareng Banjir Canal, located at the downstream of WBC, with a 100-year return period and expansion of WBC based on M/P were completed.

  The construction of EBC was almost completed in January 2010 and is now in operation.
- The plan of drainage areas between WBC and EBC was formulated. In accordance with this plan, the existing river was improved to be used as the main drainage with a 25-year return period, and the area was divided into six drainage districts, where drainage pump stations and drainage channels were constructed.
- In the plan, the improvement of the existing rivers and construction of drainage pump stations have been achieved. Currently, the rivers are drained at 18 drainage pump stations and 23 flood gates due to the influence of the tide level in Java Sea.

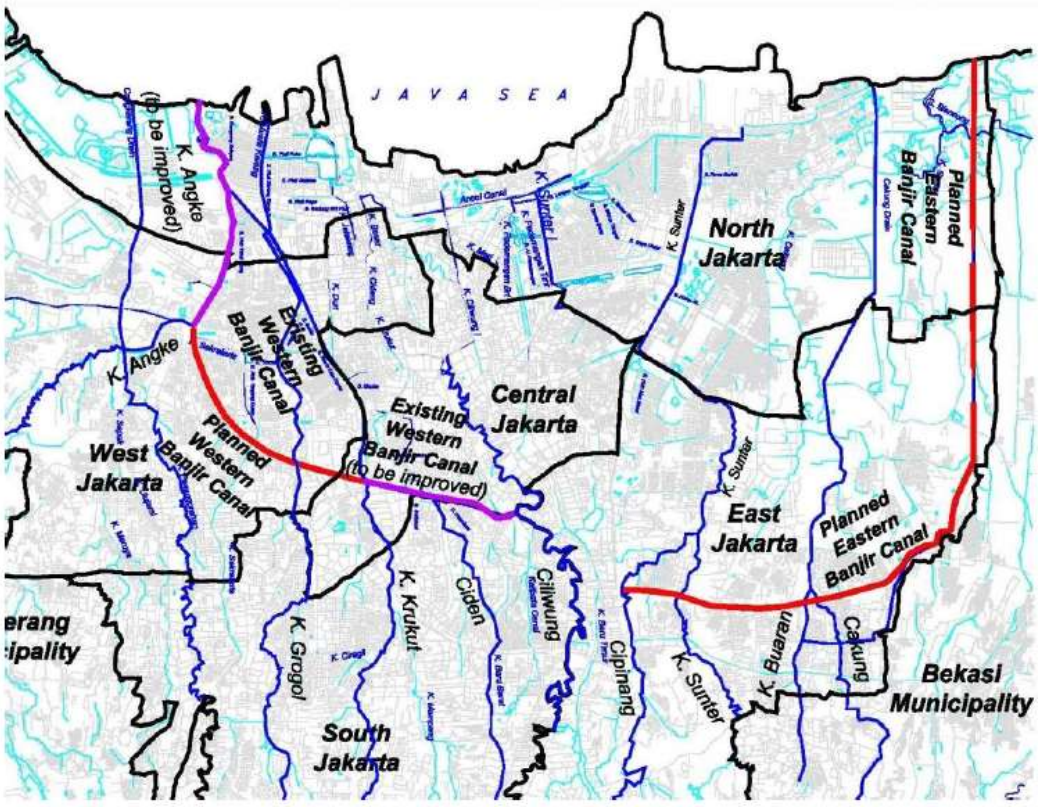


Figure 4.50 Master Plan in 1997

(2) Design Scale in 1997 MP

The master plan was established to enhance the safety level of each river in DKI Jakarta to 25-year, 50-year, and 100-year in accordance to its importance. The design discharge allocation and design scale of Mater Plan in 1997 for the eight river system are shown in Figure 4.51.

The safety level of the main three rivers flowing through the center of DKI Jakarta is as follows:

- Cengkareng floodway: 100-year.
- West Banjir Kanal: 100-year
- East Bamjir Kanal: 100-year

Table 4.20 Standards for the Design Scale of Flood in Indonesia

System	Type of Flood Control Measure	Initial Target (year)	Final Target (year)
River	Urgent Project	5	10
	New Project	10	25
	Continued Project (in rural and urban area with less than 2 million populations)	25	50
	Continued Project (in rural and urban area with more than 2 million populations)	25	100

Source: Flood Control Manual, Volume II, Guidelines for Planning and Survey, Project No WSTCF 091/011, (June 1993)

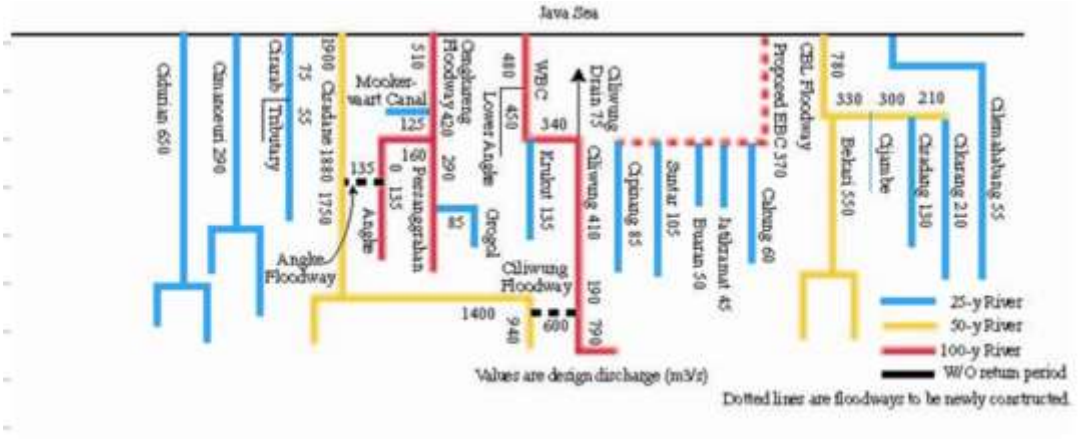


Figure 4.51 Design Discharge Allocation and Design Scale in the 1997 Mater Plan

(3) Flood Safety level in NCICD

Flood control safety levels in NCICD, which is based on legal safety standards from international perspective, is recommended as described in below.

- The most significant social issue in Northern Jakarta is the extreme flood risk the population is currently facing.
- The safety standard for Jakarta is set by the Governor Decree (PERGUB) no 121/2012. The safety standard is a yearly probability of 1:1,000 for flooding of sea-dykes (floods from the sea).
- There is no standard set for an outer seawall. As proposed in the NCICD Master Plan 2014, it is recommended to set the maximum probability of failure of an outer sea wall at a yearly probability of 1:10,000.

Table 4.21 Flood Protection Levels

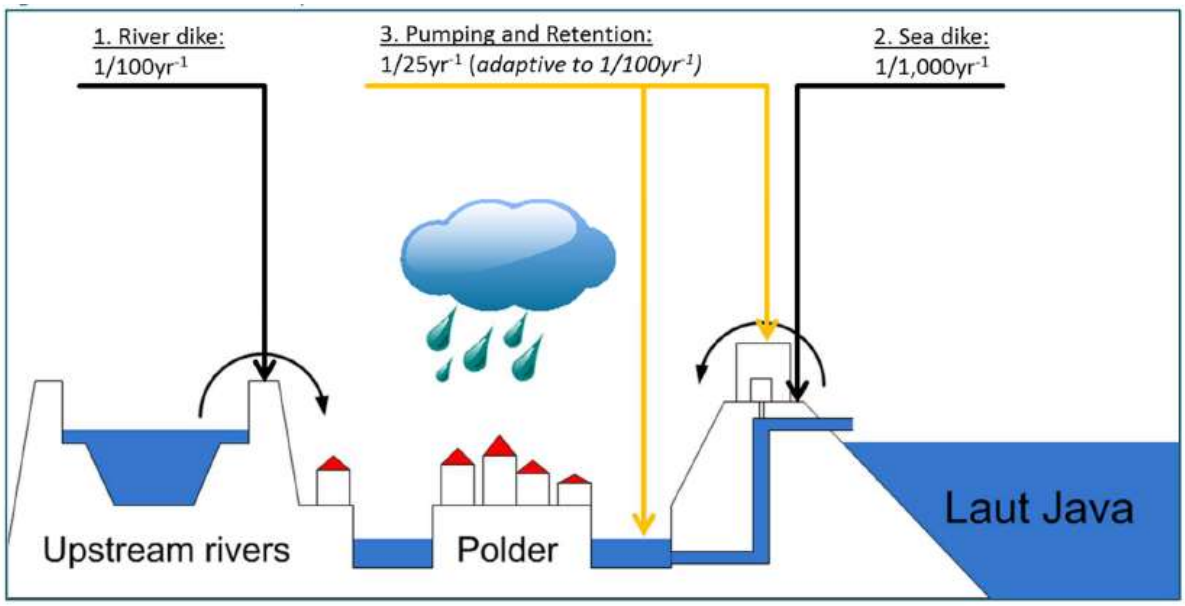
Object	Recommendation	Indonesia Legal standards adopted flood protection levels (to be confirmed)
Outer Sea Wall	1;10,000yr	n/a
Coastal Dykes	1;1,000yr	1,000yr
Offshore reservoir	1;100yr	n/a
River Dykes	1;100yr	100yr
Internal Polder areas	1:20yr	1:20

Source: Flood Safety and Basis of Design (NCICD, 19 June 2017)

(4) Design Condition of New Polder System in NCICD

The flood safety level of the new polder system in NCICD is considered as the following safety level.

1. Flood from rivers: 1/100 year
2. Flood from the sea (High tide): 1/1,000 year
3. Land inundation (Inland water): 1/25 year, (corresponds to 1/100 year)



Source: Road Map EA+ (NCICD, 27 April 2018)

Figure 4.52 New Polder Schematic And Potential Flood Risks

4.4.4 Climate Change Scenario and Land Subsidence Conditions for Simulation

The combination of the impact of climate change and land subsidence is shown in Table 4.22 . Years 2030 and 2050 are considered.

Table 4.22 Climate Change Scenario and Land Subsidence Conditions for Simulation

Year	Climate Change Scenario *1	Land use	Land Subsidence	Climate Change	
				Increase of Rainfall	Sea Level Rise
Present (2017)	Present	Present	Present	-	-
2030 2050	Present	2030 2050	With Countermeasures (Present)	-	-
			Without Countermeasures (4 Scenarios)	-	-
	RCP2.6 RCP8.5	2030 2050	With Countermeasures (Present)	✔	✔
			Without Countermeasures (4 Scenarios)	✔	✔

Note:*1: Refer to IPCC AR5 Scenario (RCP (Representative Concentration Pathway))

Source : The Project Team

4.4.5 Setting of the Simulation Conditions

Simulation conditions (for the target years 2030 and 2050) for the external force, climate change and land subsidence are summarized in Table 4.23.

Table 4.23 Simulation Conditions for the External Force, Climate Change and Land Subsidence

Item		Employed Value		Remarks
Target year		2030	2050	Based on Spatial Plan 2030
Land use		2030	2050	Based on Spatial Plan 2030
Climate Change	Increase Ratio of Rainfall	RCP 2.6：1.10 RCP 8.5：1.11	RCP 2.6：1.15 RCP 8.5：1.18	Based on Word Bank Portal Site
	Sea Level Rise (SLR)	RCP 2.6：12 cm (10 mm/year) RCP 8.5：13 cm (11 mm/year)	RCP 2.6：22 cm (7 mm/year) RCP 8.5：13 cm (8 mm/year)	Based on IPCC 5th Report Reference: Design SLR in NCICD (8mm/year)
Land subsidence		LS(A) :2～14cm LS(A-1) :3～22cm LS(B) :5～36cm LS(C):6～49cm	LS(A) :2～14cm LS(A-1) :5～39cm LS(B) :11～89cm LS(C):20～154cm	Refer to section 4.1.2
High Tide		Design high tide level PP＋1.90m (Spring Tide + Maximum sea level departure) Spring Tide(H.H.W) PP+1.15m Mean Sea level (MSL) PP+0.60m Spring Tide(L.L.W) PP+0.00m		Based on tidal data in 1925
Flood		Return Period: 1/100 Feb 2007 Flood Hydrograph		Design scale in 1997 MP, Flood protection level by NCICD JCFM 2013

Source：The Project Team

4.4.6 Inundation Simulation Cases

The description of each inundation simulation case is shown in Table 4.24.

Table 4.24 Inundation Simulation Cases

Land Subsidence Scenario	2018	2030		2050	
		Without Climate Change	With Climate Change	Without Climate Change	With Climate Change
SQ: Status quo	✔	✔	✔	✔	✔
LS(A): Small		✔	✔	✔	✔
LS(A1): Small		✔	✔	✔	✔
LS(B): Moderate		✔	✔	✔	✔
LS(C): Large		✔	✔	✔	✔

■Condition of Land Subsidence(LS)

LS	Case	Groundwater abstraction condition after Sep. 2019	Groundwater level corresponding to groundwater abstraction conditions after Sep. 2019
LS(A)	Case A	If the current groundwater abstraction volume will be reduced by 100% by Dec. 2030	The groundwater levels will recover from October 2019 and reach the original level (G.L.-4.2 m) in Dec. 2030.
LS(A1)	Case A-1	If the current groundwater abstraction volume will be reduced by 50% by Dec. 2030	The groundwater levels will recover from October 2019 and reach groundwater level corresponding to the groundwater abstraction condition in Dec. 2030.
LS(B)	Case B	If the groundwater abstraction exceeding the current groundwater abstraction volume will be regulated	The same groundwater levels (Aquifer 3: -12.10 m, Aquifer 2: -43.90 m, Aquifer 1: -5.20 m) as of Sep. 2019 will remain.
LS(C)	Case C	If the groundwater abstraction volume will increase without regulating groundwater abstraction	The groundwater levels will continue to decrease at the same rate as until Sep. 2019.

Source：The Project Team

4.4.7 Inundation Simulation Results

(1) Inundation area, inundation volume[1] and average inundation depth

The simulation results are shown in Table 4.25. The table organizes the inundated area, inundated volume, and average inundation depth across the Jakarta Special Province for each case. For each item, the ratio of the current CaseSQ-2018 in 2018 is shown as 1. Maximum inundation depth figures for each case are shown in the Appendix.

The subsidence impacts are organized by subsidence scenario and time point as follows. The comparison here is for the no climate change impact case. (Comparison of CaseSQ-2018 with CaseA-2030 to CaseC-2030 and CaseA-2050 to CaseC-2050)

・The inundation area increases in the order of settlement scenarios CaseA to CaseC, with a 1-2% increase at 2030 and a 1-5% increase at 2050.

・Inundation volume increases in the order of subsidence scenarios CaseA to CaseC, with a 10-12% increase in 2030 and a 10-21% increase in 2050.

・Average inundation depths increase in the order of subsidence scenarios CaseA to CaseC, with a 9-10% increase in 2030 and a 9-15% increase in 2050.

The followings summarizes the land subsidence impacts by subsidence scenario and time point for the climate change case (RCP8.5). (Comparison of CaseSQ-2018 with CaseA-2030_RCP8.5 to CaseC-2030_RCP8.5 and CaseA-2050_RCP8.5 to CaseC-2050_RCP8.5)

・The inundation area increases in the order of settlement scenarios CaseA to CaseC, with a 7-8% increase at 2030 and a 13-17% increase at 2050.

・Inundation volume increases in the order of subsidence scenarios CaseA to CaseC, with a 33-34% increase in 2030 and a 42-57% increase in 2050.

・The average inundation depth increases in the order of subsidence scenarios CaseA to CaseC, with a 24-25% increase at 2030 and a 25-34% increase at 2050.

Figure 4.53 shows the results of the analysis by subsidence scenario, by time of year, and by presence of climate change.

[1] Inundation volume is related to the duration of inundation. A larger inundation volume is an indicator of a longer inundation duration.

Table 4.25 Inundation Simulation Results

Case	Simulation Condition				Simulation Result			Ratio for 2018		
	Target year	Land use	Land Subsidence	Climate Change	Flood area (km^2)	Flood volume ($x10^6m^3$)	Average flood depth (m)	Flood area	Flood volume	Average flood depth
Case 1	2018	P	LS(SQ)	WO	251.86	167.10	0.66	1.00	1.00	1.00
Case 2	2030	F	LS(SQ)	WO	255.42	183.45	0.72	1.01	1.10	1.08
Case 3	2030	F	LS(A)	WO	255.58	184.10	0.72	1.01	1.10	1.09
Case 4	2030	F	LS(A1)	WO	256.00	184.90	0.72	1.02	1.11	1.09
Case 5	2030	F	LS(B)	WO	256.85	186.30	0.73	1.02	1.11	1.09
Case 6	2030	F	LS(C)	WO	257.22	187.35	0.73	1.02	1.12	1.10
Case 7	2030	F	LS(SQ)	W:RCP2.6	267.89	218.77	0.82	1.06	1.31	1.23
Case 8	2030	F	LS(A)	W:RCP2.6	268.41	219.66	0.82	1.07	1.31	1.23
Case 9	2030	F	LS(A1)	W:RCP2.6	268.63	220.17	0.82	1.07	1.32	1.24
Case 10	2030	F	LS(B)	W:RCP2.6	270.90	222.27	0.82	1.08	1.33	1.24
Case 11	2030	F	LS(C)	W:RCP2.6	270.21	222.91	0.82	1.07	1.33	1.24
Case 12	2030	F	LS(SQ)	W:RCP8.5	269.16	219.83	0.82	1.07	1.32	1.23
Case 13	2030	F	LS(A)	W:RCP8.5	269.84	221.44	0.82	1.07	1.33	1.24
Case 14	2030	F	LS(A1)	W:RCP8.5	270.05	222.06	0.82	1.07	1.33	1.24
Case 15	2030	F	LS(B)	W:RCP8.5	270.58	223.32	0.83	1.07	1.34	1.24
Case 16	2030	F	LS(C)	W:RCP8.5	271.06	224.62	0.83	1.08	1.34	1.25
Case 17	2050	F	LS(SQ)	WO	255.42	183.50	0.72	1.01	1.10	1.08
Case 18	2050	F	LS(A)	WO	255.26	184.00	0.72	1.01	1.10	1.09
Case 19	2050	F	LS(A1)	WO	255.90	185.80	0.73	1.02	1.11	1.09
Case 20	2050	F	LS(B)	WO	258.87	191.20	0.74	1.03	1.14	1.11
Case 21	2050	F	LS(C)	WO	265.57	202.90	0.76	1.05	1.21	1.15
Case 22	2050	F	LS(SQ)	W:RCP2.6	274.45	229.17	0.84	1.09	1.37	1.26
Case 23	2050	F	LS(A)	W:RCP2.6	274.66	229.88	0.84	1.09	1.38	1.26
Case 24	2050	F	LS(A1)	W:RCP2.6	276.03	232.60	0.84	1.10	1.39	1.27
Case 25	2050	F	LS(B)	W:RCP2.6	278.73	239.10	0.86	1.11	1.43	1.29
Case 26	2050	F	LS(C)	W:RCP2.6	283.86	253.30	0.89	1.13	1.52	1.34
Case 27	2050	F	LS(SQ)	W:RCP8.5	284.80	236.40	0.83	1.13	1.41	1.25
Case 28	2050	F	LS(A)	W:RCP8.5	285.44	237.30	0.83	1.13	1.42	1.25
Case 29	2050	F	LS(A1)	W:RCP8.5	287.03	239.90	0.84	1.14	1.44	1.26
Case 30	2050	F	LS(B)	W:RCP8.5	289.53	247.30	0.85	1.15	1.48	1.29
Case 31	2050	F	LS(C)	W:RCP8.5	294.63	262.00	0.89	1.17	1.57	1.34

Land Subsidence(LS) Condition
- LS(SQ): Status Quo, LS will stop（Current Status as of 2018）
- LS(A)：LS will progress to a small subsidence（ Case A projection）
- LS(A1)：LS will progress to a small subsidence（ Case A1 projection）
- LS(B)：LS will progress moderately（ Case B projection）
- LS(C)：LS will be most advanced（ Case C projection）

Land use
- P : present condition in 2018
- F : future condition in 2030

Climate Chage(CC) Condition
- W :With,Climate Chage
- WO: Without Climate Chage

Source： The Project Team



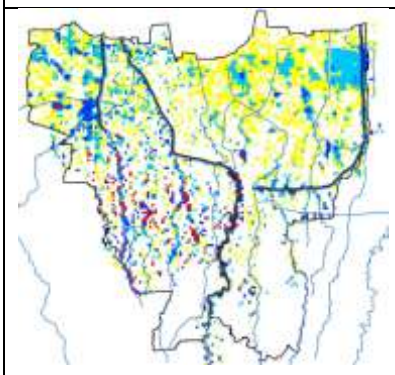
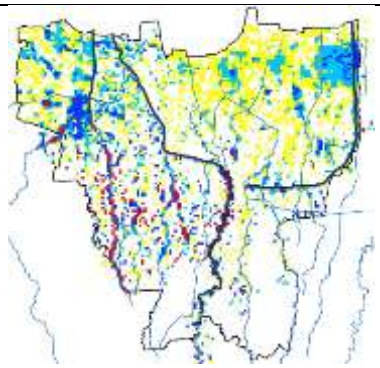
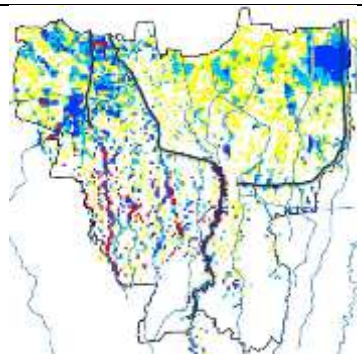
Figure 4.53 Flood simulation results by subsidence scenario, by time point, with and without climate change

(2) Impact of subsidence (statewide)

The impact of land subsidence was summarized for the subsidence scenario CaseC, which is the most advanced subsidence scenario among the prediction scenarios. The following three cases were compared. Figure 4 59 shows the maximum inundation depth maps for each case.

- CaseSQ-2018：Current status in 2018
- CaseC-2030：Most advanced case of land subsidence by 2030 (subsidence scenario CaseC)
- CaseC-2050：Most advanced case of land subsidence by 2050 (subsidence scenario CaseC)

Due to land subsidence, the inundated area, inundation volume, and average inundation depth will increase by approximately 2%, 12%, and 10%, respectively, by 2030, and by approximately 5%, 21%, and 15%, respectively, by 2050.

CaseSQ-2018	CaseC-2030	CaseC-2050
		
Inundation area：251.86 km^2 (1.00)	257.22 km^2（1.02）	265.57km^2（1.05）
Inundation volume：167.1 x 10^6 m^3 (1.00)	187.4 x10^6 m^3（1.12）	202.9 x10^6 m^3（1.21）
Average inundation depth：0.66 m (1.00)	0.73 m（1.10）	0.76 m（1.15）

( ): Value when CaseSQ-2018 is set to 1

Figure 4.54 Maximum Inundation Depth Chart (Impact of Subsidence, by Point in Time, Subsidence Scenario C)

Figure 4.55 shows the difference between the 2050 subsidence case C and the 2018 status quo inundation analysis results. The warm-colored areas in the legend indicate areas where inundation depths have increased, and the green-colored areas in the legend indicate areas where inundation depths have decreased.

Inundation depth increases in areas where subsidence is large, such as the western, central, and eastern coastal areas (red boxes in the figure).

The surrounding area has subsided, and the slope of the ground has become steeper than it is now,resulting in a decrease in inundation depth. (Blue box in the figure)

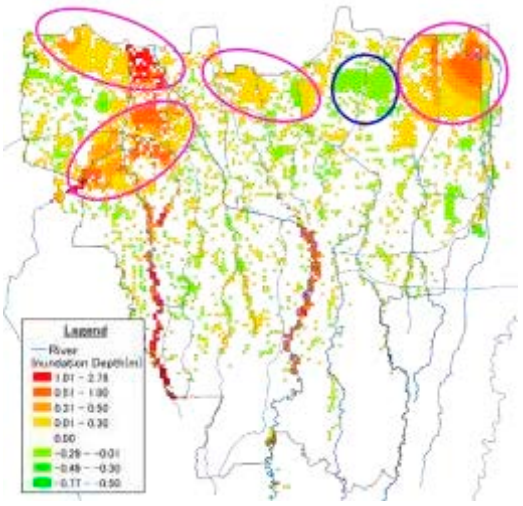
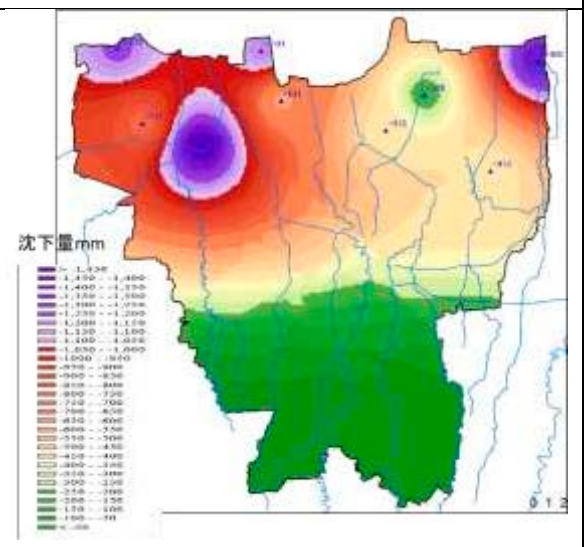
Maximum submergence depth difference diagram （CaseC-2050－CaseSQ-2018）	Land subsidence distribution map （subsidence CaseC・2050）
	

Figure 4.55 Maximum inundation differential map and subsidence distribution map Scenario C, 2050

Based on the above difference diagram, the following areas will have increased inundation depths due to the effects of land subsidence.

Northern coastal areas: PENJARINGAN, PADEMANGAN, CILINCING

Near the confluence of the CENGKARENG drainage canal and the Angke River: CENGKARENG, KEBONJERUK, KEMBANGA

(3) Climate Change Impacts (Statewide)

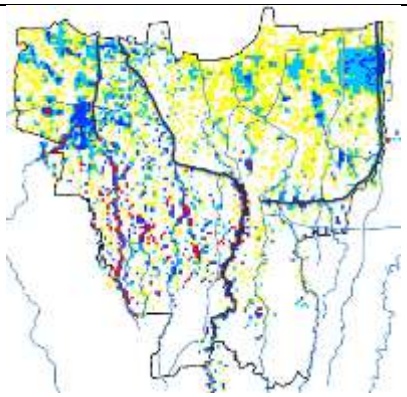
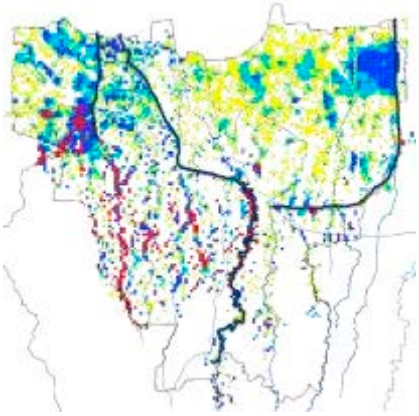
In addition to land subsidence, the following four cases were compared to determine the impacts of climate change. (See Figure 4.56) Land subsidence is assumed to be Scenario C and climate change is assumed to be the RCP 8.5 case.

- CaseC-2030：Most advanced case for land subsidence by 2030; no climate change
- CaseC-2030_RCP8.5：Most advanced case of land subsidence by 2030; RCP8.5 with climate change
- CaseC-2050：Most advanced case of land subsidence by 2050; no climate change
- CaseC-2050_RCP8.5：Most advanced case of land subsidence by 2050; RCP8.5 with climate change

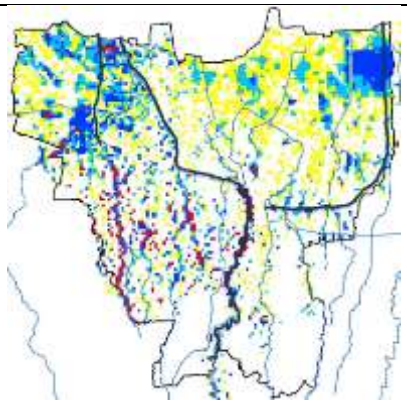
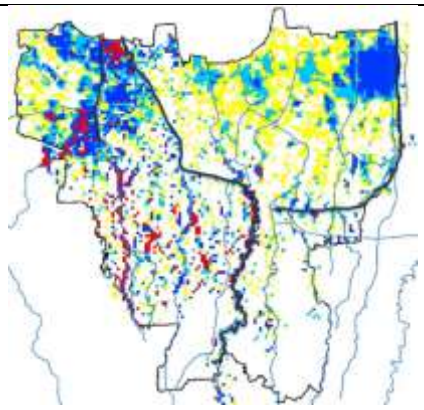
Due to climate change, the inundated area, inundation volume, and average inundation depth will increase by approximately 6%, 22%, and 15%, respectively, by 2030, and by 2050, the inundated area, inundation volume, and average inundation depth will increase by approximately 12%, 36%, and 19%, respectively.

The following impacts are occurring as a result of this climate change

- Northern coastal areas: Increased inundation damage due to sea level rise and increased rainfall in western and eastern areas
- Western region: Increased inundation damage due to increased upstream flow near the confluence of the Chiang Kha Reng drainage canal and the An Khe River.

CaseC-2030 No climate change	CaseC-2030_RCP8.5 With climate change: sea level rise 13 cm, rainfall 1.1 times
	
Inundation area：2257.22 km^2（1.02）	270.21km^2（1.05）
Inundation volume：187.4 x10^6 m^3（1.12）	222.9 x 10^6 m^3（1.33）
Average inundation depth：0.73 m（1.10）	0.82 m（1.24）

( ): Value when CaseSQ-2018 is set to 1

CaseC-2050 No climate change	CaseC-2050_RCP8.5 With climate change：Sea level rise 26cm、Rainfall 1.2 times
	
Inundation area：265.57km^2（1.05）	294.63km^2（1.17）
Inundation volume：202.9 x10^6 m^3（1.21）	262.0x10^6 m^3（1.57）
Average inundation depth：0.76 m（1.15）	0.89 m（1.34）

( ): Value when CaseSQ-2018 is set to 1

Figure 4.56 Maximum Inundation Depth Chart (Effects of Climate Change)

(4) Summary of land subsidence and climate change impacts (statewide)

The table below summarizes the impacts of land subsidence and climate change (increased rainfall and sea level rise). The percentages in the table represent the difference between the cases being compared for the ratios to the 2018 case in Table 4.24 above.

It can be seen that the impact of subsidence is smaller than the impact of climate change in terms of inundated area, inundated volume, and inundated depth, indicating that the impact of climate change is larger than the impact of subsidence on flood damage.

Table 4.26 Comparison of land subsidence and climate change impacts during flooding

	(1)Impact of land subsidence		(2)Impact of Climate change		(1)/(2)	
Comparison of the cases	CaseSQ-2018 vs. CaseC-2030	CaseSQ-2018 vs. CaseC-2050	CaseC-2030 vs. CaseC-2030_RCP8.5	CaseC-2050 vs. CaseC-2050_RCP8.5		
	2030	2050	2030	2050	2030	2050
Flood Area	2%	5%	6%	12%	0.33	0.42
Flood Volume	12%	21%	22%	36%	0.55	0.58
Average Flood Depth	10%	15%	15%	19%	0.67	0.79

Note: Values in the table represent the difference between each case for the ratio of each item in Table 4.24 above to the 2018 case; CaseSQ-2018 vs. CaseC-2030 represents the increase or decrease in the value of CaseC-2030 relative to CaseSQ-2018.

(5) Characteristics by City

The following is a city-by-city summary of the following cases of land subsidence scenario C.

In terms of inundated area, North Jakarta > West Jakarta > East Jakarta > South Jakarta > Central Jakarta in the order of 2050.

In terms of inundation volume, the order of 2050 is North Jakarta > South Jakarta > West Jakarta > East Jakarta > Central Jakarta.

In terms of inundation depth, the order in 2050 is South Jakarta > East Jakarta > North Jakarta > West Jakarta > Central Jakarta.

South Jakarta is a hilly area and rivers run low, so the inundation area is not so large and the inundation depth tends to be deep, resulting in a medium inundation volume. This is because the main cause of inundation is overflow from rivers.

North and West Jakarta are low-lying areas with a large inundated area and large inundation volume, but smaller average inundation depths. This is because the main cause of inundation is considered to be internal flooding damage due to rainfall in the area.

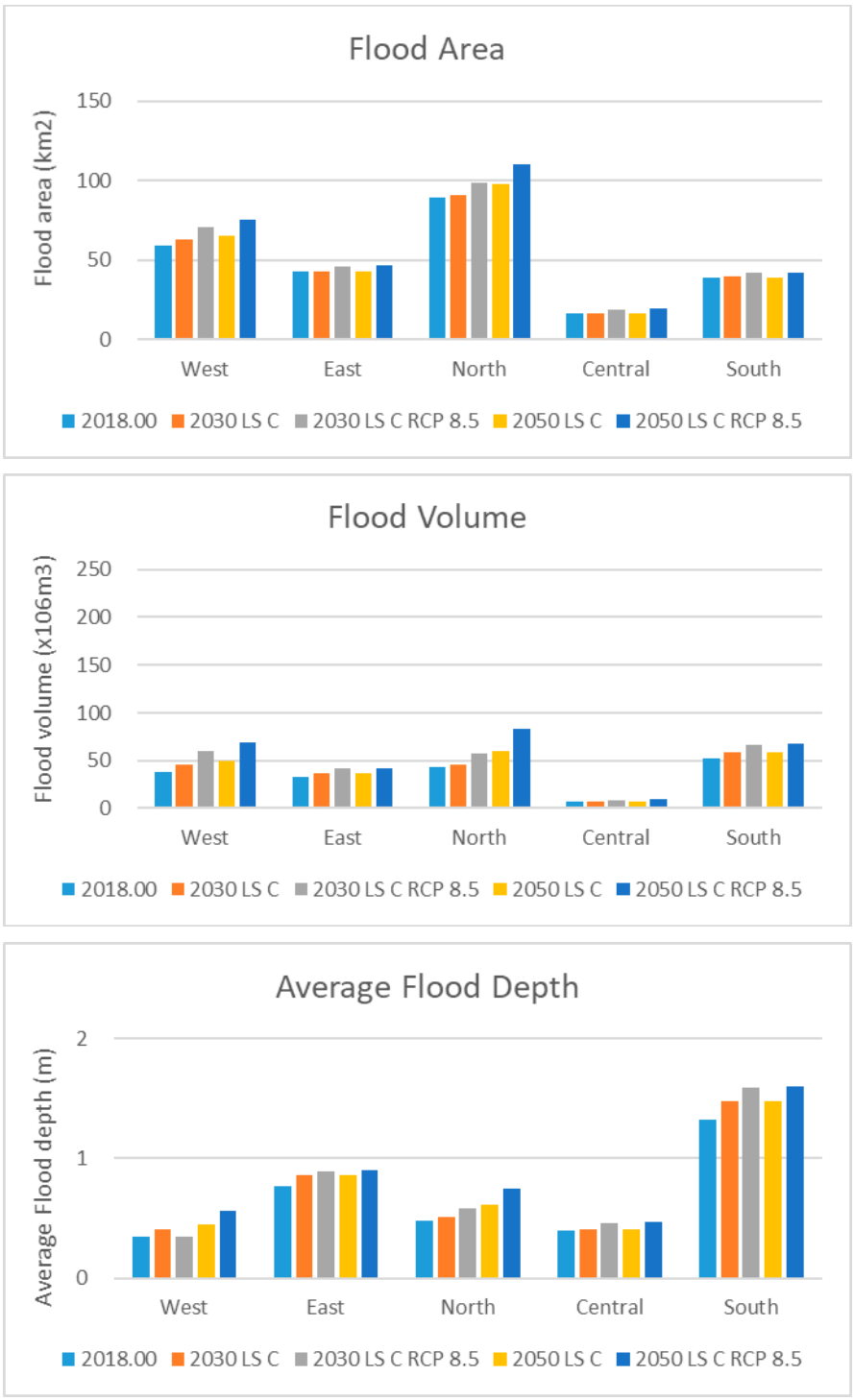


Figure 4.57 Flood simulation results by city (subsidence scenario C, by time point, with and without climate change)

(6) Characteristics in the pilot area

Of the six pilot areas described in 6.3 below, the following three pilot areas for which boring data is available were examined for land subsidence effects.

②Jakarta Fishing Port

③Cenkareng

⑤Cilincing Cakung

The table below shows the results of the subsidence scenario C for each of the three areas.

Table 4.27 Impact of subsidence in pilot area (during flooding)

Area	Case	Simulation Result				Ratio for 2018			
		Flood area (km^2)	Flood volume ($x10^6m^3$)	Average flood depth (m)	Max flood depth (m)	Flood area	Flood volume	Average flood depth	Max flood depth
②Jakarta Fishing Port	CaseSQ-2018	2.27	1.43	0.63	1.51	1.00	1.00	1.00	1.00
	CaseC-2030	2.33	1.46	0.62	1.51	1.02	1.02	0.98	1.00
	CaseC-2050	2.43	1.70	0.68	1.66	1.07	1.19	1.08	1.10
③Cenkareng	CaseSQ-2018	5.61	3.42	0.61	1.98	1.00	1.00	1.00	1.00
	CaseC-2030	5.61	3.44	0.61	1.95	1.00	1.01	1.01	0.98
	CaseC-2050	5.29	3.23	0.61	1.90	0.94	0.94	1.00	0.96
⑤Cilincing Cakung	CaseSQ-2018	8.41	4.06	0.48	1.20	1.00	1.00	1.00	1.00
	CaseC-2030	8.36	4.16	0.50	1.21	0.99	1.03	1.03	1.01
	CaseC-2050	8.62	4.71	0.55	1.21	1.03	1.16	1.13	1.01

4.4.8 High Tide Simulation Results

(1) Inundation area, inundation volume, average inundation depth

The simulation results are shown in Table 4.28. Inundation area, inundation volume, and average inundation depth along with its ratio against Case 1 are summarized in the table. The table organizes the inundated area, inundated volume, and average inundation depth for the entire Jakarta Special Province for each case. For each item, the table also shows the ratio of the current CaseSQ-2018 in 2018 to 1. Maximum inundation depth figures for each case are shown in the Appendix3.

The impact of land subsidence, in terms of inundated area, is as follows.
The impact of land subsidence alone (Case 1 compared to Case 6 and Case 21) is up to approximately 1.5 times greater.
With climate change, the impact is about 10% to 18% more, depending on the different subsidence scenarios that do not take climate change into account.

The impact of subsidence is summarized below by subsidence scenario and by point in time. The comparison here is for the no climate change impact case. (Comparison of CaseSQ-2018 with CaseA-2030 to CaseC-2030 and CaseA-2050 to CaseC-2050)
Inundation area increases in the order of subsidence scenarios CaseA to CaseC, with a 4-15% increase at 2030 and a 4-47% increase at 2050.
Inundation volume increases in the order of subsidence scenarios CaseA to CaseC, with a 9-33% increase in 2030 and a 9-121% increase in 2050.
Average inundation depths increase in the order of subsidence scenarios CaseA to CaseC, with a 4 to 16% increase in 2030 and a 4 to 51% increase in 2050.

The following table summarizes the land subsidence impacts by subsidence scenario and time point for the climate change case (RCP8.5). (Comparison of CaseSQ-2018 with CaseA-2030_RCP8.5 to CaseC-2030_RCP8.5 and CaseA-2050_RCP8.5 to CaseC-2050_RCP8.5)
The inundation area increases in the order of settlement scenarios CaseA to CaseC, with a 12% to 23% increase at 2030 and a 20% to 60% increase at 2050.
Inundation volume increases in the order of subsidence scenarios CaseA to CaseC, with a 26-52% increase in 2030 and a 45-170% increase in 2050.
The average inundation depth increases in the order of subsidence scenarios CaseA to CaseC, with a 13% to 24% increase in 2030 and a 21% to 69% increase in 2050.

Figure 4 63 shows the analysis results by subsidence scenario, by time period, and by presence/absence of climate change.

Table 4.28 Result of Inundation Simulation

Case	Simulation Condition				Simulation Result			Ratio for 2018		
	Target year	Land use	Land Subsidence	Climate Change	Flood area (km^2)	Flood volume ($x10^6m^3$)	Average flood depth (m)	Flood area	Flood volume	Average flood depth
CaseSQ - 2018	2018	P	LS(SQ)	WO	120.35	101.30	0.84	1.00	1.00	1.00
CaseSQ - 2030	2030	F	LS(SQ)	WO	120.35	101.30	0.84	1.00	1.00	1.00
CaseA - 2030	2030	F	LS(A)	WO	125.43	110.07	0.88	1.04	1.09	1.04
CaseA1 - 2030	2030	F	LS(A1)	WO	128.23	115.11	0.90	1.07	1.14	1.07
CaseB - 2030	2030	F	LS(B)	WO	132.94	125.03	0.94	1.10	1.23	1.12
CaseC - 2030	2030	F	LS(C)	WO	138.07	134.59	0.97	1.15	1.33	1.16
CaseSQ - 2030_RCP2.6	2030	F	LS(SQ)	RCP2.6	128.60	117.11	0.91	1.07	1.16	1.08
CaseA - 2030_RCP2.6	2030	F	LS(A)	RCP2.6	133.63	126.45	0.95	1.11	1.25	1.12
CaseA1 - 2030_RCP2.6	2030	F	LS(A1)	RCP2.6	136.27	131.79	0.97	1.13	1.30	1.15
CaseB - 2030_RCP2.6	2030	F	LS(B)	RCP2.6	141.98	142.41	1.00	1.18	1.41	1.19
CaseC - 2030_RCP2.6	2030	F	LS(C)	RCP2.6	147.11	152.62	1.04	1.22	1.51	1.23
CaseSQ - 2030_RCP8.5	2030	F	LS(SQ)	RCP8.5	129.50	118.49	0.91	1.08	1.17	1.09
CaseA - 2030_RCP8.5	2030	F	LS(A)	RCP8.5	134.26	127.85	0.95	1.12	1.26	1.13
CaseA1 - 2030_RCP8.5	2030	F	LS(A1)	RCP8.5	136.75	133.20	0.97	1.14	1.31	1.16
CaseB - 2030_RCP8.5	2030	F	LS(B)	RCP8.5	142.99	143.94	1.01	1.19	1.42	1.20
CaseC - 2030_RCP8.5	2030	F	LS(C)	RCP8.5	147.70	154.15	1.04	1.23	1.52	1.24
CaseSQ - 2050	2050	F	LS(SQ)	WO	120.35	101.30	0.84	1.00	1.00	1.00
CaseA - 2050	2050	F	LS(A)	WO	125.43	110.08	0.88	1.04	1.09	1.04
CaseA1 - 2050	2050	F	LS(A1)	WO	133.63	126.06	0.94	1.11	1.24	1.12
CaseB - 2050	2050	F	LS(B)	WO	152.14	164.09	1.08	1.26	1.62	1.28
CaseC - 2050	2050	F	LS(C)	WO	176.79	224.09	1.27	1.47	2.21	1.51
CaseSQ - 2050_RCP2.6	2050	F	LS(SQ)	RCP2.6	135.85	131.05	0.96	1.13	1.29	1.15
CaseA - 2050_RCP2.6	2050	F	LS(A)	RCP2.6	140.82	140.90	1.00	1.17	1.39	1.19
CaseA1 - 2050_RCP2.6	2050	F	LS(A1)	RCP2.6	150.39	158.96	1.06	1.25	1.57	1.26
CaseB - 2050_RCP2.6	2050	F	LS(B)	RCP2.6	169.44	201.12	1.19	1.41	1.99	1.41
CaseC - 2050_RCP2.6	2050	F	LS(C)	RCP2.6	190.12	265.78	1.40	1.58	2.62	1.66
CaseSQ - 2050_RCP8.5	2050	F	LS(SQ)	RCP8.5	139.39	136.91	0.98	1.16	1.35	1.17
CaseA - 2050_RCP8.5	2050	F	LS(A)	RCP8.5	144.42	146.97	1.02	1.20	1.45	1.21
CaseA1 - 2050_RCP8.5	2050	F	LS(A1)	RCP8.5	153.52	165.36	1.08	1.28	1.63	1.28
CaseB - 2050_RCP8.5	2050	F	LS(B)	RCP8.5	173.51	208.39	1.20	1.44	2.06	1.43
CaseC - 2050_RCP8.5	2050	F	LS(C)	RCP8.5	192.34	273.64	1.42	1.60	2.70	1.69

Land Subsidence(LS) Condition
- LS(SQ): Status Quo, LS will stop（Current Status as of 2018）
- LS(A)：LS will progress to a small subsidence（Case A projection）
- LS(A1)：LS will progress to a small subsidence（Case A1 projection）
- LS(B)：LS will progress moderately（Case B projection）
- LS(C)：LS will be most advanced（Case C projection）

Land use
- P : present condition in 2018
- F : future condition in 2030

Climate Chage(CC) Condition
- W :With,Climate Chage(RCP2.6 or RCP8.5)
- WO: Without Climate Chage



Figure 4.58 Flood simulation results by subsidence scenario, by time point, with and without climate change

(2) Impact of land subsidence (statewide)

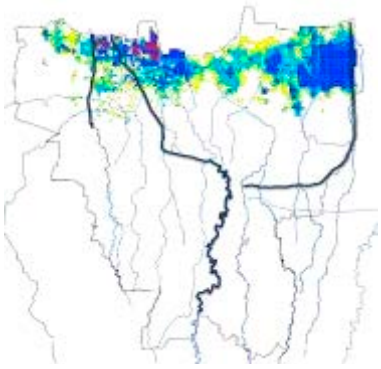
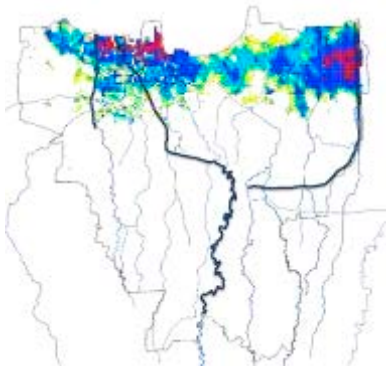
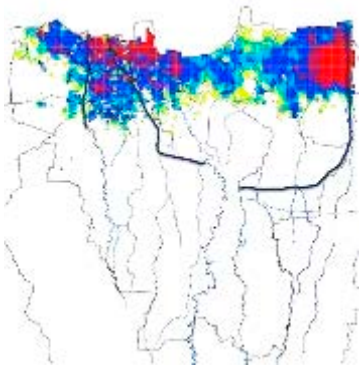
The impact of land subsidence was summarized for the subsidence scenario CaseC, which is the most advanced subsidence scenario among the subsidence projection scenarios. The following three cases were compared.

Figure 4.59 shows the maximum inundation depth maps for each case.

- CaseSQ-2018：2018 current conditions

- CaseC-2030：Case with the most advanced land subsidence by 2030 (subsidence scenario CaseC)
- CaseC-2050：Most advanced case of land subsidence by 2050 (subsidence scenario CaseC)

Due to land subsidence, the inundated area, inundation volume, and average inundation depth will increase by approximately 15%, 33%, and 16%, respectively, by 2030, and by 2050, the inundated area, inundation volume, and average inundation depth will increase by approximately 47%, 121%, and 51%, respectively.

CaseSQ-2018	CaseC-2030	CaseC-2050
		
Inundation area : 120.35 km^2 （1.00）	138.07 km^2（1.15）	176.79 km^2（1.47）
Inundation volume : 101.3 x 10^6 m^3（1.00）	134.6 x10^6 m^3（1.33）	224.1 x10^6 m^3（2.21）
Average inundation depth : 0.84 m（1.00）	0.97 m（1.16）	1.27 m（1.51）

( ): Value when CaseSQ-2018 is set to 1

Figure 4.59 Maximum Inundation Depth Chart (Effects of Land Settlement, Settlement Scenario C)

Figure 4.60 shows the difference between the 2050 subsidence case C and the 2018 status quo inundation analysis results. The warm-colored areas in the legend indicate areas where inundation depths have increased.

Inundation depths increase in areas where subsidence is large, such as the western coastal zone, central coastal zone, and eastern coastal zone. (red box in the figure)

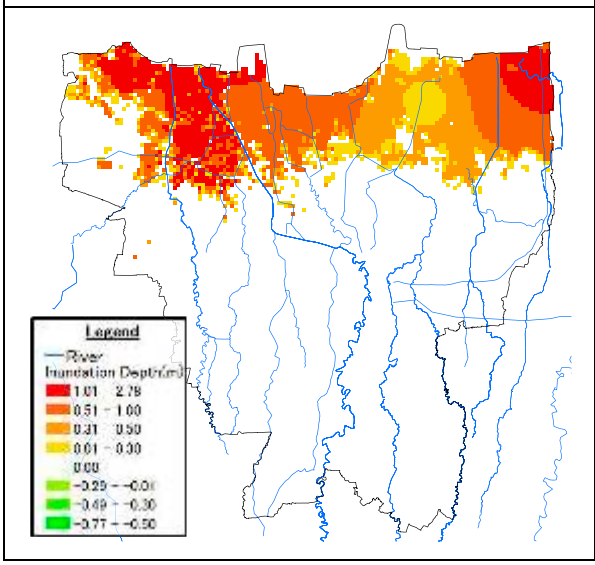
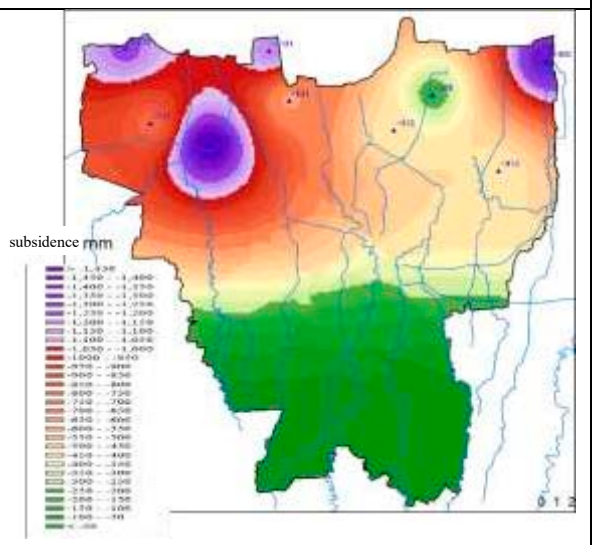
Maximum submergence depth difference diagram （CaseC-2050－CaseSQ-2018）	Land subsidence distribution map （Subsidence scenario CaseC・2050 年）
	

Figure 4.60 Maximum inundation differential map and subsidence distribution map Scenario C, 2050

From the above difference diagram, the following areas are those where the inundation depth increases by 1 m or more due to the effects of land subsidence. These coincide with the areas where land subsidence is large.

- Northern coastal areas: PENJARINGAN, CILINCING
- Near the confluence of the CENGKARENG drainage canal and the Angke River: CENGKARENG

(3) Climate Change Impacts (Statewide)

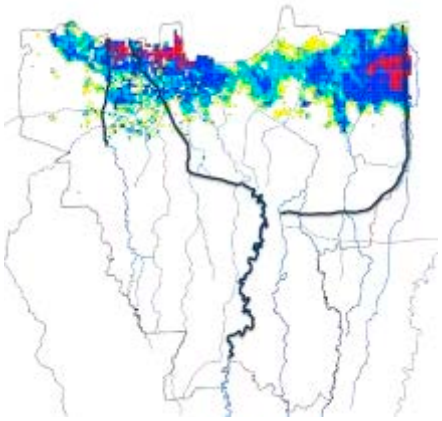
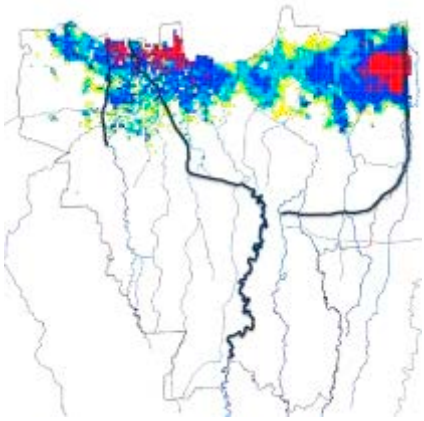
In addition to land subsidence, a comparison of the following four cases was conducted to determine the impact of climate change (see Figure 4 66). (See Figure 4.66) Land subsidence is assumed to be Scenario C, and climate change is assumed to be the RCP8.5 case.

CaseC-2030: Most advanced case for land subsidence by 2030; no climate change
CaseC-2030_RCP8.5: Most advanced case of land subsidence by 2030; RCP8.5 with climate change
CaseC-2050: Most advanced case of land subsidence by 2050; no climate change
CaseC-2050_RCP8.5: Most advanced case of land subsidence by 2050; RCP8.5 with climate change

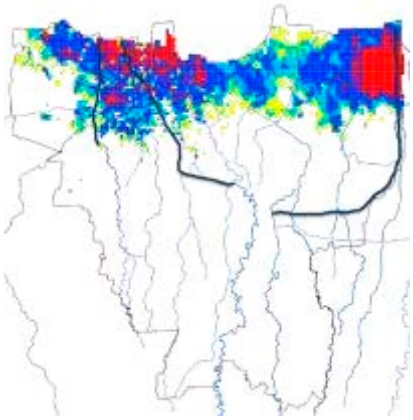
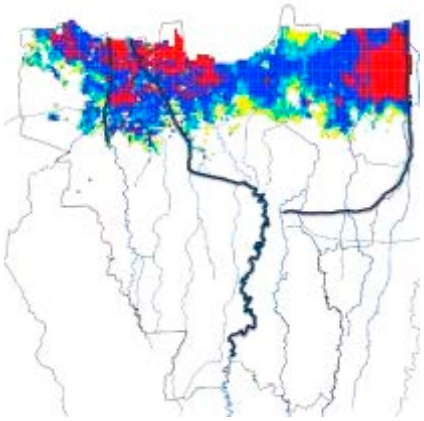
Due to climate change, inundated area, inundated volume, and average inundation depth will increase by about 8%, 19%, and 8%, respectively, in 2030, and inundated area, inundated volume, and average inundation depth will increase by about 13%, 49%, and 18%, respectively, in 2050.

Climate change is causing the following impacts

- Northern coastal areas: increased inundation damage due to sea level rise in western and eastern regions

CaseC-2030 No climate change	CaseC-2030_RCP8.5 With climate change：Sea level rise 13cm
	
Inundation area：138.07 km^2（1.15）	147.70 km^2（1.23）
Inundation volume：134.6 x10^6 m^3（1.33）	154.1 x10^6 m^3（1.52）
Average inundation depth：0.97 m（1.16）	1.04 m（1.24）

( ): Value when CaseSQ-2018 is set to 1

CaseC-2050 No climate change	CaseC-2050_RCP8.5 With climate change：Sea level rise 26cm
	
Inundation area：176.79 km^2（1.47）	192.34 km^2（1.60）
Inundation volume：224.1 x10^6 m^3（2.21）	273.6 x10^6 m^3（2.70）
Average inundation depth：1.27 m（1.51）	1.42 m（1.69）

( ): Value when CaseSQ-2018 is set to 1

Figure 4.61 Maximum Inundation Depth Chart (Effects of Climate Change)

(4) Summary of impacts of land subsidence and climate change

The subsidence and climate change impacts are summarized in the table below.

The percentages in the table indicate the difference between the cases being compared with respect to the ratio to the 2018 case in Table 4.24 above.

It can be seen that the impact of subsidence is larger than the impact of climate change for both inundation area, inundation volume, and inundation depth, and that the impact of subsidence is considerably larger than the impact of climate change for storm surge damage.

Table 4.29 Comparison of land subsidence and climate change impacts during storm surge

	(1)Impact of land subsidence		(2)Impact of climate change		(1)/(2)	
Comparison of the cases	CaseSQ-2018 vs. CaseC-2030	CaseSQ-2018 vs. CaseC-2050	CaseC-2030 vs. CaseC-2030_RCP8.5	CaseC-2050 vs. CaseC-2050_RCP8.5		
	2030	2050	2030	2050	2030	2050
Flood Area	15%	47%	8%	13%	1.88	3.62
Flood Volume	33%	121%	19%	49%	1.74	2.47
Average Flood Depth	16%	51%	8%	18%	2.00	2.83

Note: Values in the table represent the difference between each case for the ratio of each item in Table 4.24 above to the 2018 case; CaseSQ-2018 vs. CaseC-2030 represents the increase or decrease in the value of CaseC-2030 relative to CaseSQ-2018.

(5) Characteristics by City

The following is a city-by-city summary of the following cases of land subsidence scenario C.

In terms of inundation area, North Jakarta will account for the majority of the total inundation area in 2050, followed by West Jakarta, Central Jakarta, and East Jakarta.

In terms of inundation volume, North Jakarta will be mostly inundated in 2050, followed by West Jakarta, Central Jakarta, and East Jakarta.

In terms of average inundation depth, North Jakarta and West Jakarta will have the largest inundation depths in 2050, and North Jakarta will be heavily affected by subsidence.

In this study, South Jakarta was not affected by storm surge inundation.

North and West Jakarta are low-lying areas and are more susceptible to storm surge damage due to subsidence.

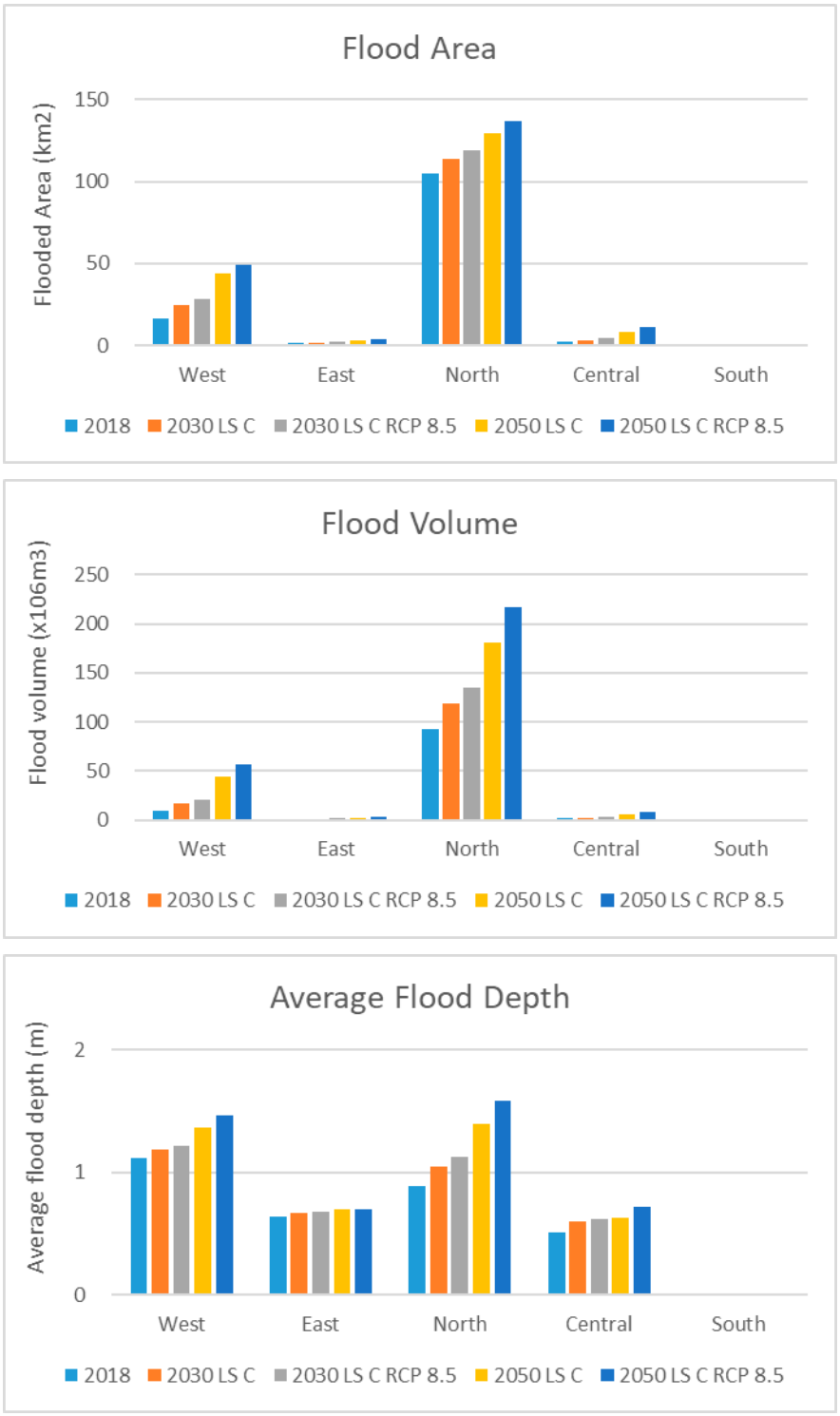


Figure 4.62 Storm surge simulation results by city (subsidence scenario C, by time point, with and without climate change)

(6) Characteristics of the pilot areas

Of the six pilot areas described in 6.3 later, the following three pilot areas for which boring data is available were summerized for land subsidence effects.

② Jakarta Fishing Port

③ Cenkareng

⑤ Cilincing Cakung

The results of the subsidence scenario C for each of the three areas are summarized below.

Table 4.30 Impact of subsidence in pilot area (during storm surge)

Area	Case	Simulation Result				Ratio for 2018			
		Flood area (km^2)	Flood volume ($x10^6m^3$)	Average flood depth (m)	Max flood depth (m)	Flood area	Flood volume	Average flood depth	Max flood depth
②Jakarta Fishing Port	CaseSQ-2018	4.92	7.81	1.73	3.27	1.00	1.00	1.00	1.00
	CaseC-2030	4.97	9.29	2.03	3.59	1.01	1.19	1.17	1.10
	CaseC-2050	5.13	12.58	2.64	4.29	1.04	1.61	1.52	1.31
③Cenkareng	CaseSQ-2018	0.74	0.21	0.29	0.58	1.00	1.00	1.00	1.00
	CaseC-2030	1.69	0.62	0.36	0.90	2.29	2.89	1.27	1.54
	CaseC-2050	3.81	2.54	0.67	1.60	5.14	11.90	2.31	2.74
⑤Cilincing Cakung	CaseSQ-2018	5.98	6.59	1.10	1.91	1.00	1.00	1.00	1.00
	CaseC-2030	6.40	7.73	1.21	2.10	1.07	1.17	1.10	1.10
	CaseC-2050	7.25	10.36	1.43	2.59	1.21	1.57	1.30	1.36

4.5 Risk of Land Subsidence

4.5.1 Damage to Infrastructure

Based on the results obtained from sections 4.1.2 and 4.1.4 above, the infrastructure affected by land subsidence in the norther region of DKI was extracted and the nature and extent of the impact of land subsidence on the infrastructure are listed in Table 4.31.

Table 4.31 Infrastructures Affected by Land Subsidence

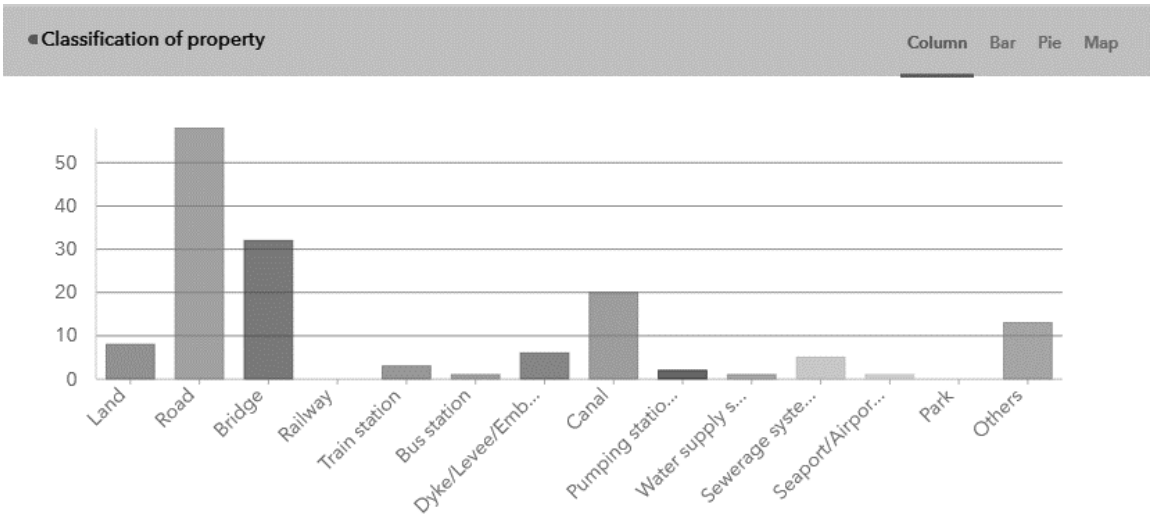
Facilitates	Influence
Road	Increase of flood frequency, increase of flood depth
Bridge	Insufficient margin, inhibition of river product
Levee	Levee height shortage
Pump Station	Lack of drain capacity due to increased head
Water Supply	Unequal settlement
Sewerage System	Unequal settlement
Port	Storm surge damage

Source: The Project Team

(1) Results of Land Subsidence Risk Assessment

Figure 4.63 and Table 4.32 describe the result of “Type of infrastructure with land subsidence impact”, indicating 58 locations of “road”, 32 locations of “bridge”, 20 locations of “canal”, 8 locations of “land”, and 6 locations of “dyke”, out of 150 surveyed locations. It also indicates a few impacts at “train station and bus station”, “pumping station”, and “seaport and airport”. Although there is 5 locations of “sewage system”, site photos do not capture any impact in the sewage system. Therefore, it is highly possible that this indicates the impact on urban canals or similar. Besides, 1 location of “water supply system” indicates a seawater intrusion to tap water.





Source：The Project Team

Figure 4.63 Result of "Type of infrastructure with land subsidence impact"

Table 4.32 Result of "Type of infrastructure with land subsidence impact"

Answers	Count	Percentage
Land	8	5.30%
Road	58	38.41%
Bridge	32	21.19%
Railway	0	0.00%
Train station	3	1.99%
Bus station	1	0.66%
Dyke/Levee/Embankment	6	3.97%
Canal	20	13.25%
Pumping station	2	1.32%
Water supply system	1	0.66%
Sewerage system	5	3.31%
Seaport/Airport	1	0.66%
Park	0	0.00%
Others	13	8.61%

Source：The Project Team

(2) Possible land subsidence impact on infrastructure

Table 4.33 list the possible land subsidence impact on infrastructure. The summary is as follows.

- Lowering of land itself, and uplifting and disjoining of structure foundation are expected as impacts on land.
- Aside from constant inundation with seawater (ROB) which mentioned previously, cracks and bumps will be generated as a road impact.
- Lack of clearance is expected as an impact on bridge.
- Structural enforcement will be necessary at terminal stations as a result of land subsidence.
- Decrease of necessary height for dike is expected.
- Necessary drainage capacity will increase as well as structural problem of pumping station.
- Seawater intrusion to water supply facility might be occurred.
- Heights of dike and land will be lack due to land subsidence.

Table 4.33 Possible land subsidence impact on infrastructure

Object	Impact/Damage
Land	Subsided land/Damage to foundation of house
Road	ROB/Crack and gap on surface
Bridge	Insufficient clearance from bridge
Railway	Subsided railway
Train station	Damage to station platform
Bus station	Damage to station platform
Dyke/Levee/Embankment	Shortage of dike height
Canal	Insufficient drainage capacity/Structural damage
Pumping station	Structural damage
Water supply system	Seawater intrusion
Sewerage system	Not sure
Seaport/Airport	Shortage of height

Source：The Project Team

4.5.2 Impact on Economic Activities

Table 4.34 shows the possible land subsidence impact on economic activities. Generally, land subsidence phenomena itself gives no major impact on economic activities or daily lives in normal time. On the other hand, impact on economic activities and daily lives is expected as indirect damages of inundation of which frequency and scale will increase due to land subsidence. Other impacts such as seawater intrusion to aquifer and structural damage of infrastructure threatens quality of life and safety.

Table 4.34 Possible land subsidence impact on economic activities

Object	Impact/Damage
Relating to infrastructure	
Land	Increasing frequency of flood, Prolonged flood inundation
Road	Traffic disturbance due to flood
Bridge	Flood due to a limitation of flow capacity, Traffic disturbance due to flood
Railway	Traffic disturbance due to flood
Train station	Unsafe condition for pedestrian
Bus station	Unsafe condition for pedestrian
Dyke/Levee/Embankment	Flood due to storm surge
Canal	Prolonged flood inundation
Pumping station	Prolonged flood inundation
Water supply system	Shortage of drinking water
Sewerage system	Not sure
Seaport/Airport	Traffic disturbance due to flood
Relating to land subsidence in general	
Increasing frequency of flood, deepen and prolonged flood inundation, traffic disturbance due to flood, consequent socio-economic damage	

Source：The Project Team

4.6 Creation of Inundation Risk Map

4.6.1 Purpose of Inundation Risk Map

In Jakarta, the flood risk and the damage increase, and the impact on the infrastructure facilities become obvious due to the influence of land subsidence. However, it is still not highly perceived that the influence of land subsidence in the administration and residents is a major problem. The inundation risk map shall be created for the following purposes.

- Administrators shall understand the risk of land subsidence and make it the basic data to make decisions in promoting adaptation measures.
- The residents shall recognize the risk of land subsidence; public opinion shall be enhanced, and make it a document to encourage business cooperation (rationalization of water use).
- To prepare for actual flood damage.

4.6.2 Contents of Inundation Risk Map

The inundation risk map shows the impact and damage of the land subsidence when the land subsidence has progressed, assuming the following disaster types and areas where the influence due to land subsidence is remarkable.

Also, the effect of alleviating each disaster type when adaptation measures for land subsidence are implemented shall be shown.

Table 4.35 Disaster Type and Target Area for Inundation Risk Map

Disaster Type	Target Area
High Tide	Coastal Area
Inland Water Inundation	Northern Area Surrounded by Banjir Canal
River Flooding	Southern Area of Banjir Canal
Impact on Urban Infrastructures	Whole DKI

Source: The Project Team

4.6.3 Information Presentation Method

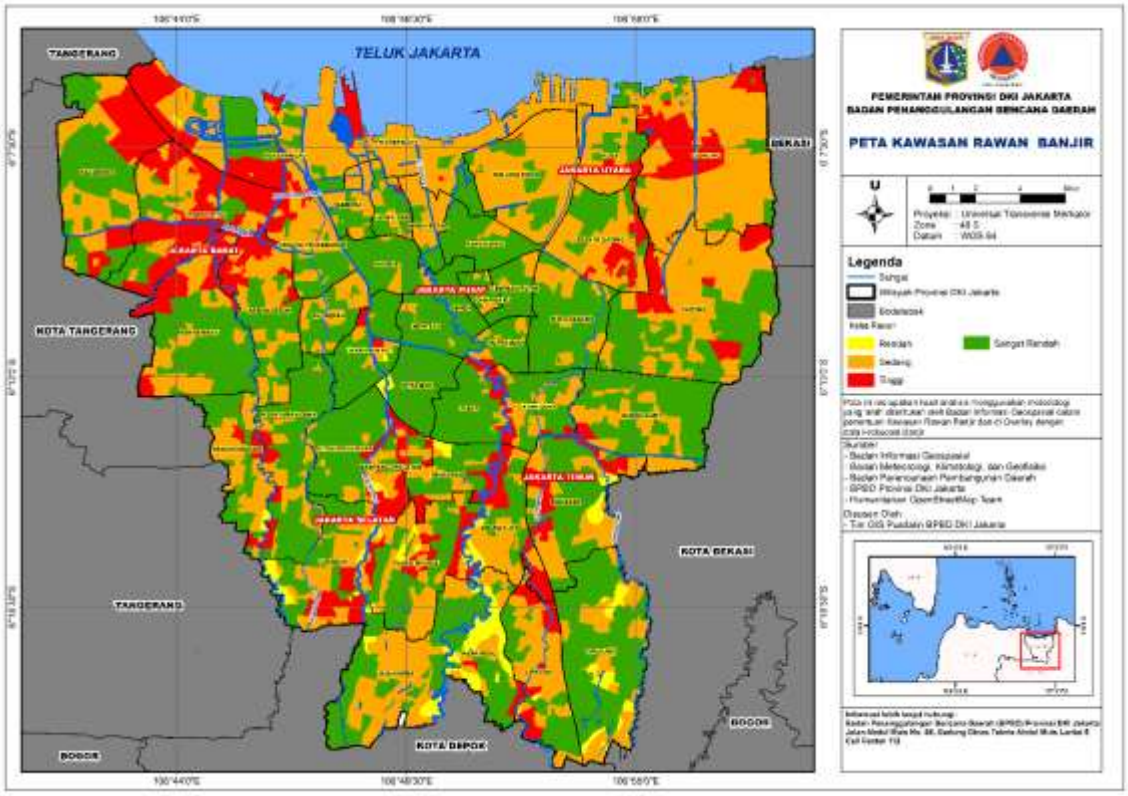
The contents and distribution method that the administrative and local residents fully recognize the influence of land subsidence and will lead to the next action shall be applied. Regarding the information to be displayed, types of water disasters are storm surge, rainfall inundation, and inundation by river water. They are classified in the map, and effects on urban infrastructure shall be added to the map. Regarding the presentation method, three media such as pamphlets, posters, and websites are assumed.

4.6.4 Collection of data relating to the inundation risk map

Existing inundation risk maps in Jakarta were collected to understand the situation of planning of disaster management in the project area. Figure 4.64 is the official flood-prone area map of Jakarta issued by BPBD. The colors in the figure indicate degrees of flood-prone risk from high (high-risk) to green (no-risk).

A document of guideline for making the flood-prone area map was not available to be collected this time, although it was reported that there were some criteria to decide the prone area. The criteria mainly consist of:

- Topography;
- Rainfall amount;
- Geological structure; and
- History of inundation



Source：BPBD

Figure 4.64 Flood Prone Area Map in DKI Jakarta

A couple of laws and regulations of the country relating to the flood-prone area map were collected as follows.

- Law of the Republic of Indonesia No. 24/2007 Concerning disaster management:
  This law defines the foundation, principal, and objective and the establishment of BNPB and BPBD and its responsibilities.
- Government Regulation of the Republic of Indonesia No. 21/2008 concerning disaster

management:
This regulation defines disaster management planning to be coordinated by a) BNPB at the national level, b) Provincial BPBD at the provincial level; c) Regency /city BPBD at regency/city level.

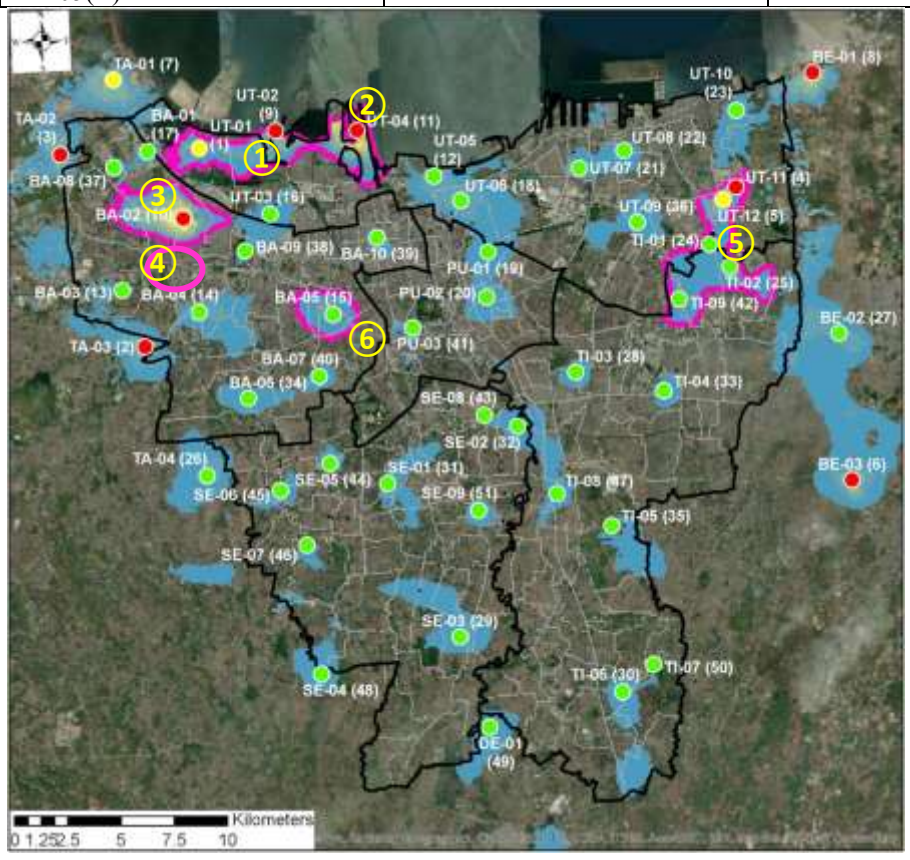
Given the law/regulation above, BPBD of DKI Jakarta issues the flood-prone area map collected in this survey.

4.6.5 Target Zones for Inundation Risk Map

Inundation risk map was created in the pilot areas. The pilot areas are shown in Table 4.36 and Figure 4.65.

Table 4.36 List of Pilot Area

	Code	Zone Name(Keamatan)	KOTA
①	UT-01(B), UT-02(A)	Panjarigan	Jakarta Utara
②	UT-04(A)	JKT Fishing Port (Panjarigan)	Jakarta Utara
③	BA-02(A)	Cengkareng	Jakarta Barat
④	-	Daan Magot(Cengkareng)	Jakarta Barat
⑤	UT-11(A), UT-12(B), TI-01(C), TI-02(C), TI-09(C)	Clincing/Cakung Area	Jakarta Utara, Jakarta Timur
⑥	BA-05(C)	Palmerah Area	Jakarta Barat



Source: The Project Team

Figure 4.65 Location Map of Pilot Area

4.6.6 Target Cases for Inundation Risk Map

Targeted cases of inundation simulation for inundation risk map are listed as follows.

Table 4.37 Targeted Cases (Flood)

【Targeted cases are marked with red】

Case	Simulation Condition				Simulation Result			Ratio for 2018		
	Target year	Lamd use	Land Subsidence	Climate Chage	Flood area (km^2)	Flood volume ($x10^6 m^3$)	Average flood depth (m)	Flood area	Flood volume	Average flood depth
Case1	2018	P	LS(SQ)	WO	251.86	167.10	0.66	1.00	1.00	1.00
Case2	2030	F	LS(SQ)	WO	255.42	183.45	0.72	1.01	1.10	1.08
Case3	2030	F	LS(A)	WO	255.58	184.10	0.72	1.01	1.10	1.09
Case4	2030	F	LS(A1)	WO	256.00	184.90	0.72	1.02	1.11	1.09
Case5	2030	F	LS(B)	WO	258.77	187.90	0.73	1.03	1.12	1.09
Case6	2030	F	LS(C)	WO	257.17	187.30	0.73	1.02	1.12	1.10
Case7	2030	F	LS(SQ)	W:RCP8.5	284.59	238.00	0.84	1.13	1.42	1.26
Case8	2030	F	LS(A)	W:RCP8.5	286.50	242.40	0.85	1.14	1.45	1.28
Case9	2030	F	LS(A1)	W:RCP8.5	287.03	244.00	0.85	1.14	1.46	1.28
Case10	2030	F	LS(B)	W:RCP8.5	288.99	248.40	0.86	1.15	1.49	1.30
Case11	2030	F	LS(C)	W:RCP8.5	290.33	253.20	0.87	1.15	1.52	1.31
Case12	2050	F	LS(SQ)	WO	255.42	183.50	0.72	1.01	1.10	1.08
Case13	2050	F	LS(A)	WO	255.26	184.00	0.72	1.01	1.10	1.09
Case14	2050	F	LS(A1)	WO	255.90	185.80	0.73	1.02	1.11	1.09
Case15	2050	F	LS(B)	WO	258.87	191.20	0.74	1.03	1.14	1.11
Case16	2050	F	LS(C)	WO	265.57	202.90	0.76	1.05	1.21	1.15
Case17	2050	F	LS(SQ)	W:RCP8.5	284.80	236.40	0.83	1.13	1.41	1.25
Case18	2050	F	LS(A)	W:RCP8.5	285.44	237.30	0.83	1.13	1.42	1.25
Case19	2050	F	LS(A1)	W:RCP8.5	287.03	239.90	0.84	1.14	1.44	1.26
Case20	2050	F	LS(B)	W:RCP8.5	289.53	247.30	0.85	1.15	1.48	1.29
Case21	2050	F	LS(C)	W:RCP8.5	294.63	262.00	0.89	1.17	1.57	1.34

Land Subsidence(LS) Condition
- LS(SQ): Status Quo, LS will stop（Current Status as of 2018）
- LS(A)：LS will progress to a small subsidence（ Case A projection）
- LS(A1)：LS will progress to a small subsidence（ Case A1 projection）
- LS(B)：LS will progress moderately（ Case B projection）
- LS(C)：LS will be most advanced（ Case C projection）

Land use
- P : present condition in 2018
- F : future condition in 2030

Climate Chage(CC) Condition
- W :With,Climate Chage
- WO: Without Climate Chage

Table 4.38 Targeted Cases (High Tide)

【Targeted cases are marked with red】

Case Name	Year	Land Subsidence	Climate Change	Remarks
Case 1	2018	LS(SQ)	WO	
Case 2	2030	LS(SQ)	WO	same as Case1
Case 3	2030	LS(A)	WO	
Case 4	2030	LS(A1)	WO	
Case 5	2030	LS(B)	WO	
Case 6	2030	LS(C)	WO	
Case 7	2030	LS(SQ)	W:RCP2.6	
Case 8	2030	LS(A)	W:RCP2.6	
Case 9	2030	LS(A1)	W:RCP2.6	
Case 10	2030	LS(B)	W:RCP2.6	
Case 11	2030	LS(C)	W:RCP2.6	
Case 12	2030	LS(SQ)	W:RCP8.5	
Case 13	2030	LS(A)	W:RCP8.5	
Case 14	2030	LS(A1)	W:RCP8.5	
Case 15	2030	LS(B)	W:RCP8.5	
Case 16	2030	LS(C)	W:RCP8.5	
Case 17	2050	LS(SQ)	WO	same as Case1
Case 18	2050	LS(A)	WO	
Case 19	2050	LS(A1)	WO	
Case 20	2050	LS(B)	WO	
Case 21	2050	LS(C)	WO	
Case 22	2050	LS(SQ)	W:RCP2.6	
Case 23	2050	LS(A)	W:RCP2.6	
Case 24	2050	LS(A1)	W:RCP2.6	
Case 25	2050	LS(B)	W:RCP2.6	
Case 26	2050	LS(C)	W:RCP2.6	
Case 27	2050	LS(SQ)	W:RCP8.5	
Case 28	2050	LS(A)	W:RCP8.5	
Case 29	2050	LS(A1)	W:RCP8.5	
Case 30	2050	LS(B)	W:RCP8.5	
Case 31	2050	LS(C)	W:RCP8.5	

Land Subsidence(LS) Condition
- LS(SQ): Status Quo, LS will stop (Current Status as of 2018)
- LS(A): LS will progress to a small subsidence (Case A projection)
- LS(A1): LS will progress to a small subsidence (Case A1 projection)
- LS(B): LS will progress moderately (Case B projection)
- LS(C): LS will be most advanced (Case C projection)

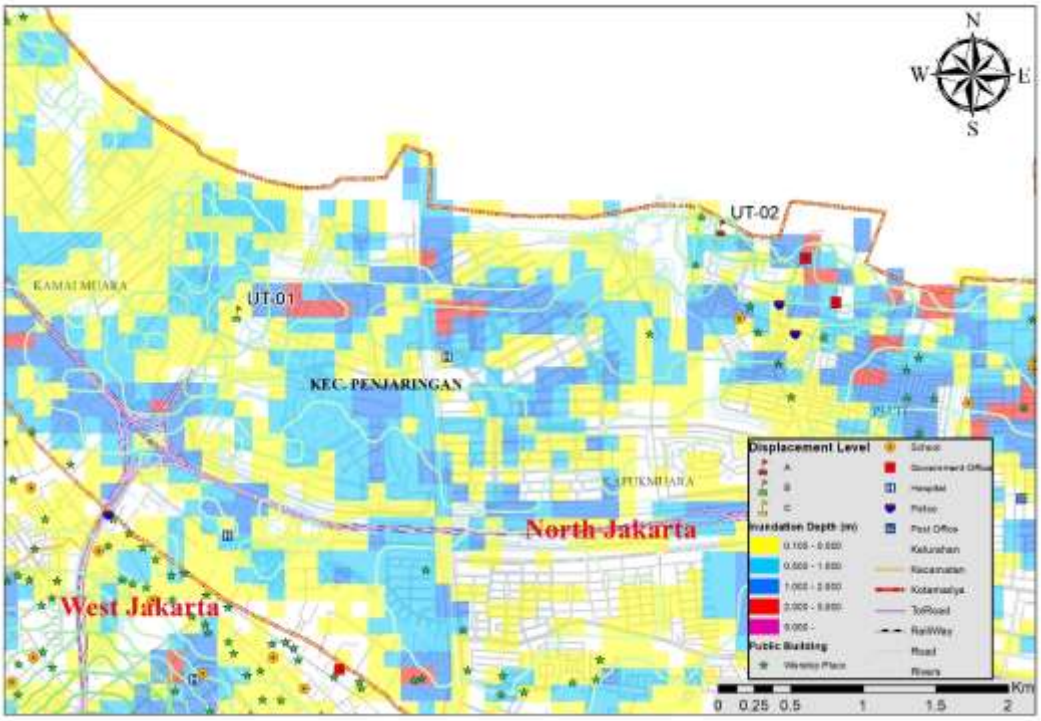
Land use
- P : present condition in 2018
- F : future condition in 2030

Climate Chage(CC) Condition
- W :With Climate Chage
- WO: Without Climate Chage

4.6.7 Creation of Inundation Risk Map (Flood)

Created inundation risk map for flood for the targeted cases are shown as follows.

- Case1_2018_SQ_P_v0_100



- Case21_2050_SQ_F_RCP8.5_vC_100

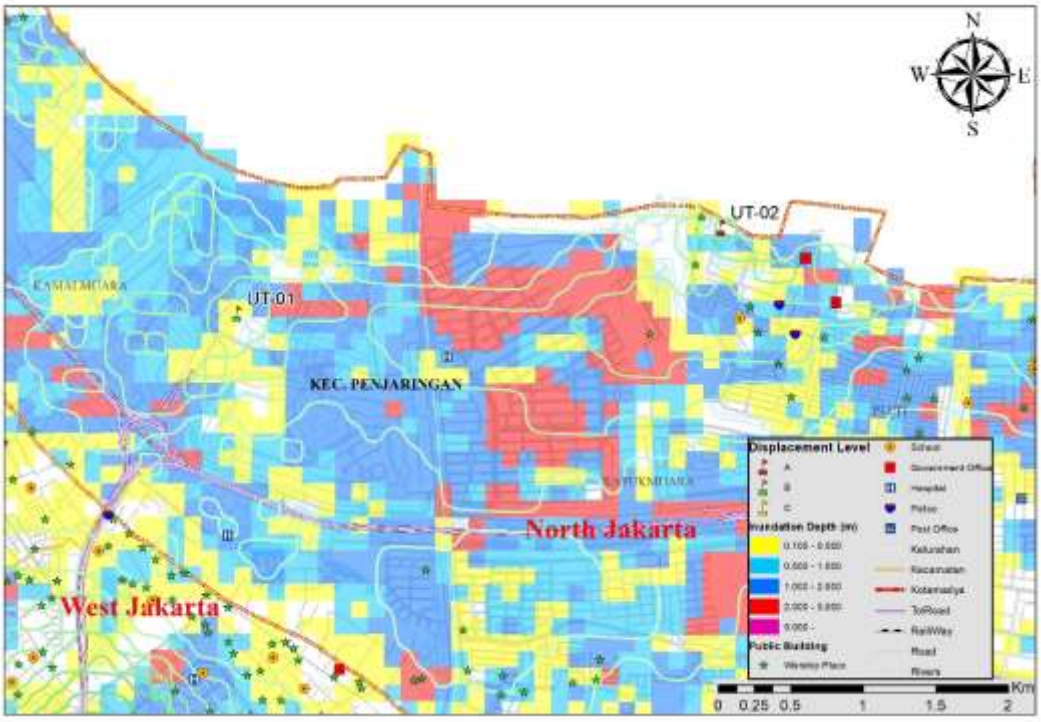
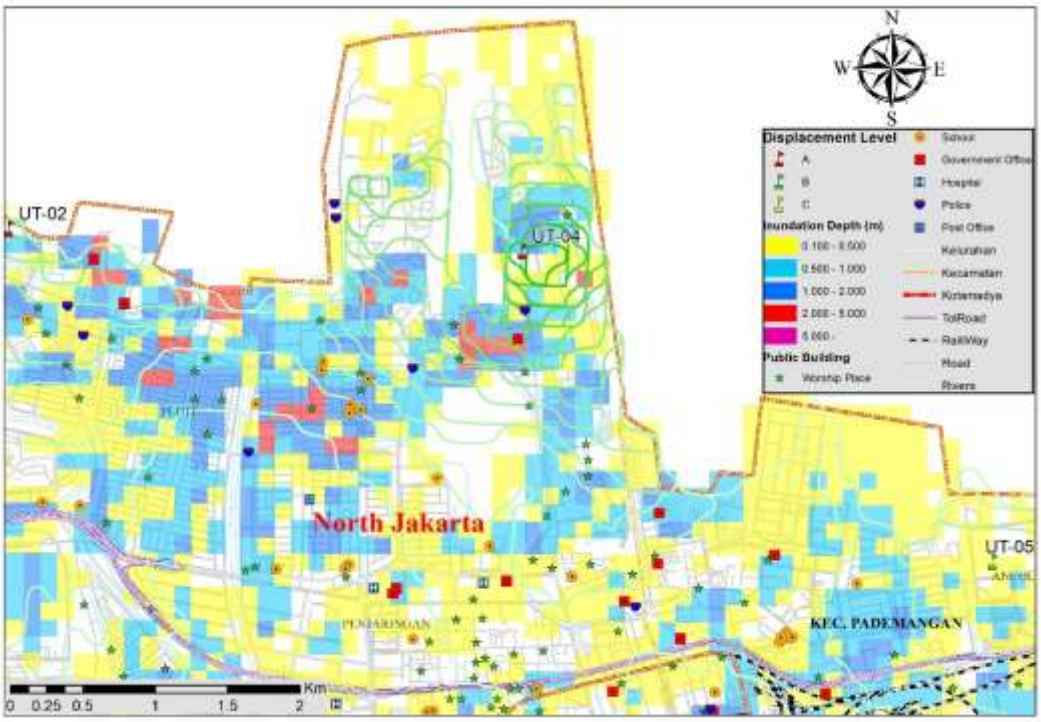


Figure 4.66　Inundation Risk Map for Flood（UT-01, 02）

- Case1_2018_SQ_P_v0_100



- Case21_2050_SQ_F_RCP8.5_vC_100

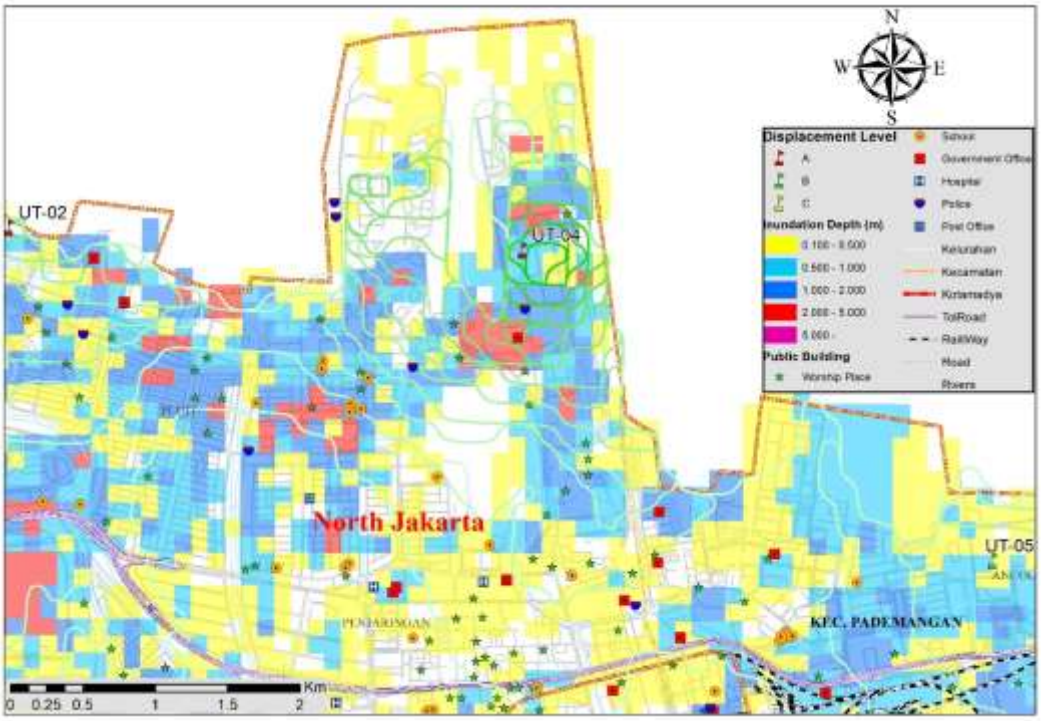
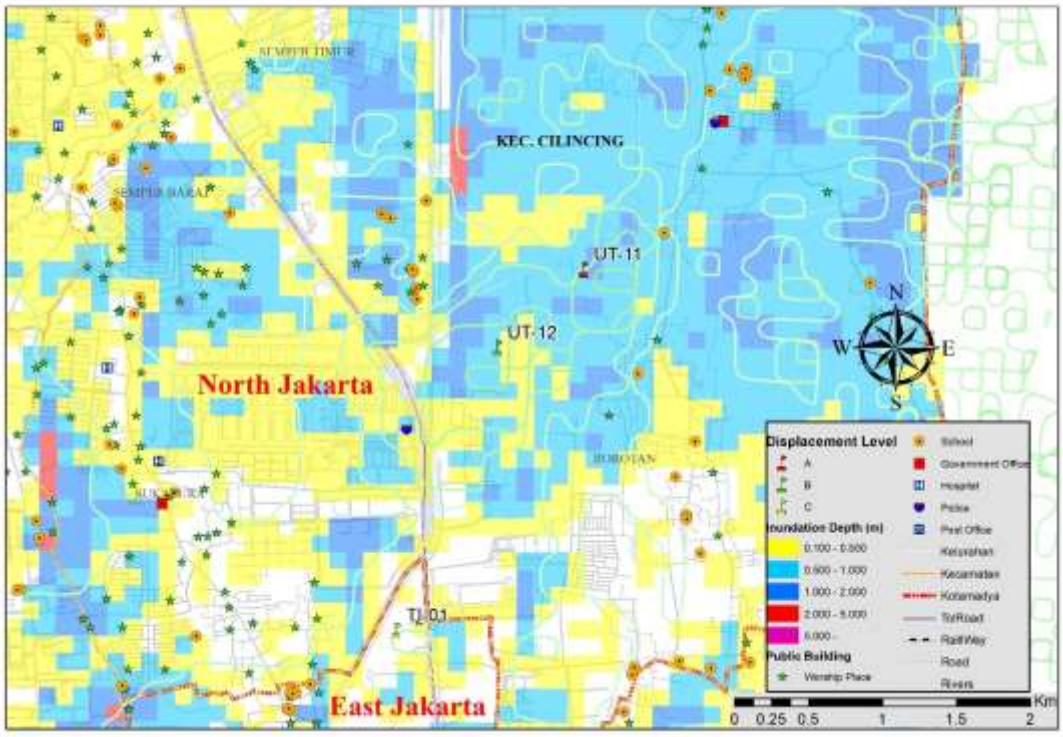


Figure 4.67　Inundation Risk Map for Flood（UT-04）

- Case1_2018_SQ_P_v0_100



- Case21_2050_SQ_F_RCP8.5_vC_100

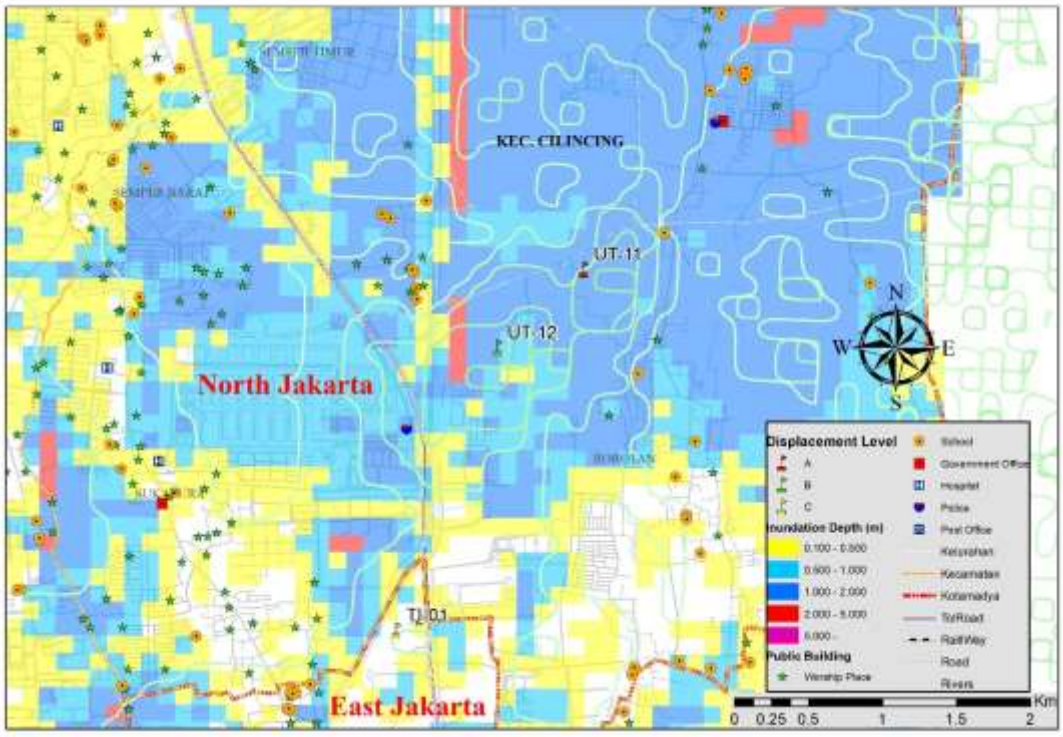
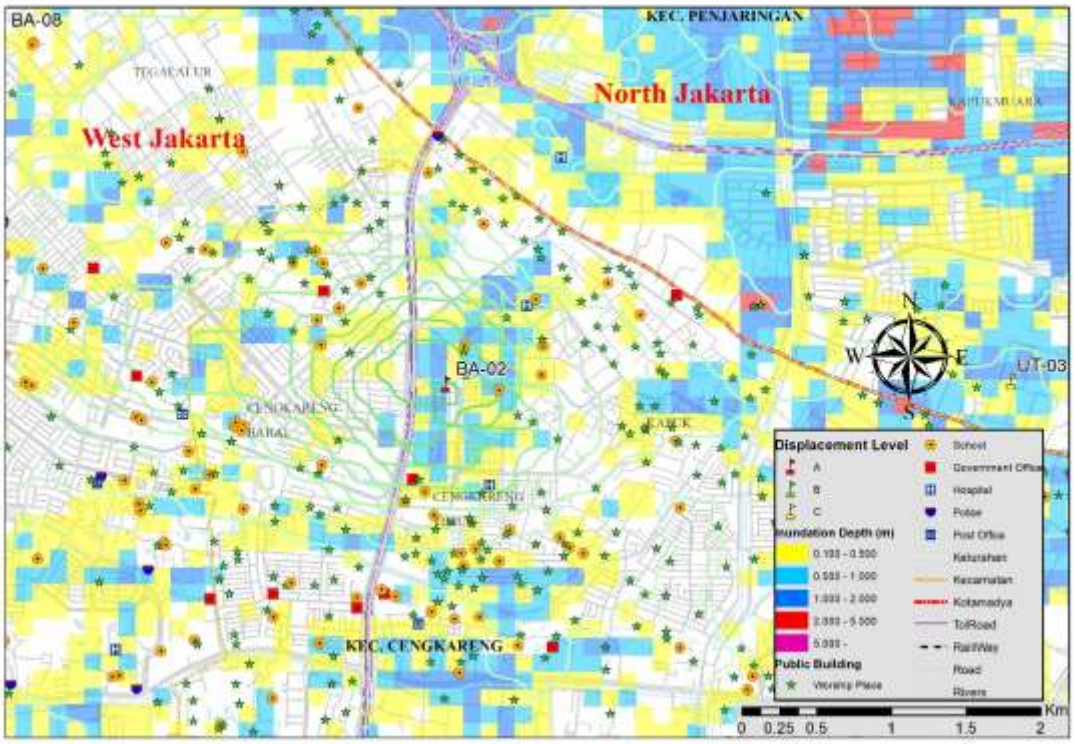


Figure 4.68　Inundation Risk Map for Flood（UT-11, UT-12）

- Case1_2018_SQ_P_v0_100



- Case21_2050_SQ_F_RCP8.5_vC_100

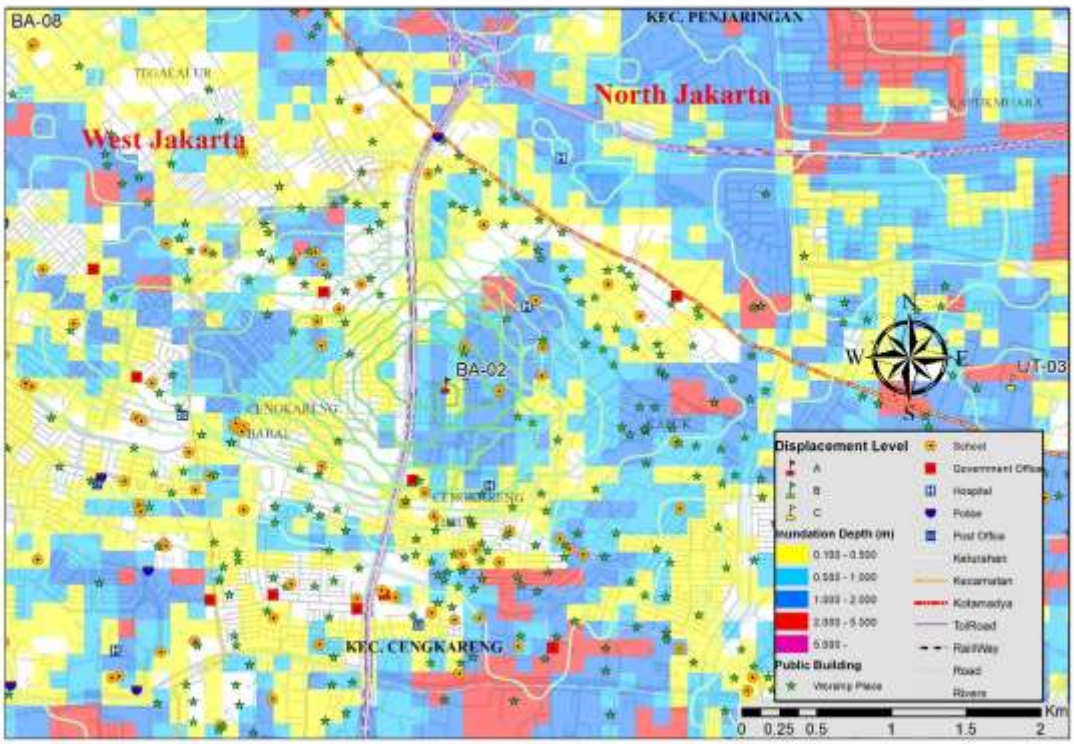
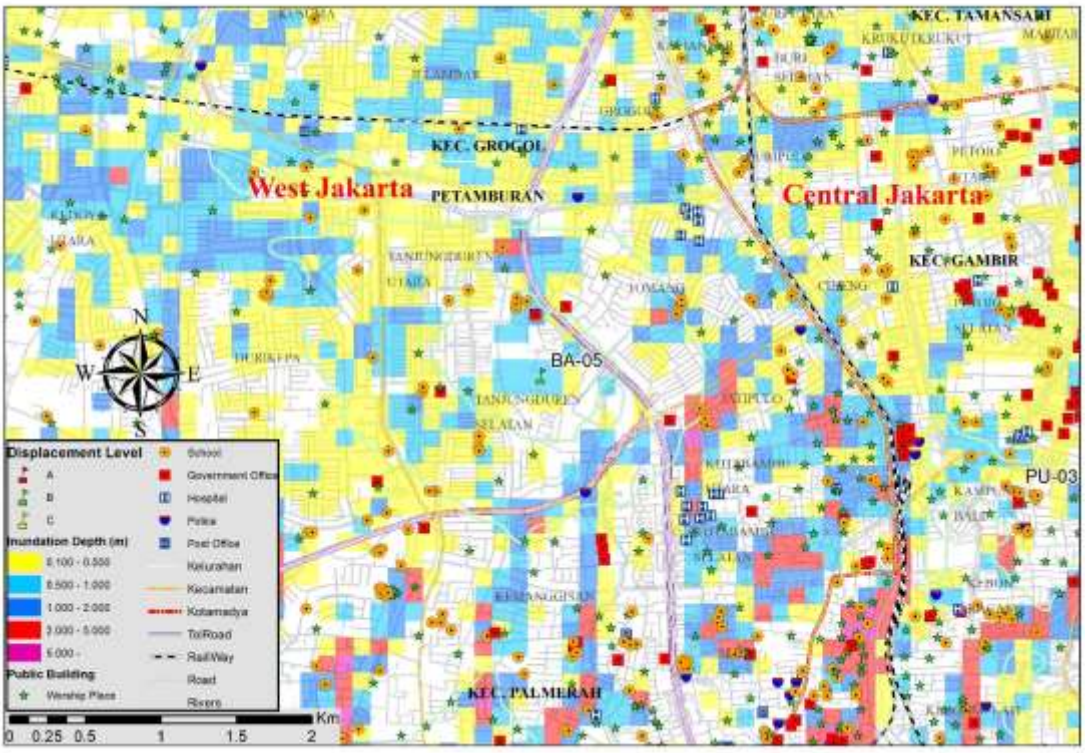


Figure 4.69　Inundation Risk Map for Flood（BA-02）

- Case1_2018_SQ_P_v0_100



- Case21_2050_SQ_F_RCP8.5_vC_100

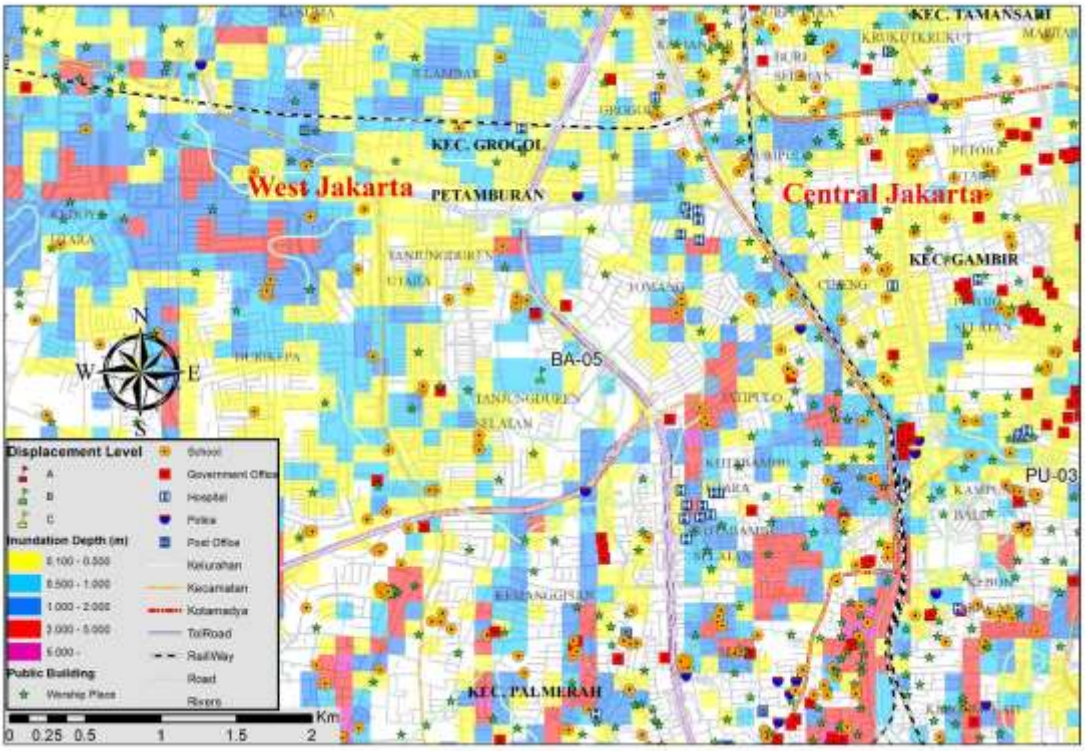
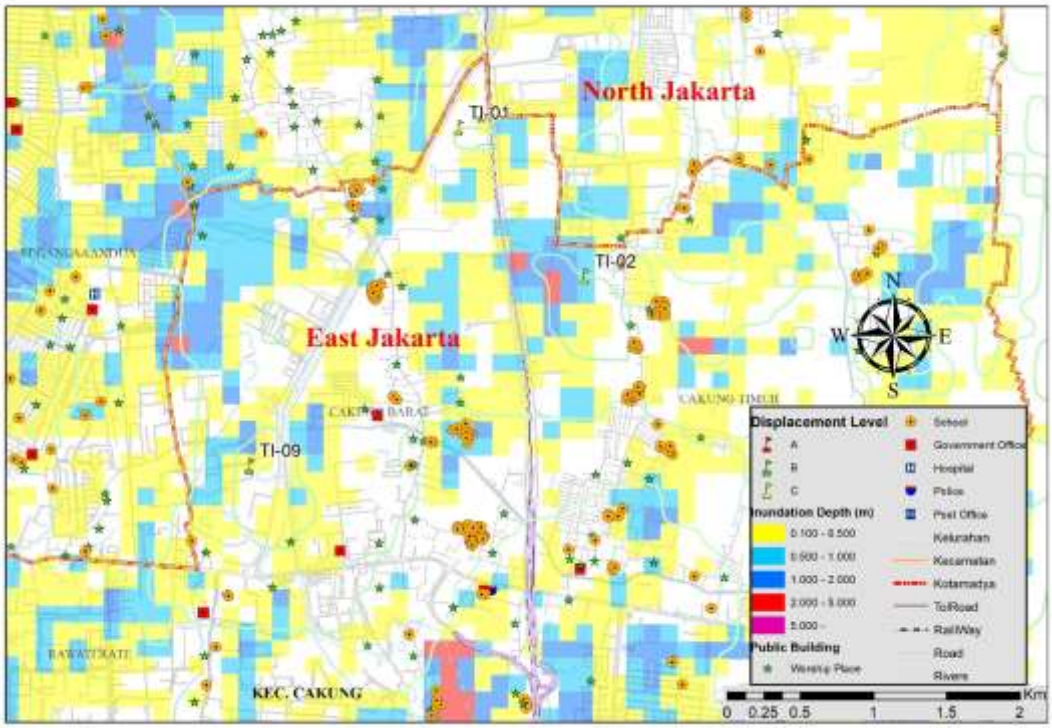


Figure 4.70　Inundation Risk Map for Flood（BA-05）

- Case1_2018_SQ_P_v0_100



- Case21_2050_SQ_F_RCP8.5_vC_100

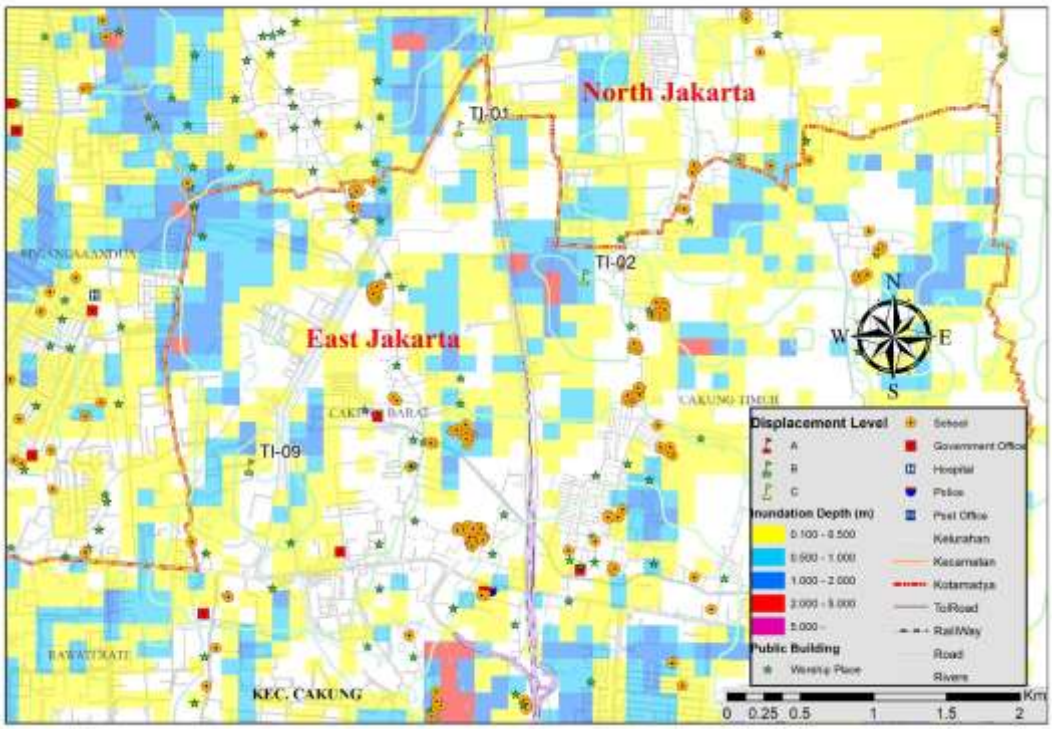
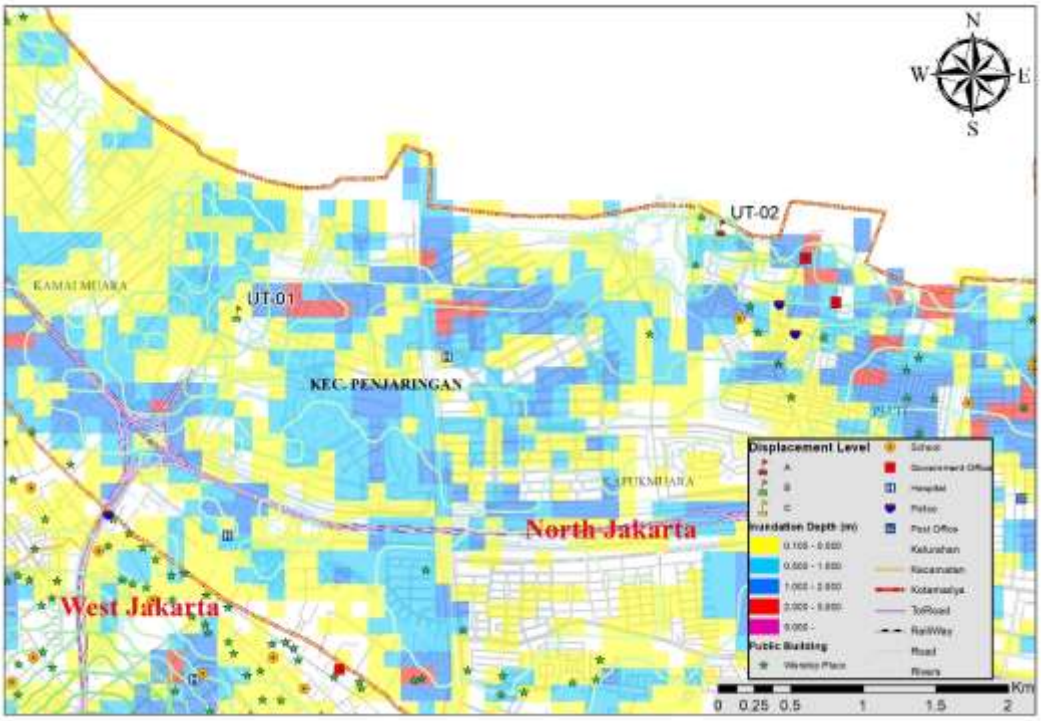


Figure 4.71　Inundation Risk Map for Flood（TI-01, 02 ,09）

4.6.8 Creation of Inundation Risk Map (High Tide)

Created inundation risk map for high tide for the targeted cases are shown as follows.

- Case1_2018 Case SQ



- Case31_2050 Case C RCP 8.5

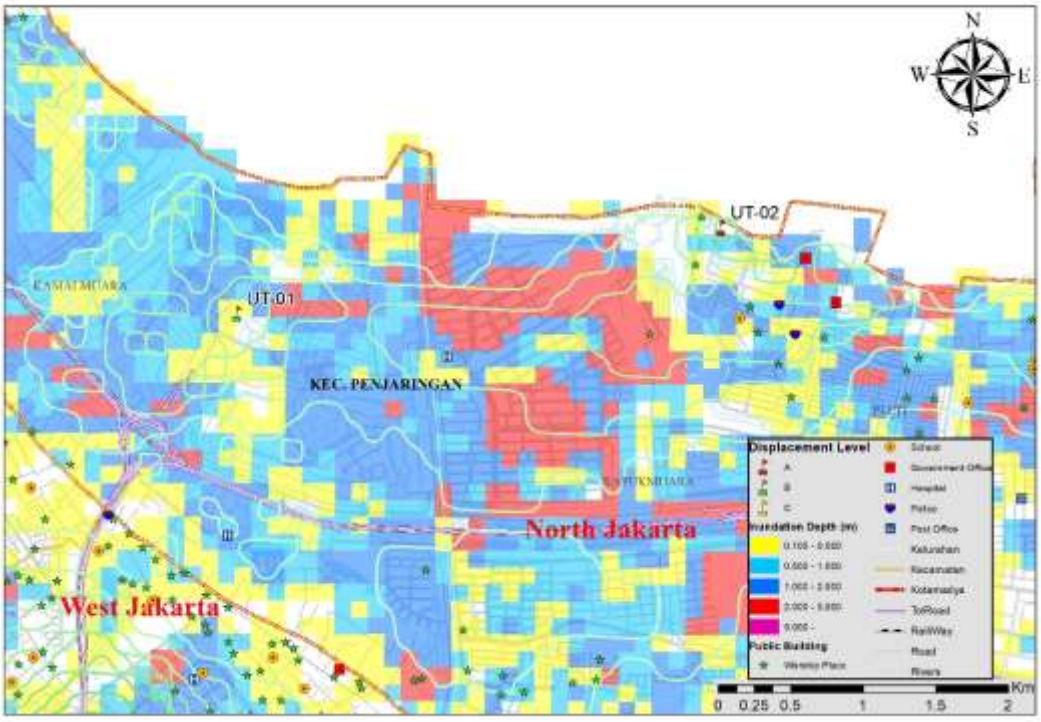
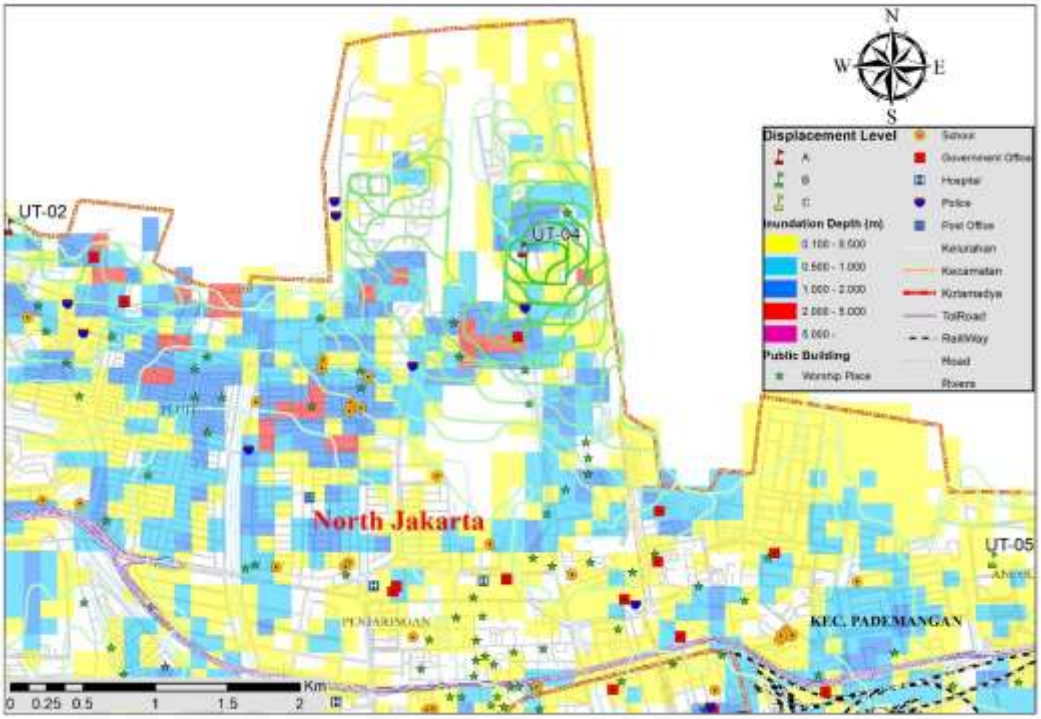


Figure 4.72 Inundation Risk Map for High Tide（UT-01, 02）

- Case1_2018 Case SQ



- Case31_2050 Case C RCP 8.5

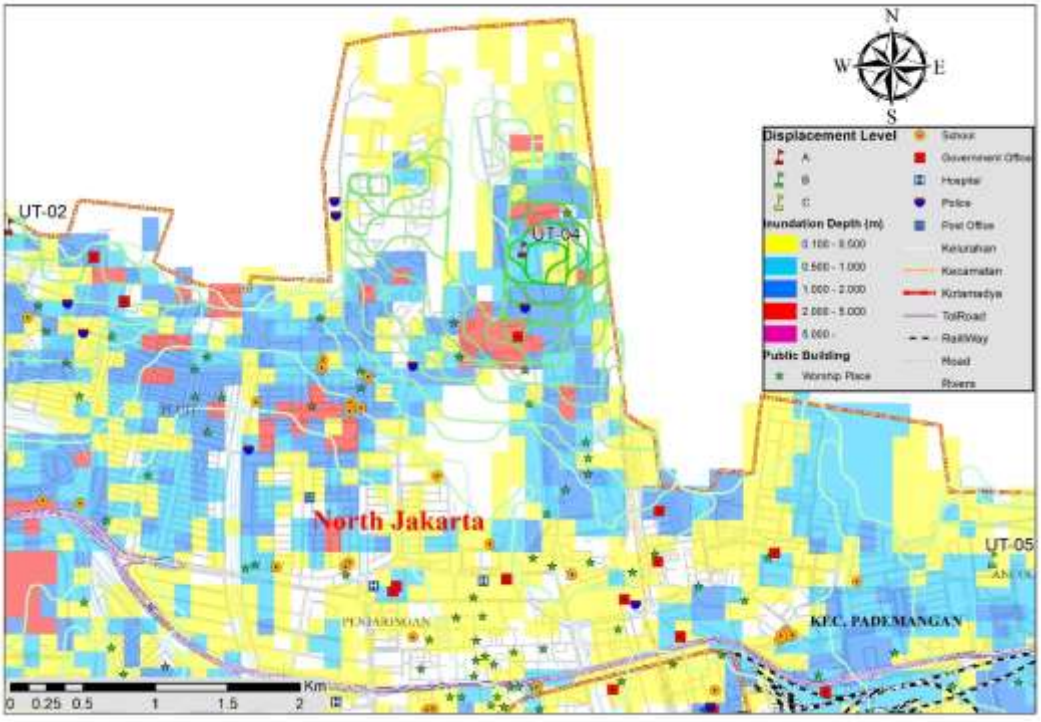
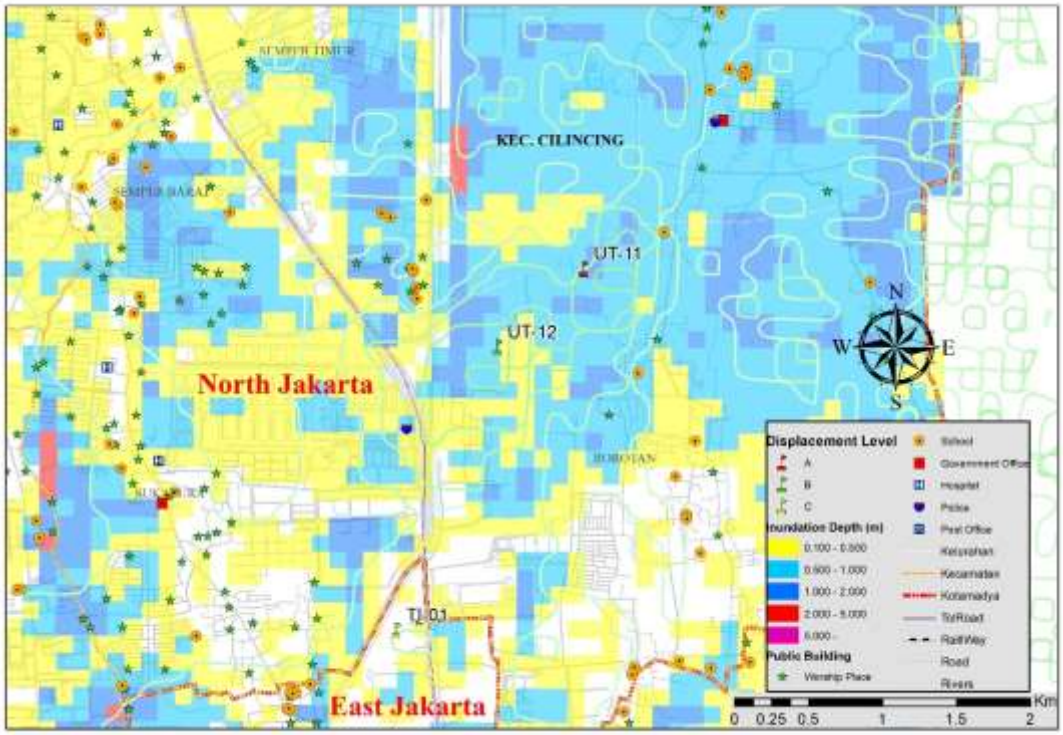


Figure 4.73　Inundation Risk Map for High Tide（UT-04）

- Case1_2018 Case SQ



- Case31_2050 Case C RCP 8.5

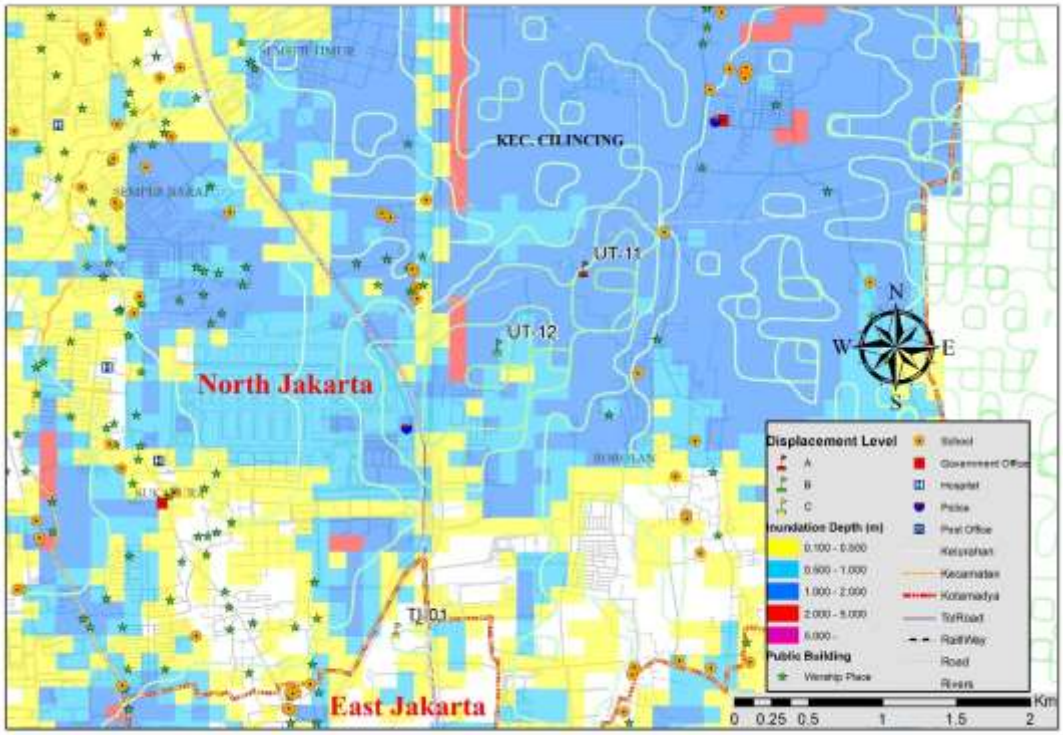
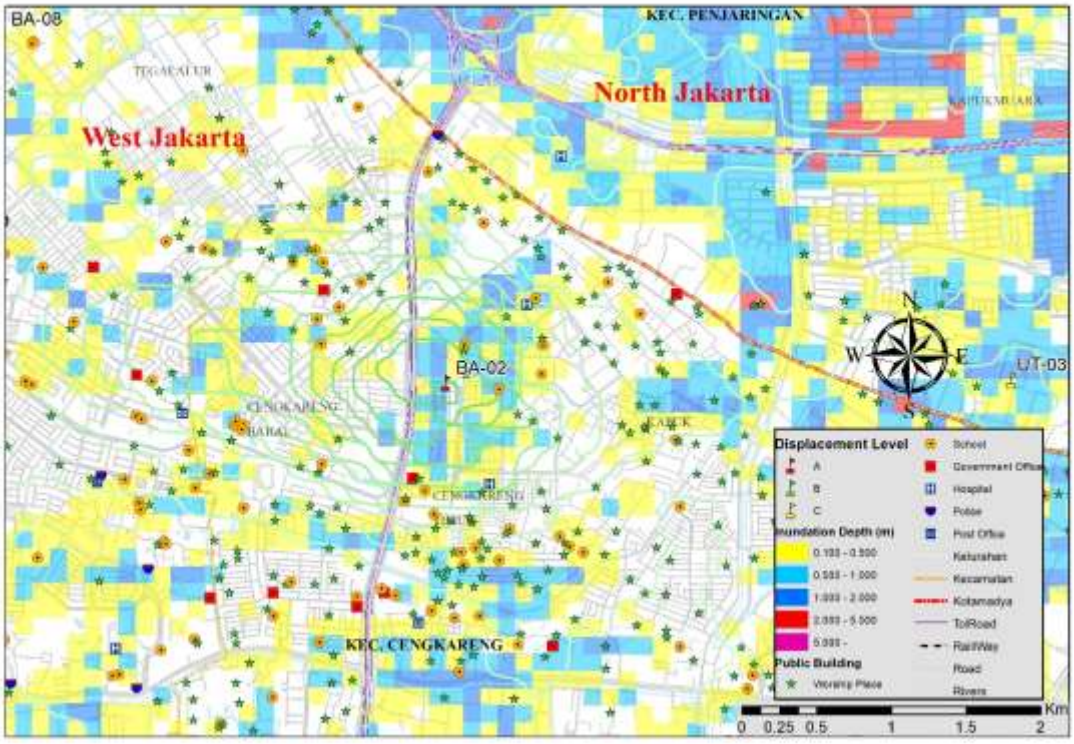


Figure 4.74　Inundation Risk Map for High Tide（UT-11, UT-12）

- Case1_2018 Case SQ



- Case31_2050 Case C RCP 8.5

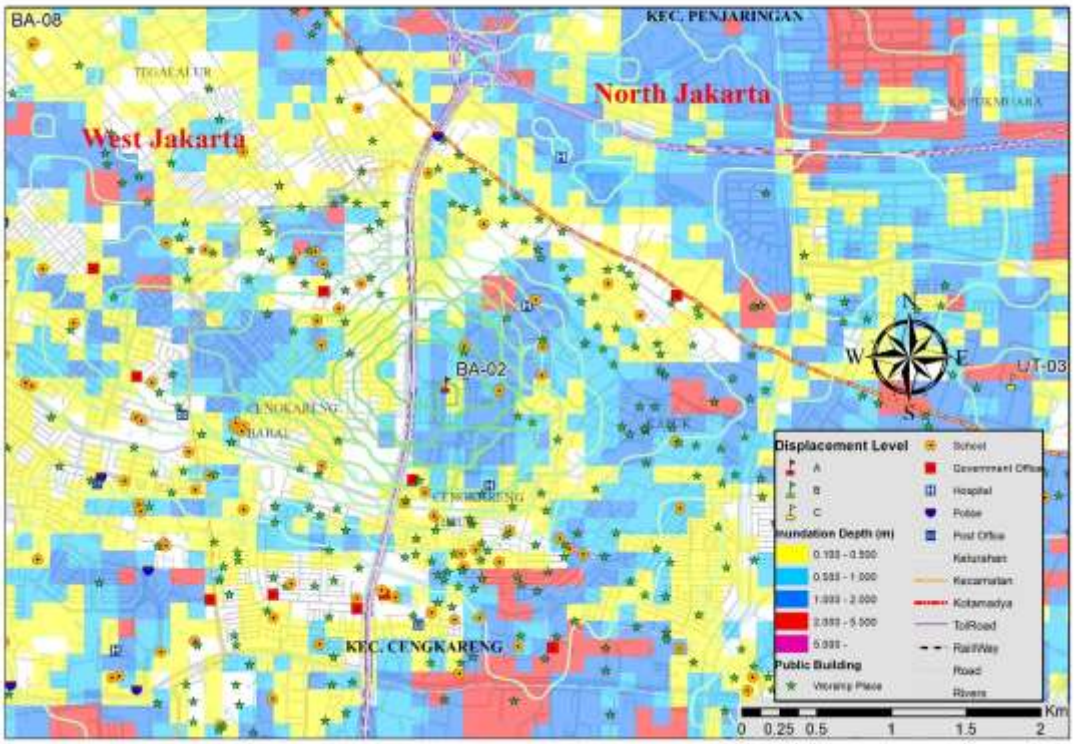
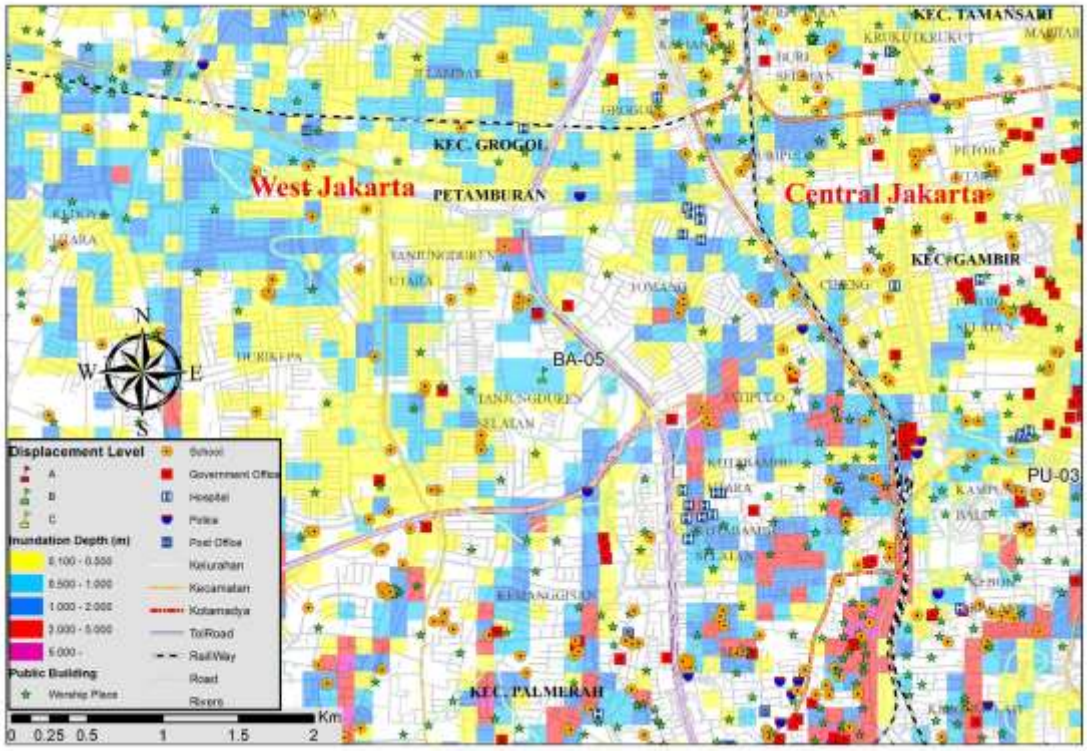


Figure 4.75　Inundation Risk Map for High Tide（BA-02）

- Case1_2018 Case SQ



- Case31_2050 Case C RCP 8.5

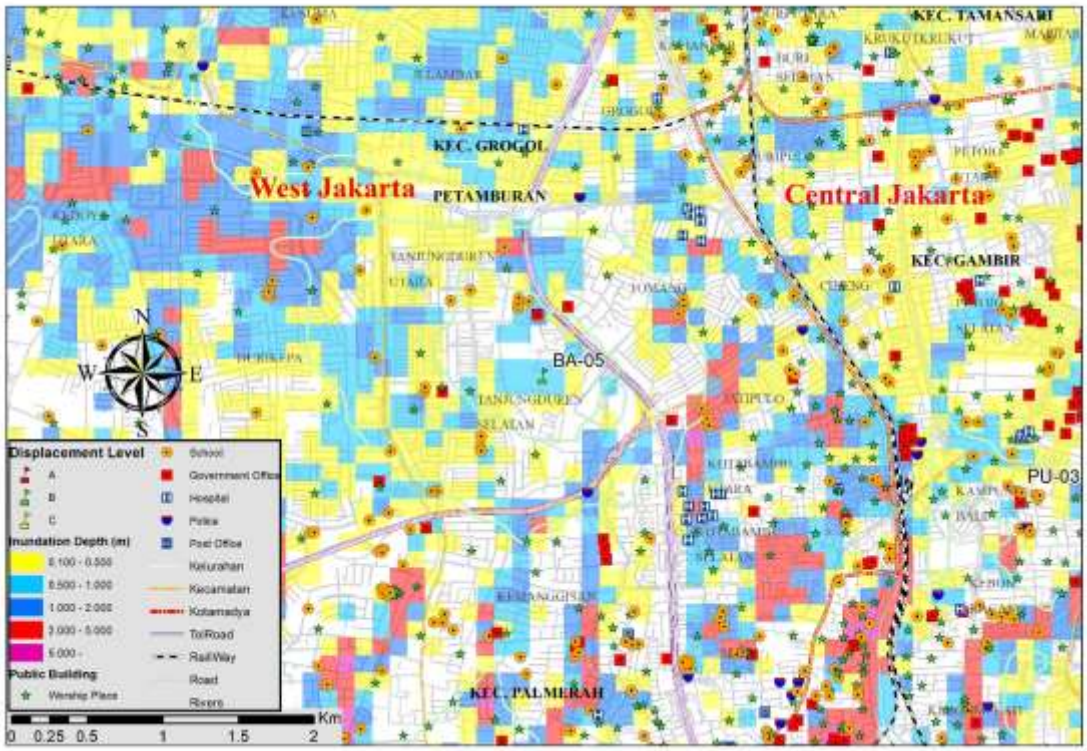
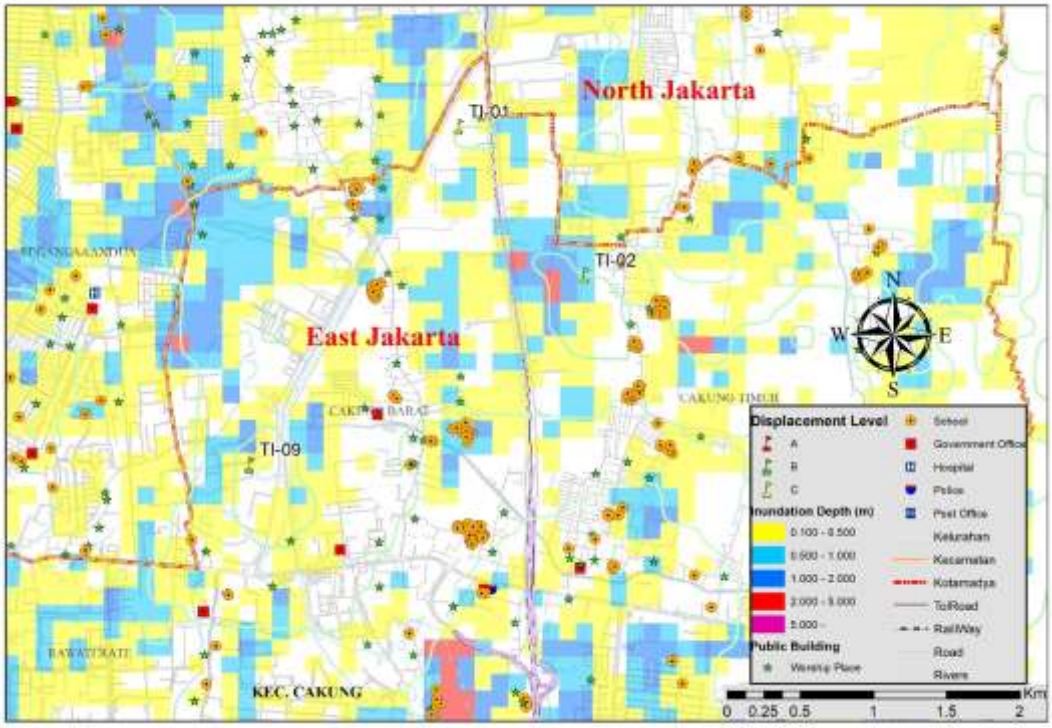


Figure 4.76　Inundation Risk Map for High Tide（BA-05）

- Case1_2018 Case SQ



- Case31_2050 Case C RCP 8.5

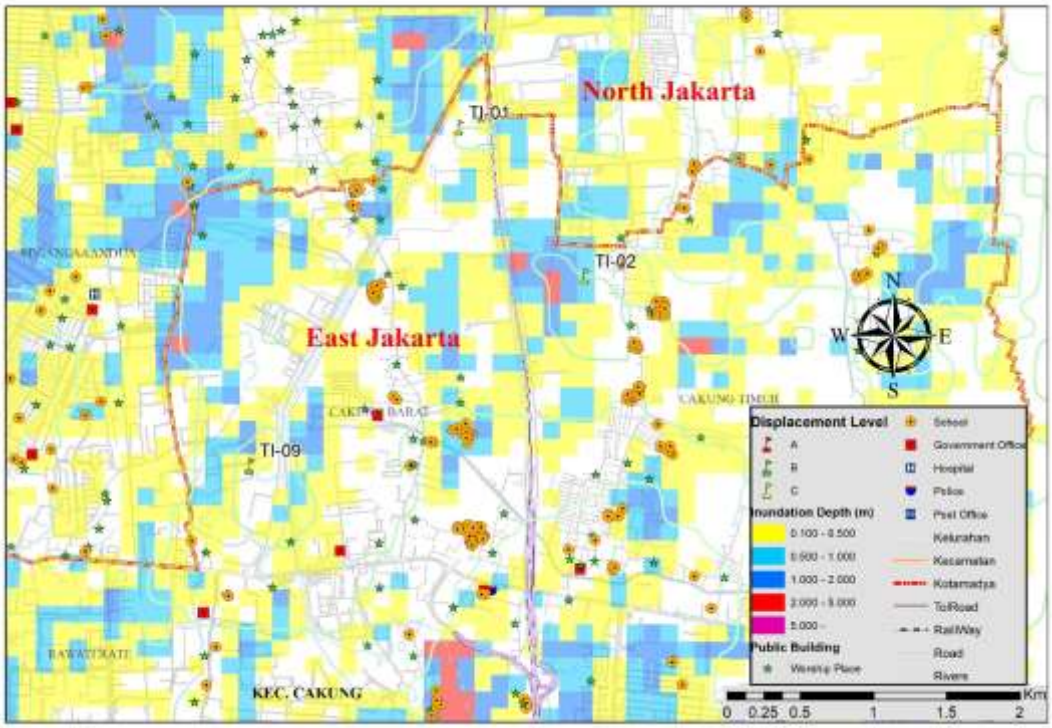


Figure 4.77　Inundation Risk Map for High Tide（TI-01, 02 ,09）

4.7 Adaptation Plan

The projects planned and implemented by the Ministry of Public Works and Housing, the Jakarta Special Province, and the NCICD will be reviewed and evaluated as adaptation measures against land subsidence.

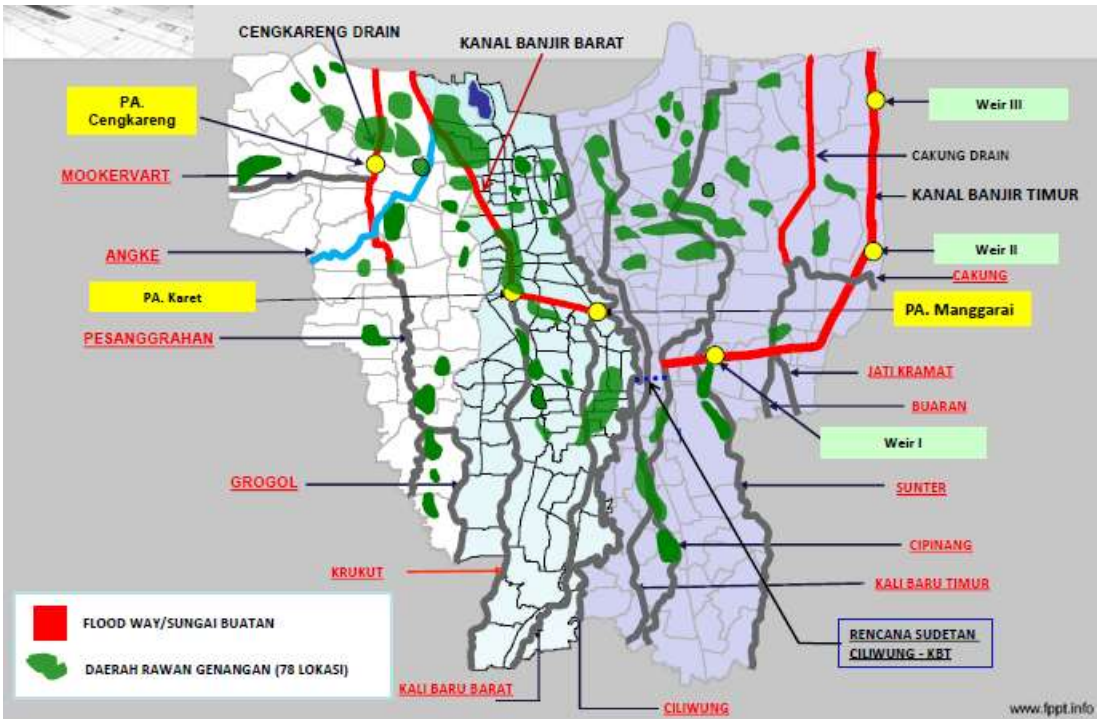
- Storm surge embankments, river embankments, and river improvement to be developed by the Ministry of Public Works and Housing as the lead agency.
- Drainage channel development and pumping stations to be developed by the Jakarta Special Province as the lead agency.
- Seawall embankment reinforcement, river embankment reinforcement, and pumping stations listed as NCICD's maintenance menu

4.7.1 Summerize existing projects

(1) Flood control

1) Rivers in Jakarta SAR and their management classification

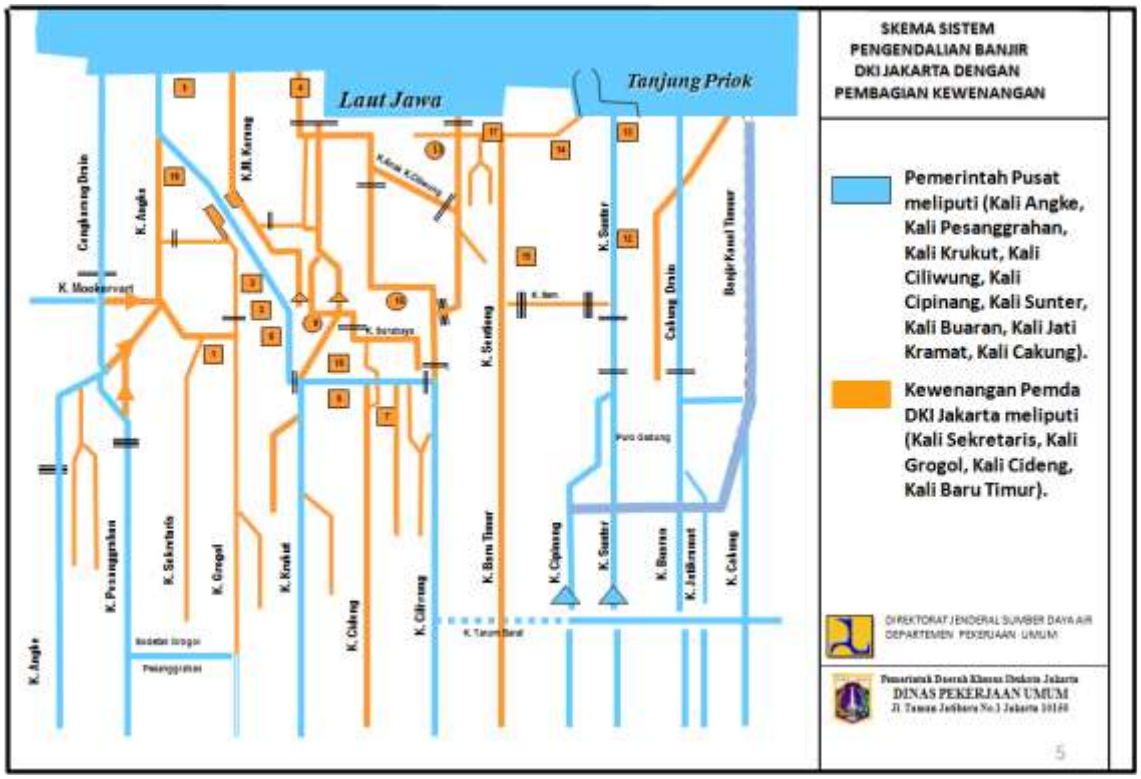
Figure 4.78 shows the rivers flowing into Jakarta SAR. It consists of 13 major rivers, including the Ciliwung River, and is managed by the Ministry of Public Works and National Housing (PU-PR) and the Jakarta Special Province (DKI Jakarta). These rivers are collected and discharged to the sea through the West Drain, which has been in service since the Dutch occupation, and the East Drain, which began service in 2011. The Ciliwung River, the largest river, is diverted entirely into the West Drain by the Manggarai Gate, and the former Ciliwung River, which remains in the low-lying area bounded by the east and west spillways, serves as a channel for inland water.



Source：MACRO CONCEPT OF JAKARTA FLOOD MITIGATIONS

Figure 4.78 13 rivers in Jakarta SAR

A diagram of the administrative divisions of PUPR and DKIJakrta is shown in Figure 4.79. Light blue in the figure indicates PUPR jurisdiction and orange indicates DKI Jakrta jurisdiction.



Source：MACRO CONCEPT OF JAKARTA FLOOD MITIGATIONS

Figure 4.79 Management classification map of 13 rivers in Jakarta SAR

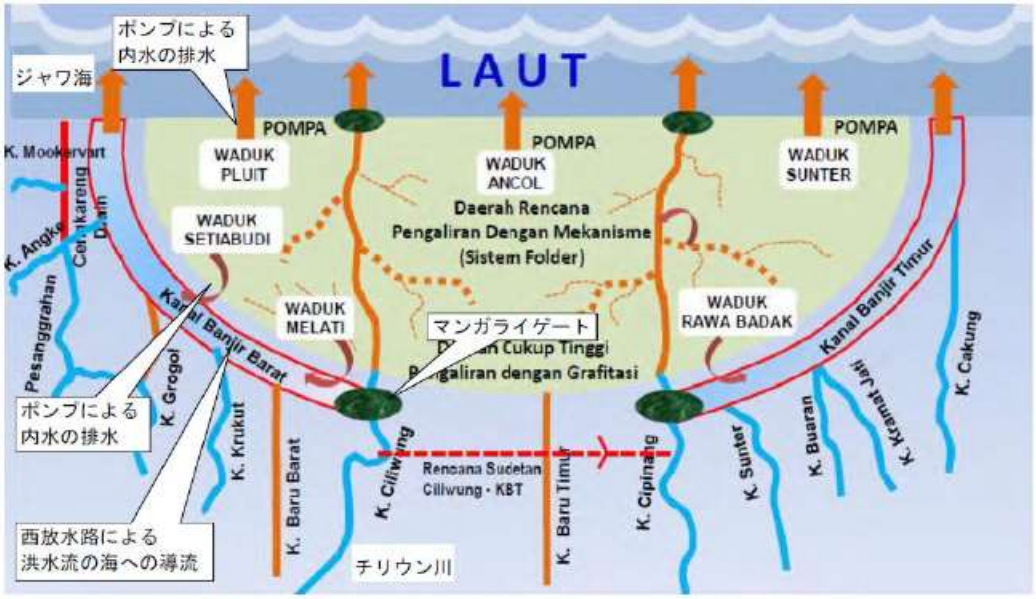
a) Basic Concept of Flood Control Measures in Jakarta Metropolitan Area

Floods occurring in the Jakarta Metropolitan Region are broadly classified into three categories: external floods caused by incoming rivers, internal floods caused by insufficient drainage capacity, and floods caused by storm surges.

The basic concept of flood control measures in the Jakarta metropolitan area is as follows.

・In the Ciliwung River lowland area, where important facilities are concentrated, floodwaters are discharged into the Java Sea through the West Drain diverted at the Manggarai Gate to prevent floodwaters from the Ciliwung River from flowing into the area.In the Cibinong River lowland areas, where industrial areas are concentrated, floodwaters are discharged into the Java Sea through the East Drainage Channel to prevent floodwaters from the Cibinong River and other rivers from flowing into the area.

・The low-lying coastal areas are in the zero-meter zone, so the inland water in the low-lying areas is discharged by pumps into the West and East Discharge Canals and the sea.



出典：JICA ジャカルタ首都圏総合治水能力強化プロジェクト ファイナルレポート

Figure 4.80Basic Concept of Flood Control Measures in the Jakarta Metropolitan Area

b) Status of flood control measures

Flood control measures include river improvement projects led by BBWS-CC (Ciliwung Cisadane Watershed Management Agency). In addition, the Jakarta Special Province and the Ministry of Public Works are implementing dredging projects to restore the functions of rivers and reservoirs.

a. River improvement projects

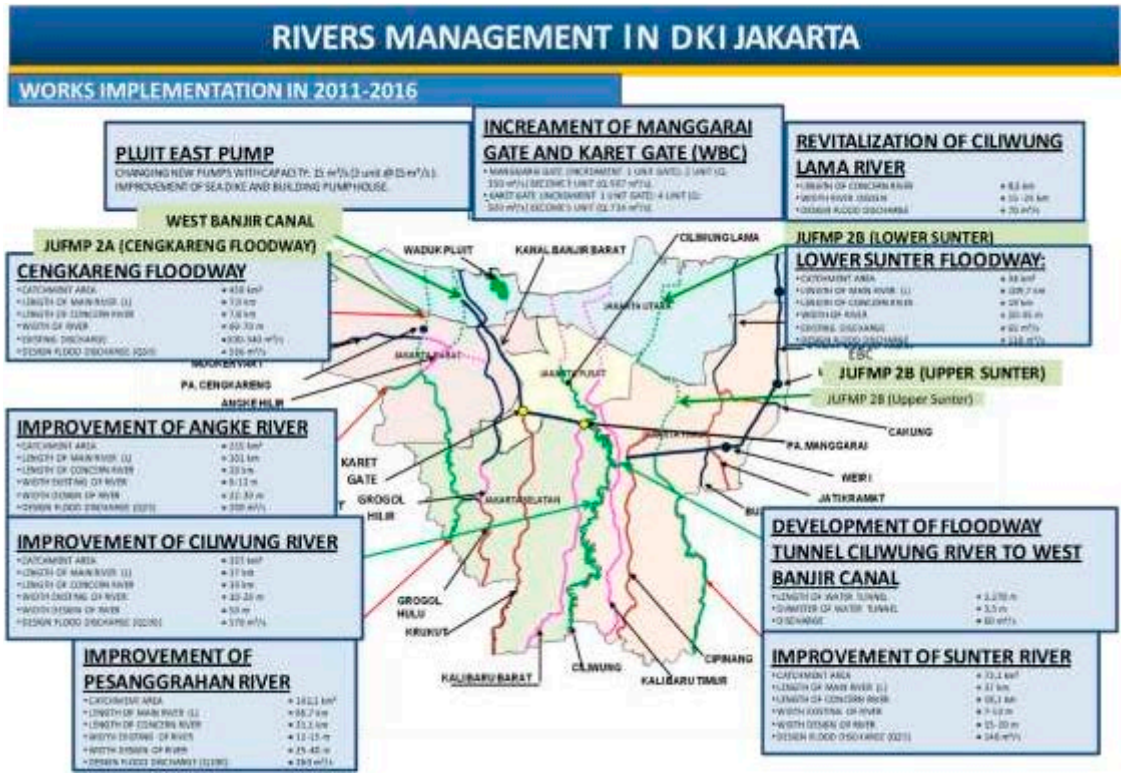
As shown in Figure 4.86 and Table 4.39, the following projects have been or are being implemented in BBWS-CC.

- River channel rehabilitation (Anke River, Pusan Grahan River, Suntar River, and Ciliwung River)
- Dredging and revetment (Chiangkaren Spillway, Lower Suntar Spillway)
- Renewal of Puluit East Pumping Station
- Functional restoration of the old Ciliwung River
- Reinforcement of Manggarai Gate and Caret Gate in the West Discharge Channel
- Construction of a diversion tunnel from the Ciliwung River to the East Spillway
- Construction of Chiawi Dam and Sukamahi Dam

River improvement projects have been implemented for four rivers, including the Chiang Kha Reng Spillway, and are largely complete except for the sections that cannot be constructed due to land acquisition issues.

Regarding the construction of a diversion tunnel from the Ciliwung River to the East Discharge Channel, the construction work near the tunnel exit has been halted due to land acquisition.

Construction of the Chiawih Sukamahi Dam began in December 2016, and as of February 2022, progress was approximately 80%, with the goal of completion by the end of FY2022.



Source：MACRO CONCEPT OF JAKARTA FLOOD MITIGATIONS

Figure 4.81 Status of river impruvoment within Jakarta SAR

Table 4.39 River improvement implementation status

Countermeasure	Contents	Implementation Status
Cengkareng Floodway	L=7.8km, B=60-70, Q50=566m3/s	Completion
Improvement of Angke River	L=20km, B=22-30m, Q=200m3/s	Completion
Improvement of Pesanggrahan River	L=21.1km, B=25-40m, Q=260m3/s	Completion
Lower Suner Floodway	L=19km, B=20-45m, Q=110m3/s	Completion
Improvement of Sunter River	L=18.1km, B=15-20m, Q25=146m3/s	Completion
Pluit East Pump	Renewal of Pump Q=15m3/s(3 unit @ 5m3/s) Improvement of Sea Dike and Building	Completion
Rivaitalization of Old Ciliwung River	L=8.5km, B=15-25km, Q=70m3/s	Completion
Increase of Mannggarai Gate and Karet Gate(WBC)	Manggarai Gate: Additional 1 gate, Total 3 Gate(Q=507m3/s) Karet Gate: Additonal 1 Gate, Total 4 Gate(Q=734m3/s)	Completion Operated in 2014
Development of Floodway Tunnel Ciliwung River to East Banjir Canal	L=1.27km , D=3.5m×2, Q=60m3/s	Completion of 0.6km , Construction is stopping due not to be able to get a land at Inlet side
Improvement of Ciliwung River	L=19km, B=10-20m, Q=570m3/s	Completion excluding land acquisition section
Ciawi Dam	Dam Height = 55m, Leght of Dam = 341m	Under Construction
Sukamahi Dam	Dam Height = 50m, Leght of Dam = 198m	Under Construction

Source：Prepared by the Consultants based on "MACRO CONCEPT OF JAKARTA FLOOD MITIGATIONS".

b. Dredging of Rivers and Regulating Ponds

Under the Jakarta Emergency Dredging Initiative (JEDI) (World Bank) project, 10 rivers and 5 regulating reservoirs are being dredged.



Source：PENGENDALIAN BANJIR JAKARTA DENGAN SISTEM “DRY DAM” PADA BENDUNGAN CIAWI DAN BENDUNGAN SUKAMAHI

Figure 4.82 Location map of dredging plan for rivers and regulating reservoirs

Table 4.40 List of dredging plans for rivers and regulating reservoirs

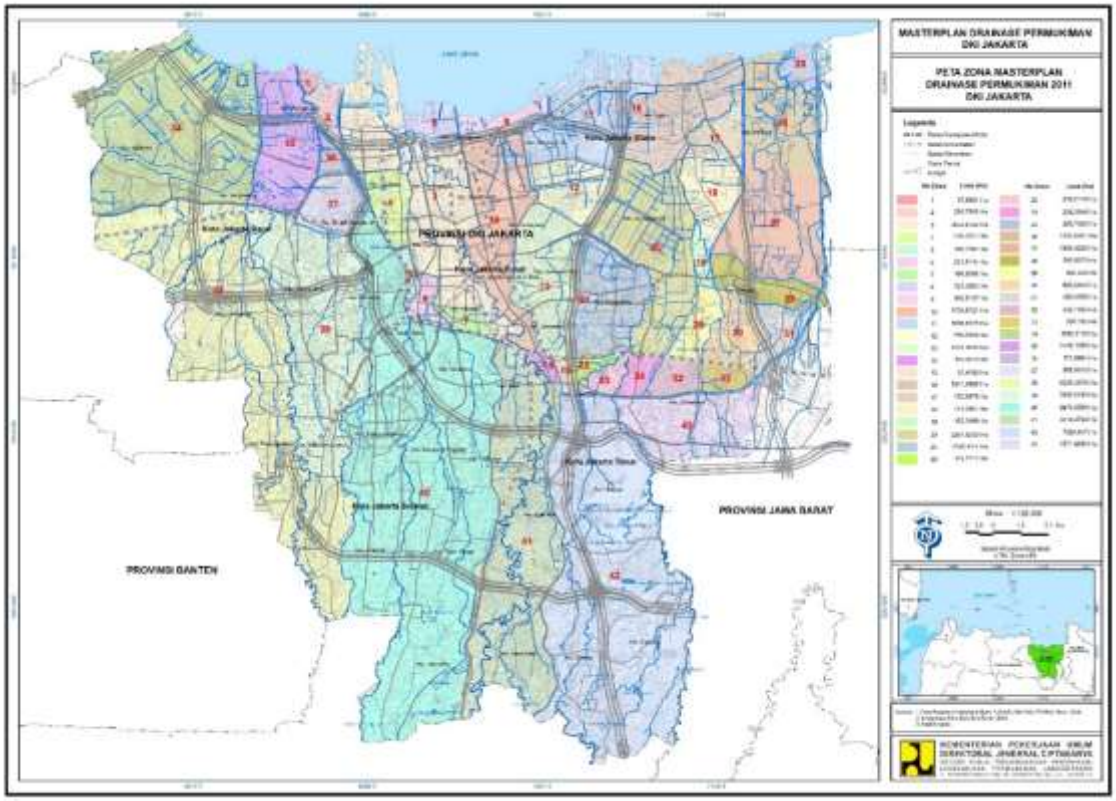
Agency	Target Floodway , Drain and Waduk	Length of Dredging/ Area of Dredging	Dredging (m3)	Embankment Repair(m)
DGWR (4 Location)	Cengkareng Floodway	8,380 m	1,202,990	4,600m(Sheet pile)
	Lower Sunter Floodway	9,980 m	379,280	1,800m(Conctere Wall)
	Upper Sunter Floodway	5,150 m	77,900	1,850m(Concrete Block Wall)
	West Banjir Canal	3,650 m	341,320	970m(Sheet pile), 220m(Palapet Wall)
DGCK (3 Location)	Lowe Angke Drain	4,050 m	241,800	248m(Sheet pile), 573m(Retaining Wall)
	Cideng Thamrin Drain	3,330 m	31,420	2,570m(Sheet pile)
	Tnajungan Drain	600 m	11,210	1,092(Sheet pile)
PU DKI (9 Location)	Ciliwung Gunung Sahari Drain	5,100 m	153,830	4,832m(Sheet pile)
	Sentiong Sunter Drain	5,950 m	133,140	3,865m(Sheet pile)
	Waduk Melati	4.9 ha	98,240	1,245m(Sheet pile), 530m(Colloctoro Drain) 130m(Embankment Repair),
	Grogol Sekretaris Diversion	2,970 m	39,480	1,781m(Heightening bank protection) 612m(Sheet pile)
	Waduk Sunter Selatan	19.2 ha	46,990	1,347m(Retainning Wall), 1,471m(Collector Drain) 232m(Sheet pile)
	Waduk Sunter Utara	33. ha	403,060	2,500m(Bankprotection, Collector Drain , Insoection Road)
	Waduk Sunter Timur III	8. ha	49,720	305m(Sheet pile)
	Pakin-Kali Besar-Jelakeng Drain	3,650 m	95,000	2,880m(Sheet pile)
	Krukut Cideng Drain	3,250 m	27,260	1,658m(Sheet pile)
	(Krukut Lama Drain)	3,490 m	14,150	2,400m(Sheet pile)
Total		59,550m/65.1ha	3,346,790	

Source：Prepared by the Consultant based on 「Project Preparation Consultant (PPC) Jakarta Urgent Flood Mitigation Project (JUFMP) – Jakarta Emergency Dredging Initiative (JEDI) Final Report」

(2) Drainage System

There are more than 60 drainage pumping stations (mainly managed by PU-PR and DKI) in Jakarta SAR, with 36 drainage pumping stations alone with a discharge of 4.0 m³/sec or higher. 2011, a drainage master plan was developed and 43 drainage districts were established as shown in Figure 4.83. In the master plan, drainage channel alignment in each drainage district is planned by FY2015, and drainage systems connected to the main drainage channels are planned (construction and repair) by FY2020.

The drainage pumping stations are constructed by the government, and after construction, operation and maintenance is transferred to the DKI. However, three drainage pump stations, Ancol (drainage capacity: 15 m³/sec, drainage area: 635 ha), Sunter III (drainage capacity: 15 m³/sec, drainage area: 570 ha), and RawaBadak (drainage area: unknown) are currently managed by the river basin agency (BBWS-CC). The new PluitEastPump (P1) (drainage capacity: 15 m³/sec) is currently in the process of being transferred to the Jakarta Special Province.



Source：Masterplan Drainase Permukiman DKI Jakarta

Figure 4.83 Drainage Districts in the Drainage Master Plan 2011

(3) NCICD (National Capital Integrated Coastal Development)

The NCICD (National Capital Integrated Coastal Development) is a redevelopment plan for the Gulf of Jakar with four strategies as shown below. For "Reducing the Threat of Flooding," the plan includes subsidence control measures, flood control measures from the sea and rivers, and ground flood control through a polder system. (See Figure 4.86)

1. Flood Threat Reduction
2. Development of the productive capacity of coastal areas
3. Improvement of the environment
4. Revitalization of the social and cultural aspects of coastal areas.



Source：PROTECTION, INTEGRATION, CONSERVATION, DAN REVITALIZATION, January 2019

Figure 4.84 NCICD Strategy

1) Outline of NCICD's Projects

Under the NCICD, the "No Regret Measure" includes three items: (1) land subsidence control, (2) flood protection from rivers and the sea, and (3) sanitation and industrial wastewater management, with a total project cost of approximately Rp. 447 trillion to be implemented from 2018 to 2050. The project contents for each item are shown in Table 4.41. Figure 4.85 shows the project plan, and Figure 4.86 shows the development plan for seawalls, river embankments, and polder systems and offshore embankments.

Table 4.41 NCICD Business Overview

Item	content
①Subsidence control （2018-2025） Rp.62.3 T*	• Surface water supply（Rp. 36.9 T） • Reduction of non-revenue water (NRW), installation of reclaimed water and stormwater storage facilities • Enforcement of groundwater withdrawal regulations • Monitoring and assessment of land subsidence（Rp.25.4 T）
② Flood protection from the sea and rivers （2018-2030） Rp.290.2 T*	• Construction of coastal and river embankments, polder (reclaimed land), drainage channel networks, reservoirs and pumping stations (Rp. 25.7 T) • Construction of offshore levees in combination with highways and land development (Rp. 262.2 T) • Construction of Ciawi & Sukamahi reservoirs (Rp. 1.3 T) • Revision of RTRW (spatial plan) in Tangerang Province (Rp. 1 M) • Normalization of the estuary of Jakarta Bay • Normalization of the upper reaches of the Ciliwung Cisadane River • F/S: Economic, financial, environmental and social considerations for NCICD and landfill sites
③ Sanitation and industrial wastewater management （2020-2050） Rp.94,7 T*	• Jakarta Sewerage System Zone 1&6 Improvement (Rp. 19.8 T) • Development of Jakarta Sewerage System in another zone (Rp. 74.9 T) • Enforcement of Environmental Law

( ): project cost, T: trillion = trillion, * Amount is the total of those with stated project cost.

Source : Prepared by the Consultant based on 「Information Material National Capital Integrated Coastal Development Implementation Projectphase2」

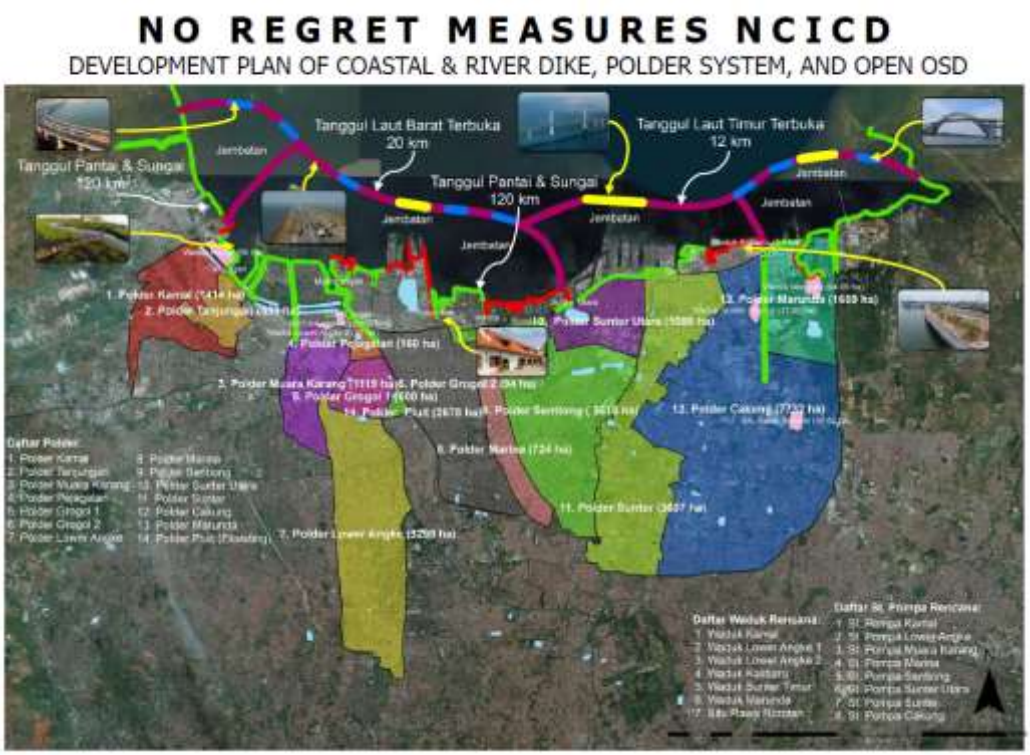
Among the above projects, the following are planned as Conditional Meaure for the offshore embankment.

If the land subsidence cannot be controlled, the project cost of Rp.24.4 trillion is budgeted for 2050, and the gates of the offshore dike will be closed for flood protection, and the construction of pumps and flood gates is planned to be carried out after 2050.



Source：Information Material National Capital Integrated Coastal Development Implementation Projectphase2

Figure 4.85 Business Plan to 2050



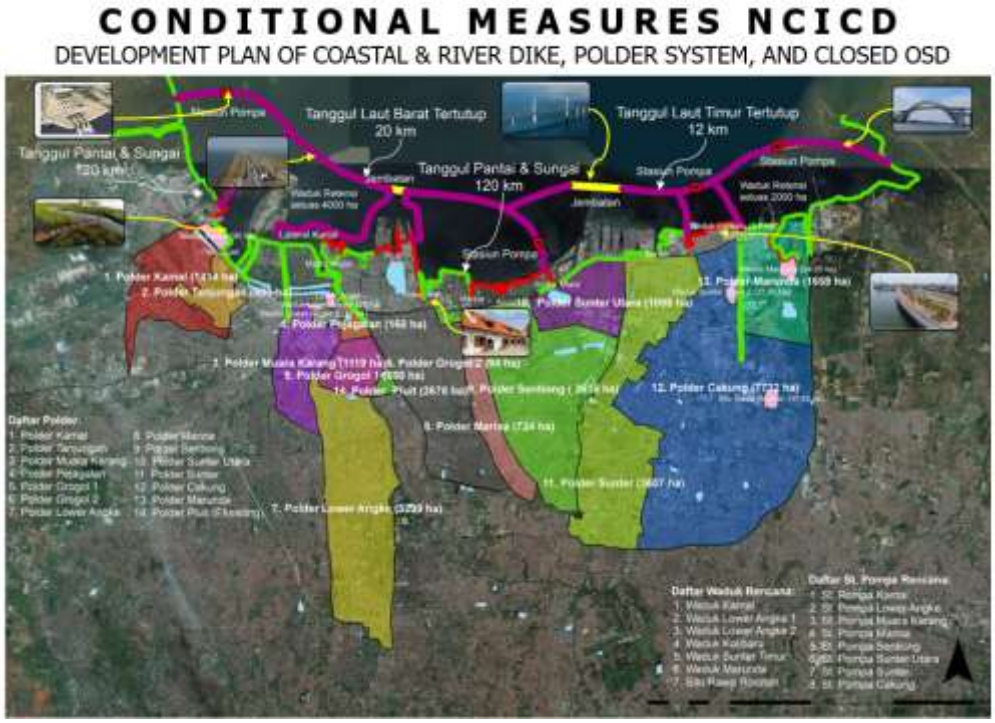
Source：Information Material National Capital Integrated Coastal Development Implementation Projectphase2

Figure 4.86 NCICD's plans for seawall and river levees, polder system and offshore levees



Source：Information Material National Capital Integrated Coastal Development Implementation Projectphase2

Figure 4.87 Diagram of NCICD's Conditional Measure



Source：Information Material National Capital Integrated Coastal Development Implementation Projectphase2

Figure 4.88 NCICD's Offshore Levee Cutoff Plan (Conditional Measure)

2) Seawall maintenance in the NCICD

The construction of seawalls and estuary levees is 120 km long, of which about 20 km, which are particularly vulnerable to flooding, are expected to be completed by 2019 as the emergency maintenance section. Of the 20-km emergency maintenance section, approximately 10 km will be implemented by public works (PUPR and DKI), and the remaining 10 km by private works.

In the PUPR section, pile driving for approximately 4.5 km of 2.3 km of Muallabalu and 2.2 km of Caribalu was completed in August 2018. 3.75 km of the DKI section has been constructed in 2015,2016.



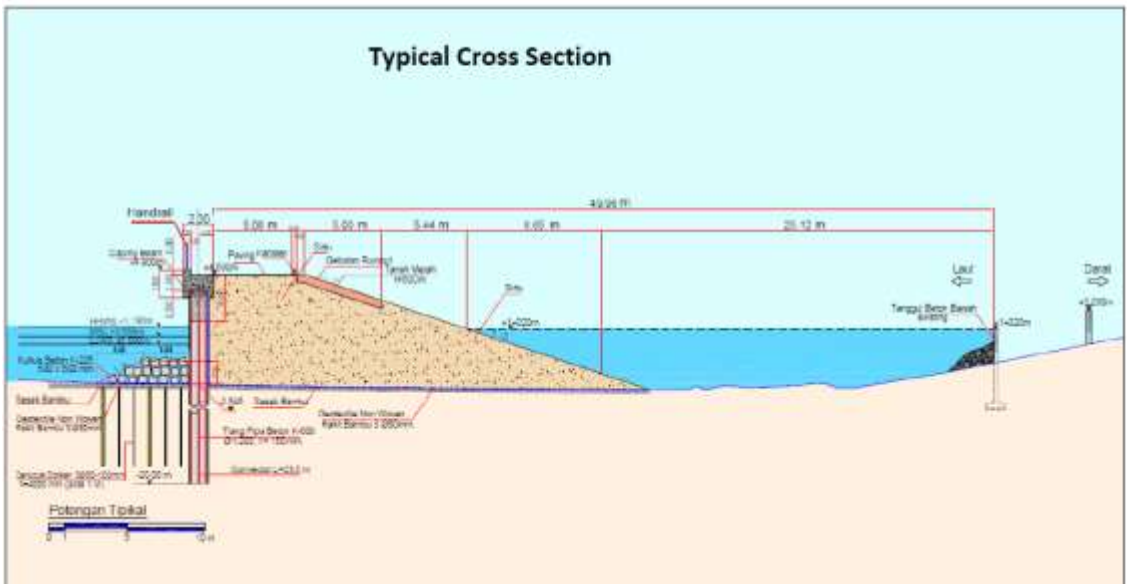
出典：Information Material National Capital Integrated Coastal Development Implementation Projectphase2

Figure 4.89 Status of seawall maintenance (as of October 2018)

Table 4.42 Status of seawall maintenance (as of October 2018)

No	Construction Project Name	Location	Project Time Frame	Output (meter)	Construction Progress (%)	Piling Progress (m)		Notes
						Existing Progress	Remaining Progress	
1	Coastal Protection in Jakarta Construction Project Stage 2 Package 1	Muara Baru, Penjaringan, North Jakarta	Nov 2015 - Aug 2018	2300	100.00%	2300	0	
2	Coastal Protection in Jakarta Construction Project Stage 2 Package 2	Kalibaru, Cilincing, North Jakarta	Nov 2015 - June 2018	2200	100.00%	2200	0	

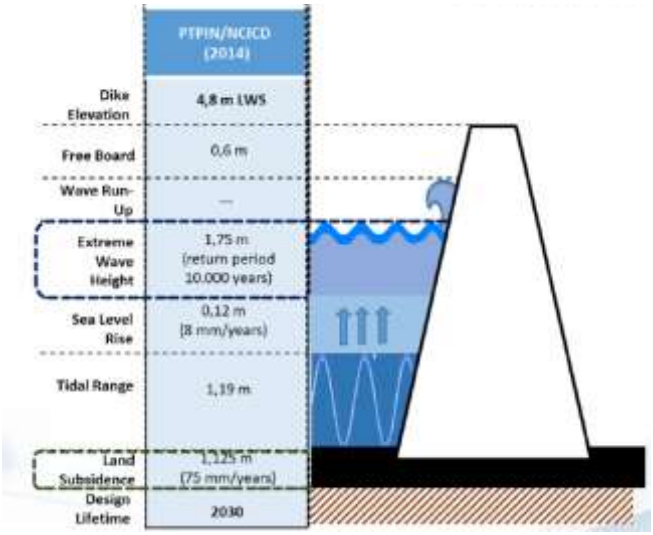
Source：Information Material National Capital Integrated Coastal Development Implementation Projectphase2



Source：Information Material National Capital Integrated Coastal Development Implementation Projectphase2

Figure 4.90 Standard cross section of seawall in Muallabalu-Calibar area

The height of the coastal levee currently under construction is set at 4.8 m according to the 2014 PIPIN/NCICD design, as shown in Figure 4 96. The height of the embankment is set for the target year of 2030, taking into account the amount of land subsidence (75 mm/year, 15 years from 2016 to 2030), difference in tidal range, sea level rise (8 mm/year), extreme wave height, and margin height.



Source：Konseptual Desain Infrastruktur Pengendali Banjir NCICD: Tanggul Sungai & Pantai (Stage A) 2019.7

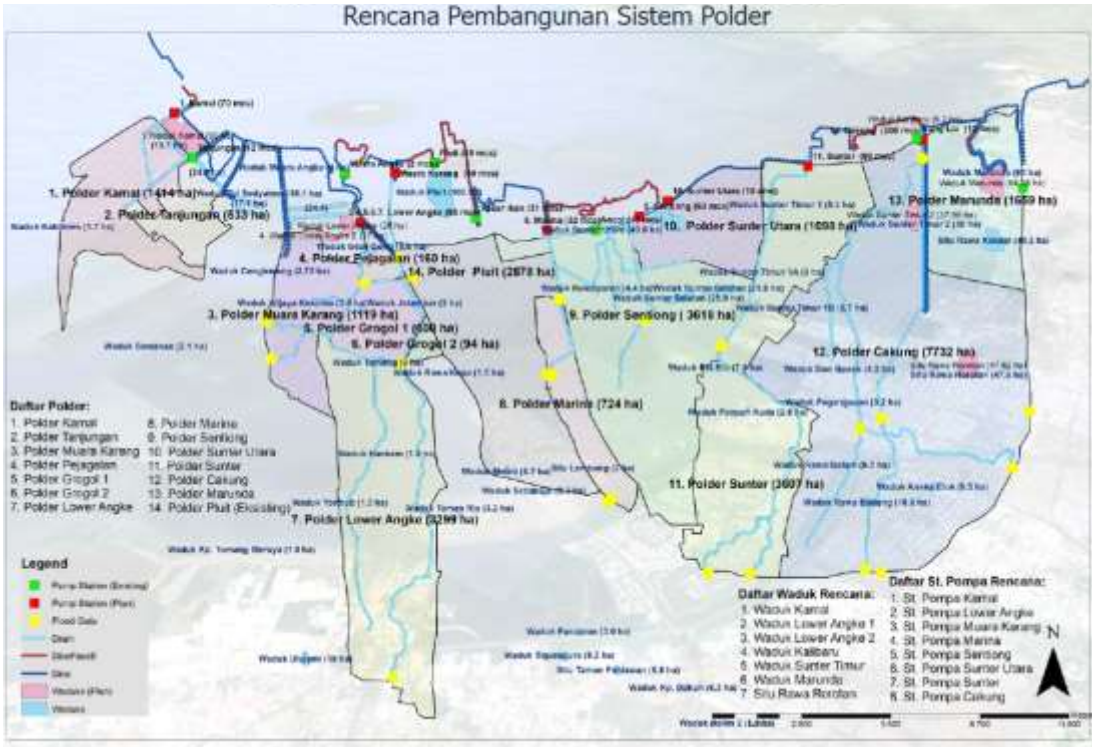
Figure 4.91 Setting the height of the seawall

3) NCICD's new polder system

A new polder system is planned to be integrated with the coastal embankment for constant drainage and flood control.

The new polder system is outlined in Figure 4.92 and Table 4.43. 14 drainage areas, 7 reservoirs, and 8 pumping stations are planned. The total drainage area is planned to be about 28,300 ha with a total discharge rate of about 740 m3/s. Of the eight planned pumping stations, the Sentiong Pump Station is currently in the construction phase and is expected to be expanded to a total drainage capacity of 50 m3/s (existing existing drainage capacity of 15 m3/s).

The Kamal Pump Staion (total water discharge capacity of 30 m3/s) has been budgeted within DKI Jakarta and is expected to be constructed by 2023.



Source：National Capital Integrated Coastal Development PROTEKSI, KONSERVASI, INTEGRASI, REVITALISASI 04 Mei 2018

Figure 4.92 New Polder System Plan

Table 4.43 New polder system drainage area and volume

Polder			Pump Station					
No.	Drainage Zone Name	Drainage Zone Area(ha)	No.	Pump Station Name	Status	Pump Capacity (m^3/s)	Total Pump Capacity (m^3/s)	Specific Pump Capacity ($m^3/s/ha$)
1	Kamal	1,414	1	Kamal	Plan	70	70	0.05
2	Tanjungan	533		Tanjungan	Existing	12	12	0.02
3	Muara Karang	1,119	2	Lower Angke	Plan	95	95	0.08
4	Pejagalan	160						
5	Grogol 1	600						
6	Grogol 2	94						
7	Lower Angke	3,299						
8	Marina	724	4	Marina	Plan	32	32	0.04
9	Sentiong	3,618	5	Sentiong	Plan	63	76	0.02
				Ancol	Existing	13		
10	Sunter Utara	1,098	6	Sunter Utara	Plan	10	10	0.01
11	Sunter	3,607	7	Sunter	Plan	90	90	0.02
12	Cakung	7,732	8	Cakung	Plan	200	212	0.03
				Bang Lio	Existing	12		
13	Marunda	1,659		No name	Existing	-		
14	Pluit(Eksisting)	2,678		Pluit	Existing	49	140	0.05
				Pasar Ikan	Existing	31		
			3	Muara Karang	Plan	60		
	Total	28,335			Total	737	737	0.03
	Existing	9,023			Existing	117		0.01
	Plan	19,312			Plan	620		0.03

Source : Prepared by the Consultant based on 「National Capital Integrated Coastal Development PROTEKSI, KONSERVASI, INTEGRASI, REVITALISASI 04 Mei 2018」

4.7.2 Adaptation Plan

As land subsidence progresses, flooding damage due to storm surge and flooding will increase, and social costs (direct and indirect damage) will increase.

In order to stop land subsidence, it is necessary to mitigate land subsidence (groundwater withdrawal restrictions, securing alternative water sources), but it takes time until land subsidence is stopped by land subsidence mitigation measures. Therefore, land subsidence adaptation measures are necessary until subsidence stops.

A subsidence adaptation plan will be developed based on the current risk of subsidence, the expected damage, and the adaptability of existing projects as subsidence mitigation measures.

(1) Adaptation plan study policy

1) Goals of land subsidence adaptation measures

・To prevent the progression of land subsidence, which would worsen flood damage caused by storm surges and floods.

2) Conditions for subsidence adaptation measures

The assumed subsidence scenario is the most progressive subsidence scenario, Scenario C (i.e., the case where groundwater pumping continues at present and subsidence is most progressive until 2050). The estimated amount of subsidence is 1,405 mm (43 mm/yr) at the Marunda site by 2050. Note that sea level rise due to climate change is not included because only the impact of land subsidence is evaluated.

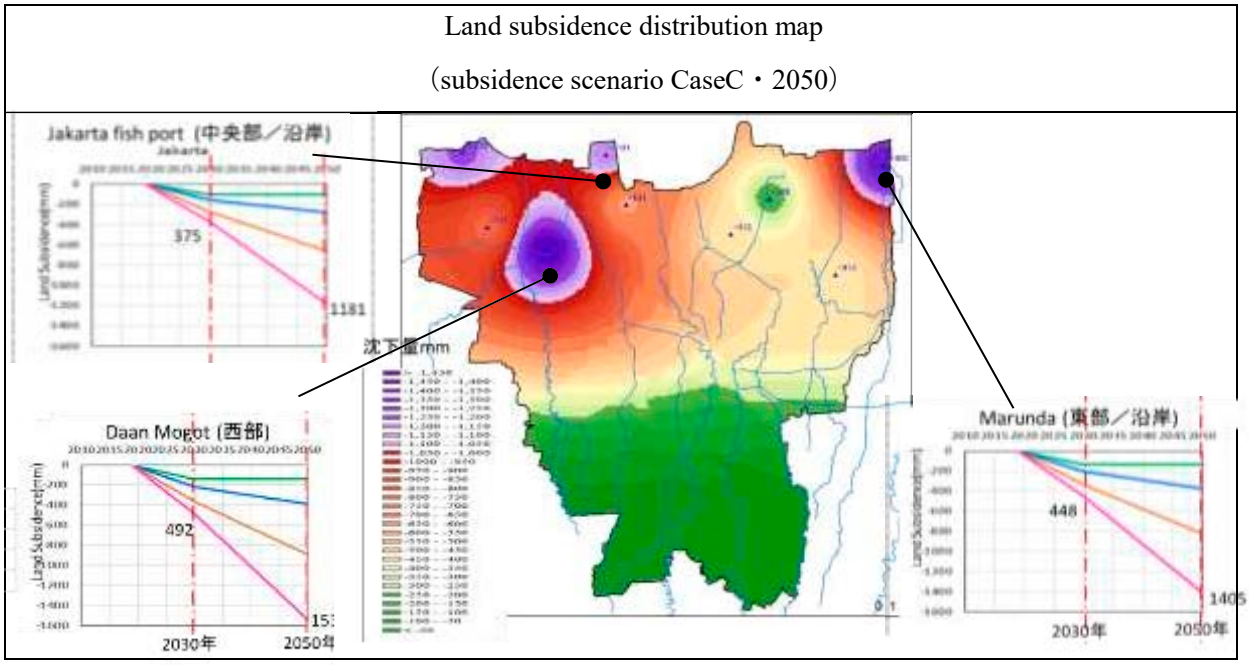
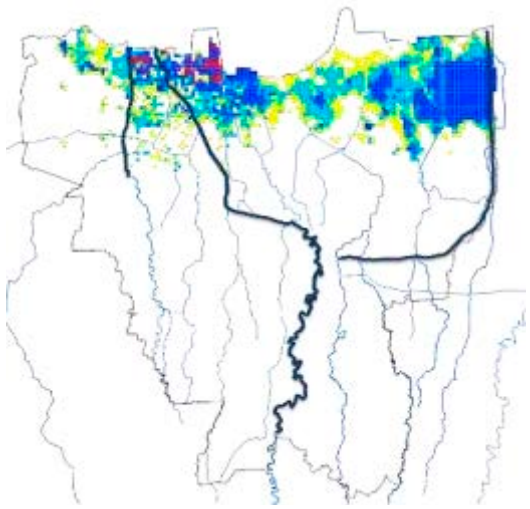
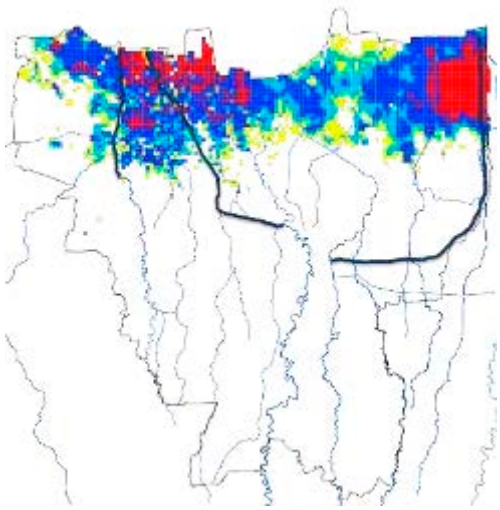
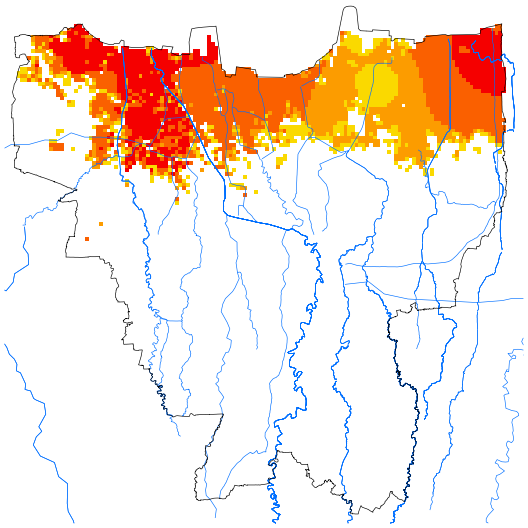


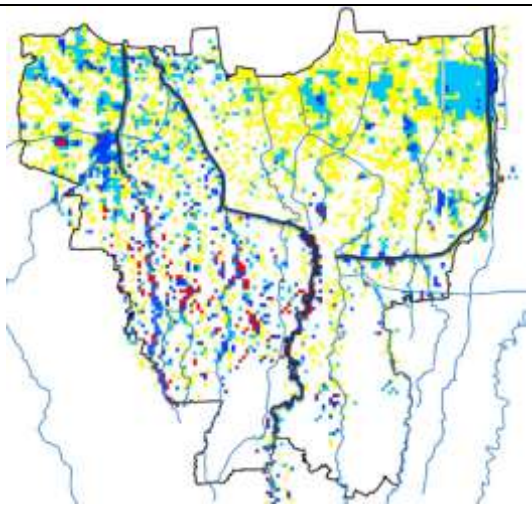
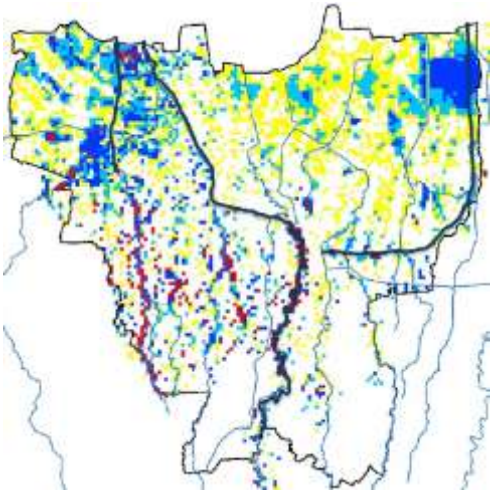
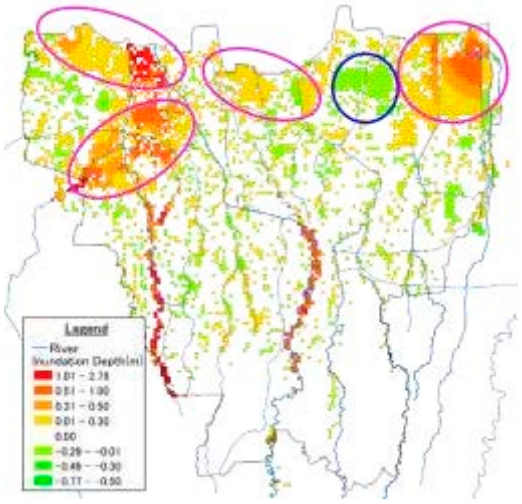
Figure 4.93 Land subsidence distribution map (subsidence scenario Case C, 2050)

The changes in inundation during storm surge and flooding in 2018 (before subsidence) and 2050 (after subsidence), respectively, are shown in Figure 4.94 and Figure 4.95. As shown in Table 4.44, the extent of inundation would increase by 56.4 km2 during storm surge (approximately 1.5 times greater than in 2018) and by 13.7 km2 during flooding (1.1 times greater than in 2018).

Maximum Inundation Depth Chart CaseSQ-2018	Maximum Inundation Depth Chart CaseC-2050
	
Inundation area：120.35 km^2（1.00）	176.79 km^2（1.47）
Inundation volume：101.3 x 10^6 m^3（1.00）	224.1 x10^6 m^3（2.21）
Average inundation depth：0.84 m（1.00）	1.27 m（1.51）
Maximum submergence depth difference diagram （CaseC-2050－CaseSQ-2018）	
	

( ): Value when CaseSQ-2018 is set to 1

Figure 4.94 Comparison of the damage due to storm surge before and after land subsidence progresses

CaseSQ-2018	CaseC-2050
	
Inundation area：251.86 km^2 (1.00)	265.57km^2（1.05）
Inundation volume：167.1 x 10^6 m^3 (1.00)	202.9 x10^6 m^3（1.21）
Average inundation depth：0.66 m (1.00)	0.76 m（1.15）
Maximum submergence depth difference diagram （CaseC-2050－CaseSQ-2018）	
	

( ): Value when CaseSQ-2018 is set to 1

Figure 4.95 Comparison of the damage due to flood before and after land subsidence progresses

Table 4.44 Inundation areas（e.g., inundation area due to storm surge and flooding）

		Inundation area (km^2)	Inundation volume(10^6 m^3)	Average inundation depth (m)
High tide	(1)CaseSQ-2018	120.35	101.3	0.84
	(2)CaseC-2050	176.79	224.1	1.27
	(2)-(1)	56.44	122.8	0.43
	(2)/(1)	1.47	2.21	1.51
Flood	(1)CaseSQ-2018	251.86	167.1	0.66
	(2)CaseC-2050	265.57	202.9	0.76
	(2)-(1)	13.71	35.8	0.10
	(2)/(1)	1.05	1.21	1.15

(2) Menu of proposed subsidence countermeasures

The following is a menu of possible measures to eliminate flooding damage during storm surges and floods caused by progressive land subsidence.

Table 4.45 Menu of possible countermeasures

Countermeasure menu	High tide	Flood
Tidal embankment	✓	-
Pump enhancement	-	✓
Raising the ground	✓	✓

*Including road bulking around the area

As a combination of these alternatives, two alternatives were compared as shown in Table 4.46: seawall improvement + pump enhancement and ground raising. From the perspectives of cost, feasibility, flexibility, and impact on the local community, the seawall + pump enhancement alternative is the appropriate solution.

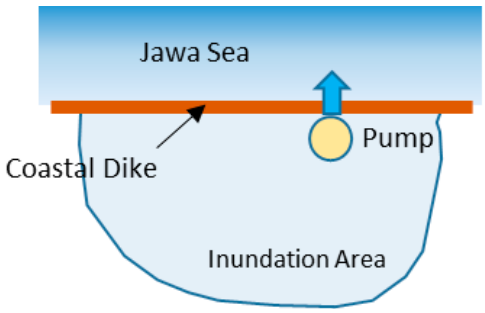
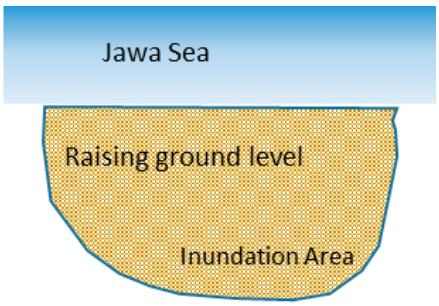
Seawall + pump augmentation	Raise the ground + road level
	

Figure 4.96 Diagram of proposed countermeasures

Table 4.46 Alternatives comparison sheet

Evaluation axis	① Seawall and estuary levee + pump enhancement		② Ground raising	
Safety	Safety level of the implemented section is improved, and the effect will be realized step by step with the progress of the countermeasures.	○	Safety level of the implemented section is improved, and the effect will be realized step by step with the progress of the countermeasures.	○
Cost	・ Cost of measures: approximately 45.5 trillion Rp.	○	・ Cost of measures: approx. 222.8 trillion Rp. or more※	
Feasibility	・ No obstacles to feasibility from a technical point of view ・ Small land acquisition ・ Need to coordinate with beach users	○	・ No obstacles to feasibility from a technical point of view ・ Small land acquisition ・ Many stakeholders and time-consuming to coordinate	
Sustainability	・ Requires regular monitoring and observation, but can be sustainable if properly maintained	○	・ Requires regular monitoring and observation, but can be sustainable if properly maintained	○
Flexibility	・ Measures such as seawalls, estuarine embankments, and drainage pump stations are technically feasible and allow for a certain degree of flexibility.	○	・ Raising the ground is technically feasible, but flexible measures are difficult to take	×
Community impact	・ During the construction, the traffic of sediment transport vehicles, etc. is expected to have an impact on the surrounding area, but the extent of the impact is considered to be limited.	○	・ During construction, sediment transport vehicles and other traffic may have a widespread impact on the surrounding area.	×
Environmental impact	・ Seawall improvement will change the landscape ・ Potential impact on habitat and habitat for plants and animals due to seawall and estuary embankment development.	△	・ Overall ground will be raised, resulting in a change in the landscape. ・ Potential impact on the habitat for plants and animals due to maintenance.	△
Overall evaluation	○		×	

※set to be equal to or greater than the amount of damage that would be increased due to subsidence.

(3) Facility size and basic specifications

For the seawall and pump enhancement, the size and basic specifications of the facilities were set under the following conditions. In the subsidence scenario C, the height of the embankment will not be sufficient for the given height after 2050 because the land will continue to sink further after 2050. As a countermeasure, the NCICD plans to close the offshore levee and install drainage pumps to lower the water level in the bay to meet the shortfall in levee height. This will also be included in the facility as a necessary long-term adaptation measure. Figure 4.97 shows a menu of adaptation measures.

Adaption Measures Menue	
Coastal & River Dikes	H=5.0m LWS, L=120km
Drainage Pump	Additional Pump Capacity Qp=414m^3/s
Closure of Offshore Dikes	Flood Gate & Pump



Figure 4.97 Menu of Adaptation Measures Measures (CaseC)

Seawalls

・The progression of land subsidence causes serious damage from storm surges in coastal areas, so it is necessary to construct seawalls to reduce flooding damage.

・The NCICD sets the height of levees based on the assumption of land subsidence, and the required levee height is estimated based on this concept.

・The required levee height is approximately 5 m + LWS, taking into account a land subsidence of 1.4 m (43 mm/year) by 2050.

・The required embankment height was set as shown in Table 4.47, using the levee height set by the NCICD as a reference.

Table 4.47 Required height of embankment

	NCICD(2014)		This Study	
Dike Elevation	4.8 m LWS		5.0 m LWS	
Dike Height	4.785 m		4.94 m	
Free Boad	0.6 m		0.6 m	
Wave Run-up	0 m		0 m	
Extreme Wave Hight	1.75 m	return period 1/10,000	1.75 m	
Sea Level Rise	0.12 m	8 mm/year	- m	without
Tidal Range	1.19 m		1.19 m	
Land Subsidence	1.125 m	75mm/year	1.4 m	CaseC
Design Lifetime	2030 year		2050 year	

Pump enhancement

・The pumps are required to mitigate flood damage because land subsidence causes serious flooding damage mainly in low-lying areas.

・The required pump size was calculated based on the results of the flood analysis.

・The required drainage volume is about 420 m3/s, which is set as a scale that can drain 35.8 x 106 m3 of incremental flooding volume due to subsidence for 24 hours.

Table 4.48 Required pump capacity

Case	Simulation Result			Difference for CaseSQ	Drainage Duration (hr)	Pump Capacity (m3/s)
	Flood area (km^2)	Flood volume ($x10^6m^3$)	Average flood depth (m)	Flood volume (x106m3)		
CaseSQ - 2018	251.86	167.10	0.66			
CaseC - 2030	257.22	187.35	0.73	20.25	24	234
CaseC - 2050	265.57	202.90	0.76	35.80	24	414

(4) Calculation of estimated costs

The estimated project cost for the facilities proposed in the subsidence adaptation plan is calculated.

The estimated cost of the proposed seawall + pump enhancement is approximately Rp. 45.5 trillion.

Seawall

・This cost is calculated as the cost required due to subsidence, referring to the NCICD data. As a result, the construction cost would be approximately 5 trillion Rp. (See Table 4.50).

Pump enhancement

・This cost is calculated as the cost required due to subsidence with reference to the NCICD data. The resulting construction cost would be approximately 16 trillion Rp. (see Table 4.52)

Offshore Dike Closing Sluice and Drainage Pump

・The cost of the offshore embankment sluice gate and drainage pump is about 24 trillion Rp, which is planned as a Conditional Measure in NCICD.

Table 4.49 cost of countermeasures

Adaption Measures Menue		Estimated Construction Cost
Coastal & River Dikes	H=5.0m LWS, L=120km	5.1 Trilion Rp.
Drainage Pump	Additional Pump Capacity Qp=414m^3/s	16.0 Trilion Rp.
Closure of Offshore Dikes	Flood Gate & Pump	24.4 Trilion Rp.
Total		45.5 Trilion Rp.

Table 4.50 NCICD Stage E/A cost

No	Item	Dimension	Construction Cost [Million USD]	Construction Cost [Billion Rp.]*
1	Coastal dikes	70.3km	219.38	3,153
2	River dikes	45.3km	122.39	1,759
3	Pumpimg station	283 m3/s	760.27	10,927
4	Retention	135 ha	799.36	11,488
	Total		1,901.40	27,327
1+2	Coastal & River dikes	115.6km	341.77	4,912

Source: National Capital Integrated Coastal Development Road Map EA+ (Apr 2018)
1 USD = 14,372 RP. (2022.02)

Table 4.51 Cost of seawalls

	Height(m)	Construction Cost	
NCICD			
Coastal & River Dikes	4.8	4,912	Bil. Rp
Construction Cost for Height(m)		1,023	Bil. Rp/m
This Project			
Coastal & River Dikes in 2050	5.0	5,117	Bil. Rp

Table 4.52 Pump Expenses

	Pump Capacity	Consrtuction Cost
	m3/s	Bil. Rp
NCICD StageE/A		
Pumpimg station	283	10,927
This Peoject		
Increase of Pump Capacity as of 2050	414	15,984

注) Consrtuction Cost for Pump Capacity：38.6 Bil. Rp./m3/s
(=10,927Bil. Rp./283m3/s)

4.8 Social costs caused by land subsidence

"Social Cost Incurred by Land Subsidence" is defined here as "a cost borne by the whole society (the people and the companies) in the area due to the land subsidence since the countermeasures are not employed" and the cost is captured from the viewpoint of the damages (to be) incurred due to land subsidence. A rough cost estimation is made based on the review of an existing related report as well as the inundation depth data produced by the simulation with new scenarios in the following sub-sections.

As it can be roughly estimated that the assets (stock) are expanded in accordance with the expansion of production (flow) in the long run, a major factor of the increase in the damage at present or in the future is the increase in the expansion of economy at present or in the future. Thus, the expansion of economy in the target area is confirmed at first. Economic growth on real base consists of increase in per capita production and that in population so the population growth can be confirmed at the same time.

4.8.1 Economic Growth

BPS Indonesia publicized real Gross Regional Domestic Product (GRDP) and inflation rate up to 2017. As is mentioned in the previous sub-section, real economic growth consists of increase in productivity and that in population. Inflation rates are used for the adjustment of the prices to the base year, 2017.

PwC Japan, a very prestigious audit corporation group, publicized "World in 2050" in 2015, where GDP forecasts were made for major countries in the world. It reported that economy in Indonesia would really grow at 4.3% yearly on average in 2015 - 2050.

Table 4.53 GRDP Real Growth Rate in DKI Jakarta

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
6.23%	5.02%	6.51%	6.73%	6.53%	6.07%	5.91%	5.91%	5.88%	6.22%

Source: DKI Jakarta in Figures

Table 4.54 Inflation Rate in DKI Jakarta

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
11.11%	2.34%	6.21%	3.97%	4.52%	8.00%	8.95%	3.30%	2.37%	3.72%

Source: DKI Jakarta in Figures, Consumer Price Index and Inflation in DKI Jakarta, 2017

4.8.2 Rough Estimation Based on the Result of Exiting Simulation

A JICA Study Report, "The Simulation Study on Climate Change in Jakarta, Indonesia, 2012" shows the result of flood damage simulation for the same target area. The simulation includes the following damages:

Table 4.55 Flood Damages Included in the Simulation

Category	Flood Damage	Target
Direct damage	Building	Household, company
	Asset and Inventory	Household, company
	Infrastructure	Road, bridge, others
Indirect damage	Loss by business suspension	Commercial sector, manufacturing sector
	Income decrease by reduction of consumption	PDAM, PLN

Source: JICA, The Simulation Study on Climate Change in Jakarta, Indonesia, 2012

New scenarios have been introduced to the above-mentioned simulation and the flood damages have been calculated. Conditions of the new scenarios are shown below:

Table 4.56 Conditions of the New Scenarios for Flood Simulations

CASE NO.	Point of Evaluation	Land Subsidence	Climate Change Scenario
1	2018	LS (SQ)	WO
6	2030	LS (C)	WO
11	2030	LS (C)	W: RCP 8.5
16	2050	LS (C)	WO
21	2050	LS (C)	W: RCP 8.5

(Legend)

Land Subsidence	Climate Change Scenario
LS (SQ): Status Quo, LS will stop (Current Status as of 2018)	W: RCP 2.6 With Climate Change (Stabilized at a low level)
LS (A): LS will progress to stop (Case A projection)	W: RCP 8.5 With Climate Change (Progress at a high level)
LS (A1): LS will progress to stop (Case A1 projection)	WO: Without Climate Change
LS (B): LS will progress moderately (Case B projection)	
LS (C): LS will be most advanced (Case C projection)	

(Note) Refer to Chapter 5 for the details of the simulation.
Source: JICA Study Team

In addition, the population by Kelurahan in 2018 is taken into consideration here. The results of the simulation with new scenarios are shown below. *The longer the countermeasures are delayed, the greater the amount of damages not only with the land subsidence but also with the economic growth during that period. In addition, the climate change will lead to further increase in the amount of damages.*

Table 4.57 Rough Estimation of Damages Caused by Flood

CASE NO.	Estimated Damages (Billion Rupiah)*	Estimated Damages (Billion USD)**	Ratio to Case 1	Explanation of Conditions
1	111,639.7	7.77	1.00	Present Situation
6	141,738.2	9.86	1.27	2030, Land Subsidence
11	167,067.2	11.62	1.50	2030, Land Subsidence + Climate Change
16	186,236.8	13.51	1.67	2050, Land Subsidence
21	242,298.2	16.86	2.17	2050, Land Subsidence + Climate Change

(*) 2017 prices
(**) IDR 1.00 = USD 0.00006958, (February 2022)
Source: JICA Study Team

Simulation on storm surge has been also conducted with new scenarios. Conditions of the new scenarios are shown below:

Table 4.58 Conditions of the New Scenarios for Storm Surge Simulations

CASE NO.	Point of Evaluation	Land Subsidence	Climate Change Scenario
1	2018	LS (SQ)	WO
6	2030	LS (C)	WO
16	2030	LS (C)	W: RCP 8.5
21	2050	LS (C)	WO
31	2050	LS (C)	W: RCP 8.5

(Legend)

Land Subsidence

LS (SQ): Status Quo, LS will stop (Current Status as of 2018)

LS (A): LS will progress to stop (Case A projection)

LS (A1): LS will progress to stop (Case A1 projection)

LS (B): LS will progress moderately (Case B projection)

LS (C): LS will be most advanced (Case C projection)

Climate Change Scenario

W: RCP 2.6 With Climate Change (Stabilized at a low level)

W: RCP 8.5 With Climate Change (Progress at a high level)

WO: Without Climate Change

(Note) Refer to Chapter 5 for the details of the simulation.
Source: JICA Study Team

In addition, the population by Kelurahan in 2018 is taken into consideration here. The results of the simulation with new scenarios are shown below. *The longer the countermeasures are delayed, the greater the amount of damages not only with the land subsidence but also with the economic growth during that period. In addition, the climate change will lead to further increase in the amount of damages*.

Table 4.59 Rough Estimation of Damages Caused by Storm Surge

CASE NO.	Estimated Damages (Billion Rupiah)*	Estimated Damages (Billion USD)**	Ratio to Case 1	Explanation of Conditions
1	58,255.0	4.05	1.00	Present Situation
6	91,770.7	6.39	1.58	2030, Land Subsidence
16	106,213.0	7.39	1.82	2030, Land Subsidence + Climate Change
21	206,448.6	14.36	3.54	2050, Land Subsidence
31	255,794.8	17.80	4.39	2050, Land Subsidence + Climate Change

(*) 2017 prices
(**) IDR 1.00 = USD 0.00006958, (February 2022)
Source: JICA Study Team

Comparing the estimated amount of damage from storm surge and flooding under the assumed scenarios of the draft adaptation plan as of 2018 (Case No. 1) and 2050 Scenario C (without consideration of climate change) (Case No. 21), Table 4 60 shows that the social cost of progressive land subsidence is about Rp. 223 trillion (19% of Jakarta SAR's (19% of GRDP).

To cope with this subsidence, measures such as coastal and estuary embankment improvement (120 km), pump enhancement in inland water area (approx. 420 m3/s enhancement), and offshore embankment closure (sluice gate + pump station) will be required, which will cost about 45.5 trillion rupiah (4% of GRDP for Jakarta SAR) as described in the previous section.) will be required.

In particular, among the adaptation measures, the cost of closing offshore levees due to the long-term progression of land subsidence is 24.4 trillion rupiah, which accounts for more than 50% of the total cost. Therefore, it is necessary to make efforts to ensure that the amount of subsidence does not exceed the estimated subsidence in the coastal and estuary levee maintenance area in progress

Table 4.60 Social cost (amount of inundation damage due to storm surge and flooding*) Unit: 1 trillion rupiah

	(a)High Tide	(b)Flood	(a)+(b)**
(1) CaseSQ-2018	58.255	111.640	169.895
(2) CaseC-2050	206.449	186.237	392.685
(2)-(1)	**148.194**	**74.597**	**222.791**

Note) *price in 2017

** It was assumed that High Tide and Flood do not occur simultaneously.

CHAPTER 5 PUBLIC AWARENESS

5.1 Consciousness Survey

5.1.1 Outline of the Survey

To proceed countermeasures against land subsidence which spread in North Jakarta and other areas, consciousness survey toward local firms and residents was subcontracted to Research Unit of Urban and Regional Studies, Center for Strategic and Global Studies, University of Indonesia. This consultant has high reputation and trust in Society and has lots of experience of social survey. The work period is from March to May, 2019. In this section, outline and results of the survey is explained.

(1) Purpose

To put effective enlightenment activities and awareness reform related to land subsidence into practice, the awareness on the land subsidence and its effects of targeted people need to be grasped as a baseline, such as residents, industrial person, commercial persons, and governmental officials.

As shown in Table 5-1, news reports on land subsidence and groundwater abstraction are increasing in Jakarta in recent years. On August 13, 2018, news reports on land subsidence have also been made on the BBC under the title "Jakarta, the fastest sinking city in the world".

Thus, coverage of ground subsidence seems to be increasing. Attitude surveys will examine how residents, factories, and commerce are actually aware of ground subsidence and groundwater use. The survey results will be used as basic data for the development of educational materials, such as selection of pilot areas and contents of the Project web site.

Table 5-1 News Reports on Land Subsidence

Name of News Paper	Language	Date	Contents
Koran Tempo	Indonesian	June 26, 2018	DKI Jakarta is requested to accelerate Coastal Embankment Project since land is sinking rapidly due to land subsidence in Jakarta
Harian Kompas	Indonesian	July 13, 2018	Supervision system of groundwater consumption in DKI Jakarta is still weak due to mismanagement of groundwater
The Jakarta Post	English	July 13, 2018	Experts have urged DKI Jakarta to immediately stop excess groundwater use to avoid further land subsidence
DetikNews	Indonesian	November 21, 2018	Governor of DKI Jakarta's statement on prediction that Jakarta will be drowned in 2025 due to land subsidence in north part of Jakarta
The Jakarta Post	English	January 18, 2019	Governor of DKI Jakarta steps up efforts to control groundwater use
Kompas	Indonesian	March 22, 2019	PUPR Minister commented to stop groundwater usage after Jatilhur Reservoir and Karian Reservoir are well developed.

Source: prepared by the Project Team based on respective news articles

(2) Survey Conductor

When conducting consciousness surveys related to land subsidence, a misunderstanding that the survey results will directly lead to groundwater abstraction restriction should be avoided. In particular, industrial persons and commercial persons are expected to be reluctant to cooperate in research. Therefore, the survey conductor needs to have high social recognition and reliability, have sufficient experience in social research, and have government relations. They shall have the ability to proceed with research carefully while avoiding social conflicts by cooperating with governmental officials.

Based on the above points, this social research was outsourced to Research Units of Urban and Regional Studies, Center for Strategic and Global Studies, University of Indonesia which have high social recognition and credibility and many social research results.

(3) Definition of "consciousness" in social research

Interview shall be done to grasp awareness in terms of current situation, causality, countermeasures, and necessary actions as shown in Table 5-2. By understanding these awareness, necessary explanation and contents for awareness raising activities shall be considered.

Table 5-2 Type of Awareness

Type of Awareness	
1. Situation Awareness	
(1)	Disaster Awareness:
(2)	Land Subsidence Awareness:
(3)	Groundwater Abstraction:
(4)	Regulation Awareness:
2. Causality Awareness	
(5)	Causality Awareness:
3. Countermeasure Awareness	
(6)	Mitigation Awareness:
(7)	Adaptation Awareness:
4. Action Awareness	
(8)	Social Action Awareness:
(9)	Individual Action Awareness:
5. Other Awareness	
(10)	Other Awareness:

Source: The Project Team

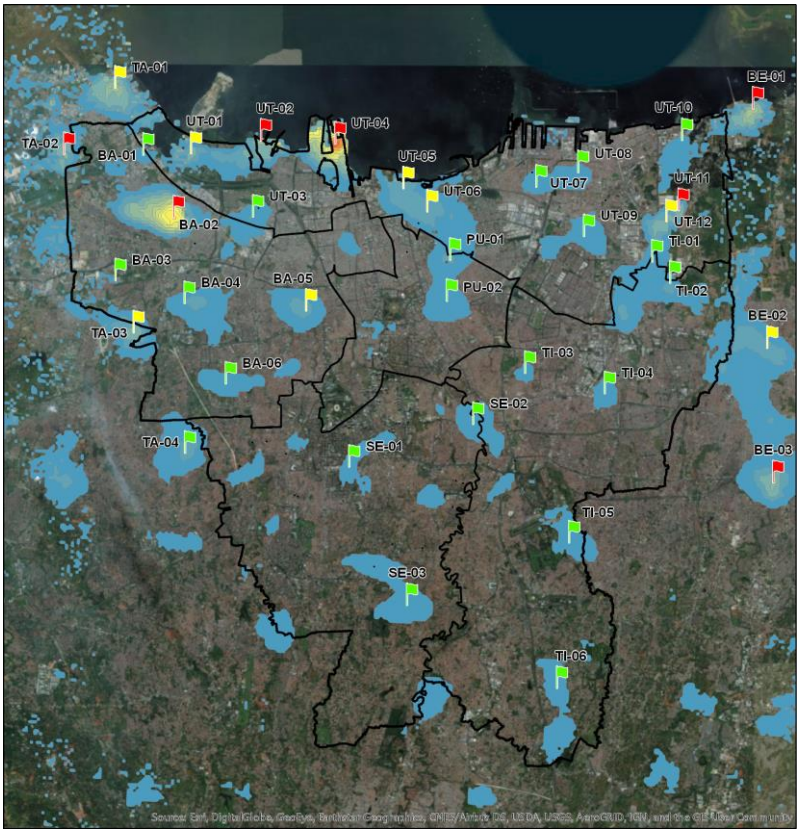
(4) Targeted Area

Based on the InSAR Analysis Results which shows Critical Zone as Figure 5.1, the candidates of target area Critical Zones are determined with the following standards and classification.

[Classification Standards]

1. Selected 50 mm/10 years or more
2. Selected Certain Wide Area (more than 5 km^2)

As a result, as shown in Table 5-3 , 16 Kecamatan fall under these areas. Figure 5.2 shows the selected Kecamatan on the map.



A: Red

More than 50 mm/year

or

More than 20 mm/year in whole period and 2014-2017 (ALOS-2)

B : Yellow

More than 20 mm/year in whole period

BUT

Less than 20 mm/year in 2014-2017 (ALOS-2)

C: Green

Less than 20 mm/year in whole period

Source: The Project Team

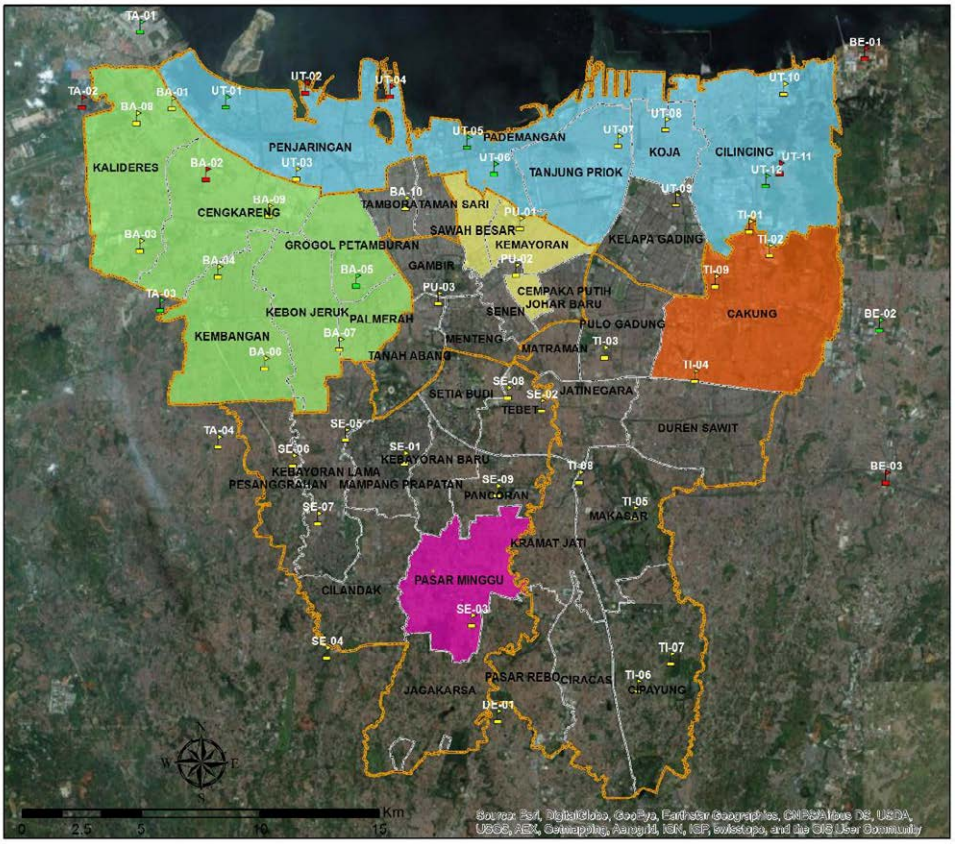
Figure 5.1 Critical Zone

Table 5-3 Targeted Area

City / Kota	District/Kecamatan	
Jakarta Utara	1. CILINCING 2. PADEMANGAN 3. TANJUNG PRIOK	4. KOJA 5. PENJARINGAN
Jakarta Barat	1. CENGKARENG 2. KALIDERES 3. KEMBANGAN	4. GROGOL PETAMBURAN 5. KEBON JERUK 6. PALMERAH
Jakarta Timur	1. CAKUNG	
Jakarta Pusat	1. JOHAR BARU 2. SAWAH BESAR	3. KEMAYORAN
Jakarta Selatan	1. PASAR MINGGU	

Total: 16 Kecamatan

Source: The Project Team



Source: The Project Team

Figure 5.2 Selected Kecamatan

(5) Targeted Groups and Methodology

The targets are residents, industrial persons, and commercial persons as shown in Table 5-4.

According to the statistics of the Indonesian Central Bureau of Statistics (BPS) in 2018, the population of Jakarta Special Region is 10,374,235 people while the number of households is 2,710,617 as of 2017.

Statistically, if 400 samples are collected, the deviation of the survey results from the actual population (allowable error) will be within 5%. Therefore, the number of samples was 400 households for the survey of residents, and this number of samples was equally divided into 16 kecamatan selected from the critical zone based on the above process. Therefore, the number of samples for each Kecamatan was estimated at 25 households.

On the other hand, samples for industrial and commercial personnel was expected to be more difficult to collect. Therefore, as a primary approach to clarify the actual situation of the company, the number of samples was narrowed down and the number of questions was increased rather than the survey of residents. In particular, understanding of regulations and the impact of changes in land prices due to land subsidence were asked.

The number of samples assumed at the start of the project was compared with the figure showing the amount of land subsidence until 2015 and the list of well registration companies owned by the former Water Management Agency of DKI Jakarta. Since there were 192 registered wells in an area where land subsidence was serious, the number of samples were 96 for industry and 96 for commerce.

The number of samples was also used during the actual social surveys, which divided into equal parts for each surveyed Kecamatan. Therefore, the number of samples for each Kecamatan were basically 6 companies for both industrial and commercial purposes.

The number of samples for residents is the number of samples whose statistical tolerance is within 5% statistically with the whole DKI Jakarta as the population. When looking at the results for each Kecamatan, the general tendency of each appears. In terms of industry and commerce, general tendency of whole DKI Jakarta appears.

Therefore, if statistical verification on industrial and commercial survey results becomes necessary to conduct, further surveys will be conducted.

In this report, the survey results of DKI Jakarta as a whole are shown for each of the residents, industrial people, and commercial people.

Regarding the selection of samples in Kecamatan, the Survey Conductor, University of Indonesia, provided information in Desa units owned by the DKI Jakarta Regional Disaster Management Bureau (BPBD) and RW/RT information possessed by the university itself.

The survey was conducted by organizing multiple teams, visiting each household and company, and conducting interviews based on questionnaires.

At the time of the interview, the survey was conducted with full understanding that it did not infringe the interests of the groundwater users and care was taken to prevent social conflicts.

Understanding and raising awareness of governmental officials regarding land subsidence is related to the ease of progress of each activity during the project period. The consciousness survey to governmental officials will not be outsourced. Instead, the person in charge for the consciousness survey shall be determined in consultation with Working Group 4 members. And the survey shall be carried out while carrying out awareness reform activities for government officials.

Table 5-4 Targeted Groups

Group	Targeted People		
	Each Kecamatan	Total (expected)	Total (Actual)
Residents	25 households	400 households	400 households
Industrial Company	6 companies	96 companies	126 companies
Commercial Company	6 companies	96 companies	96 companies

Source: The Project Team

5.1.2 Results of the Survey

(1) Residents

Table 5-5 shows summary of survey results on residents.

Table 5-5 Results of Survey on Residents

Type of Awareness	Result
Situation Awareness **(Disaster Awareness)**	Among the 400 households, 197 (about 49%) replied that they had suffered some flooding in the past five years. Among them, North Jakarta has a large percentage of households suffering from flooding. Among the 197 households, 180 households (91%) have not felt an increase in flood damage over the past five years. The road is flooded, but the house is not flooded.
(Situation Awareness) **Land Subsidence Occurrence Awareness**	301 households (75%) know the term land subsidence. (It is known in Indonesian as "ambles".) Residents know the term land subsidence through TV and social media. Residents do not understand the extent of land subsidence.
Water Usage	160 households (40%) still use groundwater. 180 households (45%) store water.
Causality Awareness	332 households (83%) responded that there was a relationship between flood damage and land subsidence, and 338 households (84.5%) answered that there was a relationship between groundwater abstraction and land subsidence. Regarding the cause of land subsidence, 154 households (38%) replied that it was groundwater abstraction, while 157 households (39%) recognized it as a building load. Other responses include "natural disasters" (16 households), "floods" (22 households), "don't know" (29 households).
Countermeasure Awareness	Regarding mitigation measures, there was an understanding of "reduction of groundwater use" (134 households) and "use of water supply" (54 households). However, there were also responses such as "Suspension of construction of high-rise buildings" (56 households). Regarding adaptation measures, there were many responses that corresponded to mitigation measures such as "strengthening laws and regulations" (261 households). There were few responses that corresponded to adaptation measures ("construction of dikes" (2 households), "creation of inundation map" (1 household)).
Action Awareness	93 respondents said that it is better to control groundwater abstraction (no matter whether shallow or deep wells).

Source: The Project Team

Based on the results of the survey, guide of future awareness raising activities are considered as follows.

Situation Awareness (Disaster Awareness)

- Except for North Jakarta, the increase in flood damage is not well recognized.
- There is no recognition of damage to property and health of residents due to flood damage.
- For this reason, the direction of awareness-raising activities that links "increased risk awareness due to flood damage" to countermeasures for land subsidence may not be effective.
- As land subsidence progresses, there is a possibility that flood damage due to road flooding may spread to house inundation, or possibility that the inundation depth that previously at the knee level will exceed the height of the child.
- In this way, awareness-raising activities can be considered to show that the risk of life and health risks can increase due to the progress of land subsidence.
- Awareness raising of such a crisis can be linked to mitigation activities that "mitigation measures are necessary to reduce the risk".

Land Subsidence Occurrence Awareness (Situation Awareness)

- To use the word "Ambles", which is familiar to the residents.
- Inform them that land subsidence is taking place in the area where they live and several meters of subsidence is occurring depending on the location.

Water Usage

- In West Jakarta, where groundwater is often used, careful awareness raising activities need to be carried out, particularly that ground subsidence measures do not forcibly regulate groundwater as domestic water, and that pumping in shallow water is not subject to regulation.
- In addition, although currently being investigated, if the investigation result confirmed that groundwater abstraction in the shallow layer does not cause land subsidence, awareness-raising activities can be promoted such that groundwater abstraction in the shallow layer is not subject to regulation.

Causality Awareness

- Nearly half of the residents cited factors other than groundwater pumping as the cause of land subsidence.
- Presenting knowledge that does not lead to misunderstandings is necessary, including the fact that groundwater pumping control in the middle and deeper layers which presupposes an alternative water resource leads to stop subsidence.

Countermeasure Awareness

- The understanding about adaptation measures needs to be increased, such as ground level never recover after land subsidence and contentious measures is going to be required once land subsidence occurred.
- It is useful to promote the understanding that mitigation measures can be strengthened immediately to reduce the risk of land subsidence, resulting in reducing the risks of life and health hazards, and prevent the cost of adaptation measures from increasing.

Action Awareness

- Necessity of control of groundwater usage seems to be relatively easily understandable among the residents.
- Awareness raising activities may be effective to conduct. It aims to increase cooperative attitude of residents toward short term countermeasures provided by the government such as rainwater

utilization and water distribution by PAM Jaya.

- Specific awareness raising activities that lead to the actual behavior of the residents is desirable to carry out. For instance, learning adaptation measures that can be performed by individuals (e.g. evacuating at an appropriate time in the event of a disaster).

(2) Industries

Table 5-6 shows summary of survey results on residents.

Table 5-6 Results of Survey on Industries

Type of Awareness	Result
Situation Awareness **(Disaster Awareness)**	Among 66 respondents, 28 respondents (42%) answered that they have been caught by flood disasters in 5 years. Among them, 24 respondents had no damage associated with the disasters (though road was flooding, water did not enter to their building).
(Situation Awareness) **Land Subsidence Occurrence Awareness**	Among 66 respondents, 52 respondents (79%) answered that they have heard the word of "Land Subsidence". They have heard the word through TV and/or Social Media. Understanding of Phenomena of Land Subsidence: "a hole of underground cause sinking" (8 respondents), "land surface is washed by sea water and/or flood" (5 respondents) Few of them have seen actual trace of land subsidence. They are not sure the extent of land subsidence.
Water Usage	22 respondents (33%) still use groundwater.
Regulation Awareness	29 respondents (44%) answered that they did not know about groundwater tax. 59 respondents (89%) answered that they did not know about regulation on infiltration wells.
Causality Awareness	20 respondents (35%) answered that the cause of land subsidence is groundwater abstraction.
Countermeasure Awareness	Respondents seem to understand about mitigation measures (27 respondents (41%) answered the control of groundwater abstraction is necessary). Respondents do not seem to know about adaptation measures.
Action Awareness	36 respondents (55%) mentioned water supply, saving water, infiltration wells, and so on.

Source: The Project Team

Based on the results of the survey, guide of future awareness raising activities are considered as follows.

Situation Awareness (Disaster Awareness)

- Nearly half of respondents have experience of water disaster, but they rarely have a recognition of direct damage by the water disaster.
- Therefore, awareness raising activities toward residence by connecting countermeasures against land subsidence with increase in awareness of risk because of water disaster may not be effective to conduct.
- As land subsidence progresses, there is a possibility that flood damage due to road flooding may spread to inundation in the office/factory, which could increase the risk of hindering business.
- In this way, awareness-raising activities can be considered to show that the risk can increase due to the progress of land subsidence.
- Awareness raising of such crisis can be linked to mitigation activities that "mitigation measures are necessary to reduce the risk".

Land Subsidence Occurrence Awareness (Situation Awareness)

- Phenomena of land subsidence is known as "Ambles" among the respondents.
- They do not know where and how much land subsidence occurs.
- Therefore, similar to the consideration for residents, it is better to convey information that land subsidence occurs in the area where they operate their business and more than several meter's land subsidence occurred in some area, by using the term of "Ambles".

Water Usage

- Awareness raising activities of groundwater abstraction control is necessary to be conducted carefully because more than half respondents still use groundwater.
- Respondents possibly does not know their own company's registration situation.
- In the future, this result can be used as a reference for studying the total amount of groundwater abstraction, including groundwater abstraction from unregistered wells.

Regulation Awareness

- The survey results imply that understanding of regulation is not spreading.
- Spreading the understanding about existing regulations is necessary.

Causality Awareness

- Some respondents showed their understanding about the relationship between groundwater abstraction and land subsidence.
- Answers such as "underground whole causes land subsidence" and "ground is swept away by seawater and flooding and the ground is lowered" emerged.
- Therefore, awareness raising about relationship among groundwater abstraction, land subsidence, and water disaster is necessary.

Countermeasure Awareness

- Understanding on multiple countermeasures shall be enhanced, such as securing alternative resources are prerequisite for groundwater abstraction control and protecting the area where land subsidence has been proceeded.
- Promoting such understanding will nurse their cooperative attitude toward land subsidence countermeasures by the governments.

Action Awareness

- Increase of negative image of restriction shall be avoided.
- We recommended to promote activities in which governmental regulation has described, such as tap water utilization, saving water, and rain water harvesting.

(3) Commercials

Table 5-7 shows summary of survey results on residents.

Table 5-7 Results of Survey on Commercial

Type of Awareness	Result
Situation Awareness **(Disaster Awareness)**	Among 126 respondents, 91 respondents (71%) answered that they have not been caught by flood disasters in 5 years. Among those who were caught by flood disasters, most of them had no damage associated with the disasters.
(Situation Awareness) **Land Subsidence Occurrence Awareness**	Among 126 respondents, 95 respondents (75%) answered that they have heard the word of "Land Subsidence". They have heard the word through TV and/or Social Media. Few of them have seen actual trace of land subsidence. They are not sure the extent of land subsidence.
Water Usage	56 respondents (44%) still use groundwater. Among them, 40 respondents do not register their well.
Regulation Awareness	95 respondents (75%) answered that they did not know about groundwater tax. 112 respondents (89%) answered that they did not know about regulation on infiltration wells.
Causality Awareness	44 respondents (35%) answered that the cause of land subsidence is groundwater abstraction.
Countermeasure Awareness	Respondents seem to understand about mitigation measures (53 respondents (42%) answered the control of groundwater abstraction is necessary). Respondents do not seem to know about adaptation measures.
Action Awareness	41 respondents (32%) mentioned water supply, saving water, infiltration wells, and so on.

Based on the results of the survey, guide of future awareness raising activities are considered as follows.

Land Subsidence Occurrence Awareness (Disaster Awareness)

- Seventy percent of responds have not experienced flood damage.
- There is no recognition that the responding companies that experienced flood damage have suffered direct damage.
- Therefore, awareness raising activities toward residence by connecting countermeasures against land subsidence with increase in awareness of risk because of water disaster may not be effective to conduct.
- As land subsidence progresses, there is a possibility that flood damage due to road flooding may spread to inundation in the office/commercial facility, which could increase the risk of hindering business.
- In this way, awareness-raising activities can be considered to show that the risk can increase due to the progress of land subsidence.
- Awareness raising of such a crisis can be linked to mitigation activities that "mitigation measures are necessary to reduce the risk".

Land Subsidence Occurrence Awareness (Situation Awareness)

- Seventy percent of responds have not experienced flood damage.
- There is no recognition that the responding companies that experienced flood damage have suffered direct damage.
- Therefore, similar to residents and industries, it is better to convey information that land subsidence occurs in the area where they operate their business and more than several meter's land subsidence occurred in some area, by using the term of "Ambles".

Water Usage

- In the area of companies that answered that they are still using groundwater, awareness raising activities related to groundwater abstraction control need to be promoted carefully.

Regulation Awareness

- The survey results imply that understanding of regulation is not spreading.
- Spreading the understanding about existing regulations is necessary.

Causality Awareness

- Only 20 of 126 companies cited groundwater abstraction as the cause of land subsidence.
- This indicates that the perception of groundwater abstraction as the cause of land subsidence may not be common.
- Therefore, in the awareness raising activities related to groundwater abstraction control, the viewpoints of "relationship between groundwater abstraction and land subsidence" and "groundwater abstraction control based on the assumption of alternative water sources" following the example in Tokyo shall be presented in an easy-to-understand manner.

Countermeasure Awareness

- Same as Industries, understanding on multiple countermeasures is necessary to enhance, such as securing alternative resources are prerequisite for groundwater abstraction control and protecting the area where land subsidence has been proceeded.
- Promoting such understanding will nurse their cooperative attitude toward land subsidence countermeasures by the governments.

Action Awareness

- Same as Industries, increase of negative image of restriction shall be avoided.
- We recommended to promote activities in which governmental regulation has described, such as tap water utilization, saving water, and rain water harvesting.

5.2 Workshops

To raise the awareness of local government staff and planning and to implement the short term action plans in the pilot areas, workshops were held in 3 cities in coastal areas.

5.2.1 Workshops in North Jakarta and East Jakarta Cities

The workshops were conducted one time each in North Jakarta and East Jakarta Cities before the COVID-19 pandemic. The outlines of workshops are as follows.

North Jakarta City

- Date: November 5, 2019, 8:30-12:00
- No. of Participants: Approx. 100
- Presenter: The Project Team, DPE, BPBD
- Presentation: Project Outline, Measures taken by DKI, Action Plan, Experiment of Land Subsidence Mechanism
- Discussions:
  - People might know land subsidence phenomena.
  - Situation of unregistered wells are uncertain even in district (*kecamatan*) and town (*kelurahan*) offices.
  - Governor decree is required so that district and town office can conduct inspection of unregistered well.
  - Rainwater harvesting program at city and district offices shall be implemented.
  - Purpose of rainwater harvesting (runoff control, alternative water resources) shall be clarified and appropriate system shall be applied. If the purpose is for alternative water resources, water quality shall be considered.
  - Section in charge for awareness rising activity in city and district.
  - Workshop in district and town, and direct awareness rising activity in community (*RT/RW*) level are required.





East Jakarta

- Date: December 18, 2019, 9:00-11:00
- No. of Participants: Approx. 80 (Attending regular meeting of city with districts and town heads)
- Presenter: The Project Team
- Presentation: Project Outline, Action Plan
- Discussions:
  - Presentation by the Project Team was recognized.
  - Time for discussion is not allocated enough due to other topics. Follow up meeting will be held.





5.2.2 Workshops in West Jakarta City and Proposal of Rainwater Harvesting System

The first workshop was held in 2019 in West Jakarta City and periodical meetings and workshops have been held. Through these dialogues, rainwater harvesting system in Palmerah and Grogol Petamburan districts was proposed. The outlines of meetings are as follows.

1st Workshop

- Date: November 12, 2019, 9:30-12:00

- No. of Participants: Approx. 140 (Attending to regular meeting of city with districts and town heads)
- Presenter: The Project Team
- Presentation: Project Outline, Action Plan, Experiment of Land Subsidence Mechanism
- Discussions:
  - Remarkable land subsidence in West Jakarta City is recognized. The Secretary in charge of economy and city development and the division of city development and environment work as the window of this issue.
  - Revelation of unregistered well is difficult for city government.
  - The industry and energy agency in the city government is conducting meter reading in cooperation with provincial government.
  - Two pilot areas namely Cengkareng and Palmerah are selected in West Jakarta City. The action plans shall be implemented in cooperation with section in charge in city government and the district offices.
  - The follow up meeting must be implemented soon.




Follow-up Meeting for 1st Workshop

- Date: November 20, 2019, 9:30-12:00
- No. of Participants: Approx. 20
- Presenter: The Project Team
- Presentation: Action Plan in West Jakarta City
- Discussions:
  - Cause of land subsidence especially heavy load by building had been discussed in 2010s. As conclusion of this argument, consensus was obtained that over abstraction of groundwater is only the cause which can be controlled.
  - The City Government agrees and supports installation of rainwater harvesting facility in the newly developed housing complex in Daan Magot.
  - The City Government will assist to approach to PAM Jaya and Palyja.
  - For further socialization, coordination among district and town office of pilot areas are

required.

- Direct awareness rising to citizens shall be considered using trial installation of Japanese technology on rainwater harvesting.




2nd Workshop

- Date: July 30, 2020, 9:00-11:00
- No. of Participants: Approx. 30
- Presenter: The Project Team, DSDA, PAM Jaya
- Presentation: Action Plan in West Jakarta City
- Discussions:
  - Task of groundwater management is shifted from DPE to DSDA.
  - The Provincial Government shall approve the concept of action plans then the City Government can implement them.
  - The DGWR of PUPR is developing alternative water resources to reduce groundwater use. In the implementation, cooperation of local governments is inevitable.
  - Coordination among the region is important to improve the effect of infiltration wells as JICA's recommendation.
  - For implementation of action plans, strong leadership of Governor and establishment of task force with JICA are required.
  - As a condition of new building construction, installation of infiltration facility is obligated. Conservation of *Situ* can be included.
  - Insufficient raw water is significant barrier for expansion of coverage area.
  - Quarterly meeting between PAM Jaya and DSDA is held for information sharing.
  - Taman Anggrek Mall already uses water supply.
  - For implementation of action plans, (a) planning and cost estimate of infiltration well and storage, (b) data on groundwater use and water supply, and (c) monitoring team, are necessary. Activity shall be conducted with guidance from the provincial government.



Meeting with Development and Environment Agency of West Jakarta City Office

- Date: October 19, 2021
- Discussions:
  - The West Jakarta City Office would like to propose rainwater harvesting system in Palmerah and Grogol Petamburan districts (*kecamatan*) where the commercial area in the districts are selected as the Pilot Area, including the discussion on candidate locations and costs.

Meeting with Grogol Petamburan District Office

- Date: November 2, 2021
- Discussions:
  - Previous meeting in the West Jakarta City Office concluded that that further discussion of solution of land subsidence should be done in the area where land subsidence was severe.
  - The commercial area with mega-shopping mall is the most severe location of land subsidence. However, installation of rainwater harvesting system is difficult due to land ownership. Common land shall be selected.
  - Meeting on selection of optimal locations and joint survey are required with the district office and the Asset Management Agency of West Jakarta City Office.

Meeting with Asset Management Agency of West Jakarta City Office

- Date: November 29, 2021
- Discussions:
  - Rainwater harvesting system is agreed to be proposed in West Jakarta City.
  - The common lands are basically the property of the provincial government and the Asset Management Agency of provincial government manage them.

- Since the Project covers whole DKI, the Project is recommended to request the data on common lands in whole DKI to the Asset Agency of the provincial government, with setting of criteria for optimal location of rainwater harvesting system. Ideally, the efforts in West Jakarta City should be expanded to whole DKI.



Meeting with Asset Management Agency of Provincial Government (BPAD)

- Date: December 17, 2021
- Discussions:
  - BPAD manages the property of province, however, the detail situation of these lands shall be confirmed with the agencies using these properties such as DSDA and Housing Agency. BPAD will organize a coordination meeting with relevant agencies.

Coordination Meeting with Relevant Agencies

- Date: December 23, 2021
- Discussions:
  - BPAD and the Project Team explained the purpose of meeting and proposal on rainwater harvesting system and obtained the consensus on principles.
  - Related agencies such as DSDA, Tourism Agency and Housing Agency appointed the persons in charge and agreed to continue discussion.

5.2.3 Lessons Learnt from Workshops and Future Development

As mentioned above, only one time workshop was conducted in North Jakarta and East Jakarta City, while periodical meetings had been held in West Jakarta City. The severe restriction of social activities due to the COVID-19 pandemic is fundamental factor of limitation, but the following reasons are expected to the difference of these cities.

- Due to the flood disaster in January 2020 and the COVID-19 pandemic, no room was available for discussing the land subsidence issues in North Jakarta and East Jakarta City.

- West Jakarta City also suffered from flood disaster in January 2020. Out of wide inundation areas in the city, the remarkable damage was the inundation of a mega-shopping mall located in Palmerah/Grogol Petamburan districts resulting the shutdown of the mall for a long time. This area is a Pilot Area of the Project and the damage might be recognized as the example of "flood risk increase due to land subsidence" causing the motivation of dialogue.
- There are three Pilot Areas with different characteristics are selected in West Jakarta City, namely Cengkareng area where land subsidence has stopped, Daan Magot area where land subsidence in future is concerned, and Palmerah/Grogol Petamburan where land subsidence is on-going in commercial area. This fact makes easy to recognize the necessity of land subsidence countermeasures.
- In Daan Magot area, the Project Team and relevant agencies has continually discussed the construction of rainwater harvesting system by the sub-contracting works. It keeps the close communication between the team and relevant agencies.
- The proposed short term measures related to regulation of groundwater use was not discussed well in any city. In East Jakarta City, an industrial area was selected as the Pilot Area and activities directly related to groundwater use regulation were proposed such as joint inspection. They might hesitate to discuss for implementation such activities.

The synthesized lessons from the above are:

- Concrete activities shall be continually discussed and implemented.
- Materialization of regulation related activities is difficult by city office level.

The following future developments are expected.

- Horizontal expansion from good practice with the Project (outsider) intervention to self-efforts, such as rainwater harvesting system development
- Proper expansion of groundwater use regulation based on the enactment of the provincial regulation

5.3 Short Term Measures in Jakarta Fishing Port

Jakarta Fishing Port or Pelabuhan Perikanan Samudera Nizam Zachman, located in North Jakarta City (hereinafter referred to as the JKT Fishing Port) experiences the most severe land subsidence area and subsidence rate is still high. Effect of land subsidence is significantly disturb the port operation such as frequent inland water inundation and devastated blocks due to ponding all of the time.



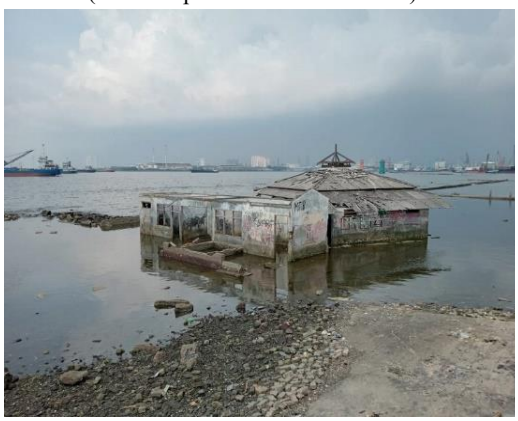
Flood in JKT Fishing Port (Mar. 5, 2019)



Entrance of a Factory
(raised to prevent flood intrusion.)



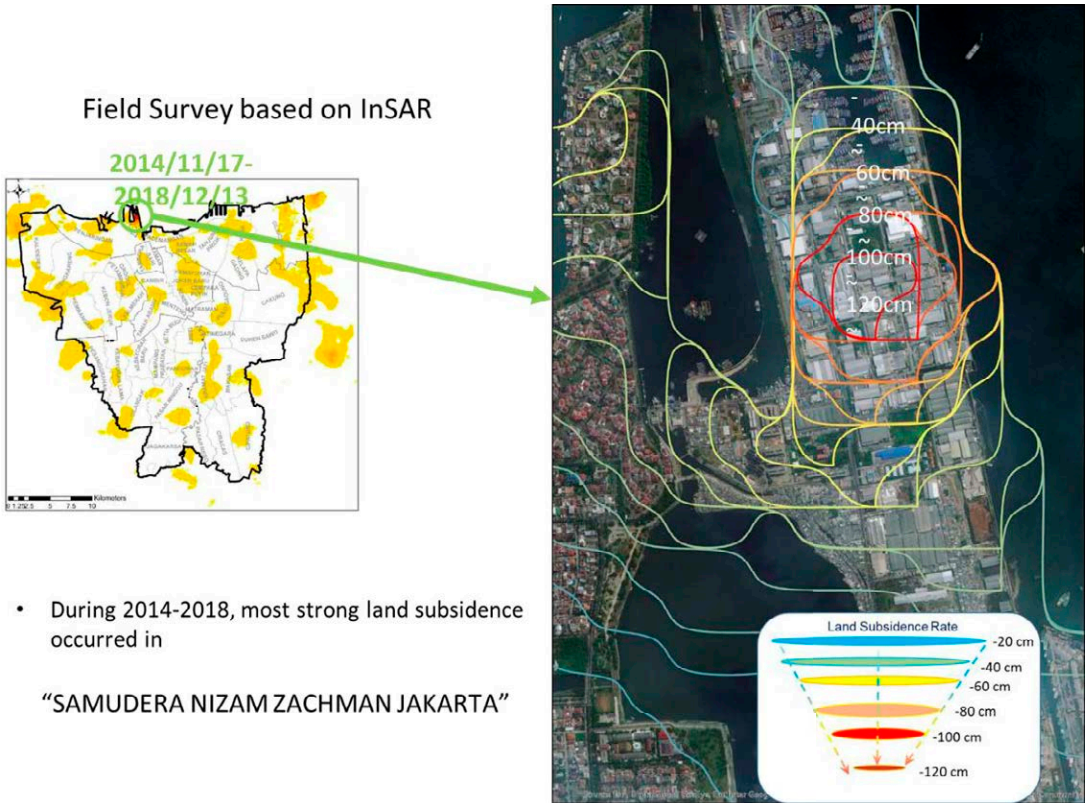
Devastated Block by Land Subsidence



Devastated Mosque

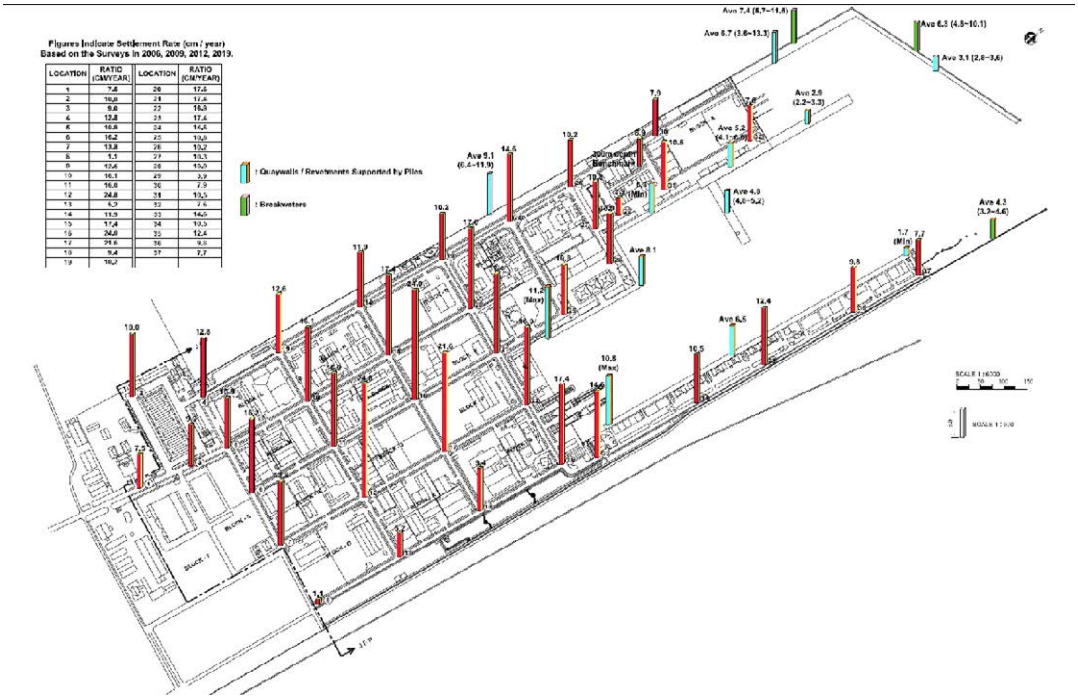
The InSAR analysis revealed that the most severe land subsidence area is the fish processing factory area in the fishing port. This fact is verified by GPS survey conducted by another JICA survey, namely "Data Collection Survey on Improvement and Rehabilitation of the Jakarta Fishing Port and Local Fishing Ports in Indonesia" (hereinafter referred to as the "Data Collection Survey"). The Project Team focused on the JKT Fishing Port with the following major discussion and activities.

As the results of these discussion and activities, necessity of monitoring wells construction in the JKT Fishing Port was recognized and DKI Jakarta made a plan to construct by the local government budget. However, it would be implemented as the sub-contracting works of the Project due to difficulty of budgeting of DKI Jakarta induced by the COVID-19 pandemic. A series of discussion was made until the construction of monitoring wells made a consensus of related stakeholders and administration process such as land acquisition was done smoothly.



Source: The Project Team

Figure 5.3 Results of InSAR Analysis



Source: Data Collection Survey on Improvement and Rehabilitation of the Jakarta Fishing Port and Local Fishing Ports in Indonesia

Figure 5.4 Results of GPS Survey

Attendance to the Meeting with Ministry of Maritime Affairs and Fisheries (KKP)

The Project Team attended the meeting on August 15, 2019 for Data Collection Survey and presented and discussed the Project outline, situation of land subsidence in the JKT Fishing Port, and action plans. The points of discussion are as follows.

- Cooperation among KKP, DKI, and other relevant agencies are inevitable.
- The Data Collection Survey proposed utilization of space between the west side coastal dyke constructed by NCICD and fishing port as a regulating pond with pump and drainages. Technical advice is requested to PUPR. DKI is also requested to conduct regulation of groundwater use and water supply.
- The cause of land subsidence and effects of topography of Jakarta Bay and shallow well shall be examined.
- The users might prefer to use groundwater due to the price of water supply in the Fishing Port, which is much higher than other areas.
- Total number of registered well in DKI was 4,500 in 2006, and decreased to 2,500 in 2019.



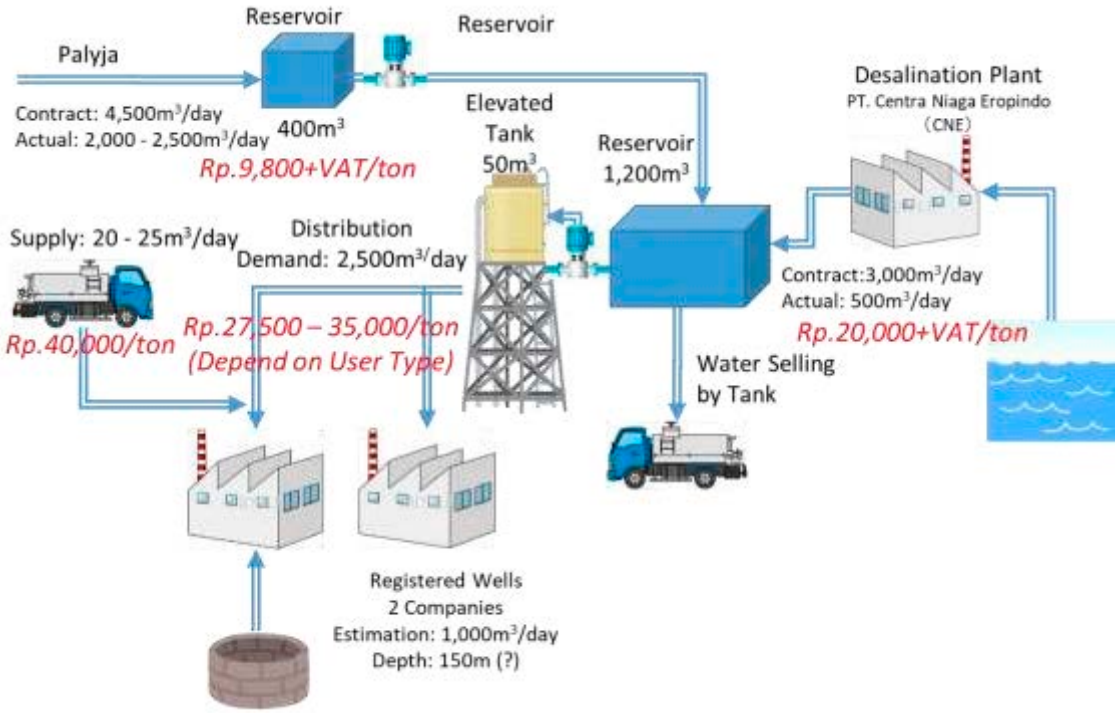


Meeting with State-Own Company for Utility Management in the Fishing Port and Fish Processing Factories

Through the dialogue with the JKT Fishing Port, a workshop with fish processing factories was arranged to be held in March 2020 as a short term action plan. However, this workshop was impossible to be held due to COVID-19. Then, through intensive discussions with the JKT Fishing Port Office, a meeting with the state-own company for utility management in the Fishing Port and private fish processing factories was held on October 22, 2020. Prior to the meeting, questionnaire survey was conducted to several cooperative factories in order to collect more information on sensitive issues. The points of discussion are as follows.

- Current situation of water supply was confirmed. Currently, sufficient water volume is supplied. However, some factories still buy tank water mainly due to water quality issue. Some factories uses rainwater for washing and cooling purpose.
- As the request for current water supply system by private factories, “review of water tariff” is dominant followed by “water quality improvement”.
- Construction of monitoring well in the JKT Fishing Port is requested with the following outcomes.
  - Core sampling during test boring can reveal hydrogeological conditions until deep layers.
  - The aquifer causing land subsidence can be detected.

- Information disclosure will be a good material for raising the awareness of private fish processing factories.



Source: The Project Team

Figure 5.5 Current Water Supply Based on Discussion on October 22, 2020

<u>Construction of Land Subsidence Monitoring Wells by Sub-contracting Works</u>

The DKI Government planned to construct land subsidence monitoring wells by provincial budget referring the one constructed by the Project in the 1st stage, and procurement of contractor for the construction was conducted. However, it was cancelled due to budget reallocation to recovery works from the 2020 flood disaster and the COVID-19 measures.

Under this situation, JICA decided to construct additional monitoring wells in Jakarta Fishing Port as a sub-contracting work, where the Project Team started to plan in early 2021. Since the duty trip was strictly prohibited at the time, several open spaces near the center of land subsidence in the port were selected as candidates of monitoring well by referring to Google image. Through the dialogue with relevant parties such as DSDA, the JKT Fishing Port Office, the state owned company, PUPR, and so on, and through two times joint surveys, the public land at west side of the port was selected. The main points of discussions are as follows.

- All the parties recognized and agreed the reason, purpose and benefit to construct the monitoring wells in the JKT Fishing Port.
- The land in the port is managed by the state-owned company. However, complicated process is required to get the right of use for the properties which is used by the private sector. Hence, construction of the monitoring wells in public land is preferable.
- The process of inauguration will be from JICA, PUPR, and the state owned company to DKI. Further, detailed process shall be confirmed. The land will be lent from the state owned company

to DKI.

- The construction schedule shall be submitted to the JKT Fishing Port Office. Reclaimed land is allowed to be used as disposal of excavated soil.
- The monitoring data will be shared to the JKT Fishing Port Office through MONAS.

Table 5-8 Major Meeting related to Monitoring Well Planning in JKT Fishing Port

Date	Participants	Topics
Apr. 13, 2021	Assistant Secretary for Construction, DKI	Project Briefing
Apr. 16, 2021	Bureau of Environment, DKI	Follow-up of Meeting with Assistant Secretary
Apr. 27, 2021	DSDA, DKI	Monitoring Framework and Construction Schedule
May 31, 2021	PUPR, KKP, JKT Fishing Port Office	Objective of Construction and Coordination
Jun. 8, 2021	PUPR, KKP, Fishing Port Office, State Owned Company, Asset Agency of DKI	Land-use Permission and Inauguration
Jun. 29, 2021	JKT Fishing Port Office, State Owned Company, DSDA	Joint Survey



Source: The Project Team

Figure 5.6 Candidates and Selected Location of Monitoring Well

5.4 Preparation of Web Site

As one of the materials for awareness raising, a web site was constructed.

Both “public awareness raising about land subsidence and countermeasures” and “data and information sharing” are intended as the objectives of website, and it contains “Overview of Land Subsidence in Jakarta”, “the JICA Project”, “Monitoring”, “News”, and “Legal References”. The contents and the screen image are shown in Table 5-9 and Figure 5.7, respectively.

Considering the self-operation after the Project, a series of meetings has been conducted and a technical

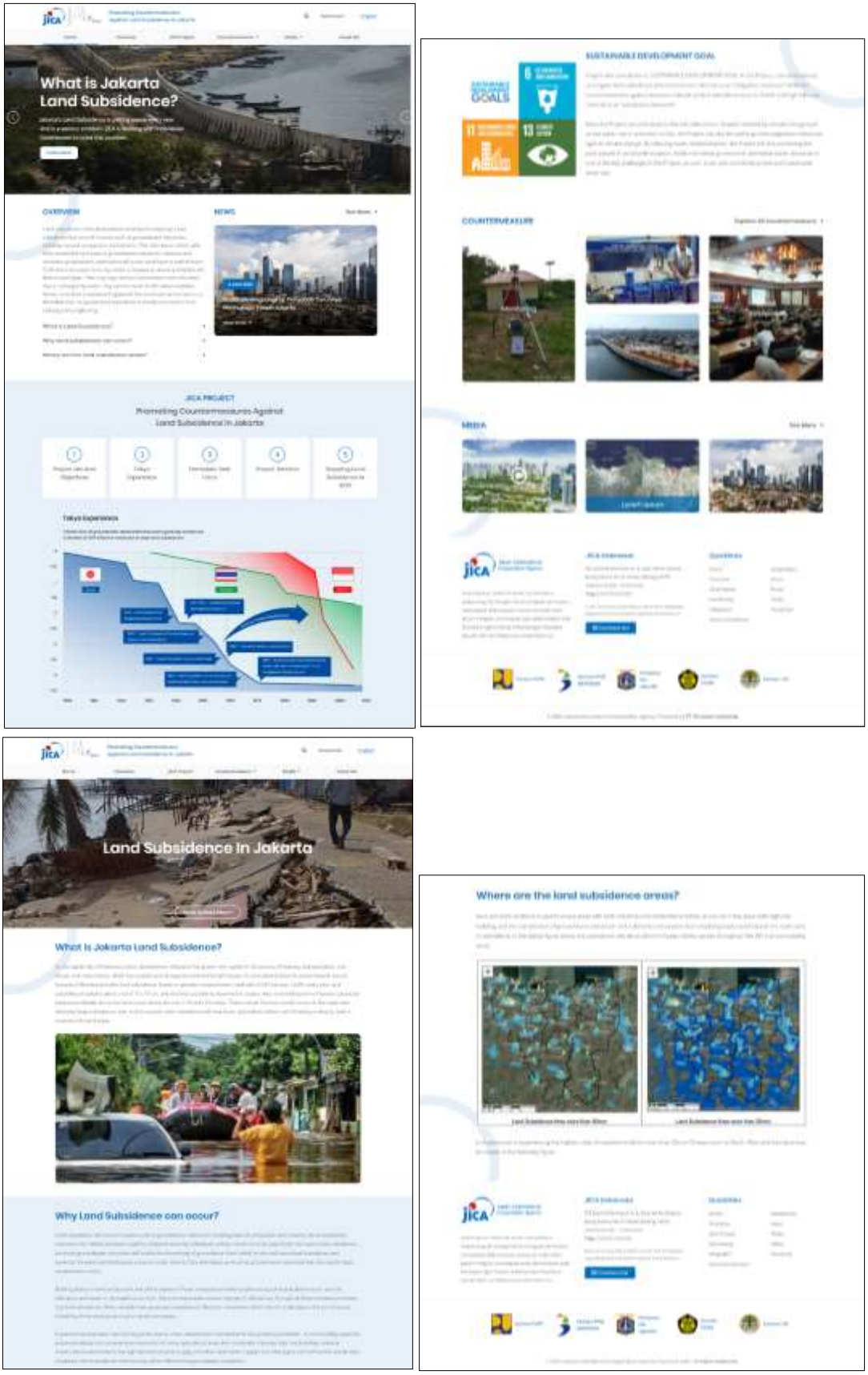
seminar for operation and maintenance was also held to the 34 staff of DSDA in January 2022. The major points confirmed in the meetings are as follows.

- The website is shifted to the server of the Communication, Information, and Statistics Agency of DKI (*Dinas Konmunikasi, Informatika, dan Statistiks, DISKOMINFOTIK*) after the Project.
- As a part of deliverable of the Project, the website will be once inaugurated to PUPR and then transferred to DKI after the necessary process.
- Maintenance and update will be the responsibility of the Data and Information Center (*Pusat Data dan Infomatika, PUSDATIN*) of DSDA, and data and information will be provided by other sections of DSDA and the related agencies.
- Database function will be enhanced to be a platform of data sharing with other agencies.
- The standard operation procedure (SOP) is provided indicating roles, workflow, and procedure of update and renewal of web site (refer to Figure 5.8).

Table 5-9 Contents of Web Site

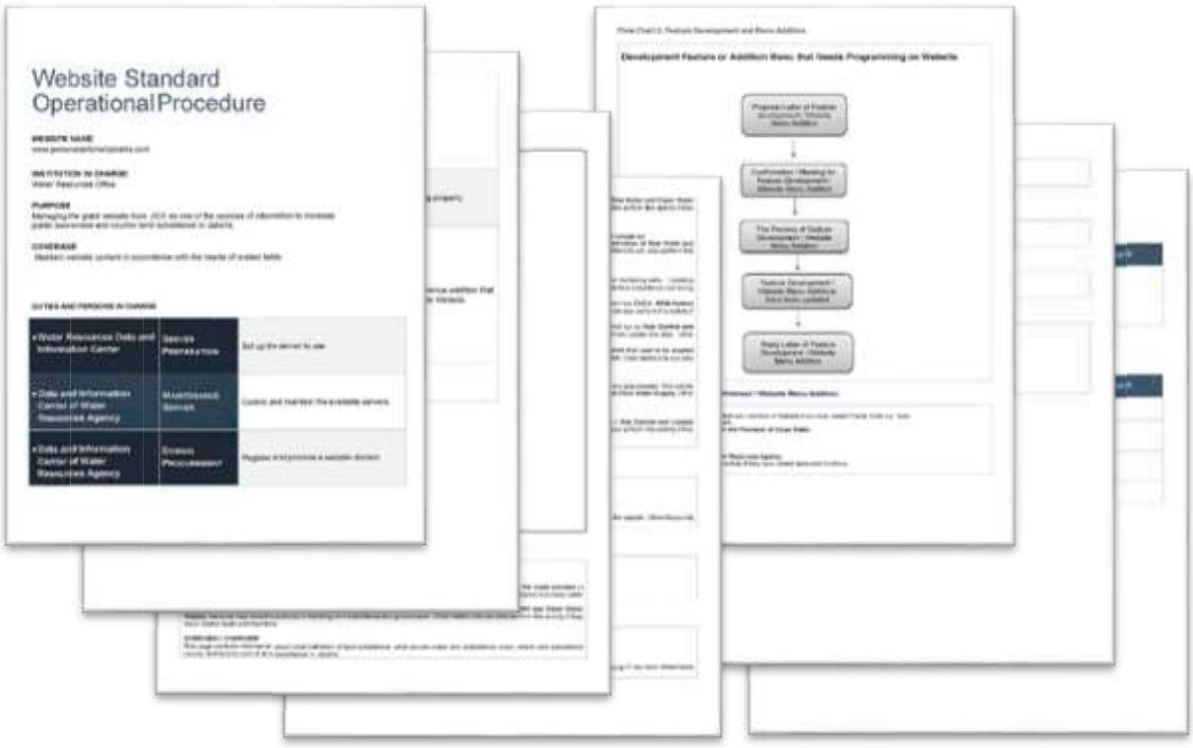
Category	Item	Contents
Overview	What is the Land Subsidence?	Outline of Land Subsidence in Jakarta (Introduction)
	Why Land Subsidence Occur?	Mechanism of Land Subsidence due to Over Abstraction of Groundwater (Animation)
	Where are the Land Subsidence Areas?	Result of InSAR Analysis
	How to Deal with the Land Subsidence?	"Monitoring", "Mitigation Measures", "Adaptation Measures", "Awareness Raising"
JICA Project	Project Site and Objective	Project Area and Objective
	Tokyo Experience	History of Land Subsidence in Tokyo
	Formulate Task Force	Related Agencies
	Project Timeline	Implementation Schedule
	Stopping Land Subsidence in 2030	Achievement after the Project
Monitoring*	Monitor Land Subsidence and Groundwater Level	Monitoring Data of Land Subsidence Monitoring Wells
	InSAR Result	InSAR Result Analysis
	GNSS and Levelling Survey 2019	GNSS Survey Result
Documentation	News	News on Project Activity, Effort by DKI and Related News
	Photos	
	Videos	
Legal Reference	ー	Related Governors Degree

*: Data is not yet disclosed.



Source: The Project Team

Figure 5.7 Screen Image of Web Site



Source: The Project Team

Figure 5.8 Standard Operation Procedure of Web Site Management (English Translation)

5.5 Signboard Construction

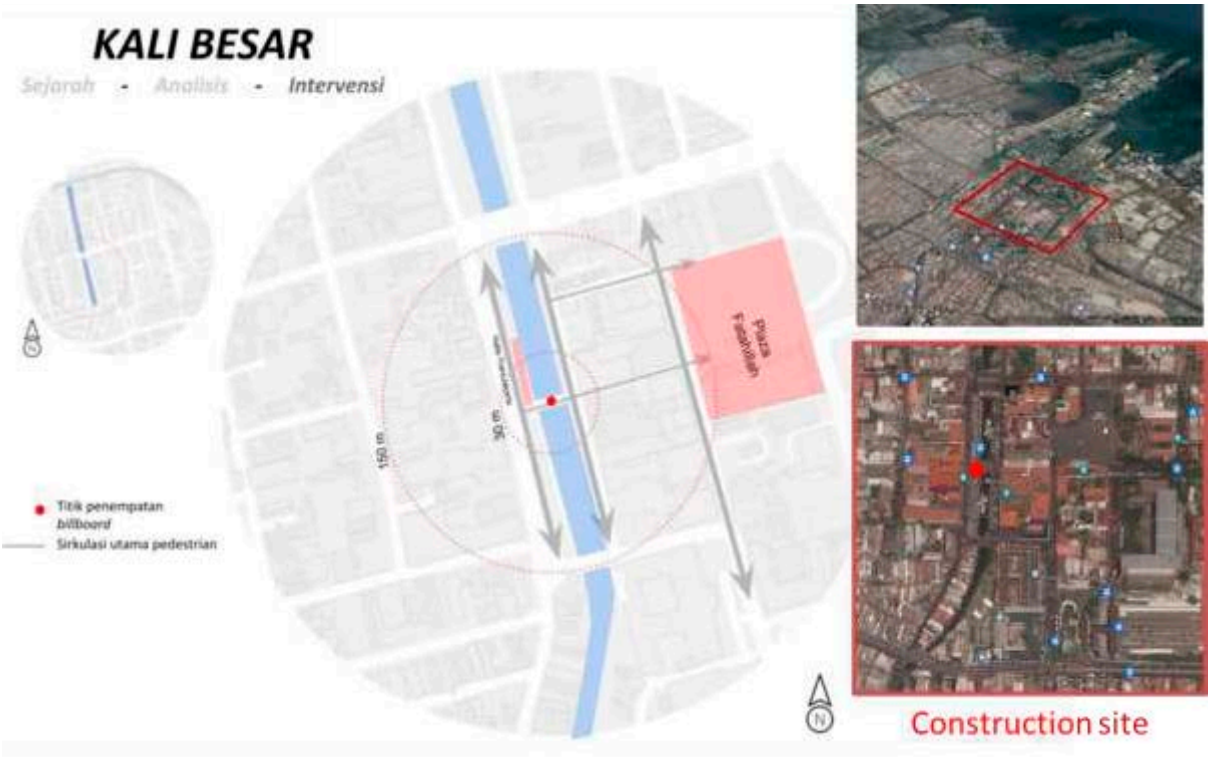
(1) Objective

Construction of a signboard has been planned as part of our awareness-raising activity. The main objectives of the signboard are as follows: 1) to raise public awareness about land subsidence, 2) to inform the public about the risk of flooding correspond with land subsidence, and 3) to inform the public about countermeasures against land subsidence.

(2) Location

For the construction of the signboard, the project team had continuous discussions with C/P, mainly DKI. As a result of the discussion, DKI proposed the signboard location to be around Kali Basar in Kota Tua area.

Kota Tua is a tourist area with historically important buildings in DKI and conservation work has been progressing rapidly in recent years. In particular, the area around Kota Station, south of Fatahillah Square, is being redeveloped mainly by DKI Bina Marga. Therefore, the location of the signboard is requested to be near Kali Basar, where redevelopment has already been completed. This area is located at the western edge of the conservation area and has a lot of pedestrian traffic, which is suitable for the construction of the signboard. The detailed location of the signboard is currently under discussion with the expert committee led by the DKI Cultural Affairs Department.



Source: The Project Team

Figure 5.9 Location (around Kali Basar)

The visit to the site was also made with Director Rizal, Director of the Bureau of Technology, who explained the significance of the construction of the sign boats.



Figure 5.10 Site visit with Technical Director Rizal

(3) Design

The project team have discussed the design with the C/P, referring to the signboard in Tokyo. As a result of the discussion, single pole type which shows the ground elevation at the beginning of the subsidence observation (1974) is selected (Figure 5.11) instead of the originally planned design (triangle plate type), considering the public safety in the area.

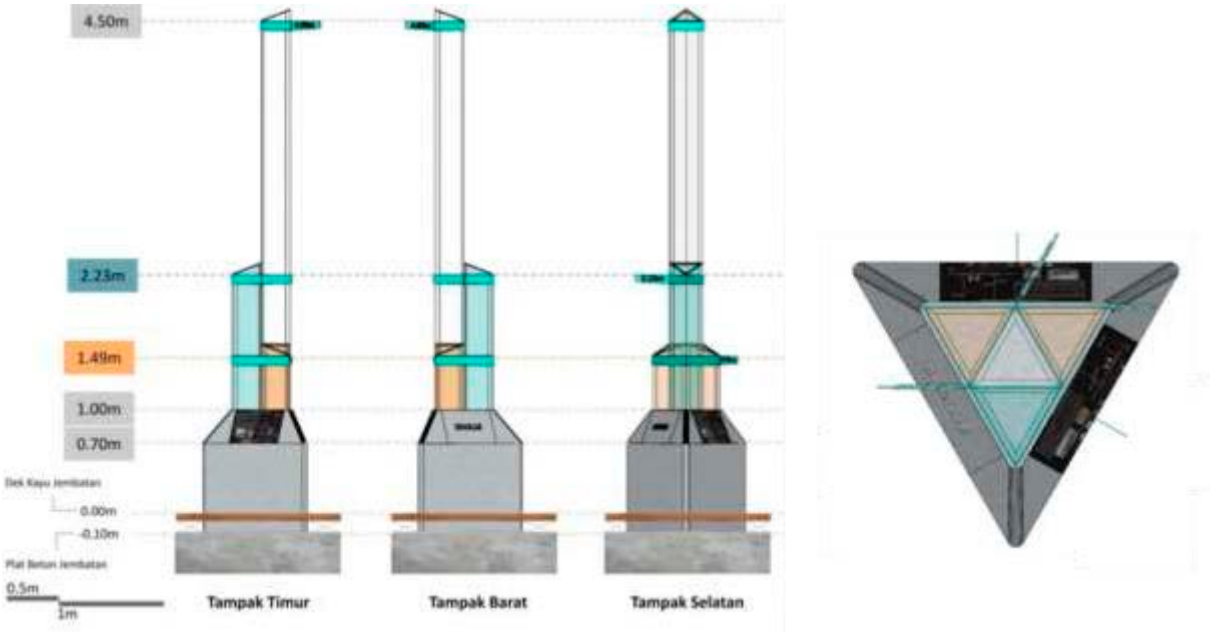
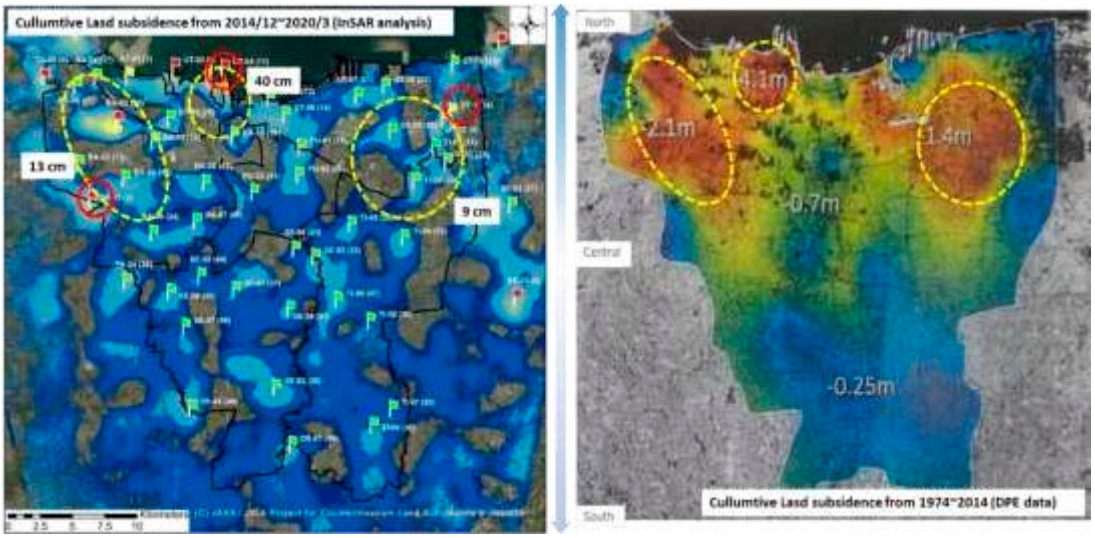


Figure 5.11 Signboard design

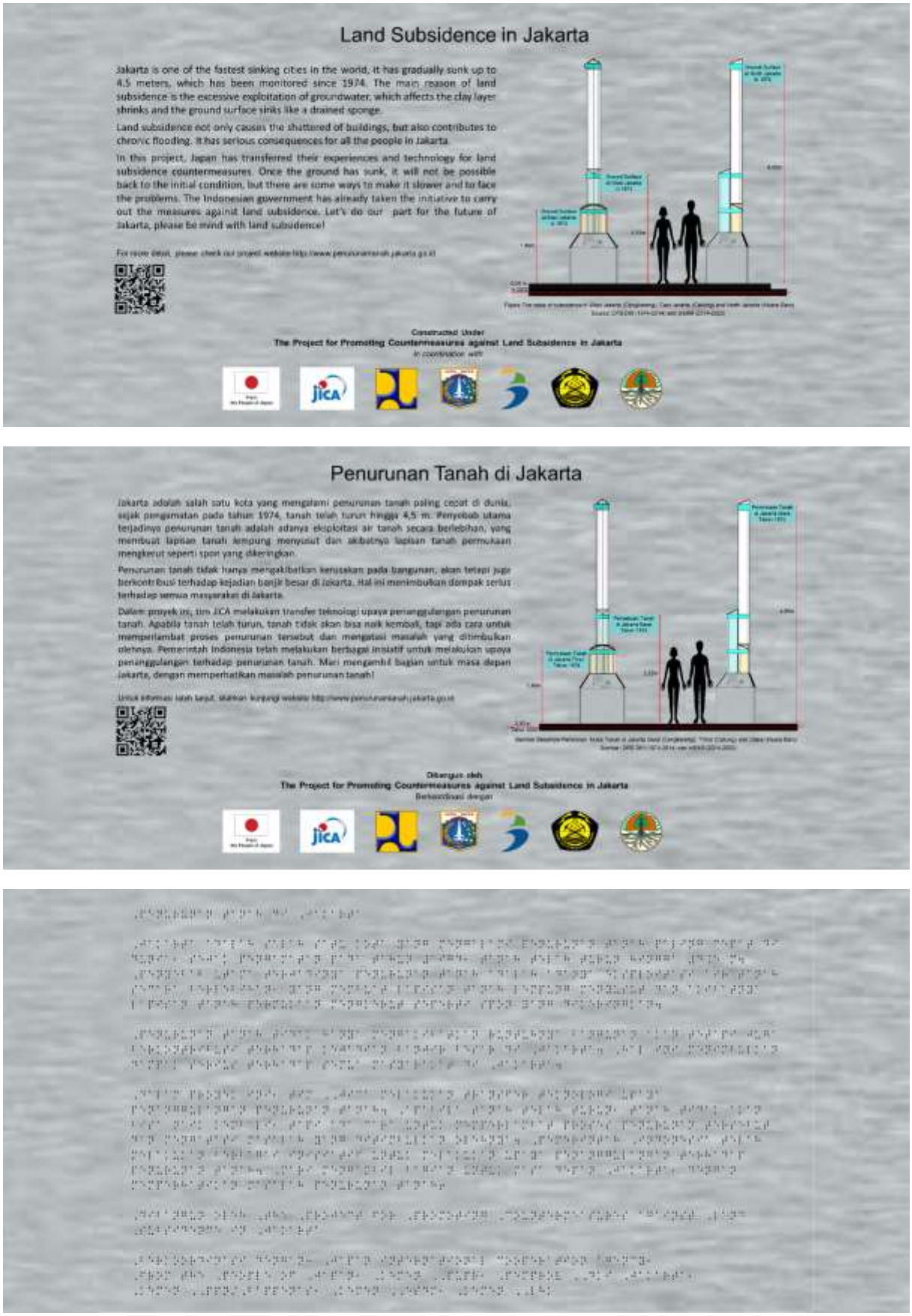
The signboard will show the amount of subsidence in the three areas of North Jakarta, West Jakarta, and East Jakarta, where subsidence is particularly significant (Figure 5.12). The subsidence from 1974 to 2014 is based on the date from DPE. While the subsidence from 2014 to 2020 is based on the results of the InSAR analysis conducted in this project.



Area	Cumulative land subsidence (m)		
	DPE (1974~2014/12)	InSAR (2014/12~2021/3)	total
North Jakarta	4.10	0.40	4.50
West Jakarta	2.10	0.13	2.23
East Jakarta	1.40	0.09	1.49

Figure 5.12 Amount of land subsidence to be described on signboard

An explanatory was placed on the signboard to describe the design, the current situation of land subsidence in Jakarta, and an introduction to the project. The design of the signboard is shown in Figure 5.13, and the QR code on the signboard can be scanned to access the website created for this project, thus achieving a synergistic effect between the signboard and the website.



Source: Consultant

Figure 5.13 Explanation board (top: English, middle: Indonesian, bottom: Braille)

(4) Post construction status

The post-construction status is shown in Figure 5 14. As of September 2022, the ropes that had been placed over the construction area to prevent infectious diseases have been removed, and many people can be seen coming and going from the adjacent Transjakarta bus stop and Fatahillah Square. In the future, it is desirable to monitor the effectiveness of the signboard in raising public awareness through the number of views of the project's website (as described on the signboard) and the number of mentions of the signboard on social networking services.

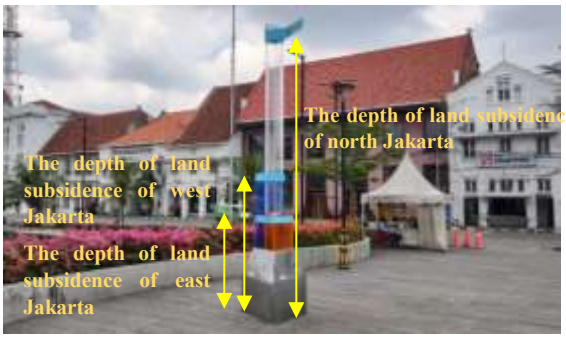
Distant view	Near view
	
The design is highly visible and stands out from its surroundings.	People can experience the amount of subsidence in the three regions within Jakarta Special Province.

Figure 5.14 Sign board construction results

CHAPTER 6 ACTION PLAN

6.1 Framework of Action Plan

Through the Project implementation, the following activities should be achieved:

- A data monitoring and management system related to land subsidence should be established.
- Effective mitigation measures and adaptation measures should be considered.
- Awareness raising should be promoted
- An action plan should be formulated.

Regarding action plans, what would be implemented during the Project implementation period are called short-term action plan, those implemented between three to 10 years are called medium-term action plan, and those implemented after 10 years are called long-term action plan.

6.2 Short-term Action Plan

6.2.1 Selection of Pilot Areas

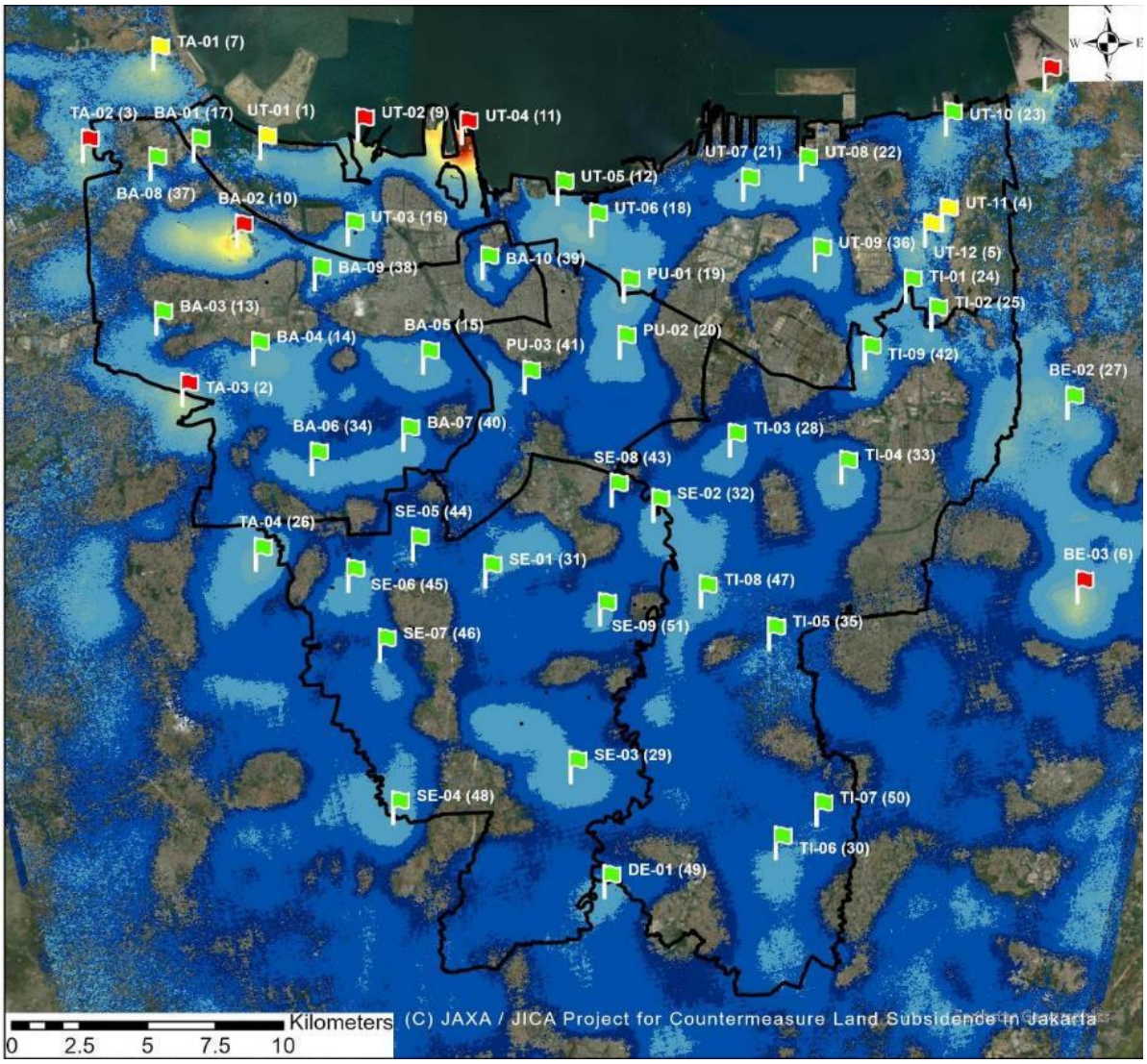
The pilot areas were selected among the severe land subsidence areas based on the results of InSAR analysis, and the short-term measures will be implemented in the pilot areas as an example of countermeasures in DKI Jakarta.

As discussed in Chapter 2, the critical zones with the following criteria are set based on the InSAR analysis.

Critical Zone A :	50 mm/y (2007-March 2020) or more, or, 20 mm-50mm/y (2007-March 2020) and 20 mm/y or more (2014-March 2020)
Critical Zone B :	20 mm-50mm/y (2007-March 2020) and 20 mm/y or less (2014-March 2020)
Critical Zone C :	20 mm/y (2007-March 2020) or less

Figure 6-1 shows the critical zones with numbering. The color of flag represents the criteria such as red for A, yellow for B and green for C. The two letters before numbers correspond to the abbreviation of the city as follows.

- UT: Utara (North Jakarta)
- TI: Timur (East Jakarta)
- BA: Barat (West Jakarta)
- PU: Pusat (Central Jakarta)
- SE: Selatan (South Jakarta)
- TA: Tangerang
- BE: Bekasi



Source: The Project Team

Figure 6-1 Critical Zones (2007-2020) (Reshown)

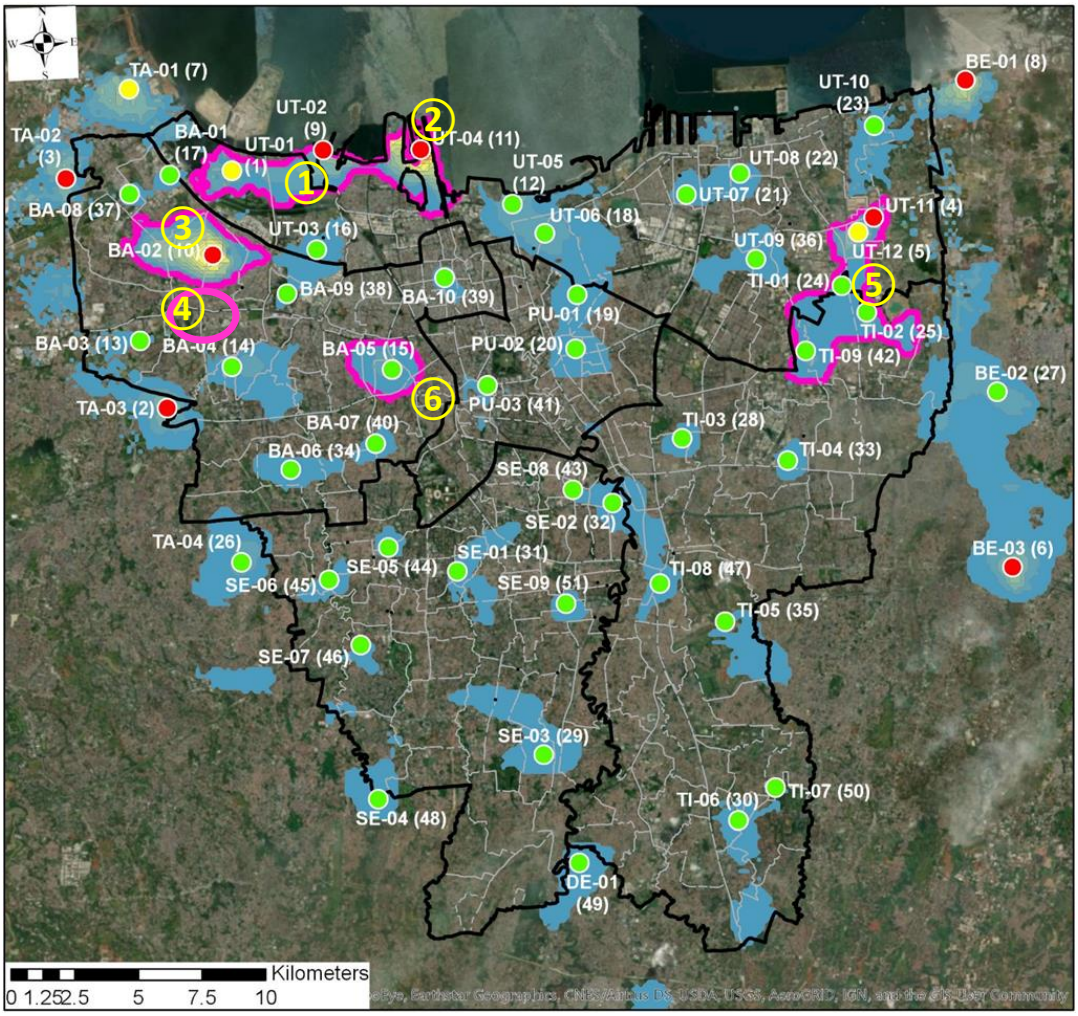
Through the discussion with counterparts, the pilot areas are selected out of the critical zones based on the following consideration/criteria.

(1) Critical Zone A or B
(2) Residential Area (Rich)
(3) Residential Area (Poor)
(4) Industrial Area
(5) Commercial Area
(6) Land subsidence already stopped
(7) Potential Land Subsidence Area with City Development Program
(8) The Most Severe Land Subsidence Area

Six areas were selected with the above consideration/criteria and approved in the 3rd JCC Meeting. The characteristics of six pilot areas and location are summarized in Table 6-1 and Figure 6-2, respectively. Figure 6-3 shows the land subsidence rates in pilot areas.

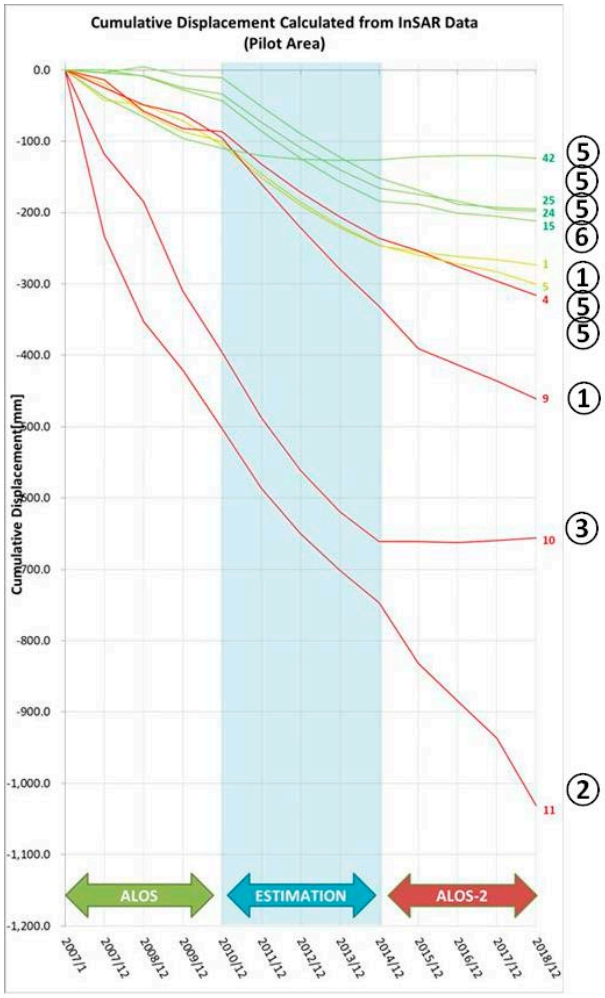
Table 6-1 Selection of Pilot Areas

	Area (Sub-district)	City	Characteristics	Reason
①	Panjaringan	North	Coastal areas near WBC, high-class residences and commercial areas in western part, high-rise apartment, golf course, leisure pool, fish market, low-income class residential areas in eastern part	Example of low/high classes residential areas
②	Jakarta Fishing Port (Panjaringan)	North	Reclaimed land, fishery process factories, fish market	Most severe land subsidence area
③	Cengkareng	West	Subsided severely in 2007-2010 but stopped in 2014-2020	Successful example
④	Daan Magot Area (Cengkareng)	West	Large apartment construction using groundwater, DKI plans integrated water management using artificial pond	For monitoring of DKI activities
⑤	Cilincing/Cakung	North/East	Severe land subsidence in industrial area	Example of industrial area
⑥	Palmerah/Grogol Petamburan	West	Large-scale commercial facilities (shopping mall, hotel, office, apartment)	Example of commercial area



Source: The Project Team

Figure 6-2 Location of Pilot Areas



Source: The Project Team

Figure 6-3 Land Subsidence Rates in Pilot Areas

6.2.2 Short Term Action Plan

(1) Planning of Short Term Action Plans

Based on the various analysis/study results in the 1st stage of the Project and considering the characteristics of the selected pilot areas, the short-term action plans were formulated for each pilot area. Besides, several action plans for the whole DKI were also planned.

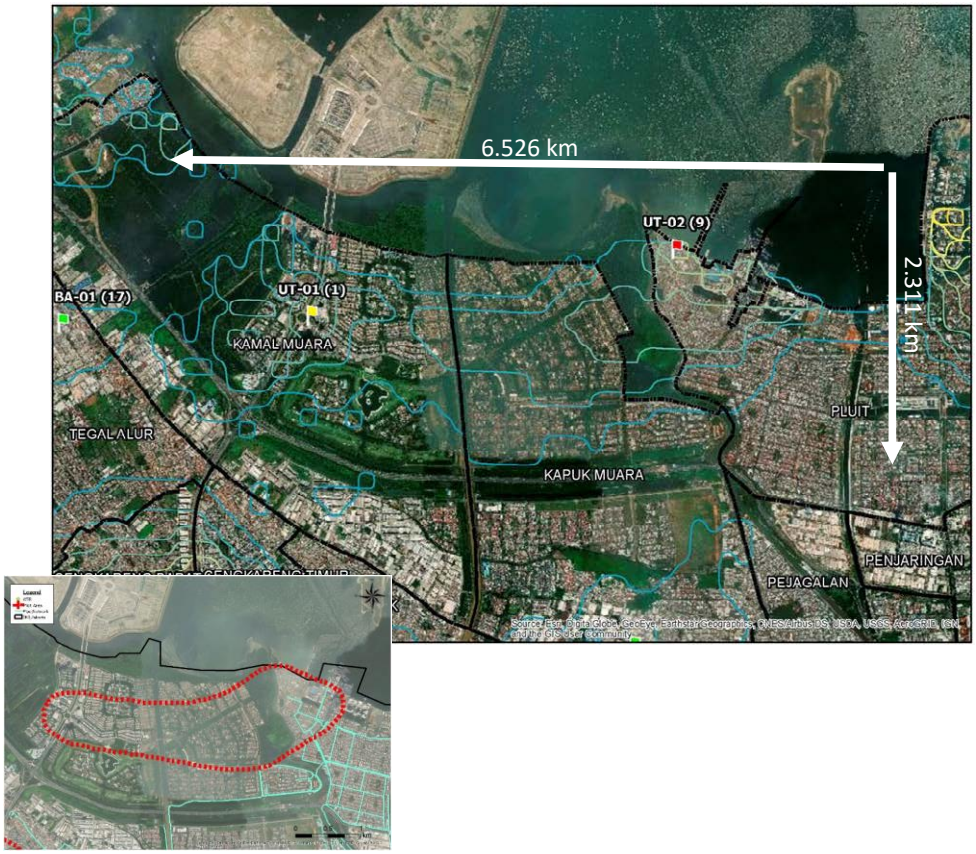
1) Panjaringan Area

The pilot area in Panjaringan is shown in Figure 6-4. This area is a coastal area locating at the river mouth of West Banjir Canal (WBC). There are high-class residential and commercial areas on the west side, while there is a low-income residential areas on the east side. Large water consumption is expected from the large apartment buildings at the east end of area, golf course, leisure pool and fish market.

The following activities were proposed as short-term measures for the Panjaringan area.

(1) Inspection of Large Facilities by DKI Jakarta
(2) Installation of *"Kios Air"* in Low-income Residential Area
(3) Rainwater Storage Facilities using Roof of Fish Market ⇒ Alternative Water Supply to Low-income Residential Area
(4) Awareness Raising Activities
(5) Well Registration Campaign

"*Kios Air*" is a water supply service conducted by PAM Jaya mainly for low-income residential areas without pipe water service. PAM Jaya installs large water tank and conveys water by truck, and water is sold per 20-L bottle called as "*Jeri Gen*" in local terms. The system is suitable for low-income residential areas including slum areas where installation of pipe water is relatively difficult due to road conditions. The system also contribute as an employment measure in low-income areas. The system can also be considered as a short-term measure and the Project would support DKI Jakarta and PAM Jaya for the dissemination of the "*Kios Air*".



Source: The Project Team

Figure 6-4 Panjaringan Area

2) Jakarta Fishing Port Area

The Jakarta Fishing Port Area is shown in Figure 6-5. This area is the most affected area by severe land subsidence in DKI Jakarta during 2007-2018. The fishing port area, so called as Samudera Nizam Zachman, is a reclaimed area and has many fishery processing factories, which is expected to be a large water consumer. Thus, the following activities were proposed as the short-term measures.

(1) Establishment of Joint Coordination Committee by Ministry of Maritime Affairs and Fisheries (KKP), Ministry of State Owned Enterprises (BUMN) and DKI Jakarta
(2) Workshop to Fishery Processing Factories
(3) Inspection of Fishery Processing Factories by DKI Jakarta
(4) Monitoring of Periodical Leveling Survey
(5) Review of Water Tariff
(6) Introduction of Rainwater Harvesting



Source: the Project Team

Figure 6-5 Jakarta Fishing Port Area

As shown in Table 6-2, Jakarta Fishing Port, which is managed by the Ministry of Maritime Affairs and Fisheries of Indonesia, is a fishing port that has been developed under Japan's ODA Loan Projects. More than 100 companies operate in this port, and the total number of employees in the whole company exceeds 40,000. It exports about 100 million yen a day and considered as a socially and economically important base.

Table 6-2 History of Development of Nizam Zachman by Japan's ODA Loan

Year of L.A.	Project
1977	Engineering Service
1979	1st Stage (Reclamation, Dredging, Bank Protection, Coat Levee, Quay)
1980	2nd Stage (Refrigerator, Buildings/Structures, Facilities)
1985	3rd Stage (Engineering Services)
1993	4th Stage (Fishery Infrastructure, Sanitary Facilities)
2004	Rehabilitation (Land Subsidence Countermeasure such as heightening)

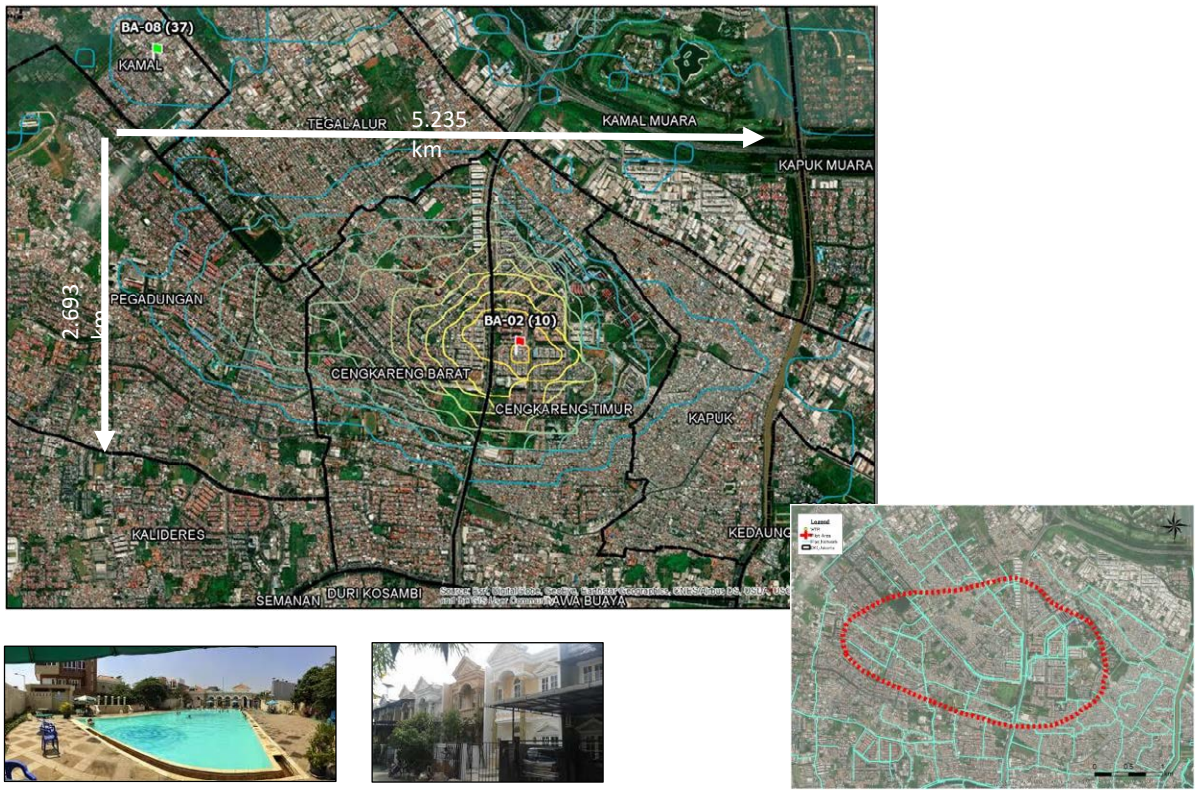
Source: The Project Team

In the fishing port, some companies still use groundwater. According to interviews with Japanese consultants who have long been involved in the development of the fishing port, consolidation settlement by landfill might have already stopped. It is speculated that land subsidence continues due to groundwater abstraction, including the possibility of unregistered wells. In the fishing port, a 300 m-deep benchmark was set up in August 2009, which has caused a phenomenon of "Apparent-Lifting-up". This can also function as a single-tube subsidence observation well in the future.

Summarizing the above, (1) the Jakarta Fishing Port is a socially and economically important base where land subsidence is remarkable, (2) the land subsidence in the area may be caused by groundwater abstraction, and (3) there is an existing land subsidence monitoring well. Therefore, if mitigation of the land subsidence by controlling of groundwater abstraction in the Jakarta Fishing Port can be confirmed, an example of effective countermeasures against land subsidence can be made. It can also contribute to the community in terms of preventing social and economic losses in the region.

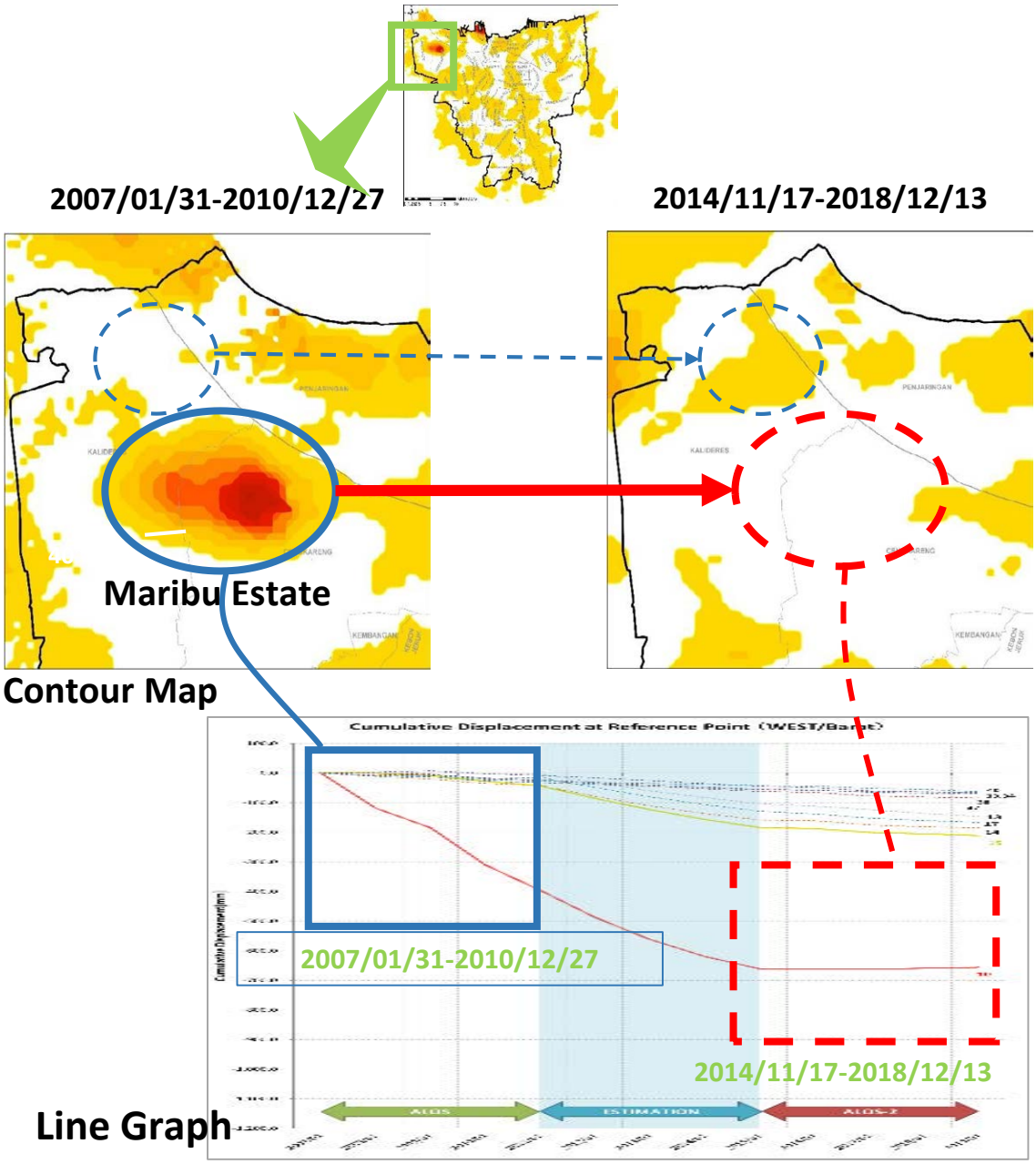
3) Cengkareng Area

The Cengkareng Area is a residential area shown in Figure 6-6. According to InSAR analysis, land subsidence was severe from 2007 to 2011; however, it stopped from 2014 to 2018 as shown in Figure 6-7. It is said that water supply service started between these two periods. Since there is a possibility to treat this area as a good example to stop land subsidence through water supply development, a survey on the cause of stop of land subsidence and consequent preparation of public relation materials would be conducted in this area.



Source: The Project Team

Figure 6-6 Cengkareng Area



Source: The Project Team

Figure 6-7 Calming Down of Land Subsidence in Cengkareng Area

4) Daan Magot Area

In Daan Magot Area, DKI Jakarta planned an integrated water management system for new housing complex using artificial reservoir for water supply, wastewater treatment, flood control and public space. Conceptual drawing and location are shown in Figure 6-8. The total area of the development site is approximately 17 ha and the construction was completed in 2020. Review and recommendation/ suggestion would be conducted in the Project to prevent land subsidence through this development.



Figure 6-8 Conceptual Drawing and Location of Housing Complex Development in Daan Magot Area

5) Cilincing/Cakung Area

The map of Cilincing/Cakung Area is shown in Figure 6-9. This area is an industrial area, where land subsidence is remarkable. The following short-term measures were planned in the Cilincing/Cakung Area.

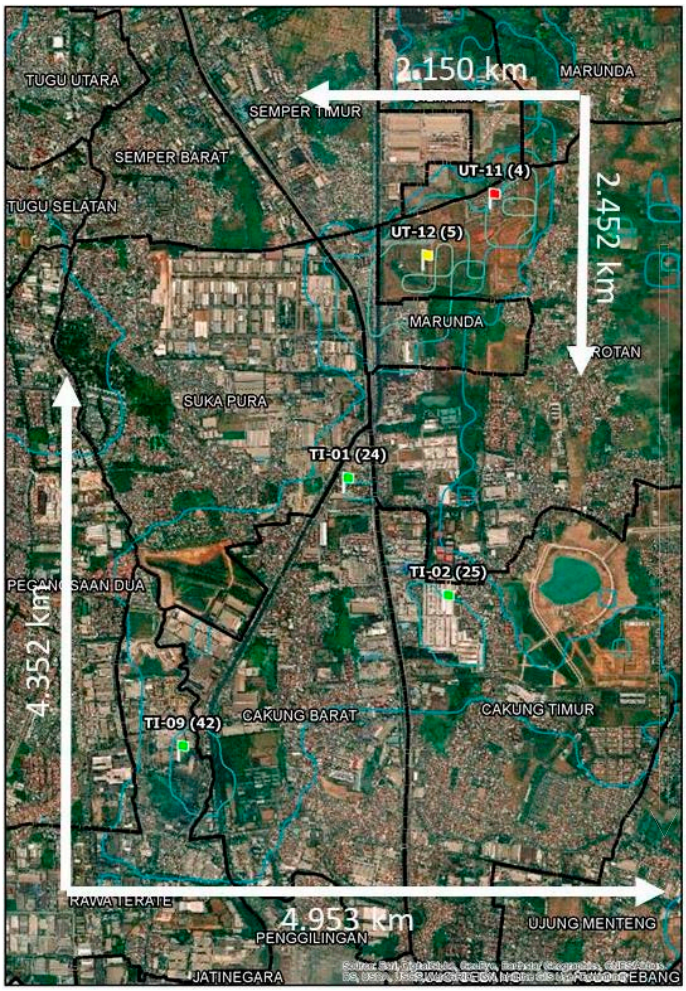
(1) Inspection of Factories by DKI Jakarta

(2) Survey and Introduction of Rainwater Harvesting and Recycling

(3) Awareness Raising Activities

(4) Well Registration Campaign







← **Middle Scale industry Area (Cilincing Area)**

Source: The Project Team

Figure 6-9 Cilincing/Cakung Area

6) Palmerah Area

Palmerah Area is a dense commercial area consisting of a big shopping mall named "*Taman Anggrek*", offices, hotels and apartments.

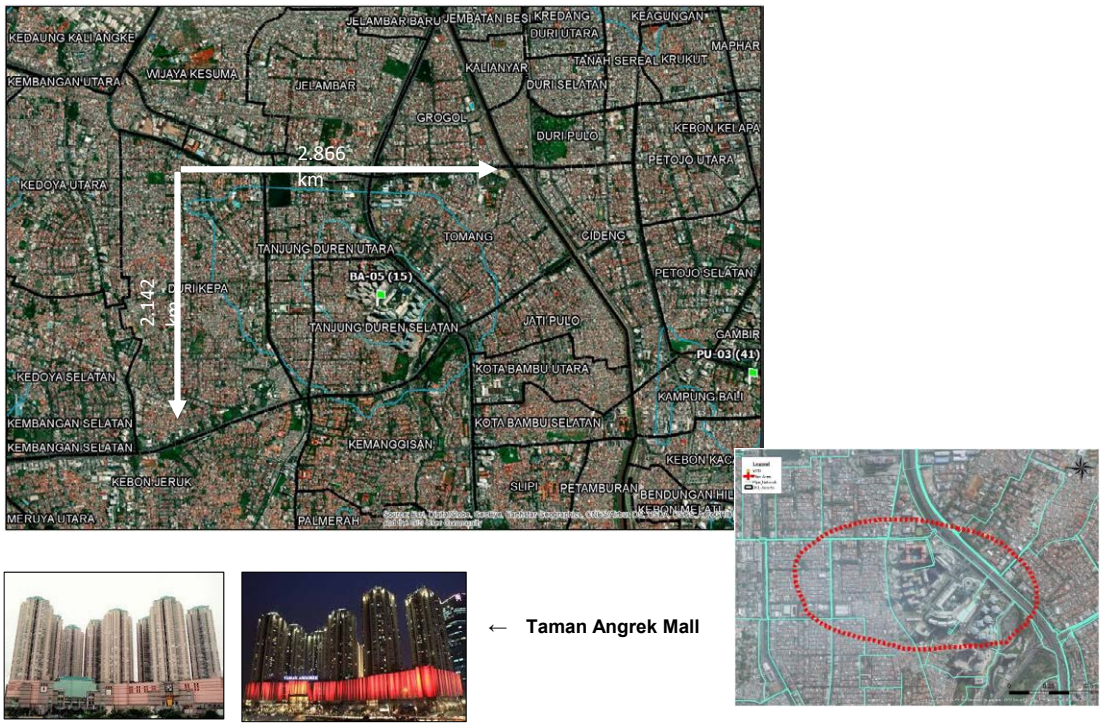
The following short-term measures were planned.

(1) Inspection of Commercial Buildings by DKI Jakarta

(2) Survey and Introduction of Rainwater Harvesting and Recycling

(3) Awareness Raising Activities

(4) Well Registration Campaign



Source: the Project Team

Figure 6-10 Palmerah Area

7) Short Term Action Plans for the Whole DKI Jakarta

Aside from the short-term action plans in the pilot areas, the following activities were planned as the short-term action plans for the whole DKI:

- Preparation of materials for awareness raising and other related activities
- Well Registration Campaign

(2) Implementation of Short Term Action Plan

The proposed action plans mentioned above were approved in the JCC3 and commenced in November 2019. Due to the restriction of social activities by COVID-19 pandemic, some activities could not have been implemented as planned; however, some activities have been implemented with acceleration of increase of awareness of land subsidence among the Indonesian society. The activities, progress and outputs of the remarkable short-term action plan were discussed in detail in the previous chapters. They were also summarized in Table 6-3 and Table 6-4. The outputs and lessons from the implementation of short-term action plan were referred to the proposal of mid and long-term action plans.

Table 6-3 Outputs and Issues of Short-term Measures in Pilot Areas

Area	Action Plan	Outputs	Evaluation and Issues
Common	Awareness Raising	**Workshops were held in North, West and East JKT City**	Follow up meetings could not be held in North and East Jakarta. Periodical meeting shall be held.
	Registration Campaign	Not yet done	Implementation plan is required.
1. Panjaringan	Joint Inspection	Request letter was submitted but not yet implemented.	Organizing of inspection team through law enforcing of the Governors Regulation.
	Kios Air	**Introduced in WS.**	Introduced by DKI and PAM Jaya
	Rainwater Harvesting	**Introduced in WS.**	Extended based on the experience in Daan Magot.
2. JKT Fishing Port	Establishment of Committee by Relevant Agencies	**Coordination meetings with Ministry of Fishery and JKT Fishing Port were held.**	Periodical meetings/discussions have been conducted.
	Workshop for Fish Processing Factories	**Questionnaire and interview were held.**	Socialization to be held after construction of additional monitoring wells.
	Management of periodical leveling survey.	Not yet done	Shall be discussed with Fishing Port
	Review Water Tariff	**Interview with State-owned Company was conducted.**	Continuous dialogue shall be made.
	Introduction of Rainwater Use	**Existing rainwater use system was studied.**	Shall be introduced in WS.
3. Cengkareng	Study on How Land Subsidence Stopped	**Interview started.**	Continue interview by DKI.
	Preparation of Materials for Public Awareness	Not yet done	Material shall be prepared based on interview.
4. Daan Magot	Rainwater Harvesting System	**Constructed in the Project**	Extended to other areas
5. Cilincing, Cakung	Joint Inspection	Request letter was submitted but not yet implemented.	Organization of inspection team through law enforcing of the Governors Regulation.
	Introduction of Rainwater Use	Not yet done	Extended based on the experience in Daan Magot.
6. Palmerah	Joint Inspection	**Workshop was held.**	Organization of inspection team through law enforcing of the Governors Regulation.
	Introduction of Rainwater Use	Not yet done	Extended based on the experience in Daan Magot.

Remarks: Bold red text means remarkable progress and outputs.
Source: The Project Team

Table 6-4 Outputs and Issues of Short-term Measures for Whole DKI

WG	Action Plan	Progress	Evaluation and Issues
WG1	Data Integration to MONAS	**Data of JICA was prepared and is now under integration. Data sharing was discussed with DKI.**	Method of data sharing with DKI and others shall be discussed.
	Assistance for Land Subsidence Monitoring Report	**Format is ready and technical transfer is done.**	Report preparation by DSDA
	Construction of Monitoring Wells by DKI	**Additional monitoring well was constructed through the Project.**	Construction of additional wells by PUPR and DKI.
WG2	Study on Non-Revenue Water and Recommendation	Not yet done	To be conducted after PAM Jaya reprivatization
	Alternative Water Resources (AWR)	**Monitoring of AWR Projects. Introduction of Rainwater Harvesting**	Continuous monitoring and extended based on the experience in Daan Magot.
WG3	Preparation of Hazard Map	**Hazard map was drafted**	Published as awareness material through website
	Estimation of Social Cost	**Social cost was estimated**	Used for awareness raising.
WG4	Signboards	**Signboards were installed in Kota Area through the Project**	Awareness raising activities by PIC
	Preparation of Materials for Public Awareness	**Website and signboard were prepared.**	Update/upgrading contents of web site.
WG5	Assistance for PIC Establishment	**Reorganized due to restructuring**	Consensus in JCC5
	Establishment of Mid-Long Term Action Plan	**Formulated**	Consensus in JCC5 and implementation plan.

Remarks: Bold red text means remarkable progress and outputs.
Source: The Project Team

CHAPTER 7 PIC ESTABLISHMENT AND ACTION PLAN

7.1 Establishment of Planning and Implementation Committee (PIC)

The Planning and Implementation Committee (PIC) was expected to have same structure with JCC. However, drastic restructuring was made in 2020 for both DKI and PUPR. And it was pointed out that the arrangement of activities was difficult because the JCC consists of 67 organizations and 38 members (note: some organizations belongs to several WG). Under this circumstances, reorganization of PIC was discussed and the followings were proposed in the JCC4 and detailed action plans and organization were agreed in JCC5. The organization and action plans will be approved and the member will be appointed by the minister of PUPR.

7.2 Structure of Working Group (WG)

The JCC consists of 5 WG namely WG1: Monitoring, WG2: Mitigation Measures, WG3: Adaptation Measures, WG4: Awareness Raising, and WG5: Secretariat. Many organizations belong to more than one WG resulting inefficient management. Thus, the structure of PIC changes into three WG considering the relations among the WG in the JCC, namely WG1: Monitoring & Awareness Raising, WG2: Mitigation & Adaptation Measures, and WG3: Secretariat.

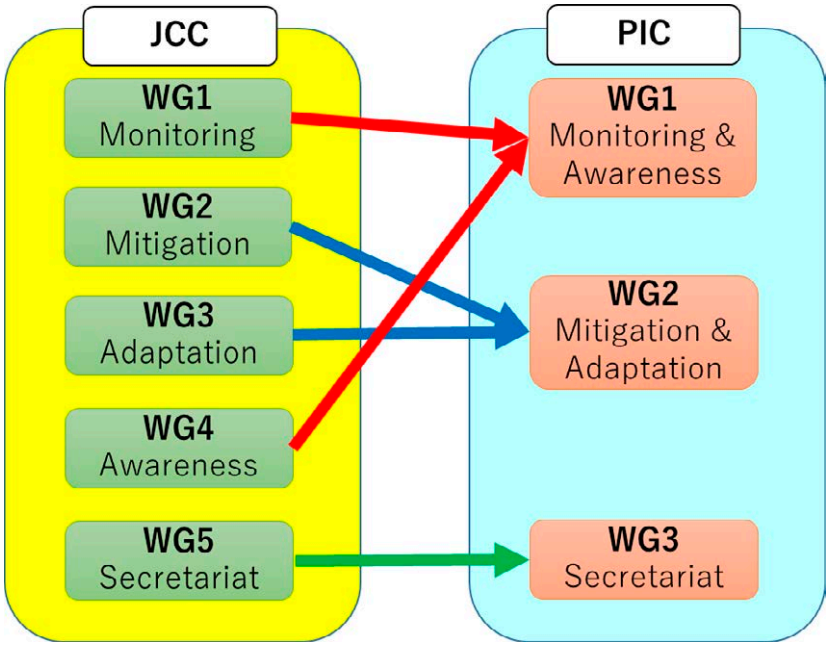


Figure 7-1 Structure of PIC

7.3 Objective and Role of PIC

For better understanding of relevant organization, the objective and role of PIC were re-established with referring the super goal of the Project mentioned in the Record of Discussion concluded between the Indonesian Government and JICA.

- To implement action plan for countermeasures against land subsidence in Jakarta
- To disseminate the experience of land subsidence countermeasures in Jakarta to other cities suffering from land subsidence

The major tasks of PIC are as follows.

- Implementation of the Action Plans by WG
- Evaluation, updating and review of the Action Plan
- Implementation of capacity building programs
- Extension to the other areas

7.4 Action Plans and Structure of Working Group

According to the restructuring of DKI and PUPR and change of roles of WG, structure, programs and actions, executing agencies, budgeting and implementation periods (short: within 3 years, middle: 3 to 10 years, long: after 10 years) were formulated through intensive discussions with relevant agencies. As the executing agencies for each action, a main agency, sub agencies and support agencies are designated. The support agencies are not to be PIC members but to support specific actions.

7.4.1 WG1: Monitoring and Public Awareness

(1) Program: Monitoring and Analysis

This program consists of monitoring using monitoring wells constructed by the Project, InSAR analysis, reporting of monitoring results, data integration and analysis. The major executing agencies are Water Resources Agency, DKI Jakarta (Dinas SDA), Directorate of Groundwater and Bulk Water, Directorate General of Water Resources, PUPR (ATAB), Directorate of Water Resources Engineering Development, Directorate General of Water Resources, PUPR (Bintek SDA), Center for Groundwater and Environmental Geology, Geological Agency, Ministry of Energy and Mineral Resources (PATGTL), and Groundwater Conservation Office under PATGTL (BKAT). InSAR analysis will be implemented with cooperation from related scientific institutions and universities.

Data integration of DKI Jakarta's data into the system called as PASTI operated by BKAT has been discussed during the Project. On the other hand, PUPR has intention to share data by other ways. Thus, these activities are divided.

Table 7-1 WG1: Monitoring and Analysis Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Continues Monitoring	Collecting data from 3 existing monitoring wells on monthly basis	Dinas SDA ATAB		APBD APBN	→	→	→
2.		Regular maintenance of monitoring wells by JICA referring to JICA guideline on OP & Data management	Dinas SDA	ATAB	APBD	→	→	→
3.		Calibration of monitoring system (AWLR, data logger, sensor) on annual basis	Dinas SDA	Bintek SDA, ATAB	APBD	→	→	→
4.		Install telemetry system for 3 existing monitoring wells (Cakung, Cengkareng and Muara Baru)	ATAB	Dinas SDA	APBN	→		
5.		Improve electrical system for 3 existing monitoring wells	Dinas SDA		APBD	→		
6.		GNSS survey in the monitoring well to compare monitoring well result on annual basis	BKAT	Dinas SDA, ITB	APBN	→	→	→
7.		Conduct InSAR analysis to monitor overall land subsidence condition in Jakarta	PATGTL	LAPAN, BIG, BRIN, ITB, Dinas SDA, BKAT	APBN		→	→
8.	Report Monitoring Data	Prepare simple monthly report for monitoring's result (excel format is available by JICA Team)	Dinas SDA	BKAT, ATAB	APBD	→	→	→
9.		Prepare annual report for monitoring result and GNSS survey	BKAT	ATAB, Dinas SDA	APBN	→	→	→
10.	Integrate Data to Monitoring System	Integrate monitoring data into PASTI (by BKAT)	BKAT	Dinas SDA	APBN	→	→	→
11.		Prepare database of PUPR to store land subsidence monitoring data	Bintek SDA	ATAB	APBN	→		
12.		Prepare & Implement agreement on data sharing between related ministries (who & how to access)	Bintek SDA	Dinas SDA, BKAT, ATAB	APBN	→	→	
13.	Data Analysis	Analyze the relationship between land subsidence and groundwater utilization based on result of monitoring data	ATAB	BKAT	APBN		→	→
14.		Determine the land subsidence rate in Jakarta by analyzing the monitoring data, INSAR and GNSS survey.	ATAB	Dinas SDA, BKAT	APBN		→	→

Remarks: LAPAN: National Institute of Aeronautics and Space, BIG: Geospatial Information Agency, BRIN: National Research and Innovation, ITB: Bandung Institute of Technology
APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(2) Program: Additional Land Subsidence Monitoring Well

As described in Sub-section 2.5.3, 15 monitoring well are planned as priority monitoring locations. One additional monitoring well was constructed by the Project in the Phase 2. Thus, remaining 14 monitoring well shall be constructed by relevant agencies with coordination for locations, land acquisition and data sharing.

Table 7-2 WG1: Additional Land Subsidence Monitoring Well Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Construct More Wells in Priority Area	Construction of 14 monitoring wells (or more as required)	BKAT, ATAB, Dinas SDA		APBN APBD	→	→	→

Remarks: APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(3) Program: Public Awareness

This program consists of construction of signboards, web site operation, workshops/seminars that were conducted in the Project. Public campaign, which could not be implemented in the Project due to COVID-19 pandemic, is also expected to be implemented. Since these actions will target civil servants and residents of DKI Jakarta, the main agencies are the agencies of DKI Jakarta such as Dinas SDA, Communication, Informatics and Statistic Agency (Diskominfotik) and Bureau for Development and Environment (Biro PLH). The central government agencies will support these activities as sub agencies.

Table 7-3 WG1: Public Awareness Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Signboard Instalment	Install more signboards in public spaces to increase public awareness on land subsidence	Dinas SDA	ATAB, BKAT	APBD	→		
2.	Prepare public friendly campaign materials	Prepare leaflet & other materials on land subsidence and distribute to public	Diskominfotik	Dinas SDA, ATAB	APBD	→		
3.	Operate Website	Update monitoring data and other land subsidence related information in website of Dinas SDA (guideline is available)	Dinas SDA, Diskominfotik	Bintek SDA, ATAB	APBD	→		
4.	Socialization / Workshops	Conduct regular socialization to community incl. factories located in high risk area	Biro PLH DKI	Dinas SDA, PAM Jaya, Walikota	APBD	→		

Remarks: APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(4) Structure of WG1

WG1 consists of the following members. PATGTL is the leader and secretariat of WG1 and has roles of hosting of WG meetings, reporting to the steering committee and facilitation of WG1 implementation plan.

- Leader : Center for Groundwater and Environmental Geology, Geological Agency, Ministry of Energy and Mineral Resources (PATGTL)
- Member : Directorate of Water Resources Engineering Development, Directorate General of Water Resources, PUPR (Bintek SDA)
- Member : Directorate of Groundwater and Bulk Water, Directorate General of Water Resources, PUPR (ATAB)
- Member : Groundwater Conservation Office under PATGTL (BKAT)
- Member : Water Resources Agency, DKI Jakarta (Dinas SDA)
- Member : Communication, Informatics and Statistic Agency, DKI Jakarta (Diskominfotik)
- Member : Bureau for Development and Environment, DKI Jakarta (Biro PLH)

7.4.2 WG2: Mitigation and Adaptation Measures

(1) Program: Implementation and Expansion of Groundwater Regulation

The DKI Jakarta Governor Regulation on Zero Deep Well was established during the Project, which prohibits construction and utilization of deep wells in designated areas. The program aims to implement the regulation and to expand the target areas. All the executing agencies are the DKI Jakarta agencies because the regulation is the local government regulation

Table 7-4 WG2: Implementation and Expansion of Groundwater Regulation Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Implementation of Pergub Zero Deep Well	Implementation and Law Enforcement on Pergub Zero Deep Well	Dinas SDA	Biro PLH, Satpol PP, Dinas Citata, PAM Jaya, Walikota	APBD	→	→	
2.	Expansion of area based on Hazard map & water supply coverage	Revise Pergub Zero Deep Well to include all land subsidence risky area in the future	Dinas SDA, Biro PLH	PAM Jaya, Biro Hukum, Biro PLH	APBD			→

Remarks: Satopol PP: Local Government Police, Dinas Citata: Human Settlements, Spatial Planning and Land Agency, PAM Jaya: Water Supply Corporation, Walikota: City Office, Biro Hukum: Legal Bureau
APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(2) Program: Alternative Water Resources

Rainwater utilization as a short term alternative water resource was promoted in the Project such as the construction of rainwater harvesting (RWH) system and discussion on applicability of RWH in the workshop in West Jakarta City. During the construction, future implementation by self-efforts by DKI Jakarta was also discussed. Besides, it is confirmed by the study conducted by Japanese government that the operation improvement of 3 dams in Citarum River makes additional water supply capacity. Beside the current program for the large scale water resources development project by Indonesian Government, the program consists such actions for reduction of groundwater use. The operation improvement of 3 dams in Citarum River will be implemented by Directorate of Operation and Maintenance, Directorate General of Water Resources, PUPR (OP SDA), which has the task of operation and maintenance of water resources facilities/structures.

Table 7-5 WG2: Alternative Water Resources Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Rainwater storage, rational water use	Continue the maintenance of rain water harvesting (RWH) facility in Mosque KH. Hasyim Asy'ari (Pesakih)	UPT Masjid (Dinas Sosial)	Dinas SDA	APBD	→	→	→
2.		Promote the development of RWH by referring to JICA's case study (RWH Pesakih) as alternative water resources for the community needs who lived in land subsidence severely affected area.	Dinas SDA	DPRKP, Biro KSD, Biro PLH, ATAB	APBD	→	→	→
3.		Promote CSR activities for rain water harvesting facility, recycle and reduce/misused of water to increase water use efficiency.	Biro KSD	Dinas SDA, Dinas Citata, Walikota, Biro PLH	APBD	→	→	
4.		Examining measures to promote installation of rainwater harvesting systems, such as incentive for factories/buildings	Bapenda	Dinas SDA, ATAB	APBD			→
5.	Dam Operation (inc. water resources dev.)	Dam rationalization operation to increase water supply	OP SDA	Bintek SDA, ATAB	APBN		→	→
6	Another alter. Water resources	Study and implementation on another alternative water resources such as utilization of Situ / Lake	ATAB, Dinas SDA		APBN APBD		→	→

Remarks: UPT Masjid: Management of Mosque, Dinas Social: Social Agency, DPRKP: Public Housing and Settlement Agency, Biro KSD: Bureau for Regional Cooperation, Dinas Citata: Human Settlements, Spatial Planning and Land Agency, Walikota: City Office, Bapenda: Regional Revenue Agency
APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(3) Program: Water Supply Improvement

Water supply development and sound operation are inevitable for reduction of groundwater use. Although the prospect of PAM Jaya after republification in 2023 is uncertain, cooperative efforts by related agencies are important for improvement of water supply such as improvement of coverage, countermeasures against non-revenue water, formulation of water supply master plan and the Regional SPAM. The installation of *Kios Air* is important in the aspects of basic human needs and SDGs as well as reduction of groundwater use. These activities shall be implemented in the short and middle term.

Table 7-6 WG2: Water Supply Improvement Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Kios Air for low income group	Utilize information of severe area of land subsidence and provide water supply	PAM Jaya	Dinas SDA	APBD	→	→	
2.		Expand the program to other risky area	PAM Jaya	Dinas SDA	APBD		→	→
3.	Measures against NRW	Measures against water leakage, Improvement of water tariff collection	PAM Jaya	Dinas SDA	APBD	→		
4.	Formulation of RISPAM DKI	Review of Water Supply MP	Dinas SDA	PAM Jaya, Direktorat Air Minum	APBD	→		
5.	Expansion of WTP and Development of Regional SPAM in DKI	Jatiluhur I, Karian Serpong, Jatiluhur II/ Djuanda	PAM Jaya, ATAB, Direktorat Air Minum	BPBUMD DKI Jakarta, Dinas SDA	APBD, APBN		→	→

Remarks: Direktorat Air Minum: Directorate of Water Supply, Directorate General of Human Settlements, PUPR, BPBUMD: Regional Public Corporation Agency
APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(4) Program: Countermeasures against Water related Disasters

The inundation risk map was made in the Project and it shall be reviewed in the future. Besides, various flood and high tide countermeasures taken by Indonesian Government shall be continued and enhanced. In the Project, the survey on acceleration of flood control MP in JABODETABEK was conducted. The proposal in this survey shall be implemented in near future.

Table 7-7 WG2: Water Supply Improvement Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Flood Risk Map considering Land Subsidence & Climate Change	Prepare hazard map of land subsidence	PATGTL	Bintek SDA, Supan, ATAB	APBN		→	→
		Prepare flood risk/ inundation map	BHLK, BTS	BRIN, BIG, Bintek SDA, BBWS Cilicis, BNPB, ATR	APBN		→	→
2.	Flood & High Tide countermeasures	Design flood countermeasure considering land subsidence's rate	BBWS Cilicis, Dinas SDA	Supan	APBN APBD	→	→	→

Remarks: Supan: Directorate of River and Coast, Directorate General of Water Resources, PUPR, BHLK: Technical Implementation Unit for Hydrology and Water Environment, Directorate General of Water Resources, PUPR, BTS: Technical Implementation Unit for Rivers, Directorate General of Water Resources, PUPR, BBWS CilCis: River Basin Organization (RBO) of Ciliwung Cisadane River, Directorate General of Water Resources, PUPR, BNPB: National Disaster Management Agency, ATR: Ministry of Agrarian and Spatial Planning / National Land Agency
APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

(5) Structure of WG2

WG2 consists of the following members. ATAB is the leader and secretariat of WG2.

- Leader : Directorate of Groundwater and Bulk Water, Directorate General of Water Resources, PUPR (ATAB)
- Member : Directorate of Operation and Maintenance, Directorate General of Water Resources, PUPR (OP SDA)
- Member : Technical Implementation Unit for Hydrology and Water Environment, Directorate General of Water Resources, PUPR (BHLK)
- Member : River Basin Organization (RBO) of Ciliwung Cisadane River, Directorate General of Water Resources, PUPR (BBWS CilCis)
- Member : Center for Groundwater and Environmental Geology, Geological Agency, Ministry of Energy and Mineral Resources (PATGTL)
- Member : Water Resources Agency, DKI Jakarta (Dinas SDA)
- Member : Water Supply Corporation (PAM Jaya)
- Member : Bureau for Development and Environment, DKI Jakarta (Biro PLH)
- Member : Bureau for Regional Cooperation, DKI Jakarta (Bir KSD)
- Member : Regional Revenue Agency, DKI Jakarta (Bapenda)

7.4.3 WG3: Secretariat

WG3, as the secretariat of PIC, has roles of coordination of whole PIC, supervision of budgeting and dissemination to other cities. The dissemination activities will be implemented by the central government agencies and DKI Jakarta will support by teaching experiences and lessons.

Table 7-8 WG3: Coordination Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Facilitating work plan coordination meeting between working group	Coordinating the formulation of action plan among all members of Working Group	Bintek SDA	Bappeda DKI, Dinas SDA	APBN	→		
2.		Conduct regular annual meeting on the progress result of each working group	Bintek SDA	Biro PLH DKI	APBN	→		

Remarks: Bappeda: Regional Planning Bureau
APBN: National Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

Table 7-9 WG3: Budgeting Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Programming annual budget for related institution	Coordinate the preparation of Programs & annual budget of each respective working groups / institutions.	SS PSDA Bappeda, Bintek SDA,	Biro PLH DKI	APBN	→		
2.	Monitoring budget allocation of related institution		SS PSDA, Bappeda	Bintek SDA, Biro PLH DKI	APBN	→		

Remarks: SS PSDA: Directorate of Water Resources Management System and Strategy, Directorate General of Water Resources, PUPR, Bappeda: Regional Planning Bureau
APBN: National Government Budget, APBD: Local Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

Table 7-10 WG3: Dissemination Program

No	Activities	Sub Activities	Executing Agency		Funding Source	Implementation Period		
			Main	Sub/Support		Short	Med	Long
1.	Expansion of Disseminating project results to outside Jakarta	Sharing lesson learned from JICA Project to other future land subsidence monitoring efforts in all of Indonesia	Bintek SDA	PATGTL	APBN	→	→	→
2.	Annual Report	Prepare annual report of all WG activities for sharing achievement & future targets and distribute to all related stakeholders	Bintek SDA		APBN	→	→	→

Remarks: APBN: National Government Budget
Short: within 3 years, Med: 3 to 10 years, Long: 10 years and after

- Leader : Directorate of Water Resources Engineering Development, Directorate General of Water Resources, PUPR (Bintek SDA)
- Member : Directorate of Water Resources Management System and Strategy, Directorate General of Water Resources, PUPR (SS PSDA)
- Member : Directorate of Groundwater and Bulk Water, Directorate General of Water Resources, PUPR (ATAB)
- Member : Center for Groundwater and Environmental Geology, Geological Agency, Ministry of Energy and Mineral Resources (PATGTL)
- Member : Regional Planning Bureau, DKI Jakarta (Bappeda)
- Member : Water Resources Agency, DKI Jakarta (Dinas SDA)
- Member : Bureau for Development and Environment, DKI Jakarta (Biro PLH)

7.5 Steering Committee

In order to initiate and superintend the PIC operation, a steering committee is established consisting of decision makers of main and coordinating agencies. Beside PUPR, DKI and ESDM, Ministry of National Development Planning / National Development Planning Agency (BAPPENAS) and Coordinating Ministry for Maritime & Investment Affairs (Kemenko Marves) join the steering committee as coordination agencies.

- Chairman : Director General of Water Resources, PUPR
- Vice Chairman : Regional Secretary of DKI Jakarta
- Member : Deputy for Facility and Infrastructure, BAPPENAS
- Member : Head of Geological Agency, ESDM
- Member : Deputy for Coordination on Environmental Management & Forestry, Kemenko Marves

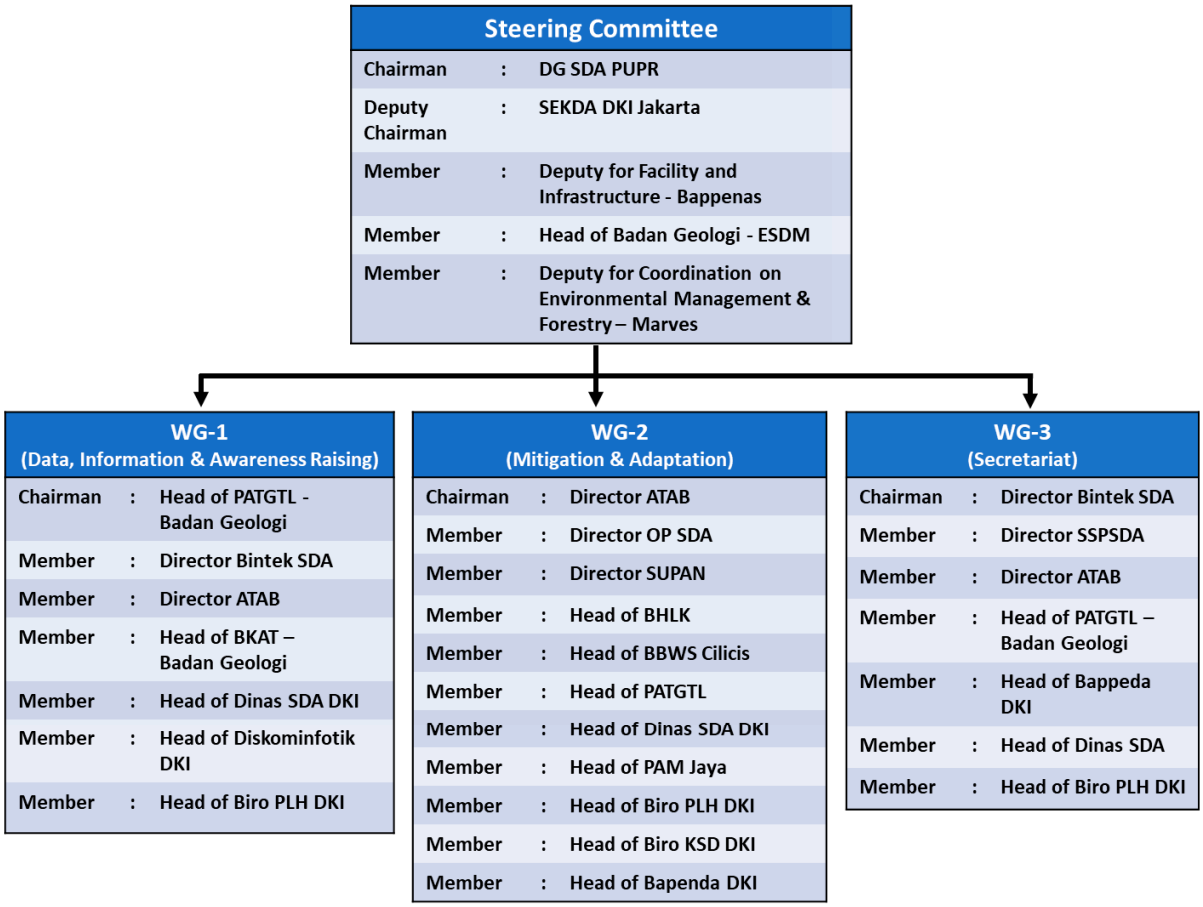


Figure 7-2 Organization of PIC

【Appendix1】JCC MINUTES OF MEETINGS

MINUTES OF MEETING
ON
PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA

AGREED UPON BETWEEN

AUTHORITIES CONCERNED IN INDONESIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
PROJECT TEAM OF JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA PROJECT TEAM)

Jakarta, May 22, 2018

Dr. Kenji Nagata
Senior Advisor
Global Environment Department
Japan International Cooperation Agency

Ir. Imam Santoso, M.Sc
Director General of Water Resources, DGWR
Ministry of Public Works and Housing

Mr. Takeshi Watanabe
Team Leader/Integrated Water Resources Management-1
JICA Project Team of the Project

Dr. H. Saefullah, M.Pd
Regional Secretary
Special Capital Province of Jakarta

In response to the official request submitted by Indonesian Government, Record of Discussion (hereinafter referred to as "R/D") on PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA (hereinafter referred to as "the Project") was signed on July 27, 2017 between the Indonesian Side (Ministry of Public Works, Ministry of Energy and Mineral and Special Capital Province of Jakarta) and Japan International Cooperation Agency (hereinafter referred to as "JICA") (collectively hereinafter referred to as "Both Parties"). Based on the R/D, the Project commenced on May 10, 2018. Upon the commencement of the Project, the first Joint Coordinating Committee (hereinafter referred to as "JCC") was held on May 22, 2018 and a series of discussions on the Work Plan submitted by the JICA Project Team was made among the participants.

In the course of discussions, both parties confirmed the main items on the 1st JCC given in Appendix.

Appendix: Main Points Confirmed

Appendix 1

Main Items Confirmed

I. PROJECT OBJECTIVES

It is emphasized that the Project would be a key step to stop land subsidence as the overall goal and sustainable efforts by related authorities were inevitable to achieve it. All the participants recognized it and all the parties confirmed the following project objectives.

"To contribute promotion of countermeasures against land subsidence in Jakarta and to strengthen capacity for planning and implementing the countermeasures by related government organizations in Indonesia through establishing a planning and implementation framework and action plan"

II. OUTLINE OF THE PROJECT

All the participants confirmed and understood the contents of the Project as presented by JICA Project Team. The following inputs were raised by the Indonesian Side.

II.1 OVERALL MANAGEMENT

- It is important of active participation of Special Capital Province of Jakarta and collaborative works of relevant authorities.
- Members of working group from Special Province of Jakarta will be reviewed for optimization.
- It is expected of the Project to clarify mechanism of land subsidence in Jakarta, especially relation between land subsidence and Groundwater abstraction.

II.2 WORKING GROUP 1

- Clear lesson learned with detailed information of Tokyo's experience is expected in the Project
- Collaborative works for analysis was requested by the Indonesia Side and the JICA Project Team agreed it.
- For InSAR analysis, utilization of several times of data is important. On the other hand, accuracy of data shall be carefully examined.

II.3 WORKING GROUP 2

- It is recognized that there are some other reasons of land subsidence than groundwater abstraction.
- Optimal law enforcement for mitigation/regulation of groundwater abstraction should be also studied in the Project with referring Tokyo's experiences.

II.4 WORKING GROUP 3

- Discussion and hearing opinions from academic persons are also important. Such opportunity will be created by academic forum planned in the Project.
- Industry and Energy Agency and Environmental Agency of Special Capital Province of Jakarta shall join the Working Group 3.

II.5 WORKING GROUP 4

- Since there are many stakeholders, awareness rising activities shall be improved and expanded by systematic ways and manners.
- Team Leader and Deputy Team Leader of the Working Group 4 are BPBD and Dinas Kominfotik of Special Capital Province of Jakarta, respectively. Besides, Dinas Cipta Karya and Dinas LH will join the Working Group.

II.6 MAIN WORK ITEMS

- Among the work items of the Project, the working group shall participate the following activities in particular.

<Working Group 1: Data/Information >

- Data collection about land subsidence
- Construction and operation of new monitoring wells to observe land subsidence and groundwater level
- Well inventory survey
- Examination of optimal data management system

<Working Group 2: Mitigation>

- Examination of optimal law enforcement methods for restriction of groundwater abstraction
- Formulation of alternative water resources development plan
- Implementation of pilot activities
- Formulation of promotion plan and action plan of mitigation measures

<Working Group 3: Adaptation>

- Social survey on land subsidence risks and groundwater use
- Compilation of optimal adaptation plan
- Estimation of social cost of land subsidence
- Formulation of promotion plan and action plan of adaptation measures

<Working Group 4: Awareness Raising>

- Social survey on land subsidence risks and groundwater use
- Concept making of visual aids
- Formulation of awareness rising activities
- Implementation of awareness rising activities

III. ESTABLISHMENT OF JOINT COORDINATION COMMITTEE (JCC) AND WORKING GROUPS

- All the parties confirmed that the Project shall be initiatively implemented by the Indonesian Side. Although an appointment letter (*Surat Keputusan*) from Minister of Public Works and Housing is still under process, and it will be finalized soon.
- During the Project period, official JCC meetings and working group meetings will be held 5 times and 8 times, respectively, as shown in Attachment-2. However, another meetings will be held as necessary.
- Besides the JCC and working group members, close collaboration with NCICD PMU and universities is expected.

IV. OVERSEAS TRAINING IN JAPAN

The JICA Mission explained proposed schedule, expected participants and tentative program of overseas training in Japan, and requested prompt response to the Indonesian Side. The Indonesian Side committed to nominate the participants and to commence necessary administrative procedure by June 30, 2018.

V. PROJECT WEB SITE

As a public relation tool, the Project Web Site shall be launched in the early stage of the Project. The JICA Project Team requested to DGWR to appoint a technician for supporting launching the Web Site in PU-Net as well as the necessary administrative procedures.

VI. OTHERS

- Indonesian Side will provide available data (including maps and photographs) and information related to the Project without further Memorandum of Understandings.
- For smooth implementation of the Project, the JICA Project Team has requested to Special Capital Province of Jakarta to provide office space for the Team.

(End of document)

Attachment-1: List of Indonesian Side JJC Members
Attachment-2: Implementation Schedule of the Project
Attachment-3: Agenda of Meeting and Presentation Materials

MINUTES OF MEETING
ON
PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA

AGREED UPON BETWEEN

AUTHORITIES CONCERNED IN INDONESIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
PROJECT TEAM OF JAPAN INTERNATIONAL COOPERATION AGENCY (JICA PROJECT TEAM)

Jakarta, January 16, 2019

Mr. Makoto Iwase
Director
Water Resources Group
Global Environment Department
Japan International Cooperation Agency

Dr. Ir. Hari Suprayogi, M. Eng
Director General of Water Resources, DGWR
Ministry of Public Works and Housing

Mr. Takeshi Watanabe
Team Leader/Integrated Water Resources Management-1
JICA Project Team of the Project

Dr. H. Saefullah, M.Pd
Regional Secretary
Special Capital Province of Jakarta

In response to the official request submitted by Indonesian Government, Record of Discussion (hereinafter referred to as “R/D”) on PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA (hereinafter referred to as “the Project”) was signed on July 27, 2017 between the Indonesian Side (Ministry of Public Works, Ministry of Energy and Mineral and Special Capital Province of Jakarta) and Japan International Cooperation Agency (hereinafter referred to as “JICA”) (collectively hereinafter referred to as “Both Parties”). Based on the R/D, the Project commenced on May 10, 2018. In accordance with the Implementation Schedule of the Project, the second Joint Coordinating Committee (hereinafter referred to as “JCC”) was held on January 16, 2019 and a series of discussions on the progress and findings of the Project, the action plan and the next schedules proposed by the JICA Project Team was made among the participants.

In the course of discussions, both parties confirmed the main items on the 2nd JCC given in Appendix.

Appendix: Main Points Confirmed

Appendix 1

Main Items Confirmed

I. SPEECH BY GOVERNOR OF DKI JAKARTA

The Governor of DKI Jakarta welcomed all the participants and showed his sincere appreciation to JICA's support to their efforts for countermeasures against land subsidence. The Governor stated that the DKI Jakarta would allocate all the necessary resources to do the countermeasures against land subsidence. Also it is stated that intention to learn from Tokyo's experiences, expectation of application of new technology, importance of productive cooperation by all relevant agencies. The Governor expected this meeting would lead implementable and actionable results, and all the related institutions would work based on each role.

II. PROJECT OUTLINE

Through the opening remarks and the presentations, the background and outline of the Project were confirmed such as history of land subsidence, importance of its countermeasure, process until the project commencement, project implementation schedule, project implementation structure, member of the JCC and Working Group (hereinafter referred to as "WG").

III. PROGRESS AND FINDINGS OF THE PROJECT

The Project Team and the Counterpart presented the progress of survey and analysis and some findings based on them. The followings are confirmed by all the parties.

III.1 CURRENT STATE OF LAND SUBSIDENCE

- Land subsidence in Jakarta is mainly caused by over abstraction of groundwater and/or unequal settlement by overloading or natural compaction. However, it is requires to clarify the mechanism of land subsidence in each location.

III.2 MONITORING WELL FOR LAND SUBSIDENCE

- Industrial and Energy Agency, DKI Jakarta (hereinafter referred to as the DPE) presented current effort of land subsidence monitoring, monitoring well construction under the Project such as mechanism, construction procedure, findings during test boring and schedule until completion including additional core boring.
- Representative of NCICD confirmed the sharing of tasks to construct land subsidence monitoring wells among DKI Jakarta, NCICD and JICA. DKI Jakarta and NCICD are requested to implement the construction as soon as possible.
- The participants confirmed the progress and effectiveness of land subsidence monitoring well by the Project, and DPE shall install GPS points where potential land subsidence monitoring well shall be built.

III.3 DISPLACEMENT OF LAND SUBSIDENCE

- Based on the InSAR analysis conducted by the Project Team, it was found that areas of land subsidence during 2007 to 2017 were scattered to whole DKI Jakarta, and it was severer in North and West Jakarta. Distributions of land

subsidence areas by satellite analysis from 2007 to 2017 has different from distribution surveyed by the levelling and GPS surveys. These differences shall be analyzed in details such as causes and impacts. It is also noted that land subsidence area extended to outside DKI Jakarta such as Tangerang and Bekasi Districts.

- The Project Team suggested that GPS survey location should be reviewed since some of current locations did not meet the land subsidence area.
- The Project Team examined the situation of groundwater use by registered wells and estimated unaccountable water use in 2015 as 10.4m^3/s, based on available statistical data. It is estimated that there is 80,000 to 100,000 unregistered wells. All the participants recognized importance of well registration.

III.4 GROUNDWATER CONDITION

- Based on the observed data, it was confirmed that there was a trend of recovering of groundwater level after 2010 in some observation points. However, considering the fact that the land subsidence still continues in many areas in DKI Jakarta, the groundwater level in the area where land subsidence continues shall be observed.
- Groundwater abstraction volume by registered well was drastically decreased in 2009. The Project Team examined the factors of this decrease and the participants recognized strict regulative activities would have enough effect.

III.5 EXISTING AND IMPROVING LEGAL FRAMEWORK

- All the participants confirmed the past and current legal framework, current activities of the integrated supervision team and issues of existing laws and regulations.
- The Project Team and WG proposed improvement of existing laws and regulations in order to facilitate well registration and to designate critical zone where the groundwater abstraction is prohibited or controlled.

III.6 OVERSEAS TRAINING IN JAPAN

- The trainee of overseas training reported the lessons learned such as intergovernmental cooperation, serious and sustainable efforts, and operation and maintenance, and these lessons would be applied to Indonesia as a good examples.
- Some suggestion were also made for better overseas training next time such as more academician should be invited to give lectures and additional data analysis training, example of regulation and decision making.
- Beside, some adaptation and mitigation options for Jakarta is presented such as polder system as adaptation, dry dam, underground channel, reservoir and aquifer storage as mitigation.

III.7 LAND SUBSIDENCE IN TOKYO

- The JICA mission presented the 70 years historical issues of land subsidence, monitoring networks, provision of industrial water and consequent mitigation of land subsidence, and adaptation measures which required as the results of land subsidence.
- It is suggested that land subsidence should be stopped as soon as possible otherwise much cost for adaptation measures would be required.

IV. ACTION PLANS

- The Project Team proposed the candidate critical zones based on the InSAR Analysis results in 2007 − 2017 and to conduct social survey for selection of the critical zones. All the participants agreed it.
- The Project Team should assist DPE for more realistic construction planning of 100 groundwater monitoring wells.
- BAPPENAS proposed that intensive meeting shall be conducted among stakeholders in this year to make more intensive communication. All the participants agreed the suggestion. BAPPENAS also commented that not only just making action plan, but also actual implementation is important.
- BAPPENAS suggested the Project Team shall visit steering committee members and explain about the Project and the action plan. The Project Team took note it.
- Representative of NCICD proposed to implement LiDAR Survey in coastal area to evaluate land subsidence situation in detail for considering countermeasures of coastal protection.

V. ESTABLISHMENT OF PIC

- The Project Team explained the idea of Project Implementation Committee, its necessity, schedule for establishment, structure, and expected activities.
- All the participants confirmed the necessity that Working Group 4 shall visit institution to inform action plan.

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Attachment: Agenda of Meeting and Presentation Materials

MINUTES OF MEETING
ON
PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA

AGREED UPON BETWEEN

AUTHORITIES CONCERNED IN INDONESIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
PROJECT TEAM OF JAPAN INTERNATIONAL COOPERATION AGENCY (JICA PROJECT TEAM)

Jakarta, October 1, 2019

Dr. Kenji Nagata
Senior Advisor on Water Resources and Disaster
Japan International Cooperation Agency

Dr. Ir. Hari Suprayogi, M. Eng
Director General of Water Resources, DGWR
Ministry of Public Works and Housing
Team Leader of the Steering Committee

Mr. Takeshi Watanabe
Team Leader/Integrated Water Resources Management-1
JICA Project Team of the Project

Dr. H. Saefullah, M.Pd
Regional Secretary
Special Capital Province of Jakarta
Deputy Team Leader of the Steering Committee

In response to the official request submitted by Indonesian Government, Record of Discussion (hereinafter referred to as "R/D") on PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA (hereinafter referred to as "the Project") was signed on July 27, 2017 between the Indonesian Side (Ministry of Public Works, Ministry of Energy and Mineral and Special Capital Province of Jakarta) and Japan International Cooperation Agency (hereinafter referred to as "JICA") (collectively hereinafter referred to as "Both Parties"). Based on the R/D, the Project commenced on May 10, 2018. In accordance with the Implementation Schedule of the Project, the third Joint Coordinating Committee (hereinafter referred to as "3rd JCC") was held on October 1, 2019 and a series of discussions on the action plan and the next schedules proposed by the JICA Project Team was made among the participants.

In the course of discussions, both parties confirmed the main items on the 3rd JCC given in Appendix.

Appendix: Main Points Confirmed

Appendix 1

Main Items Confirmed

I. OPENINIG BY DIRECTOR GENERAL OF WATER RESOURCES

The Director General of Water Resources, PUPR welcomed all the participants and showed his sincere appreciation to JICA's support to their efforts for countermeasures against land subsidence.

II. HANDING OVER OF LAND SUBSIDENCE MONITORING WELLS

Ceremony for handing over of Land Subsidence Monitoring Wells was carried out. Directorate of Water Resources Management, Directorate General of Water Resources, PUPR presented Certificate of Appreciation to Dr. Nobuyuki Tsuchiya for his contribution to the construction of the monitoring wells.

III. LAND SUBSIDENCE IN TOKYO

Dr. Tsuchiya presented the land subsidence which Tokyo experienced, the fact that ground which once subsidized never recovers even groundwater abstraction stops and groundwater recovers, Tokyo is the highest risk city in the world and past and current adaptation measures for compensation of people's lives and assets. Dr. Tsuchiya emphasized that Tokyo is still suffering from disaster risk induced by land subsidence and it needs tremendous cost.

IV. PROGRESS OF WORKING GROUPS

The Project Team presented the progress of survey and analysis and some findings based on them. JCC Secretary Members discussed as follows.

1. Verification of Data, such as InSAR analysis result, is better to be conducted jointly by JICA Project Team and Indonesian Counterparts. In October, a workshop for verification of data shall be conducted.
2. JICA Project Team and Indonesian Counterparts shall have further discussion regarding another water resources, such as Salak Halimun, Puncak.
3. JICA Project Team is better to proceed the discussion with DKI Jakarta about the control of groundwater abstraction.

V. SHORT TERM ACTION PLAN

The Project Team presented their proposed pilot areas and action plans for both pilot areas and whole DKI area. JCC Steering Committee and Secretary Members confirmed and agreed the followings.

1. Selection of Short Term Action Plan
   - JCC Steering Committee and Secretary Members agreed 6 Pilot Areas;
     (1) Penjaringan Area,
     (2) Jakarta Fishing Port (Penjarigan Area),

(3) Cengkareng Area
(4) Daan Mogot (Cengkareng Area)
(5) Clincing/Cakung Area
(6) Palmerah Area

- JCC Steering Committee and Secretary Members understood the procedures of Short Term Action Plan and start sharing the Plan and discusses with Working Group Members.

2. Dinas Perindustrian dan Energi, DKI Jakarta has already allocated budget for monitoring wells. Engineering Design of Wells and locations shall be discussed with JICA Project Team.
3. Dinas Sumber Daya Air has already proceeded to Inundation Map and supported construction of infiltration wells on inundation area. Dinas Sumber Daya Air shall support the maintenance of responsibility after handing over of Monitoring Wells.
4. PPLP, Ciptar Karya PUPR has program on rain water harvesting. JICA Project Team and PPLP, Cipta Karya shall coordinate the rain water harvesting activities.
5. Directorate of Water Recourses Management, Directorate General Water Recourses, PUPR, requested followings:
   (1) To consider that Team Leader shall stay in Indonesia longer period, and periodic meeting shall be conducted with Implementation Team.
   (2) To conduct further transfer knowledge activities as the form of seminar or workshop from JICA Project Team to Indonesian Counterparts.
   Upon these requests, JICA Project Team and Indonesian Counterparts shall discuss about next activities.

Besides the discussion of the 3rd JCC above, Indonesian Steering Committee and JICA shall start discussion about Indonesian activities which shall be implemented after the Project and JICA's supports for the activities, if necessary.

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Attachment: Agenda of Meeting and Presentation Materials

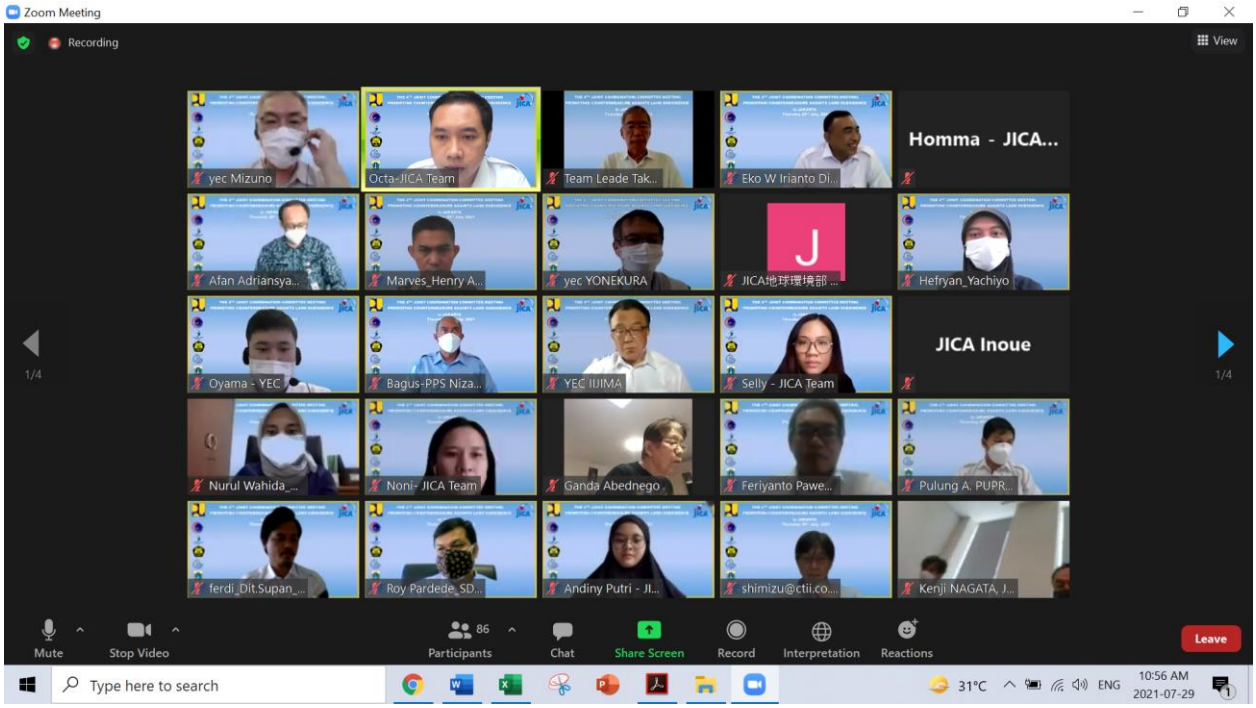
MINUTES OF MEETING
ON
PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA

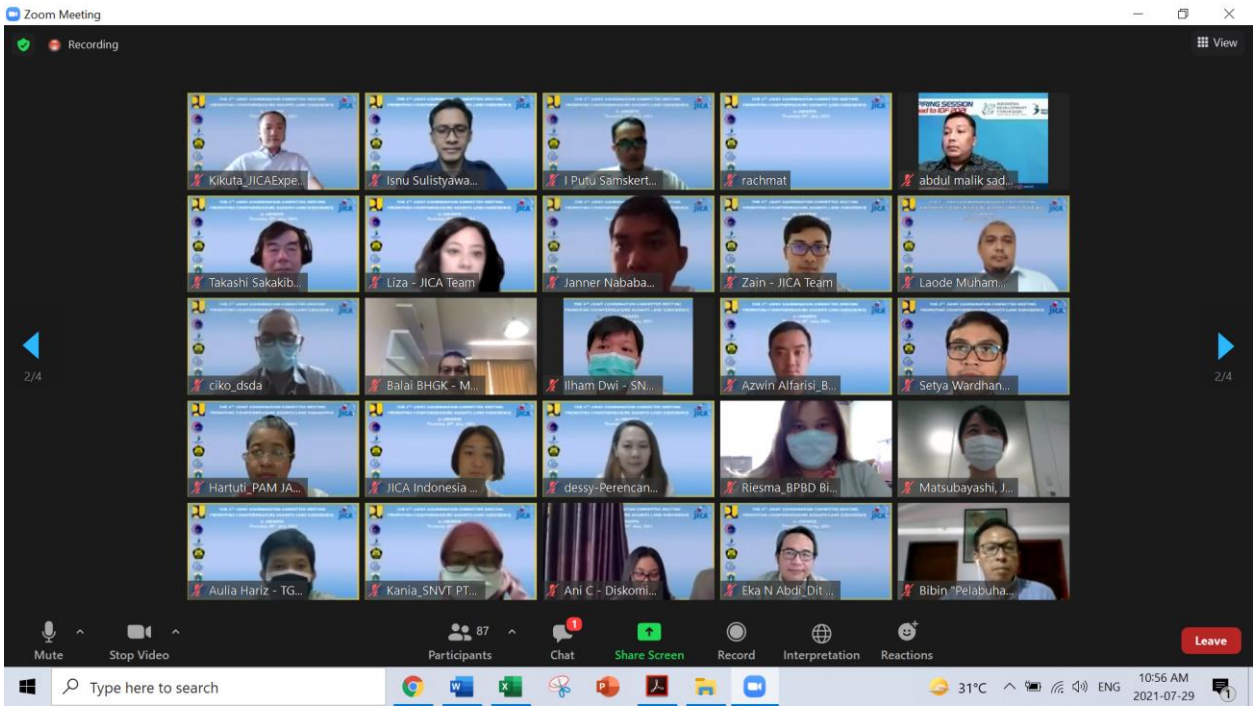
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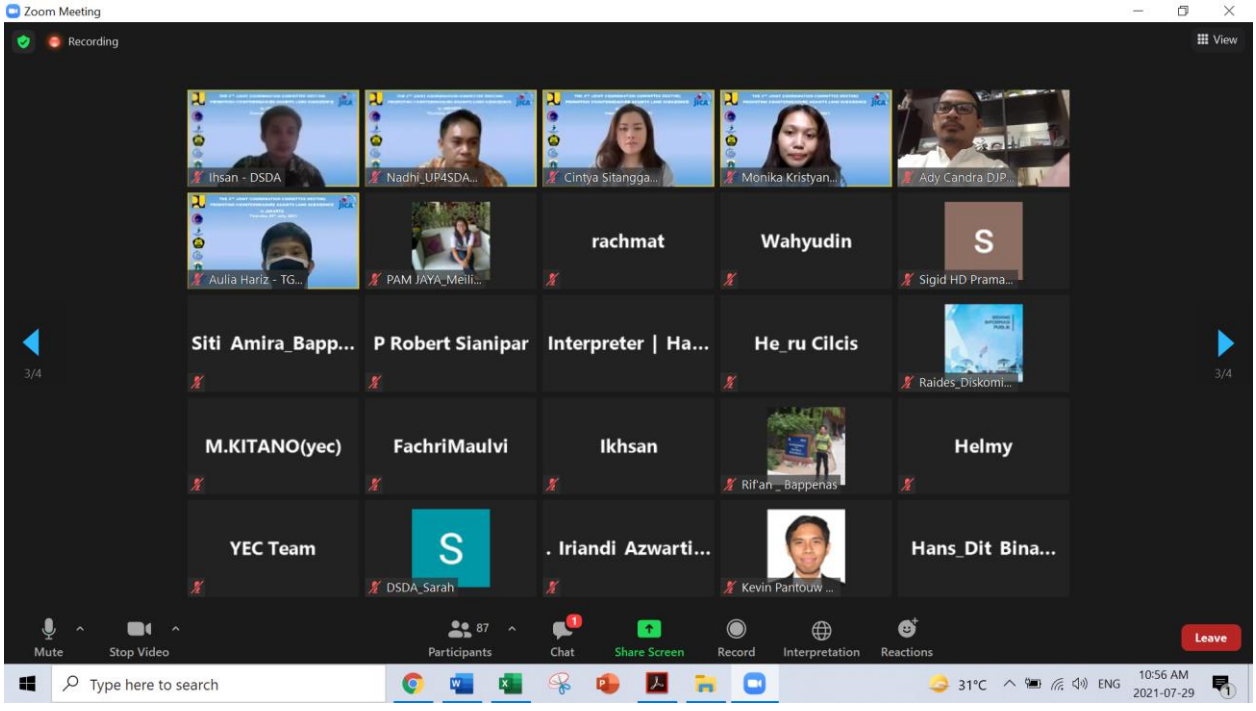
AUTHORITIES CONCERNED IN INDONESIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
PROJECT TEAM OF JAPAN INTERNATIONAL COOPERATION AGENCY (JICA PROJECT TEAM)

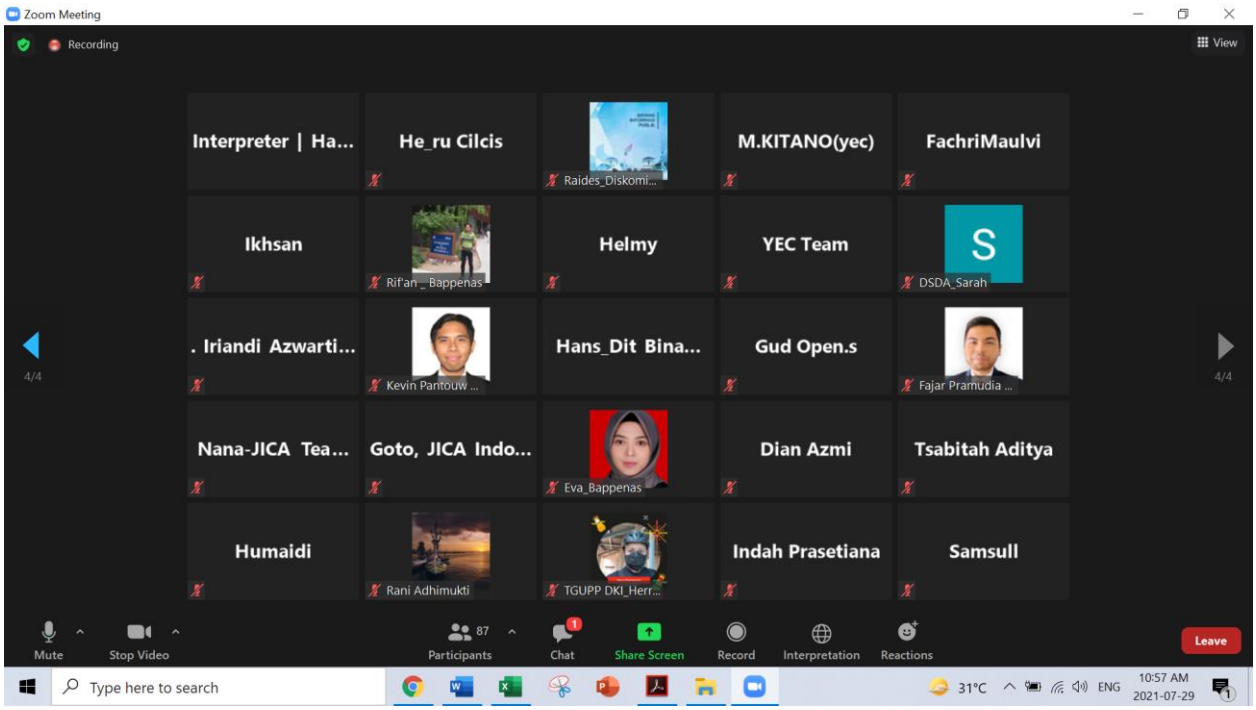
Jakarta, July 29, 2021

Meeting participants




Zoom Meeting
Recording
View
Kikuta_JICAExpe...
Isnu Sulistyawa...
I Putu Samskert...
rachmat
abdul malik sad...
Takashi Sakakib...
Liza - JICA Team
Janner Nababa...
Zain - JICA Team
Laode Muham...
ciko_dsda
Balai BHGK - M...
Ilham Dwi - SN...
Azwin Alfarisi_B...
Setya Wardhan...
Hartuti_PAM JA...
JICA Indonesia ...
dessy-Perencan...
Riesma_BPBD Bi...
Matsubayashi, J...
Aulia Hariz - TG...
Kania_SNVT PT...
Ani C - Diskomi...
Eka N Abdi_Dit ...
Bibin "Pelabuha...
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Mute
Stop Video
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Participants
Chat
Share Screen
Record
Interpretation
Reactions
Leave
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2021-07-29


Zoom Meeting
Recording
View
Ihsan - DSDA
Nadhi_UP4SDA...
Cintya Sitangga...
Monika Kristyan...
Ady Candra DJP...
Aulia Hariz - TG...
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In response to the official request submitted by Indonesian Government, Record of Discussion (hereinafter referred to as “R/D”) on PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA (hereinafter referred to as “the Project”) was signed on July 27, 2017 between the Indonesian Side (Ministry of Public Works, Ministry of Energy and Mineral and Special Capital Province of Jakarta) and Japan International Cooperation Agency (hereinafter referred to as “JICA”) (collectively hereinafter referred to as “Both Parties”). Based on the R/D, the Project commenced on May 10, 2018. In accordance with the Implementation Schedule of the Project, the fourth Joint Coordinating Committee (hereinafter referred to as “4th JCC”) was held on July 29, 2021. In this meeting, the participants discussed the progress of works and agreed on the establishment of a Planning and Implementation Committee (PIC).

In the meeting, both parties confirmed the main items on the 4th JCC presented in the Appendix.

Appendix: Main Points Confirmed

Appendix 1

Main Items Confirmed

1. Keynote Speech by Director General, DGWR

The Director of Water Resources Technical Management MPWH (as represented of Director General of Water Resources MPWH) welcomed all participants and expressed his sincere appreciation to JICA for their support on monitoring and control of land subsidence. He also explained that various activities has been conducted in the Project and the main purpose of Planning and Implementation Committee (PIC) establishment is for a holistic and coordinated countermeasures and management of land subsidence in DKI Jakarta.

2. Explanation of JICA Mission by Mr. Inoue

JICA explained that the Project objectives are to establish an action plan to promote countermeasures against land subsidence and strengthen the capacity of planning and countermeasure implementation. In this final fiscal year of the Project, it is necessary to establish the sustainability of countermeasures against land subsidence. PIC is crucial to ensure the sustainability of activities and to implement the action plan.

3. Presentation on Background of JCC 4th by JICA Team

Mr. Takeshi Watanabe explained that the outputs of Project are to have a comprehensive monitoring structure, control of groundwater abstraction volume, development of alternative water resources, and raise social awareness. Five working groups are assigned for countermeasures against land subsidence where each group is assigned with specific main output (task), i.e. data analysis, mitigation, adaptation, public awareness, and action plan. Each working group also has action plan for short term (2018-2021), medium term (2021-2028), and long term (2028~).

4. Progress of Working Groups by JICA TEAM

Progress of Working Group (WG) was delivered in the presentation with the outline as follows:

- **WG-1**: Two double tube type monitoring wells were installed in Cengkareng and Cakung where the worst land subsidence occurred according to satellite analysis (InSAR). Monitoring result showed direct relationship between groundwater level and shrinkage both in Cengkareng and Cakung. Monitoring data is shared in an integrated database named “MONAS” which was developed by Groundwater Conservation Agency (BKAT). Further, a new monitoring well is planned to be constructed at Jakarta Fishing Port Nizam-Zachman. The team predicted that in 2030, land subsidence in Cengkareng and Cakung will continues with subsidence rate of about 10 mm/year. Thus, groundwater abstraction need to be reduced and continuous monitoring need to be conducted.
- **WG-2**: In 2015, unaccountable water volume was about 10.4 m^3/s (demand 23.4 m^3/s, supply 13.0 m^3/s). Coverage ratio of water supply in 2016 is only 60%, it is expected to increase to 90% in 2030 by utilizing Jatiluhur I, Jatiluhur II, and Karian Project. WG-2 proposed short-term alternative water resources by rainwater harvesting system, where a

pilot project is planned to be constructed in Daan Mogot. WG-2 also have an action plan to identify the status of groundwater use by well inventory survey.

- **WG-3:** When land subsidence is occurred, it could not be return to initial condition. This impact to flood in land subsidence area. JICA Project Team analyze the flood in 2030 with condition when land subsidence stop and when land subsidence continuous with large rate. The result show that if land subsidence continuous with large rate, area in Cengkareng, Kebon Jeruk, Kembangan, Penjaringan, Pademangan and Tanjung Priok will suffer more severe flood.
- **WG-4**: Since 2019, several workshops were conducted to raise public's awareness on land subsidence. WG-4 also developed a website which contains comprehensive information which will be handed-over to DSDA DKI Jakarta after the Project finished. Further, a signboard is planned to be installed in the city to inform the public regarding current sea level, original ground elevation, current ground elevation, etc.

JCC 4th participants discussed as follows:

- **Coordinating Ministry for Maritime and Investment Affairs (Kemenko Marves)** (Mr. Feriyanto): Kemenko Marves has land subsidence management project in Pekalongan and Semarang (Central Java). Kemenko Marves committed to control land subsidence and will be invited to join the PIC.
- **Groundwater Conservation Agency (BKAT)** (Mr. Isnu Sulistyawan): BKAT monitor the land subsidence and geodetic since 2015, hence the data can be utilized and included in the information section.
- **Assistant Deputy of Development and Environment, Regional Secretariat of DKI Jakarta** (Mr. Afan Adriansyah Idris): Rain harvesting by JICA is expected to be a best example for development of other rain harvesting system. The effort of land subsidence countermeasures should not stopped on groundwater monitoring, but convincing the public to use piped water rather than groundwater.
- **BKAT** (Mr. Janner Nababan): Analysis on groundwater monitoring need to be clarified whether the land subsidence is caused by abstraction on middle aquifer or on shallow aquifer. Such clarification is to confirm whether groundwater abstraction on the deep aquifer is possible or not.
- **PAM JAYA** (Ms. Hartuti): PAM JAYA owns a water treatment plant in Daan Mogot with raw water source from Mokervaart River. If possible, JICA's rainwater harvesting can be integrated as an additional raw water source for PAM JAYA's water treatment plant.
- **Geological Agency, Ministry of Energy and Mineral Resources** (Mr. Wahyudin): We need to determine whether we need to regulate the groundwater abstraction first then provide the water supply or the opposite, by considering the social impact.
- **Mr. Robert Sianipar**: The land subsidence will stop in the future even though if the groundwater abstraction is not regulated, since the soil layer will be totally compacted at some point and not subsided anymore. However, such hypothesis have no assurance while land subsidence in Jakarta has reached -4 m, thus countermeasures against such serious land subsidence is crucial.

5. Establishment of Planning and Implementation Committee (PIC)

The PIC consist of three Working Groups which divided based on their roles and responsibilities. Group member for each WG were assigned and consist of various agencies and ministries, the working group member is as follows:

- **Working Group 1 (Data, Information, and Awareness Raising)**
  Head : Head of Water Resources Agency, DKI Jakarta
  Member : Director of Water Resources Technical Management, MPWH
  Member : Head of Groundwater and Geological Environmental Management Centre, Ministry of Mineral and Energy Resources
  Member : Head of Regional Disaster Countermeasure Agency, DKI Jakarta
  Member : Head of Communication, Informatics and Statistics, DKI Jakarta
  Member : Director of Water Resources Operation and Maintenance, MPWH
  Member : Head of River Basin Agency Ciliwung Cisadane, MPWH
  Member : Head of Sub Directorate Water Structure Security, MPWH
  Member : Head of Hydraulic and Water Geotechnics Agency, MPWH
  Member : Head of Groundwater Conservation Agency, Ministry of Mineral and Energy Resources
- **Working Group 2 (Mitigation and Adaptation)**
  Head : Director of Water Resources Technical Management, MPWH
  Member : Director of River and Coastal, MPWH
  Member : Head of Water Resources Agency, DKI Jakarta
  Member : Director of Water Supply Development, MPWH
  Member : Director of Jakarta Drinking Water (PAM Jaya)
  Member : Head of Sub Directorate Water Structure Security, MPWH
  Member : Head of River Engineering Agency, MPWH
  Member : Head of Hydrology and Water Environment, MPWH
- **Working Group 3 (Secretariat)**
  Head : Director of Groundwater and Raw water, MPWH
  Member : Assistant Deputy of Disaster and Climate Change Management, Coordinating Ministry of Maritime and Investment
  Member : Assistant Deputy of Development and Environment, Regional Secretariat of DKI Jakarta

This list is currently a draft and will be discussed further. The decree for PIC working group members also will be discussed further whether will be ministerial decree or governor decree.

(End of document)

Attachment: Agenda of Meeting and Presentation Materials

MINUTES OF MEETING
ON
PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA

AGREED UPON BETWEEN

AUTHORITIES CONCERNED IN INDONESIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
PROJECT TEAM OF JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA PROJECT TEAM)

Jakarta, July 7, 2022

Dr. Kenji Nagata
Senior Advisor on Water Resources and Disaster
Japan International Cooperation Agency

Ir. Jarot Widyoko, Sp-1
Director General for Water Resources, DGWR
Ministry of Public Works and Housing
Team Leader of the Steering Committee

Mr. Takeshi Watanabe
Team Leader/Integrated Water Resources Management-1
JICA Project Team of the Project

Mr. Sigit Wijatmoko, AP, M.Si.
On behalf of
Regional Secretary
Special Capital Province of Jakarta
Deputy Team Leader of the Steering Committee

In response to the official request submitted by Indonesian Government, Record of Discussion (hereinafter referred to as "R/D") on PROJECT FOR PROMOTING COUNTERMEASURES AGAINST LAND SUBSIDENCE IN JAKARTA (hereinafter referred to as "the Project") was signed on July 27, 2017 between the Indonesian Side (Ministry of Public Works and Housing, Ministry of Energy and Mineral Resources, and Special Capital Province of Jakarta) and Japan International Cooperation Agency (hereinafter referred to as "JICA") (collectively hereinafter referred to as "Both Parties"). Based on the R/D, the Project commenced on May 10, 2018. In accordance with the Implementation Schedule of the Project, the fifth Joint Coordinating Committee (hereinafter referred to as "5th JCC") was held on July 7, 2022 and a series of discussions on the action plan and Planning and Implementation Committee (hereinafter referred to as PIC) proposed by the JICA Project Team have been made before 5th JCC and agreed in the 5th JCC among the participants.

In the course of discussions, both parties confirmed the main items on the 5th JCC given in Appendix.

Appendix: Main Points Confirmed

Appendix 1

Main Items Confirmed

I. OPENING SPEECH

1. BY Director General for Water Resources (presented by Mr. Rizal – Director for Water Resources Engineering Development)

Director General for Water Resources, MPWH welcomed all the participants and showed his sincere appreciation to related ministries, authorities and JICA's support. He emphasized that after this project finish, continued follow-up is needed and it is important for PIC members to understand their responsibility and to secure budget. And the prospects for promoting countermeasures against land subsidence to other cities in Indonesia in cooperation with Coordinating Ministry for Maritime & Investment Affairs (Kemenko Marves) were stated.

2. BY Policy Analyst for Disaster, Kemenko Marves

Mr. Henry, the policy analyst for disaster, Kemenko Marves introduced their activities against land subsidence over the last three years. It is also stated that they look forward to the prospect of cooperation with all projects member and the relevant ministries, to expand the activities to cities along the north coast Java and Indonesia's new capital city (IKN), where land subsidence also occurred in a severe condition.

3. BY Regional Secretary for Special Capital Province of Jakarta (presented by Mr. Afan – Asbang LH DKI)

Regional Secretary for Special Capital Province of Jakarta stated that the Jakarta would allocate all the necessary resources to do the countermeasures against land subsidence. It is also stated that intention to learn from Tokyo's experiences, expectation of application of new technology, importance of productive cooperation by all relevant agencies. Regional Secretary expected this meeting would lead implementable and actionable results.

4. BY Head of the Geological Agency of the Ministry of Energy and Mineral Resources/ESDM (presented by Dr. Siti – PATGTL)

The Head of the Geological Agency, ESDM expressed his gratitude for being involved in the project and hope that they could continue to implement countermeasures under PIC. He also introduced the research activities in Geological Agency and hopes to expand the technology to all of Indonesia.

5. BY JICA HQ

Dr. Nagata from JICA HQ introduced the outline of the project and the purpose of PIC for implementing countermeasures against land subsidence. He emphasized the importance of keeping PIC for long time (10 – 50 years). It is also stated that the activity carried out by the Project team could be expanded to other regions in Indonesia where the people are suffering from land subsidence after the Project completion.

II. LAND SUBSIDENCE IN TOKYO

Dr. Tsuchiya presented the land subsidence which Tokyo experienced, the fact that ground which once subsidized never recovers even groundwater abstraction stops and groundwater recovers, Tokyo is the highest risk city in the world and past and current adaptation measures for compensation of people's lives and assets. Dr. Tsuchiya emphasized 1) Earlier is better to take measures against land subsidence, 2) Government initiative / leadership in cooperation with many actors is key to promote these activities and 3) As a government officer/civil servant, it was my responsibility to create our town where people living in next generation can live safely.

III. OVERALL PROJECT OUTPUT

The Project Team presented the overall output of the Project and noted that the Project was carried out with the cooperation of many participants. The major outputs of each WG are listed below. Complete PIC structure and their responsibility is as attached (Attachment-2)

WG1: InSAR Analysis, Construction of Monitoring Wells, Monitoring Data Integration, Future Land Subsidence Simulation, Manuals and Report Formats
WG2: Enforcement of Governor Regulation, Introducing Rainwater Harvesting Facility
WG3: Creating Risk Map, Developing Inundation Map
WG4: Workshop in Kota, Developing Website, Construction of Signboard

IV. Establishment of Planning and Implementation Committee (PIC)

The Project Team presented the tasks and organization of PIC. The PIC consists of three Working Groups which is divided based on their roles and responsibilities. Each working group consists of various agencies and ministries and each member is assigned as attachment. In the 5th JCC, Directorate General of Water Resources, Head of PATGTL and Regional Secretary for Special Capital Province of Jakarta agreed to the responsibilities of each organization and have signed the document. The final official document will be signed by Minister of Public Works and Housing (MPWH).

V. Q&A SESSION

JCC 5th participants discussed as follows:

The cause of land subsidence: As of Japan's experience, the cause of land subsidence also had been debated for a long time in the society. After the over 30 years argument, land subsidence stopped when groundwater pumping was completely stopped in Tokyo. In Jakarta, the cause of the subsidence is still under debate. But it is important to continue to promote mitigation measures (improvement of water supply and promotion of dam projects) because we believe that groundwater pumping contributes the most to land subsidence.

Mitigation measures in Jakarta: it is recommended to start various approach in parallel. Currently, MPWH has started the construction of several regional SPAM water supply system (target to be finish in 2030 to cover the whole Jakarta metropolitan area), while Jakarta in 2021 has introduced the Zero Deep Well regulation for selected area. It is expected to be expanded in the future.

Baseline for Land Subsidence and An Expert Panel: Government needs to develop a baseline reference on Land Subsidence in Indonesia (not only Jakarta). This reference will be

used as a basis for designing the infrastructure projects. To support this, one idea is to establish an Expert Panel team consisting of both national and international experts on land subsidence. Satellite technology like InSAR or other materials can be utilized to support this activity. Collaboration and synergy between all stakeholders are required.

Land subsidence in Indonesia: Land subsidence is not limited to Jakarta but the north coast of Java has also suffered. Therefore, with the proposed PIC structure and the Action Plans that developed and commonly agreed in this JCC, this could be a good reference to start the land subsidence campaign in Jakarta and later expanded to other risky areas in all Indonesia.

(End of document)

Attachment-1: Agenda of Meeting and Presentation Materials
Attachment-2: Signed PIC structure
Attachment-3: Signed PIC Matrix Action Plan

Organization Structure of PIC

Steering Committee		
Chairman	:	DG SDA PUPR
Deputy Chairman	:	SEKDA DKI Jakarta
Member	:	Deputy for Facility and Infrastructure - Bappenas
Member	:	Head of Badan Geologi - ESDM
Member	:	Deputy for Coordination on Environmental Management & Forestry – Marves

WG-1 (Data, Information & Awareness Raising)		
Chairman	:	Head of PATGTL - Badan Geologi
Member	:	Director Bintek SDA
Member	:	Director ATAB
Member	:	Head of BKAT – Badan Geologi
Member	:	Head of Dinas SDA DKI
Member	:	Head of Diskominfotik DKI
Member	:	Head of Biro PLH DKI

WG-2 (Mitigation & Adaptation)		
Chairman	:	Director ATAB
Member	:	Director OP SDA
Member	:	Director SUPAN
Member	:	Head of BHLK
Member	:	Head of BBWS Cilicis
Member	:	Head of PATGTL
Member	:	Head of Dinas SDA DKI
Member	:	Head of PAM Jaya
Member	:	Head of Biro PLH DKI
Member	:	Head of Biro KSD DKI
Member	:	Head of Bapenda DKI

WG-3 (Secretariat)		
Chairman	:	Director Bintek SDA
Member	:	Director SSPSDA
Member	:	Director ATAB
Member	:	Head of PATGTL – Badan Geologi
Member	:	Head of Bappeda DKI
Member	:	Head of Dinas SDA
Member	:	Head of Biro PLH DKI

Signed during 5th JCC

Commonly Agreed by:
Date: July 7th, 2022

DG SDA (PUPR)

Head of PATGTL (ESDM)

Asprum SEKDA DKI

Matriks Rencana Aksi untuk *PIC (Project Implementation Committee)*

Versi: Hasil rapat Pre JCC-2 (17 Juni 2022)

Nama (Kelompok Kerja - Pokja)	Program	Kegiatan	Sub Kegiatan	Pelaksana • Penanggung Jawab: DKI – Biro PLH	Biro KSD	Dinas SDA	Dinas Sosial / UPT Masjid	PAM JAYA	Diskominfotik	Asbang DKI	Bapenda	Bappeda	ESDM – BKAT	PATGTL	PUPR – Direktorat Bintek - SDA	Direktorat ATAB	Direktorat OP SDA	Direktorat SS	BHLK	Direktorat Supan	Direktorat Air Minum	BBWS Cilicis	Pelaksana - Pendukung	Sumber Dana: APBD	APBN	Lain-Lain (KPBU, CSR, Hibah, dll)	Jangka Waktu Pelaksanaan: Pendek < 3 Tahun	Menengah 3 - 10 Tahun	Penjang > 10 Tahun
Pokja-1 (Data, Informasi & Peningkatan Kesadaran Masyarakat)	Pemantauan dan Analisis Data	Pemantauan secara terus menerus	Pengumpulan data dari 3 (tiga) Sumur Pantau (yg di bangun JICA) setiap bulan sekali			•																		√			√	√	√
			Pemeliharaan secara berkala terhadap 3 (tiga) Sumur Pantau di atas dengan mengacu ke Buku Panduan JICA tentang OP & Pengelolaan Data			•																	Direktorat ATAB	√			√	√	√
			Kalibrasi sistem monitoring di 3 (tiga) Sumur Pantau di atas (AWLR, data logger, sensor) setahun sekali			•																	Direktorat Bintek, Direktorat ATAB	√			√	√	√
			Pemasangan sistem Telemetri untuk 3 (tiga) Sumur Pantau di atas (Cakung, Cengkareng dan Muara Baru)													•							Dinas SDA		√		√		
			Pemasangan Listrik PLN untuk 3 (tiga) Sumur Pantau di atas			•																		√			√		
			Survei GNSS di 3 (tiga) Sumur Pantau di atas sebagai perbandingan terhadap data hasil pemantauan setahun sekali										•										Dinas SDA, ITB		√		√	√	√
			Melakukan analisis InSAR untuk memantau kondisi penurunan tanah secara menyeluruh di Jakarta											•									LAPAN, BIG, BRIN, ITB, Dinas SDA		√			√	√
		Laporan Data Hasil Pemantauan	Menyusun Laporan sederhana tentang hasil pemantauan sebulan sekali (menggunakan file excel yg dibuat oleh Tim JICA)			•																	BKAT, Direktorat ATAB	√			√	√	√
			Menyusun Laporan Tahunan tentang hasil pemantauan dan Survei GNSS										•										Direktorat ATAB, Dinas SDA		√		√	√	√
		Integrasi Data ke dalam Sistem Monitoring	Integrasi data hasil pemantauan ke dalam database PASTI (BKAT)										•										Dinas SDA		√		√	√	√
			Membangun database PUPR untuk menyimpan data hasil pemantauan penurunan tanah												•								Direktorat ATAB		√		√		
			Membuat serta menjalankan perjanjian tentang *data sharing* di antara K/L dan instansi terkait (siapa & cara akses).												•								Dinas SDA, BKAT, Direktorat ATAB		√		√	√	
		Analisis Data	Membuat kajian tentang hubungan tingkat penurunan tanah dengan penggunaan air tanah berdasarkan data hasil pemantauan.													•							BKAT		√			√	√
			Menentukan tingkat penurunan tanah berdasarkan kajian terhadap data hasil pemantauan, INSAR dan survei GNSS. (hasil kajian ini akan digunakan untuk menentukan lokasi yg membutuhkan suplai air bersih, konservasi air, dll.													•							Dinas SDA, BKAT, Direktorat ATAB		√			√	√
	Pembangunan Sumur Pantau Penurunan Tanah (tambahan)	Membangun Sumur Pantau di lokasi prioritas lainnya (terkena dampak Penurunan Tanah)	Membangun 14 Sumur Pantau (atau lebih sesuai kebutuhan)			•							•			•								√	√			√	√
	Peningkatan Kesadaran Masyarakat	Memasang Signboard Penurunan Tanah	Membangun lebih banyak Signboard di tempat umum untuk meningkatkan kesadaran masyarakat tentang bahaya Penurunan Tanah			•																	Direktorat ATAB, BKAT	√			√	√	
		Membuat bahan edukasi yg mudah dimengerti oleh masyarakat	Membuat leaflet atau materi sejenis tentang bahaya penurunan tanah serta membagikan kepada masyarakat						•														Dinas SDA, Direktorat ATAB	√			√	√	
		Operasional Website penurunan tanah	'Melakukan update data hasil pemantauan serta informasi lain terkait penurunan tanah di website Dinas SDA (buku panduan tersedia)			•			•														Direktorat Bintek	√			√	√	
		Sosialisasi dan workshop	Melakukan sosialisasi kepada masyarakat secara rutin termasuk ke pabrik / industri yang terletak di area dengan tingkat risiko tinggi terkena penurunan tanah	•																			Dinas SDA, PAM Jaya, Walikota	√			√	√	
	Sekretariat (Pokja-1)	Rapat rutin Pokja-1	Menyelenggarakan rapat koordinasi dengan para anggota Pokja-1 secara rutin (per semester atau per tahun)											•									Direktorat ATAB		√		√	√	√
		Pelaporan	Kepala Pokja-1 melaporkan hasil kegiatan kepada Kepala Sekretariat (Pokja-3)											•									Direktorat ATAB		√		√	√	√
		Perencanaan	Menyusun Rencana Kerja Tahunan Pokja-1											•									Direktorat ATAB		√		√	√	√
Pokja-2 Mitigation & Adaptation	Penggunaan Hasil Analisis dalam Kebijakan Publik	Implementasi Pergub No. 93 Tahun 2021 tentang Zona Bebas Air Tanah	Implementasi Pergub No. 93 Tahun 2021 serta melakukan upaya penengakan hukum apabila terjadi pelanggaran.			•																	Biro PLH, Satpol PP, Dinas Citata, PAM Jaya, Walikota	√			√	√	
		Memperluas cakupan area (zona) berdasarkan Peta Bahaya Penurunan Tanah dan ketersediaan suplai air bersih	Melakukan revisi Pergub No. 93 Tahun 2021 untuk memperluas cakupan wilayah sesuai dengan Peta Bahaya Penurunan Tanah di masa mendatang.	•		•																	PAM Jaya, Biro Hukum, Biro PLH	√					√
	Penyediaan Sumber Air Bersih Alternatif	Penyimpanan Air Hujan, Rasionalisasi penggunaaan air	Melakukan pemeliharaan rutin terhadap fasilitas Pemanenan Air Hujan *(RWH)* di Masjid Raya KH. Hasyim Asy'ari (Pesakih)			•	•																Catatan: UPT Masjid Raya KH. Hasyim Asy'ari	√			√	√	√
			Mendukung upaya pembangunan fasilitas Pemanenan Air Hujan dengan mengacu kepada studi kasus JICA di *RWH* Pesakih sebagai sumber air alternatif untuk kebutuhan masyarakat yang tinggal di daerah yang terkena dampak penurunan tanah yang parah.			•																	DPRKP, Biro KSD, Biro PLH dan Direktorat ATAB	√			√	√	√
			Mempromosikan kegiatan CSR untuk mendukung pembangunan fasilitas pemanenan air hujan, inisiatif daur ulang dan hemat air untuk meningkatkan upaya penggunaan air secara efektif	•																			Dinas SDA, Dinas Citata, Walikota, Biro PLH	√			√	√	
			Mengkaji fasilitas / insentif untuk mendukung upaya pembangunan sistem Pemanenan air hujan, seperti memberi insentif tertentu kepada para pemilik gedung/pabrik, dll.								•												Dinas SDA, Direktorat ATAB	√					√
		Operasional Bendungan (termasuk pembangunan fasilitas sumber air)	Rasionalisasi operasional bendungan untuk meningkatkan jumlah suplai air.														•						Direktorat Bintek SDA, Direktorat ATAB		√			√	√
		Alternatif sumber air lainnya (selain panen air hujan).	Melakukan kajian tentang sumber air alternatif lainnya seperti pemanfaatan situ/danau dan sebagainya, serta mengimplementasikannya			•										•								√	√		√	√	√
	Suplai Air Bersih	Kios Air untuk masyarakat berpenghasilan rendah	Menggunakan informasi tingkat penurunan tanah (peta bahaya, dll) untuk memberikan suplai air bersih di wilayah terdampak					•															Dinas SDA	√			√	√	
			Memperluas cakupan kegiatan untuk menjangkau wilayah terdampak lainnya.					•															Dinas SDA	√			√	√	
		Menurunkan tingkat NRW *(non revenue water)*	Menurunkan tingkat NRW (non revenue water)					•															Dinas SDA	√			√		
		Penyusunan RISPAM (Rencana Induk SPAM) DKI	Penyusunan RISPAM (Rencana Induk SPAM) DKI			•																	PAM Jaya, Direktorat Air Minum	√			√		
		Pembangunan SPAM Regional DKI seperti Jatiluhur I, Karian Serpong, Jatiluhur II/Djuanda beserta fasilitas pendukungnya (IPA, dll)	Pembangunan SPAM Regional DKI seperti Jatiluhur I, Karian Serpong, Jatiluhur II/Djuanda beserta fasilitas pendukungnya (IPA, dll)					•									•					•	BPBUMD DKI Jakarta, Dinas SDA	√	√	√	√	√	
	Upaya Penanggulangan Bencana	Menyusun Peta Risiko Banjir yang mempertimbangkan faktor penurunan tanah dan perubahan iklim	Menyusun Peta Bahaya Penurunan Tanah											•									Direktorat Bintek, Direktorat Supan, Direktorat ATAB		√			√	√
			Menyusun Peta Risiko Banjir																•	•			BRIN, BIG, Direktorat Bintek SDA, BBWS Cilicis, BNPB, ATR		√			√	√
		Upaya Penanggulangan Bencana Banjir dan Gelombang Ekstrim	Memasukan faktor tingkat Penurunan Tanah dalam pembuatan desain dan konstruksi infrastruktur Banjir			•																•	Direktorat Supan	√	√				√
	Sekretariat (Pokja-2)	Rapat rutin Pokja-2	Menyelenggarakan rapat koordinasi dengan para anggota Pokja-2 secara rutin (per semester atau per tahun)														•								√		√	√	√
		Pelaporan	Kepala Pokja-2 melaporkan hasil kegiatan kepada Kepala Sekretariat (Pokja-3)														•								√		√	√	√
		Perencanaan	Menyusun Rencana Kerja Tahunan Pokja-2														•								√		√	√	√
Pokja-3 Sekretariat	Pengelolaan PIC (Project Implementation Committee)	Menfasilitasi penyelenggaraan rapat koordinasi tentang rencana kerja Pokja	Melakukan koordinasi untuk menyusun rencana aksi dari semua anggota Pokja														•	•					Bappeda DKI, Dinas SDA		√		√	√	√
			Mengadakan rapat rutin tahunan tentang status dan perkembangan kegiatan dari masing-masing Pokja														•	•					Biro PLH DKI		√		√	√	√
	Penyusunan Program Kebutuhan Anggaran	Penyusunan Program anggaran tahunan dari masing-masing instansi terkait	Melakukan koordinasi penyusunan program dan anggaran tahunan dari masing-masing Pokja / instansi.											•			•			•			Biro PLH DKI		√		√	√	√
		Melakukan monitoring terhadap alokasi anggaran dari masing-masing instansi	Melakukan monitoring terhadap alokasi anggaran dari masing-masing instansi											•			•						Dinas SDA, Biro PLH DKI		√		√	√	√
	Diseminasi Hasil Kegiatan	Memperluas diseminasi hasil kegiatan proyek JICA di Jakarta ke kota lain.	Membagikan pembelajaran yang di dapat selama pelaksanaan kegiatan proyek JICA ke kota-kota lain yang akan melakukan kegiatan pemantauan di masa mendatang														•						PATGTL		√		√	√	√
		Laporan Tahunan	Menyusun Laporan Tahunan dari seluruh kegiatan Pokja serta mempublikasikannya sebagi sarana untuk berbagi informasi tentang keberhasilan dan target kerja di masa mendatang.														•								√		√	√	√

Disepakati Bersama oleh:

Tgl: 7 Juli 2022

(_____)
Dirjen Sumber Daya Air (PUPR)

(_____)
Kepala PATGTL - Badan Geologi (ESDM)

(_____)
SEKDA Provinsi DKI Jakarta

【Appendix2】Detailed Action Plan of PIC

Action Plan Matrix for PIC (Project Implementation Committee)

Version: result of 2nd Pre JCC (June 17, 2022)

Name	Program	Activities	Sub Activities	Implementer (● Main Responsible)																				Support Implementer	Funding Sources			Implementation Period		
				DKI									ESD		PUPR															
				Biro PLH	Biro KSD	Dinas SDA	Dinas Social/UPT	PAM JAYA	Diskominfotik	Asbang DKI	Bapenda	Bappeda	BKAT	PATGTL	Direktorat Bintek - SDA	Direktorat ATAB	Direktorat OP SDA	Direktorat SS	BHLK	Directorate Rivers &	Direktorat Air Mimum	BBWS Cilicis			APBD	APBN	Others (PPP, CSR, Grant, etc.)	Short < 3 Years	Medium 3 - 10 Years	Long > 10 Years
WG-1 (Data, Information & Awareness Raising)	Monitoring & Analysis	Continuos monitoring	Collecting data from 3 existing monitoring wells on monthly basis			●																			√			√	√	√
			Regular maintenance of monitoring well by JICA referring to JICA guideline on OP & Data management			●																		Direktorat ATAB	√			√	√	√
			Calibration of monitoring system (AWLR, data logger, sensor) on annual basis			●																		Direktorat Bintek, Direktorat ATAB	√			√	√	√
			Install telemetry system for 3 existing monitoring wells (Cakung, Cengkareng and Muara Baru)													●								Dinas SDA		√		√		
			Improve electrical system for 3 existing monitoring wells			●																			√			√		
			GNSS survey in the monitoring well to compare monitoring well result on annual basis										●											Dinas SDA, ITB		√		√	√	√
			Conduct InSAR analysis to monitor overall land subsidence condition in Jakarta											●										LAPAN, BIG, BRIN, ITB, Dinas SDA		√			√	√
		Report monitoring data	Prepare simple monthly report for monitoring result (excel format is available by JICA Team)			●																		BKAT, Direktorat ATAB	√			√	√	√
			Prepare annual report for monitoring result and GNSS survey										●											Direktorat ATAB, Dinas SDA		√		√	√	√
		Integrate data to monitoring system	Integrate monitoring data into PASTI (by BKAT)										●											Dinas SDA		√		√	√	√
			Prepare database of PUPR to store land subsidence monitoring data												●									Direktorat ATAB		√		√		
			Prepare & Implement agreement on data sharing between related ministries (who & how to access)												●									Dinas SDA, BKAT, Direktorat ATAB		√		√	√	
		Data analysis	Analyze the relationship between land subsidence and groundwater utilization based on result of monitoring data													●								BKAT		√			√	√
			Determine the land subsidence rate in Jakarta by analyzing the monitoring data, INSAR and GNSS survey. (Result of this analysis will be used for determining area that need water supply, ground water conservation area, etc.)													●								Dinas SDA, BKAT, Direktorat ATAB		√			√	√
	Additional Land Subsidence Monitoring Well	Construct more wells in priority area	Construction of 14 monitoring wells (or more as required)			●							●			●									√	√			√	√
	Improve Public Awareness	Signboards installment	Install more signboards in public spaces to increase public awareness on land subsidence			●																		Direktorat ATAB, BKAT	√			√	√	
		Prepare public friendly campaign materials	Prepare leaflet & other materials on landsubsidence and distribute to public						●															Dinas SDA, Direktorat ATAB	√			√	√	
		Operate website	Update data monitoring and other land subsidence related information in website of Dinas SDA (guideline is available)			●			●															Direktorat Bintek	√			√	√	
		Socialization/Workshops	Conduct regular socialization to community incl. factories located in high risk area	●																				Dinas SDA, PAM Jaya, Walikota	√			√	√	
	Secretariat (WG-1)	Organize WG-1 meeting	Conduct regular coordination meeting between WG-1 members (per semester or annually)											●										ATAB		√		√	√	√
		Reporting	Head of WG-1 report the activity result to Head of Secretariat (WG-3)											●										ATAB		√		√	√	√
		Planning	Prepare annual Workplan of WG-1											●										ATAB		√		√	√	√
WG-2 Mitigation & Adaptation	**Utilize the Analysis result for Public Policy**	Implementation of Pergub Zero Deep Well	Implementation and Law Enforcement on Pergub Zero Deep Well			●																		Biro PLH, Satpol PP, Dinas Citata, PAM Jaya, Walikota	√			√	√	
		Expansion of area based on Hazard map & water supply coverage	Revise Pergub Zero Deep Well to include all land subsidence risky area in the future	●		●																		PAM Jaya, Biro Hukum, Biro PLH	√					√
	Provide Alternative Water Resources	Rainwater storage, rational water use	Continue the maintenance of rain water harvesting (RWH) facility in Mosque KH. Hasyim Asy'ari (Pesakih)			●	●																	**Note:** UPT Masjid Raya KH. Hasyim Asy'ari	√			√	√	√
			Promote the development of RWH by referring to JICA's case study (RWH Pesakih) as alternative water resources for the community needs who lived in land subsidence severely affected area.			●																		DPRKP, Biro KSD, Biro PLH and Direktorat ATAB	√			√	√	√
			Promote CSR activities for rain water harvesting facility, recycle and reduce/misue of water to increase water use efficiency.		●																			Dinas SDA, Dinas Citata, Walikota, Biro PLH	√			√	√	
			Examining measures to promote installation of rainwater harvesting systems, such as incentive for factories/buildings								●													Dinas SDA, Direktorat ATAB	√					√
		Dam Operation (inc. water resources dev.)	Dam rationalization operation to increase water supply														●							Direktorat Bintek SDA, Direktorat ATAB,		√			√	√
		Another alternative Water resources	Study and implementation on another alternative water resources such as utilization of Situ / Lake			●										●									√	√		√	√	√
	Water Supply	*Kios Air* for low income group	Utilize information of severe area of land subsidence and provide water supply					●																Dinas SDA	√			√	√	
			Expand the program to other risky area					●																Dinas SDA	√			√	√	
		Measures against NRW (non revenue water)	Measures against NRW (non revenue water)					●																Dinas SDA	√			√		
		Formulation of *RISPAM* DKI	Formulation of RISPAM DKI			●																		PAM Jaya, Direktorat Air Minum	√			√		
		Expansion of WTP and Development of Regional SPAM DKI in Jatiluhur I, Karian Serpong, Jatiluhur II/Djuanda	Expansion of WTP and Development of Regional SPAM DKI in Jatiluhur I, Karian Serpong, Jatiluhur II/Djuanda					●								●				●				BPBUMD DKI Jakarta, Dinas SDA	√	√	√	√	√	
	Countermeasures against water related disasters	Flood Risk Map considering Land Subsidence & Climate Change	Prepare hazard map of land subsidence											●										Direktorat Bintek, Direktorat Supan, Direktorat ATAB		√			√	√
			Prepare flood risk/ inundation map																●	●				BRIN, BIG, Direktorat Bintek SDA, BBWS Cilicis, BNPB, ATR		√			√	√
		Flood & High Tide countermeasures	Considering the land subsidence rate in design & construction of flood countermeasure			●																●		Direktorat Supan	√	√				√
	Secretariat (WG-2)	Organize WG-2 meeting	Conduct regular coordination meeting between WG-2 members (per semester or annual)													●										√		√	√	√
		Reporting	Head of WG-2 report the activity result to Head of Secretariat (WG-3)													●										√		√	√	√
		Planning	Prepare annual Workplan of WG-2													●										√		√	√	√
WG-3 Secretariat	**PIC Management**	Facilitating work plan coordination meeting between working group	Coordinating the formulation of action plan among all members of Working Group												●	●								Bappeda DKI, Dinas SDA		√		√	√	√
			Conduct regular annual meeting on the progress result of each working group												●	●								Biro PLH DKI		√		√	√	√
	Programming Budget Requirement	Programming annual budget for related institution	Coordinate the preparation of Programs & annual budget of each working groups / institutions.									●			●			●						Biro PLH DKI		√		√	√	√
		Monitoring budget allocation of related institution	Monitoring budget allocation of related institution									●			●									Dinas SDA, Biro PLH DKI		√		√	√	√
	Dissemination of Project Result	Expansion of Disseminating project results to other cities outside Jakarta	Sharing lesson learned from JICA Project to other future land subsidence monitoring efforts in all of Indonesia												●									PATGTL		√		√	√	√
		Annual Report	Prepare annual report of all WG activities for sharing achievement & future targets and distribute to all related stakeholders												●											√		√	√	√

Commonly Agreed by:

Date: July 7, 2022

(_____)
DG of Water Ressources (PUPR)

(_____)
Head of PATGTL - Badan Geology (ESDM)

(_____)
SEKDA of DKI Jakarta Province

Matriks Rencana Aksi untuk *PIC (Project Implementation Committee)*

Versi: Hasil rapat Pre JCC-2 (17 Juni 2022)

Nama (Kelompok Kerja - Pokja)	Program	Kegiatan	Sub Kegiatan	Pelaksana • Penanggung Jawab: Biro PLH	Biro KSD	Dinas SDA	Dinas Sosial / UPT	PAM JAYA	Diskominfotik	Asbang DKI	Bapenda	Bappeda	BKAT	PATGTL	Direktorat Bintek - SDA	Direktorat ATAB	Direktorat OP SDA	Direktorat SS	BHLK	Direktorat Supan	Direktorat Air Minum	BBWS Ciliciis	Pelaksana - Pendukung	Sumber Dana: APBD	APBN	Lain-Lain (KPBU, CSR, Hibah, dll)	Jangka Waktu Pelaksanaan: Pendek < 3 Tahun	Menengah 3 – 10 Tahun	Penjang > 10 Tahun
Pokja-1 (Data, Informasi & Peningkatan Kesadaran Masyarakat)	Pemantauan dan Analisis Data	Pemantauan secara terus menerus	Pengumpulan data dari 3 (tiga) Sumur Pantau (yg di bangun JICA) setiap bulan sekali			•																		√			√	√
			Pemeliharaan secara berkala terhadap 3 (tiga) Sumur Pantau di atas dengan mengacu ke Buku Panduan JICA tentang OP & Pengelolaan Data			•																	Direktorat ATAB	√			√	√	√
			Kalibrasi sistem monitoring di 3 (tiga) Sumur Pantau di atas (AWLR, data logger, sensor) setahun sekali			•																	Direktorat Bintek, Direktorat ATAB	√			√	√	√
			Pemasangan sistem Telemetri untuk 3 (tiga) Sumur Pantau di atas (Cakung, Cengkareng dan Muara Baru)													•							Dinas SDA		√		√		
			Pemasangan Listrik PLN untuk 3 (tiga) Sumur Pantau di atas			•																		√			√		
			Survei GNSS di 3 (tiga) Sumur Pantau di atas sebagai perbandingan terhadap data hasil pemantauan setahun sekali										•										Dinas SDA, ITB		√		√	√	√
			Melakukan analisis InSAR untuk memantau kondisi penurunan tanah secara menyeluruh di Jakarta											•									LAPAN, BIG, BRIN, ITB, Dinas SDA		√			√	√
		Laporan Data Hasil Pemantauan	Menyusun Laporan sederhana tentang hasil pemantauan sebulan sekali (menggunakan file excel yg dibuat oleh Tim JICA)			•																	BKAT, Direktorat ATAB	√			√	√	√
			Menyusun Laporan Tahunan tentang hasil pemantauan dan Survei GNSS										•										Direktorat ATAB, Dinas SDA		√		√	√	√
		Integrasi Data ke dalam Sistem Monitoring	Integrasi data hasil pemantauan ke dalam database PASTI (BKAT)										•										Dinas SDA		√		√	√	√
			Membangun database PUPR untuk menyimpan data hasil pemantauan penurunan tanah												•								Direktorat ATAB		√		√		
			Membuat serta menjalankan perjanjian tentang *data sharing* di antara K/L dan instansi terkait (siapa & cara akses).												•								Dinas SDA, BKAT, Direktorat ATAB		√		√	√	
		Analisis Data	Membuat kajian tentang hubungan tingkat penurunan tanah dengan penggunaan air tanah berdasarkan data hasil pemantauan													•							BKAT		√			√	√
			Menentukan tingkat penurunan tanah berdasarkan kajian terhadap data hasil pemantauan, INSAR dan survei GNSS. (hasil kajian ini akan digunakan untuk menentukan lokasi yg membutuhkan suplai air bersih, konservasi air, dll.													•							Dinas SDA, BKAT, Direktorat ATAB		√			√	√
	Pembangunan Sumur Pantau Penurunan Tanah (tambahan)	Membangun Sumur Pantau di lokasi prioritas lainnya (terkena dampak Penurunan Tanah)	Membangun 14 Sumur Pantau (atau lebih sesuai kebutuhan)			•							•			●								√	√			√	√
	Peningkatan Kesadaran Masyarakat	Memasang Signboard Penurunan Tanah	Membangun lebih banyak Signboard di tempat umum untuk meningkatkan kesadaran masyarakat tentang bahaya Penurunan Tanah			•																	Direktorat ATAB, BKAT	√			√	√	
		Membuat bahan edukasi yg mudah dimengerti oleh masyarakat	Membuat leaflet atau materi sejenis tentang bahaya penurunan tanah serta membagikan kepada masyarakat						•														Dinas SDA, Direktorat ATAB	√			√	√	
		Operasional Website penurunan tanah	Melakukan update data hasil pemantauan serta informasi lain terkait penurunan tanah di website Dinas SDA (buku panduan tersedia)			•			•														Direktorat Bintek	√			√	√	
		Sosialisasi dan workshop	Melakukan sosialisasi kepada masyarakat secara rutin termasuk ke pabrik / industri yang terletak di area dengan tingkat risiko tinggi terkena penurunan tanah	•																			Dinas SDA, PAM Jaya, Walikota	√			√	√	
	Sekretariat (Pokja-1)	Rapat rutin Pokja-1	Menyelenggarakan rapat koordinasi dengan para anggota Pokja-1 secara rutin (per semester atau per tahun)											•									Direktorat ATAB		√		√	√	√
		Pelaporan	Kepala Pokja-1 melaporkan hasil kegiatan kepada Kepala Sekretariat (Pokja-3)											•									Direktorat ATAB		√		√	√	√
		Perencanaan	Menyusun Rencana Kerja Tahunan Pokja-1											•									Direktorat ATAB		√		√	√	√
Pokja-2 Mitigation & Adaptation	Penggunaan Hasil Analisis dalam Kebijakan Publik	Implementasi Pergub No. 93 Tahun 2021 tentang Zona Bebas Air Tanah	Implementasi Pergub No. 93 Tahun 2021 serta melakukan upaya penengakan hukum apabila terjadi pelanggaran.			•																	Biro PLH, Satpol PP, Dinas Citata, PAM Jaya, Walikota	√			√	√	
		Memperluas cakupan area (zona) berdasarkan Peta Bahaya Penurunan Tanah dan ketersediaan suplai air bersih	Melakukan revisi Pergub No. 93 Tahun 2021 untuk memperluas cakupan wilayah sesuai dengan Peta Bahaya Penurunan Tanah di masa mendatang.	●		●																	PAM Jaya, Biro Hukum, Biro PLH	√					√
	Penyediaan Sumber Air Bersih Alternatif	Penyimpanan Air Hujan, Rasionalisasi penggunaaan air	Melakukan pemeliharaan rutin terhadap fasilitas Pemanenan Air Hujan *(RWH)* di Masjid Raya KH. Hasyim Asy'ari (Pesakih)			●	●																Catatan: UPT Masjid Raya KH. Hasyim Asy'ari	√			√	√	√
			Mendukung upaya pembangunan fasilitas Pemanenan Air Hujan dengan mengacu kepada studi kasus JICA di *RWH* Pesakih sebagai sumber air alternatif untuk kebutuhan masyarakat yang tinggal di daerah yang terkena dampak penurunan tanah yang parah.			•																	DPRKP, Biro KSD, Biro PLH dan Direktorat ATAB	√			√	√	√
			Mempromosikan kegiatan CSR untuk mendukung pembangunan fasilitas pemanenan air hujan, inisiatif daur ulang dan hemat air untuk meningkatkan upaya penggunaan air secara efektif		•																	Dinas SDA, Dinas Citata, Walikota, Biro PLH	√			√	√	
			Mengkaji fasilitas / insentif untuk mendukung upaya pembangunan sistem Pemanenan air hujan, seperti memberi insentif tertentu kepada para pemilik gedung/pabrik, dll.							●													Dinas SDA, Direktorat ATAB	√					√
		Operasional Bendungan (termasuk pembangunan fasilitas sumber air)	Rasionalisasi operasional bendungan untuk meningkatkan jumlah suplai air.														•						Direktorat Bintek SDA, Direktorat ATAB		√		√	√	√
		Alternatif sumber air lainnya (selain panen air hujan).	Melakukan kajian tentang sumber air alternatif lainnya seperti pemanfaatan situ/danau dan sebagainya, serta mengimplementasikannya			•										•								√	√		√	√	√
	Suplai Air Bersih	Kios Air untuk masyarakat berpenghasilan rendah	Menggunakan informasi tingkat penurunan tanah (peta bahaya, dll) untuk memberikan suplai air bersih di wilayah terdampak					•															Dinas SDA	√			√	√	
			Memperluas cakupan kegiatan untuk menjangkau wilayah terdampak lainnya.					•															Dinas SDA	√			√	√	
		Menurunkan tingkat NRW *(non revenue water)*	Menurunkan tingkat NRW ☒on revenue water)					•															Dinas SDA	√			√		
		Penyusunan RISPAM (Rencana Induk SPAM) DKI	Penyusunan RISPAM (Rencana Induk SPAM) DKI			•																	PAM Jaya, Direktorat Air Minum	√			√		
		Pembangunan SPAM Regional DKI seperti Jatiluhur I, Karian Serpong, Jatiluhur II/Djuanda beserta fasilitas pendukungnya (IPA, dll)	Pembangunan SPAM Regional DKI seperti Jatiluhur I, Karian Serpong, Jatiluhur II/Djuanda beserta fasilitas pendukungnya (IPA, dll)					•								•					•		BPBUMD DKI Jakarta, Dinas SDA	√	√	√	√	√	
	Upaya Penanggulangan Bencana	Menyusun Peta Risiko Banjir yang mempertimbangkan faktor penurunan tanah dan perubahan iklim	Menyusun Peta Bahaya Penurunan Tanah										•										Direktorat Bintek, Direktorat Supan, Direktorat ATAB		√			√	√
			Menyusun Peta Risiko Banjir															●	●				BRIN, BIG, Direktorat Bintek SDA, BBWS Ciliciis, BNPB, ATR		√			√	√
		Upaya Penanggulangan Bencana Banjir dan Gelombang Ekstrim	Memasukan faktor tingkat Penurunan Tanah dalam pembuatan desain dan konstruksi infrastruktur Banjir			•															•		Direktorat Supan	√	√				√
	Sekretariat (Pokja-2)	Rapat rutin Pokja-2	Menyelenggarakan rapat koordinasi dengan para anggota Pokja-2 secara rutin (per semester atau per tahun)													•									√		√	√	√
		Pelaporan	Kepala Pokja-2 melaporkan hasil kegiatan kepada Kepala Sekretariat (Pokja-3)													•									√		√	√	√
		Perencanaan	Menyusun Rencana Kerja Tahunan Pokja-2													•									√		√	√	√
Pokja-3 Sekretariat	Pengelolaan PIC (Project Implementation Committee)	Menfasilitasi penyelenggaraan rapat koordinasi tentang rencana kerja Pokja	Melakukan koordinasi untuk menyusun rencana aksi dari semua anggota Pokja											•		•							Bappeda DKI, Dinas SDA		√		√	√	√
			Mengadakan rapat rutin tahunan tentang status dan perkembangan kegiatan dari masing-masing Pokja											•		•							Biro PLH DKI		√		√	√	√
	Penyusunan Program Kebutuhan Anggaran	Penyusunan Program anggaran tahunan dari masing-masing instansi terkait	Melakukan koordinasi penyusunan program dan anggaran tahunan dari masing-masing Pokja / instansi.										•		•			•					Biro PLH DKI		√		√	√	√
		Melakukan monitoring terhadap alokasi anggaran dari masing-masing instansi	Melakukan monitoring terhadap alokasi anggaran dari masing-masing instansi										•		•								Dinas SDA, Biro PLH DKI		√		√	√	√
	Diseminasi Hasil Kegiatan	Memperluas diseminasi hasil kegiatan proyek JICA di Jakarta ke kota lain.	Membagikan pembelajaran yang di dapat selama pelaksanaan kegiatan proyek JICA ke kota-kota lain yang akan melakukan kegiatan pemantauan di masa mendatang												•								PATGTL		√		√	√	√
		Laporan Tahunan	Menyusun Laporan Tahunan dari seluruh kegiatan Pokja serta mempublikasikannya sebagi sarana untuk berbagi informasi tentang keberhasilan dan target kerja di masa mendatang.												•										√		√	√	√

Disepakati Bersama oleh:

Tgl: 7 Juli 2022

(_____)
Dirjen Sumber Daya Air (PUPR)

(_____)
Kepala PATGTL - Badan Geologi (ESDM)

(_____)
SEKDA Provinsi DKI Jakarta

【Appendix3】All Cases of Flood Simulations

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All Cases of Flood Simulations

Table i Conditions of the New Scenarios for Flood Simulations

CASE NO.	Point of Evaluation	Land Subsidence	Climate Change Scenario
1	2018	LS(SQ)	WO
2	2030	LS(SQ)	WO
3	2030	LS(A)	WO
4	2030	LS(A1)	WO
5	2030	LS(B)	WO
6	2030	LS(C)	WO
7	2030	LS(SQ)	W:RCP8.5
8	2030	LS(A)	W:RCP8.5
9	2030	LS(A1)	W:RCP8.5
10	2030	LS(B)	W:RCP8.5
11	2030	LS(C)	W:RCP8.5
12	2050	LS(SQ)	WO
13	2050	LS(A)	WO
14	2050	LS(A1)	WO
15	2050	LS(B)	WO
16	2050	LS(C)	WO
17	2050	LS(SQ)	W:RCP8.5
18	2050	LS(A)	W:RCP8.5
19	2050	LS(A1)	W:RCP8.5
20	2050	LS(B)	W:RCP8.5
21	2050	LS(C)	W:RCP8.5

(Legend)

Land Subsidence

LS (SQ): Status Quo, LS will stop (Current Status as of 2018)

LS (A): LS will progress to stop (Case A projection)

LS (A1): LS will progress to stop (Case A1 projection)

LS (B): LS will progress moderately (Case B projection)

LS (C): LS will be most advanced (Case C projection)

Climate Change Scenario

W: RCP 2.6 With Climate Change (Stabilized at a low level)

W: RCP 8.5 With Climate Change (Progress at a high level)

WO: Without Climate Change

Source: JICA Study Team

Table ii Rough Estimation of Damages Caused by Flood

CASE NO.	Estimated Damages (Billion Rupiah)*	Estimated Damages (Billion USD)**	Ratio to Case 1
1	111,639.7	7.77	1.00
2	139,628.5	9.72	1.25
3	139,853.3	9.73	1.25
4	140,422.8	9.77	1.26
5	142,124.6	9.89	1.27
6	141,738.2	9.86	1.27
7	164,299.4	11.43	1.47
8	164,918.0	11.47	1.48
9	165,382.4	11.51	1.48
10	166,142.6	11.56	1.49
11	167,067.2	11.62	1.50
12	180,411.6	12.55	1.62
13	180,660.3	12.57	1.62
14	181,987.2	12.66	1.63
15	186,236.8	12.96	1.67
16	194,111.4	13.51	1.74
17	226,685.3	15.77	2.03
18	226,981.1	15.79	2.03
19	228,321.7	15.89	2.05
20	233,518.5	16.25	2.09
21	242,298.2	16.86	2.17

(*) 2017 prices
(**) IDR 1.00 = USD 0.00006958, (February 2022)
Source: JICA Study Team

All Cases of Strom Surge Simulations

Table iii Conditions of the New Scenarios for Storm Surge Simulations

CASE NO.	Point of Evaluation	Land Subsidence	Climate Change Scenario
1	2018	LS (SQ)	WO
2	2030	LS (SQ)	WO
3	2030	LS (A)	WO
4	2030	LS (A1)	WO
5	2030	LS (B)	WO
6	2030	LS (C)	WO
7	2030	LS (SQ)	W: RCP 2.6
8	2030	LS (A)	W: RCP 2.6
9	2030	LS (A1)	W: RCP 2.6
10	2030	LS (B)	W: RCP 2.6
11	2030	LS (C)	W: RCP 2.6
12	2030	LS (SQ)	W: RCP 8.5
13	2030	LS (A)	W: RCP 8.5
14	2030	LS (A1)	W: RCP 8.5
15	2030	LS (B)	W: RCP 8.5
16	2030	LS (C)	W: RCP 8.5
17	2050	LS (SQ)	WO
18	2050	LS (A)	WO
19	2050	LS (A1)	WO
20	2050	LS (B)	WO
21	2050	LS (C)	WO
22	2050	LS (SQ)	W: RCP 2.6
23	2050	LS (A)	W: RCP 2.6
24	2050	LS (A1)	W: RCP 2.6
25	2050	LS (B)	W: RCP 2.6
26	2050	LS (C)	W: RCP 2.6
27	2050	LS (SQ)	W: RCP 8.5
28	2050	LS (A)	W: RCP 8.5
29	2050	LS (A1)	W: RCP 8.5
30	2050	LS (B)	W: RCP 8.5
31	2050	LS (C)	W: RCP 8.5

(Legend)

Land Subsidence

LS (SQ): Status Quo, LS will stop (Current Status as of 2018)

LS (A): LS will progress to stop (Case A projection)

LS (A1): LS will progress to stop (Case A1 projection)

LS (B): LS will progress moderately (Case B projection)

LS (C): LS will be most advanced (Case C projection)

Climate Change Scenario

W: RCP 2.6 With Climate Change (Stabilized at a low level)

W: RCP 8.5 With Climate Change (Progress at a high level)

WO: Without Climate Change

Source: JICA Study Team

Table iv Rough Estimation of Damages Caused by Storm Surge

CASE NO.	Estimated Damages (Billion Rupiah)*	Estimated Damages (Billion USD)**	Ratio to Case 1
1	58,255.0	4.05	1.00
2	69,742.9	4.85	1.20
3	74,961.7	5.22	1.29
4	78,096.7	5.43	1.34
5	84,422.9	5.87	1.45
6	91,770.7	6.39	1.58
7	79,841.0	5.56	1.37
8	85,910.9	5.98	1.47
9	89,462.1	6.22	1.54
10	98,465.1	6.85	1.69
11	105,219.2	7.32	1.81
12	80,910.8	5.63	1.39
13	86,861.3	6.04	1.49
14	90,616.1	6.31	1.56
15	99,533.5	6.93	1.71
16	106,213.0	7.39	1.82
17	94,455.5	6.57	1.62
18	101,504.1	7.06	1.74
19	115,317.1	8.02	1.98
20	150,939.4	10.50	2.59
21	206,448.6	14.36	3.54
22	120,465.4	8.38	2.07
23	130,473.4	9.08	2.24
24	149,301.9	10.39	2.56
25	188,777.2	13.14	3.24
26	247,858.1	17.25	4.25
27	126,195.1	8.78	2.17
28	137,821.3	9.59	2.37
29	155,606.0	10.83	2.67
30	195,941.7	13.63	3.36
31	255,794.8	17.80	4.39

(*) 2017 prices
(**) IDR 1.00 = USD 0.00006958, (February 2022)
Source: JICA Study Team