SAKARYA GAS FIELD DEVELOPMENT PROJECT – ENHANCEMENT OF SUBSEA PRODUCTION CAPACITY AND FLOATING PRODUCTION UNIT

Chapter 7.1 Onshore Physical Components Impact Assessment

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7.0 IMPACT ASSESSMENT

7.1 Onshore Physical Components

7.1.1 Soil and Subsoil

Based on the information collected for the definition of the baseline (see Chapter 6.2.1.5), the physical component *Soil and Subsoil* was assigned a **Medium** value of sensitivity for the following reasons:

- Limited presence of soil with agricultural potential;
- Presence of some zones with soil potential erosion;
- Limited soil contamination.

Potential impacts to soil and subsoil associated with construction and operation phases of the Project include;

- Removal of soil;
- Minor leakage of contaminants into soil.

The Project actions related to the abovementioned impact factors are the following:

- Site levelling and grading;
- General onshore engineering/construction works;
- Plant/infrastructure onshore operation.

7.1.1.1 Construction phase

Impact factors

The impact factors from the Project activities potentially affecting soil and subsoil during construction phase are listed in Table ***7-1***.

Table 7-1: Project actions and related impact factors potentially affecting soil and subsoil during construction phase

Project actions	Brief description	Impact factors
Site levelling and grading	Soil removal except for very small amounts is not planned as part of the construction phase. However, in unexpected situations during the construction phase, soil removal operations can be performed. While not anticipated, if excavation material remains, the remaining excavation material will be transported to a licensed excavation material storage/recovery facility.	Removal of Soil
General onshore engineering/construction works	During construction activities, minor leakage of contaminants can cause soil contamination.	Minor Leakage of Contaminants into Soil

Impacts potentially affecting this component are assessed here below for the construction phase.

- **Removal of Soil**

The construction in the onshore part of the Project site is limited to the landfall area and the section from the landfall to the OPF boundaries.

Soil removal is not planned as part of the construction phase. However, in unexpected situations during the construction phase, soil removal operations can be performed. If excavation material remains, the remaining excavation material will be transported to the licensed excavation material storage/recovery facility by subcontractors.

SGFD's Soil Pollution and Erosion Control Plan and Pollution Prevention Plan addresses management and mitigation measures related to this impact factor.

- **Minor Leakage of Contaminants into Soil**

Minor leakage of contaminants into soil can be caused by;

- oil and fuel leakage from vehicles and generators;
- accidental spill of any hazardous materials that are used during the construction;
- runoff from area where chemical, oil and fuel are temporarily stored (i.e. areas where paving and secondary containments are not present);
- pollution caused by temporary storage of hazardous materials and/or wastes;
- disposal of wastes, wastewater and liquid wastes;
- flooding of ponds (i.e., settling pond of concrete wastewater) or secondary containments caused by heavy precipitation;
- accidental spill of wastewater (e.g., domestic, hydrotest) to soil.

Mitigation measures

The following mitigation measures shall be implemented to mitigate the effects of the impact factors.

- **Removal of Soil**
  - Project-specific Soil Management and Erosion Control Plan and Pollution Prevention Plans will be implemented.
  - If required, to prevent off-site sediment movement, erosion control measures including geotextile filters, drainage channels, settling structures, etc. will be implemented as needed prior to the start of construction operations.
  - Wherever possible, land preparation and construction activities shall be re-scheduled during extreme weather conditions to avoid risk of erosion.
  - If required, dikes and drainage channels will be established to prevent loss of soil and runoff to water bodies around the excavated material storage areas.

- Topsoil (if required) and subsoil removal studies will be completed in compliance with the Regulation on Control of Excavated Soil, Construction and Demolition Wastes issued on March 18, 2004 at Official Gazette no: 25406 and other international practices.
- Topsoil and subsoil loss will be minimized with appropriate equipment, plan, procedure, and schedule. Also, unnecessary soil stripping will not be carried out during construction activities to minimize disturbance to vegetation, ground species and soils.
- The topsoil (if required) will be carefully removed up to its determined depth and stored at topsoil storage areas to be used for the closure activities.
- If some construction areas need to be located onto vegetated and uncontaminated land, the topsoil will be temporarily removed and properly stockpiled to be used for landscaping in the stripped areas upon completion of the works as required by the Regulation on Excavation, Construction and Demolition Wastes issued on March 18, 2004 at Official Gazette no.25406.
- Filling material will be purchased from licensed quarries.
- Excess excavated material, if any, will be disposed at licensed storage/recycling facilities as required by the Regulation on Excavation, Construction and Demolition Wastes issued on March 18, 2004 at Official Gazette no.25406. In case a licensed facility cannot be found, the Client will identify parcels, for which usage rights will be obtained from the respective right holders as per the requirements of the applicable legislation. Environmental and social assessment studies as per Management of Change Procedure will be implemented during selection and entry to the off-site excavated material storage sites. Criteria such as selecting brownfields, that are not used for agricultural or grazing purposes and having a sufficient distance to settlement areas and will be considered in the selection of excavated material storage sites.

- **Minor Leakage of Contaminants into Soil**
  - Project-specific Pollution Prevention Plan and Waste Management Plan will be implemented to ensure that the amount of release and spills can be taken under control before reaching substantial amounts that may potentially affect the quality of soil.
  - The areas, where the hazardous materials (chemicals, liquids etc.) storage tanks located (i.e., hazardous material storage areas), will be designed and constructed to avoid potential contamination into the soil (paved areas with sufficient secondary containment, proper drainage systems, storage as per Safety Data Sheet (SDS) requirements etc.). Also, the Project will comply with relevant legal and project safety requirements to avoid leakages from hazardous materials (chemicals, liquids etc.) storage facilities on-site;
  - The temporary waste storage areas will be constructed based on the requirements listed in the Regulation on Waste Management issued on April 02, 2015 Official Gazette no: 29314 and GIIP.
    - accidental spill of any hazardous materials that are used during the operation.
    - There will be a suitable space for the licensed vehicles to receive the wastes.
    - Storage area will have all kinds of precautions against possible fires (fire extinguisher, etc.).
    - Hazardous wastes and non-hazardous wastes will be stored separately, having different entrance doors.

- In order to protect the compartment where hazardous waste will be stored from precipitation, the top and four sides will be covered. The compartments where non-hazardous wastes will also be covered from precipitation.
- Storage area will be closed, the entrance door will be lockable (kept locked) and the authorized the staff will have the keys.
- The contact information of the personnel in charge of the waste storage area and warning signs will be posted at the temporary storage areas.
- Adequate drainage system will be provided to collect any leakages.
- The floor will be covered with concrete, the edges of the floor will be raised with concrete walls/parapets for hazardous waste compartment.
- In order for the concrete to be impermeable; cured concrete with a minimum thickness of 25 cm will be applied or the concrete to be used for this purpose will be in C30 (STS) standard. If this condition is not met, impermeability will be ensured by laying a of at least 1 mm between the concrete and the soil floor.
- Wastes will be stored separately from each other, in tanks and containers. Labels indicating the type of waste will be placed for each type of waste.
- Removal of wastes will be ensured in appropriate frequencies so that storage capacities at the temporary waste storage areas/storage compartments are not exceeded. Hazardous wastes (except medical waste) will be temporarily stored at the waste storage areas for a maximum duration of 6 months and non-hazardous waste for a maximum duration of one year.

- Industrial Waste Management Plans for all temporary waste storage area established by contractors (including hazardous and non-hazardous waste) will be submitted to the relevant Provincial Directorate of MoEUCC as per the format defined by the MoEUCC.
- Temporary Waste Storage Permit will be obtained from the related Provincial Directorate of MoEUCC for temporary waste storage sites at the site generating hazardous waste of more than 1,000 kg per month.
- Hazardous Materials and Hazardous Waste Compulsory Liability Insurance will be executed as per the relevant provisions of the Regulation on Waste Management for the hazardous waste temporary storage areas/containers regardless of the amount of hazardous waste stored;
- Waste reuse/recycling/recovery/disposal agreements with the Municipality and licensed recovery/disposal firms will be executed for the management of hazardous and non-hazardous waste.
- Official waste declarations for all waste generated will be submitted to the online system of MoEUCC, starting from January each year until the March at least.
- Waste storage out of the designated storage areas will be prohibited. Wastes generated in the interim storage areas will be transferred to the temporary storage area;
- Regular maintenance of vehicles and machinery/equipment will be undertaken to ensure that leakages of oil/fuel or any other hazardous material is prevented;
- Impervious (concrete etc.) surfaces will be designated for the refuelling and maintenance of the machinery/vehicles. If it is not possible according to the nature of the Project, all refuelling tankers

and all heavy machinery used at the site will have drip trays, and these trays will be placed under the pipe connection points to prevent accidental leakage to the soil during refuelling operations;

- Generators will be equipped with drip trays and to be checked regularly to prevent soil contamination;
- Secondary containments, ponds and drip trays will be checked regularly, especially during extreme weather conditions;
- Portable spill containment and clean-up materials (spill kits) will be made available and easily accessible at the construction site, instructions on how to use spill containment and clean-up materials will be included in the kits;
- Training on spill response, use of containment and clean-up material (spill kits) will be provided to works (including the subcontractor workers);
- In case of a spill/leakage incident on-site, contamination levels will be identified by means of sampling and analyses studies to be conducted by accredited laboratories and the results will be compared with baseline concentrations of the related parameters to plan corrective actions where necessary;
- No wastewater discharges of any type to land will be allowed. Polluted water (if any generated as a result of accidental leakages) will be properly collected or managed to prevent the soil pollution;
- Pumps and transmixers will be washed only at the concrete plants, concrete slurry will not be discharged into environment;
- Septic tanks will have a leakproof report, and necessary measures will be taken to prevent them from deforming in extreme weather conditions;
- Accidental spills and leakages will be managed through implementation of the Emergency Preparedness and Response Plan.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed. Based on the baseline conditions of the assessed component, the Project characteristics and actions, limited construction onshore, presence of the management plans, as well as the proper implementation of the mitigation measures proposed above, a **low to negligible impact** is expected on the soil and subsoil during the construction phase.

Table 7-2: Residual impact assessment matrix for the soil and subsoil during construction phase.

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation Effectiveness	Residual Impact Value
Removal of Soil	Duration:	Short	Medium-low	Mid term	**Negligible**	High	**Negligible**
	Frequency:	Infrequent					
	Geo. Extent:	Project footprint					

	Intensity:	Negligible					
Minor Leakage of Contaminants into Soil	Duration:	Short	Medium	Mid term	**Low**	Medium-high	**Negligible**
	Frequency:	Infrequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					
Overall assessment:	**Low**		Rationale:	Using a strong precautionary approach, the highest residual impact value may be considered as a theoretical overall residual impact value			

Monitoring measures

The following monitoring measure shall be implemented to assess the true effects of the Project on the soil and subsoil during the construction and verify the effectiveness of the mitigation measures.

- Periodic site inspections will be carried out to ensure that the planned construction site boundaries are not expanded, erosion control measures are in place;
- Periodic inspections of subcontractors in order to ensure no uncontrolled dumping of excavated material;
- Periodic visual site inspection of stormwater and wastewater drainage networks, in order to verify their integrity and functionality;
- Periodic site inspections will be carried out and reported to identify any possible leakages;
- Periodic site inspections will be carried out in order to identify any possible damage in the hazardous materials storage areas and waste storage areas;
- Trainings on spill response, use of containment and clean-up material for the workers (including the subcontractors' workers) will be recorded;
- Periodic site inspections will be carried out to ensure adequate amount of spill-response material such as spill-kits and metal trays will be present at the site and in each heavy machinery and records will be kept;
- Routine maintenance programme will be set-up and maintenance records will be kept for all vehicles and machinery/equipment;
- Licenses and permits of quarries and excavation material storage/recycling facilities will be recorded;
- Waste management practices of the subcontractors will be monitored by means of document review (e.g. permits, waste recycling/disposal agreements) and visual checks at the work sites.

7.1.1.2 Operation phase

Impact factors

The impact factors from the Project activities potentially affecting soil and subsoil during operation phase are listed below Table 7-3.

Table 7-3: Project actions and related impact factors potentially affecting soil and subsoil during operation phase

Project actions	Brief description	Impact factors
Plant/infrastructure onshore operation	During operation and maintenance activities, minor leakage of contaminants can cause soil contamination.	Minor Leakage of Contaminants into Soil

- **<u>Minor Leakage of Contaminants into Soil</u>**

Minor leakage of contaminants into soil can be caused by;

- oil and fuel leakage from vehicles and generators;
- Periodic site inspections will be carried out
- runoff from area where chemical, oil and fuel are temporarily stored (i.e. areas where paving and secondary containments are not present);
- pollution caused by temporary storage of hazardous materials and/or wastes;
- disposal of wastes, wastewater and liquid wastes;
- flooding of ponds or secondary containments caused by heavy precipitation;
- accidental spill of wastewater (e.g., domestic, industrial) to soil.

Mitigation measures

The following mitigation measures shall be implemented to mitigate the effects of the impact factors.

- **<u>Minor Leakage of Contaminants into Soil</u>**
    - Project-specific Pollution Prevention Plan and Waste Management Plan will be implemented to ensure that the amount of release and spills can be taken under control before reaching substantial amounts that may potentially affect the quality of soil.
    - The areas, where the hazardous materials (chemicals, liquids etc.) storage tanks located (i.e., hazardous material storage areas), will be designed and constructed to avoid potential contamination into the soil (paved areas with sufficient secondary containment, proper drainage systems, storage as per Safety Data Sheet (SDS) requirements etc.). Also, the Project will comply with relevant legal and project safety requirements to avoid leakages from hazardous materials (chemicals, liquids etc.) storage facilities on-site;
    - The temporary waste storage areas will be constructed based on the requirements listed in the Regulation on Waste Management issued on April 02, 2015 Official Gazette no: 29314 and GIIP.
        - The area will be separate from the facilities and buildings, away from human traffic.
        - There will be a suitable space for the licensed vehicles to receive the wastes.
        - Storage area will have all kinds of precautions against possible fires (fire extinguisher, etc.).
        - Hazardous wastes and non-hazardous wastes will be stored separately, having different entrance doors.

- In order to protect the compartment where hazardous waste will be stored from precipitation, the top and four sides will be covered. The compartments where non-hazardous wastes will also be covered from precipitation.
- Storage area will be closed, the entrance door will be lockable (kept locked) and the authorized the staff will have the keys.
- The contact information of the personnel in charge of the waste storage area and warning signs will be posted at the temporary storage areas.
- Adequate drainage system will be provided to collect any leakages.
- The floor will be covered with concrete, the edges of the floor will be raised with concrete walls/parapets for hazardous waste compartment.
- In order for the concrete to be impermeable; cured concrete with a minimum thickness of 25 cm will be applied or the concrete to be used for this purpose will be in C30 (STS) standard. If this condition is not met, impermeability will be ensured by laying a membrane of at least 1 mm between the concrete and the soil floor.
- Wastes will be stored separately from each other, in tanks and containers. Labels indicating the type of waste will be placed for each type of waste.
- Removal of wastes will be ensured in appropriate frequencies so that storage capacities at the temporary waste storage areas/storage compartments are not exceeded. Hazardous wastes (except medical waste) will be temporarily stored at the waste storage areas for a maximum duration of 6 months and non-hazardous waste for a maximum duration of one year.

▪ Industrial Waste Management Plans for all temporary waste storage area established by contractors (including hazardous and non-hazardous waste) will be submitted to the relevant Provincial Directorate of MoEUCC as per the format defined by the MoEUCC.

▪ Temporary Waste Storage Permit will be obtained from the related Provincial Directorate of MoEUCC for temporary waste storage sites at the site generating hazardous waste of more than 1,000 kg per month.

▪ Hazardous Materials and Hazardous Waste Compulsory Liability Insurance will be executed as per the relevant provisions of the Regulation on Waste Management for the hazardous waste temporary storage areas/containers regardless of the amount of hazardous waste stored;

▪ Waste reuse/recycling/recovery/disposal agreements with the Municipality and licensed recovery/disposal firms will be executed for the management of hazardous and non-hazardous waste.

▪ Official waste declarations for all waste generated will be submitted to the online system of MoEUCC, starting from January each year until the March at least.

▪ Waste storage out of the designated storage areas will be prohibited. Wastes generated in the interim storage areas will be transferred to the temporary storage area;

▪ Regular maintenance of vehicles and machinery/equipment will be undertaken to ensure that leakages of oil/fuel or any other hazardous material is prevented;

▪ Impervious (concrete etc.) surfaces will be designated for the refuelling and maintenance of the machinery/vehicles. If it is not possible according to the nature of the Project, all refuelling tankers and all heavy machinery used at the facility will have drip trays, and these trays will be placed under the pipe connection points to prevent accidental leakage to the soil during refuelling operations;

- Generators and chemical tanks will be placed in localised bunded & kerbed areas for containment of drainage, spillages and leaks in order to minimise contaminated surface water routed to the Open Drains;
- Secondary containments, ponds and drip trays will be checked regularly, especially during extreme weather conditions;
- Portable spill containment and clean-up materials (spill kits) will be made available and easily accessible at the facility, instructions on how to use spill containment and clean-up materials will be included in the kits;
- Training on spill response, use of containment and clean-up material (spill kits) will be provided to works;
- In case of a spill/leakage incident on-site, contamination levels will be identified by means of sampling and analyses studies to be conducted by accredited laboratories and the results will be compared with baseline concentrations of the related parameters to plan corrective actions where necessary;
- No wastewater discharges of any type to land will be allowed. Polluted water (if any generated as a result of accidental leakages) will be properly collected or managed to prevent the soil pollution;
- Accidental spills and leakages will be managed through implementation of the Emergency Preparedness and Response Plan.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed. Based on the baseline conditions of the assessed component, the project characteristics and actions, as well as the proper implementation of the mitigation measures proposed above, a potential **low negative impact** is expected on the soil and subsoil during the operation phase.

Table 7-4: Residual impact assessment matrix for the soil and subsoil during operation phase.

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation Effectiveness	Residual Impact Value
Minor Leakage of Contaminants into Soil	Duration:	Short	Medium	Mid term	**Low**	Medium-high	**Negligible**
	Frequency:	Infrequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					

Overall assessment:	**Low**	Rationale :	The possibility of minor leakage of contaminants into soil is the only impact factor identified for such component in the operation phase.

Monitoring measures

The following monitoring measure shall be implemented to assess the true effects of the Project on the soil and subsoil during the construction and verify the effectiveness of the mitigation measures.

- Periodic site inspections will be carried out to ensure that the open drains are free of sediments and accumulation of sediments at the sediment traps does not prevent the run-off flow;
- Periodic visual site inspection of stormwater and wastewater drainage networks, in order to verify their integrity and functionality;
- Periodic site inspections will be carried out and reported to identify any possible leakages;
- Periodic site inspections will be carried out in order to identify any possible damage in the hazardous materials storage areas and waste storage areas;
- Trainings on spill response, use of containment and clean-up material for the workers (including the subcontractors’ workers) will be recorded;
- Periodic site inspections will be carried out to ensure adequate amount of spill-response material such as spill-kits and metal trays will be present at the site and in each heavy machinery and records will be kept;
- Routine maintenance programme will be set-up and maintenance records will be kept for all vehicles and machinery/equipment.

7.1.2 Hydrology and Surface Water

Based on the information collected in the baseline (see Chapter 6.1.6), the hydrology and surface water quality component has been determined as a **high** value of sensitivity due to:

- the presence of waterbodies in AoI,
- water/sediment pollution and
- presence of hydrological changes in sub-catchments of creeks in the AoI.

Potential impacts to hydrology and surface water quality associated with the construction and operation phases of the Project include;

- Changes in flow/circulation in natural water bodies;
- Discharge of wastewater.

The Project actions related to the abovementioned impact factors are the following:

- General onshore engineering/construction works;
- Plant/infrastructure onshore operation.

7.1.2.1 Construction Phase

The impact factors from the Project activities potentially affecting the surface water quality and quantity during the construction phase of the Project will mainly be originated from the operations that have the potential to pollute surface water, either intentionally or accidentally, or that cause changes in flow/circulation in natural water bodies.

Impact factors

The impact factors from the Project activities potentially affecting hydrology and surface water quality during the construction phase are listed in Table 7-5.

Table 7-5: Project actions and related impact factors potentially affecting hydrological features during the construction phase

Project actions	Brief description	Impact factors
General onshore engineering/construction works	During construction activities, treated wastewater will be discharged into the Filyos River. Groundwater abstractions will have an impact on the baseflow of the Filyos River.	Changes in flow/circulation in natural water bodies Discharge of wastewater Minor leakage of contaminants into the water

All the impact factors identified above are assessed below for the construction phase.

- **Changes in Flow/Circulation in Natural Water Bodies**

Within the scope of Filyos Port and Industrial Area Projects the natural flow regime/streambed of Filyos River was already altered by diversion channels which were built to prevent erosion risk and to ensure flood control. The streambeds of the ephemeral streams, which are the smallest channels feeding the Filyos River, have already been disturbed and diverted to stormwater collection channels. As a result, no major impact on the recharge of Filyos River is expected, and this impact factor can be considered negligible. In addition, groundwater abstractions in the construction phase are expected to affect the baseflow of the Filyos River. The changes in baseflow rates are discussed in detail in Chapter 7.2.2.

Within the scope of the Project, a comprehensive hydrological modelling and flood hazard analysis was conducted by Suİş Proje Engineering and Consulting Co. Ltd. (Suİş). Due to the flood-prone nature of the Filyos River, this study aims to identify and quantify flood risks and provide recommendations for risk mitigation. The objective of this report is to:

- establish a HEC-RAS hydraulic model for flood hazard analysis.
- perform both steady and unsteady flow studies using the model to assess potential flood risks.
- provide recommendations for mitigating flood hazards based on model outputs.

Flood discharges were calculated using three primary methods:

- DSİ Synthetic Method: Applicable for drainage areas up to 1000 km², this method uses unit hydrographs to predict peak flood discharge.
- Mockus Method: Suitable for smaller drainage areas, this method assumes constant precipitation intensity over the basin and uses unit hydrographs to estimate flood peaks.
- Snyder Method: Used for larger drainage areas (up to 25,000 km²), it employs basin-specific coefficients to calculate flood hydrographs.

The study area was divided into 18 sub-basins based on tributaries and dam outlet points. Calculations were made for flood recurrence intervals (Q_2 to Q_{10000}) for each sub-basin (Figure 7-1, Table 7-6).

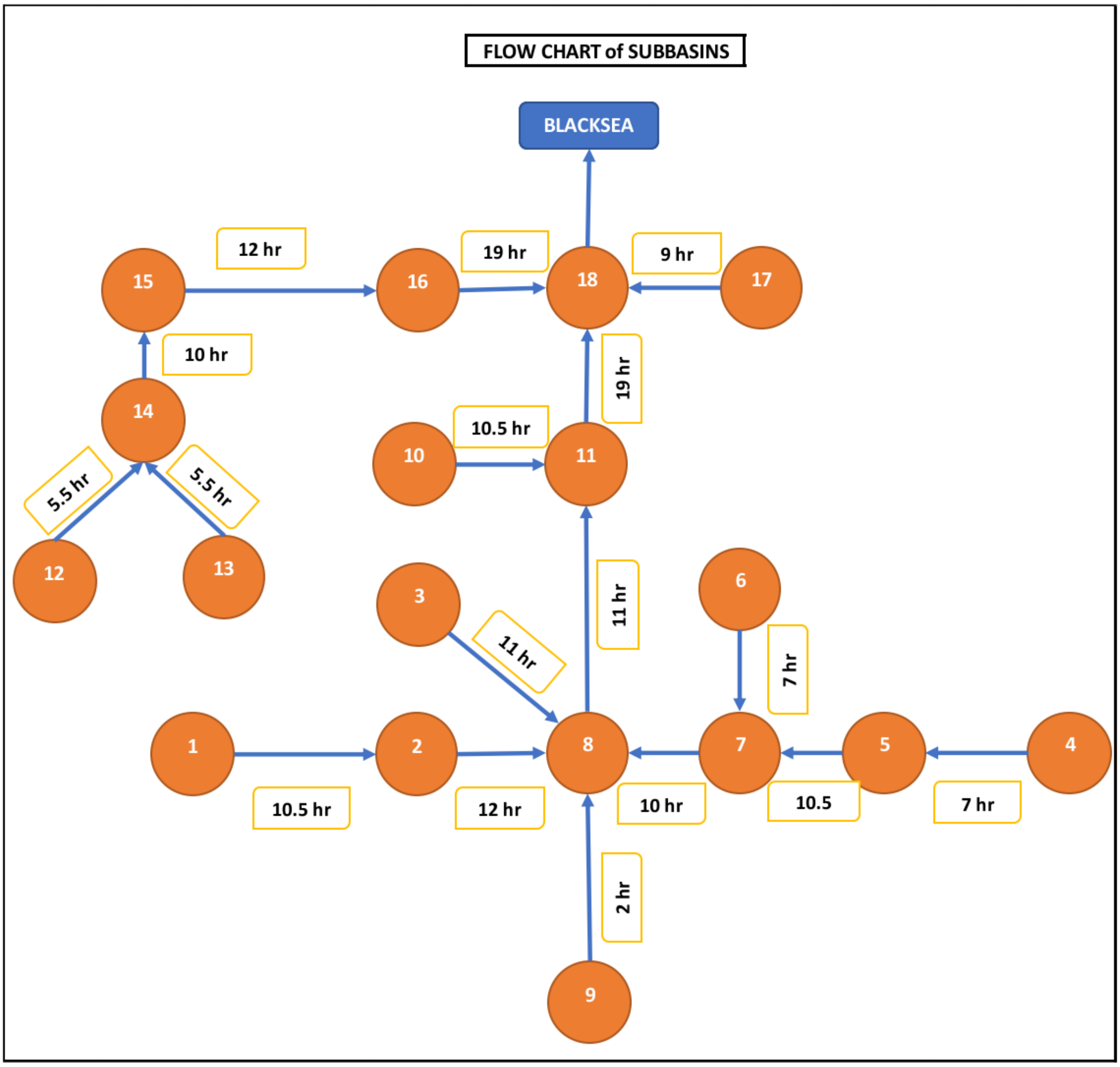


Figure 7-1: Flow Chart of Sub-Basins

Table 7-6: Characteristics of Sub-Basins

No	Precipitation Area (km^2)	L (km)	Lc (km)	CN	Ttr (h)	Elevations										
						0	1	2	3	4	5	6	7	8	9	10
1	3598.3	203.82	93.6	80	10.5	555	688	786	886	945	996	1064	1141	1158	1238	2255
2	798.72	76.99	62.08	78.6	12	318	358	388	418	459	494	547	697	839	1039	1455
3	656.14	60.76	27.12	78.8	11	338	405	499	569	637	720	832	1010	1307	1457	1885
4	816.76	45.55	19	77.6	7	667	706	746	787	838	913	976	1092	1259	1484	2275
5	939.98	50.83	24.1	77.3	10.5	454	565	593	643	714	765	865	883	948	1039	1319
6	308.47	41.91	22.11	78.9	7	758	781	804	825	852	866	875	891	938	963	1127
7	731.54	57.86	40.72	79.2	10	256	276	299	321	359	375	581	796	892	954	1062
8	689.31	55.36	20.28	76.3	11	119	136	152	169	199	227	245	265	289	314	825
9	123.54	29.24	17.07	73	2	135	250	316	433	478	550	628	798	945	1070	1775
10	337.01	40.38	20.22	74	10.5	123	179	252	318	382	451	523	608	720	867	1350
11	366.6	35.58	18.22	76.5	19	43	53	58	66	70	79	88	97	107	196	825
12	1109.95	83.5	35.84	77.5	5.5	525	598	645	685	690	711	750	825	945	1182	1595
13	733.1	52.45	20.04	75.9	5.5	531	567	597	629	668	718	778	849	958	1120	1775
14	150.42	34.43	15.45	75.4	10	364	375	397	427	449	495	525	800	1093	1335	1450
15	573.24	65.77	33.87	74.3	12	137	167	192	211	242	298	398	533	723	951	1805
16	667.64	56.95	30.19	76.9	19	43	52	62	75	94	191	295	362	489	666	1175
17	247.4	35.5	18.58	81	9	6	8	14	18	24	33	42	55	98	180	665
18	519.77	68.41	30.58	80	-	0	3	8	12	18	29	37	75	155	308	877

Flood flow rates were calculated for each sub-basin using the recurrence intervals, as shown below:

Table 7-7: Flood Flow-Rates

NO	Q2	Q5	Q10	Q25	Q50	Q100	Q500	Q1000	Q10000
1	165.14	235.38	283.29	345.21	392.14	439.83	548.16	594.81	749.79
2	78	126.83	167.24	231.61	292.69	369.04	508.69	568.83	768.61
3	80	127.12	164.11	219.8	269.61	328.59	442.41	491.42	654.25
4	58.16	79.29	91.3	104.91	114.15	122.78	144.56	153.94	185.1
5	52.97	78.22	99	130.57	158.37	190.23	253.36	280.54	370.86
6	37.2	57.72	71.31	88.48	101.22	113.86	143.31	155.99	198.11
7	66.15	102.65	126.82	157.35	180	202.49	254.85	277.4	352.31
8	89.85	164.35	226.87	321.21	402.51	493.55	678.08	757.55	1021.56
9	31.64	54.32	72.36	98.53	119.56	142.11	190.38	211.16	280.22
10	65	105.69	139.36	193.01	243.91	307.53	423.91	474.02	640.51
11	49.94	100.57	151.68	243.15	333.3	447.18	651.66	739.72	1032.26
12	58.14	84.02	105.89	139.86	170.35	205.87	275.06	304.85	403.83
13	53.61	96.92	136.93	203.8	267.69	345.91	490.52	552.79	759.68
14	18.65	33.72	47.64	70.9	93.12	120.33	170.64	192.31	264.28
15	64.98	115.12	159.36	229.28	291.48	362.68	503.38	563.97	765.26
16	109.49	194.98	269.22	380.35	476.69	585.62	804.57	898.86	1212.1
17	102.99	166.85	211.95	270.06	314.37	360.2	462.79	506.97	653.74
18	127.31	223.5	310.81	450.41	576.64	722.65	1007.64	1130.36	1538.08

To facilitate accurate flood modelling, the Filyos River is divided into four different sub-regions, each with distinct physical and hydraulic characteristics. These sub-regions are characterized by differences in:

- **Riverbed composition** (e.g., sandy, rocky, vegetated)
- **Floodplain characteristics** (e.g., flat agricultural areas, densely vegetated zones)
- **Sedimentation and erosion patterns** (e.g., areas prone to silt build-up)

By subdividing the river into smaller sections, the study can assign a specific Manning's n value to each sub-region. These n values are applied to hydrodynamic models to simulate floodwater depth and velocity. Higher n values lead to deeper water but slower flow, while lower n values result in faster, shallower water flow.

- Upper reaches: Lower n values (0.025 – 0.030), indicating faster flow.
- Middle reaches: Moderate n values (0.035 – 0.040), due to increased vegetation and sedimentation.

- Lower reaches and floodplains: Higher n values (0.045 – 0.060), due to wider, vegetated areas.

Flood assessment boundary is determined a way that involves potential flood plain. Despite of the Onshore Production Facility construction field is located right overbank of Filyos River, left overbank of river is included to map boundary for correct flood modelling (Figure 7-2). Despite of the Onshore Production Facility construction field is located right overbank of Filyos River, left overbank of river is included to map boundary for correct flood modelling (Figure 7-2).

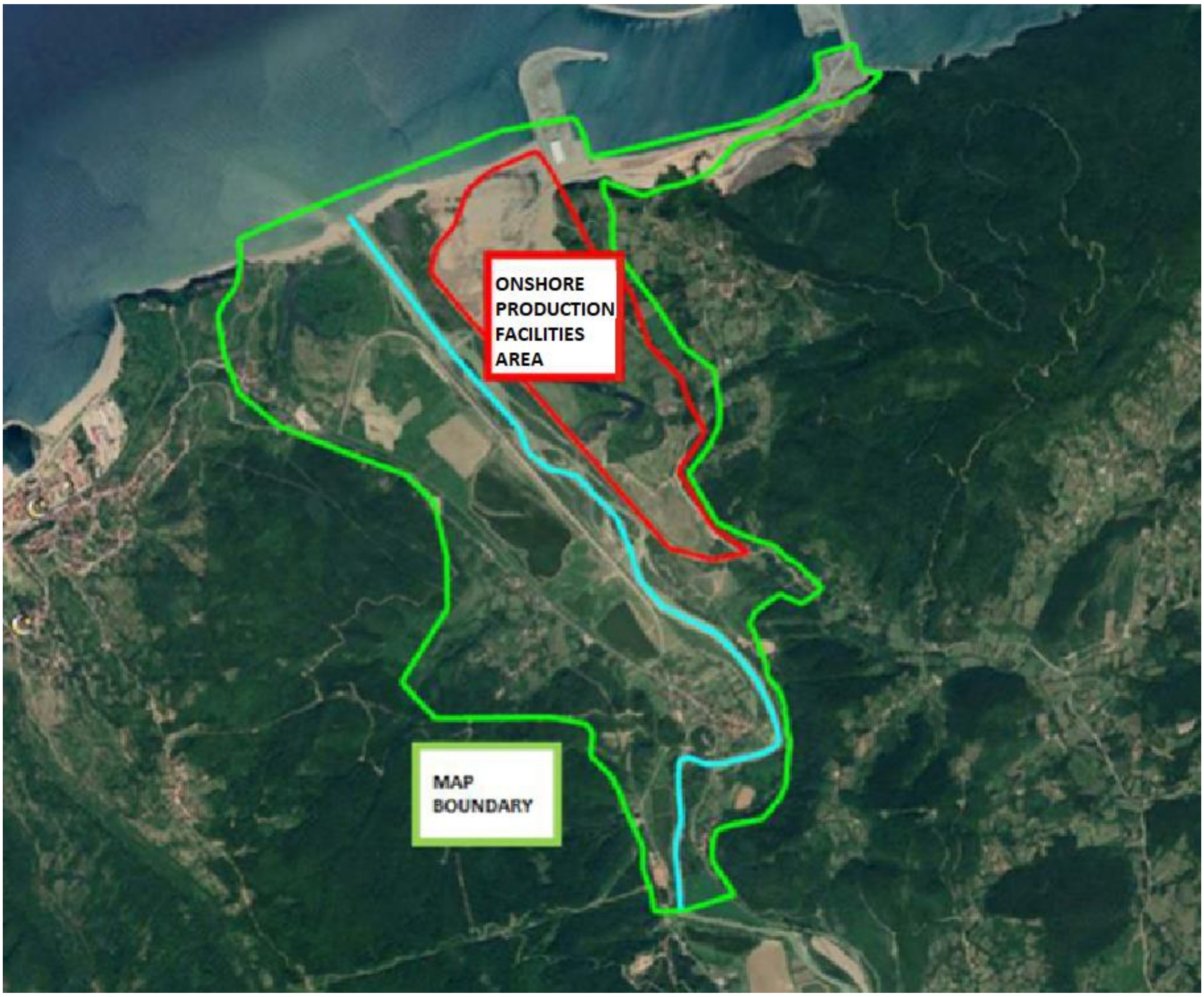


Figure 7-2: Flood Assessment Boundary (Suİş, January 2024)

A triangular irregular network (TIN) was used to generate 158 cross-sections along the Filyos River. Cross-section intervals were kept under 50 meters to ensure accuracy. In areas with art structures (e.g., bridges), the spacing was reduced to improve representation in the model. Additional cross-section details, such as slope tops, were based on field survey data. Two key bridges (upstream and downstream) were surveyed, and the data were incorporated into the HEC-RAS hydraulic model. Orthophotos were collected and combined with the DEM to serve as a base for GIS analysis and HEC-RAS simulations, enhancing the accuracy of the flood risk assessments.

Figure 7-3: Triangle Model – Digital Elevation Model and Orthophoto (Suİş, January 2024)

Various scenarios were simulated using 1D and 2D hydraulic models, specifically focusing on steady and unsteady flow conditions. The chapter outlines the methodology used for the modelling, discusses the results for different return periods, and presents key findings through detailed flood maps and hazard assessments.

Hydrodynamic models were created to simulate both 1D steady and 1D/2D unsteady flow conditions. The modelling was performed for different return periods (e.g., Q_{10000}) to simulate extreme flood events.

- **1D Steady Model**
  - The 1D steady model evaluates the behaviour of water flow under steady conditions (i.e., assuming that flow rates and water levels do not change over time). The goal of this model is to assess the impact of a high return period flood event (such as Q_{10000}, representing a flood that has a 1 in 10,000 chance of occurring in any given year).
  - Methodology: The steady flow model simulates water flow through a series of cross-sections along the Filyos River, using known flow data for various return periods (Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, Q_{100}, and Q_{10000}).
  - Results: The study provides water depth profiles for the Q_{10000} event, showing areas along the river that are most vulnerable to high water levels. This steady flow model serves as a benchmark for identifying the maximum possible water depths that the river could reach under extreme flood conditions.

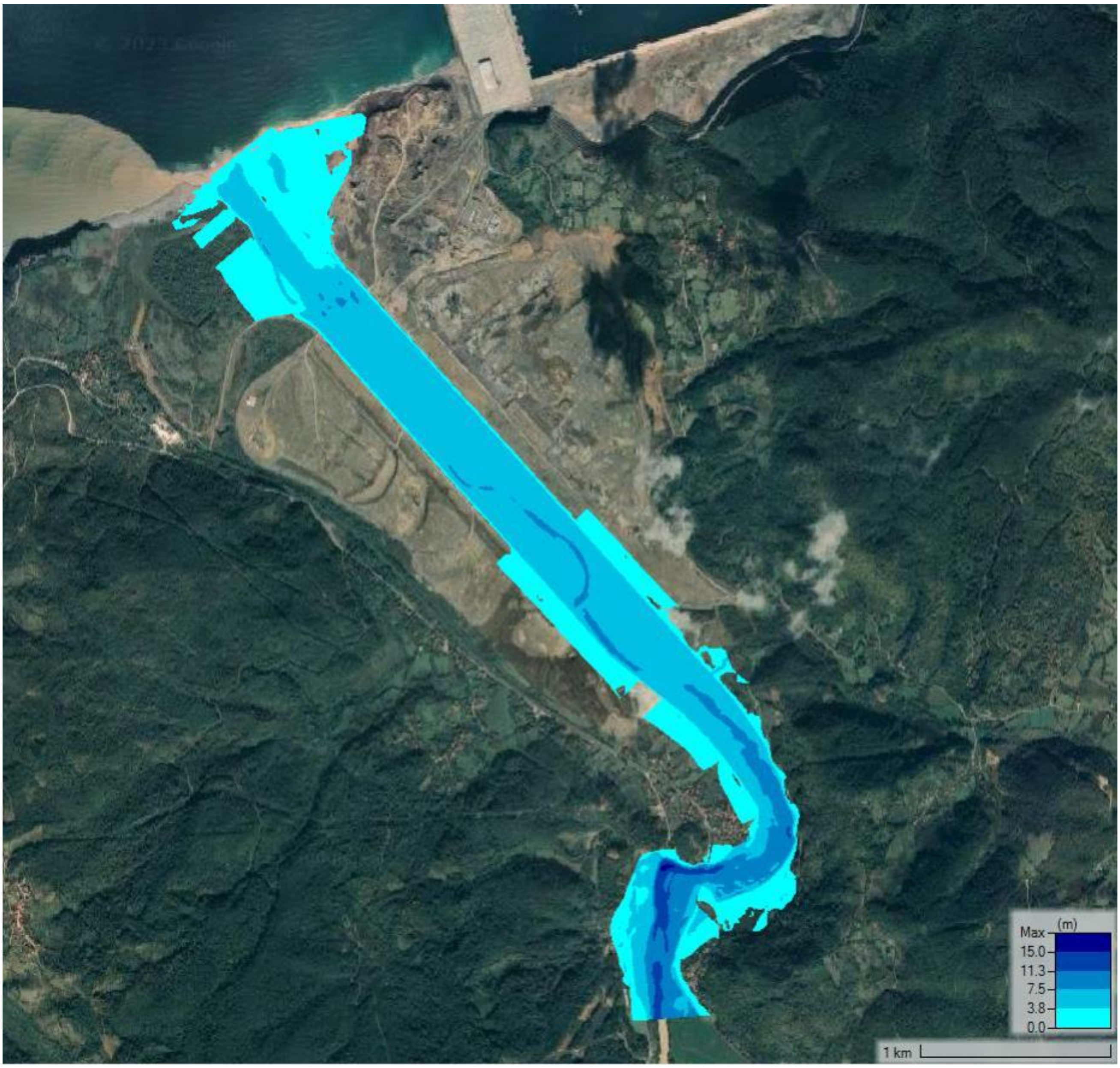


Figure 7-4: 1D Q_{10000} Steady Flow Studies and Results – Water Depth (Suİş, January 2024)

- **One-Dimensional (1D) Unsteady Flow Model**
  - The 1D unsteady flow model expands on the steady flow analysis by incorporating time-dependent variations in flow and water levels. Unsteady flow modelling is essential for understanding how floods evolve over time, including the rise and fall of floodwaters and the propagation of flood waves downstream.
  - The unsteady flow model simulates how the water level and discharge change over time for different flood scenarios, focusing on the Q_{10000} flood event. The model calculates how water spreads across

the floodplain and how quickly it recedes, considering factors such as dam releases and storage capacities in the basin.

- The results of the unsteady flow study present flood profiles for various return periods, including the Q_{10000} event. The profiles show maximum floodwater depths, flow velocities, and inundation areas. The model shows the flood rise time it takes for water levels to reach their peak after the onset of a flood event. Also, recession period, the time required for water levels to return to normal following the flood peak, was calculated.

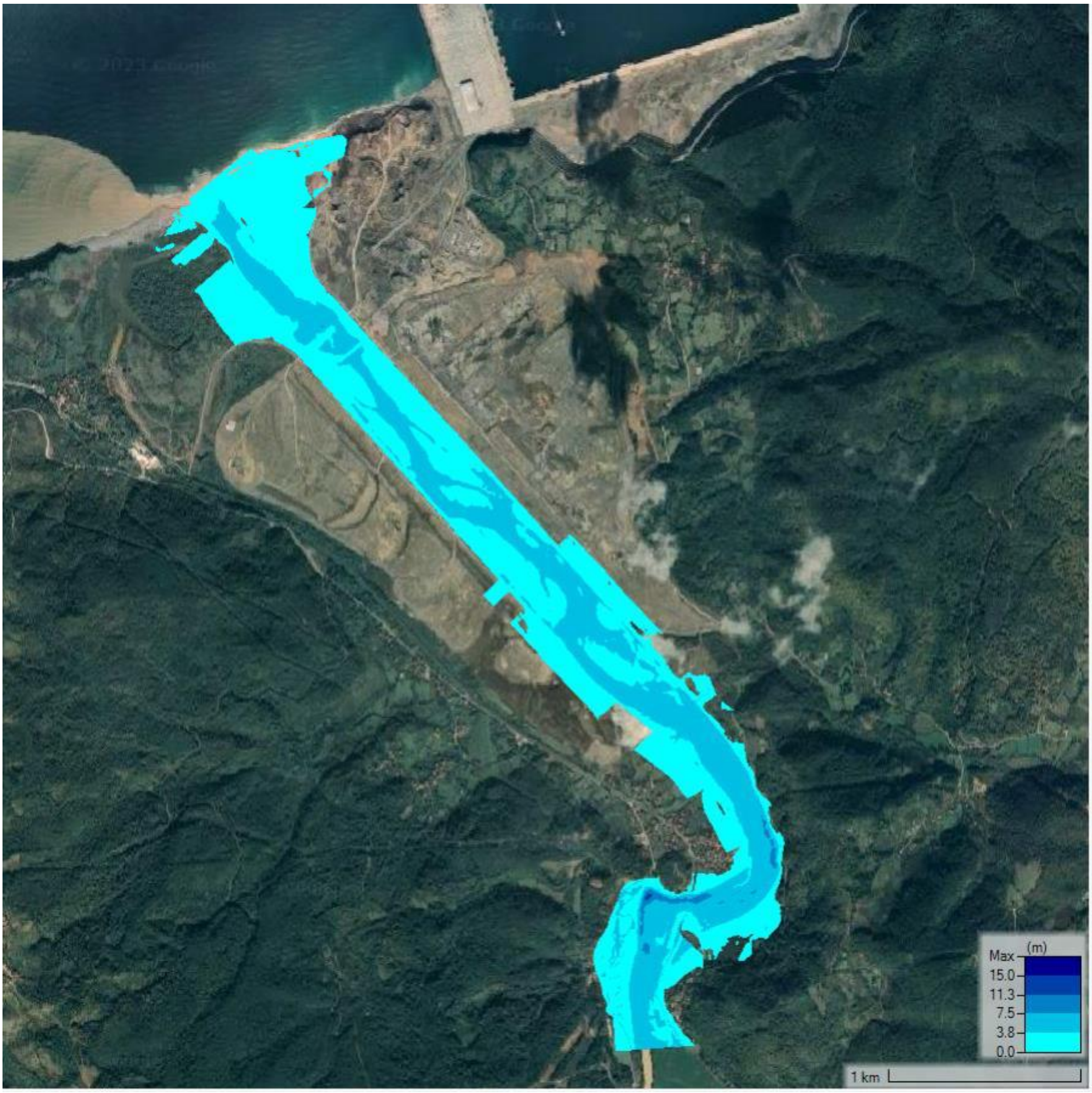


Figure 7-5: 1D Q_{10000} Unsteady Flow Studies and Results – Maximum Water Depth (Suİş, January 2024)

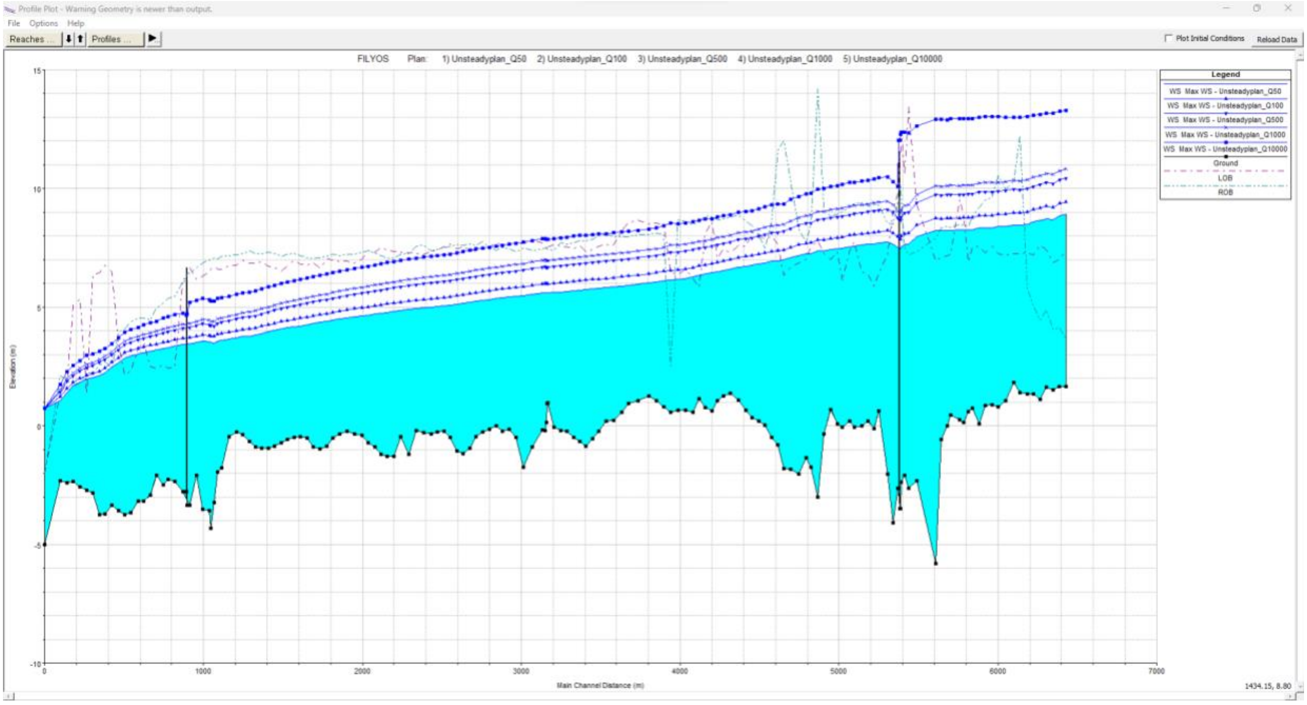


Figure 7-6: Results of 1D Unsteady Flow Profiles for All Return Periods (Suİş, January 2024)

- **Two-Dimensional (2D) Unsteady Flow**
  - The 2D unsteady flow model was developed to provide a more detailed understanding of the flood dynamics by incorporating spatial variations in flow. This model allows for the simulation of water movement not only along the river channel but also across the floodplain. By accounting for multiple flow directions and interactions between river channels and the surrounding land, the 2D model delivers a more accurate representation of complex flooding scenarios.
  - Using HEC-RAS 2D, the model divides the study area into a mesh of computational cells, with each cell representing a portion of the floodplain. Water flow between cells is simulated based on topography, land use, and hydraulic structures such as embankment and bridges.
  - Four different scenarios were simulated to predict the behavior of the Q_{10000} flood event:
    - In Scenario 1, modelling studies were carried out according to the conditions in January 2024 of the embankments in the study area and the vegetation in the stream bed in the modelling area (Figure 7-7). As a result, the overflow is observed due to a depression formed in the embankments in the upstream section of the right bank. Regulation and maintenance of the depression in these dykes, the location of which is shown in Figure 7-8 and the profile of which is shown in Figure 7-9, was recommended. When it comes to the downstream of the right bank, overflow was observed in the sections due to the vegetation on the stream bed in the area where the facility is located.

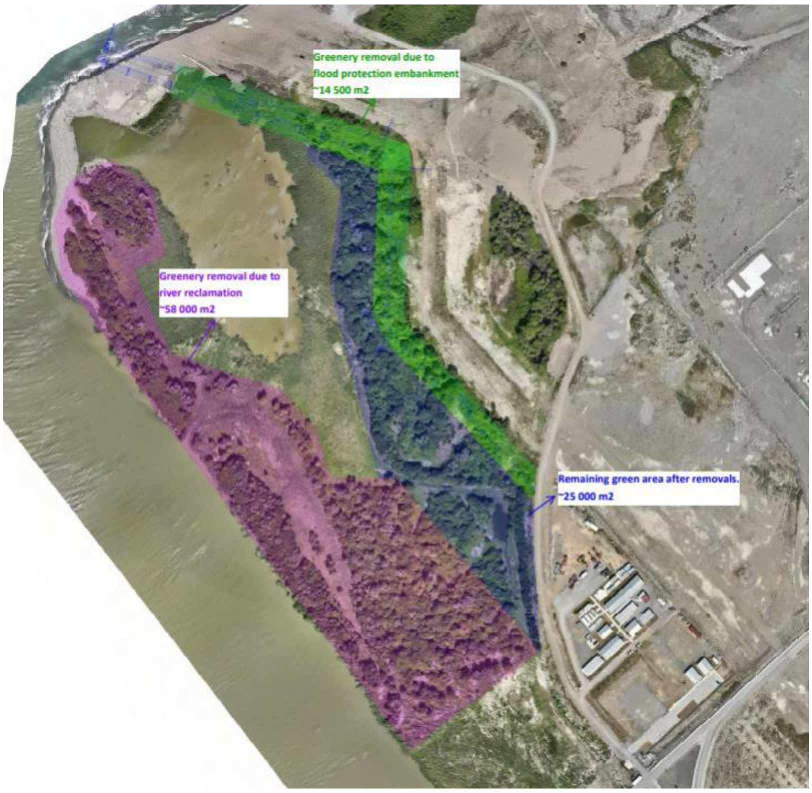


Figure 7-7: Vegetation in The Riverbed in January 2024 (Suİş, January 2024)

Figure 7-8: Pothole Location (Suİş, January 2024)

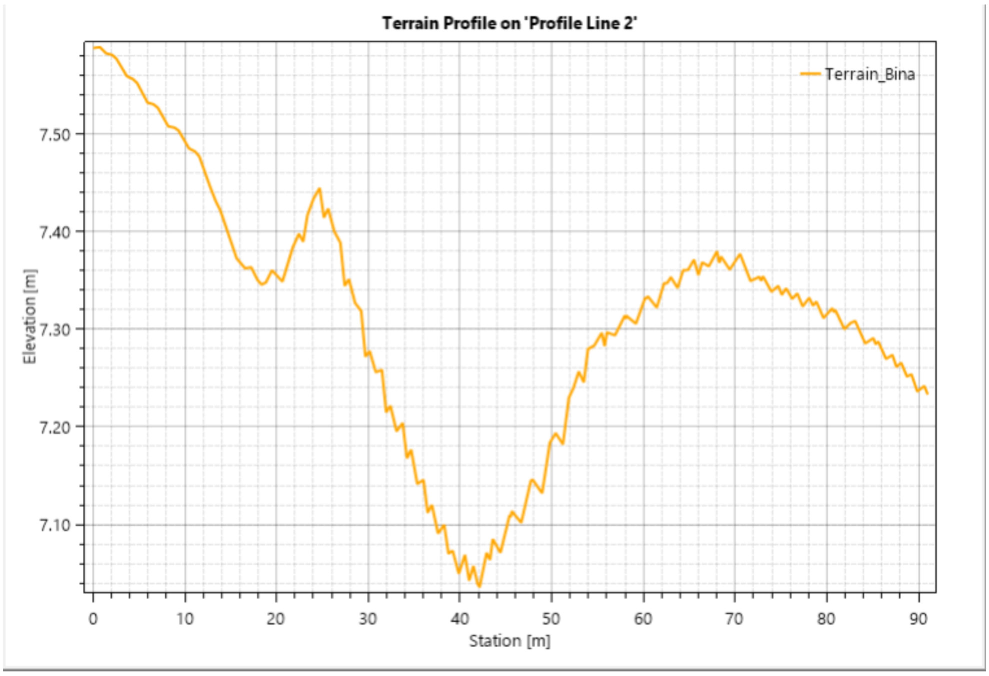


Figure 7-9: Profile of the Embankment in the Area of the Pothole (Suİş, January 2024)

- In scenario 2, modelling studies were carried out according to the current condition of the embankments in the modelling area, where the vegetation in the stream bed in the Sakarya Gas Field area was cleared. It is assumed that the vegetation is removed, therefore the spread on the right bank downstream is considerably reduced. Since no scenario different from the first case was studied in the upstream sections, the results for the upstream and left-bank are indistinguishable from the first case.
- In scenario 3, modelling studies were carried out according to the case where the embankments in the study area are extended until they reach the sea as shown in Figure 7-10 within the scope of the "Sakarya Gas Field Onshore Facilities Construction of Additional Levees" work and the vegetation on the stream bed in the Sakarya Gas Field area is left. In scenario 3, it was assumed that the extension works were completed and the 1-D modeling study was carried out accordingly. Although the dikes were extended to the sea, overtopping was observed in the cross sections towards the Gas Field Facility due to the vegetated area.
- In scenario 4, modelling studies were carried out according to the situation where the embankments in the study area were extended until they reached the sea within the scope of the "Sakarya Gas Field Onshore Facilities Construction of Additional Levees" work and the vegetation in the stream bed in the Sakarya Gas Field area was cleared. In scenario 4, it is assumed that the extension works have been completed, the vegetation has been removed and no overtopping to the right bank is observed. The cross-section comparison of Case 3 and Case 4 results is given in Figure 7-11. The red line indicates the stretcher to be extended.
- In all 4 scenarios studied, no overtopping of the downstream bridge was observed and the bridge deck at 5.80 m was sufficient for the 10,000-year flood flow. In addition, in all scenarios, in the 10,000-year flood flow, backflow was observed towards the side stream shown in Figure 7-12.

Figure 7-10: Location of Embankment within the Scope of the Sakarya Gas Field Onshore Facilities Construction of Additional Embankment Work (Suİş, January 2024)

Figure 7-11: Comparative View of Case 3 and Case 4 Sections (Suİş, January 2024)

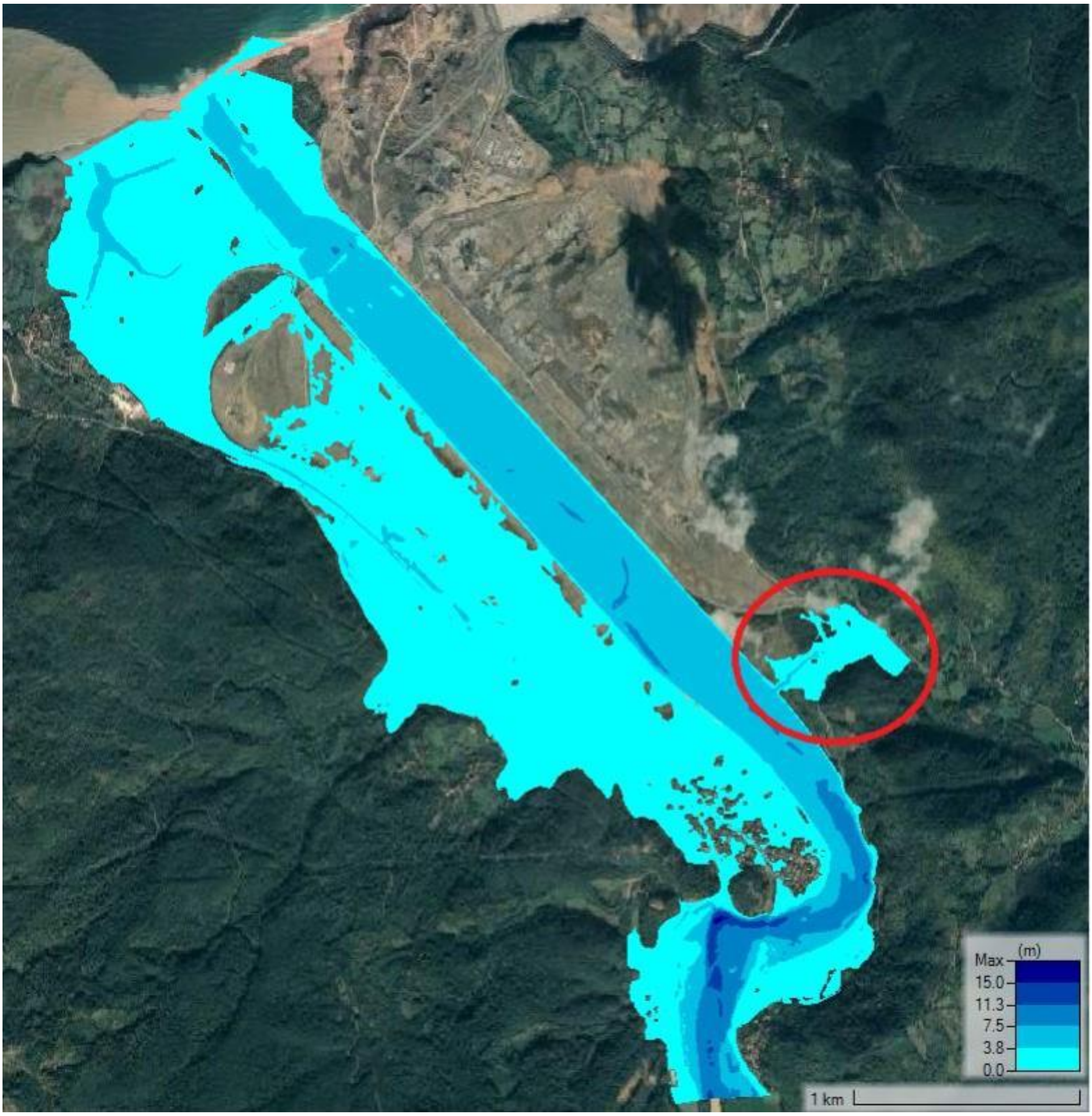


Figure 7-12: Side Stream Subject to Backflow (SuİŞ, January 2024)

- The flood hazard maps generated from the 2D unsteady flow studies illustrate the potential risk zones across the Filyos River Sub-basin. These maps categorize areas based on flood depth and velocity:
  - High Risk Zones: Areas with high water depths (> 2 meters) and velocities (> 2 m/s), which pose serious risks to life and property.
  - Moderate Risk Zones: Areas with moderate water depths (1–2 meters) and velocities (< 2 m/s), where flooding may cause structural damage but is less likely to be life-threatening.

- Low Risk Zones: Areas with minimal water depths (< 1 meter) and low velocities, where the flood risk is relatively low.

Based on the hydrological and hydraulic studies (Suİş, January 2024), the embankment recommended in Scenario 4 (Figure 7-10) was constructed in 2024 in order to protect critical infrastructure and implement regular sediment management to prevent blockages in flood channels.

Continuous monitoring through updated stream gage stations is also crucial for accurate flood forecasting and early warning systems. Suggested mitigations are discussed in the Mitigation Measures.

- **Discharge of Wastewater**

Sources of wastewater to be produced during the construction phase are listed below.

Domestic Wastewater / Sewage Wastewater due to Personnel

Water demand per capita is estimated as 223 L/person/day based on 2022 data from TUIK (Turkish Statistical Institute) Municipal Water Statistics. It is assumed that all the domestic water to be used by the Project personnel will be converted to domestic wastewater. As such, the maximum wastewater generation per day during the construction period is calculated as 557.5 m^3/day including offsite accommodation (if applicable) and construction camps. Domestic wastewater generated by personnel at the campsites will be collected by sewage infrastructure and treated in sewage wastewater treatment plants that have been established by TP-OTC. As of October 2024, there are 3 sewage treatment plants operated by TP-OTC. The generated wastewater from these plants is discharged to Filyos River in line with the environmental permit that was secured from the Provincial Directorate of Environment, Urbanization and Climate Change as per the Regulation on Environmental Permits and Licenses.

The total sewage handling capacity of the current 3 sewage treatment plants is 517 m^3/day. The maximum handling capacities of each current sewage treatment plant on site and the discharge locations are presented in Table 7-8.

Table 7-8: Maximum Capacities and Discharge Procedures of Domestic Wastewater Treatment Plants During the Construction Phase

Sewage Treatment Plants	Daily Amount/Outlet Flowrate (maximum capacities)	Discharge Location	Discharge Permit
OPF (Red Zone)	75 m^3/day	Filyos River	Obtained
ACD	40 m^3/day	Filyos River	Obtained
TP-OTC former contractor campsite area	400 m^3/day	Filyos River	Obtained

Wastewater Generated by Backwashing of Filters in the Potable Water Treatment Plants

There are 3 onshore potable water treatment plants operated by TP-OTC which generate backwash wastewater of approximately 106.5 m^3/day calculated according to 928 people of camp capacity. Campsite capacities are not expected to be increased due to the construction phase of Phase 2 since there is sufficient capacity in the campsites. Treated wastewater will be discharged to the receiving environment in line with the environmental permit to be secured from the Provincial Directorate of Environment, Urbanization and Climate Change as per the Regulation on Environmental Permits and Licenses.

Wastewater Generated from Pre-commissioning Activities

- After the completion of the construction phase and before the pipelines are put into operation, all the pipes will be hydrotested to detect possible faults in the junctions and prevent leakage. The hydrotest (pre-commissioning activities) of the onshore part of the export gas pipeline will be carried out separately from the offshore components. For pre-commissioning activities of the onshore section of the export pipeline will be filled with potable water. Approximately, 2,850 m^3 potable water will be used and it will not include chemical additives. The potable water will be supplied from Filyos or Saltukova Municipalities. For pre-commissioning activities of the offshore section of the gas export trunkline and infield flowlines will be filled with seawater. Approximately 42,523 m^3 seawater will be used. Seawater will be supplied from an intake structure (water winning spread) that will be located at Filyos Port quayside.

Overall Assessment of Wastewater Discharges

To sum up, based on the information provided by TP-OTC, the total amount of water needed for onshore part of hydrotest line is 2,850 m^3. The number of daily discharges related to hydrotesting is negligible. For this reason, water used for hydrotesting was not included in runoff assessments because discharges will be infrequent. Accordingly, treated wastewater, with a discharge capacity of up to 700 m^3/day (consisting of up to 515 m^3/day from the existing domestic wastewater treatment plant and 185 m^3/day from the backwash wastewater treatment plant) will be discharged into the Filyos River. The minimum flow rate of Filyos River which is approximately 28 m^3/sec according to long-term flow rate data (Özdemir & Güngör, 2019). Since the water budgets of the receiving environments (Filyos & Black Sea) are much larger than the discharged amounts, no quantity impact is expected or very limited in the amount discharged to the Filyos River and Black Sea. Therefore, the impact can be considered as low. Impact assessment on discharge to Black Sea is addressed in Chapter 7.3.1.3.

- **Minor Leakage of Contaminants into Water**

Leakages of contaminants into the water would be mainly expected to occur due to runoffs from areas in proximity of freshwater bodies that have experienced:

- Oil and fuel leakage from vehicles and generators;
- Accidental spill of any hazardous materials that are used during the construction;
- Runoff from area where chemical, oil and fuel are temporarily stored (i.e. areas where paving and secondary containments are not present);
- Pollution caused by temporary storage of hazardous materials and/or wastes;
- Disposal of wastes, wastewater and liquid wastes;
- Flooding of ponds (i.e., settling pond of concrete wastewater) or secondary containments caused by heavy precipitation;

- Accidental spill of wastewater (e.g., domestic, hydrotest).

Mitigation Measures

The following mitigation measures shall be implemented to mitigate the effects of the impact factors.

- **Changes in Flow/Circulation in Natural Water Bodies**

No mitigation measures are identified for the impact factor potentially affecting the hydrology and surface water quality during construction.

According to the results of the Sediment Report prepared within the scope of the Project and the results of 4 different scenarios modelled in the Flood Hazard Analysis Project, the measures to be taken, as necessary, are as follows;

- The depression in these dykes, the location of which is shown in Figure 7-8 and the profile of which is shown in Figure 7-9, will be maintained.
- In the side stream, flood waters do not spread to the right bank of the stream bed at the 100-year flood flow rate, but spread to the right bank at the 500, 1000 and 10000-year flood flows. Since there are units such as the facility entrance gate, gendarmerie, and health centre on the right bank of the side stream, rehabilitation works will be considered for this stream.
- Model studies have shown that the wooded area located downstream in the stream bed poses a hazard as it may cause a spread towards the Natural Gas Process Facility during the 10000-year flood flow. Therefore, the construction of the embankment, which was completed in 2024, will be considered as a precautionary measure.
- Bridge abutments will be cleaned frequently, especially after flood events, to prevent accumulation around the engineering structures located on the creek line, and that they are cleared of debris such as tree branches.
- Within the scope of the Flood Risk Assessment, DSİ officials were interviewed in order to examine the status of sediment facilities in the basin, the data of the Western Black Sea Basin Master Plan, which is the most comprehensive study conducted in the basin to date, were examined and accordingly, the inventory of existing and proposed sediment control facilities in the basin was prepared, sediment observation station data were evaluated and the sediment load carried in Filyos River was determined for current and future situations.
- In the "Basin Flood and Sediment Control" studies, structural measures such as Walled Flood Channels, Stacked Stone Fortified Trapezoidal Channels, Earthen Trapezoidal Channels, Reclamation Berm, Reverse Dike, Base Belt, Brit, Railing, Bridge etc. were included in addition to the existing facilities built in the past years. In addition, thresholds, maintenance and repair of facilities, cleaning of the stream bed, protection of the basin and studies for the development of vegetation in the basins, etc. were recommended to prevent the slopes. Within the scope of this project, the studies carried out were reviewed and evaluated specifically for the Filyos Sub-Basin.
  - According to the calculations made within the scope of the Filyos Natural Gas Processing Facility, according to the sediment observation station data in the Filyos Sub-Basin, there is a total sediment load of 200.10 m^3/year/km^2, which is 133 m^3/year/km^2 suspended sediment load and 50% of this value

as bed load. According to these values, it is expected that 1.94 million m^3 (9,703.30 x 200.10) of sediment will be transported annually from 9,703.30 km^2 which is currently uncontrolled, and 0.75 million m^3 (3,761.17 x 200.10) of sediment will be transported annually from 3,761.17 km^2 which will remain uncontrolled under development. These values are average values and they are independent of the amount of sediment that will come as a result of floods that may occur in 50, 100, 500 etc. recurrence years.

- The construction status of the 154 facilities proposed to be constructed in the Filyos Sub-Basin will be monitored by Works State Hydraulics (DSİ) and the commissioning of the facilities will significantly reduce the sediment load to the study area. The construction of these 154 facilities on the Yenice (Filyos) River is of utmost importance in order to reduce the amount of sediment that may reach the Sakarya Gas Field Onshore Production Facility area, and to reduce the amount of sediment that will reach the area, especially during flood times. Construction and maintenance of these upstream facilities will be continuously monitored by the relevant administrations. Periodic cleaning of the trash materials accumulated around the crossing structures on the stream beds will be done/caught to be done during the year.

- **Discharge of Wastewater**
  - The drainage system within the construction areas will be designed to collect the runoff water and discharge it into the Filyos River after proper outlet structures to prevent off-site sediment transport.
  - The wastewater from onshore pre-commissioning activities will be discharged to Filyos River by vacuum trucks or through rainwater drainage channels if the analyses results are compliant with the Project Standards.
  - The hydrotesting lines shall be depressurized immediately after the successful in disposing the test water, maximum care shall be taken not to damage any other structure and/or equipment, etc. Excessive erosion of the temporary backfill materials on the access roads, road itself and/or soil shall be avoided.
  - Project-specific Pollution Prevention Plan will be implemented for the management of hydrotest water, backwash wastewater, sewage wastewater, wastes and hazardous materials and implemented during the construction phase of the Project.
  - All discharge points would utilize discharge dispersion methods(e.g., controlled rate of discharge and use of energy dissipaters, displacement of geotextile mats or other physical erosion prevention measures) to mitigate erosion. Measures to minimise scour and reduce sediment load will be implemented at locations where hydrotest water is discharged to Filyos River and discharge velocities will be regulated to prevent erosion (e.g. controlled rate of discharge and use of energy dissipaters, displacement of geotextile mats or other physical erosion prevention measures).
  - Where possible, water used in one section of the pipeline will be transferred to adjacent sections upon completion of the hydrostatic test section in order to minimize discharge volume.
  - Discharge of wastewater to surface waters will be in compliance with the applicable regulatory requirements given in Appendix C.
  - Fueling/refilling and chemical handling activities in close vicinity of the watercourses will be restricted.

- **Minor Leakage of Contaminants into Water**
  - Project-specific Pollution Prevention Plan and Waste Management Plan will be updated for Phase 2 and implemented to ensure that the amount of release and spills can be taken under control before reaching substantial amounts that may potentially affect the quality of soil and potentially that of the nearby water bodies.
  - Detailed information on spills and leakages mitigation procedures are provided in Chapter 7.1.1.
  - Particular care will be taken on spill containment procedures and materials, and spill/leakage response training of personnel in order to avoid any contamination reaching the freshwater habitats where containment and clean-up procedures would become significantly more complex.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed.

Based on the baseline conditions of the assessed component, the Project characteristics and actions, as well as the proper implementation of the mitigation measures proposed above, low negative impact is expected on the hydrology and surface water quality during the construction phase.

Table 7-9: Residual impact assessment matrix for the hydrology and surface water quality during construction phase

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
Discharge of Wastewater	Duration:	Medium	High	Short-mid-term	**Medium**	Medium-high	**Low**
	Frequency:	Highly frequent					
	Geo. Extent:	Local					
	Intensity:	Medium					
Changes in Flow/Circulation in Natural Water Bodies	Duration:	Medium	High	Short-mid-term	**Medium**	Medium-high	**Low**
	Frequency:	Frequent					
	Geo. Extent:	Local					
	Intensity:	Medium					
Minor Leakage of Contaminants into Water	Duration:	Medium	High	Short-mid-term	**Medium**	High	**Negligible**
	Frequency:	Infrequent					
	Geo. Extent:	Local					
	Intensity:	Low					
Overall assessment:		**Low**	Rationale:	Due to the compliance with relevant standards of the impact factors, even using a precautionary approach, the residual impact values are not expected to cumulate to a higher impact value. Therefore, the average residual			

Impact Factor	Impact Factor Features	Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
			impact value may be considered as a reference for the overall impact.			

Monitoring measures

The following monitoring measure shall be implemented to assess the true effects of the Project on the hydrology and surface water quality during the construction and verify the effectiveness of the mitigation measures.

- Periodic visual site inspection of stormwater and wastewater drainage networks, in order to verify their integrity and functionality;
- Periodic site inspections will be carried out and reported to identify any possible leakages;
- Periodic site inspections will be carried out in order to identify any possible damage in the hazardous materials storage areas and waste storage areas;
- Training on spill response, use of containment and clean-up material for the workers (including the subcontractors' workers) will be recorded;
- Sampling and analysis of hydrotest water by accredited laboratories to check whether water quality is suitable for discharge;
- Monthly monitoring of discharge water quality with chemical analysis;
- Monthly monitoring of Filyos River water quality in terms of Flow (Low/med/high), Conductivity (μS/cm), Turbidity (NTU), Temperature (°C), pH, Dissolved Oxygen (mg/L) at the upstream and downstream of the wastewater discharge locations;
- Quarterly sampling of the Baseline Surface Water sampling locations and regulatory and trend analyses according to Project Standards,
- Water samplings and analyses to be performed at the hydrotest discharge point immediately after the hydrotesting activities and one month after them (i.e., a time interval from a week after to a month after is acceptable).

7.1.2.2 Operation Phase

Impact factors

The impact factors from the Project activities potentially affecting hydrology and surface water quality during operation phase are listed in following Table 7-10.

Table 7-10: Project actions and related impact factors potentially affecting hydrological features during operation phase

Project actions	Brief description	Impact factors
Plant/infrastructure onshore operation	During operation activities, wastewater will be treated and discharged to Filyos River.	Discharge of wastewater

- <u>**Discharge of Wastewater**</u>
  - There will not be any wastewater discharge on the onshore section due to the operation of Phase 2 other than the ones defined in the Phase 1 ESIA.
  - The only wastewater generated due to the onshore operation of Phase 2 will be domestic wastewater generated due to personnel and backwash water. The discharge of treated wastewater into the river is expected to increase by up to 8.10 m³ per day, in addition to the existing amount. The treated wastewater will be discharged intermittently into the river in accordance with the relevant permits.

Mitigation measures

The following mitigation measures, developed for Phase 1, will continue to be implemented to mitigate the effects of the impact factors.

- **Discharge of Wastewater**
  - As elaborated in Phase 1 ESIA, the drainage system (including closed drain and open drain) within the OPF has been designed to collect the runoff water and discharge it into Filyos River after proper outlet structures to prevent off-site sediment transport. The wastewaters from sanitary facilities, lodging premises, and kitchens are not discharged into the open drain.
  - To protect the environment from accidental contaminated water flowing into the river, manually operated sluice gate will be provided before the outfall location of the ditch for examination of stormwater for any contamination.
  - All discharge points would utilize discharge dispersion methods to mitigate erosion (e.g., controlled rate of discharge and use of energy dissipaters, displacement of geotextile mats or other physical erosion prevention measures). Discharge of wastewater to surface waters will be in compliance with the applicable regulatory requirements given in Appendix C.
  - Fuelling/refilling and chemical handling activities in close vicinity of the watercourses are restricted.
  - Project-specific Pollution Prevention Plan and Waste Management Plan will be updated for Phase 2 and implemented for the management of wastewater, waste and hazardous materials and implemented throughout the operation.

In addition, as recommended in the Flood Risk Analysis Report of the Project dated January 2024 (Appendix I), increasing berms at the Project Site can provide additional safety to avoid floods that can occur in situations where flooding is more than specified from spillways of dams in operation, dam breaking or not cleaning sedimentation from river channels. This can be considered in future according to the safety level requested by related institutions. As a result, the suggestions specified in the updated Flood Risk Analysis Report of the Project (Appendix I) will be put into practice.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed. Based on the baseline conditions of the assessed component, the project characteristics and actions, as well as the proper implementation of the mitigation measures proposed above, a potential <u>**low negative impact**</u> is expected on the hydrology and surface water quality during the operation phase.

Table 7-11: Residual impact assessment matrix for the hydrology and surface water quality during operation phase.

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
Discharge of Wastewater	Duration:	Long	High	Short-mid-term	**High**	Medium-high	**Low**
	Frequency:	Highly frequent					
	Geo. Extent:	Local					
	Intensity:	Medium					
Overall assessment:		**Low**	Rationale:	Using a strong precautionary approach, the highest residual impact value may be considered as a theoretical overall residual impact value			

Monitoring measures

The following monitoring measure shall be implemented to assess the true effects of the Project on the hydrology and surface water quality during the operation and verify the effectiveness of the mitigation measures.

- Periodic site inspections will be carried out to ensure that the open drains are free of sediments and that accumulation of sediments at the sediment traps does not prevent the run-off flow;
- Periodic visual site inspection of stormwater and wastewater drainage networks, in order to verify their integrity and functionality;
- Periodic site inspections will be carried out and reported to identify any possible leakages;
- Periodic site inspections will be carried out in order to identify any possible damage in the hazardous materials storage areas and waste storage areas;
- Training on spill response, use of containment and clean-up material for the workers (including the subcontractors' workers) will be recorded.
- Analyses will be carried out quarterly for the treated wastewater at the respective outlet points prior to discharge by accredited laboratories to check compliance with Project standards. Analyses will also be carried out at the frequency specified in the Communique on Water Pollution Control Regulation Sampling and Analysis Metho and in the environmental permit document to be obtained from the Provincial Directorate of Environment, Urbanization and Climate Change in accordance with the Environmental Permit and License Regulation. As per the IFC EHS Guidelines, wastewater monitoring will take into consideration the discharge characteristics from the process over time. If the effluent is observed to be highly variable or discharge standards are exceeded, monitoring can be carried out more frequently or through composite methods.
- Any treatment plant, including future plans, having a flow rate of 200-500 m^3/day will have a sampling manhole and automatic sampling device at the outlet point of the wastewater treatment plant according to the "Regulation on Water Pollution Control.

7.1.3 Hydrogeology and Groundwater Quality

Based on the information collected for the definition of the baseline (see Chapter 6. 1.7), the physical component Hydrogeology and Groundwater Quality was assigned a **High** value of sensitivity for the following reasons:

- Presence of shallow aquifer in AoI.
- Presence of groundwater exploitation (exploited aquifer) in AoI.
- Presence of high hydraulic conductivity in AoI.
- Presence of aquifer vulnerability in AoI.

Potential impact factors on hydrogeology and groundwater quality associated with the **construction and operation phases** of the Project include;

- Demand for freshwater;
- Discharge of wastewater, and
- Accidental introduction of hazardous chemicals.

The project actions related to the abovementioned impact factors are the following:

- General onshore engineering/construction works;
- Plant/infrastructure onshore operation.

7.1.3.1 Construction phase

Impact factors

The impact factors from the Project activities potentially affecting hydrogeology and groundwater quality during the construction phase are listed in the following Table 7-12.

Table 7-12: Project actions and related impact factors potentially affecting hydrological features during the construction phase

Project actions	Brief description	Impact factors
General onshore engineering/construction works	During construction activities, treated wastewater will be discharged into the Filyos River. Also, groundwater abstractions will have an impact on the baseflow of the Filyos River.	▪ Demand for freshwater ▪ Changes in flow/circulation in natural water bodies ▪ Discharge of wastewater

All the impact factors identified above are assessed below for the construction phase.

The major **demands for freshwater,** already arising from Phase 1, are listed below:

- The Demineralized and Potable Water Generation Package serving SGFD consists of a fresh (raw) water tank and pumps. Fresh water is supplied through an underground water well with abstraction permit. The pre-treatment section comprises multimedia pressure filters to remove sediments and suspended particles from the raw water followed by an ultrafiltration system to achieve the final removal of suspended solids and then activated carbon filters to remove residual organic matter as well as chlorine. Ultra filtrated water is be stored in a water tank for further supply to reverse osmosis and to firewater tanks. The fresh water is treated according to the specification required for Boiler Feedwater and for the Potable System. The water discharged from groundwater wells is treated by reverse osmosis.

- The system supplies potable water to facility buildings (kitchens, toilets, washbasins, etc.), as well as emergency safety showers and eye showers in production areas.
- The demineralized water system, apart from the domestic water system, processes the water which is discharged from underground wells to supply the water required by the natural gas steam boiler in Phase 1.

- The fire protection strategy of the facility focuses on the prevention and effective response to fire or explosions. The Firefighting System consists of two fire water storage tanks, each sized to provide a minimum of 6 hours supply based on a fire system design case of 4,000 gpm.
- Water supply source is from groundwater wells which is treated in Demineralized and Potable Water Generation Package before routing to storage tanks. The storage tanks will have an automatic filling system to ensure that it is maintained full. Refill of the water supply after depletion due to fire shall be completed within 8 hours maximum.

Groundwater Flow Modelling Studies

As part of the TP-OTC Filyos Natural Gas Processing Plant Project, a detailed groundwater model was developed in 2021 by Toker Drilling and Construction Engineering Consulting Co. (Toker) to ensure a sufficient water supply for firefighting purposes. This report covers the exploration and analysis of water wells in the Filyos industrial zone, aiming to meet the necessary flow rate of 1000 m³/hour for 24 hours.

Five water wells were drilled between June and August 2021, and a step-drawdown pumping test was performed to evaluate the capacity of these wells. However, the test results indicated that the existing wells could not meet the necessary flow requirements, leading to the decision to drill additional wells. This report provides a detailed analysis of the geological conditions, hydraulic properties of the aquifer, and groundwater modelling conducted to optimize the well locations and discharge rates to fulfil the project's needs.

Between May and August 2021, five water wells, named WaterWell-1, WaterWell-2, WaterWell-3, WaterWell-4 and WaterWell-5, were drilled at various locations across the site to assess their potential contribution to the water supply required for fire safety (Table 7-13, Figure 7-13). The wells were instrumented with PVC pipes, screened and gravel-packed. Following the drilling, step-drawdown tests were conducted to determine the wells' sustainable flow rates and to evaluate aquifer characteristics such as transmissivity and storage coefficients.

- WaterWell-1 and WaterWell-2: These two wells showed the highest transmissivity values, measured at 1240 m²/day and 1638.81 m²/day, respectively. Both wells discharge from the permeable alluvial aquifer. While WaterWell-2 was filtered and gravelled through the well, only the gravel/sand unit at the bottom of the alluvium was gravelled and the clayey material above it was sealed at WaterWell-1. The discharge rates for these wells varied between 4.5 and 18.35 L/sec during the tests, showing good water potential, but still far below the total required 1000 m³/hour.
- WaterWell-3, WaterWell-4, and WaterWell-5: These wells showed much lower transmissivity values, ranging from 4.51 to 14.12 m²/day, as they were drilled into volcano sediments and claystone units. The

discharge rates for these wells were also significantly lower, ranging from 0.4 to 9.05 L/sec. The poorer performance of these wells reflects the lower permeability of the formations they penetrate.

While the existing wells provided valuable information about the site's hydrogeology, their combined flow rates were insufficient to meet the required water volume for firefighting purposes. Additionally, it is expected that permeability and heterogeneity will increase as a result of the planned vibro-stone columns to accelerate settlement during the construction phase. Therefore, a decision was made to supply the existing wells with new wells strategically located in areas with higher transmissivity. To do this, a groundwater flow model was developed and presented by Toker in November 2021. This model was updated for validation as the wells proposed at the end of the study were drilled and tested. The final model was delivered in November 2022 with "The Analysis Report of Step-Drawdown Test Performed at Back-Up Well and General Assessment".

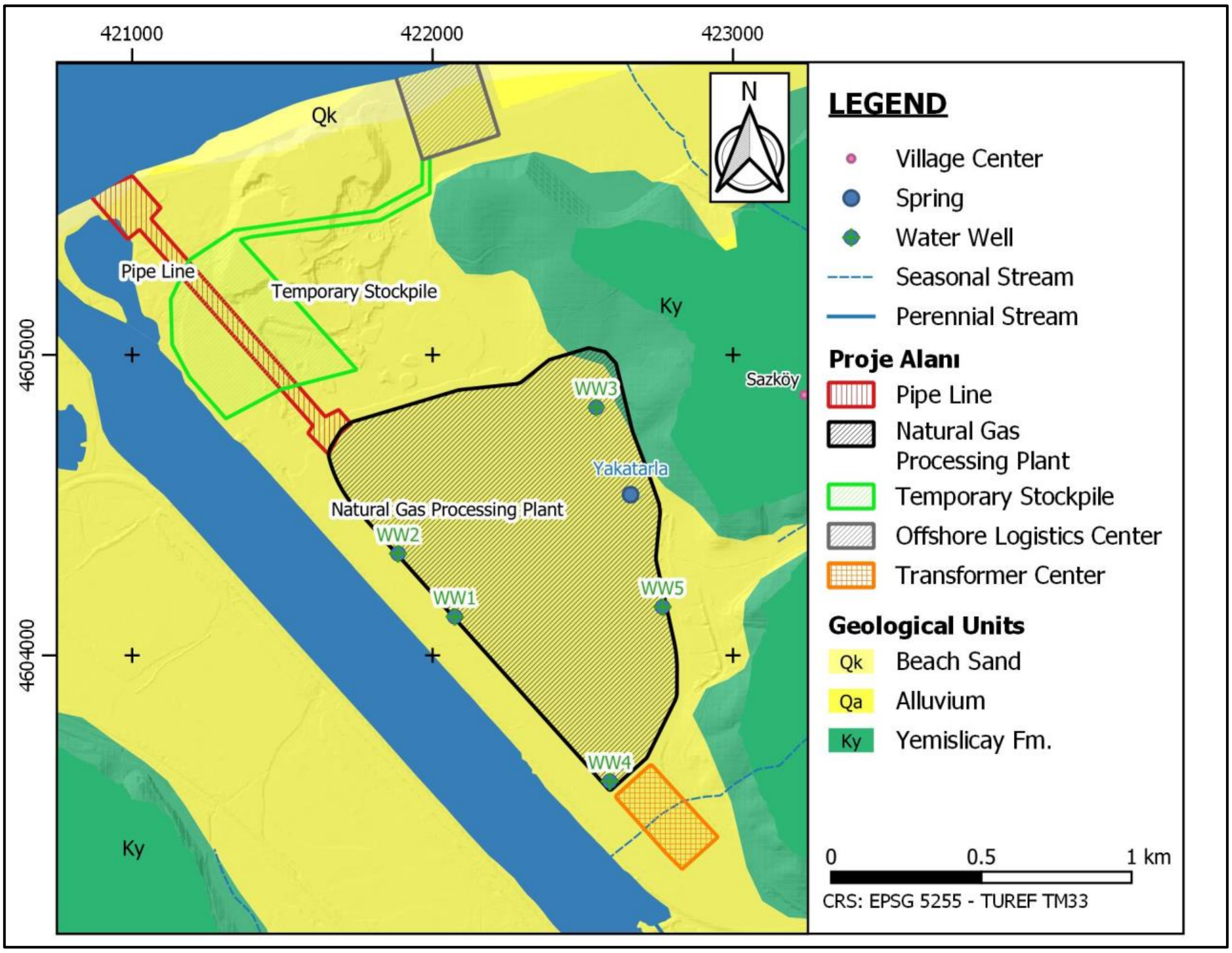


Figure 7-13: Locations of the WaterWell Coded Wells (Toker, 2021)

Table 7-13: Basic Information on the WaterWell Coded Wells (Toker, 2021)

Well Name	WaterWell-1	WaterWell-2	WaterWell-3	WaterWell-4	WaterWell-5
X (ITRF 96, m)	422073.94	421885.26	422545.41	422590	422765
Y (ITRF 96, m)	4604128.22	4604338.06	4604824.95	4603580	4604160

Well Name	WaterWell-1	WaterWell-2	WaterWell-3	WaterWell-4	WaterWell-5
Elevation (m)	5.98	6.21	7.15	5.95	6.2
Depth (m)	71	75	35	55	43
Gravelled and Screened Part of the Well (from the Surface, m)	50 - 71 m	0 - 75 m	5 - 35 m	38 - 55 m	4 - 43 m
Gravelled and Screened the Lithological Unit	Bottom of the Alluvium (Sandy and Gravelly Part + Last 3 metres of the Clay)	Alluvium (Clay, Sand, Gravel)	Alluvium (Clay)+ Residual Clay/Claystone	Bottom (Sandy and Gravelly Part) of the Alluvium + Volcanogenic Sandstone + Conglomerate	Alluvium (Clay)+ Residual Clay/Claystone
Static Hydraulic Head (GW Elevation, m)	1.52	1.6	6.135	1.655	6.05
Discharge Rates (L/sec)	4.50 - 8.50 - 12.50 - 18.35	3.90 - 7.75 - 11.75 - 13.25	1.45 - 2.25 - 3.10 - 4.50	3.92 - 5.86 - 7.97 - 9.05	0.40 - 0.95 - 1.45 - 1.95
Hydraulic Head at the end of the Test (GW Elevation, m)	-0.116	0.915	-13.79	-24.105	-11.64
T (m²/day)	1240	1638.81	14.1254	14.7837	4.51319
r²S, m²	0.000653873	0.00316423	0.0226344	0.0642971	0.0265382
a, min/m²	0.359973	0.18	-32.2788	-39.6264	-137.452
b, min/m²	0.21255	0.16	18.1611	17.8277	58.3979
C, min²/m5	0.228964	0.021	104.938	19.5274	365.353
The radius of Influence, m	1800	3000	7500	6500	3000
Suggested Discharge Rate for the GW Usage (L/sec)	Minimum 30 L/sec		3.5 - 4 L/sec	8-10 L/sec	2-2.5 L/sec

- **Conceptual Model:**

The groundwater flow model process is a multi-step and iterative process. At first, the problem is defined and is a conceptual model using hydrogeological data and information is built according to the problem. The conceptual model consists of a set of assumptions that verbally describe the system's composition, the transport processes that take place in it, the mechanisms that govern them, and the relevant medium properties. Since real-world systems are very complex, the definition of these processes is based on certain assumptions (Bear, Beljin, & Ross, 1992). Some of these assumptions are related to the determination of the recharge-discharge zone(s), boundaries of the flow area, dimension of the flow, homogeneity and isotropy of the geological units and initial and boundary conditions. The realistic expression of the conceptual model is the essence of the modelling.

In the study, the step-drawdown tests carried out in the field and the analysis of the water samples taken in these tests, the groundwater levels measured at different dates and the pore water pressure measurements have been used for the conceptual model.

- According to the results of the step-drawdown tests, transmissivity, hence the hydraulic conductivity, are high at WaterWell-1 and WaterWell-2 which are discharging from the alluvium, while these values are quite low in other wells. Therefore, it is understood that the alluvium on which the Natural Gas Processing Plant is built is permeable, but the clayey and volcanogenic units of the Yemislicay Formation, which is in direct contact with the alluvium, are relatively impermeable.
- Groundwater level measurements made in SK, SHH, BH, GSS and LSS-coded wells between February and September 2021 have been used to detect the boundary conditions. Relatively representative measurements were taken on 19 February, 3, 17, 30 March and 7, 13, and 22 April. According to the hydraulic head (groundwater level or groundwater elevation) distributions, Yemislicay formation discharges to the alluvium, and this alluvium discharges to both the Filyos Stream and the Black Sea (Figure 7-14).
- To consider both vertical and horizontal components of the groundwater flow, periodic pore water pressure measurements from the PZ-coded wells have been examined. Pressure values have been converted to hydraulic head (groundwater level/elevation) using the Bernoulli equation. After the pore water pressures were converted to hydraulic head, three different cross-sections have been drawn (Figure 7-15) and these hydraulic head values have been plotted (Figure 7-16). It has been seen that groundwater levels between -25 m and -40 m elevations are the highest in almost all periods measured, and groundwater levels are decreasing gradually at higher and lower elevations.
- Moreover, groundwater levels calculated from the pore water pressure measurements at -1 m elevation are very similar to the Filyos Stream's water level, so it increases the possibility of the alluvium's discharge to the stream. In addition, the Specific Electrical Conductivity of the groundwater sampled at the 7^{th} hour of the step-drawdown test of the WaterWell-2 was approximately 9 mS/cm, which indicates the seawater intrusion into the alluvium. Besides, nearly all of the measured chemical parameters' concentrations are quite high. However, these values are not that high at WaterWell-1, where only the gravelly-sandy part of the alluvium bottom is screened. This may be due to the natural background level of the organic clay in the alluvium or discharge from the Filyos Stream.

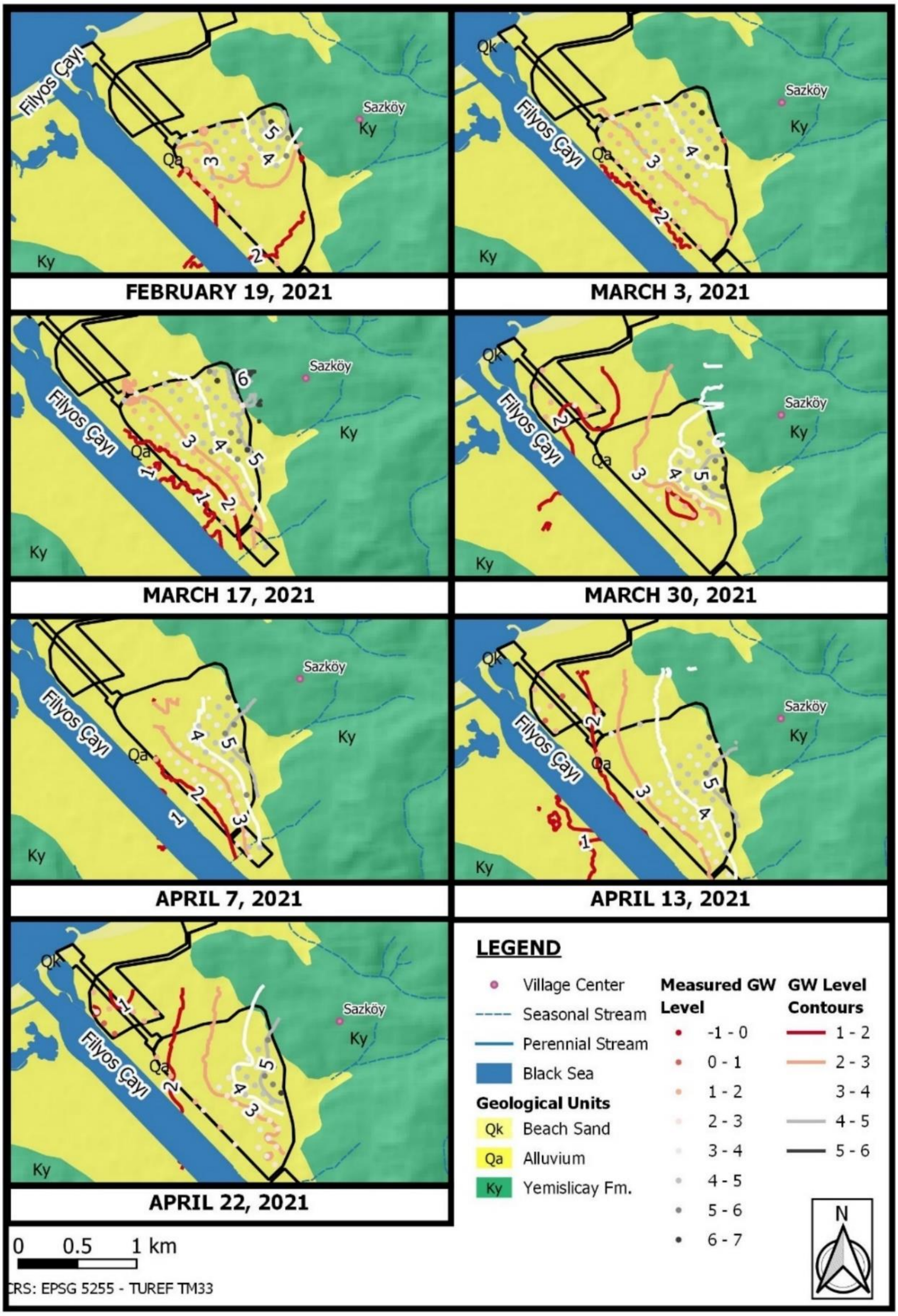


Figure 7-14: Groundwater Level Distribution According to the Measurements (Toker, 2021)

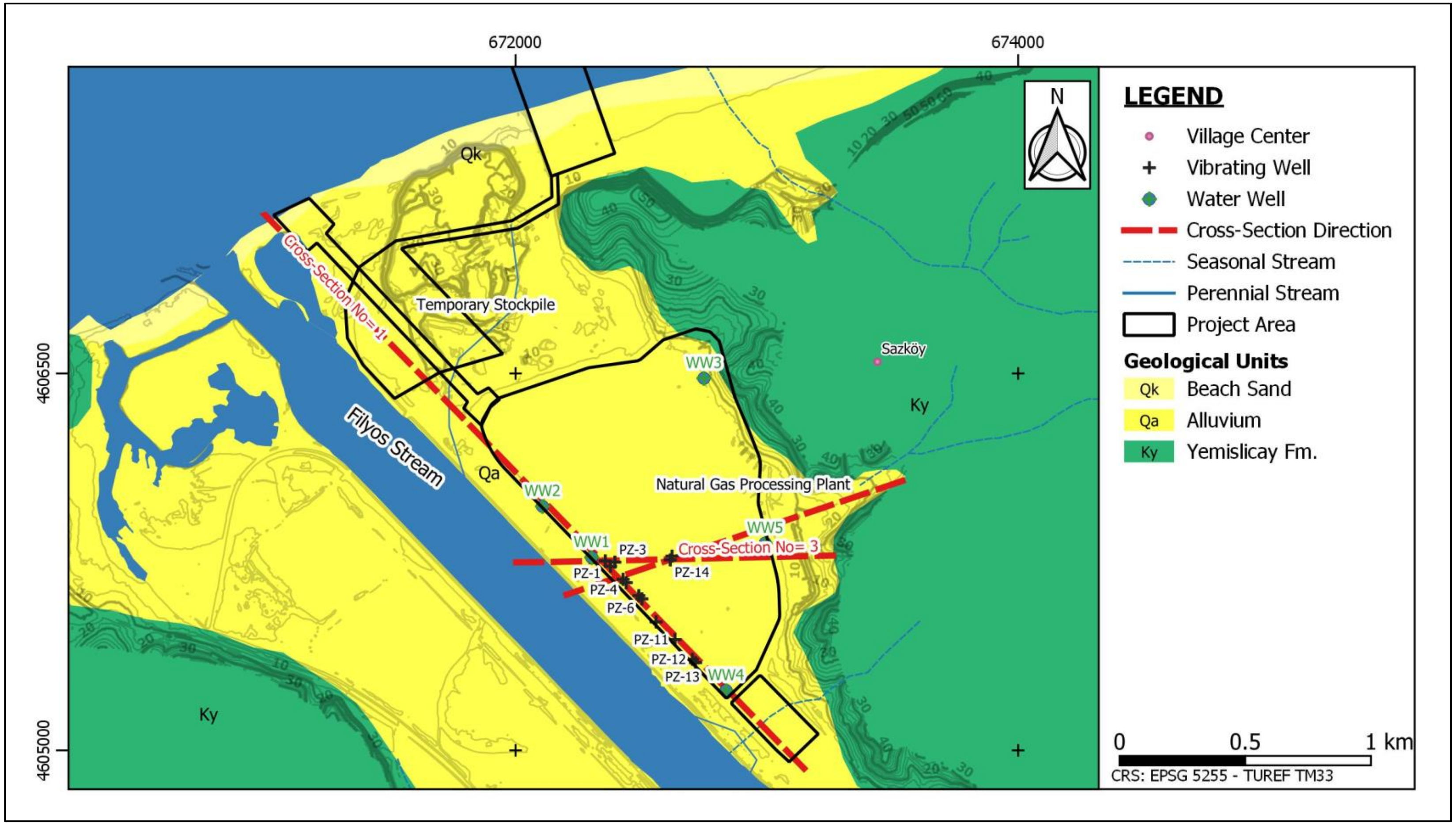


Figure 7-15: Directions of the Cross-Sections to Plot the Groundwater Levels Measured at the PZ Coded Wells (Toker, 2021)

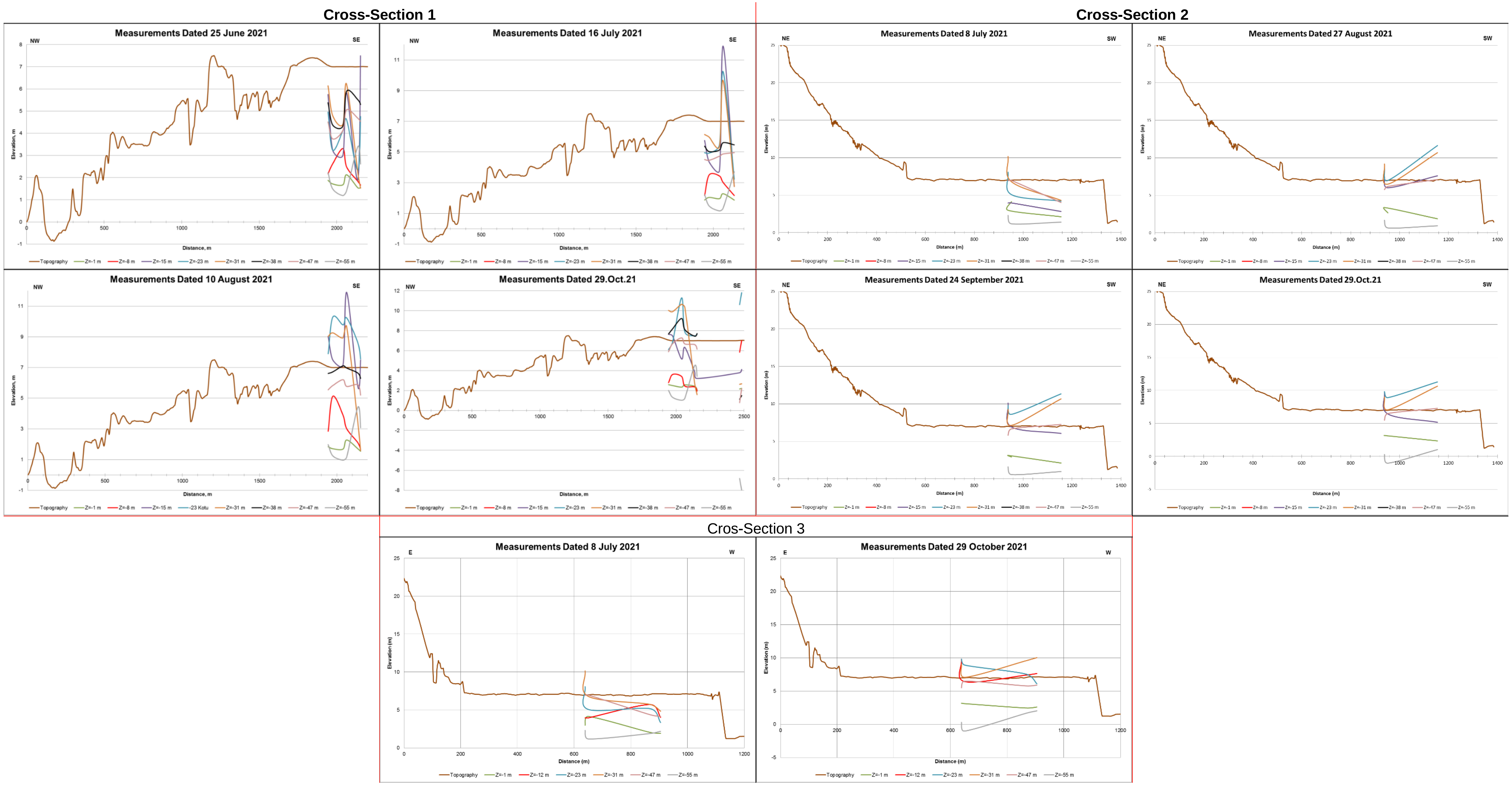


Figure 7-16: Calculated Hydraulic Heads (GW Levels) Based on the Pore Water Pressure Measurements on Different Dates in Cross-Sections 1,2 and 3 (edited from Toker, 2021)

- **Numerical Flow Model**

To determine the well locations and delay the well interference during the usage of the wells, the numerical flow model was built using MODFLOW. To represent the natural groundwater flow, the step-drawdown test carried out in WaterWell-2 on May 29, 2021, and the step-drawdown test carried out in WaterWell-1 on June 11, 2021, have been modelled. The pore water pressure measurements between these dates have also been used in the calibration. Tests and pore water pressure measurements between these dates have been used since they were relatively less affected by on-site operations (filling operations, drainage well construction, etc.).

- **Model Boundary and Topography:** While determining the model area, primarily hydrological boundaries and sinks/sources have been determined. Yemislicay Formation, which has low hydraulic conductivity, borders the east of the model area, the Filyos Stream to the west, and the Black Sea to the north. The model area is approximately 2.5 km^2. The digital elevation model has been taken from the "Sakarya Natural Gas Field Development Project Flood Risk Analysis Studies to be Made in the Onshore Production Facilities Region - Flood Risk Analysis Draft Final Report".
- **Geological Model and the Model Grid:** A geological model was created from the data from the geotechnical boreholes in order to define the boundaries between different geological units such as the alluvium and volcanic formations. Then, this model was converted into MODFLOW grids. The model grid was designed with a cell width and length of 10 meters, and the thickness of each model layer was set to approximately 10 meters. The grid had a total of 394,284 cells representing the different geological layers. The layers are all "convertible" which allows the layers to act as confined or unconfined aquifers relative to the water table. The bottom of the model is the top of the grey claystone-siltstone-sandstone, which is considered to be the base unit and belongs to the Yemislicay Formation (Figure 7-17).
- **Boundary Conditions:**
  - The main recharge source of the alluvium is the groundwater flow from the Yemislicay Formation at the eastern contact of the model area. Although the amount and direction of this flow have not been determined exactly with the available data, the fact that the groundwater levels between -25 and -40 m elevations are higher than the levels at other elevations increases the possibility that recharge occurs from this elevation range. Thus, the Cauchy type (head-dependent) boundary condition has been assigned to the residual claystone-alluvium contact located to the east of the Natural Gas Processing Site in the 7th layer.
  - The sea-water intrusion has been defined along the contact of the gravelly-sandy units in all layers with the Black Sea, and the cells in this contact have been defined with the Dirichlet boundary condition.
  - Cauchy-type boundary condition has been assigned for Filyos River, assuming that the river gains water from the groundwater when the water level of Filyos River is lower than the hydraulic head (GW level), and that the stream loses water to the groundwater system during discharge from the wells. The RIV package, which is one of the Cauchy-type boundary condition analysis methods, has been used as the boundary condition.

– In the study, in which groundwater flow between May 30 and June 11, 2021, has been modelled, step-drawdown pumping tests performed at WaterWell-2 on May 30, 2021, and at WaterWell-1 on June 11, 2021, have been simulated. The discharges in these wells have been assigned as Neumann-type boundary conditions where a specified flow enters the cell where the well is defined (Figure 7-18).

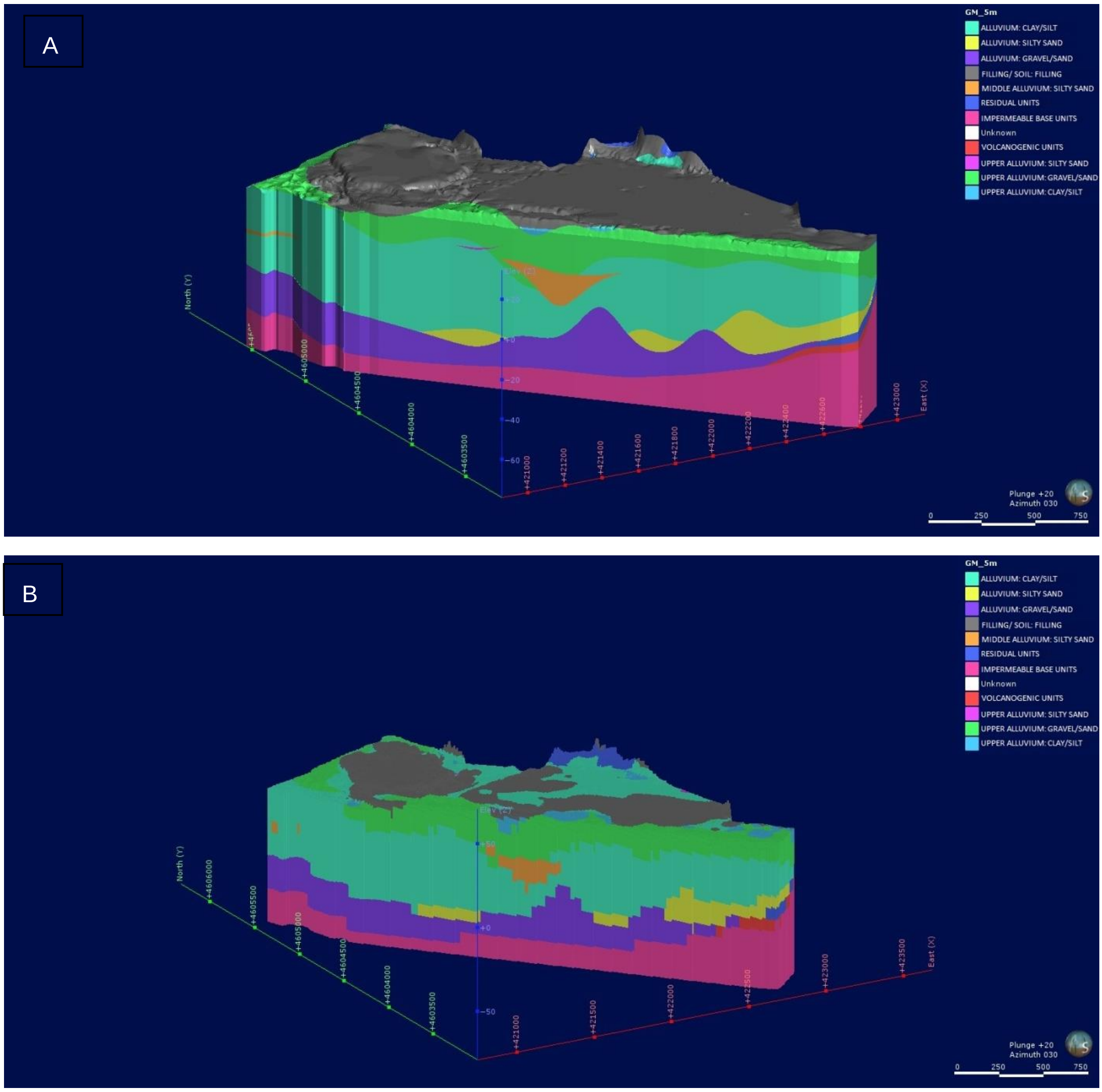
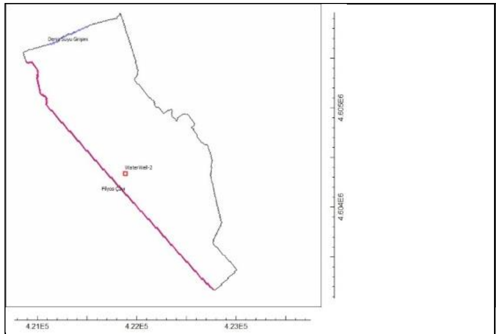
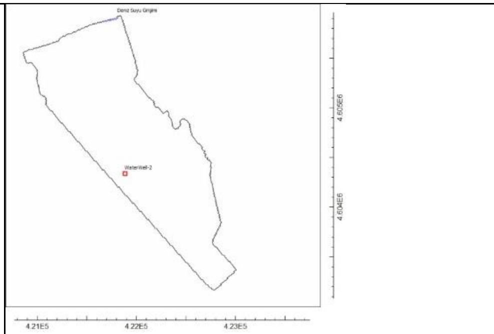
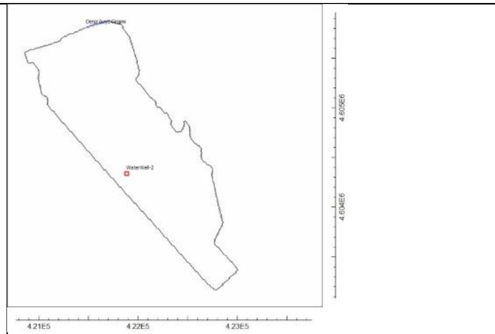
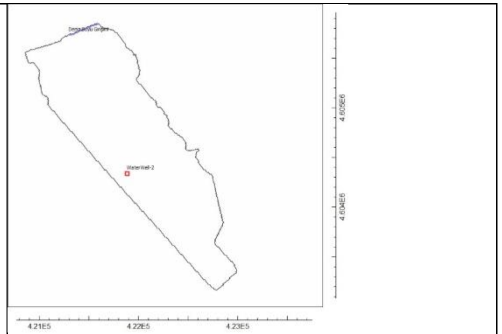
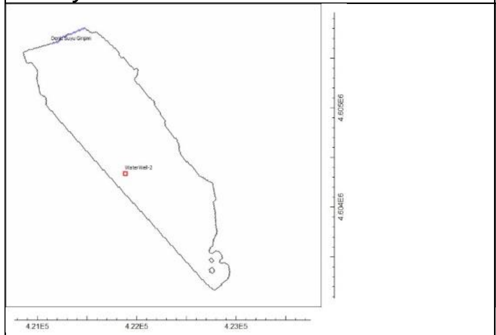
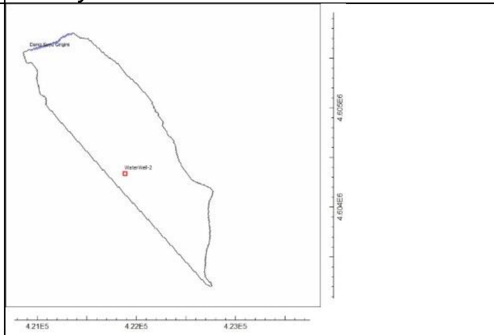
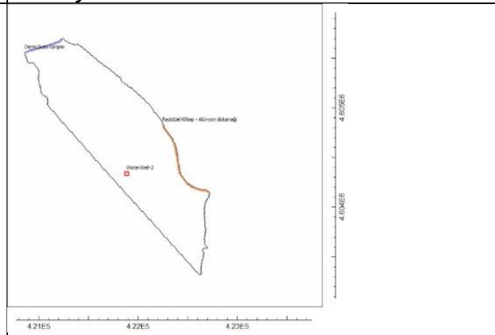
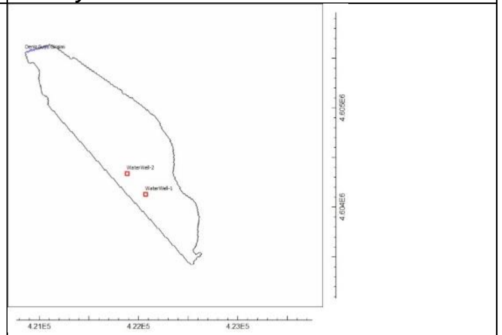
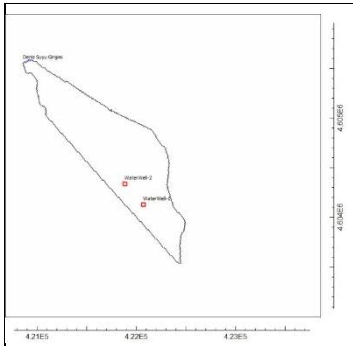
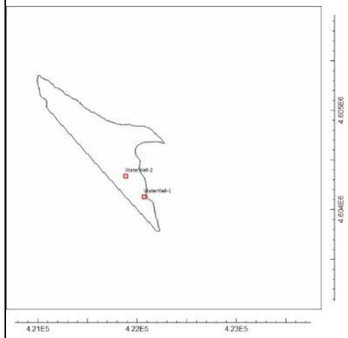


Figure 7-17: A View from the LeapFrog Geological Model and the Conversion of this Model Into MODFLOW grids

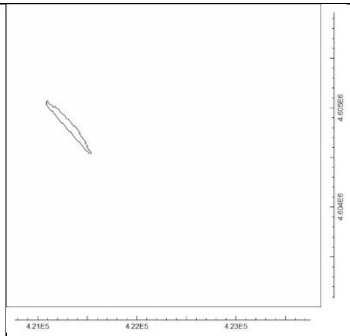
 1st Layer	 2nd Layer	 3rd Layer	 4th Layer
 5th Layer	 6th Layer	 7th Layer	 8th Layer



9th Layer



10th Layer



11th Layer

Figure 7-18: Assigned Boundary Conditions for Each Layer (edited from Toker, 2021)

- **Aquifer Parameters:** The step-drawdown tests were used to set the initial values for aquifer parameters in the groundwater model. The transmissivity of WaterWell-1, representing the sandy gravel part of the alluvium, was calculated as 1315.5 m²/day. The storage coefficient, $1.95x10^{-4}$, was used to compute the specific storage as $9.73x10^{-6}$ m^{-1}. For WaterWell-3 (residual clay), the hydraulic conductivity and specific storage were calculated as $5x10^{-6}$ m/s and $3x10^{-8}$ m^{-1}, respectively. For the volcanogenic units tested in WaterWell-4, the hydraulic conductivity was $7.5x10^{-6}$ m/s with a specific storage of $7.89x10^{-8}$ m^{-1}. Where specific tests weren't performed, values from WaterWell-2 were used for the alluvium unit. Hydraulic conductivity in the x and y directions was assumed to equal, with the z-direction set to one-tenth of these values. Specific capacity (Sy) values were estimated from literature (Todd, 1980) and varied across different layers to account for heterogeneity (Table 7-14).
- **Model Calibration:** The model was calibrated to ensure that simulated groundwater levels closely matched the measured values. During the calibration process, the aquifer parameters were modified to approximate the physically measured values. The calibration graphs of the step-drawdown tests performed in WaterWell-1 and WaterWell-2 are shown in Figure 7-19 and Figure 7-20, and the R^2 value has been calculated as 0.98. Moreover, Figure 4.13 demonstrates the comparison of the calculated hydraulic heads (groundwater levels) according to the pore water pressure measurements in PZ-2 with the simulated hydraulic heads (groundwater levels).

Table 7-14: Initial and Calibrated Aquifer Parameters (Toker, 2021)

Geological Unit	Initial Kx (m/sec)	Calibrated Kx (m/sec)	Initial Kz (m/sec)	Calibrated Kz (m/sec)	Initial Horizontal Anisotropy Coef.	Calibrated Horizontal Anisotropy Coef.	Initial Specific Storage Coef. (Ss, 1/m)	Calibrated Specific Storage Coef. (Ss, 1/m)	Initial Specific Capacity	Calibrated Specific Capacity
Filling	5.00E-06	3.00E-05	3.00E-06	3.00E-05	1.00	5.00	1.00E-06	2.80E-06	0.1	0.15
Upper Alluvium: Silty Sand	5.00E-06	5.00E-05	5.00E-06	2.50E-05	1.00	5.00	1.00E-06	2.80E-06	0.15	0.2
Upper Alluvium: Gravel/Sand	7.61E-04	1.00E-03	1.00E-04	1.00E-04	1.00	5.00	9.73E-06	9.73E-06	0.3	0.3
Upper Alluvium: Clay/Silt	5.00E-07	5.00E-06	5.00E-07	5.00E-07	1.00	5.00	1.00E-08	1.40E-06	0.05	0.05
Middle Alluvium : Silty Sand	2.50E-06	2.50E-05	2.50E-06	2.50E-05	1.00	5.00	5.00E-07	9.73E-06	0.1	0.15
Alluvium: Clay/Silt	1.09E-07	2.09E-06	2.09E-07	2.09E-07	1.00	5.00	8.34E-09	1.40E-06	0.05	0.05
Alluvium: Silty Sand	1.00E-06	1.00E-05	1.00E-06	2.50E-06	1.00	5.00	5.00E-07	2.80E-06	0.15	0.15
Alluvium: Gravel/Sand	7.61E-04	1.00E-03	1.00E-04	1.00E-04	1.00	1.00	9.73E-06	9.73E-06	0.3	0.3
Residual Clayey Unit	5.00E-06	5.00E-06	5.00E-07	5.00E-06	1.00	1.00	3.00E-08	3.00E-08	0.07	0.07

Geological Unit	Initial Kx (m/sec)	Calibrated Kx (m/sec)	Initial Kz (m/sec)	Calibrated Kz (m/sec)	Initial Horizontal Anisotropy Coef.	Calibrated Horizontal Anisotropy Coef.	Initial Specific Storage Coef. (Ss, 1/m)	Calibrated Specific Storage Coef. (Ss, 1/m)	Initial Specific Capacity	Calibrated Specific Capacity
Impermeable Base Unit	1.00E-08	1.00E-08	1.00E-09	1.00E-08	1.00	1.00	1.00E-08	3.00E-08	0.05	0.05
Volcanogenic Unit	7.50E-06	7.50E-06	7.50E-07	7.50E-06	1.00	1.00	7.89E-08	7.89E-08	0.1	0.1

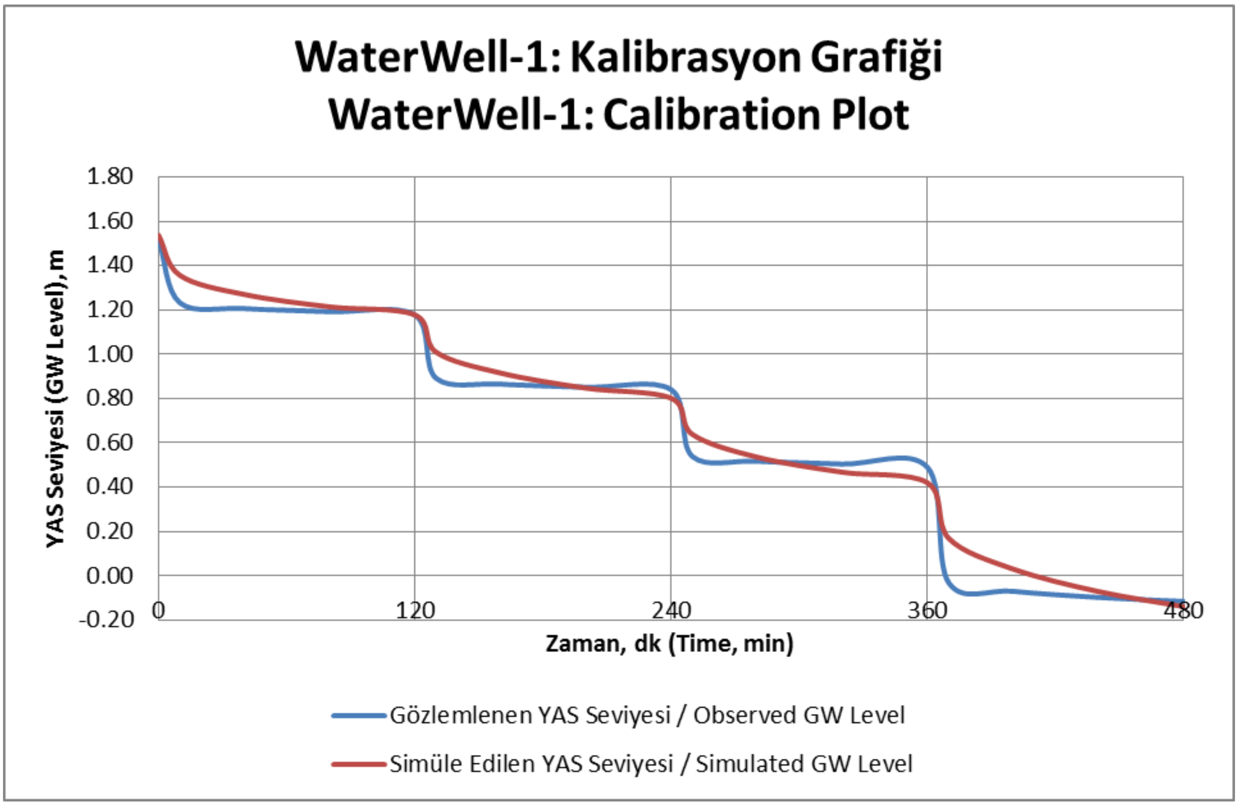


Figure 7-19: The Calibration Plot of the WaterWell-1 (Toker, 2021)

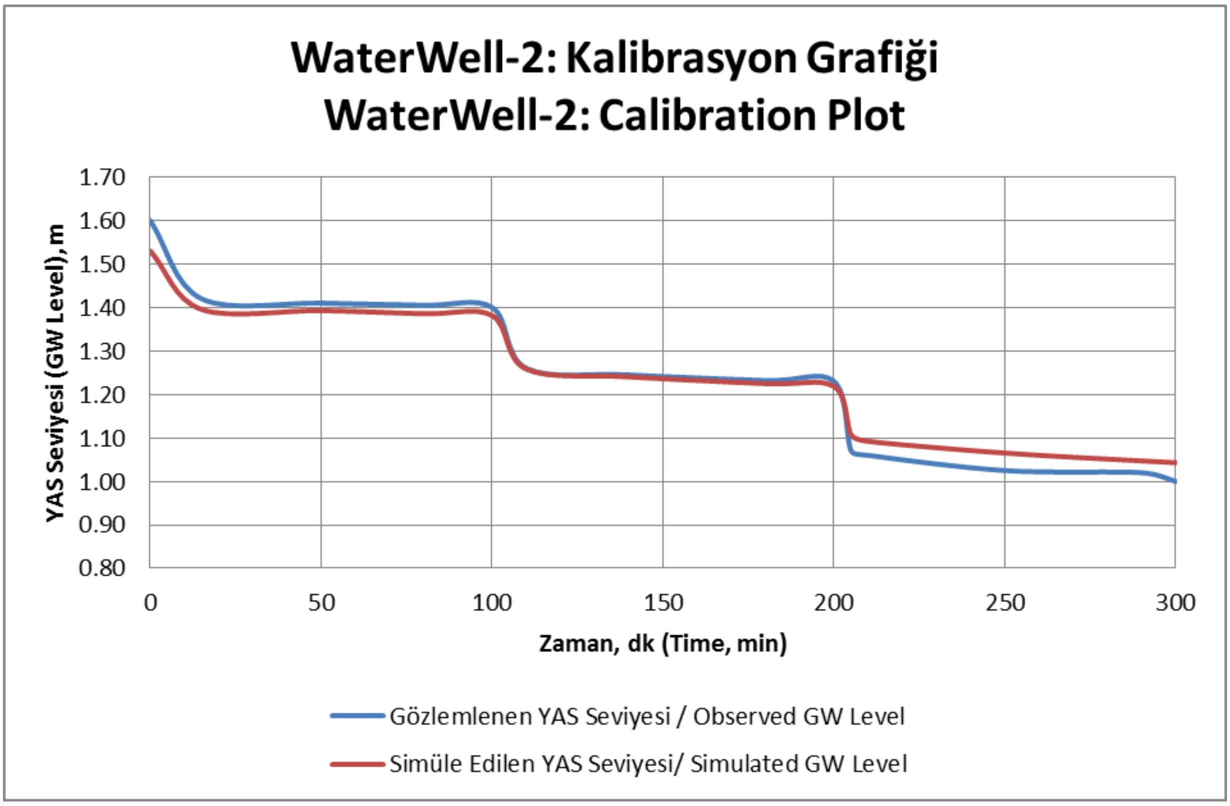


Figure 7-20: The Calibration Plot of the WaterWell-2 (Toker, 2021)

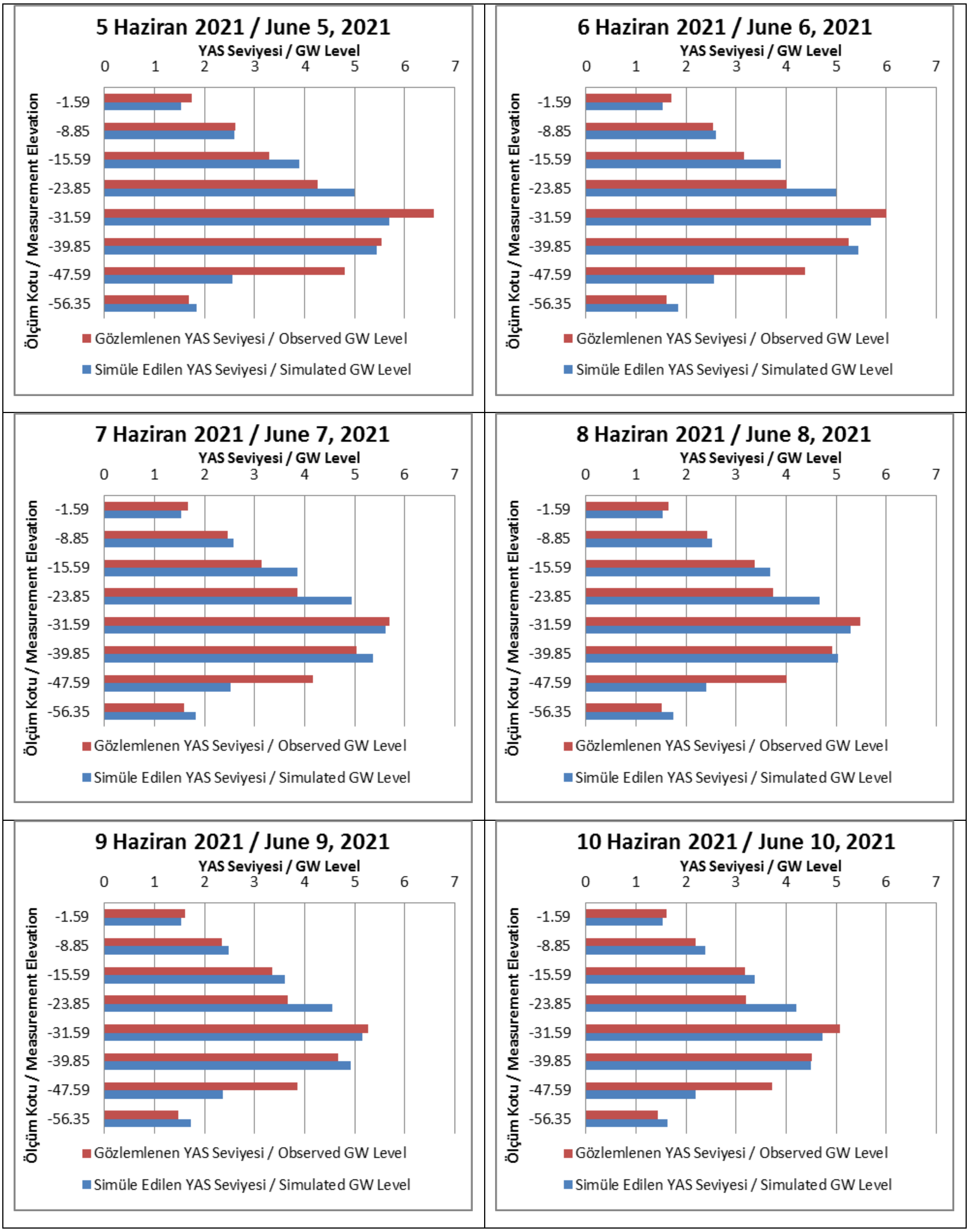


Figure 7-21: Calibrations Results Based on the Hydraulic Heads (GW Levels) Calculated by Using the Pore Water Pressure Measurements at PZ-2 (Toker, 2021)

- **Determination of Locations of WEL-Coded Wells:**

To calculate the desired amount of discharge according to the calibrated groundwater flow model, the hypothetic wells have been created in the model. For this, the highly permeable porous media caused by the vibro-stone columns has been defined using the Kozeny-Carmen Bear (1972) equation. According to that, the hydraulic conductivity was calculated at 6.36×10^{-3} m/s.

In order to supply the desired amount of water along the road route, the discharge from the hypothetical wells was simulated. It has been assumed that the hypothetical wells will discharge with 8" diameter pumps, which are the largest diameter that can be assured quickly but can also give the desired flow rate, and that these wells are gravel and filtered from the top to the bottom of the alluvium. Considering that 8" diameter submersible pumps can generally discharge a maximum of 55 L/sec, this value is used as the highest flow rate that can be discharged from a well in the model.

The wells have been determined along the roadside at the request of the TP-OTC. Wells have been selected near WaterWell-1 and WaterWell-2, where possible high conductivity values are calculated. At first, the 24 hours of pumping have been simulated independently for each well, and then all the wells are simultaneously discharged in the simulation. As a result of the trials, 5 wells have been determined approximately 150 m away from each other. Besides, in addition to the five wells that are expected to be drilled, a back-up well is proposed to be activated in case any of them breaks down during discharge, and this well is also simulated in the model. However, the initial coordinates of these wells were changed in April 2022 because of the then-existing construction and to remain away from vibro-stone columns for healthier drilling. Due to these changes, the groundwater flow model was run with new coordinates to make sure that the cone of depressions that will occur during the discharge will converge faster. Based on final calculations, in a 24-hour pumping scenario, the groundwater level has decreased to -5 m (Figure 7-23 and Figure 7-24). When examined layer by layer, it has been observed that the hydraulic head (GW level) is around -30 m as a result of the discharge in the cells representing WEL01 and WEL02 in the 7^{th} layer, which represents the elevations between -35 and -43 m. After the discharge has been completed in the 24^{th} hour, it has been calculated that the groundwater level increases rapidly because of the high hydraulic conductivity.

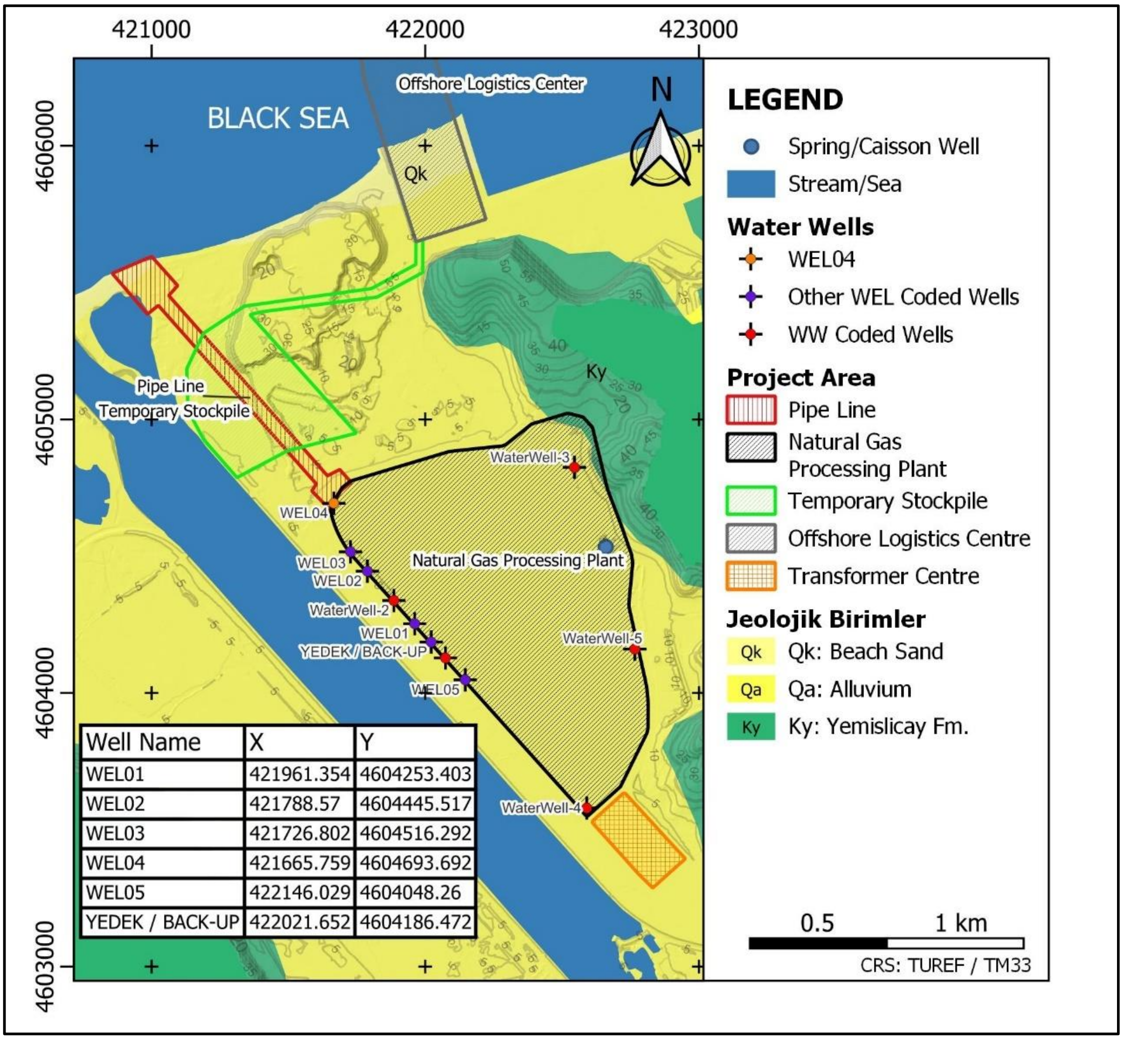


Figure 7-22: Location of the WEL-Coded Wells According to the Groundwater Flow Model

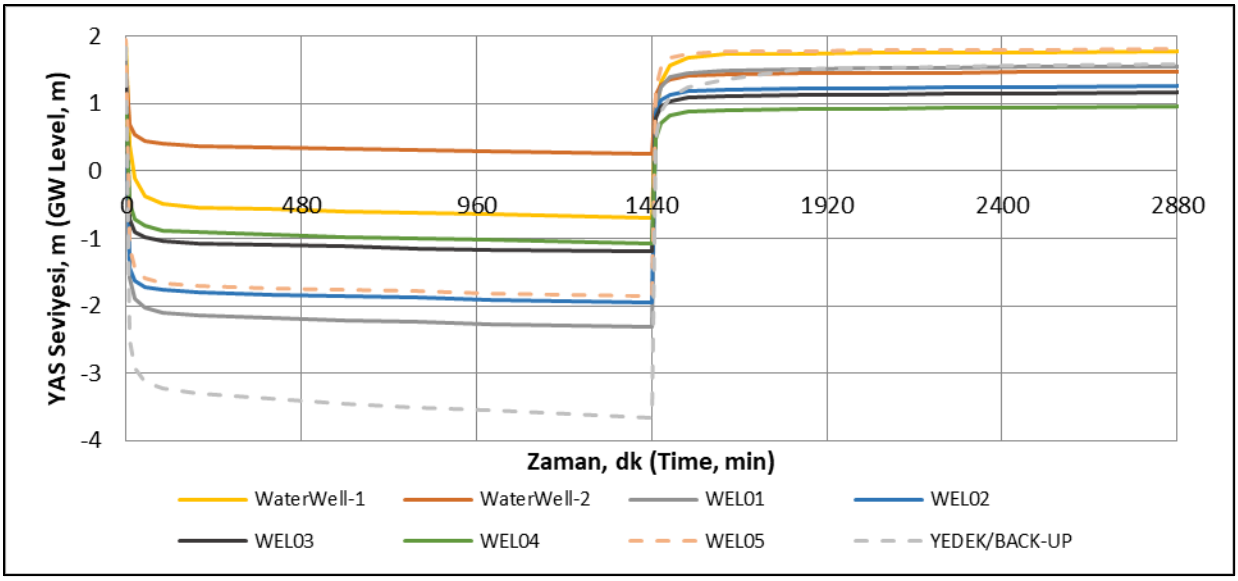


Figure 7-23: Expected Groundwater Levels in Case of a 24-Hour Discharge from the Wells in the Porous Media to Be Formed after the Vibro-stone Columns Are Completed (Toker, 2022)

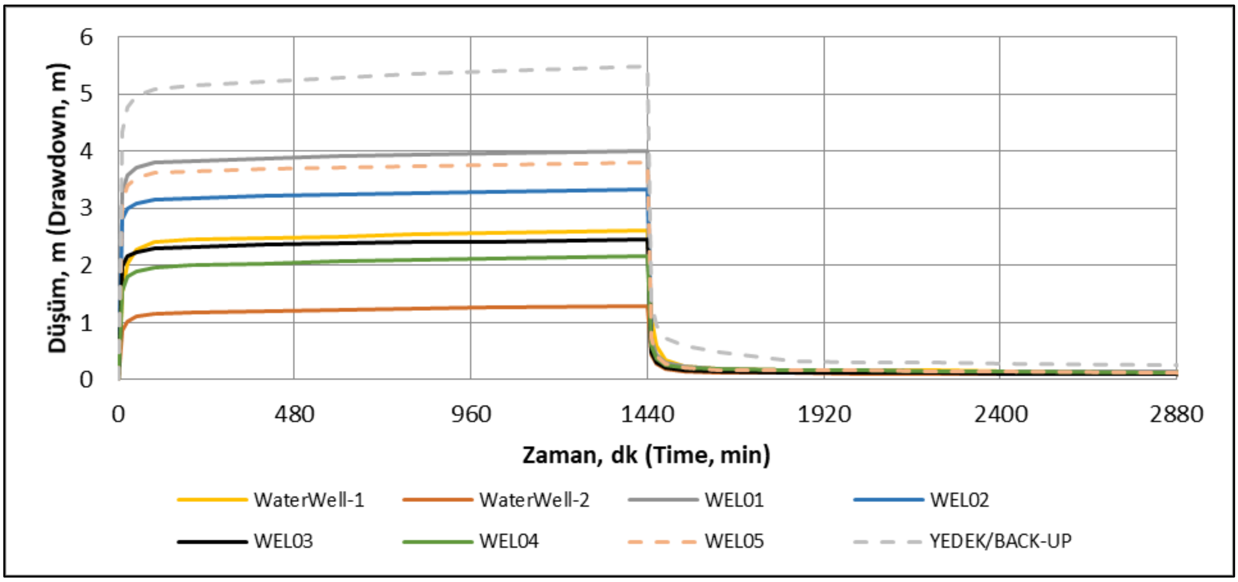


Figure 7-24: Expected Drawdowns in Case of a 24-Hour Discharge from the Wells in the Porous Media to Be Formed after the Vibro-stone Columns Are Completed (Toker, 2022)

After the completion of the last drilled well (the BACK-UP well), the required total flow rate can be used by discharging 55 l/sec from WEL-01, WEL-02, WEL-04, and BACK-UP Well and 20 l/sec from WW-1, WW-2, WEL-03, and WEL-05 (Table 5.1). Due to the high transmissivity (T) and storage coefficient (S) of the alluvium aquifer, drawdowns were small as long as the discharge was from one well.

The modeling studies and pumping test reports conducted by Toker are attached in Appendix I.

On the other hand, groundwater quality was excluded within the scope of these modelling studies conducted by Toker in 2021 and 2022. The continuous water sampling and monitoring activities indicate the saline water intrusion, which was also described as a boundary condition in the modelling activities. Therefore, water supply from these wells increase the dissolved salt minerals in the freshwater (such as Chloride and Sodium).

- **Wastewater and stormwater discharges**

The wastewater and stormwater produced during the construction phase is discharged to Filyos River. Since the flow rates and reservoir volume of the receptor is much larger than the discharged amounts, no quality impact is expected or very limited in the amount recharged to the groundwater due to the dilution of the water quality.

- **Accidental introduction of hazardous chemicals**

The possibility of contamination of aquifers in the event of intentional or accidental discharges of hazardous materials to the ground during construction, particularly in shallow overburdened areas, may increase.

Waste derived from construction can lead to groundwater pollution if it is not properly managed. The temporary storage of waste and/or hazardous substances deriving from the construction operations, if not properly managed, could result in a release of pollutants onto the soil surface/ground. Accidental leakages from hazardous substances or machine refuelling or maintenance are also potential hazards. No particularly hazardous material is predicted to be used during construction; accidental spills of pollutants from machinery/vehicles would reach groundwater only if the spilt material is in large quantities and the material is spilt over a period of time.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed. Based on the baseline conditions of the assessed component, the Project characteristics and actions, as well as the proper implementation of the mitigation measures proposed above, a potential **low negative impact** is expected on the hydrogeology and groundwater quality during the construction phase.

Table 7-15: Impact Assessment Matrix for Hydrogeology and Groundwater Quality During Construction Phase After Mitigation Measures

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation Effectiveness	Residual Impact Value
Demand for Freshwater	Duration:	Medium	Medium-high	Short-term	**Low**	None	**Low**
	Frequency:	Highly frequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					
Discharge of Wastewater	Duration:	Medium	High	Short-term	**Low**	Medium-high	**Negligible**
	Frequency:	Highly frequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					
Accidental introduction of Hazardous Materials	Duration:	Short	Medium	Short-mid-term	**Low**	Medium-high	**Negligible**
	Frequency:	Highly frequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					
Overall assessment:		**Low**	Rationale:	Using a strong precautionary approach, the highest residual impact value may be considered as a theoretical overall residual impact value			

Since the mitigation and monitoring measures are same measures for both the construction and operation periods, they are listed together after operation phase impact assessment.

7.1.3.2 Operation phase

Impact factors

The impact factors from the Project activities potentially affecting hydrogeology and groundwater quality during operation phase are listed in following Table 7-16.

Table 7-16: Project actions and related impact factors potentially affecting hydrogeology and groundwater during operation phase

Project actions	Brief description	Impact factors
Plant/infrastructure onshore operation	During operation activities, wastewater will be treated and discharged to Filyos River. Also,	▪ Demand for freshwater

Project actions	Brief description	Impact factors
	groundwater will be abstracted for the potable and process water need.	▪ Discharge of wastewater ▪ Accidental introduction of Hazardous Materials

The impacts during the operation phase are likely to be similar to the construction phase hence the activities will be similar to construction activities. The same considerations described for this component during the construction phase would be applicable to the operation phase for the groundwater pollution impact factor.

A new impact is not expected during the operation phase of the Project, other than those listed in the construction phase.

Residual Impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed. Based on the baseline conditions of the assessed component, the Project characteristics, and actions, as well as the proper implementation of the mitigation measures proposed above, a potential **medium negative impact** is expected on the hydrogeology and groundwater quality during the operation phase.

Table 7-17: Impact Assessment Matrix for Hydrogeology and Groundwater Quality During Operation Phase After Mitigation Measures

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation Effectiveness	Residual Impact Value
Demand for Freshwater	Duration:	Long	High	Short-term	**Medium**	None	**Medium**
	Frequency:	Highly frequent					
	Geo. Extent:	Project footprint					
	Intensity:	Very high					
Discharge of Wastewater	Duration:	Long	High	Short-term	**Low**	Medium-high	**Negligible**
	Frequency:	Highly frequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					
Accidental introduction of Hazardous Materials	Duration:	Short	Medium	Short-mid-term	**Low**	Medium-high	**Negligible**
	Frequency:	Highly frequent					
	Geo. Extent:	Project footprint					
	Intensity:	Low					
Overall assessment:		**Medium**	Rationale:	Using a strong precautionary approach, the highest residual impact value may be considered as a theoretical overall residual impact value.			

7.1.3.3 Mitigation Measures

The mitigation measures related to hydrogeology and groundwater quality for the construction and operation phases are as follows:

Measures incorporated in the Project Design:

- The effects of seawater intrusion are observed due to the wells currently used. In order to meet the quality standards, alternative freshwater sources will be investigated.

- The worksite will be minimized to the smallest extent possible in order to meet the Project's works and activities.
- The Project will comply with safety requirements to avoid leakages from hazardous chemicals/materials and liquids stored on-site.
- The areas, where the diesel/fuel storage tanks are located (can be named as hazardous material storage areas), will be designed and constructed to avoid potential contamination into the soil (paved areas with sufficient secondary containment, proper drainage systems etc.).
- Project-specific Pollution Prevention Plan and Waste Management Plan will be updated for Phase 2 and implemented to ensure that the amount of release and spills can be taken under control before reaching substantial amounts that may potentially affect the quality of groundwater.
- The temporary waste storage areas will be constructed based on the requirements listed in the Regulation on Waste Management issued on April 02, 2015, Official Gazette no: 29314 and GIIP.
- **General mitigation measures** are listed below:
    - Consultations will be held with State Hydraulic Works and General Directorate of Water Management regarding the hydrogeological studies and groundwater quality and any additional studies will be conducted upon the opinions of these institutions prior to the construction phase.
    - Using the monitored seasonal flow rates and any additional groundwater well data to be drilled in and/or near the Project site, the hydrogeological model can be re-calibrated (if necessary) to re-evaluate groundwater discharge-related consequences prior to the operation period.
    - Maintenance of the vehicles and machinery/equipment (if needed) will be conducted in a designated area where there is impermeable surface (concrete floor etc.) and if needed secondary containment system is present.
    - Portable spill containment and clean-up materials (spill kits) will be made available and easily accessible at the construction site, instructions on how to use spill containment and clean-up materials will be included in the kits.
    - Training on spill response, use of containment and clean-up material (spill kits) will be provided to workers (including the subcontractor workers).
    - Adequate and properly maintained tanks, paved ground, spill containment materials and proper secondary containment systems with sufficient volume will be provided for fuel/oil storage and for the storage of other fluids and hazardous substances to prevent loss into the soil.
    - Wastewater flows from any field activities (i.e., excavations, drillings, re-fuelling and vehicle/equipment washing) will be properly managed and prevented from reaching receiving environments.
    - Polluted water (if any generated as a result of accidental leakages) will be properly collected or managed to prevent mixing with any water body and the topsoil/soil pollution.
    - Discharge of untreated wastewater, residues or other waste into groundwater or into surface water will be avoided.

  - Periodic site inspections will be carried out and reported to identify any possible leakages.
  - Periodic site inspections will be carried out in order to identify any possible damage in the hazardous materials storage areas and waste storage areas.
- **Monitoring Measures:** Since the monitoring measures written in this section are the same measures for both the construction and operation periods, they are listed together here. Both the construction and operation period monitoring measures are as follows:
  - Sampling and monitoring activities started in 2021 will continue considering the Project Standards described in Chapter 3. Considering the data from the step-drawdown tests and the discharge capacities of the pumps at the installed depth, the ideal water volume to be discharged/purged from the wells will be determined, as stagnant water must be purged before collecting representative water samples[1,2,3].
  - With the monitoring to be carried out within the scope of the project, the groundwater flow model can be recalibrated or even rebuilt, the impact assessment studies can be updated and the monitoring program can be expanded with additional points.
  - Analyses will be carried out quarterly for the treated wastewater at the respective outlet points prior to discharge by accredited laboratories to check compliance with Project standards. Analyses will also be carried out at the frequency specified in the environmental permit document to be obtained from the Provincial Directorate of Environment, Urbanization and Climate Change in accordance with the Environmental Permit and License Regulation. As per the IFC EHS Guidelines, wastewater monitoring will take into consideration the discharge characteristics from the process over time. If the effluent is observed to be highly variable or discharge standards are exceeded, monitoring will be carried out more frequently or through composite methods, as necessary.
  - Treatment plants having a flow rate of 200-500 m^3/day will have a sampling manhole and automatic sampling device at the outlet point of the wastewater treatment plant according to the "Regulation on Water Pollution Control.

7.1.4 Noise and Vibration

Based on the information collected for the definition of the baseline (see Chapter 6.1.3), the physical component Noise and Vibration was assigned a Medium-High value of sensitivity for the following reasons:

- High noise levels in the AoI, and
- Close presence of communities, vulnerable targets and sensitive ecological receptors potentially exposed to noise and vibration emissions.

Potential impacts to noise and vibration associated with construction and operation phases of the Project include;

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[1] ASTM D-6452-99, 1999, Standard Guide for Purging Methods for Wells Used for Groundwater Quality Investigations

[2] United States Environmental Protection Agency (U.S. E.P.A), 2015, Standard Operating Procedure for the Standard/Well-Volume Method for Collecting a Groundwater Sample from Monitoring Wells for Site Characterization

Wilde, F.D., 2008, Guidelines for field-measured water-quality properties (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, section 6.0, October, Available only online from http://pubs.water.usgs.gov/twri9A/

- Emission o yttttt f aerial nois e and vibrations;

The project actions related to the abovementioned impact factors are the following:

- Site levelling and grading;
- Material transportation; and
- General onshore engineering/construction works.

Methodology

For the assessment of the noise and vibration to be generated during the construction phase of the Project, a noise modelling study and a vibration assessment study have been conducted as part of the ESIA in order to determine the potential impacts. The methodology used and the noise and vibration calculations are summarized in this chapter.

Noise Modelling

A noise modelling software "SoundPLAN Essential 5.0"[4] was used to determine the total noise level at the receptors during the construction phase of the Project.

1) As a first step of modelling studies, the elevation model that directly affects the noise distribution of the natural terrain is created. In the meantime, elevation contours with 5 m intervals on the topographic map were digitized and uploaded into the program. Interpolation of elevation contours was performed by the program and natural elevation data of the AoI and its surroundings were obtained to be used in the model. After the elevations are digitalized, Temporary DGM (Digitalized Ground Model) is generated.

2) At the second step, the humidity, temperature and air pressure data of the area were introduced to the model.

3) At the third step, the noise sources identified for the study area were put in the model together with their noise levels (dBA).

4) At the fourth step, the receptors identified in baseline investigations have been digitized and input into the model.

5) At the fifth step, ground effects, which is another important parameter for the noise model, were also digitized in the model. Ground effects varies between 0 to 1, where 0 corresponds to hard, reflective surfaces and 0 corresponds to soft, absorptive surfaces.

6) Finally, the modelling process has been initiated by determining a calculation area that will include all the noise sources and sensitive receptors in the study area. For the worst-case scenario simulation, all the noise sources are assumed to work at the same time and at the distances identified before. As a result of the model runs, noise levels in the identified receptors and grid noise maps for each study area are obtained.

The Noise Model assumptions and approach are listed below:

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[4] https://www.soundplan.eu/en/software/soundplanessential/

- Noise model has been developed using the vehicle & equipment types and numbers provided by TP-OTC as described in Section 3.9.2. Noise levels of the vehicles & equipment were obtained from the web search. For the vehicles and equipment could not be found via web search, noise levels have been obtained from the software library.
- The Project area humidity is taken as 72.3%, temperature is 13.8°C and air pressure is 1000.2 hPa by assuming a general average for region as described in Section 6.1.1.
- The ground effects are taken as 0.7, considering the intensity rurality of the study area.
- The model is set considering the Project activities will be performed 16 hours a day.
- The model was set considering the worst-case scenario, which represents the situation where all of the noise sources are operating at maximum volume at the same time. For this purpose, a cumulative sound power level of all the equipment to be used was calculated and entered as an area source to the model.

The receiver locations were selected depending on the sections of the possibility of having potential noise impact from the Project's construction and operation activities. Along the project field, 15 different receiver locations were selected to conduct noise impact assessment to predict the potential impact of the Project.

Identified receiver locations are representing a cluster of receivers which have the same or similar background characteristics in terms of environmental noise levels. Moreover, receivers to be evaluated can be defined as representative points which have the highest possibility to expose to noise due to Project activities. Receiver locations are presented in Table 7-18.

Table 7-18: Receiver Locations

Receiver	Receiver Type	Neighbourhood	Distance to Landfall Construction Area (m)
N-1	Residential	Aşağıishaniye	3,200
N-2	Residential	Aşağıishaniye	2,700
N-3	Residential	Sefercik	1,400
N-4	Residential	Sefercik	1,600
N-5	Residential	Gökçeler	1,800
N-6	Residential	Gökçeler	1,600
N-7	Residential	Derecikören	2,600
T-1	Road	Aşağıishaniye	4,300
T-2	Residential	Aşağıishaniye	2,400
T-3	Road	Sefercik	700
A-1	Residential	Sazköy	1,400
A-2	Residential	Sazköy	1,400
A-3	Road	Sazköy	900
A-4	Residential	Sefercik	1,300

Receiver	Receiver Type	Neighbourhood	Distance to Landfall Construction Area (m)
A-5	Residential	Sazköy	1,900

Vibration

Calculations were conducted according to the information and reference vibration levels gathered from Federal Transit Administration (FTA) document. The major vibrational activity is pile-driving for the construction phase. Therefore, the reference vibration value is accepted as pile driver (impact) – typical according to the FTA.

Table 12-2. Vibration Source Levels for Construction Equipment (From measured data.[7,8,9,10])

Equipment		PPV at 25 ft (in/sec)	Approximate L_v† at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.170	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.210	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

† RMS velocity in decibels (VdB) re 1 micro-inch/second

Figure 7-25: Reference Vibration Levels of Construction Equipment – FTA Document[5]

The peak particle velocities at the identified receivers are calculated with reference vibration velocities and distances in between the working area and receiving bodies as shown in the equation below.

$$PPVreceiver = PPVreferance \times (dref/drec)^{1.5}$$

PPV: peak particle velocity (mm/s),

dref: reference distance (m),

drec: receiver distance (m)

[5] Quagliata, 2018

7.1.4.1 Construction Phase

Impact factors

The impact factors from the Project activities potentially affecting in terms of noise and vibration during construction phase are listed in Table 7-19.

Table 7-19: Project actions and related impact factors during construction phase

Project actions	Brief description	Impact factors
Site levelling and grading;	Earthwork equipment will operate during ground reinforcement, excavation, filling works at the onshore section and offshore vessels will operate during excavation of the trench in shallow water (up to 2 km) in correspondence of the land approach.	Emission of aerial noise and vibrations
Material transportation	Removed soil and construction material will be transported out and in the construction area using trucks and heavy machinery. Building material will include crushed rocks and gravel for the landfall area. Sediment will be transported between storage area and pipeline route. Pipe loading and transportation works will be carried out. Offshore vessels will operate during material and sediment transportation.	Emission of aerial noise and vibrations
General onshore engineering/construction works;	Heavy machinery will be operating on the landfall area.	Emission of aerial noise and vibrations

All the impact factors identified above are described below and assessed in the matrix that follows.

- **<u>Emission of aerial noise and vibrations</u>**

Increased noise and vibration levels are expected due to operation of generators, heavy machinery, bored piles, etc. during;

- site levelling, grading and ground reinforcement works of onshore construction areas,
- material transportation including excavation material, equipment in and out in the onshore construction areas;
- pipe loading transportation between Coastal Logistics Center and pipeline route by vessels;
- sediment transportation between temporary storage area and pipeline route;
- operation of vessels during excavation of the trench in shallow water (up to 2 km);

- general onshore construction works.

As a result of examination of construction schedule of different Project components,

Noise Modelling

Most logical way to express constructional noise is to create area noise sources with the noise modelling software. Since a variety of constructional equipment will be used during the entire construction phase, it may be complicated to mirror the real noise case into the modelling software. Logic used while modelling constructional noise is determining the reasonable and necessary amount of constructional equipment in a reasonable area.

Modeling was carried out according to the areas where construction will commence on, and the equipment list provided by TP-OTC which was presented in Table 7-20.

Table 7-20: Machinery/Equipment Sound Power Levels

Equipment	Number	Sound Power Level (dBA)
Roller	1	107.9
Concrete Pump	1	109.0
Excavator	2	107.2
Loader	1	107.2
Pay welder	2	109.0
Grader	1	105.5
Hi-Up	1	106.9
Side Boom	3	106.8
Generator	1	97.3
Truck	2	109.2
Tractor	1	103.9
Backhoe Loader	1	101.1
Crane	1	110.4
Low-Bed	1	109.2
Concrete Mine Truck	1	107.9

L_{WT} of construction machine and equipment that will be used in the construction area is calculated as 120.6 dBA using the following total calculation formula for the equipment defined in the Roadway Construction Noise Model User's Guide (RCNM) of the United States (US) Federal Highway Administration:

$$L_{WT} = 10 * log_{10}(\sum_{i=1}^{n}(N_i * 10^{\frac{L_{Wi}}{10}}))$$

- L_{Wi}: Sound power level of the i-th piece of equipment
- N_i: Number of pieces of equipment i
- n: Total number of different types of equipment

Construction zones and total sound power levels are presented in Table 7-21.

Table 7-21: Construction Zones –Total Sound Power Levels

Construction Zone	Total L_w'' (dBA)
Coastal Transition Section (Operation of vessels)	70.0
Landfall	120.6

For the construction phase, environmental noise and vibration levels were calculated by using appropriate methods taking into account of construction equipment, dredging and piling activities (see Chapter 3.2.4 for equipment list used in the modelling). It is assumed that the machines given for each construction area will work with a homogeneous distribution in the relevant regions.

Noise modelling results at selected receiver points are presented in with respect to the limits set by the Regulation on Control of Environmental Noise (see Table 7-22) and with respect to IFC guideline values (Table 7-23). The construction phase noise distribution map which represents the two shifts during daytime and evening according to Turkish Regulation and daytime according to IFC guidelines is presented in Figure 7-26 for daytime.

For cumulative assessment, model results were compared with the average baseline values which are already reflecting the operational noise impact of SGFD Phase-1 to show for cumulative noise value and to show the potential level of dBA change. Since there will not be any works to be performed at nights, no cumulative noise calculations were made for the night-time periods.

Table 7-22: Modelled Construction Noise Levels and Baseline Noise Levels at the Receptors (Compared with Turkish Regulation Limits)

Receiver	Receiver Type	Neighbourhood	Distance to Landfall Construction Area (m)	Model Result L_{eq} (dBA)			Average Baseline Measurements (dBA)			Cumulative Results (dBA)			Limit Value L_{eq} (dBA)			Limit Exceedance Max (dBA)
				L_{day}	L_{eve}	L_{night}	L_{day}	L_{eve}	L_{night}	L_{day}	L_{eve}	L_{night}	L_{day}	L_{eve}	L_{night}	
N-1	Residential	Aşağıishaniye	3,200	10.2	10.2	-	47.4	47.2	44.6	47.4	47.2	-	**65.0**	**60.0**	**55.0**	0.0
N-2	Residential	Aşağıishaniye	2,700	9.3	9.3	-	39.0	36.8	36.4	39.0	36.8	-	**65.0**	**60.0**	**55.0**	0.0
N-3	Residential	Sefercik	1,400	46.3	46.3	-	50.2	45.9	43.0	51.7	49.1	-	**65.0**	**60.0**	**55.0**	0.0
N-4	Residential	Sefercik	1,600	45.0	45.0	-	52.4	52.2	44.0	53.1	53.0	-	**65.0**	**60.0**	**55.0**	0.0
N-5	Residential	Gökçeler	1,800	37.9	37.9	-	53.3	53.8	43.9	53.4	53.9	-	**65.0**	**60.0**	**55.0**	0.0
N-6	Residential	Gökçeler	1,600	39.1	39.1	-	53.0	53.1	43.2	53.2	53.3	-	**65.0**	**60.0**	**55.0**	0.0
N-7	Residential	Derecikören	2,600	33.9	33.9	-	52.2	46.3	38.8	52.3	46.5	-	**65.0**	**60.0**	**55.0**	0.0
T-1	Road	Aşağıishaniye	4,300	4.1	4.1	-	54.1	54.2	43.9	54.1	54.2	-	**65.0**	**60.0**	**55.0**	0.0
T-2	Residential	Aşağıishaniye	2,400	35.6	35.6	-	53.9	54.7	44.4	54.0	54.8	-	**65.0**	**60.0**	**55.0**	0.0
T-3	Road	Sefercik	700	51.2	51.2	-	51.1	49.4	43.9	54.2	53.4	-	**65.0**	**60.0**	**55.0**	0.0
A-1	Residential	Sazköy	1,400	28.1	28.1	-	50.9	43.1	37.1	50.9	43.2	-	**65.0**	**60.0**	**55.0**	0.0
A-2	Residential	Sazköy	1,400	41.8	41.8	-	50.7	48.2	43.5	51.2	49.1	-	**65.0**	**60.0**	**55.0**	0.0
A-3	Road	Sazköy	900	41.9	41.9	-	48.2	46.5	43.9	49.1	47.8	-	**65.0**	**60.0**	**55.0**	0.0
A-4	Residential	Sefercik	1,300	14.1	14.1	-	51.4	49.1	43.9	51.4	49.1	-	**65.0**	**60.0**	**55.0**	0.0
A-5	Residential	Sazköy	1,900	38.9	38.9	-	45.6	44.7	39.9	46.4	45.7	-	**65.0**	**60.0**	**55.0**	0.0

L_{day}: Equivalent continuous sound pressure level for reference time interval day (07:00-19:00).
L_{eve}: Equivalent continuous sound pressure level for reference time interval evening (19:00-23:00).
L_{night}: Equivalent continuous sound pressure level for reference time interval night (23:00-07:00).

Table 7-23: Modelled Construction Noise Levels and Baseline Noise Levels at the Receptors (Compared with IFC Limits)

Receiver	Receiver Type	Neighbourhood	Distance to Landfall Construction Area (m)	Model Result L_{eq} (dBA)		Average Baseline Measurements (dBA)		Cumulative Results (dBA)		Difference Between Baseline and Modelled Noise Levels (dBA)		Limit Value L_{eq} (dBA)			Limit Exceedance Max (dBA)
				L_{day}	L_{night}	L_{day}	L_{night}	L_{day}	L_{night}	L_{day}	L_{night}	L_{day}	L_{night}	Difference	
N-1	Residential	Aşağıishaniye	3,200	10.2	-	47.4	47.2	47.4	-	0.0	0.0	**55.0**	**45.0**	**3.0**	0.0
N-2	Residential	Aşağıishaniye	2,700	9.3	-	39.0	36.8	39.0	-	0.0	0.0	**55.0**	**45.0**	**3.0**	0.0
N-3	Residential	Sefercik	1,400	46.3	-	50.2	45.9	51.7	-	1.5	0.0	**55.0**	**45.0**	**3.0**	0.0
N-4	Residential	Sefercik	1,600	45.0	-	52.4	52.2	53.1	-	0.7	0.0	**55.0**	**45.0**	**3.0**	0.0
N-5	Residential	Gökçeler	1,800	37.9	-	53.3	53.8	53.4	-	0.1	0.0	**55.0**	**45.0**	**3.0**	0.0
N-6	Residential	Gökçeler	1,600	39.1	-	53.0	53.1	53.2	-	0.2	0.0	**55.0**	**45.0**	**3.0**	0.0
N-7	Residential	Derecikören	2,600	33.9	-	52.2	46.3	52.3	-	0.1	0.0	**55.0**	**45.0**	**3.0**	0.0
T-1	Road	Aşağıishaniye	4,300	4.1	-	54.1	54.2	54.1	-	0.0	0.0	**55.0**	**45.0**	**3.0**	0.0
T-2	Residential	Aşağıishaniye	2,400	35.6	-	53.9	54.7	54.0	-	0.1	0.0	**55.0**	**45.0**	**3.0**	0.0
T-3	Road	Sefercik	700	51.2	-	51.1	49.4	54.2	-	3.1	0.0	**55.0**	**45.0**	**3.0**	0.0
A-1	Residential	Sazköy	1,400	28.1	-	50.9	43.1	50.9	-	0.0	0.0	**55.0**	**45.0**	**3.0**	0.0
A-2	Residential	Sazköy	1,400	41.8	-	50.7	48.2	51.2	-	0.5	0.0	**55.0**	**45.0**	**3.0**	0.0
A-3	Road	Sazköy	900	41.9	-	48.2	46.5	49.1	-	0.9	0.0	**55.0**	**45.0**	**3.0**	0.0
A-4	Residential	Sefercik	1,300	14.1	-	51.4	49.1	51.4	-	0.0	0.0	**55.0**	**45.0**	**3.0**	0.0
A-5	Residential	Sazköy	1,900	38.9	-	45.6	44.7	46.4	-	0.8	0.0	**55.0**	**45.0**	**3.0**	0.0

L_d: Equivalent continuous sound pressure level for reference time interval day (07:00-22:00).
L_n: Equivalent continuous sound pressure level for reference time interval night (22:00-07:00).
Limit exceedances (above 3 dBA) are presented in **red**.

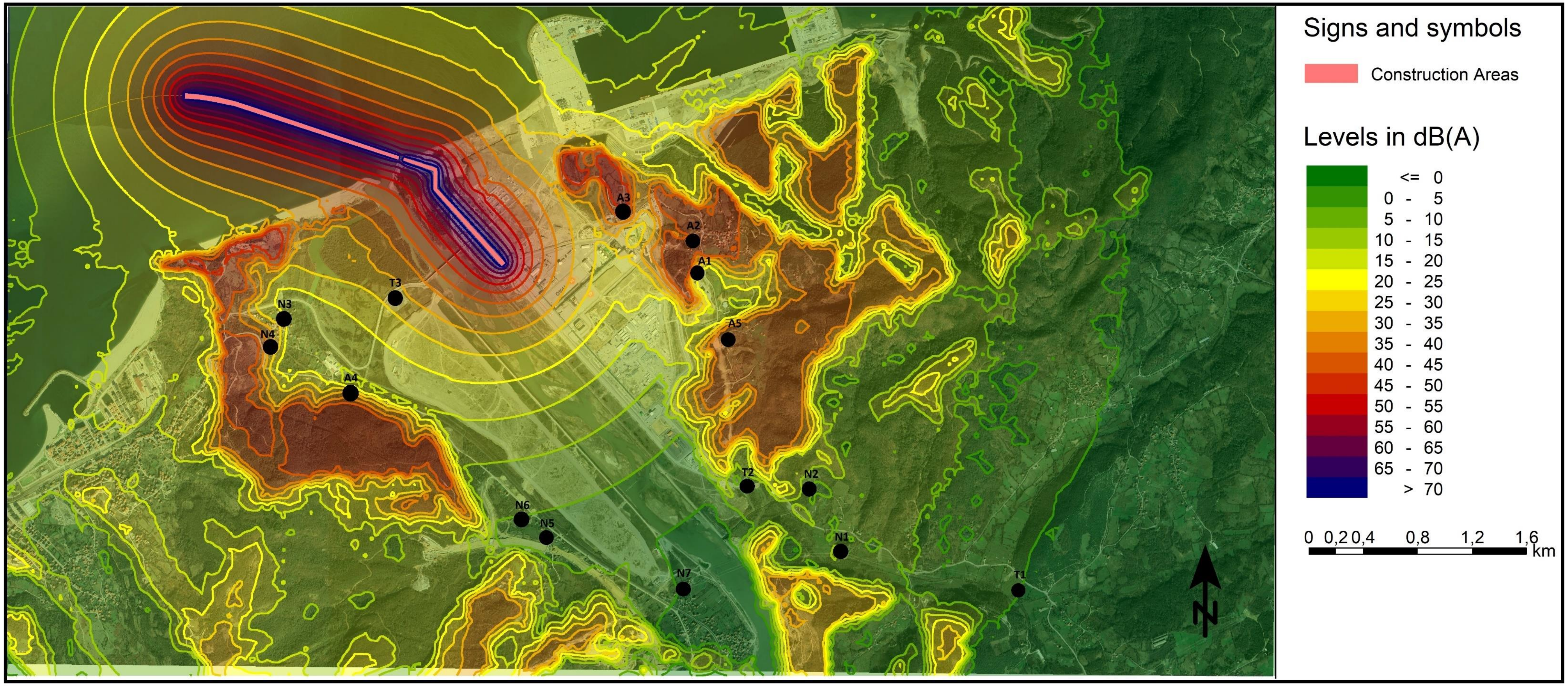

Figure 7-26: Construction Phase Noise Distribution Map – Day-Time

As it can be seen from assessment tables related with the construction phase of the Project, all receiver points comply with the limit values set by the Turkish Regulation as well as IFC guideline values.

Vibration Assessment

During the construction period, the primary source of vibration that might affect nearby receptors is expected to be pile driving activities due to the proximity of the construction area.

In order to simulate maximum vibration that may occur at receptors, calculations and assessment will be conducted in terms of environmental vibration sourced from pile driving activities. No blasting activity is planned for the construction period of the Project.

Critical distances from the construction area are calculated as 10 meter according to the limit defined in the Regulation on Control of Environmental Noise and 100 meters according to the BS 5225-2:2009 document. As can be seen from Figure 7-27, construction activity closer than this distance to the receiving bodies will have impact.

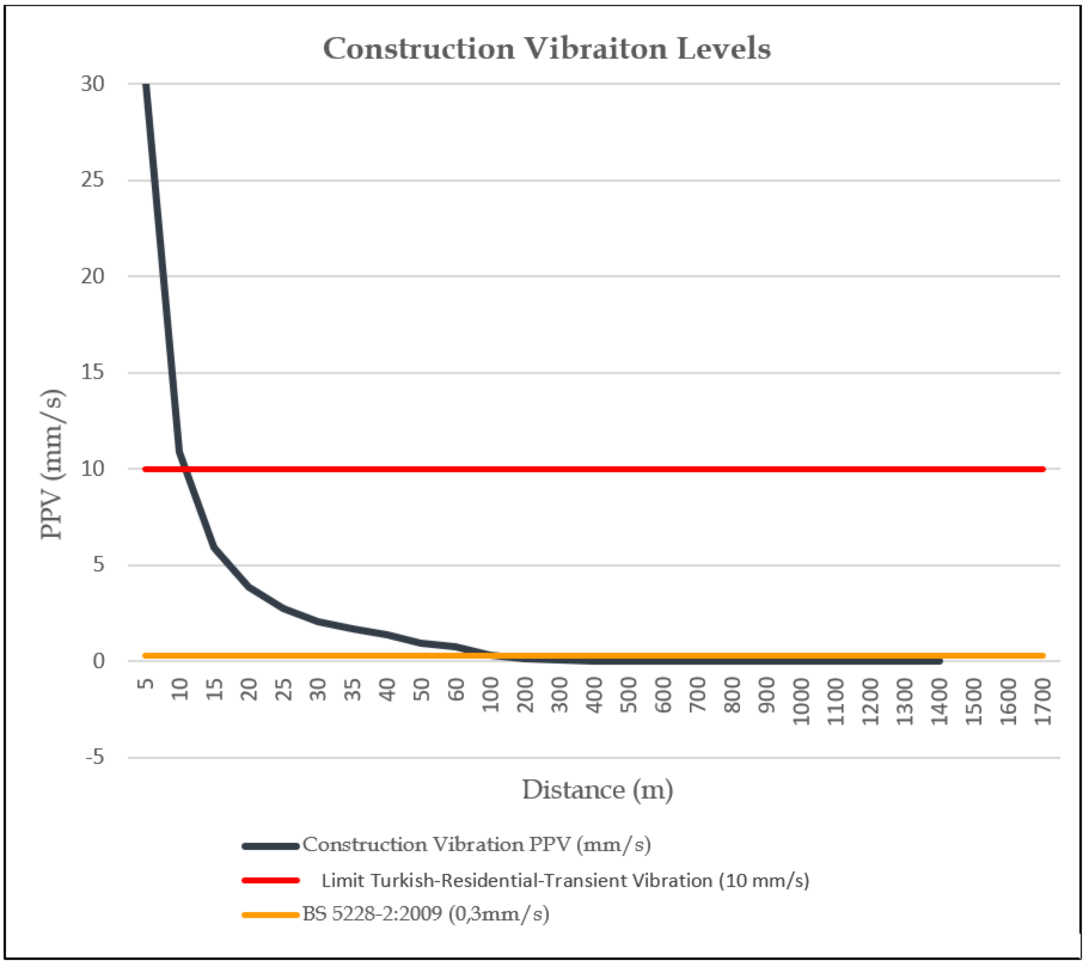

Figure 7-27: Construction Vibration Levels and Limit Values [6]

[6] Antoinette Quagliata, Transit Noise and Vibration Impact Assessment Manual, FTA, 2018.

Calculated construction vibration levels at receiver points are presented in Table 7-24. As it can be seen from the table, none of receiving body is within the critical distance and the calculated vibration values as a result of construction activities are within the limit values given by both Turkish Regulation and BS 5225-2:2009 document.

Table 7-24: Construction Vibration Results

Receiver Points	Distance (m)	Calculated Vibration Values at Relevant Distances (mm/s)	Limit Values (mm/s)	
			Turkish	BS5228-2
N-1	3,200	0.0019	10	0.3
N-2	2,700	0.0025	10	0.3
N-3	1,400	0.0066	10	0.3
N-4	1,600	0.0054	10	0.3
N-5	1,800	0.0045	10	0.3
N-6	1,600	0.0054	10	0.3
N-7	2,600	0.0026	10	0.3
T-1	4,300	0.0012	10	0.3
T-2	2,400	0.0029	10	0.3
T-3	700	0.0186	10	0.3
A-1	1,400	0.0066	10	0.3
A-2	1,400	0.0066	10	0.3
A-3	900	0.0127	10	0.3
A-4	1,300	0.0073	10	0.3
A-5	1,900	0.0042	10	0.3

Mitigation measures

In order to overcome construction noise related problems, possible alternative mitigations will be applied by each contractor which suits best the practical dynamics of the construction activities;

- Speed limit applications will be applied throughout site for the Project vehicles that will transport construction materials/equipment.
- Machinery, equipment and vehicles with lower sound power levels and sound reduced models will be preferred.
- Properly refurbished and/or new machinery, equipment and vehicles will be used to the extent possible.
- Maintenance of construction vehicles will be conducted regularly by means of a regular vehicle maintenance and repair program as per the recommendations of the manufacturer.
- Where applicable, silencers will be installed on the exhaust of vehicles.
- Portable barriers and acoustic enclosures will be put around equipment where necessary.
- In case of any grievance, temporary noise barriers will be deployed near sensitive receptors where practical.

- Natural topography will be used to create a barrier against noise where feasible.
- Construction traffic through the settlements will be avoided, whenever alternative routes and/or service roads are available.
- Idling of construction vehicles will be avoided.
- Night-time activities will be avoided where possible.

Monitoring results will be taken into account in the extent of implementation of mitigation measures.

Since there is no vibration impact observed at the receiving locations for the construction phase, mitigation is not required.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed.

Based on the baseline conditions of the assessed component, the Project characteristics, and actions, as well as the proper implementation of the mitigation measures proposed above, a potential **low impact** is expected in terms of the noise and vibration during the construction phase.

Table 7-25: Residual impact assessment matrix for the noise and vibration during construction phase.

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
Emission of Noise	Duration:	Medium	Medium-high	Short/Mid-term	**Medium**	Medium	**Low**
	Frequency:	Highly Frequent					
	Geo. Extent:	Local					
	Intensity:	High					
Emission of Vibration	Duration:	Medium-short	Medium-high	Short/Mid-term	**Low**	None	**Low**
	Frequency:	Frequent					
	Geo. Extent:	Local					
	Intensity:	Negligible					
Overall assessment:		**Low**	Rationale:	Mitigation measures proposed are expected to decrease the noise emission to meet with Project standards leaving with low residual impact. Since construction activities has limited time extent, along with the completion of the Project no residual impact expected at any kind of receiving bodies in terms of noise and vibration.			

Monitoring measures

The following monitoring measure shall be implemented to assess the true impacts of the Project in terms of the noise and vibration during the construction and verify the effectiveness of the mitigation measures.

- Inspection of vehicle/machinery/equipment maintenance records.
- Site inspections to be conducted to check the construction activities.

Quarterly noise monitoring studies are currently being conducted as part of the commitments under the SGFD ESIA for Phase 1. Since construction activities for Phase 2 will be less intense compared to Phase 1, noise measurements will continue to be conducted quarterly during the construction period of Phase 2. Additionally, supplementary noise measurements will be carried out if any grievances are received.

7.1.4.2 Operation Phase

Impact factors

The impact factors from the Project activities potentially affecting noise and vibration during operation phase are listed in Table 7-26.

Table 7-26: Project actions and related impact factors during operation phase

Project actions	Brief description	Impact factors
Plant/infrastructure onshore operation	During operations, the main sources of noise and vibration impact will continue to be produced by the operation of OPF, without significant contribution from the Phase 2.	Emission of aerial noise and vibrations

All the impact factors identified above are described below and assessed in the matrix that follows.

- **<u>Emission of aerial noise and vibrations</u>**

The noise and vibration impacts associated with the operation of the OPF were thoroughly assessed in the SGFD Phase 1 ESIA which was disclosed in 2022. As part of the Phase 1 commitments, TP-OTC has been conducting periodic noise measurements at the nearest sensitive receptors to monitor the noise impacts of the OPF operation, as presented in Section 6.1.3. According to the results, noise levels measured during OPF operation have consistently met IFC guideline value and Turkish regulatory limit values. No additional noise impacts are expected during Phase 2 operation beyond those assessed in the SGFD Phase 1 ESIA. Therefore, the noise results presented in the baseline section are considered representative for Phase 2 operation. Consequently, no additional noise assessment for the operation phase was conducted in this ESIA Report.

Vibration measurements were carried out during Phase 1 construction phase and presented in Section 6.1.3. The results indicated that vibration levels met regulatory limits during the Phase 1 construction phase, when machinery and equipment load was at its peak. During the operation phase, vibration impacts from OPF operation will be negligible. Thus, no additional vibration assessment for the operation phase was conducted in this ESIA Report.

Mitigation measures

The mitigation measures defined in the SGFD Phase 1 ESIA are currently being implemented during the operation of OPF. Considering the baseline noise measurement results, no additional mitigation measures are recommended.

Monitoring measures

The following monitoring measures are currently being implemented during the operation of SGFD Phase 1. Considering that the baseline noise measurement results are within both the limits and guideline values defined in the regulatory framework, no additional measures are recommended for SGFD Phase 2.

- Inspection of vehicle/machinery/equipment maintenance records.
- Site inspections to be conducted to check the operational activities.

Monthly noise monitoring during the first quarter, quarterly monitoring during the first year and annually monitoring for the rest of the operation phase will be conducted at noise sensitive receptors and additional monitoring in case complaints are received.

7.1.5 Air Quality

Based on the information collected for the definition of the baseline (see Ch 6.1.2), the physical component *Air Quality* was assigned a **Medium-high** value of sensitivity for high NOx, PM10 and PM2,5 concentrations in the **RSA,** and high PM10, SO_2 concentrations in the **AoI**. The AoI considered to be sensitive for the following reasons:

- Close presence of communities, vulnerable targets and sensitive ecological receptors potentially exposed to air emissions
- Other ongoing projects (under construction and planning stage) around the Project area.

Potential impacts to air quality associated with construction phase of the Project include;

- Emissions of particulate matter due to site levelling and grading, material transportation, onshore construction works
- Gaseous emissions from vehicles and construction equipment during site levelling and grading, material transportation, onshore construction works,

Potential impacts to air quality associated with operation phase of the Project include:

- Emissions of gaseous pollutants from the onshore part of the Project.

Impacts potentially affecting this component are assessed in the following sections for the construction phase and operation phase.

7.1.5.1 Construction Phase

Impact factors

Construction is a source of dust emissions that may have substantial temporary impact on local air quality. Emissions during the construction activities are associated with ground excavation, cut and fill operations, and construction of the phase-2 onshore pipeline. Dust emissions often vary substantially over different phases of the construction process. In order to obtain more specific results and to be able to comment on the dust control plan for specific process, dust emissions are considered by breaking down the construction process into phases. The impact factors from the Project activities potentially affecting air quality during construction phase are listed in Table 7-27.

Table 7-27: Project actions and related impact factors potentially affecting air quality during construction phase

Project actions	Brief description	Impact factors
Onshore construction activities (site levelling and grading, material transportation, etc.)	During land preparation dust will occur due to earthworks including excavation, backfilling, grading, equipment movement, loading and unloading. Dust emissions will occur due to wind erosion from stockpiles. Exhaust emissions will be released from the construction machinery and trucks during land preparation activities and material transportation.	Dust emissions Exhaust emissions from vehicles and construction machinery

Impacts potentially affecting this component are assessed here below for the construction phase.

- **<u>Onshore construction activities – Dust Emissions</u>**

Dust emissions from land preparation activities are estimated using the emissions factors given in the Annex 12 of the Regulation on Industrial Air Quality Pollution Control (IAQPC) (see below in Table 7-28). Uncontrolled emission factors represent the situations where activities are carried out without taking any mitigation measures. On the other hand, the controlled factors stand for the cases where activities are carried out with measures in place such sprinkling, keeping materials moist, loading and unloading without skidding, etc.

Table 7-28: Emission Factors used in Dust Emission Estimation

Source of emission	Emission factors		Emission Factor Unit
	Uncontrolled Conditions	Controlled Conditions	
Excavation	0.025	0.0125	kg/ton
Loading	0.010	0.005	kg/ton
Unloading	0.010	0.005	kg/ton
Transportation (total distance)	0.7	0.35	kg/km-vehicle

Land preparation activities and corresponding dust emissions are calculated based on the following assumptions on cut and fill amounts, bulk density of soil, duration of earth works, size of the area on which activities take place, working hours per day, capacity of each truck, etc. The variables used in estimation of dust emissions are presented in the following tables. Considering that the project activities will follow the proposed mitigation measures, dust emissions are calculated based on the controlled condition emission factors. In the onshore part of the construction works, in order to lay onshore part of the pipeline, preparation works on the land will be carried out. First, the route of the pipeline in the landfall area will be excavated, and the land will be prepared/graded to create a stable working surface for pipeline laying. After the pipelaying operation the excavated material will be used for the backfilling of the trench.

Table 7-29: Dust Emission Estimation

Dust Emission due to excavation works:	
Excavation amount	20 ton/hour
Dust emission due to excavation (under controlled conditions)	20 ton/h x 0.0125 kg/ton = **0.25 kg/h**
Dust Emission due to loading excavated soil:	
Hourly excavation amount	20 ton/h
Dust emission due to excavation (under controlled conditions)	20 ton/h x 0.005 kg/ton = **0.1 kg/h**
Dust Emission due to transportation of material (especially rocks/padding from supplychain):	
Average transport distance within the project area	0.5 km (one way) (regarding the unpaved roads), 1 km (round trip)
Truck carrying capacity	30 tons/vehicle
Frequency of transports	1 vehicle / hour
Dust emission due to transportation (under controlled conditions)	1 vehicle/h x 0.35 kg/km-vehicle x (1 km * 1) = **0.35 kg/h**
Dust Emission due to unloading backfill material:	
Hourly backfilling amount	30 ton/h
Dust emission due to unloading of backfill (under controlled conditions)	30 ton/h x 0.005 kg/ton = **0.15 kg/h**

Dust emission due to excavation, loading and unloading are calculated based on the following formula:

$$\text{Dust Emission}\left(\frac{\text{kg}}{\text{h}}\right) = \text{Emission Factor}\left(\frac{\text{kg}}{\text{ton}}\right) \text{x Production Amount}\left(\frac{\text{ton}}{\text{h}}\right)$$

where:

$$Production\ Amount = \frac{\text{Excavation/Loading/Unloading Amount}}{\text{Duration of works (days)} * \text{Working hours per day (h/day)}}$$

Dust emission due to transportation are calculated based on the following formula:

$$\text{Dust Emission}\left(\frac{\text{kg}}{\text{h}}\right) = \text{Emission Factor}\left(\frac{\text{kg}}{\text{km}-\text{vehicle}}\right) \text{x Distance}\left(\frac{\text{km}}{\text{vehicle}}\right) \text{x Number of vehicles}\left(\frac{\text{vehicle}}{\text{h}}\right)$$

The total estimated dust emissions from the onshore construction activities (specifically at the landfall area) are below the threshold requiring an air quality dispersion study, as defined by Turkish regulations (1 kg/hour of dust emissions). Therefore, an air quality modelling study for dust emissions was not deemed necessary for the onshore construction phase. Given that the estimated dust emissions are expected to remain low, and the earthworks (such as excavation and material handling) will occur in non-dry soils near the shoreline, no significant negative impacts are anticipated within AoI.

- **Onshore construction activities – Exhaust Emissions**

During site preparation activities, heavy duty vehicles (i.e. trucks) will be used to transfer material to the site for pipeline route preparation. It is assumed that one truck will be on site in hourly basis.

For estimation of NO_x, VOC, CO, PM and SO_2 emissions from on road heavy-duty vehicles, emission factors of European Environment Agency (EEA), EMEP/EEA air pollutant emission inventory guidebook are used[7]. It is assumed that all the heavy-duty vehicles have diesel engine. Tier 2 approach, which is based on detailed machinery classification, is used for estimation of the exhaust emissions from the corresponding EFs presented in Table 7-30.

Table 7-30: Tier 2 Emission Factors for Diesel Heavy-Duty Vehicles

	NOx	VOC	CO	PM
Emission Factors (g/veh-km)	0.507	0.012	0.121	0.0013

Source: European Environment Agency (EEA), EMEP/EEA air pollutant emission inventory guidebook 2019 – Update Oct. 2021, Table 3-21 EFs for diesel heavy-duty vehicles >32tons and having Euro VI technology.

The generic algorithm for calculating emissions from road transport using the Tier 2 methodology is:

$$E_i = \sum \mathrm{N} \times \mathrm{M} \times \mathrm{EF}_i$$

where:

E_i = mass of emissions of pollutant i (g/hour),

N= number of vehicles,

M = total distance driven by vehicles per time [km/veh],

EF_i = average emission factor for pollutant i [g/veh-km],

i = pollutant type.

SO_2 emissions are estimated by assuming that all sulphur in the fuel is transformed completely into SO_2 using the formula below:

$$E_{SO2} = 2 \sum \mathrm{k}_S \times \mathrm{FC}$$

where:

k_S = weight related sulphur content of fuel [kg/kg] (taken as 400 ppm),

FC = fuel consumption [kg] (FC of heavy-duty trucks > 32ton and having Euro IV technology is 251 g/km).

[7] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i

In the following table, a summary of the total emissions calculated for NOx, VOC, CO, PM and SO_2 due to transfer of material to the site is shown. 1.5 km section of the road up to Zonguldak Çaycuma Road connection is considered in emission calculations.

Table 7-31: Emissions during transfer of fill material to the project site

Parameters	NO_x	VOC	CO	PM	SO_2
Emissions in kg/h	0.00076	0.000018	0.000182	0.0000002	0.0027

For estimation of NOx, CO, VOC, SO2 and PM10 emissions from construction equipment, the emission factors given in Table 7-32 were used. It is assumed that all the NRMM will have diesel engine.

Table 7-32: Emission Factors for Diesel Non Road Mobile Machinery

Engine Power (kWh)	NOx (g/kWh)	VOC (g/kWh)	CO (g/kWh)	PM10 (g/kWh)	Fuel Consumption (g/kWh)
P<8	6.08	0.68	4.8	0.4	270
8<=P<19	6.08	0.68	3.96	0.4	270
19<=P<37	3.81	0.42	2.2	0.015	262
37<=P<56	3.81	0.28	2.2	0.015	260
56<=P<75	0.4	0.13	2.2	0.015	260
75<=P<130	0.4	0.13	1.5	0.015	255
130<=P<560	0.4	0.13	1.5	0.015	250
P>560	3.5	0.13	1.5	0.045	250

Source: European Environment Agency (EEA), EMEP/EEA air pollutant emission inventory guidebook 2016 (Update May 2017), Table 3-6[8].

The generic algorithm used for emission calculation is as follows:

$$E_i = \text{Engine Power } [\text{kW}] \times \text{EF}_i \, [\frac{\text{g}}{\text{kWh}}] \times \frac{1 \text{ kg}}{10^3 g}$$

where:

E_i = mass of emissions of pollutant i [kg/h],

EF_i = average emission factor for pollutant i [g/kWh],

i = pollutant type.

SO_2 emissions are estimated by assuming that all sulphur in the fuel is transformed completely into SO_2 using the formula below:

$$E_{SO2} = 2 \sum \text{k}_S \times \text{FC} \times 10^{-3} kg/g$$

where:

[8] https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-4-non-road-1

E_{SO2} = mass of SO2 emissions [kg/h],

k_S = weight related sulphur content of fuel [kg/kg] (taken as 400 ppm),

FC = fuel consumption [g/kWh].

The machinery type and number, engine powers and associated emissions are given in Table 7-33 for each contractor work area. The peak time of construction machinery operation period is considered to be between June-September 2022.

Table 7-33: Total Engine Power and Emissions for the Construction Machinery

	Number	Power (kW)	NOx (kg/h)	VOC (kg/h)	CO (kg/h)	PM10 (kg/h)	SO2 (kg/h)
Roller	1	170	0.0736	0.0239	0.2760	0.0028	0.0368
Excavator	2	178	0.1424	0.0463	0.534	0.0054	0.0712
Grader	1	136	0.0544	0.0177	0.2040	0.0020	0.0272
HI-UP	1	175	0.0700	0.0228	0.2625	0.0026	0.0350
Side boom	3	175	0.21	0.0683	0.7875	0.0079	0.105
Generator	1	128	0.0512	0.0167	0.192	0.0019	0.0261
Truck	2	175	0.1400	0.0455	0.5250	0.0053	0.0700
Tractor	1	77	0.0308	0.0100	0.1155	0.0012	0.0157
Crane	1	205	0.082	0.0267	0.3075	0.0031	0.041
Loader	1	183	0.0732	0.0238	0.2745	0.0027	0.0366

Total emissions for each pollutant are given in the following table in kg/h with the relevant threshold value for the air emission dispersion modelling requirement defined by the Turkish Regulation (Table 2.1 in Annex-2 of the SKHKKY). Since the amount of each pollutant emission originated from the construction equipment is below the threshold value (see Table below) air quality modelling study was not conducted for these pollutants.

Table 7-34: Total Emissions for the Construction Machinery in kg/h

Parameter	Total Calculated Emission (kg/hour)	Threshold Value Defining Modelling Study Requirement by the Turkish Regulation (kg/hour)
NO_X	0.93	4
VOC	0.30	3
CO	3.48	50
PM	0.03	1
SO2	0.47	6

Mitigation Measures

The following mitigation measures shall be implemented to mitigate the effects of the impact factors.

- **Onshore construction activities – Dust Emissions**

In order to reduce the air emissions from the construction machinery and equipment, the following actions will be implemented during the construction phase:

- Locate activities and rock / earth stockpiles away from sensitive receptors (natural or residential);
- Moisturize the material and soil to prevent wind whipping;
- Keep stockpiles for the shortest possible time;
- Slow down or cease the work under strong winds, such as reducing work activities or using water spray to reduce dust dispersion.
- Minimise amounts of material handling and avoid double handling;
- Seal or re-vegetate completed earthworks as soon as reasonably practicable after completion;
- Ensure all vehicles carrying loose or potentially dusty material to or from the site are fully sheeted;
- Enforce speed limits and reduce vehicle movements and idling on site;
- Use water suppression for control of loose materials on paved or unpaved road surfaces;

- **Onshore construction activities – Exhaust Emissions**

The following actions will be implemented to reduce generation of dust in the construction area:

- vehicle engines and other machinery will be kept turned on only if necessary, avoiding any unnecessary emission;
- machinery and equipment will be periodically checked and maintained to ensure their good working condition;
- all equipment and machinery must be maintained for compliance with standards and technical regulations for the protection of the environment and have appropriate certifications;
- activities will be conducted trying to use the minimum required number of means at the same time;
- electric small-scale mechanization and technical tools will be used when available and feasible.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed.

Based on the baseline conditions of the assessed component, the project characteristics and actions, as well as the proper implementation of the mitigation measures proposed above, a potential **low negative impact** is expected on the air quality during the construction phase.

Table 7-35: Residual impact assessment matrix for the air quality during construction phase

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
	Duration:	Medium		Short-term	**Low**	Low	**Low**

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
Dust emissions	Frequency:	Highly Frequent	Medium-high				
	Geo. Extent:	Local					
	Intensity:	Medium					
Gaseous Emissions from vehicles and construction machinery	Duration:	Medium	Medium-high	Short-term	**Low**	Low	**Low**
	Frequency:	Highly Frequent					
	Geo. Extent:	Local					
	Intensity:	Medium					
Overall assessment:		**Low**	Rationale:	Using a strong precautionary approach, the highest residual impact value may be considered as a theoretical overall residual impact value			

Monitoring measures

The following monitoring measure shall be implemented to assess the true effects of the Project on the air quality during the construction and verify the effectiveness of the mitigation measures.

- Regular (daily) visual monitoring to ensure that the dust mitigation measures are in place;
- Routine maintenance programme will be set-up and maintenance records will be kept for all vehicles, machinery/equipment, and vessels;
- Periodic inspection of subcontractors to ensure that all vehicles, construction machinery and vessels used on site evidence regular maintenance schedule in line with regulatory requirements;
- Maintaining logbook by recording any exceptional incidents that cause extra dust or gas emissions, either on- or offsite, and the action taken to resolve the situation in the log book; and
- Air quality monitoring of NOx, SO2 and PM10 at the closest sensitive receptors during peak time of construction activities and earthworks, and also in case of grievance.

7.1.5.2 Operation Phase

Impact factors

The impact factors from the Project activities potentially affecting air quality during operation phase are listed in Table 7-26.

Table 7-36: Project actions and related impact factors during operation phase

Project actions	Brief description	Impact factors
Plant/infrastructure onshore operation	During operations, the main sources of noise and vibration impact will be produced by the operation of OPF (Emissions from OPF can be categorized as	Emission of gaseous pollutants and/or greenhouse gases

	fugitive, combusted, and *associated emissions* including several different kinds of air pollutants, such as methane, VOC, CO2, CO, NOx, and trace amounts of SO2 and PM.) During the operation of Phase-2, fugitive VOC emissions are expected.	

- **Emission of gaseous pollutants**

Emissions from the onshore part can be categorized as *fugitive, combusted,* and *associated emissions* as explained below:

i) Fugitive emissions refer to the natural gas vapors that are released to the atmosphere during OPF operations. Fugitive emissions can be either intentional (i.e., vented emissions to guard against over pressuring) or unintentional (i.e., leaked emissions from routine wear, tear, and corrosion; improper installation or maintenance of equipment). Fugitive emissions can contain several different kinds of air pollutants, including methane, VOCs, and HAPs (Hazardous Air Pollutants).

ii) Combustion emissions refers to the byproducts that are formed from the burning of natural gas during OPF operations. Combusted emissions are commonly released through either the flaring of natural gas for safety and health precautions or the combustion of natural gas for process heat, power, and electricity in the system (e.g., for compressors and other machinery). The chemical process of combusting natural gas releases several different kinds of air pollutants, including CO_2, carbon monoxide (CO), nitrogen oxides (NOx), and trace amounts of sulfur dioxide (SO_2) and particulate matter (PM).

iii) Associated refers to secondary sources of emissions that arise from associated operations in natural gas systems. Associated emissions may result from the combustion of other fossil fuels (i.e., other than the natural gas stream) to power equipment and machinery.

The impacts of the OPF operations were captured by the air quality monitoring campaign results given in the Section 6.1.2. The additional air quality impacts of the onshore part of the Phase-2 operations will be fugitive VOC emissions that may be associated with the connection equipment (e.g. valves, flanges, open-ended lines, pump seals, compressor seals, etc.). These emissions have been estimated by use of the emission factors provided in Annex 12 of the Regulation on Control of Industrial Air Pollution. The estimated fugitive VOC emissions from the connection equipment are given in table below.

Table 7-37: Fugitive VOC Emissions from Connection Equipment

Equipment Type	Service	Emisison Factor (kg/h.source)	Number of Onshore Equipment (for Phase 2)	Estimated VOC Emission (kg/h)
Valve	Gas	0.0045	345	1.5525
	Heavy Oil	0.0000084	N/A	N/A
	Light Oil	0.0025	57	0.1425
Pump	Gas	0.0024	N/A	N/A
	Light Oil	0.013	N/A	N/A

Equipment Type	Service	Emisison Factor (kg/h.source)	Number of Onshore Equipment (for Phase 2)	Estimated VOC Emission (kg/h)
Flange	Gas	0.00039	951	0.37089
	Heavy Oil	0.00000039	N/A	N/A
	Light Oil	0.00011	185	0.02035
Open-Ended Lines*	Gas	0.002	3	0.006
	Heavy Oil	0.00014	N/A	N/A
	Light Oil	0.0014	N/A	N/A
Pressure Relief Devices	Gas	0.0002	37	0.0074
	Heavy Oil	0.0000075	N/A	N/A
	Light Oil	0.00021	N/A	N/A
Compressor	Gaz	0.0088	2	0.0176
	Heavy Oil	0.000032	N/A	N/A
	Light Oil	0.0075	N/A	N/A
			Total VOC Emission	**2.11724**

The total fugitive VOC emission is estimated as 2.12 kg/h, which is lower than the limit (3 kg/h) given in the Regulation on Control Industrial Air Pollution, Annex 2, Table 2.1. Therefore, air quality modelling study is not performed for fugitive VOC emissions.

In the Phase-2 of the Project, there will not be air emitting components in the onshore part other than the OPF in the scope of SGFD Phase-1. The air quality impacts associated with the operation of the OPF were thoroughly assessed in the SGFD Phase 1 ESIA which was disclosed in 2022. As part of the Phase 1 commitments, TP-OTC has been conducting periodic air quality measurements at the nearest sensitive receptors to monitor the air emission impacts of the OPF operation, as presented in Section 6.1.2. According to the results, air quality levels measured during OPF operation have consistently met IFC guideline values and Turkish regulatory limit values. No additional air impacts are expected during Phase 2 operation beyond those assessed in the SGFD Phase 1 ESIA other than fugitive VOC emissions. Therefore, the air quality results presented in the baseline section are considered representative for Phase 2 operation, as well.

Mitigation Measures

Fugitive emissions

The following design measures have been considered for the reduction of potential atmospheric leaks from components and instruments, and releases to atmosphere from vessels and inspection points during maintenance:

- Flanged manual valves will have flanges integral with valve body and no welding on valve flanges permitted
- Swing check valves will be provided with limit stops to prevent disc from remaining in open position
- By-pass valves will be globe type
- All (pipeline) fittings will be seamless in construction unless otherwise specified
- In accordance with API 622 all control valves will undergo fugitive testing to the standard ISO 15848 (2015)
- Project places upper permissible leak limit of 100 pm at stem package flange
- All fillet welds for by-pass installation shall be 100% examined by DP/MO tested and butt weld joints shall be 100% examined by radiography or ultrasonic examination
- The Project will utilise isolation for the following:
  - Valve – Single Block and Bleed (SBB): A single block valve with bleed valve (vent/drain) installed on the same side as the isolated section
  - Valve – Double Block and Bleed (DBB): Double block valve with single bleed valve installed
  - Spectacle Blind: Two discs are attached to each other by section of steel similar to the nose piece of a pair of glasses. One of the discs is a solid plate, and the other is a ring, whose inside diameter is equal to that of a flange. Either can be rotated into the pipe stream. When ring is in stream there is flow; when solid plate is moved in place flow is prevented
  - Line Blind: Solid plate that is installed in pipeline which completely prevents flow through pipe
  - Spade Solid plate used to cut off flow in pipeline.
- All hydrocarbon handling equipment will have facility for spectacle blind, spade/spacer or removable spool. Spectacle blinds shall be used in preference to spaces whenever design allows. Pumps will be fitted with isolation valves (SBB/DBBB) on both suction and discharge ends as close to pump inlet/outlet as possible to minimise vapor build up. Eccentric type flat side up reducers will be used to avoid accumulation of gas pockets.
- Control valves, relief valves, pressure instrumentation, and flow instrumentation will be used as an isolation method for the components on the service lines.
- Project vessels/tanks requiring entry, i.e., for inspection/maintenance purposes will have facility for isolation of the vessel from the main process lines. Isolation of the vessel from both inlet and outlet flows will be achieved through installation of valve isolation (single block and bleed or double block and bleed), spectacle blind, line blind, removable nozzle, or spade.

- For closed and open drainage from the vessels/tanks, the following isolation will be used:
  - Vessels with Hazardous (Closed) drains will be isolated using manual isolation valve (NC) followed by spectacle blind and then ball valve (NC) arrangement.
  - Non-hazardous (open) drains will use single block valve (LO) followed by U-bend and connected to the common open drain header.
- Isolation equipment will be installed as close as possible to the vessel/tank to minimise amount of gas between isolation point and vessel. Positive isolation will be achieved prior to depressurisation of tank/vessel.
- Pig receiver will use DBB isolation. Each receiver will be fitted with flanged purge connection with isolation valve and check valve.
- The following design considerations have been put forth as given in the Piping design philosophy:
  - Protective coating will be applied to pipeline to reduce risk of fracture and accidental releases.
  - Threaded connections will not be used for process connections (except instrument take-offs after the process isolation valve).
  - Use of flanges on pipe will be kept to a minimum, limited to connecting lines to equipment.
- Leak Detection and Repair (LDAR) programs will be developed and implemented as a part of the management system.

Residual impacts

The table below summarizes the impacts caused by the identified impact factors on the component assessed.

Based on the baseline conditions of the assessed component, the project characteristics and actions, as well as the proper implementation of the mitigation measures proposed above, a potential **negligible impact** is expected on the air quality during the operation phase.

Table 7-38: Residual impact assessment matrix for the air quality during operation phase

Impact Factor	Impact Factor Features		Component Sensitivity	Impact Reversibility	Impact Value	Mitigation effectiveness	Residual impact value
Emission of gaseous pollutants	Duration:	Long	Medium-high	Short -term	**Low**	Low	**Negligible**
	Frequency:	Frequent					
	Geo. Extent:	Project Footprint					
	Intensity:	Low					
Overall assessment:		**Negligible**	Rationale:	Using a strong precautionary approach, the highest residual impact value may be considered as a theoretical overall residual impact value			

Monitoring measures

The following monitoring measure shall be implemented to assess the true effects of the Project on the air quality during the operation and verify the effectiveness of the mitigation measures.

- Routine maintenance programme will be set-up and maintenance records will be kept for all units, machinery/equipment, and vessels;
- A logbook will be maintained and any exceptional incidents will be recorded
- Periodical ambient air quality monitoring at the sensitive receptors will be performed as defined in the disclosed ESIA of the Phase-1. No additional monitoring will be required in the scope of the Phase-2.

7.1.6 Greenhouse Gas Emissions

This section presents calculation and assessments of the greenhouse gas (GHG) emissions to be originated from the activities of the Project and Project's contribution to climate change.

The GHG emissions estimation methods used in this assessment generally follow internationally accepted practices for conducting Environmental Assessments. Where applicable, the Greenhouse Gas Protocol/A Corporate Accounting and Reporting Standard prepared by the World Business Council for Sustainable Development/World Resources (April 2004; hereafter referred to as the GHG Protocol) is applied. The GHG Protocol provides guidance for preparing corporate GHG inventories, as well as sector-specific and general calculation tools that can be used for estimating GHG emissions. The GHG protocol has been adopted by the Global Reporting Initiative (GRI). The GHG Protocol introduces the concept of direct and indirect emissions and scopes for GHG emission inventory under three broad categories, as follows:

Scope 1 – Direct GHG emissions:

Carbon emissions occurring from sources that are owned or controlled by the Project (e.g., emissions from combustion in owned or controlled boilers, furnaces and vehicles, process and fugitive emissions).

Scope 2 – Indirect GHG emissions:

Carbon emissions from the generation of purchased electricity, heat or steam consumed by the Project.

Scope 3 – Other indirect GHG emissions:

Carbon emissions which are a consequence of a company's activities but occur from sources not financially or operationally controlled by the company (e.g., emissions from waste, the extraction and production of purchased materials; and employee travel to and from work).

The GHG Protocol requires reporting of Scope 1 (direct emissions from site) and Scope 2 (emissions from on-site energy consumption) emissions only. Scope 1 and Scope 2 emissions are typically the focus of most corporate inventories, although many organizations choose to account for other activities such as employee travel and downstream emissions from waste. These sources are classified as Scope 3 (indirect) emissions and are reported optionally. Given the nature of Project operations, Scope 1 emissions will be the most significant. Accordingly, Scope 1 have been the primary focus of the GHG inventory. Additionally, Scope 2 emissions have been estimated considering the electricity consumption expected during Project life. Scope 3 emissions are not included in these estimations.

7.1.6.1 Legislative Framework

Climate change is a global phenomenon, which is the result of anthropogenic activities, mainly energy use, industrial processes and land use changes. Due to its multidimensional nature, fighting climate change requires actions at different scales, e.g., international, regional and local. This section summarizes the legislative framework regarding climate change accordingly.

International Standards

The main international body dealing with climate change is the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992 Rio Earth Summit and ratified by 195 countries. UNFCCC guides countries on cooperation to fight climate change and to cope with its impacts. Currently, Ratification of Doha amendment to the Kyoto Protocol, covering 2013 – 2020 is under the focus of Türkiye, while the Paris Agreement is ratified by Türkiye and the Law on the Approval of the Paris Agreement by the Turkish Grand National Assembly entered into force after being published in the Official Gazette dated October 7th, 2021 and numbered 31621.

According to the IFC PS3, the client will consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project. These options may include, but are not limited to, alternative project locations, adoption of renewable or low carbon energy sources, sustainable agricultural, forestry and livestock management practices, the reduction of fugitive emissions and the reduction of gas flaring.

For projects that are expected to or currently produce more than 25,000 tonnes of CO_2-equivalent annually,[9] the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary,[10] as well as indirect emissions associated with the off-site production of energy[11] used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognized methodologies and good practice.[12]

According to the EP2, GHG emissions will be calculated in line with the GHG Protocol[13] to allow for aggregation and comparability across Projects, organisations and jurisdictions. Clients may use national reporting methodologies if they are consistent with the GHG Protocol. The client will quantify Scope 1 and Scope 2 Emissions.

The EPFI will require the client to report publicly on an annual basis on GHG emission levels (combined Scope 1 and Scope 2 Emissions) and GHG efficiency ratio, as appropriate, during the operational phase for Projects emitting over 100,000 tonnes of CO_2 equivalent annually. Clients will be encouraged to report publicly on Projects emitting over 25,000 tonnes. Public reporting requirements can be satisfied via host country regulatory

[9] The quantification of emissions will consider all significant sources of greenhouse gas emissions, including non-energy related sources such as methane and nitrous oxide, among others.

[10] Project-induced changes in soil carbon content or above ground biomass, and project-induced decay of organic matter may contribute to direct emissions sources and shall be included in this emissions quantification where such emissions are expected to be significant.

[11] Refers to the off-site generation by others of electricity, and heating and cooling energy used in the project.

[12] Estimation methodologies are provided by the Intergovernmental Panel on Climate Change, various international organizations, and relevant host country agencies.

[13] The GHG Protocol is based on a comprehensive globally standardised framework to measure and manage greenhouse gas (GHG) emissions from operations. Available from ghgprotocol.org.

requirements for reporting or environmental impact assessments, or voluntary reporting mechanisms such as the Carbon Disclosure Project, where such reporting includes emissions at Project level.

Turkish Legislation

Türkiye's climate policy is shaped by Climate Change Adaptation Strategy and Action Plan (2024 – 2030) and Climate Change Mitigation Strategy and Action Plan (2024 – 2030). Also 12th National Development Plan (2024 – 2028) emphasizes reduction of GHG emissions and strengthening climate change adaptation actions. It also emphasizes sustainable management of natural resources with low carbon growth and green economy.

The table below lists Turkish legislation related to climate change and GHG emissions.

Table 7-39: Turkish Legislation on Climate Change and GHG Emissions

Date	Number	Title
28.12.2003	25330	Regulation on Availability of Customer Information regarding Fuel Economy and CO_2 Emissions of New Automobiles
09.10.2013	28790	Notice on Voluntary Carbon Market Project Registration
17.05.2014	29003	Regulation on Monitoring of Greenhouse Gas Emissions
22.07.2014	29068	Notice on Monitoring and Reporting Greenhouse Gas Emissions
02.12.2017	30258	Notice on Validation of Greenhouse Gas Reports and Accreditation of Validator Institutions
29.06.2022	31881	Regulation on Fluorinated Greenhouse Gases

Regulation on Monitoring of Greenhouse Gas Emissions aims to define the procedures and principles on monitoring, calculating, verifying and reporting the greenhouse gases emissions. Annex 1 of the Regulation includes the Projects that subject to this Regulation, and which will monitor, report and verify the GHG emissions in the GHG mechanism established by MoEUCC.

Since the Project is one of the listed Projects specified in Annex 1, the Project is subject to this Regulation and to calculate, verify and teport GHG emissions annually.

7.1.6.2 GHG Emission Calculation Methodology

Following sections summarize the emission calculation methods, input parameters and assumptions that are used to estimate the annual GHG emissions of the Project.

The GHG considered in the assessment include Carbon dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). There are no Project activities which are expected to emit Sulphur hexafluoride (SF_6), Perfluorocarbons (PFCs) or Hydrofluorocarbons (HFCs), therefore, these compounds are not included in the GHG assessment.

The Project is anticipated to include sources that produce GHGs during construction and operation phases. It is assumed that more GHG sources will be present during the construction phase than the closure phase. Therefore, the assessment for construction phase is used as a representative estimation for the closure phase since the activities at the closure phase yet to be clear right now.

The emissions estimation methods used to quantify annual GHGs follow internationally accepted practices for conducting ESIAs and, where applicable, the Regulation on Monitoring Greenhouse Gas Emissions.

GHGs have the potential to affect future climate as they contribute to the greenhouse effect by absorbing longwave radiation, emitted by the Earth, in the atmosphere, increasing temperature and changing weather patterns. There is a potential for the Project activities to release GHG emissions that could contribute incrementally to climate change.

GHG emissions are expressed as tonnes of equivalent CO_2, calculated by multiplying the annual emissions of each indicator compound by its 100-year global warming potential (GWP). A single measure is used when evaluating effects, namely the maximum annual GHG emissions resulting from the Project activities in tonnes of carbon dioxide equivalent (CO_2e). The maximum annual GHG emissions from the Project activities will put in context of the annual GHGs at both a national and global level.

The GHG Protocol provided by the World Business Council for Sustainable Development/World Resources Institute (WBCSD/WRI, 2004) outlines guidance for preparing corporate GHG emission inventories and introduces the concept of direct and indirect emissions and scopes for the inventory. Given the nature of the Project operations, the most significant emissions will be Scope 1, which are direct GHG emissions occurring from Stationary Sources, Mobile Sources that are owned or controlled by the TP-OTC (e.g., emissions from combustion in vehicles, and fugitive emissions).

GHG emissions are assessed based on Project schedules and information provided by TP-OTC regarding to amounts of fuel and explosive use, number of equipment/vehicles and other potential GHG sources. Scientifically accepted and well documented emission factors from the latest published Türkiye's National Inventory Report (NIR) released in 2023 under UNFCCC[14] are used. Where local guidance is not available then emission factors from the Intergovernmental Panel on Climate Change (IPCC), are also used. A discussion of the global warming potentials is provided by Section below. Table 7-40 provides a summary of the activities for which GHG emissions are calculated.

Table 7-40: GHG Emissions Calculation Summary

Phase	Source	GHG Emissions
Construction	Vehicles & generator (onshore) - Combustion of Diesel Oil	On-site vehicle emissions, due to diesel combustion
	Electricity Consumption	Indirect emissions due to used electricity in camp sites
	Heating center - Combustion of LNG	Emissions from the boilers
	Vessel (offshore) – combustion of marine gas oil	Emissions from vessels
Operation	Vessel (offshore) – combustion of marine gas oil	Emissions from the generator
	Air transport with helicopter – combustion of jet fuel	Emissions from helicopter
	Fuel gas consumption in boilers and gas turbines (on FPU)	Emissions from the boilers and gas turbines

[14] Türkiye National Inventory Report (NIR) for UNFCCC, 2023, https://unfccc.int/documents/627786

Phase	Source	GHG Emissions
	Diesel consumption in emergency system (on FPU)	Emissions from the generators and fire water pumps
	Flare (on FPU)	Emissions from flaring activity
	Fugitive emissions from connection equipment (both on FPU and phase-2 pipeline in onshore)	Emission from valves and flanges

Global Warming Potential

Emissions from CO_2, CH_4 and N_2O are converted to equivalent CO_2 (CO_2e). The GHG emissions are expressed as tonnes of CO_2e by multiplying the annual emissions of each GHG by its 100-year global warming potential (GWP). The GWP of each gas represents the ability of the gas to trap heat in the atmosphere in comparison to CO_2.

The GWPs are taken from the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines for the preparation of GHG inventory reports (UNFCCC, 2014), which represents the values used to prepare the national and global emissions inventories referenced in the main report. Table **7-41** provides the GWPs used in the GHG calculations.

Table 7-41: Global Warming Potentials from the Intergovernmental Panel on Climate Change

GHG Compound	GWP
CO_2	1
CH_4	25
N_2O	298

Scope 1: Direct GHG Emissions

The Greenhouse Gas Protocol (GHG Protocol) provided by the World Business Council for Sustainable Development/World Resources Institute (WBCSD/WRI, 2004) outlines guidance for preparing corporate GHG emission inventories and introduces the concept of direct and indirect emissions and scopes for the inventory. Scope 1 accounts for direct GHG emissions from sources that are owned or controlled by the Project Owner.

Stationary Combustion

Stationary combustion sources for the Project include gas turbines, boilers, diesel generators, flare. GHG Emissions from Project is determined based on the fuel consumption, and maximum annual usage time of each source, as provided by TP-OTC.

The emission factors on an energy basis are obtained from the IPCC 2006 Guidelines (Volume 2), Chapter 2 – Stationary Combustion Table 2.2. These emission factors are presented in Table 7-42 below.

Table 7-42: Stationary Combustion - Energy-based Emission Factors and Net Calorific Value

Phase	Source	Net Calorific Value (TJ/Gg)	Reference	Emission Factor (kg GHG/TJ)			Reference	Fuel Density (kg/m³)
				CO_2	CH_4	N_2O		
Construction	Use of Generators - Combustion of Diesel Oil	40.4	Turkish Notification on Monitoring and Reporting of GHG Emissions (Official Gazette Date/Number: 22.07.2014/29068), Table 5.1	74,100	3.0	0.6	IPCC 2006 guidelines, Chapter 2 – Stationary Combustion Table 2.3	832*
Construction	Operation of heating center - Combustion of LNG	44.4		64,200	3.0	0.6	IPCC 2006 guidelines, Chapter 2 – Stationary Combustion Table 2.2	-
Operation	Flare – Combustion of natural gas	48		56,100	1.0	0.1	IPCC 2006 guidelines, Chapter 2 – Stationary Combustion Table 2.2	840**
Operation	Operation of FPU main units and electricity generation - Combustion of Fuel Gas	48		56,100	1.0	0.1	IPCC 2006 guidelines, Chapter 2 – Stationary Combustion Table 2.2	840**

* Density of diesel oil is specified as 820 - 845 kg/m³ (15 °C) in Safety Data Sheet of Turkish Petroleum Corporation. Average of the upper and lower limit values is calculated.
** Supplied by the TP-OTC

GHG emissions to be originated from the emergency systems were provided by the TP-OTC.

The equations for calculating the volume-based emission factors for CO_2, CH_4 and N_2O are the same as those presented below Section.

Mobile Fuel Consumption

The GHG emissions from mobile equipment to be used during the construction phase of the Project, are calculated based on fuel consumption and fuel-specific emission factors on an energy basis from the IPCC 2006 Guidelines (Volume 2), Chapter 3 – Mobile Combustion Table 3.3.1 and related 2019 Refinement. These emission factors are presented in Table **7-43** below.

Table 7-43: Mobile Combustion - Energy-based Emission Factors and Net Calorific Value

Phase	Source	Net Calorific Value (TJ/Gg)	Reference	Emission Factor (kg GHG/TJ)			Reference	Fuel Density (kg/m^3)*
				CO_2	CH_4	N_2O		
Construction	Vehicles - Combustion of Diesel Oil	40.4	Turkish Notification on Monitoring and Reporting of GHG Emissions (Official Gazette Date/Number: 22.07.2014/29068), Table 5.1	74,100	4.15	28.6	IPCC 2006 guidelines, Chapter 3 – Mobile Combustion Table 3.3.1	832
Construction	Vessel - Combustion of Marine Gas Oil	43	Turkish Notification on Monitoring and Reporting of GHG Emissions (Official Gazette Date/Number: 22.07.2014/29068), Table 5.1	74,100	7.0	2.0	IPCC 2006 guidelines, Chapter 3 – Mobile Combustion Table 3.5.2, Table 3.5.3	860**
Operation	Vessel - Combustion of Marine Gas Oil	43	Turkish Notification on Monitoring and Reporting of GHG Emissions (Official Gazette Date/Number: 22.07.2014/29068), Table 5.1	74,100	7.0	2.0	IPCC 2006 guidelines, Chapter 3 – Mobile Combustion Table 3.5.2, Table 3.5.3	860**
Operation	Operation of Helicopter - Combustion of Jet fuel	44.3	IPCC 2006 guidelines, Chapter 1 – Table 1.2	71,500	0.5	2	IPCC 2006 guidelines, Chapter 3 – Mobile Combustion Table 3.6.4, Table 3.6.5	

* Density of diesel oil is specified as 820 - 845 kg/m³ (15 °C) in Safety Data Sheet of Turkish Petroleum Corporation. Average of the upper and lower limit values is calculated.
** Supplied by the TP-OTC

A sample equation provided below presents the methods for calculating the volume-based emission factors (EF) for CO_2, CH_4 and N_2O:

CO_2 Emission Factor:

$$EF_{CO_2}\left(\frac{kg\ CO_2}{L}\right) = \text{Energy based EF}\left(\frac{\text{t CO}_2}{\text{TJ}}\right) \times \text{Net Calorific Value}\left(\frac{\text{TJ}}{\text{kT}}\right) \times \text{Density of Diesel}\left(\frac{\text{kg}}{\text{m}^3}\right) \times \frac{1{,}000\ \text{kg CO}_2}{1\ \text{t CO}_2} \times \frac{1\ \text{kT}}{1{,}000{,}000\ \text{kg}} \times \frac{1\ m^3}{1{,}000\ \text{L}}$$

Total CO_2 Emissions from Mobile Equipment:

$$E_{CO_2} = \text{Fuel Combustion}\left(\frac{\text{L}}{\text{yr}}\right) \times \text{Emission Factor}\left(\frac{\text{kg CO}_2}{\text{L}}\right) \times \frac{1\ \text{tonne}}{1{,}000\ \text{kg}}$$

Scope 2: Indirect GHG Emissions

Scope 2 emissions are 'indirect' GHG emissions associated with the Project that are a consequence of the activities of the company but occur at sources owned or controlled by another company.

Scope 2 accounts indirect GHG emissions from the generation of purchased electricity, heat or steam consumed by the company.

Electricity Consumption

The Scope 2-Indirect GHG emissions are expected to be from electricity consumption. For the emission factor of electricity consumption, Turkish National Electricity Grid Emission Factor (0.7279 t CO_2/MWh) calculated by the Turkish Ministry of Energy and Natural Resources is used. The equation for calculating the indirect GHG emissions due to the electricity purchased is given below.

$$E_{CO_2} = \sum_i E_i * EF$$

Where;

E_{CO2}: Total indirect CO_2 Emissions due to electricity consumption (t CO_2),

E_i: Use of electricity for each activity (MWh),

EF_i: National Electricity Grid Emission Factor (t CO_2/MWh),

i: Activity that consumes electricity.

7.1.6.3 Construction Phase

Stationary Combustion Emissions

During the construction phase of the Project, Stationary Combustion GHG emissions will be generated from:

- Combustion of diesel fuel due to use of generators during construction works and
- Combustion of LNG due to boilers/heaters for the workers' campsites.

During the construction phase of the Project, one generator will be used for landfall construction works and boilers will be operated for heating purposes. Diesel fuel will be use in the generator with a consumption rate of 26,600 lt/year and LNG will be used in boilers/heaters with a consumption rate of 834751 kg/year.

The total Stationary Combustion GHG Emissions were calculated using the equations defined in above sections. The yearly GHG emissions due to Stationary Combustion were calculated as 2,444.6 tonne CO_2/year.

Mobile Combustion Emissions

During the construction phase of the Project, Mobile Combustion GHG emissions will be due to the use of on-road and off-road vehicles, machinery and equipment. The fuel that will be used for machinery, vehicles and equipment will be diesel. Moreover, for the offshore part of the construction works, marine vessels will be operated which will use marine gas oil (MGO) as fuel. The total estimated diesel consumption in the onshore part of the construction works is given by the TP-OTC as 153,155 liters/year due to use of mobile vehicles. Moreover, the annual total amount of MGO is calculated based on the information given by the TP-OTC as 77,268 tonnes/year. Then the total Mobile Combustion GHG Emissions were calculated using the equations defined in the above section as 249,186.6 tonne CO_2/year.

Electricity Consumption

During the construction phase, electricity will be utilized. According to the information provided by the TP-OTC, total of 18218.1 MWh electricity will be used during the construction phase in the onshore part. Using the emission factor and the formula defined in the above section, the yearly GHG emission originated from the electricity utilization during the construction phase was calculated as 13,260.9 tonne CO_2/year.

Total GHG Emissions in Construction Phase

The annual GHG emissions for construction phase of the Project are presented in Table **7-44**. These annual emissions are calculated for the maximum construction scenario described above. They are based on rough estimates and may significantly overestimate the actual emissions.

Table 7-44: Annual Project GHG Emissions for Construction Phase

Source	Calculated GHG (as t CO_2e/y)			Total GHG amount	
	t CO_2/y	t CH_4/y	t N_2O/y	t CO_2e/year	Percentage (%)
Vehicles (onshore) - Combustion of Diesel Oil	381.5	0.5	43.9	425.9	0.16
Electricity Consumption	13,260.9	-	-	13,260.9	5.01
Heating center - Combustion of LNG	2,368.7	2.8	6.6	2,378.1	0.90
Vessel (offshore) – combustion of marine gas oil	246,199.0	581.4	1,980.2	248,760.7	93.91
Generator (onshore) - Combustion of Diesel Oil	66.3	0.1	0.2	66.5	0.03
TOTAL				264,892.1	100.00

The table above presents the annual emissions from the construction phase, with contribution of each source to the overall GHG emissions of the Project. Tonnes of CO_2e are calculated using the GWPs defined in the calculation methodology section.

Table 7-45: Comparison of Project GHG Emissions to National and Global Emissions

Source	Construction
Project GHG Emissions (tonnes CO_2e/year)	264,892.1
Comparison to Türkiye-wide Total (%)	0.0474%
Comparison to Global Total (%)	0.0014%
Türkiye-wide GHG Emissions (2021)[15] (tonnes CO_2e/year)	**558,270,482**

[15] Obtained from TURKSTAT, Türkiye 2021 National Inventory Report (NIR) for UNFCCC

Source	Construction
UNFCCC Annex-I 2021 GHG Emissions[16] (tonnes CO_2e/year)	**19,207,285,454**

Table 7-45 summarizes the annual overall emissions in tonnes of CO_2e for the Project construction phase. Data for Türkiye's GHG releases are obtained from Türkiye's latest National Inventory Report (NIR for the year 2023) for UNFCCC and total of Annex-I countries GHG releases are obtained from UNFCCC GHG database for the last inventory year 2021. For the construction phase, regarding that the maximum calculated GHG emissions will be probably for only one year based on the pipeline construction schedule, the Project's contribution to the total emissions reported for the country level and global reporting programs is not very significant.

It is accepted that increased anthropogenic GHG emissions are contributing to climate change. However, the GHG emissions due to the Project represent unmeasurable increase in global GHG emissions. Country scale and GHG emission levels are anticipated to be maintained.

The combined annual emissions from the construction phase of the Project are about **264,892.1 t CO_2e per annum**. This annual value surpasses the 25,000 t CO_2e threshold defined in IFC PS3 and Equator Principles IV. Therefore, technically feasible and cost-effective mitigation options will be considered for marine vessels operation.

7.1.6.4 Operation Phase

Stationary Combustion Emissions

During the operation phase of the Project, Stationary Combustion GHG emissions will be generated due to the FPU operation from:

- Combustion of fuel gas in boilers and gas turbines for electricity production and continuation of FPU operations,
- Combustion of diesel in generators and fire water pumps and
- Combustion of natural gas/fuel gas due to flaring activities.

During the operation phase of the Project, electricity and steam will be generated at gas turbines and boilers for FPU operations. Fuel gas will be the main source of these operations, where the consumption of fuel gas provided by the TP-OTC will be 163,803,135 m^3/year. Moreover, monthly one-time flaring could be required for the flare operation. According to information given by the TP-OTC that a total of 5,267,520 m^3/year fuel will be flared. During the operation phase, generators will be used in case needed. Diesel fuel will be the main source for the operation of these generators and emergency fire water pumps system. The total annual CO_2 emission provided by the TP-OTC is 69 tonne/year. Then the total Stationary Combustion GHG Emissions were calculated using the equations given in the calculation methodology section. The yearly GHG emissions due to Stationary Combustion were calculated as 364,644.8.1 tonne CO_2/year.

Mobile Combustion Emissions

During the operation phase of the Project, Mobile Combustion GHG emissions will be due to the use of marine vessel (PSVs) for support of the FPU operations and operation of helicopter. It is mentioned by the TP-OTC

[16] Obtained from UNFCCC GHG database, https://di.unfccc.int/time_series

that PSV's will be operated for three times a week and helicopter will be operated for 4 times a week. The fuel that will be used for PSVs will be marine gas oil (MGO) while it is Jet fuel (namely JET A1) for helicopter operations. The annual estimated MGO consumption is given by the TP-OTC as 1,782 tonne/year while the consumption of JET A1 will be 244,363 liters/year. Then the total Mobile Combustion GHG Emissions were calculated using the equations defined in the above sections as 6,364.7 tonne CO_2/year.

Fugitive Emissions

Fugitive emissions includes emissions associated with venting emissions (blowdown vent emissions), emissions from equipment leaks (including metering stations, pipeline mains, service lines, and damage events) and other fugitive sources. Onshore and offshore fugitive emissions have been estimated by use of the emission factors provided in Annex 12 of the Regulation on Control of Industrial Air Pollution. The estimated fugitive VOC emissions from the connection equipment are supposed to be formed mainly by methane emissions. Global warming potential of methane has taken into consideration while calculating GHG emissions from fugitive sources. The annual estimated GHG emissions due to fugitive sources were calculated as 6,089.65 tonne CO_2/year.

Table 7-46: Annual Estimated GHG Emissions due to Fugitive Sources

Part	Equipment Type	Service	Emisison Factor (kg/h.source)	Number of Onshore Equipment (for Phase 2)	Estimated VOC Emission (kg/h)	Ton/year CO_2/year
ONSHORE	Valve	Gas	0.0045	345	1.5525	339.9975
		Light Oil	0.0025	57	0.1425	31.2075
	Flange	Gas	0.00039	951	0.37089	81.22491
		Light Oil	0.00011	185	0.02035	4.45665
	Open-Ended Lines*	Gas	0.002	3	0.006	1.314
	Pressure Relief Devices	Gas	0.0002	37	0.0074	1.6206
	Compressor	Gas	0.0088	2	0.0176	3.8544
OFFSHORE (FPU)	Valve	Gas	0.0045	2760	12.42	2,719.98
		Light Oil	0.0025	4197	10.4925	2,297.858
	Pump	Light Oil	0.013	139	1.807	395.733
	Flange	Gas	0.00039	2099	0.81861	179.2756
		Light Oil	0.00011	4068	0.44748	97.99812
	Open-Ended Lines*	Gas	0.002	32	0.064	14.016
	Pressure Relief Devices	Gas	0.0002	213	0.0426	9.3294
		Light Oil	0.00021	87	0.01827	4.00113

Part	Equipment Type	Service	Emisison Factor (kg/h.source)	Number of Onshore Equipment (for Phase 2)	Estimated VOC Emission (kg/h)	Ton/year CO_2/year
	Compressor	Gas	0.0088	3	0.0264	5.7816
					TOTAL	6,089.65

Total GHG Emissions in Operation Phase

The annual GHG emissions for operation phase of the Project are presented in Table **7-47**. These annual emissions are calculated for the operation phase described above. They are based on rough estimates and may overestimate the actual emissions.

Table 7-47: Annual Project GHG Emissions for Operation Phase

Source	Calculated GHG (as t CO_2e/y)			Total GHG amount	
	t CO_2/y	t CH_4/y	t N_2O/y	t CO_2e/year	Percentage (%)
Stationary Sources (Boilers and Gas Turbines) - Combustion of Fuel Gas	352,872.6	157.3	187.4	353,217.3	93.8
Stationary Sources (Flare) - Combustion of Fuel Gas	11,347.5	5.1	6.0	11,358.5	3.0
Stationary Sources (Generators and fire water pumps) - Combustion of Diesel Oil	69			69	0.02
Mobile Sources (Helicopter Operations) – Combustion of JET A1	622.3	0.1	5.2	627.6	0.2
Mobile Sources (Marine Vessel) – Combustion of MGO	5,678.0	13.4	45.7	5.737.1	1.5
Fugitive Emissions of VOC	-	6,089.65	-	6,089.65	1.6
TOTAL				376,471.5	100.00

The table above presents the annual emissions from the operation phase, with contribution of each source to the overall GHG emissions of the Project. Tonnes of CO_2e are calculated using the GWPs from Section above.

Table 7-48: Comparison of Project GHG Emissions to National and Global Emissions

Source	Operation
Project GHG Emissions (tonnes CO_2e/year)	376,471.5
Comparison to Türkiye-wide Total (%)	0.0674%
Comparison to Global Total (%)	0.0019%

Source	Operation
Turkiye-wide GHG Emissions (2019)[17] (tonnes CO_2e/year)	**558,270,482**
UNFCCC Annex-I 2019 GHG Emissions[18] (tonnes CO_2e/year)	**19,207,285,454**

Table **7-47** summarizes the annual overall emissions in tonnes of CO_2e for the Project operation phase. Data for Türkiye's GHG releases are obtained from Türkiye's latest National Inventory Report (NIR for the year 2023) for UNFCCC and total of Annex-I countries GHG releases are obtained from UNFCCC GHG database for the last inventory year 2021. For the operation phase, regarding the GHG emissions, the Project's contribution to the total emissions reported for the country level and global reporting programs is not significant.

It is accepted that increased anthropogenic GHG emissions are contributing to climate change. However, the GHG emissions due to the Project represent unmeasurable increase in global GHG emissions. Country scale and global greenhouse gas emission levels are anticipated to be maintained.

The combined annual emissions from the operation phase of the Project are **371,009.5 t (371 kt) CO_2e per annum**. The emissions from the Project are estimated to be above 100 kt CO_2e annually. EP4 required projects with emissions above 100 kt CO_2e annually to conduct an alternatives assessment to identify the best practicable environmental options and consideration of alternative fuel or energy sources that were considered for the project. An alternatives assessment has been conducted for the Project and has been summarized in Chapter 4.

Mitigation Measures

The annual GHG emissions calculations for the construction and operation phases of Project are presented in the sections above. These annual emissions are based on the approximate data and preliminary estimations provided by TP-OTC. Therefore, these calculations may be significantly underestimated or overestimated compared to the actual emissions. Considering these approximations, GHG emission calculations for construction and operation phases will be conducted again once the actual consumption amounts, and design parameters are known.

Project resource efficiency and GHG emissions will be managed in accordance with the Resource Efficiency and Pollution Prevention Plan, and Air Quality Management Plan to be prepared for the Project.

As stated above, the Project's contribution to national and global GHG emissions and climate change is not significant since both the annual and total emissions are not high compared to Turkish and Global GHG emissions. Since the annual GHG emissions for the construction phase of the Project are above the threshold value defined in IFC PS3 and Equator Principles IV, GHG emissions that arise from the construction phase of the Project will be quantified and reported publicly on an annual basis.

In addition, the following measures will be applied to reduce GHG emissions and increase resource efficiency as much as possible:

[17] Obtained from TURKSTAT, Türkiye 2021 National Inventory Report (NIR) for UNFCCC

[18] Obtained from UNFCCC GHG database, https://di.unfccc.int/time_series

- The Best Available Techniques w be taken into consideration in Project design as much as possible. The applicability of the Best Available Techniques (BATs) developed within the European regulatory framework [i.e., Integrated Pollution Prevention and Control, "IPPC", BAT Reference Documents (BREFs) according to the European Directive 2010/75/EU (IED)] will be evaluated and integrated into the Project design.
- All employees will be provided climate, resource and energy efficiency awareness training.
- The most efficient equipment in terms of fuel usage and effective operation will be chosen. Maintenance of all machinery and equipment will be periodically conducted to ensure efficient fuel use and effective operation as well.
- Efficient resource and material use will be promoted through the development and implementation of a Resource Efficiency and Pollution Prevention Plan to reduce direct and indirect GHG emissions due to the Project. Other aspects of resource efficiency regarding water usage are covered in Project Description and related impact assessment section.
- No idling and out-of-scope operation of the machinery and equipment will be allowed.
- During the closure phase, rehabilitation of land will help to recover lost carbon sink by converting the disturbed land to its original state as much as possible, which will act as a long-term mitigation measure.
- Green Energy Certificate which indicates that a certain amount or entire electricity used by the Project comes from renewable energy sources, will be obtained in order to induce a decrease in Scope 2 related GHG emissions which is linked to the construction and operation phases of the Project.

Monitoring

The GHG emitting activities identified in this Report will be monitored for reporting and verifying of GHG emissions of the Project during construction and operation period.

For each monitoring activity and measure/action identified, the table shows:

- The reference (or source) documents (i.e., ESIA, Turkish standard, permits, IFC Performance Standards and EHS Guidelines or other GIIP);
- Frequency/timing of the measurement,
- The Key Performance Indicator (KPI), and related quantitative target (if the target consists of a regulatory limit this will also be indicated); and,
- The related responsible party for implementing the related monitoring activity