CONSULTANCY SERVICES FOR RIVER BASIN MANAGEMENT

REF: 11EKA/D65/ACS/BRT/PRG/18-07-2022

GHADIR RIVER BASIN

FINAL REPORT

JUNE 2023

HawkaMaa - EU
حوكماء - الإتحاد الأوروبي
Funded by the European Union
بتمويل من الاتحاد الأوروبي

To cite this document:

ACTED, WeWorld-GVC, & BTD. (2023). Consultancy Services for River Basin Management: Ghadir River Basin Final Report, Beirut Lebanon.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AMSL	Above Mean Sea level
BGL	Below Ground level
BMLWE	Beirut and Mount Lebanon Water Establishment
CAPEX	Capital Expenditure
CDR	Council for Development and Reconstruction
CSO	Civil Society Organizations
DMA	District Metered Area
GBWSAP	Greater Beirut Water Supply Augmentation Project
GRB	Ghadir River Basin
IWRM	Integrated Water Resources Management
LULC	LandUse and LandCover
MEW	Ministry of Energy and Water
Mm^3	Million cubic meters
MCM	Million Cubic Meter
MoA	Ministry of Agriculture
MoE	Ministry of Environment
NA	Not Available/Applicable
NDU	Notre Dame University
NGO	Non-Governmental Organization
NWSS	National Water Sector Strategy
OPEX	Operating Expense
PoM	Programme of Measures
PS	Pumping Station
RBM	River Basin Management
SDG	Sustainable Development Goal
TDS	Total Dissolved Solids
USD	United States Dollar
WEAP	Water Evaluation And Planning
WHO	World Health Organization
WRMM	Water Resources Management Model
WTP	Water treatment Plant
WWTP	Wastewater Treatment Plant

1 Background

1.1 Project Description

This is the second report on the water resources management of Ghadir River Basin (GRB) located in the upstream southern region of Beirut. The baseline report involved a comprehensive assessment of the water and environmental resources of GRB from 2000 to 2020, focusing on both quantitative and qualitative aspects.

To facilitate this assessment, we developed a detailed Water Resources Management Model using node-based distributed water balance modeling through the Water Evaluation and Planning (WEAP) software. The assessment provides insights into the water availability, water demand, water supply, and unmet demand (per sector) in the basin over the past two decades. Additionally, it includes an evaluation of the current state of surface water pollution based on a recent field survey and water sampling.

Our work is part of the larger project "CONSULTANCY FOR RIVER BASIN MANAGEMENT FOR AL ASSI BASIN/BEKAA, GHADIR BASIN/BEIRUT AND MOUNT LEBANON, NAHR AL OSTUAN BASIN/AKKAR," which is funded by the EU MADAD program and conducted in collaboration with the HAWKAMAA-EU Consortium partners.

The purpose of the project is to support effective multi-stakeholder decision making and action through water balance modeling to improve the conservation and management of water resources in the basin and maximize the economic, environmental and social benefits. The broader objective is to improve water management in selected river basins by implementing a range of demand management measures which can alleviate water stress, increase water availability and network efficiency while decreasing losses.

In addition to addressing water quantity issues, our work also focuses on assessing the current pollution levels in the river. This assessment serves as a call to action for the local community and stakeholders, urging them to take steps to reduce pollution in the basin and mitigate the existing problem.

The project promotes an inclusive participatory approach, not only by disseminating the results and outputs to the various target groups, but by also involving them in the consultation process.

Thus far, the following activities have been concluded in preparation of the final report:

- Second sampling campaign and laboratory analysis of water samples from 5 sampling sites along GRB for the winter season conducted on March 22nd, 2023.
- Second participatory workshop with the stakeholders on June 2nd, 2023 at ESA, Beirut.
- Drafting of the second and final report on the assessment of the water resources demand in GRB, based on the outputs of the WEAP model including the simulation of future scenarios, and selected water demand measures.

1.2 Link to NWSS

The Ministry of Energy and Water (MoEW) prepared and adopted the Lebanese National Water Sector Strategy (NWSS) in 2010 which was endorsed by the Government of Lebanon in 2012 (Resolution No.2, Date 09/03/2012). Seven years later, in 2019, the MoEW decided to review what has been realized from the original roadmaps and to update the water and wastewater strategies of 2012 by setting a detailed action plan to implement reforms and create a hydrogeological data management system and improve service coverage. The Updated NWSS 2020 merges the National Water and Wastewater strategies of 2012 into one consolidated strategy. It maintains the main strategic principles of the water policies adopted by the Government of Lebanon in 2012, but reassesses the set priorities in light of today's actual context, and sets the ground for the period extending between 2020 and 2035.

It takes into account the adopted Water Code (law 192/2020) and its structuring principles, which are in turn in line with the water sector organizing Law 221/2000 and its amendments, as well as studies and projects completed between 2012 and 2021 in the fields of potable water, wastewater and irrigation, and management initiatives implemented during the same period. The newly ratified Water Code includes several Integrated Water Resources Management (IWRM) implementation principles and aims to regulate, develop, rationalize, and exploit water resources, protect them from depletion and pollution and improve the efficiency of transport, distribution, and maintenance systems for the operation of water installations to ensure the sustainable management of the Lebanese natural water resources.

As per the water code, the Ministry aims at achieving a financially sustainable sector, that is citizen-centered and service oriented, and which would ultimately allow to reach an integrated approach of the water sector.

The updated strategy can be considered as a shift into practical, implementable plans, projects and governance initiatives that set the ground to move towards the UN's Sustainable Development Goal SDG 6 and realize the principles of an IWRM. While doing so, the updated NWSS 2020 targets as well SDG 2 (Zero Hunger), SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), SDG 14 (Life below Water), SDG 15 (Life on Land) and SDG 17 (Partnerships for Goals); these will be explored throughout the document.

Based on the United Nations' SDG 6, the MoEW aims at providing safe, equitable and affordable water and wastewater services to all, and to properly allocate water resources to the different economic sectors (agriculture, industry, tourism, services, etc..) based on the priorities of the Government's recovery plan.

These commitments are translated by strengthening the IWRM through targeted proposed projects and improved governance at the basin level, thus the river basin management studies of Al Assi, Ghadir and Al Ostuan. The proposed projects for the water systems within Ghadir River Basin are included in Section 5.3 and incorporated in the simulation.

1.3 Methodology

The assessment of the future water resources management situation in GRB was carried out following the below methodology:

1- Second water quality sampling campaign in coordination with NDU water laboratory, carried out on March 22nd, 2023. The lab report is attached in Appendix A.

2- Development of future water demand and climatic scenarios.

3- Suggestion and design of future demand management measures.

4- Simulation of the selected future scenario using the WEAP model developed in the baseline phase to assess the future situation of the water resources management within the basin.

5- Suggestion of policy relevant targets, Programme of Measures (PoM) and Action Plan based on WEAP model output and in coordination with the outcome of the participatory workshop involving local stakeholders with the purpose of improving the conservation and management of the river basin and optimize the economic, environmental, and social benefits of GRB.

6- Drafting of the Final Report based on the overall project area description and the outputs of the WEAP model, including a water quality assessment and the outputs of the field survey and sampling campaign.

2 Second Water Quality Sampling Campaign

2.1 Description

A sampling campaign for water quality check was carried out on the 22nd of March 2023 by NDU Laboratory team in coordination with BTD and Acted. This section will only present a brief summary of the campaign including main results. The complete report is attached in Appendix A.

This second campaign was made over the wet season to show compliance with established criteria.

The sampling plan and location were prepared in a way to guarantee representative samples, thus providing an accurate description of the overall quality of the water in GRB.

Furthermore, sampling sites were located in areas that are safe to access, accessible under all conditions of flow, and well mixed to ensure a homogenous sampling collected is easily identifiable for later sampling.

Permanent sampling locations were chosen by BTD to ensure that representative samples can be compared over time. However, to ensure the total number of samples was kept within the scope of the project and as per the contract description, point 4 was removed from the second campaign as it was limited to 5 samples and samples were already taken upstream and downstream that location.

Table 1 and Figure 1 show the coordinates and Name of the points chosen for sampling in Ghadir River. Figure 2 shows the sampling location at point 1 Jeser el Aramel.

Table 1 Coordinates and location of the chosen points for sampling

ID	Name	Latitude	Longitude	Altitude
1	Jeser Al Aramel	33.81853	35.51131	23
2	Aser Zaaiter	33.82323	35.52477	48
3	Wadi chahrour/ sofla	33.82099	35.54734	90
4	Kfarchima-Lecico	-	-	-
5	Tiro-Airport	33.81952	35.50077	14
6	Costa Brava Beach	33.80324	35.48022	0

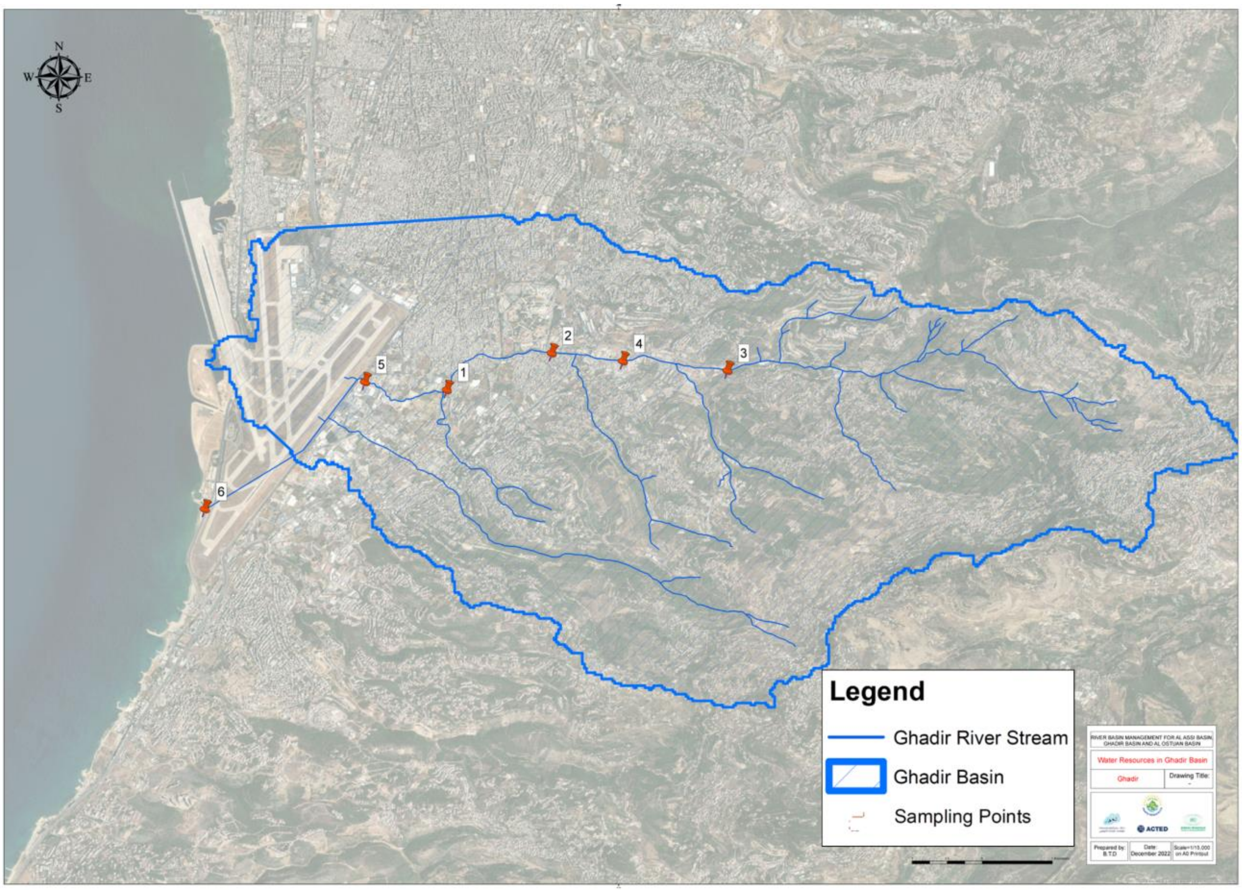


Figure 1 Water quality sampling sites location

Figure 2 Sampling Location 1 at Jeser el Aramel

2.2 Results

Below is a summary of all the results got from testing Ghadir river (Table 2). Highlighted in red are the values that exceed the WHO standards for the tested quality parameter.

Table 2 Summary of the results

Test/Point	WHO Standard for Drinking	Pt 1	Pt 2	Pt 3	Pt 5	Pt 6
Turbidity (NTU)	**<5**	111.0	92.1	20.8	40.9	2101.2
pH (pH)	**6.5-8.45**	8.2	8.5	8.4	8.2	7.9
RDO (mg/L)	**-**	8.6	8.7	9.1	6.9	3.9
S-Conductivity (µS/cm)	**1000**	602.3	498.7	594.9	1742.5	4328
Salinity (PSU)	**-**	0.3	0.3	0.3	0.9	2.3
TDS (mg/L)	**500**	399	385	387	1134	2812
TSS (ppm)	**-**	9.5	36	17	159	1796
TS (ppt)	**1500**	408	421	400	1293	4610
Temp(°C)	**24-30**	16.6	16.8	16.3	16.7	17.1
Nitrate (mg/L)	**10-50**	2.75	3.15	3.28	2.91	1.42
Lead (mg/L)	**0.01**	0.11	0.55	0.1	0.16	0.7
Cadmium (mg/L)	**0.01**	0.044	0.05	0.041	0.101	0.14
Barium (ppm)	**0.7**	2.1	2.2	2	2.4	2.6
Mercury (цg/L)	**0.06**	0.01	0.04	0.04	0.06	0.09
Sodium (ppm)	**60**	3.5	3.9	3.3	46	101
Potassium (ppm)	**12**	0.1	0.1	0.1	5	12
Lithium (ppm)	**-**	0.01	0.02	0.001	0.05	0.07
Calcium (ppm)	**100-300**	0.02	0.001	0.01	19	23
Phosphorus (mg/L)	**0.5**	<0.3	<0.3	<0.3	<0.3	<0.3
Chloride (mg/L)	**100-500**	20	102	17	300	360
Ammonia (mg/L)	**1.5**	5.88	3.93	2.63	16.8	2.17
Sulfate	**45**	68	62	67	122	350
Fluoride	**0.5**	0.8	0.7	0.8	0.8	0.8
DO	**Above 5**	8.7	8.7	9.1	6.2	3.9
BOD	**4**	89	95	56	142	214
COD	**0.5**	124	132	79	188	290
Total Coliform	**0**	55	111	121	122	142
Fecal	**0**	20	32	34	39	46
Ecoli	**0**	11	19	27	29	30

2.3 Discussion

Water samples were collected from Ghadir River during the wet season and tested for physical qualities, chemical contents, and microbiological counts. Six sampling points were selected. Water quality parameters, such as conductivity, DO, BOD, COD, pH, TS, DS, and Fecal Coliform were analyzed. The concentration of lead, cadmium, mercury, barium, lithium, sodium, potassium, chloride, sulfate, fluoride, ammonia, phosphorus, and nitrate was also analyzed at all the points. The examination of the results is shown below:

Measuring **Dissolved Oxygen** (**DO**) in drinking water is an important property of water quality. DO is critical for fish and other aquatic organisms to survive. DO values for Al-Ghadir river, along our reach varied between 3.9 mg/L to 8.7 mg/L. WHO standard for sustaining aquatic life is <4 mg/L, whereas for drinking purposes it is 6 to 8.5 mg/L. Therefore, all the examined points are not suitable for aquatic life. The DO has increased and improved considerably after the rainfalls in the season and increased as they were very low and not suitable for aquatic life in report 1 (<1mg/L), during the dry season. The rainwater has improved the quality of the river in terms of DO. Low levels of oxygen (hypoxia) or no oxygen levels (anoxia) means that there are excess organic materials, such as large algal blooms, that are decomposed by microorganisms in the studied river.

While in the case of **Biological Oxygen Demand (BOD)** concentration, the results recorded values ranging from 56 mg/L at point 3 to 214 mg/L at point 6. Most rivers have BOD_5 below 1 mg/L. Moderately polluted rivers may have a BOD_5 value in the range of 2 to 8 mg/L. High BOD_5 levels (>8mg/L) can be a result of high levels of organic pollution, caused usually by poorly treated wastewater, or from high nitrate levels (EEA, 2001). WHO standard for surface water is 25 mg/L, which is exceeded to a great extent as shown by the values in Table 10. High BOD_5 values were detected at all sites which may be attributed to high levels of Nitrates and phosphates. These high values indicate that sewage or industrial wastewater is penetrating Al-Ghadir river. High biochemical oxygen demand can be caused by high levels of organic pollution, caused usually by poorly treated wastewater or non-treated wastewater penetrating the river; high nitrate levels, which trigger high plant growth. Both result in higher amounts of organic matter in the river. Notwithstanding the above, it is important to mention that BOD has decreased considerably after the rain fall as it ranged between 356 mg/L and 622 mg/L in the dry season indicating the rainfalls improved the quality of the water in terms of BOD but the water at al Ghadir river still needs a long road of treatment and attention before being suitable to be used for agriculture in terms of BOD.

Chemical Oxygen Demand (**COD**) is another important parameter of water quality assessment. A standard for surface purposes is 125 mg/L, which is exceeded for most sites in the studied river. Table 10 shows the COD data of five sampling points. The highest levels of COD recorded (280mg/L at point 6) may be also attributed to raw sewage discharge, and for the same reasons stated in the BOD examination. COD was diminished at all sites after the rainfall and has reached a value of 79mg/L as point 3.

Concerning the **pH** which is an indicator of the acidic or alkaline condition of water status, the standard for any purpose is 6.5-8.5, in that respect; the values of our sampled water conform with the standards because the values vary between 7.9 and 8.4. All sites exhibited values of pH within the limits of the natural values that support aquatic life.

Adding to the above, the value of **electric conductivity** (**EC**) of Al-Ghadir river varied between 498 and 4328 µs/cm. Conductivity depends on the number of ions present in water. The conductivity is high for points 5 and 6and exceeded the acceptable standards for rivers and surface water (< 1500 µs). A main observation from the results is that conductivity is directly influenced by TDS, the higher the TDS the higher the EC (Lawson, 2011).

Likewise, **total solids concentrations** concentrations in the wet season varied between a minimum of 400 mg/L at point 3 and a maximum of 4610 mg/L at point 6. Many factors contribute to high levels of total solids in water, with soil erosion being a major contributor. An increase in the water volume due to rainfall have decreased the amount of total solids at all the point between the two seasons.

Concerning **Dissolved Solids (DS)**, the standard for drinking water is 500 mg/L. The minimum and maximum values obtained from the samples in the wet season are 382 at point 2 mg/L and 2812 mg/L at point 6. In this respect, we can conclude that Al-Ghadir river water quality is not acceptable. High levels of TDS at some points are caused by the presence of potassium, chlorides, and sodium and by toxic ions (lead arsenic, cadmium, and nitrate), and result in an undesirable taste that could be salty, bitter, or metallic, discolour the water, and create an unpleasant odour. (Lawson, 2011).

Similarly, the WHO standard for **ammonia** in surface water is 1.5 mg/L. The results yielded from the test results showed higher values for all the sites reaching 16.8 mg/L at point 5, which means it is very dangerous in terms of ammonia pollution. Yet these results are way lower than those detected before the rainfall. These high levels of ammonia might be attributed to agricultural runoff in addition to raw sewage discharge. Likewise, ammonia peak might be associated with a nutrient influx in streams with little to no flow and low DO content (Ryan et al. 2002). Ammonia levels above the recommended limits may harm the whole aquatic life. Ammonia toxicity is thought to be one of the main causes of unexplained losses in fish hatcheries. Excess ammonia may accumulate in the organism and cause an alteration of metabolism or increases in body ph. Adversely, the levels of **nitrate** exhibited a similar fluctuation among the sites ranging all within the acceptable levels (5 mg/l).

Apart from the above, we have traced metal detection in the water. These chemicals are classified as being potentially hazardous and toxic to most forms of life. Results reported that trace metals' concentrations for **lead, mercury, and cadmium** were very high at all points and mostly elevated at points 5, and 6. It is important to mention that cadmium levels are above the acceptable ranges for agricultural use at all sites. The above results imply that the river is receiving cadmium and lead from the direct discharge of industrial wastes directly into the river. The elevated concentration of these toxic compounds in the water can be detrimental to people's health. For example, even in small doses, lead exposure can cause brain and nervous system damage, while PFAS exposure is linked to cancer, thyroid disease, and other health problems.

Moreover, some of the chemical elements like **Sodium, potassium, lithium, and calcium** are essential as micronutrients for the life processes in animals and plants (Kar et al., 2008). Fortunately, acceptable concentrations were found in GRB.

Similarly, **phosphorus** concentrations recorded values less than 0.3 in the wet season. Comparing these results with WHO limits, they fall in the acceptable level of phosphorus (1mg/L) in rivers. These were reduced after the rainfall, as the values at the end of the summer season were above 2.77 mg/L .

Similarly, **chloride** concentration documented values varying from 17 at point 3 to 360 mg/L at points 6. Compared with WHO guidelines, the level of chloride at the latter sites confirms that there are industrial effluents or urban runoff at the location of the sample 5 and 6.

The **sulphate** recorded a mean value of less than 67 mg/L for sites 1,2, and 3. Compared with WHO guidelines, the results fall within the acceptable range (<200 mg/L), however at sites 6, the concentration of sulphate exceeded the acceptable level. Yet the sulphate level of all the point has decreased during the wet season. Acid drainage, fertilizer leaching from agricultural soils, wetland drainage, and agricultural and industrial wastewater runoff as well as sea level changes are the main direct and indirect sources of the anthropogenic SO42- input to AL Ghadir river.

Moreover, **fluoride** concentrations were recorded at all sites, yet no marked variation was observed (<1mg/L at all points). Acceptable values were found at all sites.

Apart from the physical and chemical parameters, the water was tested for microbiological pollutants. The results of the five sampling points show that all sites are bacteriologically contaminated to an extreme extent. Total, fecal, and E-coli were detected at all sites and were too numerous indicating the critical condition of excessive microbiological contamination. The presence of fecal coliform bacteria in very high levels indicates potential health risks to swimmers and implies the unsuitability of the water at these critical points for specific water most domestic water uses. The source of organic and microbial pollutants present in the water can be accounted for by the seepage of industrial wastewater into the river and support the presence of agricultural runoff, and animal waste, raw sewage, (Amacha et al., 2012). Several health outcomes such as gastrointestinal infections might be associated with fecally polluted water which may result in a significant burden of disease (WHO 2001). Yet at all sites, a reduction in the amount of colonid was detected at the end of the wet season.

To sum up, the results from data analysis show that, the water is certainly unfit for drinking purposes without any form of treatment. But as we know, once a trend in pollution sets in, it generally accelerates to cause greater deterioration. So, a few years from now, serious water quality deterioration could take place.

2.4 Conclusion

The water quality of Ghadir River Basin was analyzed. The physical, bacteriological, and chemical composition of the river was studied in the wet season. All sites exhibited values of pH within the limits of the natural values that support aquatic life. The levels of TDS were fluctuating among the sites with the highest values recorded at site 6 which is extremely violating the guideline and implies seawater and wastewater intrusion. Higher BOD_5 values were detected at sites 5 and 6 which may be attributed as well to seepage of industrial and raw sewage water. The levels of nitrate exhibited a clear fluctuation among the sites ranging yet falling below the limit for surface water. The estimated indices at sites 5 and 6 exhibited the worst water quality conditions among the studied sites.

WHO specifies guidelines and imperative values for drinking and aquatic life were used. This assessment was adopted as the Lebanese Ministry of Environment (MoE) Standards for surface water, do not include all of the parameters reported here.

Results revealed that the water quality of the Ghadir river is very polluted and generally affected by activities related to industrial wastes and raw sewage wastes.

3 Characterization of Ghadir Aquifer Systems

3.1 Geological conditions of Ghadir River Basin

The geological features of Lebanon were primarily described by the French geologist Louis Dubertret, who compiled a general "Geological Map of Lebanon" on 1:200,000 scale (Dubertret, 1955), as well as more detailed geological maps for specific regions at a scale of 1:50,000. The geological map of Ghadir River Basin (GRB), shown in Figure 3, was based on Dubertret's work. For this project, three geological sections (MN, OP, QR) were constructed to enhance the understanding and visualization of the study area's geological structure, as shown in Appendix C. Moreover, this appendix includes six geological sections (AB, CD, EF, GH, IJ and KL) sourced from the literature (Doummar et al., 2015). The locations of these cross sections are indicated on **Error! Reference source not found.**. The aforementioned appendix also features another geological section produced by UNDP (1970), which crosses the study area. However, this section is not marked on the geological map due to the unavailability of its exact coordinates.

The exposed geological formations within GRB range between Lower Cretaceous and Quaternary Periods. The Jurassic sequence, predominantly found to the northeast of the study area, does not outcrop within GRB. However, it is anticipated that some public wells tap this formation in the subsurface of the study area.

The Quaternary deposits, covering approximately 31% of the study area, lie unconformably over the Upper Cretaceous formations in the coastal zone. The Chekka Formation (C6) mainly consists of jointed and fissured chalky to marly limestone, alternating with marl beds. The geological cross sections found in the literature present some inconsistencies regarding the presence of C6 in the subsurface. Nevertheless, Dubertret's 1:50,000 maps depict small patches of C6 outcropping immediately west of the C4-C5 in various locations on the eastern side of Dahieh area. However, erosion might have caused the absence of C6 in certain subsurface areas. In Beirut and its vicinity, the Quaternary formation primarily comprises alluvial, beach and aeolian deposits, with a thickness ranging between 5 and 80m based on drilling data. Lithologically, the Quaternary deposits mainly consist of brown soils, (decalcified) red soils, terrigenous alluvium, sandy alluvium, argillaceous colluvium, pebbles and sands. The partial and weak cementation of these lithologies results in relatively high porosity within this unit (Ukayli, 1971).

According to the works of Ukayli (1971) and Elezian (1985), the Miocene Formation also lies unconformably over the Sannine Formation in Beirut. Hajj (1987) highlighted that the Miocene Formation has a thickness of approximately 100 meters in Choueifat area and consists of marl and marly limestone interbedded with conglomerates. This formation, found in isolated patches, covers less than 4% of GRB and has experienced weathering and erosion.

The Cretaceous sequence covers approximately 65% of the study area. Its main outcrops within GRB include the Sannine Formation (C4), Hammana Formation (C3), Abeih-Mdairej Formation (C2), and Chouf Formation (C1):

- Sannine Formation (C4) is of Cenomanian age (Walley, 1997) and can reach a thickness of up to 700 meters if not eroded (Elezian, 1985). Nader (2000) reported that, on a national scale, this formation generally becomes thinly bedded, with a high content of chalk and chert towards the coast. The C4 Formation is typically divided into three subunits: C4a, C4b and C4c (from oldest to youngest). It is stratigraphically overlain by the Turonian

Maameltain Formation (C5) and the Senonian Chekka Formation (C6) (both not exposed in the study area). The Maameltain and Sannine formations have similar lithologies and are commonly referred to as C4-C5 Formation (i.e., Sannine-Maameltain Formation).

- Hammana Formation (C3) has an approximate thickness of 125 meters according to Ghattas (1975) and generally consists of Albian dolomitic and marly limestones, with thin beds of Aptian marls at its base (Peltekian, 1980; Walley, 1997).
- Mdairej Formation (C2b), dating to the Aptian age (Walley, 1997), has a thickness of about 50 meters according to El-Kareh (1970) and is predominantly composed of massive, compact and reefal carbonate rocks (Ukayli, 1971). This formation exhibits higher porosity than C2a and is influenced by mass wasting and weathering processes (notably, rock blocks are observed on the underlying Abeih Formation) (Doummar et al., 2015).
- Abeih Formation (C2a) of Lower Aptian age has an approximate thickness of 175 meters (Doummar et al., 2015). It comprises clays and marly units at its base, transitioning into sandy limestone (Peltekian, 1980). Notably, on a national scale, the geological contact between this formation and the underlying Chouf Sandstone Formation is a gradational transitional contact (Walley, 1997).
- The Chouf Formation (C1) of Neocomian age has an approximate thickness of 175 meters. On the national scale, it is mainly composed of sandstone, argillaceous sandstone, ferruginous sandstone, clay and volcanic rocks (Dubertret, 1945, Kanaan, 1966; Walley, 1997). Doummar et al. (2015) reported that the sandstone within this formation consists of poorly sorted quartz grains that locally intercalate with clay beds or lenses.

Lastly, the Jurassic Formation represents the oldest exposed formations in Lebanon and mainly consists of limestone, dolomitic limestones, and basalts.

From a structural geology perspective, the study area lies over the west-dipping Mount Lebanon Flexure, corresponding to the hanging wall of the offshore Mount Lebanon Thrust (Elias et al., 2007). Additionally, numerous secondary faults have resulted in the disruption of geological units (as evident in the geological cross sections). Doummar et. al (2015) emphasized that deformation is partially accommodated by two fault systems in GRB: the first system comprises of E-W to ENE-WSW striking structures, while the second system consists of NW-SE striking structures. In most of the encountered rock formations within the study area, fault activity and larger-scale tectonic pressures are associated with closely spaced joints, fissures and cracks (Doummar et al., 2015). It is noteworthy that well-developed fractures generally serve as favorable pathways for groundwater flow, unless filled with fine material or subject to mineralization.

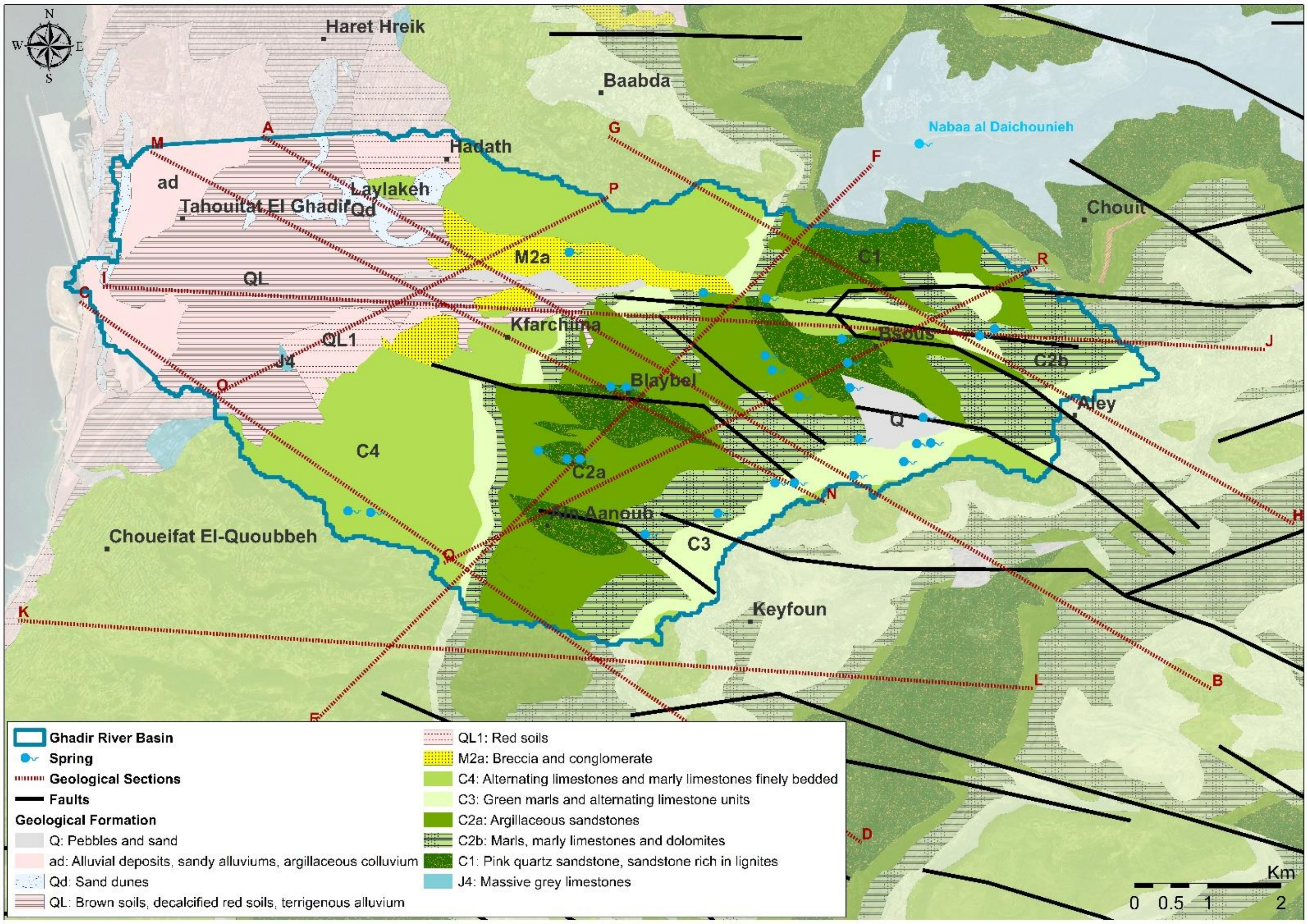


Figure 3 Geological map of GRB (modified from Dubertret, 1955) showing the location of the geological cross sections

3.2 Hydrogeological conditions of GRB

3.2.1 Hydrogeological formations and properties

Most of the hydrogeological formations encountered within GRB extend beyond the basin's surface limits as will be described in Section 3.3. The main tapped aquifers in GRB's subsurface are (from older to younger): the Jurassic Complex (J4-J7) (noting that J5 can particularly act as aquiclude, and J6-J7 can be considered as semi-aquifers according to MoEW and UNDP (2014)), Sannine Formation (C4) except its middle member (C4b), Miocene Formation, and the Quaternary deposits. The Chouf Formation (C1) is considered a semi-aquifer while Abeih-Mdairej Formation (C2) as well as Hammana Formation (C3) are generally characterized by poor hydraulic properties (with some exceptions that will be further highlighted in the next paragraphs).

Springs emerging within GRB are small-scale springs mainly discharging during high flow periods (no discharge data were available for those springs). Most of them originate from the Chouf Formation and at the boundary between the Mdairej marls and the Hammana dolomitic limestone (Figure 3).

The different lithologies of the Quaternary are partially and weakly cemented (Ukayli, 1971) which should typically lead to favorable hydraulic properties within this formation. In some parts of the study area (as shown by the geological section IJ produced by Doummar et al. (2015) and that of UNDP (1970), both included in Appendix A), the marl layers of the Chekka Formation (C6) may act as a flow barrier between the Quaternary and Sannine formations. On the other hand, Peltekian (1980) mentioned that the Quaternary Formation overlies the Sannine Formation in some locations, which allows hydraulic connection between those two formations.

The most important aquifer in the study area is the Sannine Formation of Cenomanian Age (C4): it is a highly karstified aquifer (characterized by a high secondary porosity), hence groundwater mainly flows through conduits and fractures. The upper and lower hydrogeological units C4c and C4a are considered karst aquifers due to their significant secondary porosity, while the middle unit (C4b) acts as an aquiclude (due to its low permeability) separating the two permeable units (Khadra, 2003). As such, C4a is considered as a confined aquifer (except in its recharge areas) since it is overlain by an aquiclude (C4b) and underlain by the impervious Hammana Formation (C3). Finally, it should be noted that the extensive abstractions from this aquifer as well as its proximity to the Sea, and its fractured nature increase the aquifer’s vulnerability to seawater intrusion as will be further discussed in Section 3.4.

In GRB, the Quaternary and Sannine aquifers are isolated from the rest of the underlying formations by the Albian Hammana Formation (C3). Ghattas (1975) highlighted that the C3 marls protect the underlying formations from salinization caused by seawater intrusion.

Mdairej Formation (C2b), characterized by extensive jointing (hence good fracture permeability) is considered as semi-aquifer due to its limited geometry and recharge area. On the other hand, Abeih Formation (C2a) acts as an aquiclude limiting the hydraulic connection between the Chouf and Mdairej formations unless potential for preferential flow through faults and fractures exists. In fact, the presence of fractures may facilitate the flow between the different formations.

The Chouf Sandstone Formation (C1) was considered a porous medium semi-aquifer by MoEW and UNDP (2014) due to its relatively good permeability and minor storage of groundwater. The Chouf Formation features a steady flow since groundwater percolates and moves slowly between its sand grains. In addition, it is expected that this formation has a lower productivity as compared to the Sannine and Jurassic formations (as hinted by Section 3.2.4). However, other authors consider the Chouf Formation as an aquifer (and locally as a semi-aquifer) since it is characterized by matrix porosity where cementation is weathered and eroded (Doummar et al., 2015). On another note, Doummar et al. (2015) also highlighted that the Chouf Formation is locally characterized by high iron content caused by oxidation reactions.

Finally, the uplift in the late Jurassic to early Cretaceous Periods led to the exposure, erosion and karstification of the Jurassic Limestone. In particular, the Middle Jurassic Formation (J4), lithologically composed of karstic limestone, is one of the major aquifers in Lebanon. Although the Jurassic Complex is not outcropping within the study area, some wells are tapping its formations.

3.2.2 Groundwater levels and directions

Within the study area, groundwater mainly flows in a western direction following the major dip directions and topographic gradients. Groundwater flow in the carbonate rock aquifers present within the study area seems to be mostly governed by fracture flow (particularly along the west/northwest – east/southeast faults). Figure 4 shows the groundwater level contours reported by UNDP (1970) for the Quaternary aquifer within the limits of GRB. The reported contours (for the year 1970) show groundwater levels of 1 to 8m AMSL for the Quaternary aquifer (with an estimated hydraulic gradient of 0.0018 in the southern part of the River Basin and 0.0029 in the northern part for the year 1970). Those contours also show that the natural groundwater direction in the concerned aquifer is towards the west (i.e. towards the Mediterranean Sea). MoEW and UNDP (2014) reported that the groundwater levels in coastal formations are still comparable to the levels reported by UNDP (1970) since the abstracted freshwater is mostly compensated by the intruding seawater. Between 2012 and 2013, groundwater levels were monitored by MoEW and UNDP (2014) in Batchay and Kfarchima-Rayyes public wells, both tapping the C4-C5 formation (Figure 4). Further details on those two wells are provided in Sections 3.3.2 and 3.3.3.

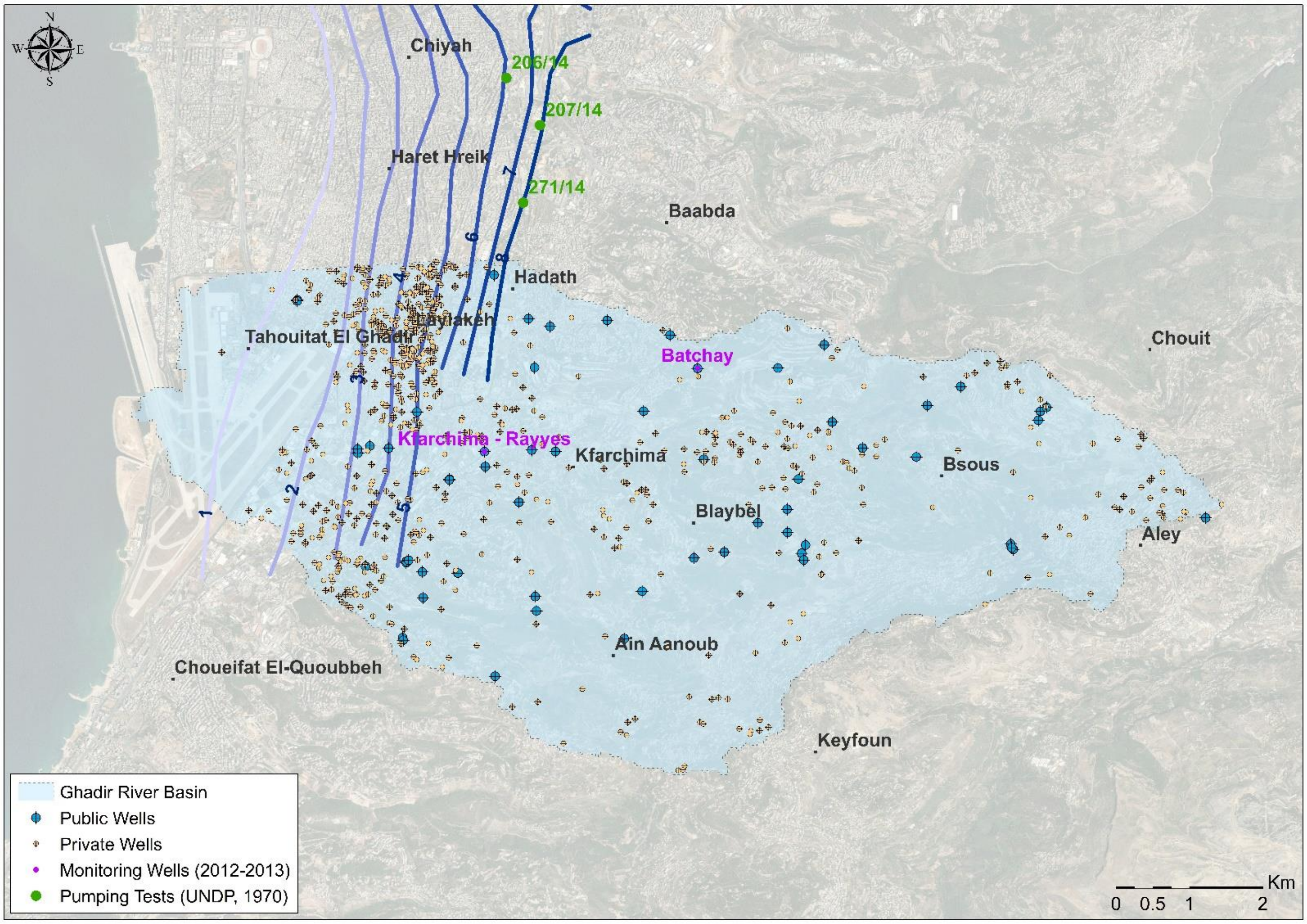


Figure 4 Public and private wells of GRB, monitoring wells, and nearby pumping tests. This map also shows the Quaternary-Tertiary groundwater level contours in meters AMSL obtained from UNDP (1970)

3.2.3 Groundwater recharge and storage

According to UNDP (1970), around 21% of the rainfall contributes to the groundwater recharge of the Sannine Formation. However, this value might be greater due to the karstic nature of this aquifer. A recent study (Frem and Saad, 2021) produced a spatially distributed groundwater recharge map for Lebanon based on the GROWA model (Kunkel and Wendland, 2002). Based on the results of that study, 37% of the rainfall can contribute to the groundwater recharge of the Sannine Formation within the study area. Estimations for other formations show a natural recharge rate of 19% for the Miocene and Chouf formations, and 17% for the Abeih-Mdairej Formation within GRB. Due to the high urbanization coinciding with the outcropping areas of the Quaternary deposits, natural groundwater recharge into that formation can be assumed to be negligible (noting that leakage from wet utilities can be expected). Hence, a tentative maximum recharge rate of 5% can be assumed for the Quaternary Formation. From a structural geology perspective, Doummar et al. (2015) suggested that faults are possibly conveying most of the recharge water from the higher areas through conduits that were developed along them.

Storage was also estimated for the different permeable to semi-permeable formations. Hence, the subsurface extent of those formations as well as the average thickness were estimated based on the produced and available geological cross sections. In addition to the formation's geometry, information on storage coefficient were needed. With the absence of extensive pumping test data within the study area, the storage coefficient ranges were mainly assumed based on pumping test results reported by UNDP (1970) and tabled values (Domenico and Mifflin, 1965; Morris and Johnson, 1967; Heath, 1983). It is important to note that the range of storage values for the rock formations is wide since their storage coefficients may vary by orders of magnitude. Hence, the adopted average values are prone to uncertainties and should be cautiously used in context groundwater modelling or water resources management.

3.2.4 Groundwater abstractions

This Section provides an overview of the analysis conducted based on BTD's available data (compiled from multiple sources such as MoEW and UDNP (2014) and BMLWE's database) for 60 public wells and 742 private wells within GRB. Coordinates and ground elevations were provided for all the wells, and Figure 4illustrates the spatial distribution of both public and private wells within the study area. For some of the private wells and most of the public wells, information on operational status, drilling year, outcropping formation, tapped aquifer, well diameter, pumping rate and well usage were available. According to BTD's data, 30 public wells are operational within the extents of GRB. In the absence of well construction details (mainly screened/open interval), well depth can usually support the analysis aiming to predict which aquifer is tapped (with a reasonable level of certainty). As indicated in Table 3, 70% of these public wells are tapping the C4 aquifer while 13% are tapping the C1, 7% the C2 and 10% the Jurassic. The estimated total public abstractions for current domestic use (assuming an extreme case of 24 hours operation) are about 39000 m^3/d (noting that abstractions from the C4 aquifer alone accounts for about 31900 m^3/d). Public wells tapping the C4 Formation have an average pumping rate of 63 m^3/h while those tapping the Jurassic Formation have a comparable rate of 62 m^3/h. On the other hand, public wells tapping the C1 and C2 formations have respective yields of 23 and 11 m^3/h. This observation is in-line with the fact that the C4 and Jurassic formations are the most important aquifers within the study area's subsurface and are hence expected to be the most productive aquifers, while C1 is considered as a semi-aquifer and C2 is divided into a semi-aquifer in its upper part (C2b) and aquiclude in its lower part (C2a). Doummar et al. (2015) highlighted that many operational wells are drilled along west/northwest – east/southeast trending faults. On another note, Mechref wells located outside of the study area are tapping the C4 aquifer. This information was included due to the importance of those public wells for GRB's water supply. However, most of the monitored existing wells in Mechref are showing high EC values (>1500 μS/cm) and are facing an ongoing deterioration of water quality (BTD, 2022).

As previously mentioned, basic data on 742 private wells were available. However, well depths were reported for only 21% of those private wells. Almost one third of the private wells with depth information are expected to be tapping the Quaternary deposits (especially in the northwestern part of the study area), and another third is expected to be tapping the Sannine Formation. Figure 5 shows the depth distribution histogram of the private wells. It can be seen that the majority of the wells (around 38%) are relatively shallow and have a depth of less than 50m. However, a considerable number of private wells (around 34% of them) is also tapping a depth of 100 to 150m. Out of the 742 private wells, only 51 wells had information on pumping rates. It was found that the minimum abstraction is 5 m³/d while the maximum abstraction is 86 m³/d. Estimating total abstractions from private wells is challenging due to uncertainty on the total number of wells (licensed and unlicensed), their operation mode, well diameter, pump capacity, well depth, etc. In reality, the number of private wells within the study area is expected to be much higher than 742.

Table 3 Average pumping rates and percentage of public wells tapping each formation

Formation	Percentage of public wells tapping each formation	Average pumping rate per well (m^3/h)
Sannine Formation (C4)	70%	63
Abeih-Mdairej Formation (C2)	7%	11
Chouf Formation (C1)	13%	23
Jurassic Formation	10%	62

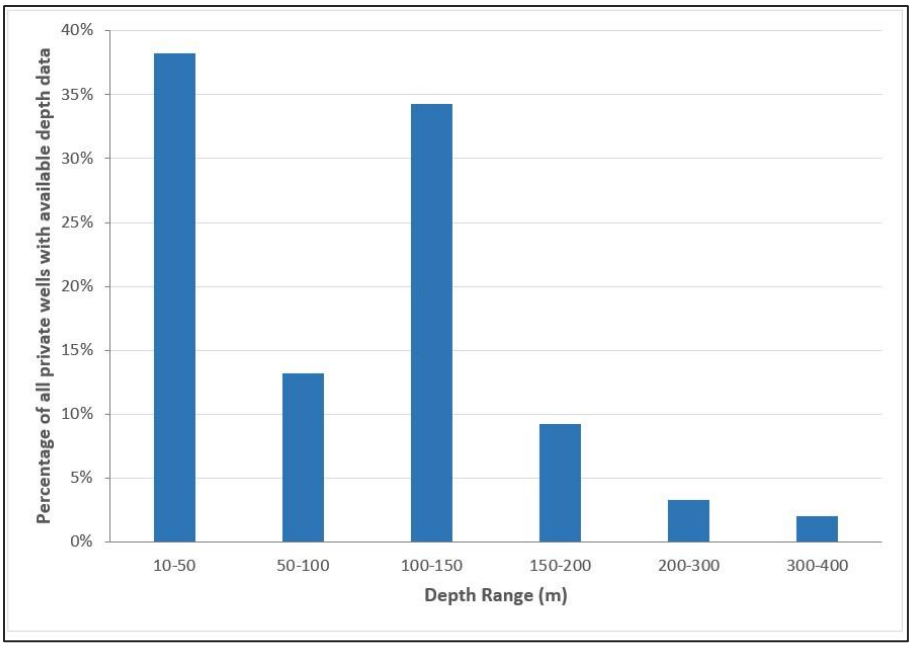


Figure 5 Depth distribution of private wells with depth information

3.3 Characteristics of the hydrogeological units on a regional scale

Figure 6 shows the regional extent of each of the hydrogeological units (MoEW and UNDP, 2014) that are outcropping within GRB: Beirut Neogene-Quaternary Unit, Hadath-Hazmieh Cretaceous Unit, Sarafand-Khaldi Cretaceous Unit, unproductive Aptian-Albian sequence, and Metn-Chouf Sandstone Cretaceous Unit. Subsequent sub-sections provide a characterization of these units based on existing literature and available data. Blank areas are intentionally left to maintain focus on the extent of the units of interest.

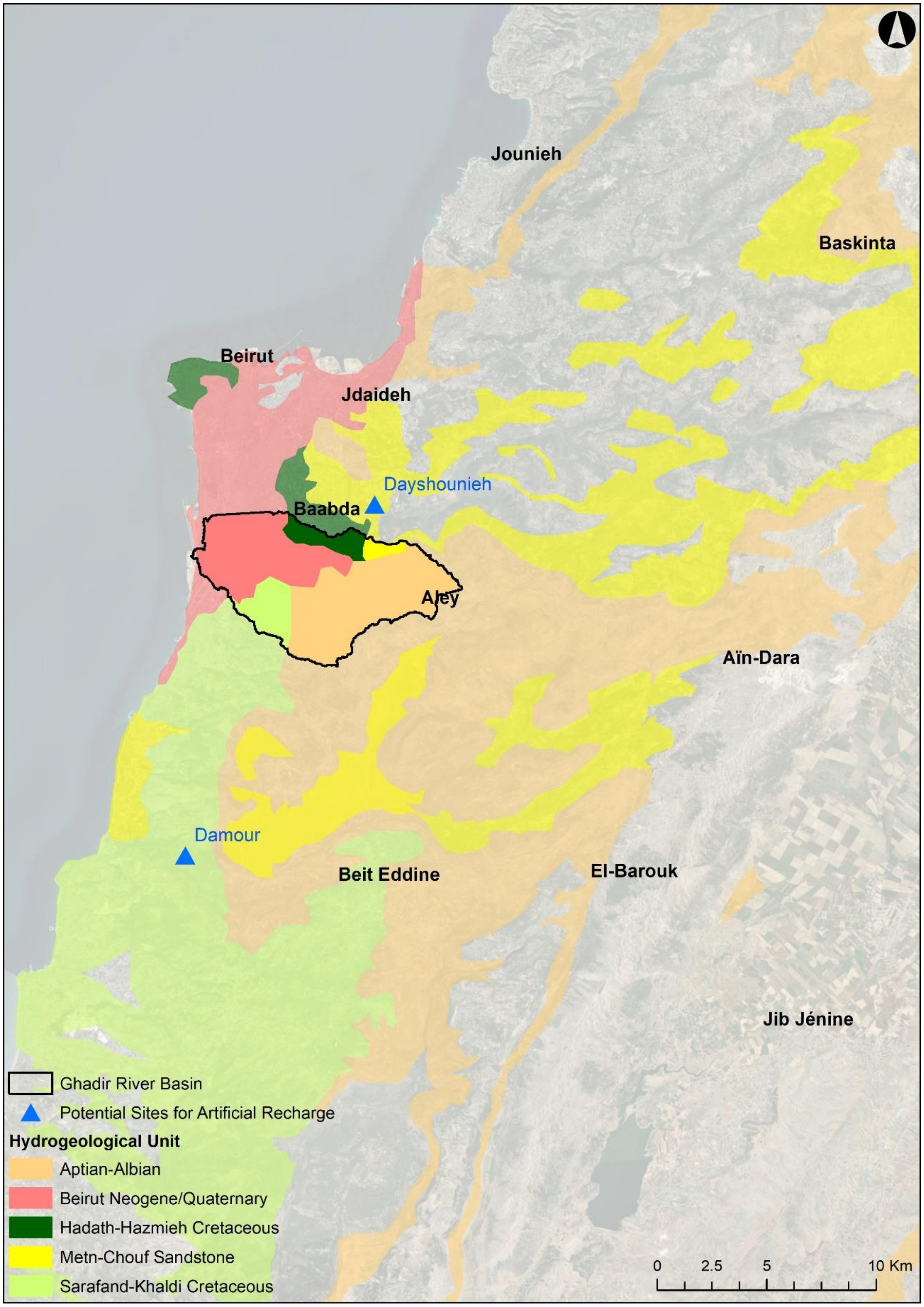


Figure 6 Regional extent of the hydrogeological units outcropping within GRB (produced using the delineation of hydrogeological units reported by MoEW and UNDP (2014)).

3.3.1 Beirut Neogene-Quaternary Unit

At a regional scale, the Beirut Neogene-Quaternary Unit showed an approximate deficiency of around 38 MCM (equivalent to 648 mm) during the considered dry year (2010-2011) and 35 MCM (equivalent to 584 mm) during the considered wet year (2011-2012) according to the estimates of MoEW and UNDP (2014). The authors also highlighted that groundwater abstractions from public and private wells are not well defined, and that only one spring emerges in this formation.

Table 4 presents an assessment of groundwater recharge for this hydrogeological unit. Notably, the findings of the UNDP (1970) study suggest that groundwater recharge accounts for approximately 15% of the received precipitation – a value that closely aligns with the subsequent estimates conducted by MoEW and UNDP (2014). It is important to underscore that the outcropping area of this unit is characterized by a significant degree of urbanization, which poses challenges to natural groundwater recharge processes. In fact, the presence of urban areas restricts the infiltration of rainwater into the subsurface, limiting the replenishment of groundwater resources and increasing the flood risk.

Those Quaternary alluvial deposits are reported to be permeable with transmissivity values ranging between 1E-04 and 1E-03 m^2/s and a storage coefficient of around 0.1 (UNDP, 1970). Insights about groundwater levels and flow directions in this unit were presented in Section 3.2.2.

Table 4 Groundwater recharge of the Beirut Neogene-Quaternary Unit for its entire outcrop

Hydrogeological Unit	Outcropping Area (km^2)	Reference	Groundwater Recharge	
			MCM	Precipitation ratio (%)
Beirut Neogene-Quaternary	59	Dry year (MoEW & UNDP 2014)	5	13
		Dry year (MoEW & UNDP 2014)	9	15
		UNDP (1970)	17	15

3.3.2 Hadath-Hazmieh Cretaceous Unit

Most of the coastal aquifers are subject to considerable water balance deficiencies since they are heavily urbanized and exploited. In particular, Hadath-Hazmieh Cretaceous Basin has an estimated deficiency of approximately 7 MCM (equivalent to 544 mm) during the considered dry year and 4 MCM (equivalent to 291 mm) during the considered wet year (MoEW and UNDP, 2014). It is reported that only two springs emerge in this formation.

Table 5 presents two different assessments of groundwater recharge for this hydrogeological unit. UNDP (1970) reported that 21% of the received precipitation contributes to the replenishment of groundwater reserves. However, the more recent analysis conducted by MoEW and UNDP (2014) suggests that groundwater recharge ranges from 54% of the received precipitation during dry years to 61% during wet years.

Information on the hydraulic properties of this formation in the vicinity of the study area were available thanks to pumping tests conducted in the 60s. Data reported by UNDP (1970) show that transmissivity values ranged between 0.005 and 0.15 m^2/s (leading to typical fractured limestone hydraulic conductivity range of values). However, it is important to note that the pumping tests that gave the lower and upper values of this range of transmissivity are only located 750m apart, which shows the high heterogeneity of this formation's properties. The pumping test giving the higher transmissivity value was carried out in Hazmieh region in Well 207/14 having a depth of 100m, while the test giving the low value was conducted in Chiyah area in Well 206/14 having a depth of 175m. Finally, the storage coefficient was estimated to be 0.045 (based on another pumping test carried out in Well 271/14 in Hadath). Locations of those three wells area indicated on Figure 4.

Groundwater levels in two monitoring wells in Hazmieh to the north of GRB showed a decrease of about 3 to 4m as compared to values reported by UNDP in the year 1970. As shown byFigure 7, the groundwater level in one of Hazmieh wells, tapping the Cenomanian-Turonian aquifer, varied between 3m below MSL in summer and 4m above MSL in winter, and showed a gradual groundwater level increase in the winter season (1m approximately after each rainfall event). On the other hand, groundwater levels measured in a monitoring well located in Batchay (within GRB) varied between 142 and 157m AMSL (Batchay well is shown on Figure 4).

The studies conducted by MoEW and UNDP (2014) have identified 22 potential locations in Lebanon where artificial aquifer recharge could be implemented. Among these 22 sites, Daychounieh and Damour sites (indicated in Figure 6) are particularly relevant for GRB since reducing the salinity of groundwater in the vicinity of those areas could ultimately alleviate the pressure on GRB's groundwater resources. In 2016, several feasibility studies on artificial aquifer recharge have been conducted by UNICEF for various locations. In particular, BTD (2016) studied the feasibility of artificial aquifer recharge in the Damour area (see Section 3.3.3).

The Hadath-Hazmieh Cretaceous Unit is proposed to be recharged from the Daychounieh spring. MoEW and UNDP (2014) indicated an available annual volume of 1.8 to 3.5 MCM for artificial recharge (constituting 24 to 46% of the considered dry year's natural recharge and 16 to 31% of the considered wet year's natural recharge). Daoud (1973) assessed the recharge capacity of the Hadath-Hazmieh Cretaceous Unit since this aquifer was stressed due to overexploitation, noting that it was also subject to seawater intrusion. The aforementioned study included four (gravity) injection tests on two wells approximately located at an elevation of 36 to 40m AMSL; the groundwater table was reported to be at a depth of about 12m BGL. The tests were carried out between April 1968 and May 1971 for durations of about 10 to 210 days with injection rates between 135 and 174 L/s. Daychounieh spring was the main source of freshwater for those injection tests. A groundwater level increase of about 1.2m was measured in an observation well approximately located 0.5 km southwest of the injection wells while no groundwater level change was observed in another well at 5.5 km southwest of the injection points. Moreover, an enhanced groundwater quality was noticed in the immediate vicinity of the injection area, particularly a decrease in the salinity of the groundwater was noticed in the observation well located 0.5km southwest of the injection wells as shown by Figure 8. Hence, Daoud (1973) concluded that artificial recharge in the Hadath-Hazmieh Cretaceous Unit can mitigate seawater intrusion, while noting that additional monitoring is required. However, the obtained values remained above the freshwater salinity level of 500 mg/L suggested by Mayer et al. (2005) and Rhoades et al. (1992). The authorities decided to keep recharging the aquifer through those two injection wells, and the recharge operations are believed to had occurred at least until the beginning of the Civil War.

Table 5 Groundwater recharge of the Hadath-Hazmieh Cretaceous Unit for its entire outcrop

Hydrogeological Unit	Outcropping Area (km^2)	Reference	Groundwater Recharge	
			MCM	Precipitation ratio (%)
Hadath – Hazmieh-Cretaceous	13.3	Dry year (MoEW & UNDP 2014)	5	54
		Dry year (MoEW & UNDP 2014)	8	61
		UNDP (1970)	2	21

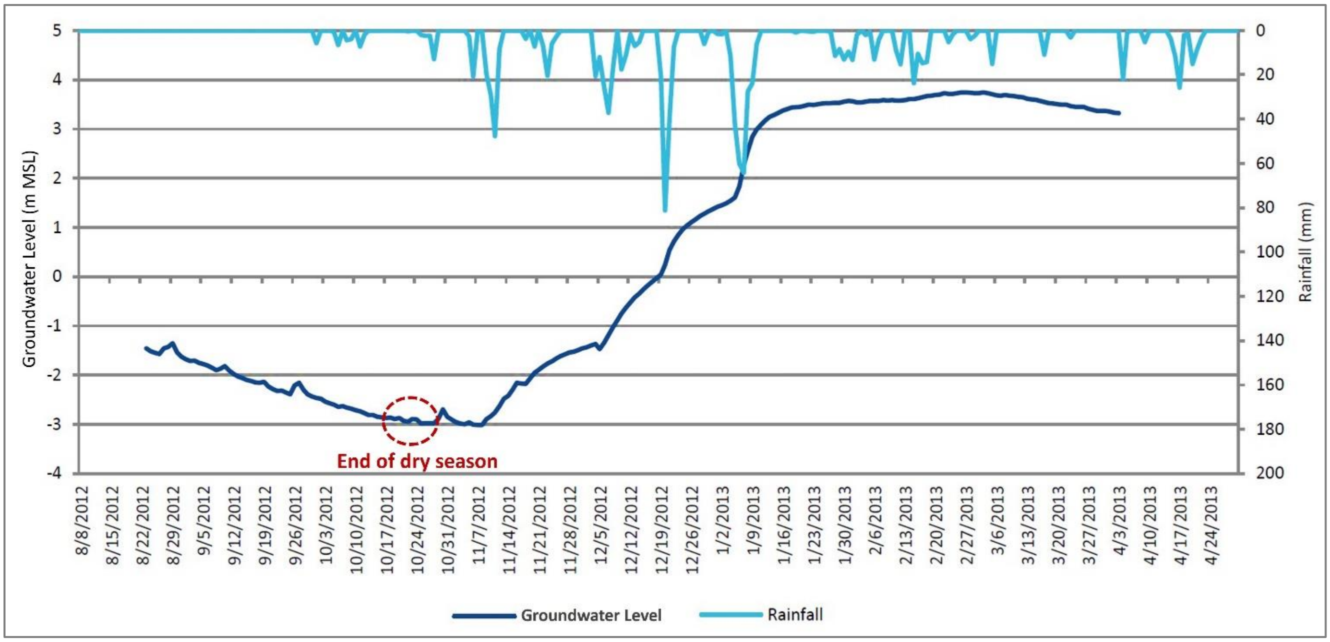


Figure 7 Groundwater level variations of Hazmieh's monitoring well along with rainfall data from a nearby station (modified from MoEW and UNDP, 2014)

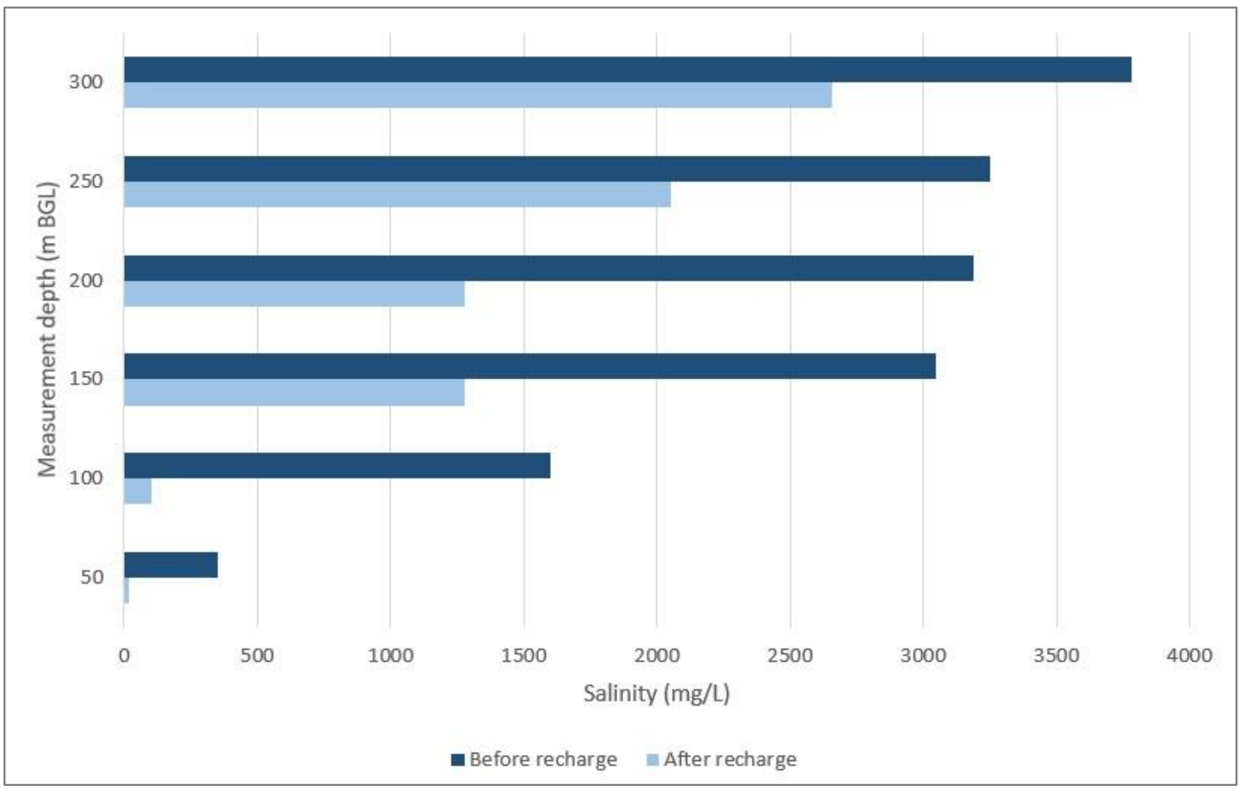


Figure 8 Salinity levels in an observation well located at about 0.5km southwest of the injection wells following freshwater injection for a period of 7 months (values adopted from Daoud (1973))

3.3.3 Sarafand-Khaldi Cretaceous Unit

This unit is mainly karstic, highly fractured and comprises upper and lower aquiferous units. Generally, it is expected that groundwater flow is towards the southwest within this formation that also features the presence of several faults which may also dictate the flow direction (MoEW and UNDP, 2014). The estimations of the aforementioned authors showed a positive water balance of about 108 MCM during the considered dry year and 221 MCM during the considered wet year. However, the retention and storage of this unit are not well defined. Table 6 displays two different estimates of groundwater recharge for this hydrogeological unit: UNDP (1970) study found that 40% of the received precipitation contributes to replenishing the groundwater reserves. However, the more recent analysis by MoEW and UNDP (2014) suggests that groundwater recharge ranges from 66% of received precipitation during dry years to 70% during wet years. Although the Sarafand-Khaldi Cretaceous Unit has wide exposures, it does not feature a large number of springs since its groundwater mainly recharges the deeper parts of the aquifer (MoEW and UNDP (2014)).

Between 2012 and 2013, groundwater levels were monitored in four areas within the Sarafand-Khaldi Cretaceous Basin: Chhim area (four wells), Damour area (three wells), Saida area (two wells) and Khaldi area (one well). Within this group of 10 wells, Khaldi well is the only one falling within the limits of GRB. The well in Khaldi (known as Kfarchima-Rayyes well and shown on Figure 4) was manually monitored: groundwater levels approximately varied between 16m below MSL and +12m above MSL (MoEW and UNDP, 2014). This large groundwater level difference of about 28m can be easily attributed to excessive groundwater abstractions in the area.

Artificial groundwater recharge is mainly important for this aquifer in order to face or limit seawater intrusion. MoEW and UNDP (2014) indicated an available annual volume of 82 to 119 MCM for artificial recharge (constituting 52 to 76% of the considered dry year's natural recharge and 28 to 40% of the considered wet year's natural recharge). If found to be adequate in terms of water quality or if treated, the use of Ghadir River's water for artificial groundwater recharge can also contribute to the flood risk mitigation (especially during winter). The same authors estimated that an annual volume of about 0.4 to 0.9 MCM would be available from the Ghadir River for the artificial groundwater recharge operations. Further to the south, artificial recharge using 20 to 40 MCM/year of Awali River's water and 9 to 18 MCM/year of Damour River's water was proposed by MoEW and UNDP (2014). According to the same study, 53 to 60 MCM/year of treated wastewater effluent (out of which 35 to 40 MCM from Ghadir WWTP) can also potentially contribute to the artificial recharge of this aquifer.

In the following paragraphs, artificial aquifer recharge in Damour will be further highlighted due to the significant role that the groundwater resources in that area plays in Beirut's water supply. As previously mentioned, the plan involves utilizing the Damour River as the source of injection water, targeting the C4-C5 formation.

BTD (2016) presented two different designs for Managed Aquifer Recharge schemes. The first design involves constructing two infiltration galleries perpendicular to the Damour river on the right side of the valley, while the second design is based on artificial recharge through wells. In practice, it is expected that the use of galleries would allow a more homogeneous distribution of recharge; it should also increase the chances of achieving high infiltration rates into the fissure system while minimizing the risk of fast-flow through the conduit systems. In addition, the intended galleries' proximity to the river's elevation eliminates the need for pumping (that will be necessary if recharge wells are to be drilled upstream of the public wells). In the gallery design, one tunnel is planned to extend horizontally 1100m into the C4c aquifer, while the other tunnel is designed to extend 1300m into the C5b aquifer (both tunnels being parallel to the shoreline). This design aims to ensure a wider spread of recharge to possibly benefit most public wells in the Mechref area. On the other hand, and in order to achieve the desired infiltration rate of 600 L/s, six wells aiming to recharge the C5b aquifer across its entire depth of 125m, and another six wells aiming to recharge the C4c aquifer at depths of up to 250m were proposed by BTD (2016). The high static groundwater levels may pose challenges for the well recharge option, making it more difficult to achieve sufficient recharge rates. Additionally, the local drilling contractors may encounter significant difficulties under these site conditions. It should be noted that the proximity to the Damour Fault might pose a potential threat to artificial recharge in the Damour area since preferential flow pathways along the fault could transport recharged water into the Mediterranean Sea.

The approximate cost for artificial recharge through galleries was estimated to be around 18,000,000 USD, which is more expensive than drilling infiltration wells near the Damour River (BTD, 2016). Rolf (2017) reported an implementation cost of 5,700,000 USD for the well recharge option, with respective annual maintenance and operation costs of 271,000 USD and 124,000 USD.

Table 6 Groundwater recharge of the Sarafand-Khaldi Cretaceous Unit for its entire outcrop

Hydrogeological Unit	Outcropping Area (km^2)	Reference	Groundwater Recharge	
			MCM	Precipitation ratio (%)
Sarafand-Khaldi Cretaceous	315	Dry year (MoEW & UNDP 2014)	142	66
		Dry year (MoEW & UNDP 2014)	255	77
		UNDP (1970)	123	40

3.3.4 Aptian-Albian sequence

The Aptian-Albian sequence outcrops in many parts of Lebanon, as shown in Figure 6. As mentioned earlier, Abeih-Mdairej Formation (C2) and Hammana Formation (C3), which predominantly constitute this sequence, are generally characterized by poor hydraulic properties. Therefore, this unit is generally considered unproductive, with some exceptions.

3.3.5 Metn-Chouf Sandstone Cretaceous Unit

For the Metn-Chouf Sandstone Cretaceous Unit, estimations of MoEW and UNDP (2014) showed a positive water balance of about 42 MCM during the considered dry year and 75 MCM during the considered wet year. However, the retention and storage of this unit are also not well defined. 563 springs (out of which only 28 have discharge data) emerge in this formation. The average discharge rate of those springs varies between 0.1 and 100 L/s (but mostly less than 10 L/s). Table 7 provides estimates of the groundwater recharge for this unit based on previous studies. It was consistently noticed that groundwater recharge values estimated by UNDP (1970) are much lower than those of MoEW and UNDP (2014) for all the hydrogeological units. Specifically, the 1970 study indicated that groundwater recharge into this unit accounted for only 10% of the total precipitation received. However, the more recent 2014 study reported recharge values from 35% to 40% of the received precipitation.

As documented by UNDP (1970), a transmissivity value of 3E-04 m^2/s was estimated through the analysis of pumping tests conducted in wells tapping this formation, but situated at a considerable distance upstream of GRB.

Table 7 Groundwater recharge of the Metn-Chouf Sandstone Cretaceous Unit for its entire outcrop

Hydrogeological Unit	Outcropping Area (km^2)	Reference	Groundwater Recharge	
			MCM	Precipitation ratio (%)
Metn-Chouf Sandstone Cretaceous	199	Dry year (MoEW & UNDP 2014)	73	40
		Dry year (MoEW & UNDP 2014)	105	35
		UNDP (1970)	28	10

3.4 Seawater intrusion and groundwater quality considerations

Figure 9 shows some wells that were visited and monitored during the campaign carried out by BTD between August and December 2020: 14 out of those wells, located in the mountainous areas, are mostly tapping the Cenomanian-Turonian formations. On the other hand, 11 relatively shallow wells in the coastal plain of Hadath-Choueifat area, are mainly tapping the Quaternary formation. It is important to note that Figure 9 mainly shows the northern part of GRB and areas located outside the basin. To simplify the understanding of this map, the reader can note that Dahieh 8, Dahieh 11, Dahieh 12, Rahif Al Sabeaa, Al-Siraj, Bir Ed Dbaa, Aassaily, Antounieh, Batchay and Tallet Er Rayess wells are located within GRB. The following points summarize the main findings of BTD (2022) for this area:

- Groundwater abstracted from wells located in Baabda showed low Electrical Conductivity (EC) values of 600 to 1000 µS/cm, while that of Dahieh wells had EC values ranging between 2,000 and 26,000 µS/cm. Moreover, as illustrated in Figure 10, groundwater abstracted from inland wells tapping the Cenomanian-Turonian aquifers (or deeper) had chloride (Cl^-) concentrations ranging from 50 to 100 mg/L. These concentrations are significantly lower than those of Dahieh coastal wells, where chloride concentrations can reach a maximum of 20,000 mg/L (close to seawater's chloride concentration);
- In particular, the groundwater of Dahieh-1 well had the highest EC value among the area shown in Figure 7, averaging at 40,100 µS/cm;
- Significant EC variations (exceeding 10,000 µS/cm) were observed between consecutive weekly measurements in certain wells, indicating that salinity levels are highly sensitive to pumping as a result of upcoming;
- The analysis of the chemical composition of wells in Dahieh demonstrated the existence of brackish-salt to salt NaCl groundwater (typically associated to seawater). In contrast, the wells in Baabda displayed fresh $CaHCO_3$ groundwater, suggesting that the water chemistry is similar to the recharge water found in the hills surrounding Beirut;
- The hydrochemical state of groundwater in the frontal part of the Cenomanian-Turonian aquifer is significantly deteriorated. In fact, the analysis of groundwater samples from Galerie Semaan well revealed that the chemical water type was NaCl, with a chloride concentration of 3,000 mg/L. The three wells of Dahieh 11, 12 and 13 also showed high average EC values. The reached depths by those wells range between -15 and -232m below MSL (Figure 10). Hence, it can be concluded that seawater has reached the Cenomanian-Turonian aquifer over its entire front from North to South in the Baabda-Dahieh area;

- It also seems that seawater by-passed the Tertiary and Upper Cretaceous marls by invading the alluvial and dune deposits of the Quaternary cover, or across the fractures and faults. It is important to note that the complexities of the geological and structural settings have an important role not only in the recharge processes but also in regulating the seawater intrusion dynamics. In fact, faulting and folding structures can form conduits or barriers for groundwater recharge and/or seawater intrusion. Where present, the poorly permeable Senonian formation (C6) forms a natural barrier which can locally limit the exchange between freshwater and seawater and which also confines the underlying limestone aquifers. However, as previously mentioned, there is a doubt that seawater by-passed this natural hydrogeological barrier. This provides further support for Peltekian's (1980) hypothesis, previously presented in Section 3.2.1.

In comparison with historical information, chloride concentrations measured in the coastal wells in Dahieh during the year 2020 are approximately ten times larger than concentrations reported by UNDP in 1970. MoEW and UNDP (2014) had already highlighted this increase with Cl^- concentrations measured between 2004 and 2005. MoEW and UNDP (2014) stated that the freshwater-saltwater interface shifted further inland and is at a shallower depth than 1970.

UNDP (1970) reported an average Cl^- concentrations of about 70 mg/L for the Cenomanian-Turonian aquifer in Baabda. MoEW and UNDP (2014) as well as BTD (2022) showed low Cl^- concentrations in the upper part of this aquifer and seawater intrusion in its lower part. Based on the available information, BTD (2022) concluded that the seawater intrusion in the Baabda-Dahieh coastal area, particularly in the lower-lying Quaternary covered region of Dahieh, has significantly worsened since 1970. The intrusion of seawater also affects the Cenomanian-Turonian aquifer system in this area, primarily along its frontal portion, while the upper (eastern) part of the aquifer remains unaffected by seawater intrusion. The reported extent of seawater intrusion in the year 1970 within GRB reached 2000 to 2700m away from the shoreline. Currently, the approximate boundary between freshwater and seawater can be estimated to be around 4500m inland from the coastline in this area (BTD, 2022). Hence, the intrusion limit is most likely moving further inland as many wells located further inland beyond the 1970's limit showed brackish groundwater. However, more comprehensive investigations are necessary to accurately delineate this interface in the subsurface.

Kazpard et al. (2007) performed a combined hydrochemical and stable water isotopes (^{2}H and ^{18}O) analysis for samples collected from 13 wells tapping the limestone aquifer in Beirut and its suburbs. They concluded that groundwater in the southern suburb of Beirut is affected by various sources of pollution (untreated wastewater, industrial effluents, seawater intrusion, etc.). The aforementioned authors found that Total Dissolved Solids (TDS) concentrations in samples collected in Beirut's southern suburb reached a maximum value of 7,000 mg/L. They also detected high chloride, sulfate and nitrate levels for the same samples.

According to the study conducted by Saadeh and Azzam (2008), numerous public and private wells in Greater Beirut exhibited salinities and TDS concentrations surpassing 5,000 mg/L. This was particularly evident in the densely populated southern suburb of Beirut. The research further highlighted that the mixing front, characterized by increased salinity, continues to ingress from the southwest to the northeast, penetrating the southern suburbs of Beirut. The measured chloride concentrations in the southern suburbs of Beirut were also found to be among the highest compared to the other wells (Figure 11) Note: the authors of this report do not endorse the interpolation carried out by Saadeh and Azzam (2008).

Besides seawater intrusion, vertical pollution poses a significant threat to groundwater quality. Vertical pollution refers to the infiltration of contaminants from the surface into the groundwater due to various human activities. In the case of the GRB, several anthropogenic sources contribute to the pollution of groundwater. In particular, the discharge of untreated or partially treated sewage can introduce contaminants into the soil before eventually percolating down to the groundwater. Industrial activities also contribute to the contamination of groundwater in GRB. Effluents from industries such as pulp and paper, dyes, tanning, batteries, ceramics, distilleries, car oils, stones, marbles, and serum products as well as wastes from the farms of sheep and poultry contain various contaminants (Mcheik et al., 2015a). If these effluents are discharged directly into the river without appropriate treatment, the sediments and soils in the surrounding areas can become contaminated. Over time, the pollutants can leach downward, seeping into the groundwater and causing contamination (Mcheik et al., 2015b). In the lower course of the river, where the concentration of pollutants tends to be higher, the risk of groundwater contamination is more pronounced (Mcheik et al., 2013). Among others, factors such as the flow of the river, slope, soil type, hydrogeological properties (mainly porosity, hydraulic conductivity and dispersivity) can influence the rate and extent of pollutant transport into the groundwater. Contaminated groundwater poses a significant risk to human health and ecosystems. Consuming or utilizing water that is contaminated with hazardous substances can cause various waterborne diseases and long-term health problems. Furthermore, the contamination can have adverse effects on the ecological conditions within GRB, affecting both aquatic and terrestrial groundwater-dependent ecosystems (GDEs).

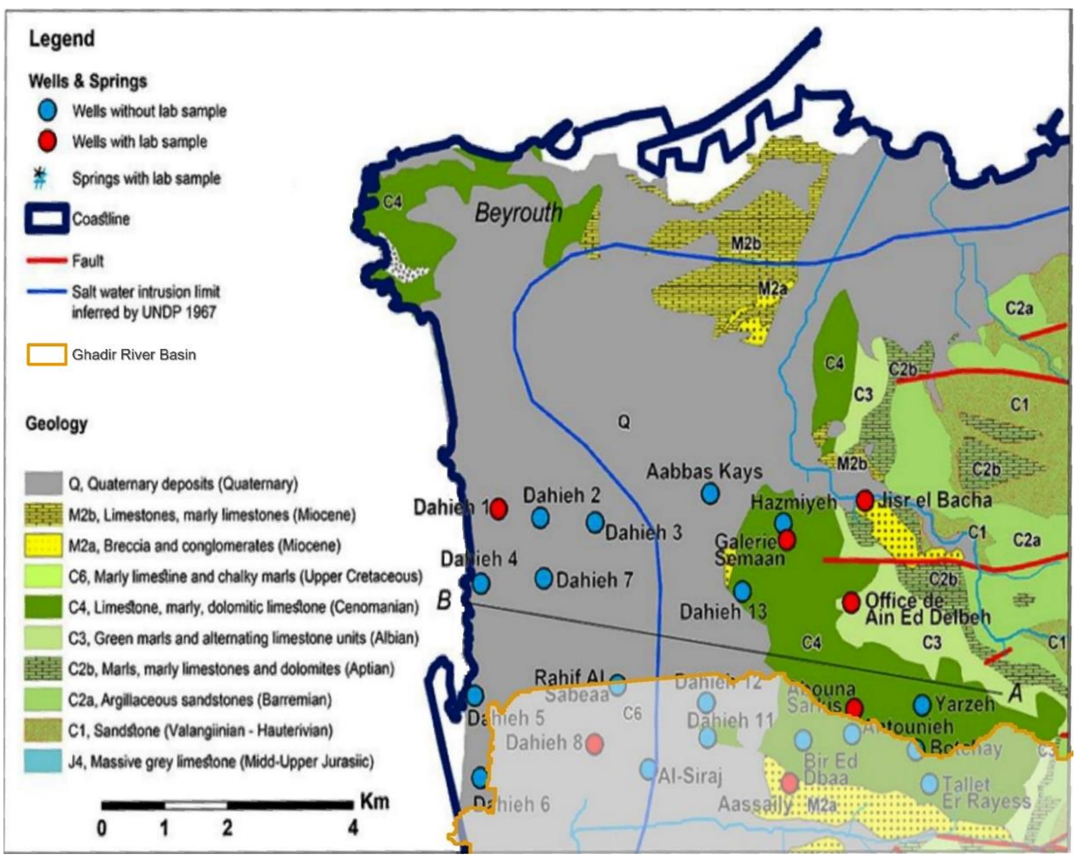


Figure 9 Geological map showing the northwestern part of GRB, observed and/or tested wells during the 2020 survey in Beirut and Baabda (modified from BTD, 2022)

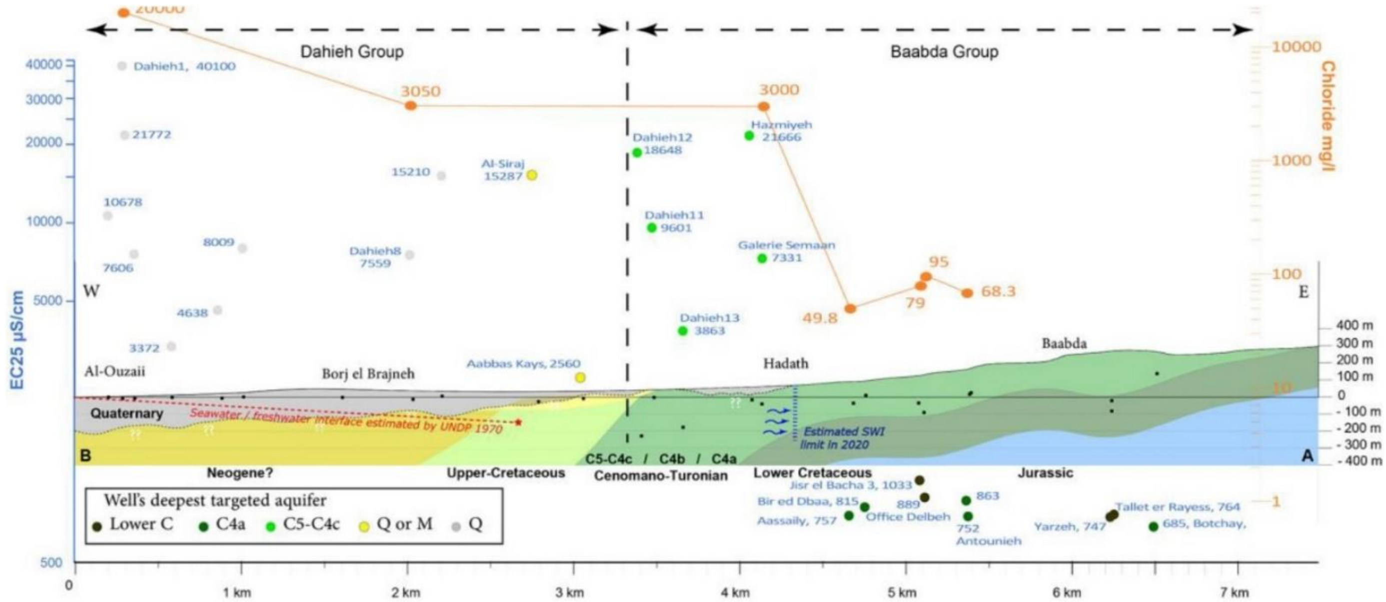


Figure 10 Geological section of the Baabda-Dahieh coastal area (BTD, 2022)

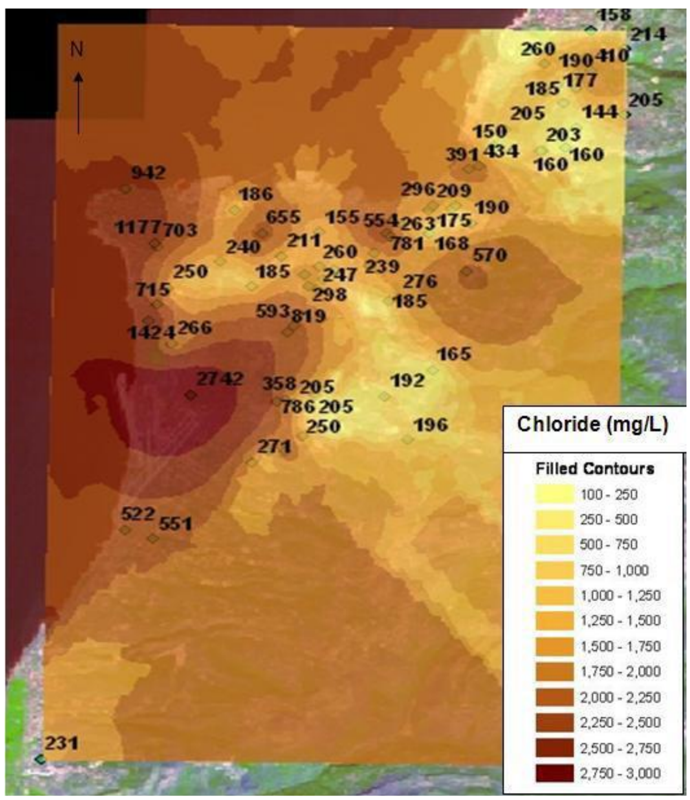


Figure 11 Chloride concentrations in Greater Beirut during August 2005 and August/October 2006 (Saadeh and Azzam, 2008).

3.5 Recommendations

3.5.1 Technical recommendations

This Section highlights several recommendations to better understand seawater intrusion dynamics and reverse its impacts in the affected areas, protect groundwater quality, and optimize groundwater abstractions. Implementing these recommendations will require extensive studies, advanced modeling techniques, and comprehensive data collection, ultimately contributing to the sustainable management of groundwater resources:

a. Carry out detailed hydrogeological assessments: study each hydrogeological unit to better understand seawater intrusion dynamics, identify groundwater quality issues, accurately delineate groundwater basins, define hydrogeological properties, estimate groundwater budgets, and develop 3D numerical groundwater flow models for the different hydrogeological units and coupled groundwater flow-transport models where appropriate;

b. Study the feasibility of the most common countermeasures of saltwater intrusion, hypothetically represented by Figure 12. Those measures may include, among others:

   - Well field reorganization: this solution consists of reviewing the well field design by optimizing extraction rates and/or drilling wells further inland. Although it sounds obvious and simple, this solution would also require detailed studies;
   - River bank filtration: this method consists on inducing recharge from a hydraulically connected river.
   - Positive hydraulic barriers: it consists of artificial recharge well(s) aiming to raise the groundwater level, hence push the intruded seawater towards the coast;
   - Negative hydraulic barriers: it consists of pumping well(s) that aim to intercept the intruded seawater, hence protect parts of the aquifer against salinization;
   - Subsurface barriers: artificial subsurface dams that can be built to physically prevent seawater intrusion; however, this solution is mainly suitable for unconsolidated geological formations;
   - Integrated Fresh-Keeper (IFK) wells: this technique aims to create a vertical hydraulic barrier that intercepts upcoming brackish water below the upper screen of the well that needs to be protected. However, this approach is to be seen as a localized remedy;
   - Aquifer Storage Recovery (ASR) schemes: it consists of injecting freshwater, storing it and then extracting it from the same well;
   - Aquifer Storage Transfer Recovery (ASTR) schemes: this technique is similar to ASR, but includes transfer of the recharged water between different aquifers, units or areas;

It is important to consider that reversing the effects of severe seawater intrusion through artificial recharge techniques may take decades based on studies by Bear (1999) and Barlow (2003).

c. Implementation of the Greater Beirut Water Supply Augmentation Project (GBWSAP): besides meeting the domestic water demand of Greater Beirut, this project will encourage people to abandon or at least minimize groundwater abstractions, contributing to the efforts of reversing the impacts of seawater intrusion;

d. Collect borehole logs: collecting borehole logs would allow a better representation of the subsurface;

e. Assess the extent, thickness, and properties of the Senonian marls formation (C6 formation): for the implementation of Managed Aquifer Recharge projects, it is particularly important to assess the extent, thickness and properties of the C6 formation as it may act as a flow barrier. Hence, it will be judicious to drill exploration boreholes and/or perform geophysical logging of uncased wells;

f. Carry out geophysical surveys: in particular, 2D surveys such as ERT (Electrical Resistivity Tomography) would allow to identify the location of the freshwater-saltwater interface, assess the potential presence of karstic conduits, as well as to assess groundwater occurrence and help understanding the aquifer's geometry;

g. Collect data on hydraulic properties, mainly hydraulic conductivity and storage coefficient, of the coastal aquifers and overlying formations would be highly advantageous. Those properties can be mainly obtained through the analysis of pumping test data;

h. Assess the sustainable yield: besides the safe yield, it is crucial to implement studies aiming to assess the sustainable yield to consider the needs of the groundwater-dependent ecosystems.

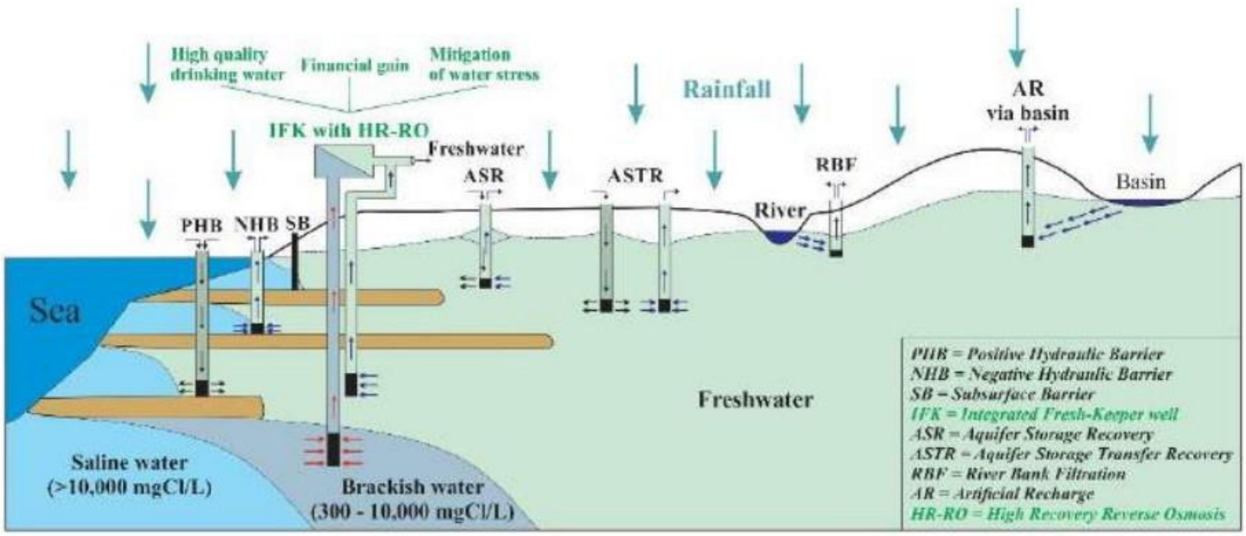


Figure 12 The most common countermeasures of saltwater intrusion (Khadra et al. 2017)

3.5.2 Management recommendations

The following management recommendations aim to address the challenges and promote sustainable groundwater exploitation in the study area. By developing an evidence-based strategy, implementing effective monitoring programs, and incorporating groundwater considerations into urban planning, stakeholders can better manage seawater intrusion, protect water quality, and ensure the long-term viability of groundwater resources:

a. Develop an evidence-based strategy for sustainable groundwater exploitation in collaboration with stakeholders, led by the MoEW;

b. In addition to the technical measures to control seawater intrusion, public awareness campaigns and capacity development are highly beneficial;

c. Ensure continuous monitoring for all hydrogeological units, especially those facing severe seawater intrusion, continuous monitoring of groundwater level, EC, pH, and temperature values with a specific temporal resolution is recommended. Major anions and cations should be also analyzed from wells. The obtained data can help building a better understanding of the recharge mechanisms, overall hydrodynamic responses, and aid in the calibration of numerical groundwater flow and/or transport models; additionally, it is highly advised to measure bromide and strontium concentrations in coastal wells to build a better understanding of the seawater intrusion dynamics;

d. Conduct a survey of all public and private wells (to the best possible extent);

e. Incorporate groundwater vulnerability into urban planning strategies when determining the location of potential pollution sources such as future urban areas and industrial zones, and into Lebanon’s coastal zone management strategies in general;

f. Control future urban expansion to mitigate reduced local groundwater recharge and potential degradation in groundwater quality;

g. Implement the Solid Waste Management Strategy to prevent or at least limit random siting of waste dumps and ensure control and treatment of leachates.

4 Future Scenarios

The future water demand scenarios for river basin management depend on various factors, including population growth, urbanization, economic development, and climate change. If no proactive measures are taken, the business-as-usual scenario could lead to increased water stress and strain on river basin management. Factors like population growth, urbanization, and economic development may drive increased water consumption, resulting in unsustainable use patterns. Climate change could exacerbate water scarcity and alter precipitation patterns, further complicating river basin management.

Inadequate water infrastructure and limited regulatory measures might hinder efficient water allocation and use, potentially resulting in conflicts among stakeholders. This could negatively impact the ecological health of the river basin, with consequences on biodiversity, habitat degradation, and water-related ecosystem services. The social and economic repercussions, such as reduced water availability for drinking water supply, irrigation, and industrial processes, may affect livelihoods, food security, and economic development in the region.

To address these challenges, proactive measures such as water efficiency, demand management policies, water reuse, recycling initiatives, stakeholder engagement and participatory decision-making processes, are crucial for sustainable river basin management. By adopting a proactive approach, river basin management can strive for sustainability, resilience, and equitable allocation of water resources, while safeguarding the ecological health of the river basin for future generations.

Thus, and for the clarity of the report, the future scenarios were categorized between business-as-usual and intervention scenarios which include the demand management scenarios described in section 5.4. The list of future business as usual scenarios that shall be simulated and analyzed for 2035 is presented in Table 8.

Table 8 Future business as usual scenarios for 2035

Name	Description
Domestic Water Demand Increase Scenario	Built on the baseline scenario of 2020 with increase of domestic water demand and supply based on the expected demographic adopted in baseline report
Climate Change Scenario*	Climate change scenario with incorporation of CMIP6 climate anomalies

* The climate change scenario can be applied either separately or in combination with the other future scenarios.

4.1 Water Demand Scenario

4.1.1 Domestic water demand

As described in the baseline report, there are 11 different water distribution systems partially or totally included within GRB. By 2035, the future population living within the basin limits is supposed to reach a total of 350,735 with an estimated water demand of 70,147 m^3/d. reference

These water systems are supplied by their own wells and springs located within or beyond GRB. There are a total of 30 water sources located within GRB. Wells are supplying a total flow of 36,971 m^3/d to feed the population living within the basin limits, while a flow of 2,083 m^3/d is diverted to feed the population living outside the basin. In 2035, additional flow will be extracted from Richane wells, increasing the total flow to 37,323 m^3/d.

It is important to note that these flows estimates were based under optimal operation conditions to cover the deficit with the current infrastructure i.e. Deir Mar Yousef well will be operating 24 hours continuously instead of suggesting the drilling of new wells while the well of El Zwaytine will be operating 16 hours as no deficit is shown.

There are 4 tapped springs falling outside GRB that are supplying the basin with domestic water. Der Qoubel spring is currently out of service and not feeding the system. In addition, Mechref wells are also contributing with a small part in Ghadir specifically Bourj el Barajnet. Hence, a total flow of 8,237 m^3/d is currently diverted from external springs which is expected to increase to 9,625 m^3/d by 2035.reference

The water supply deficit in GRB is significant as the total supply in 2020 is 44,489 m^3/d while the total demand is 61,891 (m^3/d). However, at the water distribution system level, some systems are in excess such as Choueifat system while others are in deficit like Bsous, Ain el Delbe, Daychounieh and Mechref wells. These deficits will be covered by the GBWSAP project once Bisri dam/ Awali conveyor project in 2035 (see section 5.3). Table 9 below shows the deficit within GRB of each water distribution system.

Table 9 GRB water distribution systems

ID	Water System Name	Served population within GRB		Total Water Demand (m^3/d)		Total Water Supply (m^3/d)		Total deficit/excess (m^3/d)	
		2020	2035	2020	2035	2020	2035	2020	2035
1	Raayan	34495	41433	6899	8287	6180	8287	-719	0
2	Bsous	3215	4026	643	805	86	86	-557	-719
3	Chweifat	85329	95489	17066	19098	19355	19701	2289	603
4	Ain El Delbe	60166	67946	12033	13589	7272	7272	-4761	-6317
5	Bsaba	1700	2129	340	426	1296	1296	956	870
6	Daychouniyeh	88529	99070	17706	19814	1638	1638	-16067	-18176
7	Boutchay	681	853	136	171	691	691	555	520
8	Kfarchima	21258	23789	4252	4758	4493	4493	241	-265
9	Bleibel	948	1187	190	237	1901	1901	1711	1664
10	Deir Qoubel	868	1086	174	217	389	395	216	178
11	Mechref wells	12267	13727	2453	2745	1188	1188	-1265	-1557
Total/ Total deficit*		**309455**	**350735**	**61891**	**70147**	**44489**	**46948**	**-23370**	**-27034**

*The total deficit expresses the sum of all deficit of the water systems in deficit

4.1.2 Irrigation water demand

4.1.2.1 Cultivation development and area expansion

The National Agriculture Strategy (NAS) for 2020-2025 aims to transform the agricultural sector in Lebanon into a more productive and profitable industry, ultimately reducing the country's food import bill. This objective encompasses various dimensions, including resilience, efficiency, and profitability. One of the key interventions is to increase the production basis of agrifood products, including increasing access to and availability of land, such as through land reclamation. The strategy also prioritizes the inclusion of women in agricultural production, processing, and marketing. Stakeholders in the sector have requested subsidies for land reclamation and irrigation schemes to expand production, as well as protection of local markets and development of innovative technologies in agriculture. The four programs under this pillar include increasing total agricultural production, adopting good agricultural practices and livestock management, encouraging and supporting innovative and modern technologies, and improving the quality and safety of agricultural and food products. These interventions are aimed at increasing agricultural output quantity and quality to substitute import of selected products according to the country's comparative advantages.

Agriculture in GRB has experienced a decline in recent years due to urbanization and the shift towards industrialization, and as a result there has been a reduction in the amount of agricultural land available and it is most likely that the trend will stay the same in the future. Therefore, to take the most constraining scenario for water resources demand in the future, it was assumed that there will be no reduction in irrigable land in the future and the irrigation extent and practice will stay the same.

Consequently, the total irrigation water requirements for the study area is:

$$7500 \text{ m}^3\text{/ha/year} \times 110 \text{ ha} = 825{,}000 \text{ m}^3\text{/year}$$

The above value represents irrigation water requirement (demand). The effective water use is likely to deviate from this value and to be around 70%, hence 575,000 m^3/year due to water scarcity.

4.2 Climate Change Scenarios

4.2.1 Future climate change in Lebanon

The Second (SNC, 2011), Third (TNC, 2016) and Fourth National Communication (FNC, 2022) to the United Nations Framework Convention on Climate Change (UNFCCC) developed by the MoE in 2011, 2016 and 2022 presented the expected climate change effects in Lebanon obtained from university research programs and scenarios that have been developed for Lebanon through the application of the PRECIS RCM model (SNC), MENA CORDEX RCM (TNC), EURO CORDEX RCM at resolution 12.5 km x 12.5 km (FNC).

SNC

The main results of key climate variables in Lebanon as simulated by PRECIS were presented as changes of the respective periods of the near and distant future compared to the “control” period of the last 20-30 years or the “recent past/ present”. According to PRECIS model and in relation to the present climate, by 2040 temperatures will increase from around 1°C on the coast to 2°C in the mainland, and by 2090 they will be 3.5°C to 5°C higher. Comparison with Lebanese National Meteorological System LNMS historical temperature records from the early 20th century indicates that the expected warming has no precedent. Rainfall is also projected to decrease by 10% to 20% by 2040, and by 25% to 45% by the year 2090. This combination of significantly less wet and substantially warmer conditions will result in an extended hot and dry climate. Temperature and precipitation extremes will also intensify. In Beirut, hot summer days (T_{max} > 35°C) and tropical nights (T_{min} > 25°C) will last, respectively, 50 and 34 days more by the end of the century. The drought periods, over the whole country, will become 9 days longer by 2040 and 18 days longer by 2090.

In terms of seasonal changes, temperatures will increase more in summer and precipitation will decrease more in winter, while positive changes are predicted for autumn.

TNC

The TNC included the analysis results of the projected climatic changes in Lebanon and their impacts on natural resources based on the generation of dynamically downscaled regional climate modelling projection covering the Arab/Middle East North Africa (MENA) domain in accordance with the CORDEX program under RCP4.5 and RCP8.5 scenarios. These projections were carried out through the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources in the Arab Region (RICCAR) led by the United Nations Economic and Social commission for Western Asia (ESCWA). The projections were then linked to two regional hydrological models to specifically analyze the impact of climate change on the region’s freshwater resources.

In Lebanon, the projections by the end of the century compared to the baseline period of 1986-2005 results showed an increase in temperature by up to 3.2°C with an increasing warming trend reaching up to 43 additional days with maximum daily temperature higher than 35°C. It also showed a decrease in precipitation by 4% under RCP 4.5 and 11% under RCP8.5 with trends towards drier conditions with an increase in number of consecutive dry days (when precipitation < 1.0 mm) which indicates the extension of dry summer season. This combination of significantly less wet and substantially warmer conditions will result in hotter and drier climate.

FNC

The FNC, recently published by the MoE, provides an update on the country's greenhouse gas emissions, vulnerability to climate change, and efforts to address climate change. The FNC has adopted future climate projections for Lebanon from the IPCC Sixth Assessment Report (AR6) on Impact, Adaptation and Vulnerability as it is the most recent and comprehensive assessment of climate change impacts and future risks at global and regional levels. The report generated for the first-time new scenarios based on a three-dimensional matrix comprised of the Representative Concentration Pathways (RCPs), Socioeconomic Pathways (SSPs), and Climate Shared Policy Assumptions (SPAs).

The IPCC AR6 builds on the four pathways previously developed under the AR5 (2018) (RCP2.6, RCP4.5, RCP6.0, and RCP8.5), which were limited to different levels of greenhouse gases (emissions and other radioactive forcings, and adds five new narratives (SSPs) that take into consideration socioeconomic factors such as global population growth, access to education, urbanisation, economic growth, resources availability, technology developments and lifestyle changes (Meinshausen et al., 2020). The results of this more inclusive framework produced the Integrated Assessment Pathways (IAMs), which support the coordination across climate change research communities and provide a basis for systematic analysis of key questions of mitigation and adaptation, under different climate and socioeconomic futures.

Several projects (Verner et.al, 2017 and World Bank, 2022b) and research studies (Almazroui, 2019; Bucchignani et al., 2018; Driouech et al., 2020; Ntoumos et al., 2020; Spinoni et al., 2020; Zittis et al. 2021; Varela, et al., 2020; Zittis, et al., 2019; Zittis and Hadjinicolaou, 2017) have examined the climatic profile of Lebanon and/or the Eastern Mediterranean and the Middle East over the years, intending to project probable changes in the near and far future. In particular, and due to the complex topography and various microclimates in Lebanon and the lack of spatially and temporally complete meteorological records, various external data sources, tools, and models, such as the EURO CORDEX dataset, the CMIP5/CMIP6 datasets, the ARAB Domain dataset generated by RICCAR, the World Bank's Climate Change Knowledge platform, and others, have been used to conduct climatological studies in Lebanon, yielding a wide range of results.

- Temperature

Adjusted climate projections from EURO CORDEX show that the annual mean temperature increase ranges from 1.6°C (RCP4.5) to 2.2°C (RCP8.5) by mid-century and from 2.2°C (RCP4.5) to 4.9°C (RCP8.5) by end-century when compared to the reference period 1986-2005.

In the analysis done under RICCAR (ESCWA, 2021), downscaling at 10 km was performed for annual and seasonal air temperatures for an ensemble of six SSP5-8.5 models for the near-term (2021-2040) and midterm (2041- 2060) periods. The increase of annual temperature for the period 2021- 2040 as compared to the reference period (1995-2014) is on the average around 1.2°C, with limited deviations between coastal and mountainous areas (although the increase is most pronounced in the latter ones). The respective increase of annual temperature for the period 2041-2060 is on average around 2°C, while it ranges from 1.8°C to 3°C depending on the area (coastal/inland south to mountainous respectively) within Lebanon.

- Precipitation

Precipitation is expected to decrease by 6.5% to 9% by mid-century and by 9% to 22% by end-century based on RCP scenarios' most recent projections (RCP4.5 and RCP8.5 respectively). It is important to note that previous scenarios from 2014 projected a 4% decrease in precipitation per each degree of global warming, which further highlights the fact that recent projections are showing almost 1.5 times the previously projected impacts for both mid- and end-century scenarios since temperatures are increasing more intensely and within a shorter timeframe. Climate projections for annual precipitation for the SSP5-8.5 scenario show a more severe reduction of 10% to 16% by mid-century and by end-century respectively as compared to the reference period of 1995-2014.

- Consecutive Dry Days

Increase in all regions for the periods 2021-2040 and 2041- 2060 for SSP5-8.5 is expected, although more pronounced at the southern regions and along the coast. On the basis of several precipitation indicators, drought risk is expected to increase towards 2050 under all scenarios (RCP4.5 and RCP8.5 as well as for SSP5-8.5).

- Heat waves

Increase in duration and intensity is expected, with considerable health impacts to people living in urban areas as well as enhanced needs for energy consumption for cooling needs. In terms of the days with temperature above 35o C (SU35) and 40°C (SU40), they are expected to almost double for the period 2041- 2060 compared to the reference period 1995-2014 with the increase being more pronounced in the case of summer, at both the coastal and inland regions of Lebanon.

- Extreme events

Compound events of heatwaves and droughts are expected to increase almost fivefold for the period 2041-2060 as compared to the reference period 1986-2005. The increase will reflect up to 15 more incidents for inland Lebanon, and 20+ incidents for the northeast and southeast regions. Increase will be overall less pronounced in coastal regions.

4.2.2 Adopted Climate Change Data

In this study, climate projection data from the World Bank Climate Change Knowledge Platform were adopted for climate change scenario. CCKP is a modeled data from the global climate model compilations of the Coupled Model Inter-comparison Projects CMIP6 which supports the IPCC's Sixth Assessment Report. Projection data is presented at a monthly temporal resolution but at 100km x 100km spatial resolution. CCKP continues to add new, additional indicators as they are produced and as appropriate.

Climate projections for Lebanon for the SSP2-4.5 scenario show an increase in the annual mean temperature by 0.9°C for 2020-2039 and 2.5°C by end-century. SSP5-8.5 scenario shows an increase in the annual mean temperature by 1.1°C by mid-century and 4.7°C by end-century, which is more or less aligned with the RCP scenario analysis. As for the precipitation, a change of the monthly precipitation between +20% and – 17% for SSP2-4.5 scenario and of +5% and -11% is expected for SSP5-8.5 scenario.

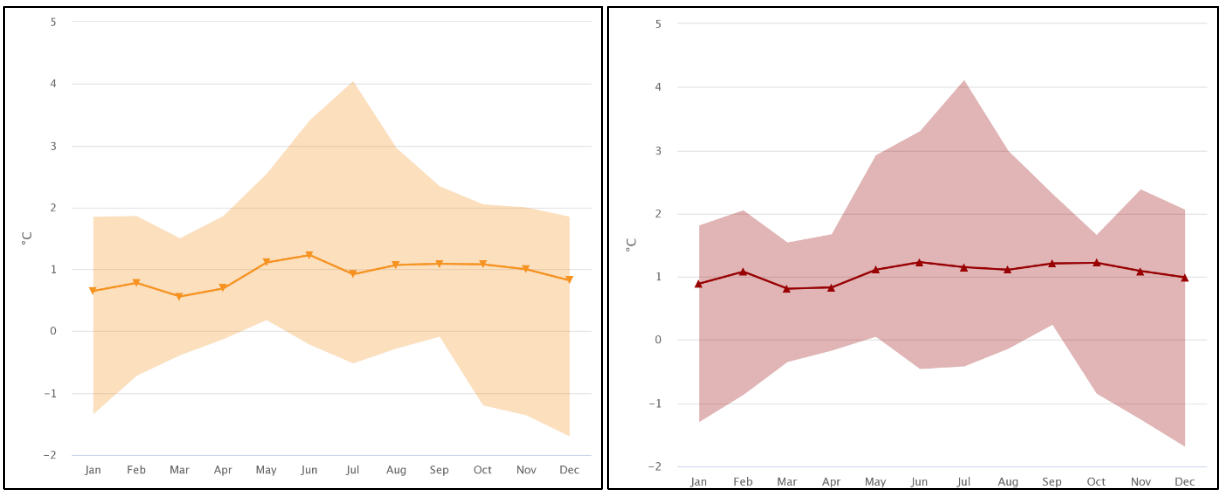


Figure 13 Projected change of mean temperature for 2020-2039 in Lebanon under SSP2 – 4.5 and SSP5-8.5 (Reference Period: 1995-2014) from World Bank CCKP.

Table 10 Projected change of mean temperature for 2020-2039 in Lebanon under SSP2 – 4.5 and SSP5-8.5 (Reference Period: 1995-2014) from World Bank CCKP.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Historical Reference Period 1995-2014	7.6	8.2	10.7	14.3	18.1	22.3	24.8	25.2	22.9	18.9	13.5	9.2
SSP2-4.5	8.3	9.0	11.3	15.0	19.2	23.5	25.7	26.2	23.9	20.0	14.5	10.0
Anomaly	0.7	0.8	0.6	0.7	1.1	1.2	0.9	1.1	1.1	1.1	1.0	0.8
SSP5-8.5	8.5	9.3	11.5	15.1	19.2	23.5	25.9	26.3	24.1	20.1	14.6	10.2
Anomaly	0.9	1.1	0.8	0.8	1.1	1.2	1.2	1.1	1.2	1.2	1.1	1.0

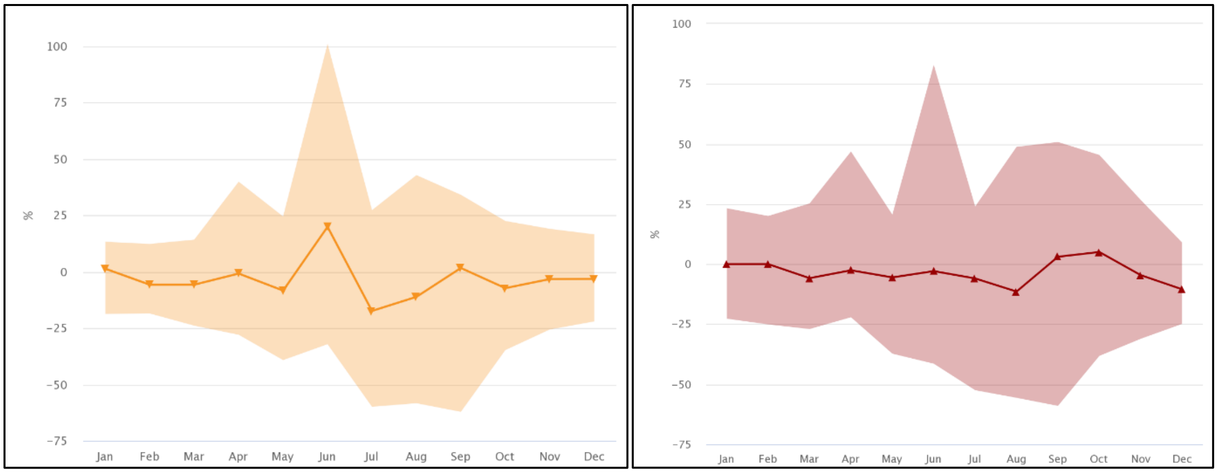


Figure 14 Projected Precipitation Percent Change anomaly for 2020-2039 in Lebanon under SSP2 – 4.5 and SSP5-8.5 (Reference Period: 1995-2014) from World Bank CCKP.

Table 11 Projected Precipitation Percent Change anomaly for 2020-2039 in Lebanon under SSP2 – 4.5 and SSP5-8.5 (Reference Period: 1995-2014) from World Bank CCKP.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SSP2-4.5	1.3	-5.8	-5.8	-0.9	-8.4	19.8	-17.4	-11.2	1.6	-7.3	-3.3	-3.3
SSP5-8.5	0.0	0.0	-5.8	-2.6	-5.5	-2.9	-6.0	-11.4	3.1	5.1	-4.6	-10.5

4.2.3 Impact of climate change on domestic water demand

Assessing the impact of climate change on domestic water demand is a complex task that requires considering multiple factors, including the socio-demographic composition of homes residing in different types of dwellings, cultural, behavioral, and attitudinal aspects of water consumption, as well as the availability and quality of water resources. Additionally, the impact of climate change on water demand is not uniform across different regions, and it varies based on local climate conditions, water availability, population density, and economic factors.

Moreover, water consumption patterns are not static and are influenced by several complex factors, such as cultural and social norms, economic incentives, technological innovations, and policy interventions. Therefore, understanding the underlying factors driving water consumption and the potential impacts of climate change on water demand requires a multidisciplinary approach that incorporates both quantitative and qualitative research methods.

Furthermore, there are various challenges associated with conducting research on urban home water use behavior, such as the lack of reliable data on water consumption, difficulties in measuring water consumption accurately, and limited public awareness and understanding of the importance of water conservation. Therefore, researchers need to use innovative and robust research methods to overcome these challenges and gain a more comprehensive understanding of the complex factors driving water demand and use in urban settings.

In this regard, a study addressing the impact of climate change on water demand by linking water demand and weather using Coupled General Circulation Models, was conducted in Naples (Italy) and revealed that the total district water demand could increase by 9-10% during the weeks with the highest temperatures, and this increase varied depending on the social characteristics of the users. Moreover, the study highlighted the relevance of disaggregating consumption based on social characteristics to determine the climate change effects on water demand more accurately. Future weather scenarios for 2040-2100 suggest that the daily water demand could increase mainly due to increases in air temperature, which could lead to significant supply and operational failures in water systems. (Fiorillo et al. 2021).

However, there is uncertainty regarding the impact of climate change on domestic water demand. While some studies suggest an increase in water demand due to higher temperatures and changes in precipitation patterns, the exact magnitude of this effect is not clear. Furthermore, the seasonality of water demand and water availability in Mediterranean countries is an important factor to consider, with demand typically higher in dry months which is of a relatively minor influence compared to the overall demand throughout the year, especially in moderate countries like Lebanon.

Hence, assuming that the fresh water demand (domestic, industrial and physical losses) shall increase by 10% during summer season (90 days), the overall increase would be only 2.5% increasing the total domestic water demand in 2035 from 70,142 m^3/d to 71,896 m^3/d.

5 Water Demand Management Measures and Mitigation Scenarios

5.1 Overview

Water demand management refers to the implementation of policies or measures which serve to control or influence the amount of water used. Effective water demand management requires a combination of measures, such as improving water efficiency and conservation, reducing water losses, promoting water reuse and recycling, and managing demand through pricing and other economic instruments. It is a shift towards more sustainable water use practices and policies to ensure the availability of clean water resources for future generations with a stakeholder engagement and public awareness in achieving sustainable water use.

There are several different water demand management measures that can be implemented to promote sustainable water use. Some of these measures include:

- Integrating water management across sectors: This involves adopting a holistic approach to water management that considers the needs of different sectors, such as agriculture, industry, and households, as well as the ecological requirements of aquatic ecosystems.
- Improving water efficiency: This involves using water more efficiently through the use of water-efficient technologies, appliances, and practices. For example, installing low-flow showerheads, toilets, and faucets, or using water-efficient irrigation systems can help reduce water consumption.
- Promoting water conservation: This involves encouraging water conservation behaviors among individuals and communities. This can include public awareness campaigns, education and outreach programs, and incentives for water conservation.
- Reducing water losses: This involves reducing the amount of water lost due to leaks, pipe failures, or other issues in water supply systems. This can be achieved through improved maintenance, repairs, and upgrades to water infrastructure.
- Managing demand through pricing and economic instruments: This involves using pricing and other economic instruments to influence water consumption patterns. This can include tiered pricing structures, water-use charges, or water-saving incentives.
- Relying on renewable energy : Water treatment facilities are significant energy consumers. By adopting renewable energy sources such as solar panels and wind turbines to power these facilities, it is possible to reduce the energy-related water consumption in the treatment and distribution of water.

These measures can be implemented at various levels, from individual households to large-scale water supply systems, to promote sustainable water use and reduce water demand.

5.2 Proposed measures at the participatory approach

On November 28th 2022, a participatory workshop was held at Antonine University Baabda. The workshop was attended by the mayors and members of municipalities, representatives from the Ministry of Energy and Water, Beirut and Mount Lebanon Water Establishment, research institutions, academia and CSOs. During the workshop, various challenges faced by the GRB were discussed, including river pollution, industries violations, random dumps, building irregularities, social and environmental problems, governance, human resources, environmental impact, unlicensed wells, drinking water networks, and non-enforcement of laws.

To address these challenges, the stakeholders have proposed the establishment of a specialized committee comprising various governmental departments such as the MoEW, BMLWE, MoE, Ministry of Public Health, Ministry of Interior, etc. The committee's tasks include adherence to laws and the suppression of violations. A directive plan for the management of natural resources should also be developed, and the committee should meet regularly.

Other solutions discussed during the workshop included the definition and delineation of Ghadir riverbed public domain, removal of all illegal structures within the river domain, implementing the flood mitigation measures as addressed in the CDR study, rehabilitation of Ghadir WWTP and increase of the collection network coverage, separating water and wastewater intermix, identify and locate primary point sources of pollution, groundwater recharge for seawater intrusion, conducting awareness campaigns.

Overall, the participatory workshop was a success in bringing together stakeholders to address the challenges faced by GRB and develop a collaborative approach to managing its resources.

The suggested solutions were translated into the following measures:

- Implementing CDR study for GRB flood mitigation.
- Increase the frequency and effectiveness of riverbed cleaning activities.
- Implement separate stormwater and wastewater drainage systems to prevent intermixing.
- Strengthen enforcement mechanisms to prevent illegal construction activities within the riverbed.
- Enforce stricter regulations and standards for industrial wastewater treatment and discharge.
- Develop plans for the rehabilitation, expansion and upgrade of the sewer system.
- Implement proper management practices to prevent saltwater intrusion, such as groundwater aquifer recharge, reduce reliance on contaminated private wells, and promoting sustainable water use.
- Strengthen the capacity and financial resources of local municipalities to effectively manage and address environmental issues in the basin.

Several of these measures are aligned with the measures proposed by the updated NWSS 2020, detailed in the next section.

5.3 Proposed measures in the Updated NWSS 2020

The Updated NWSS 2020 outlines several water management measures that can be implemented to reduce water consumption and promote more efficient use of water resources in GRB. These measures include:

Improved water sector governance

- The legal framework: In-depth revision of all legal documents governing the water sector with identification of overlaps and inconsistencies, with the aim of producing a Code. Prioritization of bylaws required by Law 192/2020 based on importance and urgency. Development of bylaws in consultation with appointed stakeholders.
- The Institutional Framework: develop and implement a human resources strategy for the water sector. This measure aims to address issues related to recruitment and retention, training and development, performance management, and succession planning. Improving the capacity and effectiveness of water institutions in Lebanon through a human resources strategy is seen as a critical measure to ensure the sustainable management and delivery of water services.
- Supervision, Monitoring & Reporting: Creation of a monitoring department within MoEW to enhance the administrative supervision framework of MoEW by focusing on the performance of the Water Establishments (WEs). Standardizing the structure of reports and audits is another measure, including the development of annual and monthly activity reports and annual external audits and evaluations of the WEs. Finally, the establishment of a unified database to include all sector monitoring data and ensure it is regularly updated is recommended.
- The financial and commercial frameworks: Establishment of financial and commercial frameworks to support the sustainable management of water resources in Lebanon. This includes the development of a cost-recovery strategy, the establishment of water tariffs based on cost and service level, and the introduction of a transparent and efficient financial management system.
- Operation and maintenance: establishment of a comprehensive operation and maintenance plan for the water sector facilities and equipment. This includes the development of an asset management system, routine and preventative maintenance procedures, and training programs for staff.

Integrated water resources management

- Integrated Water Resources Management (IWRM): Development and implementation of IWRM through the establishment of basin schemes and the enforcement of the water code. This measure involves the adoption of an integrated approach to manage water resources, where different stakeholders from various sectors are engaged in planning and decision-making processes to ensure the sustainability of water resources in the country. The basin schemes refer to the delineation of water resources based on river basins or aquifers, and the development of plans for the management of water resources in these areas. These plans take into consideration the different uses of water resources, such as agricultural, industrial, and domestic use, and aim to ensure the optimal allocation of water resources while preserving the environmental and ecological balance.

- Integrated Hydrological Information System (IHIS): Creating IHIS that consists of data measurement at all types of water resources and the establishment of a data center at MoEW, interlinked with data centers at the level of the WEs
- Groundwater resources management: Establishment of a comprehensive groundwater monitoring network to manage the country's groundwater resources. This includes developing a database of groundwater wells and measuring water levels, quality, and quantity at regular intervals to ensure sustainable use of groundwater resources. The data collected will be used to inform decision-making, identify areas of concern, and develop appropriate management strategies. Additionally, the measure also includes the development of a groundwater protection strategy to safeguard the quality and quantity of the resource.
- Water quality monitoring: establishing a comprehensive water quality monitoring network to identify and assess the quality of water resources in Lebanon. This network will be used to monitor the quantity and quality of water resources, identify pollution sources, and measure the impact of pollution on water quality. The information obtained from the network will be used to develop effective management strategies to maintain and improve the quality of water resources in Lebanon.
- Disaster risk management (DRM): implementation of DRM measures in order to reduce the negative impacts of natural disasters on water resources and water-related infrastructure such as floods, droughts and forest fires. The DRM measures include emergency response plans, risk assessments, early warning systems, capacity building and public awareness campaigns, as well as collaboration with other sectors and stakeholders. The objective is to improve the resilience of the water sector to disasters and ensure the continuity of water supply services.
- Non-conventional water resources: promotion of the use of non-conventional water resources such as artificial aquifer recharge, wastewater reuse and rainwater harvesting. The strategy emphasizes the need for regulations, incentives, and awareness campaigns to encourage the adoption of non-conventional water resources.

<u>Service Coverage</u>

In order to satisfy the water needs of the population residing in GRB up to 2035 and cover the water deficit occurring, the Updated NWSS 2020 highlights several proposed projects as part of its implementation. These proposed projects include the expansion of surface water storage through dams and hill lakes, drilling new wells, the construction of wastewater treatment plants enhancing water quality and reducing pollution and the rehabilitation of water networks hence improving network efficiency. These projects aim to improve the water sector's efficiency, sustainability and reliability in meeting the growing demand for water in Lebanon.

In summary, the projects selected for the priority 1 phase in Baabda Aley district include:

- 54 km of distribution network,
- 11 wells to be drilled and equipped,
- 13 reservoirs to be constructed,
- 1 WTP and 1 PS to rehabilitate
- 2 springs to catch

The projects selected for the priority 1 phase in Chouf district include:

- 13 km of transmission lines,

Furthermore, the projects selected for the priority 2 phase consist of the installation or extension of distribution networks where needed. In Baabda/Aley district, 106 km are proposed to be executed while in Chouf district, 39 km have to be installed. Moreover, the implementation of SCADA system (A Supervisory Control and Data Acquisition system (SCADA) acts as a centralized monitoring and control hub for the components of the water network , including reservoirs, pumps, valves, pipelines …) and DMA systems (A DMA system divides a distribution network into smaller areas that will provide a flow control for each area, leak detection and isolation, water quality monitoring, …) are suggested to connect all the components and facilitate the control and monitoring. Irrigation within GRB is considered for the priority 3 phase. The proposed projects are detailed in Table 12 to Table 16.

Table 12 List of projects proposed in the updated NWSS 2020 within GRB which objective is to increase domestic water supply

Sector	District	Distribution/Collection System	Proposed Project
WATER	BML-W. C. District of Baabda Aley	Daychouniyeh	Drilling and equipping 11 wells (18.5l/s each)
	BML-D. Chouf	-	Bisri Dam 125 MCM (Supplying 10 MCM for GRB)

The demand of 6 distribution systems within GRB will be supplied from Bisri Dam/ Awali conveyor (planned to be executed in 2035 according to NWSS) from outside the basin with a total of 26980 m^3/day or 10 Mm^3/ year. The supply for each of the distribution system are presented in Table 13.

Table 13 Daily water supply from Bisri dam/ Awali conveyor for each of water system within GRB

Water Distribution system	Water Supply (m^3/day)
Ain el delbe	6000
El Daychounieh	11500
Bsous	800
Kfarchima	400
Mechref	1080
Chweifat	7200
Total	26980

Table 14 List of water projects proposed in the updated NWSS 2020 within GRB

Project code	Description	Estimated cost (USD)
BML-W C. District of Baabda Aley		
BML-W. C.2	Chweifat Distribution system Including: Priority 1 Priority 2 - 55 km Distribution network	4,700,000 $
BML-W. C.3	El Daychounieh Distribution system Including: Priority 1 - Drilling and equipping 11 wells - 24 km Distribution networks - Rehabilitation of Daychouniyeh WTP - Treatment for Galery Semaan Well - Rehabilitation of Jamhour Pumping Station - Artificial Recharge of Hadath-Hazmieh Underground Water Basin	15,500,500 $
BML-W. C.4	Ain el Delbeh Distribution system, including: Priority 1 Priority 2 - 1.5 km Distribution network	130,000 $
BML-W. C.5	Local Distribution system Including: Priority 1 Priority 2 - 49.5 km Distribution network	3,960,000 $
BML-W. C.6	Raayan Distribution system Including: Priority 1 - 30 km Distribution networks - Catchment works of Ain El Saouda and Ain El Jawzeh Springs - Construction of 1 x 500 m³, 1 x 400 m³, 2 x 250 m³, 2 x 100 m³, 5 x 150 m³, 2 x 1000 m³ reservoirs Priority 2 - 467 km Distribution network	5,200,000 $ 39,300,000 $
BML-W. C.7	For All Systems: Priority 1 - Remote Control and Monitoring of Water Systems (SCADA And DMA) Priority 2 - Remote Control and Monitoring of Water Systems (SCADA and DMA)	10,000,000 $ 5,000,000 $
	Total Baabda Aley district	**83,790,000**
	Out of which: Priority 1	30,700,000
	Priority 2	53,090,000
	Priority 3	-
BML-W E. District of Chouf		
BML-W. E.4	Raayan system Including: Priority 1 - 13 km Transmission line Priority 2 - 39 km Distribution network	1,240,200 $ 3,310,000 $
BML-W. E.6	For All Systems: Priority 1 - Remote Control And Monitoring Of Water Systems (SCADA And DMA) Priority 2 - Remote Control And Monitoring Of Water Systems (SCADA and DMA)	10,000,000 $ 5,000,000 $
	Total Chouf district	**19,550,200**
	Out of which: Priority 1	11,240,200
	Priority 2	8,310,000
	Priority 3	-

Table 15 List of wastewater projects proposed in the updated NWSS 2020 within GRB

Project code	Description	Estimated cost (USD)
BML-WW C. District of Baabda Aley		
BML-WW. C.4	El Ghadir collection system - 329 km Collection network	47,000,000
	Total Baabda Aley district	**47,000,000**
	Out of which: Priority 1	47,000,000
	Priority 2	-

Table 16 List of irrigation projects proposed in the updated NWSS 2020 within GRB

Project code	Description	Estimated cost (USD)
BML-IR D. District of Baabda		
BML-IR. D.1	Baabda scheme - 4 km Concrete channels to rehabilitate - 1.5 km Earth channels to concrete - Extension of Networks to Cover Present Dry Farm Area	2,591,700
	Total Baabda district	**2,591,700**
	Out of which: Priority 1	-
	Priority 2	-
	Priority 3	2,591,700

5.4 Mitigation/Intervention scenarios

Two mitigation/intervention scenarios can be defined based on the different water demand management measures previously presented in sections 5.2 and 5.3. These scenarios and their combinations shall be built over the future business-as-usual scenarios.

The first is a scenario that takes into account the impact of the proposed water supply increase infrastructure under the updated NWSS 2020 in 2035.

The second is a scenario that assumes complete coverage of domestic and irrigation water demand by additional infrastructure to meet unmet demand.

Table 18 the complete list of scenarios and their combinations that shall be simulated and analyzed in WEAP for 2035.

Table 17 Complete list of future scenarios

Scenarios Name	Description	Combination ID
Business as Usual	Increase of domestic water demand and supply according to demographic expansion	S0
NWSS Proposed	Implementation of water supply infrastructure and water conservation measures as proposed in the NWSS for 2035	S1
Domestic Complete Coverage	Simulation with the implementation of additional infrastructures to meet unmet domestic demand	S2
Climate Change*	Climate change scenario with incorporation of CMIP6 climate anomalies	S0CC, S1CC, S2CC

* The climate change scenario can be applied in combination with all the other scenarios. A unique scenario was implemented, SSP5-8.5, considering that the variation between the different climate change scenarios is negligible both for temperature and precipitation, simplifying the multiplicity of scenarios in WEAP.

Table 18 List of future scenarios combinations

Combination ID	Business as Usual	Climate Change	NWSS Measures	Complete Domestic Coverage
S0	X			
S1	X		X	
S2	X		X	X
S0CC	X	X		
S1CC	X	X	X	
S2CC	X	X	X	X

6 WEAP Results of Future Scenarios

6.1 Results Exploration

This section will explore the main results obtained for the future scenarios modeling of GRB.

6.1.1 Results of Hydrological model

Within GRB the river is not being used for water supply purposes and it is hard to envision measures that could harness this surface water availability in a cost-effective manner. Nevertheless, we have assessed the potential impact in the hydrological model due to climate change. Within Table 19 we can observe the adopted effects of climate change within precipitation and evapotranspiration as opposed to the reference values used during the calibration of the baseline.

Table 19 Climate Change effects in hydrological model inputs

Month	Precipitation (mm)			Reference Evap (mm)	
	SSP5-8.5 (%)	Prec Hist	CC Prec	EtRef	EtR CC
Jan	0.0	158.5	158.5	47.7	59
Feb	0.0	126.3	126.3	56.4	62
Mar	-5.8	66.5	62.6	86.4	94
Apr	-2.6	34.0	33.1	116.7	120
May	-5.5	16.5	15.6	154.1	154
Jun	-2.9	1.1	1.1	183.8	196
Jul	-6.0	0.0	0.0	197.4	220
Aug	-11.4	0.0	0.0	180.4	208
Sep	3.1	10.9	11.3	139.0	153
Oct	5.1	52.8	55.5	109.6	120
Nov	-4.6	87.6	83.6	73.6	82
Dec	-10.5	143.0	128.0	50.7	63

The table above includes the projected anomaly for our chose climate change scenario expressed in percentage and the resulting projected precipitation (CC Prec) against the historical value. In a similar way, the Reference Evapotranspiration, both historical and projected can be noted, showing the amount of water that could result in actual evapotranspiration that depends on the land use at site.

As a consequence, results presented in Figure 15 show a 4.9 % reduction in the component of runoff reaching Ghadir river. This reduction is mainly perceived in March and December. The overall discharge volume is 11.0 Mm^3/year within projected business as usual scenario S0, dropping to 10.4 Mm^3/year in climate change projected scenario S0CC.

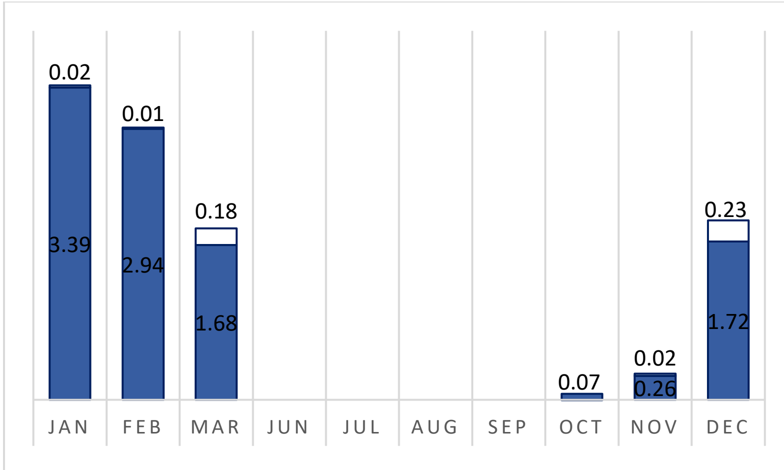


Figure 15 Hydrological model results with climate change expressed in average discharge volume in Mm³

6.1.2 Results of WEAP Node based model

Within this section we will focus only on scenarios including climate change (S0CC, S1CC and S2CC), as it is more conservative and it is unlikely to remain in historical climate conditions within the following decades.

The starting point of our assessment is the S0CC business as usual scenario which serves as a baseline under climate change. Figure 16 shows the WEAP schematic for the node-representation of GRB.

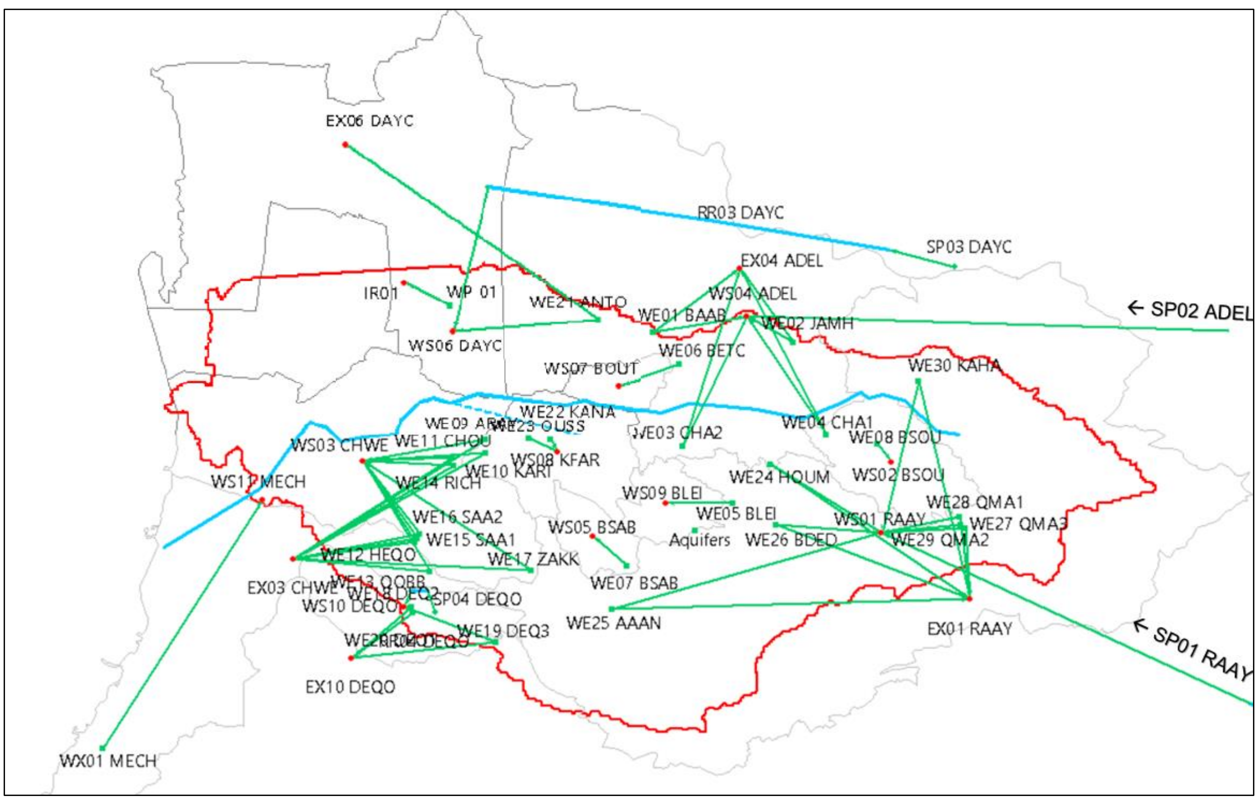


Figure 16 WEAP node-based representation for GRB

6.1.2.1 S0CC – Business as Usual Scenario under Climate Change

In this scenario, it was assumed that when it comes to climate change effects in demand, a 10% increase is foreseen during the summer months noticed within the domestic supply of water systems, as described in section 4.2.3: Impact of climate change on domestic water demand. Therefore, domestic supply increases from 125 l/cap/day to 137.5 l/cap/day during summer, averaging consumption of 46.8 m^3/person/year. The demand of the irrigation sector would not be augmented n GRB. As a result, the total demand of GRB is the following:

- Total Demand 2020 = 17.7 Mm^3/year
- Total Demand 2035 = 20.4 Mm^3/year

These demands **do not** account for losses. Figure 17 shows the augmentation of the demand for the different water systems.

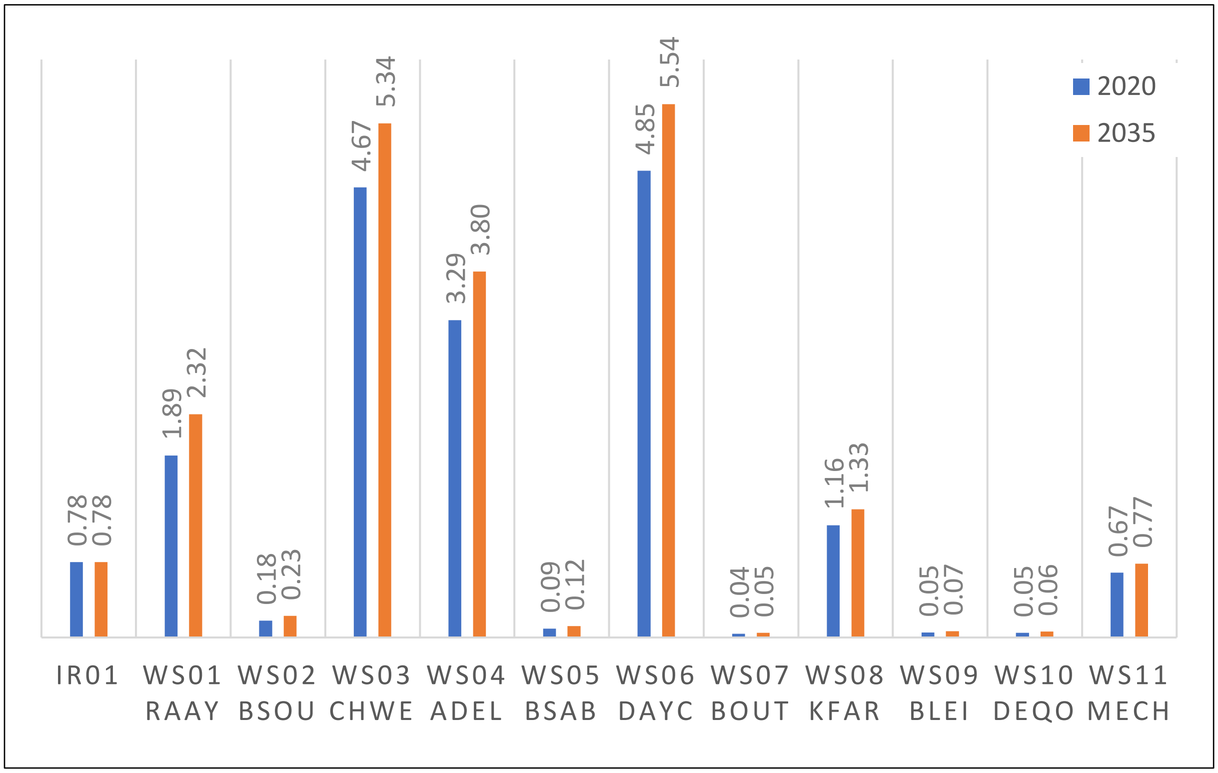


Figure 17 Water demand under S0CC for 2020 and 2035 (Mm^3/year)

On the other hand, Figure 18 shows the water supply, classified into springs and wells. There is a slight augmentation in supply following the augmentation of demand up to the limit that the corresponding sources can provide. Within S0CC scenario, the Raayan Spring as well contemplates an increase from 2550 m^3/d to 4657 m^3/d as this is already established.

As a result, the total supply of GRB is the following:

- Total Supply 2020 = 15.7 Mm^3/year
- Total Supply 2035 = 16.7 Mm^3/year

These demands **do** account for losses.

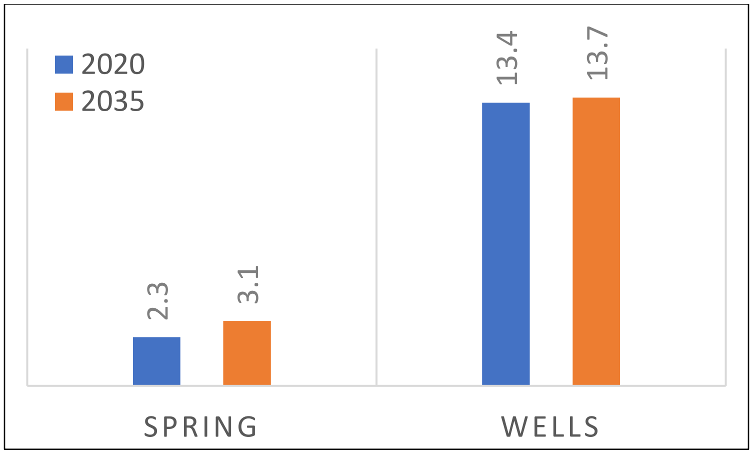


Figure 18 Water supply under SOCC for 2020 and 2035 (Mm³/year)

When comparing water demand, water supply and the actual water delivered after the losses occur, we obtain the coverage represented in Figure 19. It is important to mention that in this scenario no measures were implemented to reduce the losses, thus considering 50% efficiency, which account for all the losses in the system, from extraction, conduction, storage and distribution losses.

As a result, the total coverage of GRB is the following:

- Total Coverage 2020 = 46% & Total Unmet Demand = 9.6 Mm^3/y
- Total Coverage 2035 = 42 % & Total Unmet Demand = 11.7 Mm^3/y

These coverage and unmet demand **do** account for losses.

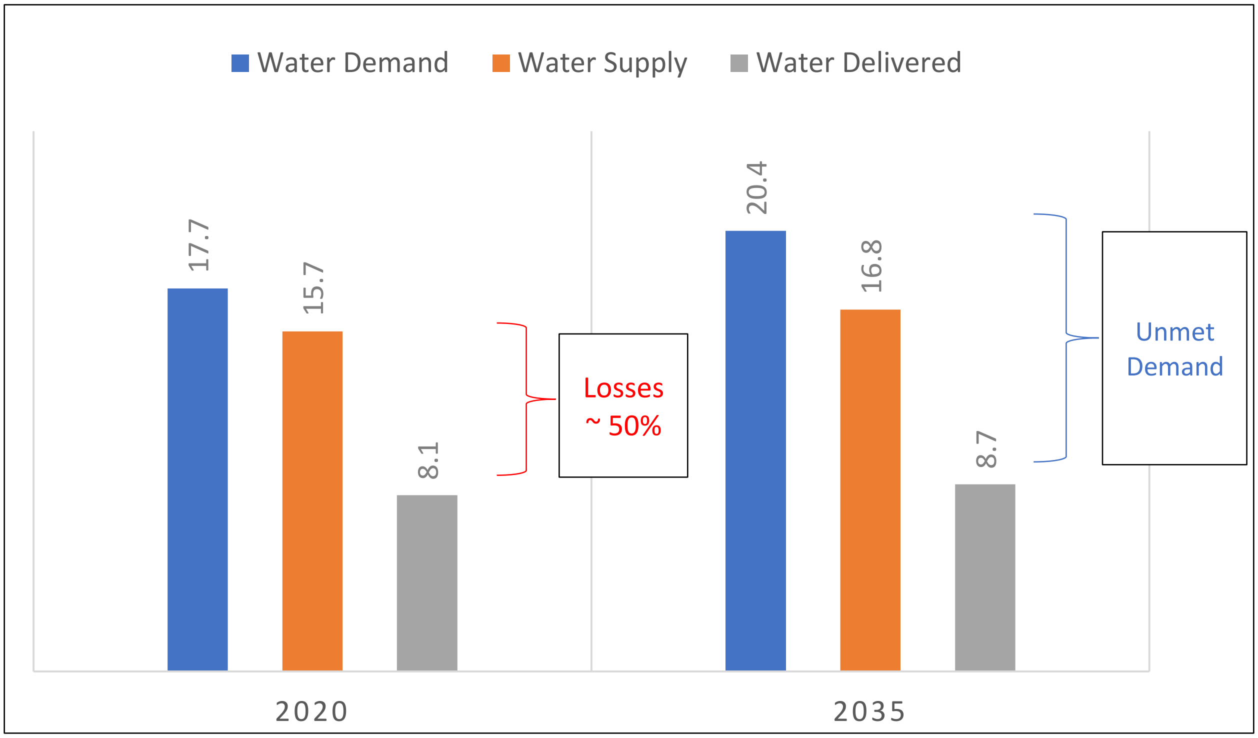


Figure 19 Coverage representation under SOCC for 2020 and 2035 (Mm³/year)

This unmet demand is shared between different systems, as represented in Figure 20. Being Daychouniyeh, Ain el Delbe, Chweifat, Raayan, Mechref and Kfarchima the systems affected by shortages.

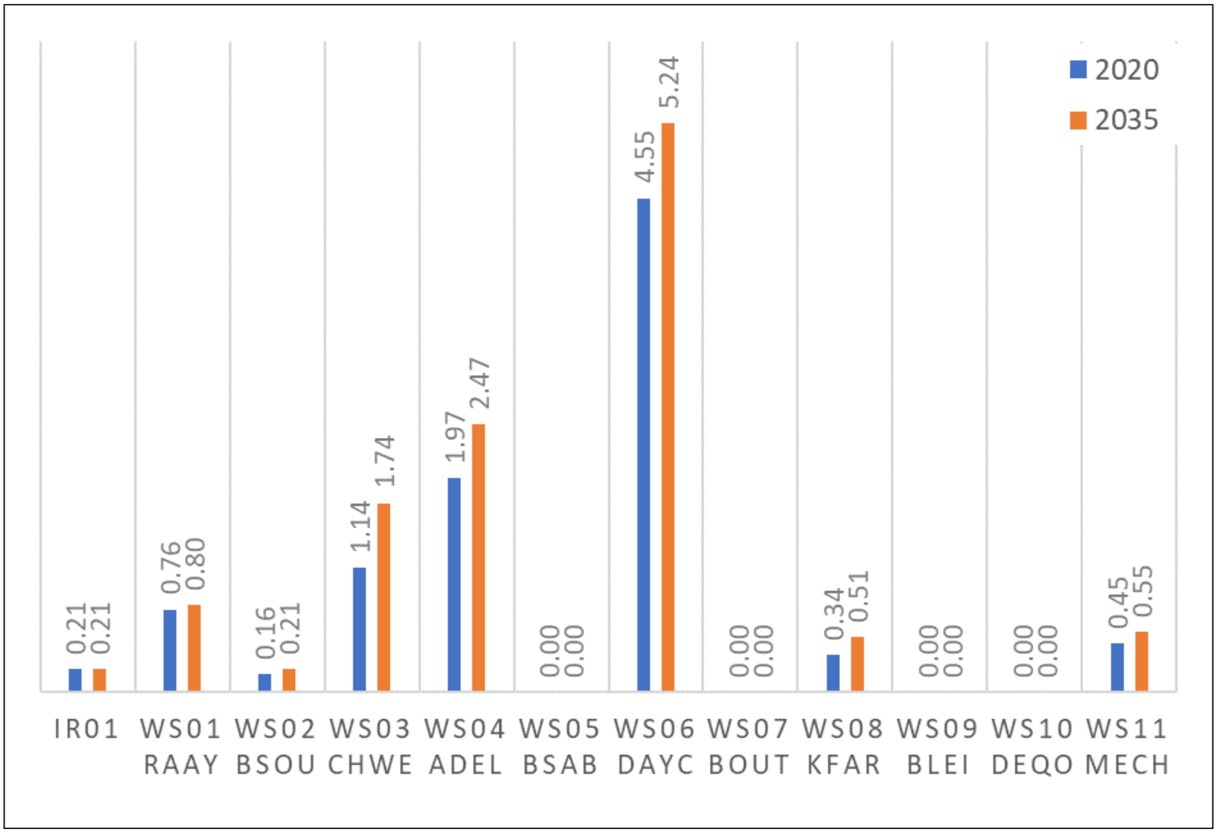


Figure 20 WS Unmet Demand under S0CC for 2020 and 2035 (Mm³/year)

6.1.2.2 S1CC – NWSS scenario under Climate Change

To deal with this unmet demand, several measures were proposed and shall be implemented before 2035 as described in section 5. These measures were included within the WEAP model as follows:

- Network efficiency increasing from 50% to 75%
- Additional supplies:
- Greater Beirut Water Supply Augmentation Project will be supplying up to 32000 m^3/d during summer and an average of 28890 m^3/d on a yearly basis, or 10.5 Mm^3/year. These values were obtained from an iterative calibration with WEAP unmet demand.
- Daychouniyeh wells: 11 wells of 20.5 l/s operating 24 hours to supply the portion of Mechref system that is inside GRB (6%), adding as a result 1169 m^3/d, or 0.4 Mm^3/year.
- A safe yield limit to promote sustainable groundwater abstraction, based on a bibliography review set to be 90% of the recharge of each aquifer.
- The Mechref wells external source which supplied Mechref system was disregarded from this system as there is a chance that there would be salinity issues in the future and they would be decomissioned.

Figure 21 shows the additional sources included in the model. The GBWSAP is identified as CE01 AWAL, while the 11 Daychouniyeh wells are included as WE31 DAYC and are supplying the Mechref system WS11 MECH.

As a result, from these additions, the unmet demand was reduced significantly, **reaching full coverage**, with the exception of the irrigation node IR01.

Figure 22 shows the increase of supply as part of the measures and the important of the effect of reducing losses within GRB coverage.

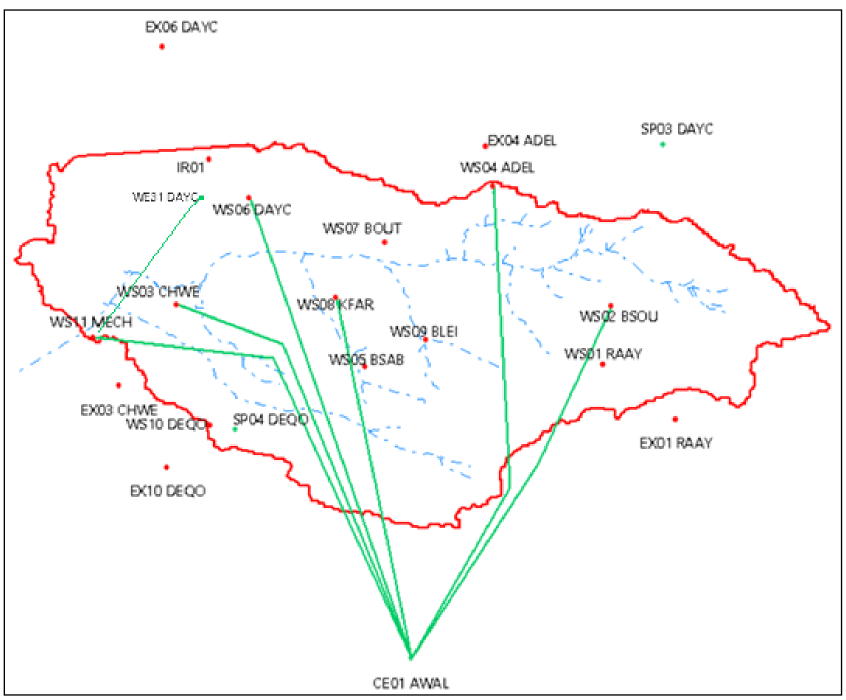


Figure 21 WEAP node-based representation for new sources under S1CC - NWSS scenario

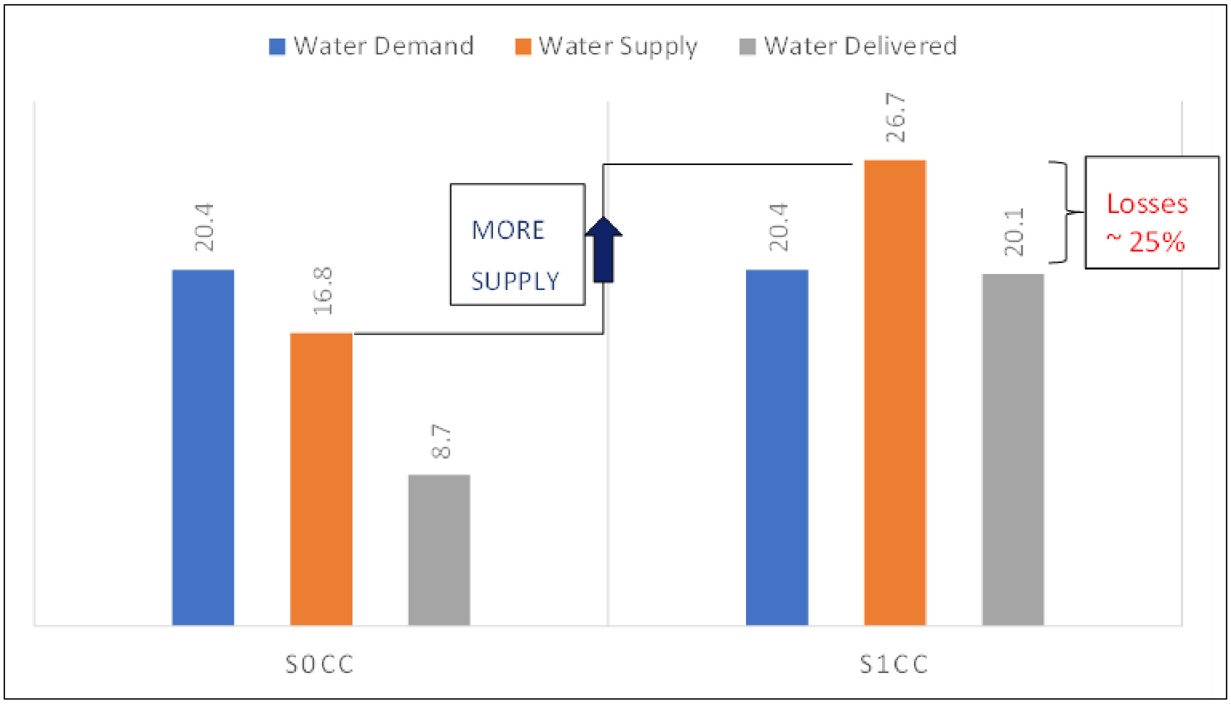


Figure 22 Coverage representation under S0CC and S1CC for 2035 (Mm³/year)

It is worth mentioning as well that the addition of the Safe Yield criteria for sustainable groundwater abstraction did not limit the current use. Although a further and deeper groundwater study is needed to precise this, initial results are encouraging. Current unavailability over groundwater monitoring data under a complex aquifer system prevented a deeper analysis of these aspects (see section 3).

6.1.2.3 S2CC – Complete Domestic Coverage scenario under Climate Change

Since complete domestic coverage was already achieved under the S1CC scenario, we have studied the effects of adding domestic water saving artifacts throughout GRB to optimize the domestic water demand. From a bibliographic review (see section 7.1.1), we estimate that a 25.5% reduction of domestic water demand can be reduced.

This reduction helps reducing the amount of supply needed for covering the demand throughout GRB. Figure 23 shows the reduction in water demand and water supply. As a result, we can see in Figure 24 the reduction of 3.4 Mm^3/year from GBWSAP and 2.9 Mm^3/year from the different wells achieving a total of 6.3 Mm^3/year.

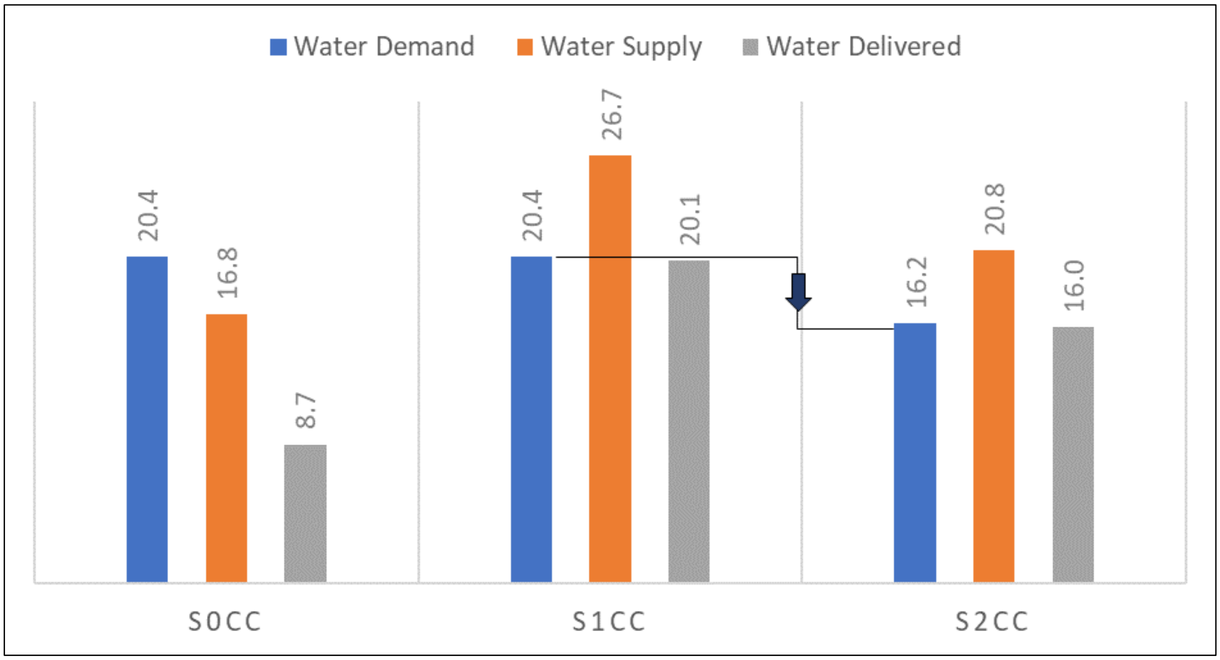


Figure 23 Coverage representation under S0CC, S1CC and S2CC for 2035 (Mm^3/year)

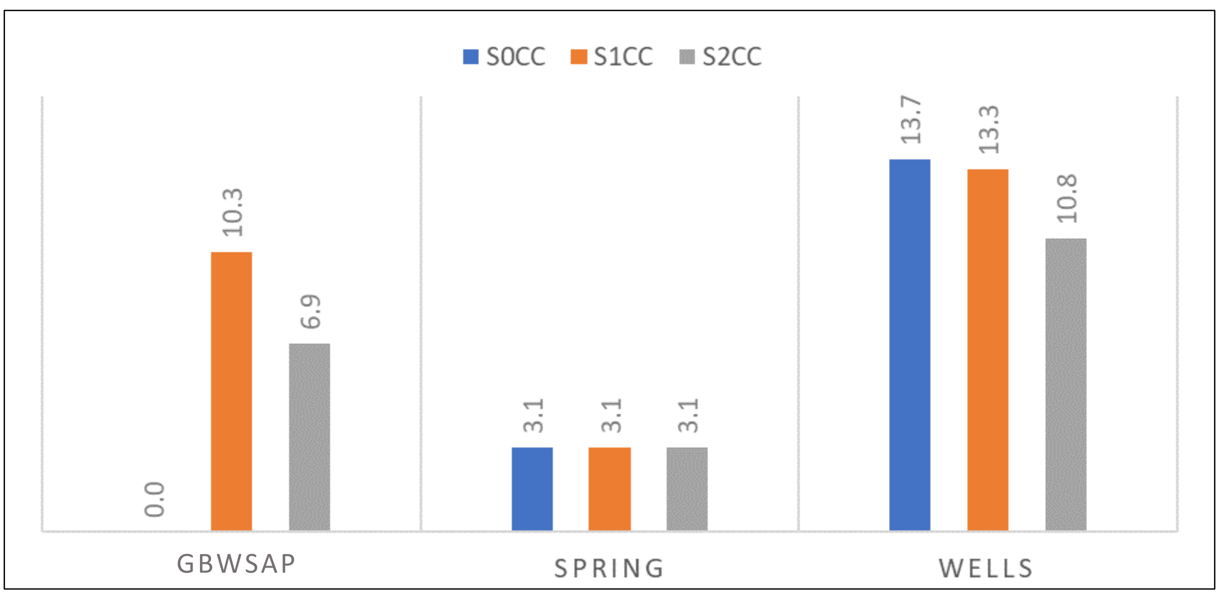


Figure 24 Water supply under S0CC, S1CC and S2CC for 2035 (Mm^3/year)

6.1.2.4 Summary of WEAP scenarios and results

As a summary, the following Table presents the different scenario combinations and results. The table presents as well the Net Present Value of each scenario. The estimations behind these values will be presented in the cost-benefit section.

Table 20 Summary of the WEAP scenarios and results

Combination & ID	S0CC	S1CC	S2CC
Business as Usual	X	X	X
Climate Change	X	X	X
NWSS Measures		X	X
Complete Domestic Coverage			X
Main modifications	Business as Usual considering climate change effects = 10% demand increase during summer	Network efficiency (50 to 75%) New Sources: GBWSAP = 10.5 Mm3/y Daychouniyeh wells = 0.4 Mm3/y Safe yield limit = 90% recharge of aquifers Mechref wells disregarded due to salinity	Water Saving artifacts = 25.5% reduction of domestic water demand
Water Demand (Mm^3/year)	20.4	20.4	16.2
Water Supply (Mm^3/year)	16.8	26.7	20.8
Water Delivered (Mm^3/year)	8.7	20.1	16
Unmet Demand (Mm^3/year)	11.7	0.3	0.2
Average coverage	42.6%	98.5%	98.8%
Net Present Value (M USD)	-25	-211	-211

7 GRB Policy Targets, Programme of Measures and Action Plan

7.1 Policy Targets and Programme of Measures

When designing a PoM, each measure comes with an associated investment cost. On top of the results of any assessment of measures, additional socio-economic factors come into interplay, such as the readiness of the technological solution, social acceptability, equitability, any constraints related to the implementation of the measures, etc. which can facilitate or impede the uptake and effectiveness of the measure. It is thus of paramount importance to stimulate a discussion with various stakeholders who bring in their local knowledge and expertise, and can verify the applicability of the findings, or highlight relevant constraints.

In this context, the objectives of the participatory approach in the GRB were to:

- Assess the level of awareness of stakeholders within the basin on the problem of unmet demand and water quality, its drivers and root causes, and future projections.
- Discuss and define, together with relevant stakeholders, a bundle of measures which are deemed adequate to tackle the issues of water supply reliability and water pollution in the basin, in order to safeguard their relevance and acceptability.
- Define relevant policy targets and an associated Programme of Measures (PoMs) in GRB based on a participatory process with stakeholders from all levels (central, regional, local), and draft an Action Plan with their relevant roles.

Following the site visits, the participatory workshop, the analysis of the basin characteristics, WEAP results, and the water quality campaigns, we concluded that GRB faces several challenges that impacts its water resources and overall management, mainly:

- Water Scarcity: Ghadir experiences water scarcity due to limited water resources within the basin and increasing water demands from domestic use and industry, hence relying on external sources. Climate change and population growth further exacerbate the scarcity issue.
- Poor Water Quality: Pollution from industrial discharges, and improper wastewater and solid waste management practices lead to water pollution and degradation of GRB water resources. This deteriorates water quality, affecting both human health and ecosystem health.
- Groundwater Overexploitation: Excessive extraction of groundwater, often due to unsustainable water supply and unregulated private wells, lead to groundwater depletion and intrusion of seawater.
- Flood: The recurrence of flood events has led to grave consequences affecting the urbanized area west of Old Saida Road in terms of property damages and, in a few cases, the unfortunate loss of human life.
- Lack of Collaboration and Integration: The absence of effective collaboration and coordination among relevant stakeholders, such as the MoE, MoEW, Municipalities, hinders comprehensive mitigation efforts.

As a result, a set of five (5) policy targets have been defined for the GRB. These policy targets would be subsequently addressed through a comprehensive action plan with relevant PoM. The primary purposes would be mitigating the issues of unmet demand and prevailing water stress conditions in the basin, as well as improving the water quality and limiting water pollution which can affect socio-economic growth and welfare. These are presented in Table 21 below.

Table 21 Policy targets resulting from participatory approach

Target Name	Target Code	No. of measures
Increase water use Efficiency and water Supply Reliability	ERS	6
Promote water COnservation	PCO	1
Protection of the Water resources and the Environment	PWE	10
PARticipatory water management	PAR	4
Socio-economic DEVelopment	DEV	1

To achieve these targets, a bundle of measures has been defined for each target, spanning from technical (infrastructure) and regulatory measures, to financial, educational and socio-economic measures, and addressing multiple sectors (i.e. the urban, agricultural, industrial, touristic, environmental). A total of 22 measures have been elaborated as presented in Table 22 and detailed further below.

Table 22 Programme of Measures for GRB

Measure ID	Name of the Measure	Category	Sector
Measures linked to the target "Increase water use efficiency and water supply reliability" (ERS)"			
ERS_U1	Actions to modernize the operation of water supply networks and improve water efficiency	Infrastructure	Urban
ERS_U2	Greater Beirut Water Supply Augmentation Project (GBWSAP)	Infrastructure	Urban
ERS_U3	Water metering and subscription to BMLWE,	Infrastructure	Urban
ERS_U4	Drafting / Updating of the BMLWE Water Supply Masterplan	Regulatory	Urban
ERS_M1	Regulating water tariffs, achieving cost recovery	Regulatory	Mix
ERS_M2	Monitoring and control of illegal abstractions and private wells, and definition of safe yield per groundwater body	Regulatory	Mix
Measures linked to the target "Promote Water Conservation (PCO)"			
WCO_U1	Water saving in households and buildings (public, commercial)	Infrastructure	Urban
Measures linked to the target "Protection of the Water resources and the Environment (PWE)"			
PWE_U1	Adjust existing / Implement separate stormwater and wastewater drainage systems to prevent intermixing.	Infrastructure	Urban
PWE_U2	Assessment of potential Artificial Aquifer Recharge for the prevention of seawater intrusion	Infrastructure	Urban
PWE_U3	Drinking water protection perimeters	Regulatory	Urban
PWE_U4	Municipal solid waste management	Regulatory	Urban
PWE_E1	Flood protection and mitigation (Ghadir flood control, CDR 2014)	Infrastructure	Environment
PWE_E2	Quantitative and qualitative water resources monitoring programme, Meteorological and Hydrometric network expansions and improvement	Infrastructure	Environment
PWE_E3	Increase the frequency and effectiveness of riverbed cleaning activities	Infrastructure	Environment
PWE_E4	Register of all pollution sources, estimation of pollution loads, assessment of significant pressures, and control of illegal dumping activities	Regulatory	Environment
PWE_UI1	Wastewater collection and treatment, maintenance of existing WWTP	Infrastructure	Urban, Industry
PWE_UI2	Drafting/Updating of BMLWE Wastewater Masterplan	Regulatory	Urban, Industry
Measures linked to the target "Participatory Water Management (PAR)"			
PAR_M1	Development of Ghadir River Basin Coordination Committee	Regulatory	Mix
PAR_M2	Strengthen the capacity and financial resources of local municipalities to effectively manage and address environmental issues in the basin.	Regulatory	Mix
PAR_M3	Raising awareness and sensitizing the community on the water resources and environmental related issues in Ghadir	Education	Mix
PAR_M4	Strengthen environmental program actions in primary education	Education	Mix
Measures linked to the target "Socio-Economic Development (DEV)"			
DEV_M1	Capacity building activities	Education	Mix

7.1.1 Urban sector

Measure ID and Name	ERS_U1: Actions to modernize the operation of water supply networks and improve water efficiency
Description	This measure focuses on modernizing the operation of water supply networks and improving water efficiency through the use of advanced technologies, upgraded infrastructure, and optimized operations. It aims to reduce water losses and enhance overall water management practices to achieve more sustainable water use. It includes: Leakage detection and control, rehabilitation of existing networks (incl. storage reservoirs), expansion of the BMLWE water supply network branches and connections. Improving network efficiency from 50% to 75%. The installation of solar panels in pumping stations is to be assessed.
Target	Residents, Municipalities, BMLWE
Activity Breakdown	In the Updated NWSS - 2020, there is a number of proposed rehabilitation/ expansion projects for BMLWE (see section 5.30). It includes the implementation of new distribution networks, wells, storage reservoirs, pumping stations, treatment plant, etc. until 2035. In summary, the proposed projects in Baabda/Aley district include: • 54 km of distribution network, • 106 km distribution network (priority 2), • 11 wells to be drilled and equipped, • 13 reservoirs to be constructed, • 1 WTP and 1 PS to rehabilitate • 2 springs to catch The proposed projects in Chouf district include: • 13 km of transmission lines, • 39 km distribution network (priority 2) Moreover, the implementation of SCADA and DMA systems is suggested to connect all the components and facilitate the control and monitoring.
Timespan/Timeline	Medium - Long term, planned to be executed before 2035. Once the measure is implemented the expected results/impact will be immediate.
Budget breakdown	CAPEX Baabda Aley: 83,790,000 USD Chouf: 19,550,200 USD
Constraints	Financial constraints, Stakeholder resistance

<table>
<tr><th>Measure ID and Name</th><th>ERS_U2: Greater Beirut Water Supply Augmentation Project (GBWSAP)</th></tr>
<tr><td>Description</td><td>Construction of the proposed Bisri dam and completion of Bisri/Awali scheme
Bisri Dam: Rockfill dam H = 73 m, L = 740 m; Lake: V=125 Mm^3, A=450 Ha;</td></tr>
<tr><td>Target</td><td>Residents, BMLWE, MoEW, World Bank</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Preparation and Land Expropriation (Achieved)
Act.2: Construction works
Act.3: Operation and Monitoring</td></tr>
<tr><td>Timespan/ Timeline</td><td>Medium to Long term
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Year 1</th><th>Year 2</th><th>Year 3</th><th>Year 4</th><th>Year 5</th><th>Year 6</th><th>Year 7</th><th>Year 8</th><th>Year 9</th></tr>
<tr><td>1</td><td>Expropriation and Land Preparation</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Construction works</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td></td><td></td></tr>
<tr><td>3</td><td>Operation and Monitoring</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td></tr>
</table></td></tr>
<tr><td>Budget Breakdown</td><td>CAPEX: Bisri Dam: 364,000,000 USD
Awali Project: 31,900,000 USD</td></tr>
<tr><td>Constraints</td><td>Financial crisis, Stakeholder resistance,</td></tr>
</table>

Measure ID and Name	ERS_U3: Water metering and subscription to BMLWE
Description	Water metering is essential to identify how much water is actually used/ consumed in households, commercial or public buildings, etc., and thus better plan water allocation. Subscribing to the BMLWE can support better water supply management, and increase of the economic resources for the rehabilitation or expansion of water supply networks. Includes: installation of water meters in households, public buildings (e.g. schools), camps, commercial buildings. This measure also includes the installation of district water meters to monitoring main transmission and distribution lines in order to better control the distribution and address leakage issues. Approximately 186,000 meters have been installed within BMLWE.;
Target	Residents, BMLWE, MoEW
Activity Breakdown	Act.1: Identify water users Act.2: Conduct site assessments Act.3: Design the metering system Act.4: Procure equipment Act.5: Install water meters and flow meters Act.6: Train water users Act.7: Integrate with billing system Act.8: Monitor and maintain

<table>
<tr>
<td>Timespan/
Timeline</td>
<td>Medium term
Once the measure is implemented the expected results/impact will be immediate. Yet, this requires that the meters’ measurements are read at regular basis and the respective volumes recorded are properly organized into a central database. Automatic data acquisition systems can be installed to facilitate the activity.
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Month 7</th><th>Month 8</th><th>Month 9</th><th>Month 10</th><th>Month 11</th><th>Month 12</th></tr>
<tr><td>1</td><td>Identify water users</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Conduct site assessments</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Design the metering system</td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Procure equipment</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Install water meters and flow meters</td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>6</td><td>Train water users</td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>7</td><td>Integrate with billing system</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>8</td><td>Monitor and maintain</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
</table>
</td>
</tr>
<tr>
<td>Budget
Breakdown</td>
<td>In the NWSS the installation of 16,500 Service Connections + 50,000 Water Meters is foreseen.
The associated CAPEX is 26,250,000$
O&M is the responsibility of the BMLWE.</td>
</tr>
<tr>
<td>Constraints</td>
<td>Financial, infrastructure limitations, cost implications, lack of awareness, lack of political will</td>
</tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>ERS_U4: Drafting / Updating of the BMLWE Water Supply Masterplan</th></tr>
<tr><td>Description</td><td>Drafting/updating of the BMLWE Water Supply Masterplan to meet water supply needs in the medium and long term</td></tr>
<tr><td>Target</td><td>Residents, Residential areas, households, BMLWE</td></tr>
<tr><td>Activity Breakdown</td><td>Both the MoEW and BMLWE are responsible for establishing long term consolidated planning for water, irrigation and wastewater

Act 1: Review existing policies and regulations
Act 2: Conduct water demand assessment
Act 3: Evaluate water supply
Act 4: Develop wastewater management plan
Act 5: Engage stakeholders
Act 6: Develop implementation strategies</td></tr>
<tr><td>Timespan/ Timeline</td><td>Short term
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th></tr>
<tr><td>1</td><td>Review existing policies and regulations</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Conduct water demand assessment</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Evaluate water supply</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Develop wastewater management plan</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Engage stakeholders</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Develop implementation strategies</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>Cost of the Masterplan: internal work of the engineers of the BMLWE
Subcontracting cost for specific expertise</td></tr>
<tr><td>Constraints</td><td>Financial crisis, Stakeholder resistance, BMLWE shortage of staff</td></tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>WCO_U1: Water saving in households and buildings (public, commercial)</th></tr>
<tr><td>Description</td><td>A variety of available technologies designed to deliver domestic water saving targeting the urban water uses (e.g. low flow flush, taps and showerhead, aerators, etc.) can be installed in households, offices, schools, hospitals, public buildings, etc.</td></tr>
<tr><td>Target</td><td>Residents, BMLWE</td></tr>
<tr><td>Activity Breakdown</td><td>The purchase and installation of the water saving fixtures in the households can be undertaken by households, municipalities, BMLWE, MoEW, or NGOs, depending on funding mechanisms (e.g. subsidies, reduction in water fees, donors' funds, etc.)
The operation and good maintenance of the fixtures is the responsibility of the household or public building operators and end-users (in case of schools, etc.)</td></tr>
<tr><td>Timespan/Timeline</td><td>Short-Medium term.
Once the measure is implemented the expected results/impact will be immediate.</td></tr>
<tr><td>Budget breakdown</td><td>CAPEX varies from 1.9 million USD to 96 million USD, for a population of 309455 capita, depending on the solution/ measures applied and target reduction in the unmet demand that is aimed to achieve.
The CAPEX needs to be paid up-front, either by each household or through Programs, incentives, subsidies, etc.
<table>
<tr><th>Total CAPEX ($)</th><th>Water saving (Mm³)</th><th>Water Saving per HH (%)</th><th>Shower Heads (1 Item)</th><th>Dual Flash Toilet</th><th>Low flow taps (2 Items)</th><th>Efficient Washing Machine</th><th>Dish Washer</th></tr>
<tr><td>$ 1,860,000</td><td>2.9</td><td>20.4%</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>$ 4,950,000</td><td>3.8</td><td>26.9%</td><td>X</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>$12,400,000</td><td>4.3</td><td>30.0%</td><td>X</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td>$15,500,000</td><td>5.2</td><td>37.0%</td><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>$52,600,000</td><td>6.0</td><td>42.5%</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>$95,930,000</td><td>6.6</td><td>46.5%</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
</table>
Table 23 Annual Equivalent Cost (AEC) of the urban demand management measures based on a 7% discount rate
<table>
<tr><th>Water Saving Measure</th><th>Unit Cost $</th><th>N (Useful life in years)</th><th>AEC ($)</th></tr>
<tr><td>Dual Flush Toilet</td><td>$ 170</td><td>7</td><td>$ 32</td></tr>
<tr><td>Showerheads (1 item)</td><td>$ 30</td><td>3</td><td>$ 11</td></tr>
<tr><td>Low flow taps (2 items)</td><td>$ 50</td><td>3</td><td>$ 19</td></tr>
<tr><td>Efficient washing machine</td><td>$ 600</td><td>7</td><td>$ 111</td></tr>
<tr><td>Dishwasher</td><td>$ 700</td><td>7</td><td>$ 130</td></tr>
<tr><td>TOTAL</td><td></td><td></td><td></td></tr>
<tr><td>Per household (HH)</td><td>$ 1,550</td><td></td><td>$ 1,057</td></tr>
<tr><td>Per capita (cap)</td><td>$ 310</td><td></td><td>$ 264</td></tr>
</table>
</td></tr>
<tr><td>Constraints</td><td>Cost consideration, lack of awareness, resistance to change, lack of incentives</td></tr>
</table>

Toilet flushes, usually accounting for one third of the domestic water use on average can deliver reductions up to 50% of the water used. Common options include the replacement of older style single-flush models (14 L/flush) with low-flush gravity toilets (6 L/flush), dual-flush valve operated toilets (4 L/flush), air-assisted pressurized toilets (2 L/flush). Evidence exists that flush volumes down to 4L do not cause any problems in the drains and sewers in terms of the waste disposal.

Taps and Showerheads can be adjusted and render saving by installing water saving devices and inexpensive retrofits. Various options are available for retrofitting kitchen and bathroom taps, which are estimated to account for more than 15% of domestic indoor use, with respective savings of 20-30% and less than 2 years paybacks: fitting of new water efficient tap-ware (spray taps, push taps, etc.), low-flow aerators, durable tap washers, flow restrictors and regulators, automatic shutoff. Showerheads are usually gravity fed, electric or pumped (power showers). The average consumption of showers ranges across the households as it depends on many interrelated factors: frequency of use (from 0.75-2.5 showers/day) average shower time duration (2-5 minutes), type of shower, flow rate (6-16 L/minute), etc. Yet, evidence exists that showers and baths account for 20-35% of the household water consumption and installing water saving devices (flow restricting devices, low-flow showerheads - aerating or laminar-flow, cut-off valves, etc.) can secure around 30-40% water savings. It worth mentioning that the expected savings from the installation of smart water saving devices in taps and showerheads is also highly influenced by the use patterns and habits of the users.

Washing Machines and Dishwashers can be replaced with more efficient ones delivering water and energy savings. Washing of clothes is probably the third largest consumer of domestic water, around 20%. Installing high-efficient washing machines can save up to 40% of the volume need per cycle. Modern washing machines use about 50 L/cycle or 35 l/cycle for the most efficient ones, as opposed to 150 L/cycle in the 1990's, due to technological advances (i.e. intelligent sensor systems, advanced and customized washing programmes, improved time functions, etc.). Dishwashers manufactured prior to the year 2000 typically consume 15-50 L/load, while modern dishwashers consume 7-19 L/load under normal setting and as low as 8-12 L/load under the eco-setting, which means average water savings at the range of 40-60%. The share of water use consumed by dishwashers varies from 6-14% as it depends on the cycle time, the frequency of use and their degree of penetration in the households, the latter being influenced by e.g. lack of space, conception that this investment is not necessary due to small load of dishes feasible to be hand-washed, etc.

Water pricing reform usually involves a modification in the rate structure and/or the water tariffs in order to influence the consumers' water use. It often includes the shifting from decreasing block rates to uniform block rates, the shifting from uniform rates to increasing block rates, the increasing of rates during summer months, or the imposing excess-use charges during times of water shortage. This economic instrument needs a very careful design as it can easily raise conflicts among users and trigger many disputes.

<table>
<tr><th>Measure ID and Name</th><th>PWE_U1: Adjust existing or implement separate stormwater and wastewater drainage systems</th></tr>
<tr><td>Description</td><td>Adjust existing or construct new separate networks for collection of municipal wastewater (blackwater from toilets, greywater and industrial wastewater) and urban runoff (stormwater) in newly developed residential, commercial and industrial areas.</td></tr>
<tr><td>Target</td><td>BMLWE, MoEW, Municipalities</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Assessment of existing collection and drainage network
Act.2: Stakeholder engagement
Act.3: Design of the separate networks
Act.4: Construction of separate networks and separation of existing systems
Act.5: Operation and maintenance</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Year 1</th><th>Year 2</th><th>Year 3</th></tr>
<tr><td>1</td><td>Assessment of existing collection and drainage network</td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Stakeholder engagement</td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Design of the separate networks</td><td></td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Construction of separate networks and separation of existing systems</td><td></td><td></td><td></td><td></td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td></tr>
<tr><td>5</td><td>Operation and maintenance</td><td></td><td></td><td></td><td></td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>NA</td></tr>
<tr><td>Constraints</td><td>Financial, existing networks, Stakeholder coordination, lack of awareness, regulatory framework</td></tr>
</table>

Measure ID and Name	PWE_U2: Assessment of potential Artificial Aquifer Recharge for the prevention of seawater intrusion
Description	There are significant unexploited runoffs during the rainy season. Injecting part of it in the aquifers would have a positive impact on the potential groundwater availability and would reduce seawater intrusion in GRB. Artificial Aquifer Recharge has a great potential to increase the renewable resources and ease the water stress in Lebanon.
Target	BMLWE, MoEW, Municipalities
Activity Breakdown	Act.1: Review and update of feasibility studies Act.2: Data collection and Analysis Act.3: Development of 3D Variable-Density Flow and Solute Transport model Act.4: Expansion of study area Act.5: Data collection and monitoring Act.6: Policy and management recommendation Act.7: Stakeholder collaboration and coordination
Timespan/Timeline	Medium term Once the measure is implemented the expected results/impact will be immediate

Activity	Description	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Year 1	Year 2	Year 3
1	Review and update of feasibility studies	■	■							
2	Data collection and Analysis	■	■	■	■	■	■			
3	Development of 3D Variable-Density Flow and Solute Transport model				■	■	■	■		
4	Expansion of study area							■		
5	Data collection and monitoring				■	■	■	■	■	
6	Policy and management recommendation							■		
7	Stakeholder collaboration and coordination							■	■	■

Budget breakdown	CAPEX: 500,000 USD
Constraints	Water availability, water quality, hydrogeological conditions, regulatory framework, financial, stakeholder engagement, climate change and uncertainty

Measure ID and Name	**PWE_U3: Drinking water protection perimeters**
Description	Detailed demarcation of protection zones around groundwater abstraction points (springs, wells) for water abstraction > 1,000,000m^3 per year
Target	MEW, BMLWE, Municipalities
Activity Breakdown	Act.1: Vulnerability and risk assessment Act.2: Demarcation of protection zones Act.3: Development of protection plans Act.4: Enforcement and control Act.5: Awareness-raising
Timespan/Timeline	Medium term Once the measure is implemented the expected results/impact will be immediate
Budget breakdown	Internal staff work of MoEW Study costs if a relevant study is sub-contracted
Constraints	Legal and regulatory framework, lack of awareness

Activity	Description	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
1	Vulnerability and risk assessment	■	■	■			
2	Demarcation of protection zones	■	■				
3	Development of protection plans		■	■	■		
4	Enforcement and control			■	■	■	■
5	Awareness-raising					■	■

<table>
<tr><th>Measure ID and Name</th><th>PWE_U4: Municipal Solid Waste Management (SWM)</th></tr>
<tr><td>Description</td><td>In addition to Costa Brava dumpsite, solid waste management in GRB is managed by municipalities and usually in 4 exposed dumpsites located in communal land (e.g., Mashaa land belonging to the monasteries). Some dumpsites accept only municipal solid waste and other accept both MSW and construction and demolition waste.</td></tr>
<tr><td>Target</td><td>Municipalities, BMLWE, MoEW, MoE, MoPH, NGOs/CSOs.</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Assessment of existing solid waste management practices and infrastructure
Act.2: Identification of suitable sites
Act.3: Development of solid waste management plan, development of action plans,
Act.4: Establishment of collection systems
Act.5: Implementation of waste segregation and awareness campaigns
Act.6: Procurement and installation of equipment and facilities
Act.7: Monitoring and enforcement of waste management regulations
Act.8: Closure and rehabilitation of existing dumpsites
Act.9: Monitoring and maintenance of new waste management facilities</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Sem. 2</th><th>Sem. 3</th><th>Sem. 4</th></tr>
<tr><td>1</td><td>Assessment of existing SWM practices and infrastructure</td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Identification of suitable sites</td><td></td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Development of SWM plan</td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Establishment of collection systems</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Implementation of waste segregation and awareness campaigns</td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Procurement and installation of equipment and facilities</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>7</td><td>Monitoring and enforcement of waste management regulations</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>8</td><td>Closure and rehabilitation of existing dumpsites</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>9</td><td>Monitoring and maintenance of new SWM facilities</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>The budget for municipal solid waste management can vary widely depending on the specific needs and circumstances of the municipality, and the range of the budget breakdown provided earlier reflects this variability. The total budget for municipal solid waste management can range from 650,000 USD to 3,000,000 USD excluding the dumpsite construction.</td></tr>
<tr><td>Constraints</td><td>Limited facilities, lack of awareness, institutional and governance challenges, financial.</td></tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>PWE_UI1: Wastewater collection and treatment, maintenance of existing WWTP</th></tr>
<tr><td>Description</td><td>Expansion of the BMLWE wastewater collection network.
Assessment of the current operational status and capacities of existing Ghadir WWTP and identification of necessary actions for their proper operation.</td></tr>
<tr><td>Target</td><td>Residents, Residential areas, BMLWE</td></tr>
<tr><td>Activity Breakdown</td><td>Act 1: Assessment of the current wastewater infrastructure, networks and WWTP and their operational status.
Act 2: Identification and prioritization of necessary actions
Act 3: Design of new collection networks and WWTP
Act 4: Rehabilitation and expansion of existing collection networks and construction Table 15.</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term.
Once the measure is implemented the expected results/impact will be immediate.
<table>
<tr><th>Activity</th><th>Description</th><th>Year 1</th><th>Year 2</th><th>Year 3</th><th>Year 4</th><th>Year 5</th><th>Year 6</th></tr>
<tr><td>1</td><td>Assessment of the current wastewater infrastructure, networks and Ghadir WWTP and their operational status.</td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Identification and prioritization of necessary actions</td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Design of necessary collection networks</td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Rehabilitation and expansion of existing collection networks and WWTPs</td><td></td><td></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>According to the Updated NWSS 2020, the CAPEX of the wastewater projects in the BMLWE District of Baabda Aley within GRB amount to 47 million USD. The OPEX of Ghadir WWTP is estimated to 385,000 USD.</td></tr>
<tr><td>Constraints</td><td>Financial, political resistance, operation and maintenance, lack of awareness</td></tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>PWE_UI2: Drafting/Updating of BMLWE Wastewater Masterplan</th></tr>
<tr><td>Description</td><td>Drafting/updating of the BMLWE Wastewater Collection and Treatment Masterplan to meet future needs in the medium and long term</td></tr>
<tr><td>Target</td><td>BMLWEs, MoEW, municipalities, and private operators</td></tr>
<tr><td>Activity Breakdown</td><td>The activity breakdown for drafting/updating the BMLWE Wastewater Collection and Treatment Masterplan:

Act. 1: Data collection and analysis
Act. 2: Technical and financial feasibility studies
Act. 3: Stakeholder consultations
Act. 4: Development of wastewater treatment options
Act. 5: Development of wastewater collection options
Act. 6: Cost-benefit analysis
Act. 7: Drafting of the wastewater masterplan
Act. 8: Review and approval process</td></tr>
<tr><td>Timespan/Timeline</td><td>Short term.
Once the measure is implemented the expected results/impact will be immediate

<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Month 7</th><th>Month 8</th></tr>
<tr><td>1</td><td>Data collection and analysis</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Technical and financial feasibility studies</td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Stakeholder consultations</td><td></td><td></td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Development of wastewater treatment options</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td></td><td></td></tr>
<tr><td>5</td><td>Development of wastewater collection options</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td></td><td></td></tr>
<tr><td>6</td><td>Cost-benefit analysis</td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td></td><td></td></tr>
<tr><td>7</td><td>Drafting of the wastewater masterplan</td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td></tr>
<tr><td>8</td><td>Review and approval process</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td></tr>
</table>
</td></tr>
<tr><td>Budget breakdown</td><td>Internal staff resources of BMLWE
Subcontracting costs if the study needs to be supported by external consultants.
In the NWSS, the adoption of a shared wastewater management framework is planned with goals to address the issue of the organization responsible for managing the WW network and treatment plants (WEs, municipalities, private operators) and determine the financing method (estimated cost 250,000$ for all Lebanese territory)</td></tr>
<tr><td>Constraints</td><td>Financial, stakeholder engagement, regulatory framework, lack of will,</td></tr>
</table>

7.1.2 Other Environmental and Regulatory and mixed measures

<table>
<tr><th>Measure ID and Name</th><th>ERS_M1: Regulating water tariffs, achieving cost recovery</th></tr>
<tr><td>Description</td><td>Water pricing reform usually involves a modification in the rate structure and/or the water tariffs in order to influence the consumers’ water use. This economic instrument needs a very careful design as it can easily raise conflicts among users and trigger many disputes. It also must be noted that there is always a price elasticity that needs to be considered, and that beyond a certain threshold any further increase in water price might not bring any further decrease in the water consumption.</td></tr>
<tr><td>Target</td><td>BMLWE, MoEW, NGOs, CSOs/ Municipalities</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Tariff analysis
Act.2: Cost assessment
Act.3: Stakeholder consultation
Act.4: Regulatory framework
Act.5: Tariff setting and tariff approval process
Act.6: Public awareness and communication</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term.
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Month 7</th><th>Month 8</th><th>Month 9</th></tr>
<tr><td>1</td><td>Tariff analysis</td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Cost assessment</td><td></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Stakeholder consultation</td><td></td><td></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Regulatory framework</td><td></td><td></td><td></td><td></td><td style="background:#4472C4"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Tariff setting and tariff approval process</td><td></td><td></td><td></td><td></td><td></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td></tr>
<tr><td>6</td><td>Public awareness and communication</td><td></td><td></td><td></td><td></td><td></td><td></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td><td style="background:#4472C4"></td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>Also, a water pricing elasticity study to establish fair and equitable water tariffs, which also achieved costs recovery, is necessary, which has some associated cost if additional experts, outside the BMLWE staff, are used</td></tr>
<tr><td>Constraints</td><td>Political resistance, Socio-economic, Lack of awareness, administrative and institutional capacity, technical and financial, Legal and regulatory framework</td></tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>ERS_M2: Monitoring and control of illegal abstractions and private wells, and definition of safe yield per groundwater body</th></tr>
<tr><td>Description</td><td>Illegal abstractions from groundwater cause drawdown of the aquifer and sea intrusion, while jeopardize the safe yield. The measure includes: field surveys to register all illegal abstractions, measures to control these abstractions, as well as the installation of water meters in private wells for subsequent monitoring of the abstracted volumes. Creation and operation of a single registry of licensed water wells from the water permitting process, shared among the relevant authority. Definition/ update of groundwater safe yield for each groundwater body. Additionally, the requirements (regulatory framework) for granting permits for new wells need to be revised in view of the groundwater sustainability.</td></tr>
<tr><td>Target</td><td>Municipalities, BMLWE, MoEW, CSO, NGOs</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Review and update existing legislation and regulations
Act.2: Capacity Building and Training
Act.3: Illegal Abstraction Identification and Mapping
Act.4: Awareness and outreach
Act.5: Stakeholder Engagement and Collaboration
Act.6: Enforcement and compliance
Act.7: Regular monitoring and reporting</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term.
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Month 7</th><th>Month 8</th><th>Month 9</th></tr>
<tr><td>1</td><td>Review and update existing legislation and regulations</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Capacity Building and Training</td><td></td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Illegal Abstraction Identification and Mapping</td><td></td><td></td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Awareness and outreach</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Stakeholder Engagement and Collaboration</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>6</td><td>Enforcement and compliance</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>7</td><td>Regular monitoring and reporting</td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>Internal costs of the BMLWE. Additional staff (inspectors) is required</td></tr>
<tr><td>Constraints</td><td>Lack of legal framework, lack of coordination between stakeholders, Political and administrative challenges, Informal practices and resistance, Lack of awareness,</td></tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>PWE_E1: Flood protection and mitigation (Ghadir flood control, CDR 2014)</th></tr>
<tr><td>Description</td><td>This measure aims to minimize the impacts of flooding on communities and ecosystems through a combination of proactive planning, infrastructure development, community engagement, and sustainable practices. Implementation of the CDR study including check dams, river bed protection and channelling, etc. Also, the implementation of Early Warning Systems (EWS)</td></tr>
<tr><td>Target</td><td>Municipalities, BMLWE, CNRS, LRA, MoEW, CSOs, NGOs</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Flood risk assessment
Act.2: Infrastructure design (check dams, etc.)
Act.3: Riverbed adjustment and expropriations
Act.4: Infrastructure construction
Act.5: Establish Monitoring and Early Warning Systems
Act.6: Awareness campaigns
Act.7: Stakeholder engagement</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term.
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Sem. 1</th><th>Sem. 2</th><th>Sem. 3</th><th>Sem. 4</th><th>Sem. 5</th><th>Sem. 6</th></tr>
<tr><td>1</td><td>Flood risk assessment</td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Infrastructure design</td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Riverbed adjustment and expropriations</td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td></tr>
<tr><td>4</td><td>Infrastructure construction</td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td></tr>
<tr><td>5</td><td>Establish Monitoring and Early Warning Systems</td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td></tr>
<tr><td>6</td><td>Awareness campaigns</td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td></tr>
<tr><td>7</td><td>Stakeholder engagement</td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>CAPEX: Ghadir river flood control study (CDR) Option 1: 61.1 Million USD
Option 2: 20.4 Million USD (refer to section 2.2.3 Ghadir river control)</td></tr>
<tr><td>Constraints</td><td>Urbanization and illegal construction, Financial, poor stormwater management, Poor solid waste management, climate change, lack of awareness;</td></tr>
</table>

Measure ID and Name	**PWE_E2: Quantitative and qualitative water resources monitoring programme, Meteorological and Hydrometric network expansion and improvement**
Description	Procurement, purchase and installation of a monitoring network to monitor the quantitative status of surface and groundwater bodies, as well as their water quality. Operation and maintenance of the network, and entry of all collected data into a water database to be shared among the relevant stakeholders. Implementation of the IHIS proposed in the Updated NWSS 2020
Target	MEW, BMLWE, LRA, LNMS, LARI, Municipalities, NGOs/CSOs, Universities
Activity Breakdown	Act.1: Assessment study of the current situation of the hydrometric, climatic and water quality monitoring and stations Act.2: Planning and design for the expansion and improvement of the monitoring networks Act.3: Procurement Act.4: Installation of the monitoring equipment and software Act.5: Training of the staff for the monitoring and operation of the network Act.6: Data Collection Act.7: Analysis and Reporting Act.8: Operation and Maintenance
Timespan/Timeline	Medium term. Once the measure is implemented the expected results/impact will be immediate

Activity	Description	Sem. 1	Sem. 2	Sem. 3	Sem. 4	Sem. 5	Sem. 6
1	Assessment study	■	■				
2	Planning and design		■	■			
3	Procurement			■			
4	Installation of the monitoring equipment and software				■	■	■
5	Training of the staff			■	■		
6	Data Collection			■	■	■	■
7	Analysis and Reporting			■	■	■	■
8	Operation and Maintenance			■	■	■	■

Budget breakdown	CAPEX MH A. Meteorological and Hydrometric network expansions and improvements: 6,066,400 $ MH-B. Integrated Hydrological Information System 9,548,400 $
Constraints	Financial crisis, lack of awareness, priority,

<table>
<tr><th>Measure ID and Name</th><th>PWE_E3: Increase the frequency and effectiveness of river bed cleaning activities</th></tr>
<tr><td>Description</td><td>Increasing the frequency and effectiveness of riverbed cleaning activities involves regular and systematic cleaning of the river bed to remove accumulated sediment, debris, and pollutants. It aims to maintain and restore the natural flow capacity of the river, improve water quality, and reduce the risk of flooding.</td></tr>
<tr><td>Target</td><td>MoE, MoEW, Municipalities, CSO, NGOs.</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Assessment and planning
Act.2: Contracting cleaning activities
Act.3: Setting the cleaning operation schedule
Act.4: Cleaning activities and operation
Act.5: Monitoring and evaluation
Act.6: Stakeholder engagement</td></tr>
<tr><td>Timespan/Timeline</td><td>Short term.
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th><th>Month 7</th><th>Month 8</th><th>Month 9</th></tr>
<tr><td>1</td><td>Assessment and planning</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Contracting cleaning activities</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Setting the cleaning operation schedule</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Cleaning activities and operation</td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>5</td><td>Monitoring and evaluation</td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
<tr><td>6</td><td>Stakeholder engagement</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td><td>■</td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>NA</td></tr>
<tr><td>Constraints</td><td>Financial, Regular and legal framework, Accessibility and logistics, Lack of awareness;</td></tr>
</table>

<table>
<tr><th>Measure ID and Name</th><th>PWE_E4: Register of all pollution sources, estimation of pollution loads, assessment of significant pressures, and control of illegal dumping activities</th></tr>
<tr><td>Description</td><td>Many illegal wastewater outfalls exist within GRB. (i.e. direct disposal of untreated domestic sewage into the river). A first step is to identify and map all these outlets, and then to ban and control illegal wastewater discharges. Similarly, uncontrolled waste damping occurs in GRB. It is thus also relevant to identify and map all these uncontrolled sites, and then to ban and control illegal waste dumping.</td></tr>
<tr><td>Target</td><td>MoE, MoEW, Municipalities, CSO, NGOs.</td></tr>
<tr><td>Activity Breakdown</td><td>Act.1: Mapping and recording of all wastewater outfalls (Licensed and illegal) and waste dumping sites (legal and uncontrolled)
Act.2: Estimation of all pollution loads, from point sources
Act.3: Analysis of the discharged wastewater characteristics, including chemical and biological analysis
Act. 4: Monitoring and control of wastewater discharge into the river/ fields
Act. 5: Updating and reviewing of the relevant permits for waste disposal
Act. 6: Monitoring and control of waste dumping into the river/ landscape.</td></tr>
<tr><td>Timespan/Timeline</td><td>Medium term.
Once the measure is implemented the expected results/impact will be immediate
<table>
<tr><th>Activity</th><th>Description</th><th>Month 1</th><th>Month 2</th><th>Month 3</th><th>Month 4</th><th>Month 5</th><th>Month 6</th></tr>
<tr><td>1</td><td>Mapping and recording</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Estimation of all pollution loads</td><td></td><td>■</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>Analysis of the discharged wastewater</td><td></td><td></td><td>■</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Monitoring and control of wastewater discharge</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td></tr>
<tr><td>5</td><td>Updating and reviewing of the relevant permits</td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td></tr>
<tr><td>6</td><td>Monitoring and control of waste dumping</td><td></td><td></td><td></td><td></td><td>■</td><td>■</td></tr>
</table></td></tr>
<tr><td>Budget breakdown</td><td>NA</td></tr>
<tr><td>Constraints</td><td>Lack of awareness;</td></tr>
</table>

Measure ID and Name	**PAR_M1: Development of Ghadir River Basin Coordination Committee**
Description	Define the modalities, roles and operational framework for the formation of a GRB committee, charged with safeguarding water resources and the environment
Target	Municipalities, BMLWE, MoEW, MoE, MoA, MoPH, NGOs/CSOs:
Activity Breakdown	-
Timespan/Timeline	Short - Medium term. Once the measure is implemented the expected results/impact will be immediate
Budget breakdown	NA
Constraints	Legislation and regulatory framework, lack of engagement, lack of awareness

Measure ID and Name	PAR_M2: Strengthen the capacity and financial resources of local municipalities to effectively manage and address environmental issues in the basin.
Description	Promote water conservation, educate people on water use efficiency, raise awareness on the impacts of illegal abstraction and over-abstraction, raise awareness on the impact of illegal wastewater discharge and waste dumping, sensitize people to act in favour of the river, build sense responsibility and ownership. Includes: awareness campaigns, outreach activities to the community
Target	BMLWE, Municipalities, NGOs/CSOs
Activity Breakdown	-
Timespan/Timeline	Medium term. Once the measure is implemented the expected results/impact will be immediate
Budget breakdown	Human resources and staff of the involved parties
Constraints	Limited data, lack of awareness, limited engagement, lack of coordination, socio economic conditions, resistance to change,

Measure ID and Name	PAR_M3: Raising awareness and sensitizing the community on the water resources and environmental related issues in GRB
Description	Promote water conservation, educate people on water use efficiency, raise awareness on the impacts of illegal abstraction and over-abstraction, raise awareness on the impact of illegal wastewater discharge and waste dumping, sensitize people to act in favor of the river, build sense responsibility and ownership. Includes: awareness campaigns, outreach activities to the community
Target	BMLWE, Municipalities, NGOs/CSOs
Activity Breakdown	NA
Timespan/Timeline	Medium term. Once the measure is implemented the expected results/impact will be immediate
Budget breakdown	Human resources and staff of the involved parties
Constraints	Limited data, lack of awareness, limited engagement, lack of coordination, socio economic conditions, resistance to change,

Measure ID and Name	PAR_M4: Strengthen environmental program actions in primary education
Description	Educate the youth on water conservation, the impacts of illegal abstraction and over-abstraction, the impacts of illegal wastewater discharge and waste dumping, Includes: education programmes in schools, students as "gradients" of GRB future
Target	NGOs/CSOs, Local Universities, Municipalities,
Activity Breakdown	-
Timespan/Timeline	Medium term. Once the measure is implemented the expected results/impact will be immediate
Budget breakdown	NA
Constraints	Limited curriculum integration, teaching material, institutional support, funding, social and cultural factors,

Measure ID and Name	DEV_M1: Capacity building activities
Description	Capacity building mainly for the staff on the BMLWE and the technical staff of the municipalities
Target	BMLWE, MoEW, NGOs/CSOs,
Activity Breakdown	-
Timespan/Timeline	Medium to long term. Once the measure is implemented the expected results/impact will be immediate
Budget breakdown	NA
Constraints	Funding, community engagement, lack of awareness;

7.2 Action Plan

GRB PoM and Action Plan were developed taking into account the necessity for socio-economic growth while simultaneously mitigating potential threats to human health and marine ecosystems mainly caused by absence of sustainable solid waste and wastewater management plans and from flood events. It encompasses key stages of Ghadir RBM planning, including basin characterization, evaluation of current and future water management practices, and formulation of appropriate measures.

The updated NWSS 2020 has taken into account the adopted Water Code (law 192/2020) and set the ground to move towards UN's Sustainable Development Goal SDG 6 and realize the principles of an IWRM at the river basin level as main approach with all its implementation principles, in particular the principle of sustainable development. This shall optimize water resources distribution according to its availability now and in the future, taking into consideration climate change and urban development scenarios. The developed PoM as defined and discussed with different stakeholders (MEW, BMLWE, MoA, MoE, Municipalities, etc.) are aligned with all three pillars of the Updated NWSS 2020.

Pillar 1: Implementing Reforms and Improving Sector Governance

Pillar 2: Achieving IWRM

Pillar 3: Service Coverage

Thus, the action plan corresponding to Ghadir RBM shall also be aligned with the NWSS action plan. Hence the following:

At the regulatory, reform and governance level, the

- MoEW shall regulate water tariffs and reform the water pricing in order to influence the consumers' water use (ERS_M1). It shall monitor and control illegal abstractions and private wells and define the safe yield per groundwater body (ERS_M2). Also at the regulatory level, the MoEW shall work on licensing water trucking to minimize it to emergencies, or very remote areas, and regulate the companies working in the basin to ensure that water is collected from known and metered sources. It shall ensure protection zones around groundwater abstraction points (PWE_U3).
- BMLWE shall work on drafting a new Water Supply Masterplan to meet water supply needs in the medium and long term (ERS_U4). It shall draft a wastewater collection and treatment Master Plan (PWE_UI2).

- The Ministry of Interior shall strengthen the capacity and financial resources of local municipalities to effectively manage and address environmental issues within GRB (PAR_M2)

At the IWRM level, the:

- MoEW shall work on developing water resources monitoring programs (PWE_E2), developing River Basin Coordination Committees of Ghadir and all Lebanese rivers (PAR_M1) whose main scope includes following up the implementation of GRB Action Plan.
- BMLWE shall work on separating stormwater from wastewater networks to prevent intermixing (PWE_U1). It shall also work on implementing water metering for domestic

and irrigation water to identify actual consumption and subscription (ERS_U3). It shall also work on implementing the flood protection and mitigation as proposed in the CDR study of 2014 (PWE_E1).

- MoE shall register all pollution sources, estimate pollution loads, assess significant pressures, and control illegal dumping activities (PWE_E4).
- Municipalities shall work on rational management of municipal waste (PWE_U4) and increase the frequency and effectiveness of the riverbed cleaning activities (PWE_E3).
- All stakeholders, mainly municipalities and schools shall work on raising awareness and sensitizing the community on the water resources and environmental related issues in GRB (PAR_M3), on strengthening environmental program actions in primary education (PAR_M4).

At the Service Coverage level, the:

- MoEW and BMLWE shall take actions to modernize the operation of water supply networks (ERS_U1), implement the GBWSAP (ERS_U2), rehabilitate existing wastewater collection networks and treatment plants and expand new networks (PWE_UI1).
- The BMLWE shall assess the potential of Artificial Aquifer Recharge for the prevention of seawater intrusion (PWE_U2)
- All stakeholders, mainly MoEW, BMLWE and Municipalities shall work towards implementing water saving in households and buildings by using a variety of available technologies designed for this purpose (WCO_U1), they shall also work on capacity building of the technical staff (DEV_M1).

Essentially, Ghadir Action Plan (Table 24) coordinates the PoM and other relevant programs within the river basin district such as the updated NWSS 2020, and forms the basis for river basin projects plans, which suggests estimated costs and benefits for each proposed measure, and institutional responsibility clarified, and classified according to a priority scale set from 1 to 3 based on the Urgency, Risk and Impact of the measure with 1 representing High Urgency, High Risk, High Impact; 2: Medium Urgency, Medium Risk, Medium Impact; and 3: Low Urgency, Low Risk, Low Impact;

Table 24 GRB Action Plan

ID	Name of the Measure / Action	Implementer	Budget	Timeline			Priority
				2025	2030	2035	
ERS_U1	Actions to modernize the operation of water supply networks and improve water efficiency	BMLWE	$ 103,340,200				1
ERS_U2	Greater Beirut Water Supply Augmentation Project (GBWSAP)	BMLWE, MoEW	$ 396,000,000				1
ERS_U3	Water metering and subscription to BMLWE	BMLWE, MoEW	$ 26,250,000				2
ERS_U4	Drafting / Updating of the BMLWE Water Supply Masterplan	BMLWE	NA				1
ERS_M1	Regulating water tariffs, achieving cost recovery	BMLWE, MoEW	NA				2
ERS_M2	Monitoring and control of illegal abstractions and private wells, and definition of safe yield per groundwater body	BMLWE	NA				1
WCO_U1	Water saving in households and buildings (public, commercial)	BMLWE	$ 2,500,000 to $ 129,000,000				3
PWE_U1	Adjust existing / Implement separate stormwater and wastewater drainage systems to prevent intermixing.	BMLWE, Municipalities	NA				1
PWE_U2	Assessment of potential Artificial Aquifer Recharge for the prevention of seawater intrusion	BMLWE, MoEW	$ 500,000				2
PWE_U3	Drinking water protection perimeters	BMLWE, MoEW	NA				2
PWE_U4	Municipal solid waste management	Municipalities	$ 650,000 to $ 3,000,000				1
PWE_E1	Flood protection and mitigation (Ghadir flood control, CDR 2014)	MEW, CDR	$ 20,400,000 to $ 61,100,000				1
PWE_E2	Quantitative and qualitative water resources monitoring programme, Meteorological and Hydrometric network expansions and improvement	MEW	$ 15,500,000				2
PWE_E3	Increase the frequency and effectiveness of riverbed cleaning activities	Municipalities	NA				1
PWE_E4	Register of all pollution sources, estimation of pollution loads, assessment of significant pressures, and control of illegal dumping activities	Municipalities	NA				3
PWE_UI1	Wastewater collection and treatment, maintenance of existing WWTP	BMLWE/ MoEW	$ 47,000,000				1
PWE_UI2	Drafting/Updating of BMLWE Wastewater Masterplan	BMLWE	$ 250,000				1
PAR_M1	Development of Ghadir River Basin Coordination Committee	MEW	NA				3
PAR_M2	Strengthen the capacity and financial resources of local municipalities to effectively manage and address environmental issues in the basin.	Ministry of Interior	NA				3
PAR_M3	Raising awareness and sensitizing the community on the water resources and environmental related issues in Ghadir	BMLWE	NA				2
PAR_M4	Strengthen environmental program actions in primary education	Ministry of Education	NA				3
DEV_M1	Capacity building activities	BMLWE	NA				3

8 Cost Benefit Analysis

The cost-benefit analysis was adopted from the BMLWE point of view. Thus, benefits were associated with more revenues from water tariffs or an increase in the supply efficiency.

8.1 Capital Expenses

The CApital EXpenses CAPEX of the new infrastructures and investments to be implemented by measures as included in WEAP are shown in Table 25.

Table 25 List of the estimated Capital cost by measure and correspondent scenario

ID	Name of the Measure / Action	Implementer	Budget	Scenario	Impact
ERS_U1	Actions to modernize the operation of water supply networks and improve water efficiency	BMLWE	$ 103,340,200	S1CC	Increase Network Efficiency to 75%
ERS_U2	Greater Beirut Water Supply Augmentation Project (GBWSAP)	BMLWE, MoEW	$ 396,000,000	S1CC	Increase Domestic Water Supply
ERS_U3	Water metering and subscription to BMLWE	BMLWE, MoEW	$ 26,250,000	S1CC	Increase Network Efficiency to 75%
WCO_U1	Water saving in households and buildings (public, commercial)	BMLWE	$ 2,500,000 to $ 129,000,000	S2CC	Decrease Domestic water consumption
	Daychounieh: Drilling 11 wells	BMLWE	$ 7,286,440	S1CC	Increase Domestic Water Supply

8.2 Operation and Maintenance Expenses

The analysis takes into account the OPeration EXpenses OPEX for both new and existing infrastructures. The inclusion of existing infrastructure allows for the identification of the advantages associated with enhancing the efficiency of water conveyance.

The O&M cost analysis includes the expenses related to pumping groundwater from public wells, both for existing wells and newly constructed ones. However, it is important to note that this cost does not apply to Awali conveyor system as it operates based on gravitational supply. The average O&M cost has been evaluated as follows:

- Average energy cost (fuel for the pumps) of 0.40 $/kWh.
- Average energy requirement to extract groundwater of 0.68 kWh/m^3.

The product of both terms yields an **average O&M cost of 0.27 $/m^3**. This cost per volume unit was added in WEAP to compute the O&M cost based on the volume of pumped groundwater. By doing so, the cost will decrease as measures are implemented to minimize losses, allowing for an assessment of the net benefits associated with these measures.

8.3 Benefits

The benefits were based on the water tariff as provided by BMLWE, the served population and projected collection rate:

- Water tariff: 62.50 $/household/year (equivalent to 3,125,000LL for an average USD rate of 50,000LL set in 2023).
- Collection rate after measures: 80%.
- Served population based on demographic growth.

The benefit per cubic meter was computed with the assumption that the collection rate is 80%.

- Assuming a household hosts on average five persons, the average benefit is 12.5 $/cap/year.
- With the domestic water demand of 150 L/cap/day actually delivered to household, the average benefit is 0.22$/m$^{3.}$ With collection rate 80% the **average benefit** becomes **0.18$/m^3**.

It can be noted that the volumetric benefit of 0.18 $/m^3 is smaller than the volumetric O&M cost (0.27 $/m^3). Adding the fact that part of pumped groundwater is lost through leakages (50% in the current situation), i.e., more water is being pumped than delivered to households, it is clear the current the situation is a deficit.

8.4 Financing the CAPEX and implementation phases

CAPEX was represented in WEAP as a yearly loan payment, with the following parameters:

- 25 years of payments, starting in the first year of construction or implementation;
- 2% interest annual rate;
- uniform annual installments.

For simplicity, it was assumed that all activities would be completed by 2030. The construction or implementation phases vary as follows:

- Increasing water efficiency to 75% through modernization and metering: 5 years, starting in 2025.
- GBWSAP: 7 years, starting in 2023.
- Daychounieh wells: 2 years, starting in 2028.
- Water saving in households and buildings (public, commercial): 5 years, starting in 2025.
- Finally, a discount rate of 7% annually was assumed.

8.5 Results

Figure 25 shows the Net Benefit Results on an annual basis, considering the upper mentioned analysis for scenarios S0CC, S1CC and S2CC.

- In the baseline situation, but with climate change (scenario S0CC), the costs are greater than the benefits and the yearly net benefit is around $ -2.5 million.
- In scenario S1CC, there are significant CAPEX costs, on top of existing OPEX in S0CC. New infrastructures also come with additional OPEX. Improving the efficiency, or reducing the leakages, of the water supply system reduces the OPEX but to a much smaller extent compared to the CAPEX of implementing this improvement in efficiency. The benefits increase after the implementation of new wells, but to a much smaller extent than the increase in cost. So all in all, the Net benefit is greatly negative, especially after implementing the GBWSAP (CAPEX Dam in the graph) and eventually reaches a yearly value close to $ -30 million.
- Results of the scenario S2CC are almost the same as S1CC, with a very little improvement in revenue, very little reduction in OPEX and a Net benefit slightly less negative.

The same computations but with Present Value, using a discount rate of 7%, are shown on Figure 26. The equivalent Net Present Value (NPV), shown in Figure 27, is negative:

- S1CC: -210.6 Million $
- S2CC: -210.8 Million $.

To provide further context into the values calculated in the figures, Table XX provides an overview of the main modifications within each scenario that are reflected into the estimated CAPEX, OPEX and Benefits.

Combination & ID	S0CC	S1CC	S2CC
Business as Usual	X	X	X
Climate Change	X	X	X
NWSS Measures		X	X
Complete Domestic Coverage			X
Net Present Value	-25.1	-210.6	-210.8
Benefit	14.4	19.2	19.3
OPEX	-39.4	-42.8	-41.2
CAPEX - GWSAP	0	-148.1	-148.1
CAPEX - WELLS	0	-1.0	-1.0
CAPEX - EFFICIENCY	0	-38.0	-39.9

values expressed in Million USD dollars, CAPEX efficiency for S2CC includes water saving artifacts

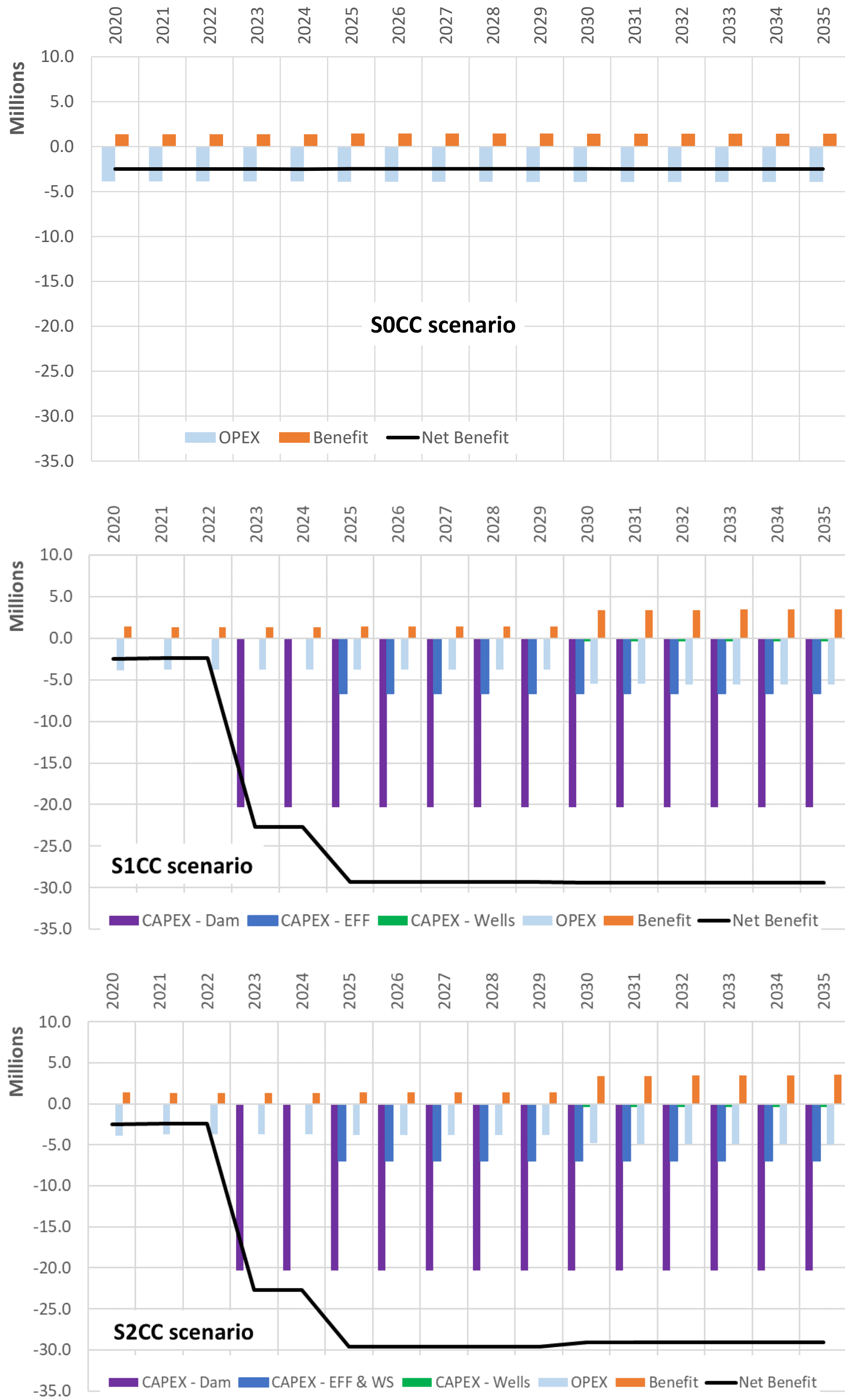


Figure 25 Costs and Benefits of the scenarios S0CC, S1CC and S2CC

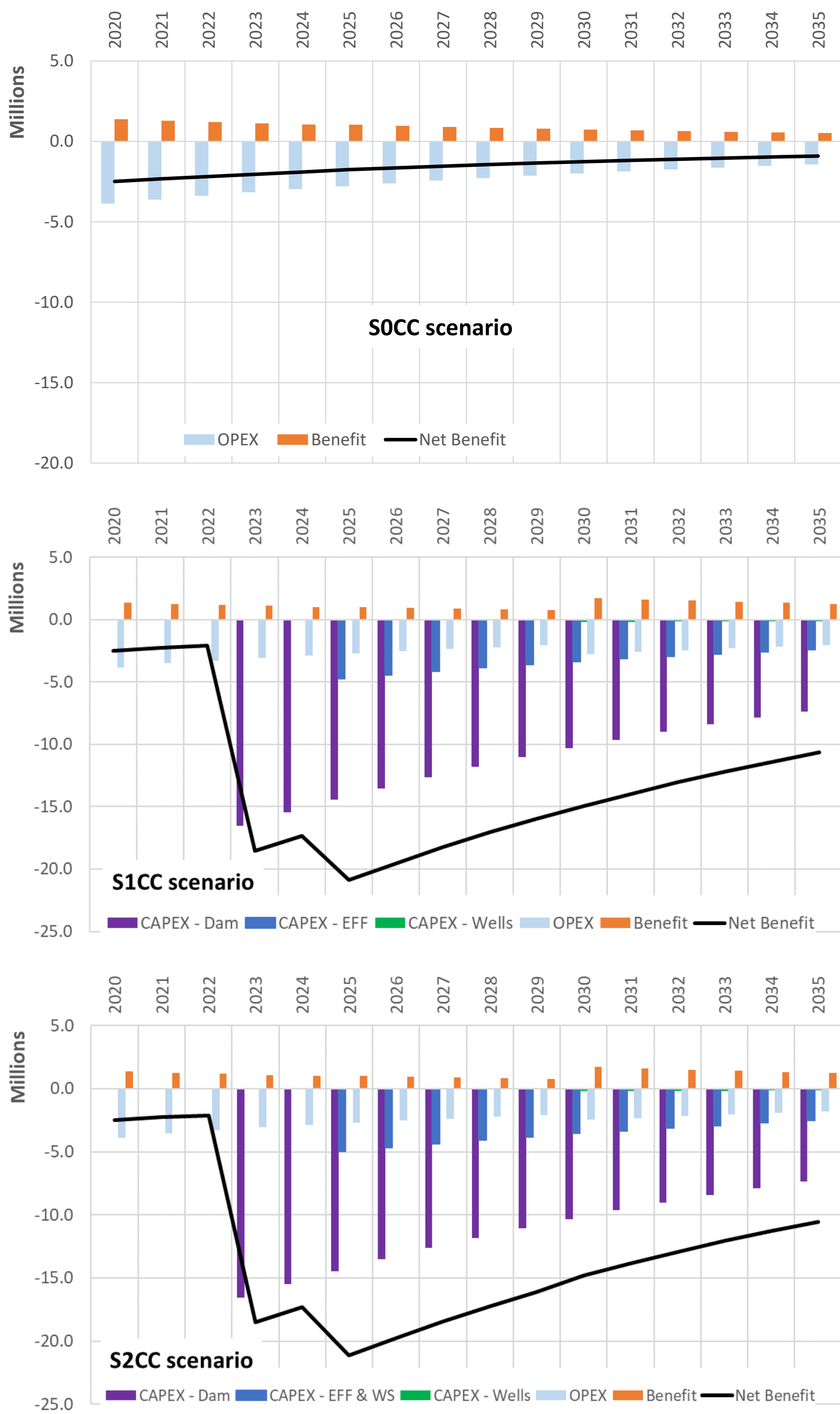


Figure 26 Present Value Costs and Benefits of the scenarios S0CC, S1CC and S2CC, with a discount rate of 7%.

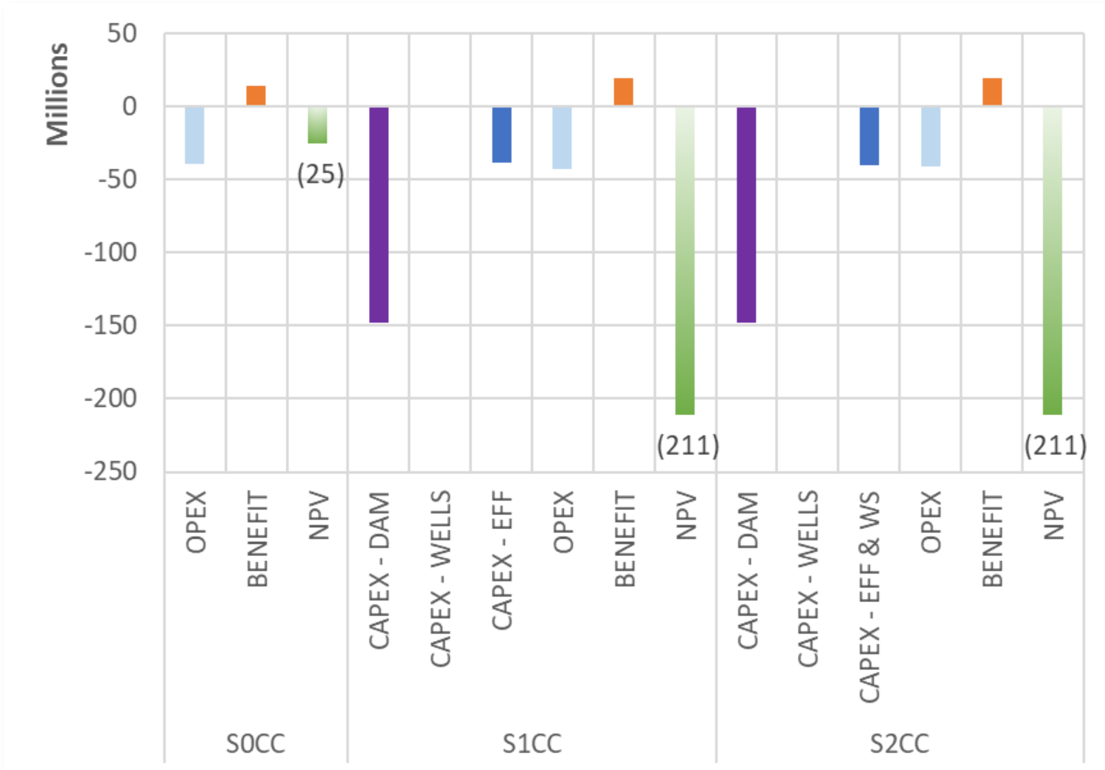


Figure 27 NPV of S0CC, S1CC and S2CC, with a discount rate of 7%.

The financial indicators are not positive after investments. It shows that, as long as price for drinking water is maintained as it is currently, the decision for investment should not be based solely on a financial outlook, but also, and importantly, on the need for equitable access to water.

9 Conclusion

A detailed water balance model has been developed for GRB for the period 2020-2035, allowing the representation of the components of the hydrological cycle & catchment process along with the water demand and use aspects in the catchment. Four main challenges were identified: Insufficient water supply, groundwater extraction and seawater intrusion, solid waste, wastewater and water pollution and Ghadir river flooding.

On the **water supply** level and after WEAP modelling of scenario S1CC, it is safe to say that most of the expected demand increase can be covered by the implementation of the projects suggested in the Updated NWSS 2020 especially GBWSAP which will decrease the reliance on public and private groundwater extraction. Nevertheless, it is also crucial to increase the efficiency to 75% and reduce the water losses throughout the systems to achieve full coverage. Besides the major infrastructure investment required to secure Bisri dam and Awali conveyor, coordination between different stakeholders to achieve the vital and required loss reductions is paramount.

Moreover, an ambitious scenario S2CC was modeled where water saving artifacts are set in place in the households throughout of the whole system, which would yield significant benefits but would require an even further articulation and challenges for implementation. Amongst the main benefits of the addition of the water saving artifacts, we could mention, less water supply needed, less pumping and treatment costs, less water losses, leading to better efficiency in pumping and treatment costs, less wastewater to be treated or disposed and more environmental benefits.

On the **groundwater** level, the seawater intrusion is evident in coastal and mountainous areas, impacting wells and leading to increased salinity levels and chloride concentrations. The expansion of seawater intrusion over time poses a significant threat to the Cenomanian-Turonian aquifer system. Additionally, vertical pollution from untreated sewage and industrial activities contributes to groundwater contamination, highlighting the need for effective pollution control measures. The degradation of groundwater quality not only poses risks to human health but also affects the ecological conditions within the basin.

On the **pollution** level (solid waste and wastewater), two sampling campaigns for water quality check were carried out during dry and wet seasons by NDU Laboratory team in coordination with BTD and ACTED. The field observations and laboratory results showed the presence of organic and microbial pollutants present in the water that can be accounted for by the seepage of industrial wastewater into the river and support the presence of raw sewage, which shows that the water is certainly unfit for drinking or various other purposes. If the pollution trend continues as it is currently set, serious water quality deterioration could take place few years from now if no action was applied to remove the sources of pollution.

On the **flooding** level, and over the past decade, the recurrence of flood events has led to grave consequences affecting the urbanized area, in terms of property damages. The CDR has commissioned Dar Al Handasah in 2014 to explore and seek feasible flood control and protection solutions for the recurring flood events of Ghadir River and two alternatives were proposed.

9.1 General Recommendations

To effectively tackle the water supply, pollution, and flood challenges in the GRB, the following recommendations have been put forth:

- Utilize the program of measures to design and implement projects in the urban, environmental, and industrial sectors, at the basin level.
- Increase the water supply by adopting the suggested projects of the Updated NWSS 2020.
- Support the development of wastewater collection networks and the rehabilitation and expansion of Ghadir treatment plant.
- Develop and implement a sustainable solid waste management system within Ghadir River Basin.
- Optimize groundwater abstractions, protect groundwater quality, and develop an advanced understanding of the seawater intrusion dynamics and reverse its impacts in the affected areas.
- Adopt and implement CDR study from 2014 on Ghadir flood control and protection solutions for the recurring flood events.
- Improve the monitoring and data collection systems for water resources. This includes expanding the network of hydrometeorological stations and investing in advanced technologies for data collection.
- Encourage local capacity building and foster collaboration and shared responsibility among stakeholders by facilitating meetings, platforms, and workshops.
- Establish a supervision body or assign focal points at the Ministry-level to supervise and monitor the implementation of the river basin management plan.

9.2 Perspective

The continuous development of the WEAP model is of paramount importance to ensure the sustainability and success of the proposed measures and projects within GRB. This comprehensive water balance model, which has been instrumental in representing the intricate water resources, along with water demand and usage patterns, has significantly contributed to the formulation of future supply scenarios.

10 Appendix

A. Water quality sampling campaign report

AL GHADIR RIVER WATER QUALITY MONITORING 2nd water testing campaign

MAY 2023

NDU Team Members
Dr. Jacques Harb/Quality Assurance-Reporting
Dr. Claudette Hajj/Monitoring and Testing
Mr. Elie Lahoud/Sampling

Table of Contents

List of Tables

List of Figures

1 Overview of the followed Monitoring Process in Al Ghadir River

Notre Dame University of Louaize (NDU) team abided by the EPA (2013) guidelines during the monitoring and testing of the water quality in Al Ghadir River. The monitoring steps followed by NDU are presented in Figure 1 below.

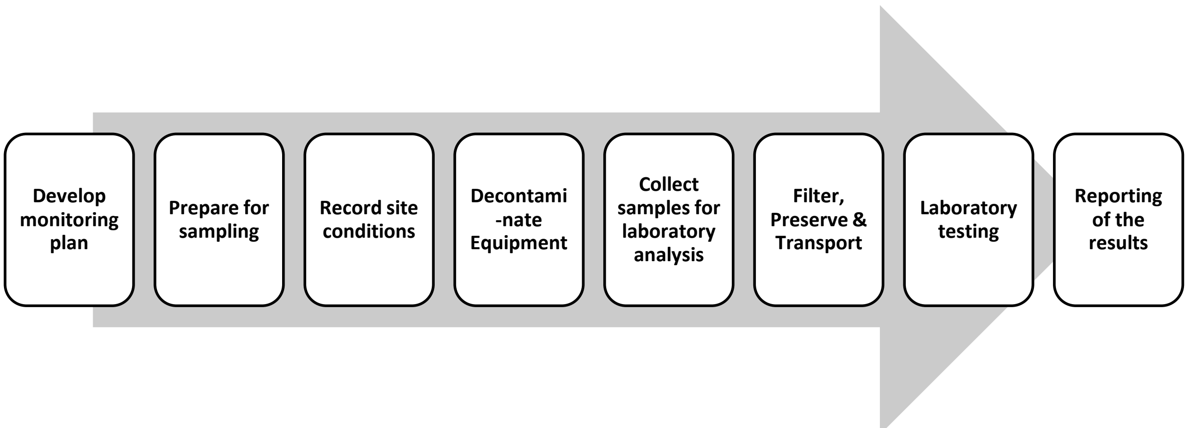


Figure 1 Stages of monitoring Process followed by NDU Team

1.1 Developing the Monitoring Plan

To guarantee that monitoring of Al Ghadir river basin is relevant, accurate, targeted, and cost-effective, a monitoring plan was developed by Notre Dame University after coordination with BTD. The last documents contained all the details of the actions, responsibilities, and timeframes that enables a delivery that meets the project objectives. Figure 2 shows the elements of the monitoring plan.

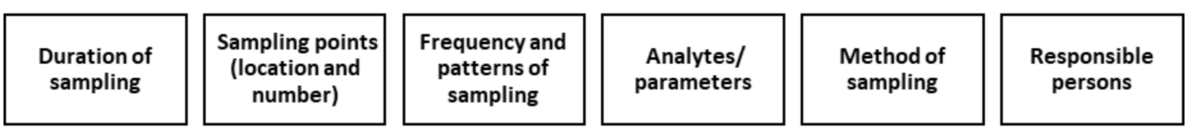


Figure 2 Elements of the Monitoring Plan

To accurately reflect the quality of the water in Al Ghadir, sampling was planned in a way that reflects water quality during both the dry and the wet seasons. The locations of 6 samples were chosen by BTD and GVC. The first sampling from Al Ghadir river took place on 22nd of March 2023.

1.1.1 Duration of sampling

For this report, sampling was made over the wet season from the Al Ghadir river to show compliance with established criteria.

1.1.2 Sampling Locations

The sampling plan to monitor water composition in Al Ghadir river was prepared in a way to guarantee that samples are collected at sites and times that provide a representative sample, thus providing an accurate description of the overall quality of the water in the river. Furthermore, sampling sites were located in areas that are safe to access, accessible under all conditions of flow, and well mixed to ensure a homogenous sampling collected is easily identifiable for later sampling.

Furthermore, sampling sites were located in areas that are safe to access, accessible under all conditions of flow, and well mixed to ensure a homogenous sampling collected is easily identifiable for later sampling. Permanent sampling locations were chosen by BTD to ensure that representative samples can be compared over time. However, to ensure the total number of samples was kept within the scope of the project and as per the contract description, point 4 was removed from the second campaign. Table 1 and Figure 1 show the coordinates and Name of the points chosen for sampling in Al Ghadir River.

Table 1 Coordinates and location of the chosen points for sampling

Number	Name	Latitude	Longitude
1	Jeser Al Aramel	33.81853	35.51131
2	Aser Zaaiter	33.82323	35.52477
3	Wadi chahrour/ sofla	33.82099	35.54734
4	Kfarchima-Lecico	-	-
5	Tiro-Airport	33.81952	35.50077
6	Costa Brava Beach	33.80324	35.48022

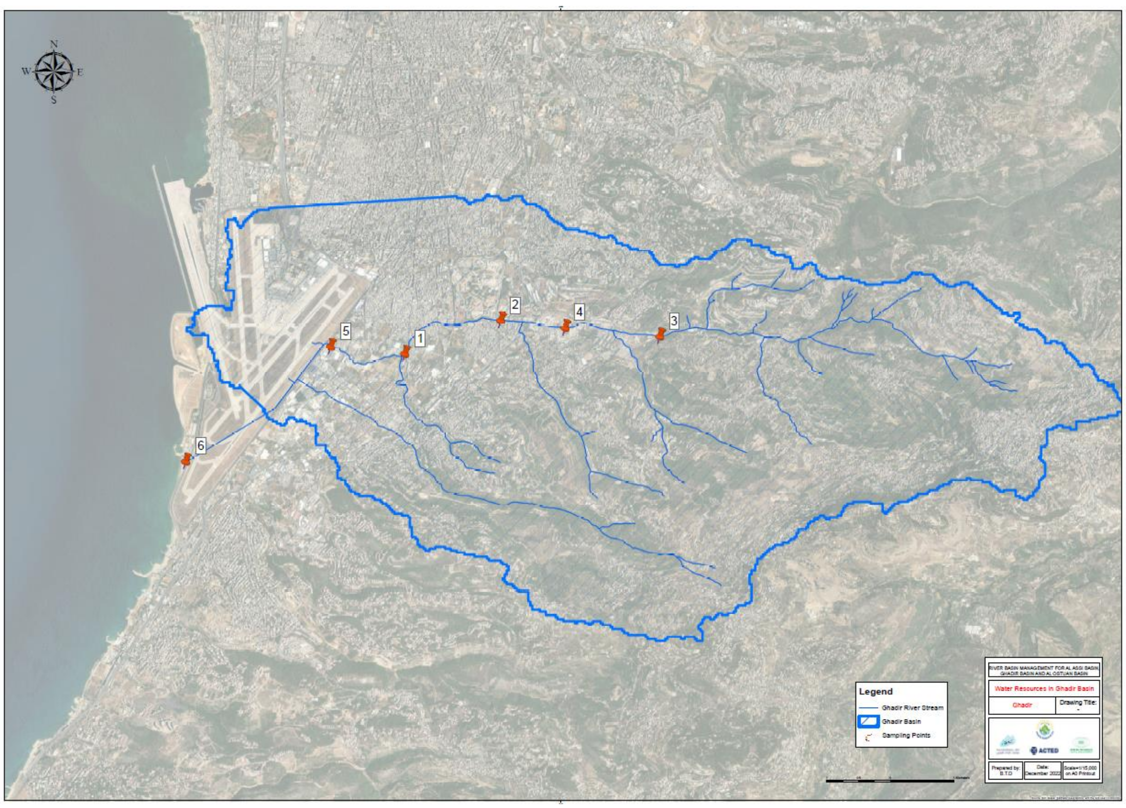


Figure 3 Representation of the different sampling locations

1.1.3 Water sampling and Procedures

The number of samples needed to determine the composition of water defines the accuracy/precision of the project (Griffiths, 2012). During the Al Ghadir first visit on March 22nd (2022), six sampling points were chosen by BTD and agreed upon by the ACTED team. The grab sampling technique was used in Al Ghadir This method is recommended when the parameters to be tested are not expected to greatly vary over time.

Grab samples were chosen for this trip as they are considered samples that provide a 'snapshot' of the water quality characteristics at the time of sampling (dry season). Therefore, grab sampling was used as it shows the concentrations at the Five points location (differently) and time of sampling.

A sample of water was taken directly from the river at all the points using both plastic and glass containers.

Sub-surface samples were taken from approximately 15 to 20 cm depth, as the water was very shallow in the river, with care taken to ensure that no floating films or organic material were collected unless they were of specific interest. NDU team tried to collect the sample at a reasonable distance from the edge. In all points, NDU team collected the samples directly into the sample container without using intermediate containers.

1.1.4 Sampling frequency and patterns of sampling

NDU team agreed with the stakeholders that two sampling campaigns will occur in Al Ghadir River. The first during December 2022 and the second during March 2023. This sampling frequency (twice a year in two different seasons) ensures that the characteristics of the waters are adequately described resulting in a good understanding of the system and potentially accurate reporting of compliance or noncompliance with the standards (Hespanhol, & Prost, 1994).

1.1.5 Analytes

The choice of analytes with ACTED team depended on the contaminants present in Al Ghadir River and the criteria against which the monitoring is to be evaluated.

Table 2 below includes the final list of analytes to be examined on Al Ghadir river:

Table 2 Final list of analytes

Turbidity (NTU)	Phosphorous (mg/L)
pH (pH)	Chloride (mg/L)
ORP (mV)	Ammonia (mg/L)
RDO (mg/L)	Sulphate
Conductivity (µS/cm)	Fluoride
TDS (ppt)	Lithium
TS (ppt)	Calcium
Temp (°C)	Potassium
Nitrate (mg/L)	Sodium
Lead (mg/L)	DO
Cadmium (mg/L)	BOD
Barium (ɥg/L)	COD
Mercury (ɥg/L)	Total Coliform
Ecoli	Fecal Coliform

2 Planning the Sampling Event

Careful planning and preparation of the sampling event amongst NDU, BTD, and ACTED is important and help to save time and resolve the number of problems that might occur during sampling. Overall, the sampling event was very smooth, and no unexpected hurdle occurred. This was the result of careful preparation of the trip that constitutes of the following:

2.1 Logistics

The basic steps followed by NDU for planning the sampling event are as follows:

1. NDU team reviewed the monitoring plan before the trip, including monitoring locations, number of samples required, sampling methods, and Occupational Health, Safety and Welfare (OHS&W) issues.
2. NDU team informed the personnel at NDU laboratories of the intended schedule.
3. NDU team prepared a list of the needed logistics such as the containers of suitable material and volume that contain preservatives. Table 3 shows a sample of the table that describes the followed procedure to do the testing.
4. BTD team scheduled the monitoring event. NDU team planned for the day including planning how and when NDU will transport the samples back to the laboratory. NDU team prepared a template to be taken on-site that aimed to show how samples are to be preserved and delivered to the laboratory as quickly as possible and within recommended holding times. This is especially relevant for samples with holding times of 24 hours or less (see Table 3).
5. NDU team checked all equipment required for the sampling event. It ensures that the equipment is operational and calibrated and checked one day before the sampling event. Moreover, Dr. Claudette Hajj and her team from NDU have decontaminated the equipment and the sample containers to be used or even reused between samples.

Table 3 Containers, Preservation Methods and Holding times

Analyte	Container Type	Volume (ml)	Filling Technique	Preservation	Holding time
Conductivity	Glass or Plastic	100	Fill container completely to exclude air	Not required	24 Hrs.
BOD	Glass	1000	Do not pre-rinse container with sample	Refrigerate and store in the dark	24 Hrs.
PH	Glass or Plastic	100	N.A.	Refrigerate	6 Hrs.
Solids	Glass or Plastic	500	Fill a container to exclude air	Refrigerate	24 Hrs.
Turbidity	Glass or Plastic	100	Fill container completely to exclude air	Not required	24 Hrs.
Metals	Glass or Plastic	100	N.A.	Acidify with nitric acid to pH 1 to 2	1 month
Fecal,E coliforms	Sterilized Glass or plastic,	200	Do not completely fill a container	Refrigerate	preferably < 6 hrs.

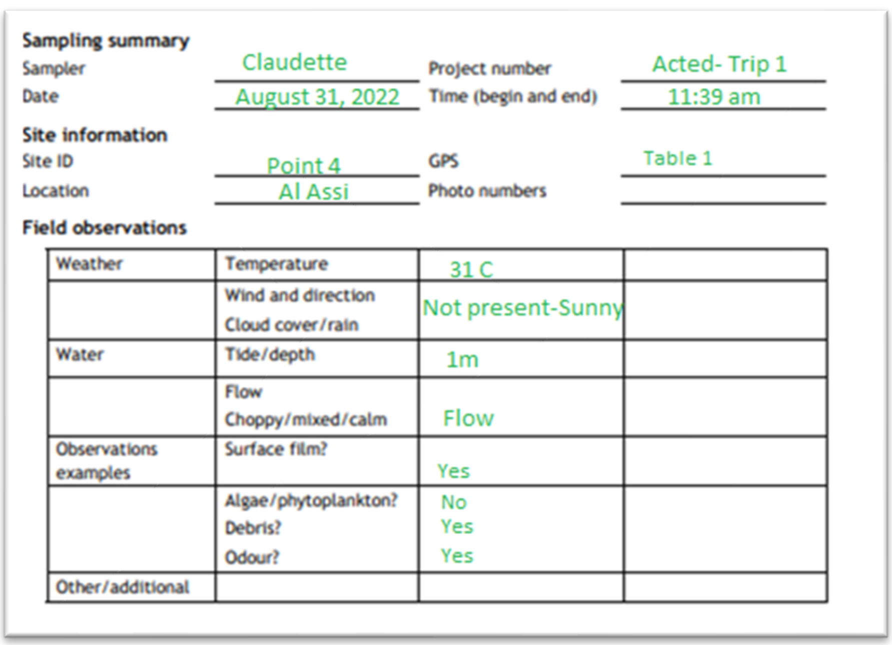
Figure 4 Autoclaving the Containers

2.2 Preparation of the Equipment before and during the Sampling

Major items of equipment that were prepared by the NDU team before the sampling process are:

1. Prepare and print the Records of observations and actions sheet. Table 4 was prepared to guarantee that a complete record of each sampling site and event is kept.

Table 4 Records of observations and actions sheet Sample



Sampling summary

Sampler	Claudette	Project number	Acted- Trip 1
Date	August 31, 2022	Time (begin and end)	11:39 am

Site information

Site ID	Point 4	GPS	Table 1
Location	Al Assi	Photo numbers	

Field observations

Weather	Temperature	31 C	
	Wind and direction Cloud cover/rain	Not present-Sunny	
Water	Tide/depth	1m	
	Flow Choppy/mixed/calm	Flow	
Observations examples	Surface film?	Yes	
	Algae/phytoplankton? Debris? Odour?	No Yes Yes	
Other/additional			

During every sampling event, observations of field conditions that could assist in the interpretation of monitoring data were recorded by NDU team. This provides useful information about the water being sampled, which can help diagnose the source and potential impact of pollutants found by chemical analysis.

Examples of such field conditions recorded by the NDU team are as follows:

- Presence of Wind and Rain: YES/**NO**
- Shading from clouds and vegetation YES/**NO**
- Any abnormalities that indicate pollution or affect water quality, such as the absence of flow, presence of surface scum, **watercolor or odors**, excessive algal or plant growth, dead fish, or invertebrates should also be noted. The above was recorded at each point.

2. Prepare and print all Chain of Custody forms that includes all the details about each sample (sampler name, time, date, type of tests, preservation method used, container type and size, type of analysis needed) and labels and packed them for the trip.
3. Use Navigational aids (NAVA 400 GPS) to accurately locate the sampling site for future reference.
4. Decide before the trip on the field testing meters.

Decide on the analytes that quickly degrade after they are sampled and therefore must be tested in the field. Some field measurements were undertaken in situ. The following analytes were measured in the field as concentrations of these analytes can be significantly changed during transport and storage:

- Dissolved oxygen (DO)
- Temperature
- PH
- Conductivity
- Redox (reduction/oxidation potential)
- Turbidity
- Chlorine
- Salinity

The above analytes were measured using multi-parameter meters. Field meters were calibrated one day before use. In particular, dissolved oxygen, pH, and turbidity that drift from day to day were calibrated using a standard solution twice during the sampling day.

5. To preserve the integrity of the sample, the team ensured appropriate sample containers for each of the various parameters. The sample containers and preservation methods are presented in Table 2.
6. Prior to heading to the site, the team decontaminated the sampling equipment. All sampling equipment presents a risk of cross-contamination and therefore are thoroughly cleaned between samples with ethanol and distilled water. Moreover, multiple-use equipment is decontaminated prior to each sampling and between the collection of samples.
7. Most types of the sample require chilling as a means of preservation. NDU team prepared the needed esky. Samples are stored on ice in a car refrigerator, and the temperature maintained between 1°C and 4°C by adding two packs of ice every 2 hrs.

2.3 Collection of samples for analysis

Samples were collected using grab sampling from all the points in triplicates as shown in Figure 5 to Figure 10. Before the samples collection, the team made sure that the equipment is inert, and does not cause contamination or interference with the sample.

As organics have a tendency to adsorb to plastic, stainless steel equipment such as buckets and sampling rods were used. Glass sample containers were used in most cases, additional samples were taken in plastic containers. The team followed EPA Appendix 2 for information on the type of sampling container (eg glass, plastic), typical required volume, filling technique and preservation requirements for common analytes.

2.4 Sample Identification, Transport, and Storage

Samples were labelled by NDU team so they can be readily identified at all times. Sample containers were marked using permanent markers in such a way that they can be identified and distinguished from other samples in the laboratory. Care was taken when packing samples, as they are often subject to vibration during transport. Sample labels have specified a clear and unique identifying code that can be cross-referenced to the monitoring location and time of sampling and includes: the date, time, location, name of sampling site, and name of a sampler.

Figure 5 Sampling directly into the container

Figure 6 Filling and Labeling of the Samples on Site

During sample transport and storage, the NDU team followed key precautions to ensure effective transport and storage:

- Samples are appropriately packed to avoid breakage and cross-contamination.
- Ensure the time between sampling and analyzing not to exceed holding time.
- Sample containers are sealed, carefully packed with appropriate packing material, chilled or frozen (as required), and transported in an appropriate cooler or fridge.

2.5 Lab testing

Table 5 shows the test methods used at NDU labs to perform the needed testing. The procedure followed in these sections were accurately followed.

Table 5 Test methods

Parameter	Test Method
BOD 5	EMDC1 1173: Part 3 ± Five-day BOD Method
COD	EMDC1 1173: Part 4 ± Dichromate Digestion Method
PH	EMDC1 1173: Part 2 ± Electrometric Method
Temperature	EMDC1 1173: Part 1 ± Electrometric Method
Total Suspended Solids	EMDC1 1173: Part 1 ± Gravimetric Method
TS	EMDC1 1173: Part 3 ± Gravimetric Method
Turbidity	APHA Standard Methods:2130 B. Nephelometric Method
Chlorides (Cl -)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression of Eluant Conductivity
Cadmium	EMDC1 1173: Part 7 ± Flame Atomic Spectrometry Absorption Spectrometry
Barium (Ba)	EMDC1 1173: Part 7 ± Direct Nitrous Oxide-Acetylene Flame Atomic Absorption
Fluorides (F-)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression
Lead	EMDC1 1173: Part 7 ± Flame Atomic Absorption Spectrometry
Mercury (Hg)	EMDC1 1173: Part 10 ± Cold-Vapor Atomic
Nitrates (NO3 -)	APHA Standard Methods: 4110 B. Ion Chromatography with Chemical Suppression
Phosphorus	EMDC1 1173: Part 6 ± Colorimetric
Lithium	EMDC1- Flame photometry
Calcium	EMDC1 Flame photometry
Sodium	EMDC1 Flame photometry
Potassium	D992 Flame photometry
Nitrate	D1254 11C2: Flame Atomic Absorption Spectrometry
Ammonia	D1426: Flame Atomic Absorption Spectrometry
Total Coliform Organism	ISO 6222:1999, Microbiological method

3 Lab Results

Results obtained following the physical, biological and chemical testing of data collected (see Table 6 to Table 10), shows that almost all stations are characterized by median of pH between 7.0 and 7.9; so, the values are generally within appropriate limits for water supply and aquatic life. Total Dissolved Solids are a measure of all ions in a solution (TDS). TDS measurements were greater than 385 ppm for all the samples.

The ammonium concentration in the samples carried out during the months of mars 2023 showed acceptable values compared to WHO international standards. The amounts of nitrate, heavy metals, and chloride have not given values that exceed the accepted standards. Very high cadmium, sulphate and BOD concentration that exceed the acceptable limits for agricultural usage were found at most points.

Below are the results of the field measurement:

Table 6 Results of Point 1

Point Number	**Point Name**			**Nb of readings**
1	**Jeser Al Aramel**			**3**
Report Properties	Start Time = 2023-03-22 09:40:00 Duration = 00:00:20			
Sample Number	1a	1b	1c	**Average**
Turbidity (NTU)	98.6	113.1	121.3	**111.0**
RDO (mg/L)	8.6	8.6	8.6	**8.6**
S-Conductivity (µS/cm)	614.5	588.0	604.3	**602.3**
Salinity (PSU)	0.3	0.3	0.3	**0.3**
Resistivity	1939.1	2026.4	1970.8	**1978.8**
Density	1.0	1.0	1.0	**1.0**
TDS (mg/L)	399	382	392	**391.0**
TSS (mg/L)	9	10	9	**9.5**
TS (mg/L)	410	408	407	**408**
pH (pH)	8.2	8.1	8.1	**8.1**
Temperature (°C)	16.6	16.6	16.6	**16.6**
Nitrate (mg/L)	2.40	2.90	2.75	**2.75**
Lead (mg/L)	0.11	0.12	0.9	**0.11**
Cadmium (mg/L)	0.040	0.049	0.046	**0.044**
Barium (mg/L)	2.1	2.1	2.1	**2.1**
Mercury (ɥg/L)	0.01	0.01	0.01	**0.01**
Sodium (ppm)	3.0	3.2	4.1	**3.5**
Potassium (ppm)	0.1	0.1	0.1	**0.1**
Lithium (ppm)	0.01	0.01	0.01	**0.01**
Calcium (ppm)	0.02	0.02	0.02	**0.02**
Phosphorous (mg/L)	<0.3	<0.3	<0.3	**<0.3**
Chloride (mg/L)	20	16	23	**20**
Ammonia (mg/L)	5.80	6.7	5.3	**5.88**
Sulphate	66	66	72	**68**
Fluoride	0.8	0.8	0.8	**0.8**
DO	8.7	8.5	9	**8.7**
BOD	92	86	89	**89**
COD	120	128	124	**124**
Total Coliform	55	53	58	**55**
Fecal	20	21	20	**20**
E coli	11	11	11	**11**

Figure 7 Sampling at point 1

Table 7 Results of Point 2

Point Number		**Point Name**		**Nb of readings**
2		**Aser Zaaiter**		**3**
Sample Number	2a	2b	2c	Average
Turbidity (NTU)	105.1	70.4	100.7	**92.1**
RDO (mg/L)	8.7	8.8	8.7	**8.7**
S-Conductivity (μS/cm)	498.1	499.4	498.5	**498.7**
Salinity (PSU)	0.3	0.3	0.3	**0.3**
Resistivity (Ω·cm)	2008.7	2002.2	2006.0	**2005.6**
Density (g/cm³)	1.0	1.0	1.0	**1.0**
TDS (mg/L)	385	385	385	**385**
TSS (mg/L)	37	35	36	**36**
TS (mg/L)	422	426	421	**421**
pH (pH)	8.5	8.5	8.5	**8.5**
ORP (mV)	18.5	9.8	4.2	**10.8**
Temperature (°C)	16.8	16.8	16.8	**16.8**
Nitrate (mg/L)	3.25	3.15	3.05	**3.15**
Lead (mg/L)	0.55	0.54	0.54	**0.55**
Cadmium (mg/L)	0.05	0.05	0.05	**0.05**
Barium (mg/L)	2.1	2.1	2.3	**2.2**
Mercury (ɥg/L)	0.04	0.04	0.04	**0.04**
Sodium (ppm)	3.7	3.8	4.0	**3.9**
Potassium (ppm)	0.1	0.1	0.1	**0.1**
Lithium (ppm)	0.02	0.02	0.02	**0.02**
Calcium (ppm)	0.001	0.001	0.001	**0.001**
Phosphorous (mg/L)	<0.3	<0.3	<0.3	**<0.3**
Chloride (mg/L)	100	100	105	**102**
Ammonia (mg/L)	3.90	3.96	3.93	**3.93**
Sulphate	61	62	62	**62**
Fluoride	0.7	0.7	0.7	**0.7**
DO	8.5	8.7	8.8	**8.7**
BOD	90	101	94	**95**
COD	135	130	130	**132**
Total Coliform	113	113	108	**111**
Fecal	29	36	31	**32**
Ecoli	18	18	21	**19**

Table 8 Results of Point 3

Point Number		Point Name		Nb of readings
3		Wadi Chahrour al Sofla		3
Sample nb	3a	3b	3c	Average
Turbidity (NTU)	19.9	21.8	20.8	**20.8**
RDO (mg/L)	9.1	9.1	9.0	**9.1**
S-Conductivity (µS/cm)	595.0	595.0	594.8	**594.9**
Salinity (PSU)	0.3	0.3	0.3	**0.3**
Resistivity (Ω·cm)	2015.8	2015.8	2016.1	**2015.9**
Density (g/cm³)	1.0	1.0	1.0	**1.0**
TDS (mg/L)	387	387	387	**387**
TSS (mg/L)	13	13	13	**17**
TS (mg/L)	397	398	405	**400**
pH (pH)	8.4	8.4	8.4	**8.4**
Temperature (°C)	16.3	16.3	16.3	**16.3**
Nitrate (mg/L)	3.25	3.25	3.35	**3.28**
Lead (mg/L)	0.1	0.1	0.1	**0.1**
Cadmium (mg/L)	0.040	0.042	0.041	**0.041**
Barium (mg/L)	2	2	2	**2**
Mercury (ųg/L)	0.04	0.04	0.04	**0.04**
Sodium (ppm)	3.2	3.2	3.4	**3.3**
Potassium (ppm)	0.1	0.1	0.1	**0.1**
Lithium (ppm)	0.001	0.001	0.001	**0.001**
Calcium (ppm)	0.01	0.01	0.01	**0.01**
Phosphorous (mg/L)	<0.3	<0.3	<0.3	**<0.3**
Chloride (mg/L)	18	17	17	**17**
Ammonia (mg/L)	2.60	2.66	2.63	**2.63**
Sulphate	65	67	69	**67**
Fluoride	0.8	0.8	0.8	**0.8**
DO	9.5	9.5	8.1	**9.1**
BOD	56	56	56	**56**
COD	77	79	81	**79**
Total Coliform	117	126	122	**121**
Fecal	34	34	34	**34**
E coli	27	27	27	**27**

Figure 8 Sampling at point 3

Table 9 Results of Point 5

Point Number		Point Name		Nb of readings
5		**Tiro-Airport**		**3**
Sample Nb	5a	5b		**Average**
Turbidity (NTU)	43.7	39.9	39.1	**40.9**
RDO (mg/L)	6.9	6.9	6.9	**6.9**
S-Conductivity (µS/cm)	1742.5	1742.5	1742.3	**1742.4**
Salinity (PSU)	0.9	0.9	0.9	**0.9**
Resistivity (Ω·cm)	681.2	681.5	681.8	**681.5**
Density (g/cm³)	1.0	1.0	1.0	**1.0**
TDS (mg/L)	1133	1139	1130	**1134**
TSS (mg/L)	152	165	159	**159**
TS (mg/L)	1290	1298	1292	**1293**
pH (pH)	8.2	8.2	8.2	**8.2**
Temperature (°C)	16.8	16.7	16.7	**16.7**
Nitrate (mg/L)	2.91	2.91	2.91	**2.91**
Lead (mg/L)	0.16	0.16	0.16	**0.16**
Cadmium (mg/L)	0.103	0.101	0.100	**0.101**
Barium (mg/L)	2.4	2.4	2.4	**2.4**
Mercury (ɥg/L)	0.06	0.06	0.06	**0.06**
Sodium (ppm)	45	46	49	**46**
Potassium (ppm)	5	5	5	**5**
Lithium (ppm)	0.05	0.05	0.05	**0.05**
Calcium (ppm)	19	19	19	**19**
Phosphorous (mg/L)	<0.3	<0.3	<0.3	**<0.3**
Chloride (mg/L)	305	302	294	**300**
Ammonia (mg/L)	17	17	16.4	**16.8**
Sulfate	117	126	118	**122**
Fluoride	0.8	0.8	0.8	**0.8**
DO	5.7	6.1	6.8	**6.2**
BOD	147	134	145	**142**
COD	189	196	179	**188**
Total Coliform	119	118	129	**122**
Fecal	39	39	39	**39**
E coli	27	30	29	**29**

Figure 9 Sampling point 5

Table 10 Results of Point 6

Point Number		Point Name		Nb of readings
6		Costa Brava Beach		3
Sample nb	6a	6b	6c	Average
Turbidity (NTU)	2107.1	2095.3	2101.2	**2101.2**
RDO (mg/L)	4.0	3.9	3.9	**3.9**
S-Conductivity (μS/cm)	4341.8	4312.7	4331.2	**4328.6**
Salinity (PSU)	2.3	2.3	2.3	**2.3**
Resistivity (Ω·cm)	271.2	272.8	272.4	**272.1**
Density (g/cm^3)	1.0	1.0	1.0	**1.0**
TDS (mg/L)	2799	2816	2820	**2812**
TSS (mg/L)	1799	1787	1802	**1796**
TS (mg/L)	4600	4609	4622	**4610**
pH (pH)	7.9	7.9	7.9	**7.9**
Temperature (°C)	17.1	17.1	17.1	**17.1**
Nitrate (mg/L)	1.41	1.44	1.41	**1.42**
Lead (mg/L)	0.7	0.7	0.7	**0.7**
Cadmium (mg/L)	0.15	0.12	0.15	**0.14**
Barium (mg/L)	2.6	2.6	2.6	**2.6**
Mercury (ųg/L)	0.09	0.09	0.09	**0.09**
Sodium (ppm)	106	96	101	**101**
Potassium (ppm)	13	13	11	**12**
Lithium (ppm)	0.07	0.07	0.07	**0.07**
Calcium (ppm)	21	21	26	**23**
Phosphorous (mg/L)	<0.3	<0.3	<0.3	**<0.3**
Chloride (mg/L)	366	361	354	**360**
Ammonia (mg/L)	2.14	2.18	2.19	**2.17**
Sulfate	350	350	350	**350**
Fluoride	0.8	0.8	0.8	**0.8**
DO	4.1	4.00	3.7	**3.9**
BOD	211	219	213	**214**
COD	288	289	293	**290**
Total Coliform	145	141	141	**142**
Fecal	49	47	42	**46**
E coli				

It is important to mention that the watercolour at the day of sampling was weird to the samplers, leaning to orange. The sampler suggested it might include a lot of soil from mountain or it might be due to the presence of tiles factories in the neighboured that are discharging the colours used in the water as seen in figure 10.

Figure 10 Sampling point 6

Water safety and quality are fundamental to human development and well-being. Providing access to safe water is one of the most effective instruments in promoting health and reducing poverty. To analyze the water quality in the Al Ghadir river we need to compare our lab results values to the water standards that are intended to protect public health. Recognizing this, we are abiding by World Health Organization (WHO) normative "guidelines" that present an authoritative assessment of the health risks associated with exposure to health hazards through water and of the effectiveness of approaches to their control.

WHO Water quality guidelines specify the conditions water must meet to protect those specific uses. Measuring Al Ghadir river water results against water quality standards shows which bodies of water or which exact location needs restoration and protection and dictates how we set limits on pollutant discharges from public and private facilities.

Below, Table 11 shows the WHO Standards Limit for surface water. Our value from AL Ghadir water testing will be compared to these limits to examine it is quality.

Table 11 WHO Standards Limit Table (Boyd,2019)

Chemical Product	WHO Limit	Chemical Product	WHO Limit
Ph	6.5-8.45	CL- (mg/L)	250
Temp °C	15-21	F^{-} (mg/L)	1.5
EC (ɥS/cm)	1500	$PO_4{}^{3-}$ (mg/L)	1
TDS (mg/L)	500	Ca^{2+} (mg/L)	200
BOD (mg/L)	25	Mercury (mg/L)	0.002
COD (mg/L)	25	Barium (mg/L)	1.3
Na^{2+} (mg/L)	150	Cadmium (mg/L)	0.005
$K+^{+}$(mg/L)	12	Lead (mg/L)	0.015
$NH_4{}^{+}$ (mg/L)	1.5	Total Nitrogen	50
$SO_4{}^{2-}$ (mg/L)	250	$NO_3{}^{-}$ (mg/L)	50

Below is a summary of all the results got from testing AL Ghadir river (Table 12). Highlighted in red are the values that exceed the WHO standards for the tested quality parameter.

Table 12 Summary of the results

Test/Point	Pt 1	Pt 2	Pt 3	Pt 5	Pt 6
Turbidity (NTU)	111.0	92.1	20.8	40.9	2101.2
pH (pH)	8.2	8.5	8.4	8.2	7.9
RDO (mg/L)	8.6	8.7	9.1	6.9	3.9
S-Conductivity (μS/cm)	602.3	498.7	594.9	1742.5	4328
Salinity (PSU)	0.3	0.3	0.3	0.9	2.3
TDS (mg/L)	399	385	387	1134	2812
TSS (ppm)	9.5	36	17	159	1796
TS (ppt)	408	421	400	1293	4610
Temp(°C)	16.6	16.8	16.3	16.7	17.1
Nitrate (mg/L)	2.75	3.15	3.28	2.91	1.42
Lead (mg/L)	0.11	0.55	0.1	0.16	0.7
Cadmium (mg/L)	0.044	0.05	0.041	0.101	0.14
Barium (ppm)	2.1	2.2	2	2.4	2.6
Mercury (ųg/L)	0.01	0.04	0.04	0.06	0.09
Sodium (ppm)	3.5	3.9	3.3	46	101
Potassium (ppm)	0.1	0.1	0.1	5	12
Lithium (ppm)	0.01	0.02	0.001	0.05	0.07
Calcium (ppm)	0.02	0.001	0.01	19	23
Phosphorus (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3
Chloride (mg/L)	20	102	17	300	360
Ammonia (mg/L)	5.88	3.93	2.63	16.8	2.17
Sulfate	68	62	67	122	350
Fluoride	0.8	0.7	0.8	0.8	0.8
DO	8.7	8.7	9.1	6.2	3.9
BOD	89	95	56	142	214
COD	124	132	79	188	290
Total Coliform	55	111	121	122	142
Fecal	20	32	34	39	46
Ecoli	11	19	27	29	30

4 Discussion and Interpretations

Water samples were collected from Ghadir River during the wet season and tested for physical qualities, chemical contents, and microbiological counts. Six sampling points were selected. Water quality parameters, such as conductivity, DO, BOD, COD, pH, TS, DS, and Fecal Coliform were analyzed. The concentration of lead, cadmium, mercury, barium, lithium, sodium, potassium, chloride, sulfate, fluoride, ammonia, phosphorus, and nitrate was also analyzed at all the points. The examination of the results is shown below:

Measuring **Dissolved Oxygen** (**DO**) in drinking water is an important property of water quality. DO is critical for fish and other aquatic organisms to survive. DO values for Al-Ghadir river, along our reach varied between 3.9 mg/L to 8.7 mg/L. WHO standard for sustaining aquatic life is <4 mg/L, whereas for drinking purposes it is 6 to 8.5 mg/L. Therefore, all the examined points are not suitable for aquatic life. The DO has increased and improved considerably after the rainfalls in the season and increased as they were very low and not suitable for aquatic life in report 1 (<1mg/L), during the dry season. The rainwater has improved the quality of the river in terms of DO. Low levels of oxygen (hypoxia) or no oxygen levels (anoxia) means that there are excess organic materials, such as large algal blooms, that are decomposed by microorganisms in the studied river.

While in the case of **Biological Oxygen Demand (BOD)** concentration, the results recorded values ranging from 56 mg/L at point 3 to 214 mg/L at point 6. Most rivers have BOD_5 below 1 mg/L. Moderately polluted rivers may have a BOD_5 value in the range of 2 to 8 mg/L. High BOD_5 levels (>8mg/L) can be a result of high levels of organic pollution, caused usually by poorly treated wastewater, or from high nitrate levels (EEA, 2001). WHO standard for surface water is 25 mg/L, which is exceeded to a great extent as shown by the values in Table 10. High BOD_5 values were detected at all sites which may be attributed to high levels of Nitrates and phosphates. These high values indicate that sewage or industrial wastewater is penetrating Al-Ghadir river. High biochemical oxygen demand can be caused by high levels of organic pollution, caused usually by poorly treated wastewater or non-treated wastewater penetrating the river; high nitrate levels, which trigger high plant growth. Both result in higher amounts of organic matter in the river. Notwithstanding the above, it is important to mention that BOD has decreased considerably after the rain fall as it ranged between 356 mg/L and 622 mg/L in the dry season indicating the rainfalls improved the quality of the water in terms of BOD but the water at al Ghadir river still needs a long road of treatment and attention before being suitable to be used for agriculture in terms of BOD.

Chemical Oxygen Demand (**COD**) is another important parameter of water quality assessment. A standard for surface purposes is 125 mg/L, which is exceeded for most sites in the studied river. Table 10 shows the COD data of five sampling points. The highest levels of COD recorded (280mg/L at point 6) may be also attributed to raw sewage discharge, and for the same reasons stated in the BOD examination. COD was diminished at all sites after the rainfall and has reached a value of 79mg/L as point 3.

Concerning the **pH** which is an indicator of the acidic or alkaline condition of water status, the standard for any purpose is 6.5-8.5, in that respect; the values of our sampled water conform with the standards because the values vary between 7.9 and 8.4. All sites exhibited values of pH within the limits of the natural values that support aquatic life.

Adding to the above, the value of **electric conductivity** (**EC**) of Al-Ghadir river varied between 498 and 4328 µs/cm. Conductivity depends on the number of ions present in water. The conductivity is high for points 5 and 6and exceeded the acceptable standards for rivers and surface water (< 1500 µs). A main observation from the results is that conductivity is directly influenced by TDS, the higher the TDS the higher the EC (Lawson, 2011).

Likewise, **total solids concentrations** concentrations in the wet season varied between a minimum of 400 mg/L at point 3 and a maximum of 4610 mg/L at point 6. Many factors contribute to high levels of total solids in water, with soil erosion being a major contributor. An increase in the water volume due to rainfall have decreased the amount of total solids at all the point between the two seasons.

Concerning **Dissolved Solids (DS)**, the standard for drinking water is 500 mg/L. The minimum and maximum values obtained from the samples in the wet season are 382 at point 2 mg/L and 2812 mg/L at point 6. In this respect, we can conclude that Al-Ghadir river water quality is not acceptable. High levels of TDS at some points are caused by the presence of potassium, chlorides, and sodium and by toxic ions (lead arsenic, cadmium, and nitrate), and result in an undesirable taste that could be salty, bitter, or metallic, discolour the water, and create an unpleasant odour. (Lawson, 2011).

Similarly, the WHO standard for **ammonia** in surface water is 1.5 mg/L. The results yielded from the test results showed higher values for all the sites reaching 16.8 mg/L at point 5, which means it is very dangerous in terms of ammonia pollution. Yet these results are way lower than those detected before the rainfall. These high levels of ammonia might be attributed to agricultural runoff in addition to raw sewage discharge. Likewise, ammonia peak might be associated with a nutrient influx in streams with little to no flow and low DO content (Ryan et al. 2002). Ammonia levels above the recommended limits may harm the whole aquatic life. Ammonia toxicity is thought to be one of the main causes of unexplained losses in fish hatcheries. Excess ammonia may accumulate in the organism and cause an alteration of metabolism or increases in body ph. Adversely, the levels of **nitrate** exhibited a similar fluctuation among the sites ranging all within the acceptable levels (5 mg/l).

Apart from the above, we have traced metal detection in the water. These chemicals are classified as being potentially hazardous and toxic to most forms of life. Results reported that trace metals' concentrations for **lead, mercury, and cadmium** were very high at all points and mostly elevated at points 5, and 6. It is important to mention that cadmium levels are above the acceptable ranges for agricultural use at all sites. The above results imply that the river is receiving cadmium and lead from the direct discharge of industrial wastes directly into the river. The elevated concentration of these toxic compounds in the water can be detrimental to people's health. For example, even in small doses, lead exposure can cause brain and nervous system damage, while PFAS exposure is linked to cancer, thyroid disease, and other health problems.

Moreover, some of the chemical elements like **Sodium, potassium, lithium, and calcium** are essential as micronutrients for the life processes in animals and plants (Kar et al., 2008). Fortunately, acceptable concentrations were found in GRB.

Similarly, **phosphorus** concentrations recorded values less than 0.3 in the wet season. Comparing these results with WHO limits, they fall in the acceptable level of phosphorus (1mg/L) in rivers. These were reduced after the rainfall, as the values at the end of the summer season were above 2.77 mg/L .

Similarly, **chloride** concentration documented values varying from 17 at point 3 to 360 mg/L at points 6. Compared with WHO guidelines, the level of chloride at the latter sites confirms that there are industrial effluents or urban runoff at the location of the sample 5 and 6.

The **sulphate** recorded a mean value of less than 67 mg/L for sites 1,2, and 3. Compared with WHO guidelines, the results fall within the acceptable range (<200 mg/L), however at sites 6, the concentration of sulphate exceeded the acceptable level. Yet the sulphate level of all the point has decreased during the wet season. Acid drainage, fertilizer leaching from agricultural soils, wetland drainage, and agricultural and industrial wastewater runoff as well as sea level changes are the main direct and indirect sources of the anthropogenic SO42- input to AL Ghadir river.

Moreover, **fluoride** concentrations were recorded at all sites, yet no marked variation was observed (<1mg/L at all points). Acceptable values were found at all sites.

Apart from the physical and chemical parameters, the water was tested for microbiological pollutants. The results of the five sampling points show that all sites are bacteriologically contaminated to an extreme extent. Total, fecal, and E-coli were detected at all sites and were too numerous indicating the critical condition of excessive microbiological contamination. The presence of fecal coliform bacteria in very high levels indicates potential health risks to swimmers and implies the unsuitability of the water at these critical points for specific water most domestic water uses. The source of organic and microbial pollutants present in the water can be accounted for by the seepage of industrial wastewater into the river and support the presence of agricultural runoff, and animal waste, raw sewage, (Amacha et al., 2012). Several health outcomes such as gastrointestinal infections might be associated with fecally polluted water which may result in a significant burden of disease (WHO 2001). Yet at all sites, a reduction in the amount of colonid was detected at the end of the wet season.

To sum up, the results from data analysis show that, the water is certainly unfit for drinking purposes without any form of treatment, but for various other surface water usage purposes, it still could be considered quite acceptable. But as we know, once a trend in pollution sets in, it generally accelerates to cause greater deterioration. So, a few years from now, serious water quality deterioration could take place.

5 Conclusion

The water quality of the Ghadir River was analyzed. The physical, bacteriological, and chemical composition of the river was studied in the wet season. All sites exhibited values of pH within the limits of the natural values that support aquatic life. The levels of TDS were fluctuating among the sites with the highest values recorded at site 6 which is extremely violating the guideline and implies seawater and wastewater intrusion. Higher BOD_5 values were detected at sites 5 and 6 which may be attributed as well to seepage of industrial and raw sewage water. The levels of nitrate exhibited a clear fluctuation among the sites ranging yet falling below the limit for surface water. The estimated indices at sites 5 and 6 exhibited the worst water quality conditions among the studied sites.

WHO specifies guidelines and imperative values for drinking and aquatic life were used. This assessment was adopted as the Lebanese Ministry of Environment (MoE) Standards for surface water, do not include all of the parameters reported here.

Results revealed that the water quality of the Ghadir river is very polluted and generally affected by activities related to industrial wastes and raw sewage wastes.

6 Quality Assurance and Performance

Quality assurance (QA) plan contains the policies, procedures and actions established to provide and maintain a degree of confidence in data integrity and accuracy. For the monitoring trip to AL Ghadir River to successfully meet its objectives, NDU took rigorous and thorough steps to ensure that its testing campaign is reliable. The team followed EPA standards for monitoring and sampling procedures. The QA system shown in Table 13 was followed.

Moreover, Water sampling quality control ensures that the monitoring data taken sufficiently represents the in-situ conditions of the Al Ghadir River. Any significant change of contamination to the sample due to containers, handling and transportation is identified through the incorporation of QC. Therefore, all labs tests at NDU were taken in triplicates and a comparison of the results was examined. In all cases no outliers was found, and the average was taken for all the parameters

Table 13 Quality control in monitoring

Monitoring Step	**QC protocols**	**Purpose**	**Refer to Compulsory**
Develop monitoring plan	Various, including control sites, multiple sample locations, duplicate samples, sampling times	Ensure the sample collected is representative of the body from which it was taken	Section 1 in this report
Sample collection	Appropriate containers, filling, and preservation techniques	Minimize changes to sample (physical and chemical)	Section 2
	Sample blanks—field, transport, equipment, and container	Quantify contamination of samples during the sampling process	Section 3
	Decontamination of sampling equipment	Minimize contamination	Section 3
Field testing	Equipment calibration	Minimize and quantify bias and error in-field equipment	Section 3
Transport and storage	Appropriate preservation techniques	Minimize physical and chemical changes to sample	Section 4
Analysis	NDU lab accredited by ABET for required analysis	Ensure the laboratory undertakes appropriate QC including spikes, calibration of equipment, and make sure the results are reported in triplicates	Section 5 and 6
Reporting	Peer review validation	Validate that sampling is undertaken as per the monitoring plan and by sampling guidelines	Section 5 to 7

References

Boyd, C. E. (2019). *Water quality: an introduction*. Springer Nature.

Griffiths, C., Klemick, H., Massey, M., Moore, C., Newbold, S., Simpson, D., & Wheeler, W. (2012). US Environmental Protection Agency valuation of surface water quality improvements. *Review of Environmental Economics and Policy*.

Hespanhol, I., & Prost, A. M. E. (1994). WHO guidelines and national standards for reuse and water quality. *Water Research*, *28*(1), 119-124.

United States. Environmental Protection Agency. Office of Water Regulations, & Standards. (2013). *Water quality standards handbook*. US Environmental Protection Agency, Office of Water Regulations and Standards.

B.First Participatory Workshop Report

Challenges

Municipalities

- Problem with intermixing of rainwater and wastewater and the need for separation.
- Illegal construction within Ghadir river bed.
- Industrial pollution along the riverbed – need to revise CDR studies for this issue.
- No integration between ministries (MoE, MoEW, and MoI) and the need for collaboration.
- Insufficient cleaning of Ghadir riverbed.
- Problem with leachate generated from Costa Brava landfill.
- Inadequate capacity of the existing sewer lines in the area and the need for new survey and increase the hydraulic capacity of the system.

Research Institutes and Academia

- Identify and locate primary point sources of pollution and address priorities (e.g., industries, farmers, etc.)
- Absence of government in regards to alleviating pollution on Ghadir river and proposition towards micro and decentralized management. Recommendation to install several small-scale WWTPs to limit pollution and reduce load on the existing central preliminary Ghadir WWTP.
- Absence of identification of project stakeholders and no reliance in specific criteria during solution discussions.
- Problem with salt water intrusion into the many private wells in the watershed area leading to contaminated water not suitable for domestic usage – recommendation to head towards usage of surface water sources and groundwater aquifer recharge.

Environmental Activists and Organizations

- Problem with industrial pollution and necessity to do preliminary or secondary treatment for each industry prior discharge into the wastewater network or the surface water.
- Absence of municipal roles and their financial weakness.
- Decentralized vs. centralized wastewater solutions – a study of cost/benefit and requirement of proper alternative analysis and selection criteria.

Suggested Solutions

Group A:

- Definition and delineation of the public Ghadir riverbed border/domain.
- Removal of all illegal structures within the river domain and assignment and implementation of penalties.
- Updating of the already assigned solutions (from studies with the CDR) and their compilation
- Better involvement and inclusion of the municipalities and locate funding sources
- Division of the problem into subparts and solving one subpart after the other
- Awareness campaigns
- As a temporary and immediate solution, proposition to construct retainment structures to protect the illegal houses within the river domain from heavy flash floods during the rainy season.

Group B:

- Creation of a committee that is responsible for planning and assigning of solution for the industrial pollution in the area
- Awareness campaigns
- Legal Accountability
- Complete surveying of illegal structures within the riverbed domain
- Investing in rainwater harvesting projects
- Groundwater recharge
- Excavation of additional pathways for the river to disperse and divide the flow and therefore reduce the intensity and concentration of the floods.

Group C:

- Maintenance of the existing wastewater network and installation of new networks to increase the connection coverage rate to Ghadir WWTP and upgrading of the plant to include additional secondary and tertiary treatment stages.
- Construction of a system of decentralized small-scale WWTPs and finding of mutual benefits
- Increase awareness campaigns

C.Geological sections

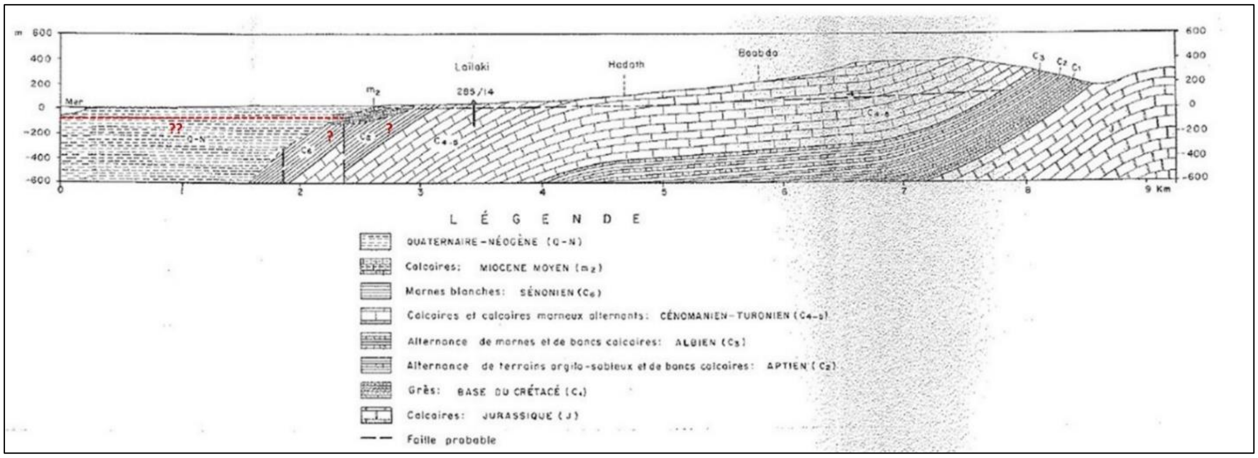


Figure D-1: Geological section crossing through the study area (modified from UNDP, 1970)

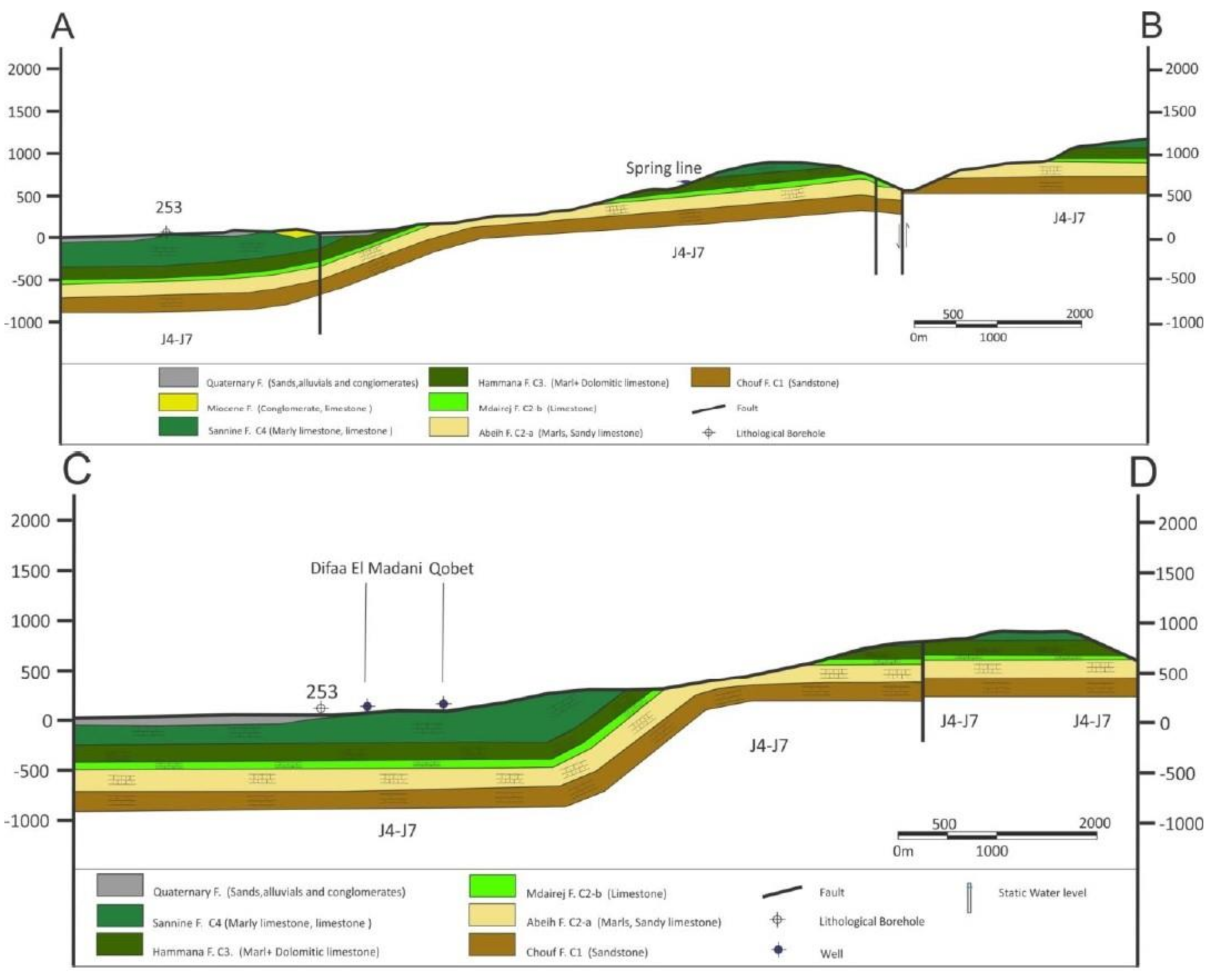


Figure D-2: Geological cross sections AB & CD (Doummar et al., 2015)

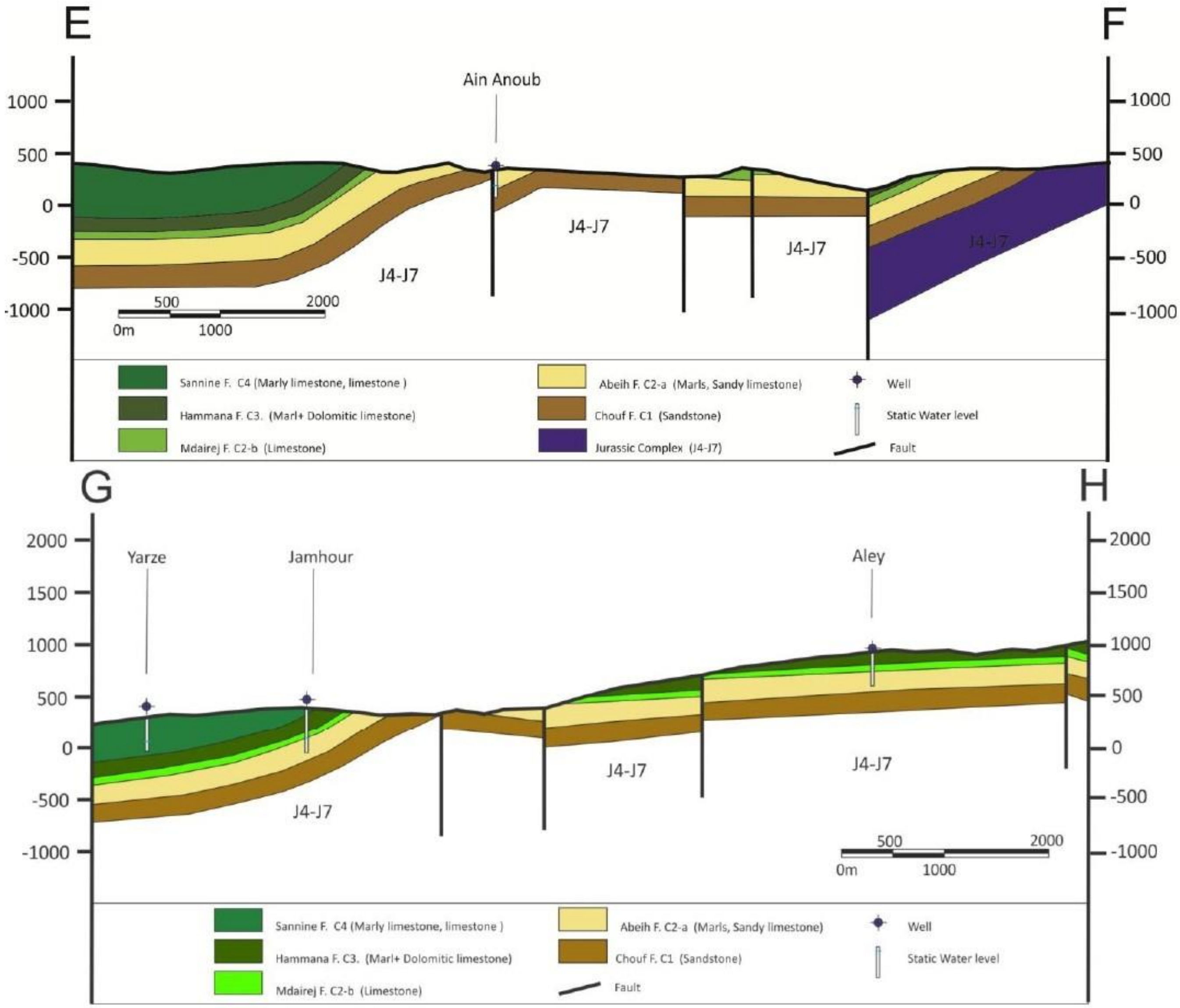


Figure D-3: Geological cross sections EF & GH (Doummar et al., 2015)

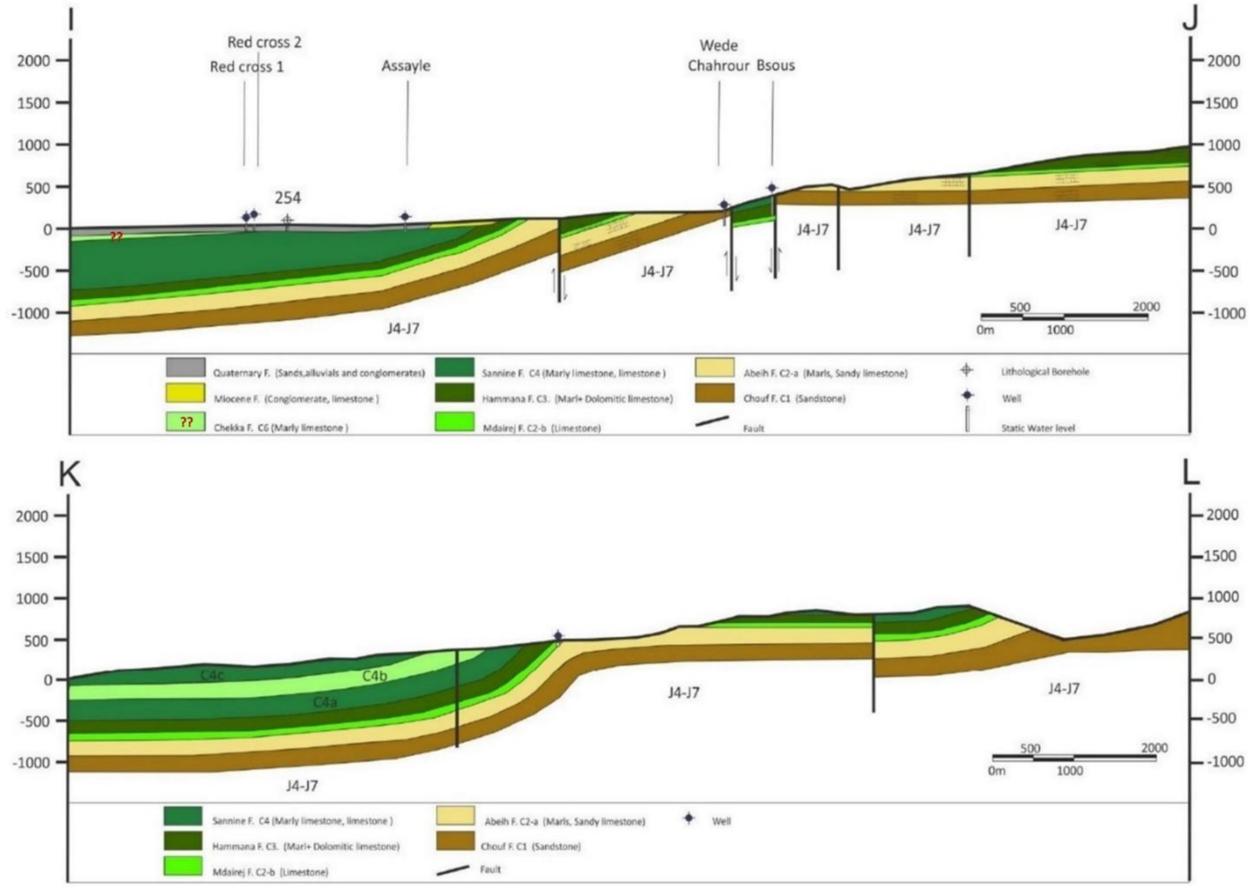


Figure D-4: Geological cross sections IJ & KL (Doummar et al., 2015)

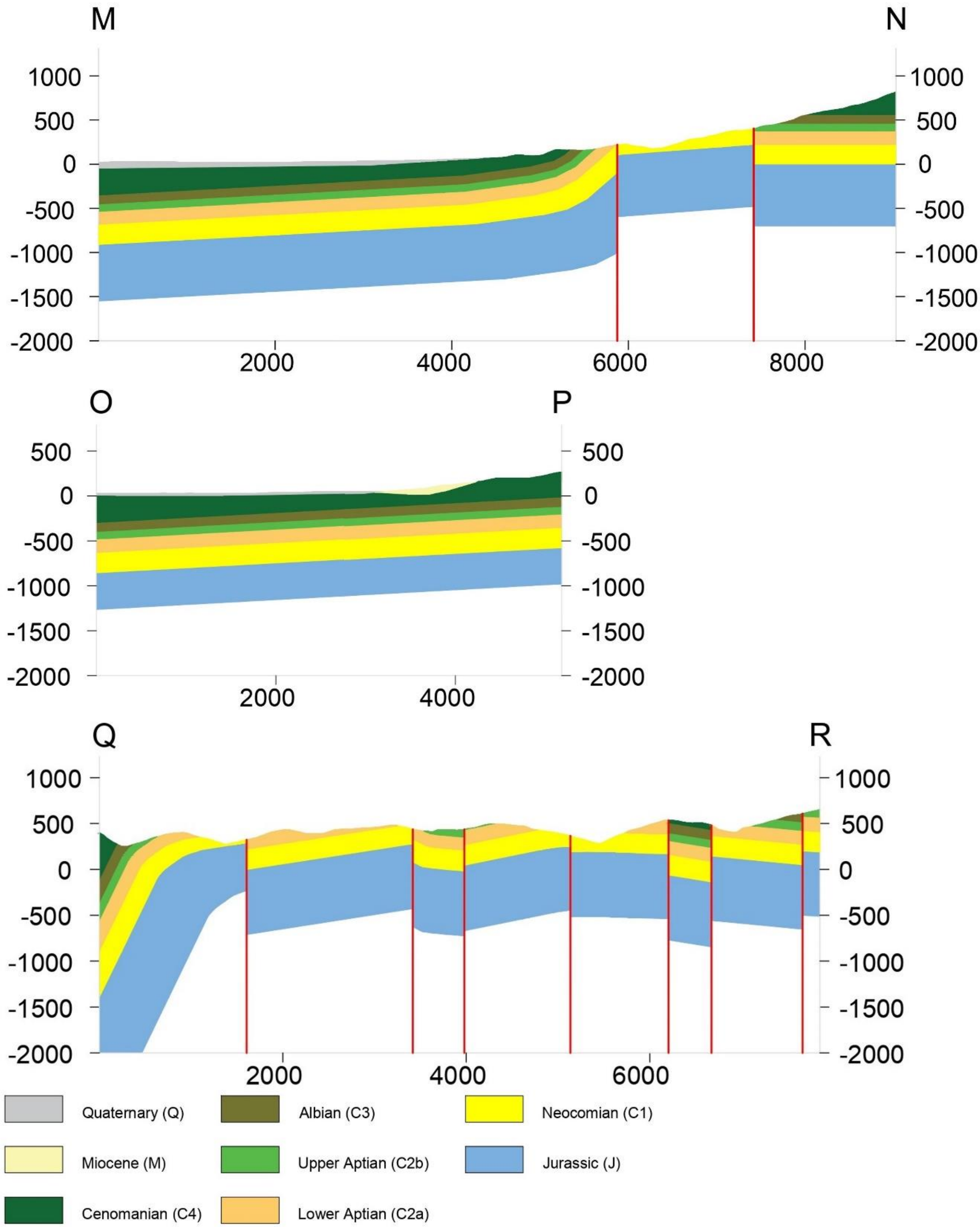


Figure D-5: Geological cross sections MN, OP & QR generated for the sake of this project (note: red vertical lines represent faults)

D.WEAP detailed results

Transmission Link Flow (Cubic Meter)
Scenario: Reference (S0), All Transmission Links, Annual Total

Transmission Link	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from RW01 RAAY to WS01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from RW04 ADEL to WS04 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from RW06 DAYC to WS06 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from SP02 ADEL to RR02 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from SP03 DAYC to RR03 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	1103340	1103481	1103381	1103340	1103381	1103340	1103340	1103374	1103340	1103340	1103340	1103340	1103340	1103340	1103340	1103373
Transmission Link from WE05 BLEI to WS09 BLEI	103806	105551	107295	109040	110785	112529	114274	116019	117764	119508	121253	122998	124742	126487	128232	129976
Transmission Link from WE06 BETC to WS07 BOUT	74569.5	75825.1	77080.7	78336.3	79591.9	80847.5	82103.1	83358.7	84614.3	85869.9	87125.5	88381.1	89636.7	90892.3	92147.9	93403.5
Transmission Link from WE07 BSAB to WS05 BSAB	186150	189282	192413	195545	198677	201809	204940	208072	211204	214335	217467	220599	223730	226862	229994	233125
Transmission Link from WE08 BSOU to WS02 BSOU	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	440848	440835	440835	440837	440835	440805	440805	440805	440805	440805	440805	440805	440871	440805	440805	440805
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	882935	882935	882935	882935	882935	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970

Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	95046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2190
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	2102.4	3693.8	5285.2	6876.6	8468	10059.4	11650.8	13242.2	14833.6	16425	18016.4	19607.8	21199.2	22790.6	22192
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94109.5	94102.5	94098
Transmission Link from WE22 KANA to WS08 KFAR	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE23 OUSS to WS08 KFAR	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	315120	315122	315122	315122	315122	314805	314805	314805	314805	314805	314805	314805	314805	314805	314869	314805
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WP 01 to IR01	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270
Transmission Link from WX01 MECH to WS11 MECH	433572	433572	433572	433572	433572	433572	433572	433576	433572	433572	433572	433572	433572	433572	433572	433572
Sum	18050909	18058763	18066386	18074070	18081833	19753568	19761292	19769053	19776738	19784462	19792185	19799909	19807698	19815367	19823148	19830836

Transmission Link Flow (Cubic Meter)
Scenario: S1 - NWSS, All Transmission Links, Annual Total

Transmission Link	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	242774	246721	250667	254614	258561	262508
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	2116465	2154327	2192190	2230053	2267915	2305778
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	6377742	6429042	6480342	6531641	6582941	6634240
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	35064.3	47381.9	59699.4	72016.9	84334.5	96652
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	539912	547018	554123	561228	568334	575439
Transmission Link from RW01 RAAY to WS01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from RW04 ADEL to WS04 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from RW06 DAYC to WS06 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from SP02 ADEL to RR02 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from SP03 DAYC to RR03 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	1103340	1103481	1103381	1103340	1103381	1103340	1103340	1103374	1103340	1103340	1103760	1103760	1103760	1103760	1103760	1103760
Transmission Link from WE05 BLEI to WS09 BLEI	103806	105551	107295	109040	110785	112529	114274	116019	117764	119508	80835.3	81998.5	83161.6	84324.7	85487.9	86651
Transmission Link from WE06 BETC to WS07 BOUT	74569.5	75825.1	77080.7	78336.3	79591.9	80847.5	82103.1	83358.7	84614.3	85869.9	58083.7	58920.7	59757.8	60594.9	61431.9	62269
Transmission Link from WE07 BSAB to WS05 BSAB	186150	189282	192413	195545	198677	201809	204940	208072	211204	214335	144978	147066	149154	151241	153329	155417
Transmission Link from WE08 BSOU to WS02 BSOU	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31390	31390	31390	31390	31390	31390
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	440848	440835	440835	440837	440835	440805	440805	440805	440805	440805	0	23700.7	73146	122591	172037	221482
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	882935	882935	882935	882935	882935	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	258225	283970	283970	283970	283970	283970

Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	95046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2190
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	2102.4	3693.8	5285.2	6876.6	8468	10059.4	11650.8	13242.2	14833.6	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	94535	94535	94535	94535	94535	94535	94535	94535	94535	73973.3	75034.3	76095.2	77156.1	78217.1	77088
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94170	94170	94170	94170	94170	94170
Transmission Link from WE22 KANA to WS08 KFAR	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE23 OUSS to WS08 KFAR	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1230050	1230050	1230050	1230050	1230050	1230050
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	315120	315120	315120	315120	315120	314805	314805	314805	314805	314789	146389	180154	213919	247684	281449	315214
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	426632	426632	426632	426632	426632	426632
Transmission Link from WP 01 to IR01	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270
Transmission Link from WX01 MECH to WS11 MECH	433572	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	18050909	17625189	17632812	17640496	17648259	19319996	19327720	19335477	19343166	19350874	28283974	28484865	28685756	28886647	29087539	29288430

Transmission Link Flow (Cubic Meter)
Scenario: S2 - Full coverage, All Transmission Links, Annual Total

Transmission Link	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	184514	187622	190730	193838	196947	200055
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	1102681	1132498	1162315	1192132	1221949	1251766
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	4895425	4935823	4976222	5016620	5057018	5097417
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	334522	340117	345713	351308	356903	362499
Transmission Link from RW01 RAAY to WS01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from RW04 ADEL to WS04 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from RW06 DAYC to WS06 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from SP02 ADEL to RR02 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from SP03 DAYC to RR03 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	1103340	1103481	1103381	1103340	1103381	1103340	1103340	1103374	1103340	1103340	1103760	1103760	1103760	1103760	1103760	1103760
Transmission Link from WE05 BLEI to WS09 BLEI	103806	105551	107295	109040	110785	112529	114274	116019	117764	119508	63657.8	64573.8	65489.8	66405.7	67321.7	68237.7
Transmission Link from WE06 BETC to WS07 BOUT	74569.5	75825.1	77080.7	78336.3	79591.9	80847.5	82103.1	83358.7	84614.3	85869.9	45740.9	46400.1	47059.3	47718.5	48377.6	49036.8
Transmission Link from WE07 BSAB to WS05 BSAB	186150	189282	192413	195545	198677	201809	204940	208072	211204	214335	114170	115814	117458	119103	120747	122391
Transmission Link from WE08 BSOU to WS02 BSOU	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31390	31390	31390	31390	31390	31390
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	440848	440835	440835	440837	440835	440805	440805	440805	440805	440805	0	0	0	0	0	0
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	882935	882935	882935	882935	882935	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	248608	287546	326484	365422	404361	443299
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	0	0	0	0	0	0

Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	95046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2190
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	2102.4	3693.8	5285.2	6876.6	8468	10059.4	11650.8	13242.2	14833.6	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	94535	94535	94535	94535	94535	94535	94535	94535	94535	58254	59089.5	59925	60760.5	61595.9	60241.4
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94170	94170	94170	94170	94170	94170
Transmission Link from WE22 KANA to WS08 KFAR	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE23 OUSS to WS08 KFAR	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	909175	918875	928575	938275	947975	957675
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	485980	512570	539160	565750	592340	618930
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	0	0	0	0	0	0
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	315120	315120	315120	315120	315120	314805	314805	314805	314805	314789	0	0	0	0	0	0
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	426632	426632	426632	426632	426632	426632
Transmission Link from WP 01 to IR01	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270
Transmission Link from WX01 MECH to WS11 MECH	433572	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	18050909	17625189	17632812	17640496	17648259	19319996	19327720	19335477	19343166	19350874	23056644	23214846	23373048	23531249	23689451	23847653

Transmission Link Flow (Cubic Meter)
Scenario: S0CC - Climate Change, All Transmission Links, Annual Total

Transmission Link	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from RW01 RAAY to WS01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from RW04 ADEL to WS04 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from RW06 DAYC to WS06 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from SP02 ADEL to RR02 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from SP03 DAYC to RR03 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	1103340	1103340	1103343	1103355	1103341	1103340	1103340	1103355	1103394	1103340	1103343	1103383	1103355	1103343	1103353	1103359
Transmission Link from WE05 BLEI to WS09 BLEI	103806	105679	107577	109481	111389	113302	115220	117143	119071	121004	122942	124885	126833	128786	130743	132706
Transmission Link from WE06 BETC to WS07 BOUT	74569.5	75917.1	77283.1	78652.7	80025.9	81402.6	82782.8	84166.6	85554	86944.9	88339.4	89737.4	91139	92544.1	93952.7	95365
Transmission Link from WE07 BSAB to WS05 BSAB	186150	189511	192919	196335	199760	203194	206637	210089	213549	217019	220497	223984	227480	230985	234499	238021
Transmission Link from WE08 BSOU to WS02 BSOU	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.3	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	440848	440835	440835	440835	440835	440805	440805	440805	440805	440805	440805	440805	440825	440807	440805	440805
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	882935	882935	882935	882935	882935	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970

Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	95046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2190
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	2219.63	3951.77	5688.41	7429.55	9175.19	10925.3	12680	14439.1	16202.8	17970.9	19743.6	21520.8	23302.4	25088.6	24689.3
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535	94535
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94100	94098	94098	94098
Transmission Link from WE22 KANA to WS08 KFAR	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE23 OUSS to WS08 KFAR	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229876	1229875	1229875	1229875	1229875
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	315120	315122	315122	315122	315122	314843	314862	314805	314805	314883	314852	314858	314805	314815	314884	314812
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WP 01 to IR01	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270
Transmission Link from WX01 MECH to WS11 MECH	433572	433572	433572	433572	433572	433572	433572	433572	433572	433572	433572	433572	433573	433572	433572	433572
Sum	18050909	18059189	18067595	18076033	18084468	19757026	19765537	19774008	19782583	19791164	19799714	19808362	19816926	19825547	19834290	19842912

Transmission Link Flow (Cubic Meter)
Scenario: S1CC - NWSS, All Transmission Links, Annual Total

Transmission Link	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	246593	250988	255394	259812	264240	268680
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	21089.7	44105	67280.2	90615.6
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	2182933	2228120	2273414	2318815	2364323	2409939
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	6474929	6536876	6598968	6661205	6723587	6786114
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	58401.2	73275.3	88184.3	103128	118107	133121
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	553379	561959	570560	579181	587821	596482
Transmission Link from RW01 RAAY to WS01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from RW04 ADEL to WS04 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from RW06 DAYC to WS06 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from SP02 ADEL to RR02 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from SP03 DAYC to RR03 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	1103340	1103340	1103343	1103355	1103341	1103340	1103340	1103355	1103394	1103340	1103760	1103760	1103760	1103760	1103760	1103760
Transmission Link from WE05 BLEI to WS09 BLEI	103806	105679	107577	109481	111389	113302	115220	117143	119071	121004	81961.6	83256.8	84555.3	85857.2	87162.3	88470.7
Transmission Link from WE06 BETC to WS07 BOUT	74569.5	75917.1	77283.1	78652.7	80025.9	81402.6	82782.8	84166.6	85554	86944.9	58892.9	59824.9	60759.3	61696	62635.2	63576.6
Transmission Link from WE07 BSAB to WS05 BSAB	186150	189511	192919	196335	199760	203194	206637	210089	213549	217019	146998	149323	151653	153990	156332	158681
Transmission Link from WE08 BSOU to WS02 BSOU	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.2	31385.3	31385.2	31390	31390	31390	31390	31390	31390
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	440848	440835	440835	440835	440835	440805	440805	440805	440805	440805	86856.9	127637	166395	203367	240319	277251
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	882935	882935	882935	882935	882935	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	265042	283970	283970	283970	283970	283970

Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	95046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2190
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	2219.63	3951.77	5688.41	7429.55	9175.19	10925.3	12680	14439.1	16202.8	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	94535	94535	94535	94535	94535	94535	94535	94535	94535	75004	76185.7	77370.5	78558.3	79749.1	78752.8
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94170	94170	94170	94170	94170	94170
Transmission Link from WE22 KANA to WS08 KFAR	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE23 OUSS to WS08 KFAR	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1230050	1230050	1230050	1230050	1230050	1230050
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	315120	315120	315120	315120	315120	314843	314862	314805	314805	314883	186177	214288	239547	264808	290046	314958
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	426632	426632	426632	426632	426632	426632
Transmission Link from WP 01 to IR01	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270
Transmission Link from WX01 MECH to WS11 MECH	433572	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	18050909	17625615	17634021	17642459	17650894	19323454	19331965	19340436	19349011	19357592	28626700	28855235	29081391	29308023	29535105	29762334

Transmission Link Flow (Cubic Meter)
Scenario: S2CC - Full coverage, All Transmission Links, Annual Total

Transmission Link	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	189265	192445	195624	198804	201984	205164
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	1185357	1215881	1246407	1276933	1307460	1337988
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	5016310	5057673	5099036	5140401	5181768	5223135
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	351272	357001	362730	368459	374189	379918
Transmission Link from RW01 RAAY to WS01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from RW04 ADEL to WS04 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from RW06 DAYC to WS06 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	930750	930750	930750	930750	930750	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805	1699805
Transmission Link from SP02 ADEL to RR02 ADEL	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000	876000
Transmission Link from SP03 DAYC to RR03 DAYC	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700	503700
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555	75555
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070	189070
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	1103340	1103377	1103340	1103346	1103358	1103340	1103346	1103340	1103360	1103340	1103760	1103760	1103760	1103760	1103760	1103760
Transmission Link from WE05 BLEI to WS09 BLEI	103806	105531	107277	109023	110769	112514	114260	116007	117753	119499	65058.7	65995.7	66932.7	67869.8	68806.8	69743.9
Transmission Link from WE06 BETC to WS07 BOUT	74569.5	75810.9	77067.3	78323.8	79580.2	80836.7	82093.2	83349.8	84606.4	85863	46747.5	47421.8	48096.1	48770.5	49444.9	50119.3
Transmission Link from WE07 BSAB to WS05 BSAB	186150	189246	192380	195514	198648	201782	204916	208050	211184	214318	116683	118364	120046	121728	123410	125093
Transmission Link from WE08 BSOU to WS02 BSOU	31385.2	31385.2	31385.2	31385.2	31385.2	31385.3	31385.2	31385.2	31385.2	31385.6	31390	31390	31390	31390	31390	31390
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185	536185
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	440848	440835	440835	440835	440835	440830	440835	440811	440805	440805	0	0	0	0	0	0
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	882935	882935	882935	882935	882935	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225	1009225
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080	946080
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	1419120	365123	404991	444860	484730	524601	564473
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	283970	283970	283970	283970	283970	283970	283970	283970	283970	283970	0	0	0	0	0	0

Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	95046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2190
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	2084.36	3676.77	5269.23	6861.73	8454.27	10046.8	11639.5	13232.1	14824.9	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	94535	94535	94535	94535	94535	94535	94535	94535	94535	59535.9	60390.6	61245.3	62100	62954.8	61619.5
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	94098	94098	94098	94098	94098	94098	94098	94098	94098	94098	94170	94170	94170	94170	94170	94170
Transmission Link from WE22 KANA to WS08 KFAR	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895	409895
Transmission Link from WE23 OUSS to WS08 KFAR	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	1229875	938202	948134	958066	967998	977930	987863
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145
Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	630720	630720	630720	630720	630720	630720	630720	630720	630720	630720	535470	553658	571293	588874	606399	623869
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	0	9018.48	15916	15916	15916	15916
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	63145	63145	63145	63145	63145	63145	63145	63145	63145	63145	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	126290	126290	126290	126290	126290	126290	126290	126290	126290	126290	0	0	2673.63	12300.6	21983.3	31721.9
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	315120	315120	315120	315121	315120	314938	314842	314785	314848	314929	0	0	0	0	0	0
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	426632	426632	426632	426632	426632	426632
Transmission Link from WP 01 to IR01	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270	605270
Transmission Link from WX01 MECH to WS11 MECH	433572	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	18050909	17624997	17632689	17640425	17648163	19320088	19327732	19335374	19343181	19350972	23482940	23644889	23806843	23968801	24130763	24292730

Transmission Link Flow (Cubic Meter)
Scenario: Reference (S0), All Transmission Links

Transmission Link	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from RW01 RAAY to WS01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from RW04 ADEL to WS04 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from RW06 DAYC to WS06 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from SP02 ADEL to RR02 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from SP03 DAYC to RR03 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	93712	84636	93712	90680	93712	90680	93712	93712	90680	93712	90680	93712	93712	84641.2	93712	90687	93712	90687	93712	93712	90687	93712	90687	93712
Transmission Link from WE05 BLEI to WS09 BLEI	8816.4	7963.2	8816.4	8532	8816.4	8532	8816.4	8816.4	8532	8816.4	8532	8816.4	11039.1	9970.8	11039.1	10683	11039.1	10683	11039.1	11039.1	10683	11039.1	10683	11039.1
Transmission Link from WE06 BETC to WS07 BOUT	6333.3	5720.4	6333.3	6129	6333.3	6129	6333.3	6333.3	6129	6333.3	6129	6333.3	7932.9	7165.2	7932.9	7677	7932.9	7677	7932.9	7932.9	7677	7932.9	7677	7932.9
Transmission Link from WE07 BSAB to WS05 BSAB	15810	14280	15810	15300	15810	15300	15810	15810	15300	15810	15300	15810	19799.7	17883.6	19799.7	19161	19799.7	19161	19799.7	19799.7	19161	19799.7	19161	19799.7
Transmission Link from WE08 BSOU to WS02 BSOU	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	37445	33813.3	37445	36230	37445	36230	37445	37445	36230	37445	36230	37445	37439	33812	37439	36230	37439	36230	37439	37439	36230	37439	36230	37439
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	74989	67732	74989	72570	74989	72570	74989	74989	72570	74989	72570	74989	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118
Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	8072.4	7291.2	8072.4	7812	8072.4	7812	8072.4	8072.4	7812	8072.4	7812	8072.4	186	168	186	180	186	180	186	186	180	186	180	186
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	1884.8	1702.4	1884.8	1824	1884.8	1824	1884.8	1884.8	1824	1884.8	1824	1884.8
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	8029	7252	8029	7770	8029	7770	8029	8029	7770	8029	7770	8029
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992
Transmission Link from WE22 KANA to WS08 KFAR	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE23 OUSS to WS08 KFAR	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363

Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	26764	24172	26764	25900	26764	25900	26764	26764	25900	26764	25900	26764	26727	24156	26727	25890	26727	25890	26727	26727	25890	26727	25890	26727
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WP 01 to IR01	0	0	0	0	104544	104561	104561	104561	104544	82500	0	0	0	0	0	0	104544	104560	104560	104560	104544	82500	0	0
Transmission Link from WX01 MECH to WS11 MECH	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824
Sum	1481692	1338284	1481692	1433879	1586236	1538439	1586252	1586252	1538423	1564192	1433879	1481692	1632848	1474839	1632848	1580198	1737392	1684758	1737409	1737409	1684742	1715348	1580198	1632848

Transmission Link Flow (Cubic Meter)
Scenario: S1 - NWSS, All Transmission Links

Transmission Link	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	22295.2	20137.6	22295.2	21576	22295.2	21576	22295.2	22295.2	21576	22295.2	21576	22295.2
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	195833	176882	195833	189516	195833	189516	195833	195833	189516	195833	189516	195833
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	563456	508928	563456	545280	563456	545280	563456	563456	545280	563456	545280	563456
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	8208.8	7414.4	8208.8	7944	8208.8	7944	8208.8	8208.8	7944	8208.8	7944	8208.8
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	48872.7	44143.2	48872.7	47296.7	48872.7	47296.7	48872.7	48872.7	47296.7	48872.7	47296.7	48872.7
Transmission Link from RW01 RAAY to WS01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from RW04 ADEL to WS04 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from RW06 DAYC to WS06 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from SP02 ADEL to RR02 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from SP03 DAYC to RR03 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	93712	84636	93712	90680	93712	90680	93712	93712	90680	93712	90680	93712	93744	84672	93744	90720	93744	90720	93744	93744	90720	93744	90720	93744
Transmission Link from WE05 BLEI to WS09 BLEI	8816.4	7963.2	8816.4	8532	8816.4	8532	8816.4	8816.4	8532	8816.4	8532	8816.4	7359.4	6647.2	7359.4	7122	7359.4	7122	7359.4	7359.4	7122	7359.4	7122	7359.4
Transmission Link from WE06 BETC to WS07 BOUT	6333.3	5720.4	6333.3	6129	6333.3	6129	6333.3	6333.3	6129	6333.3	6129	6333.3	5288.6	4776.8	5288.6	5118	5288.6	5118	5288.6	5288.6	5118	5288.6	5118	5288.6
Transmission Link from WE07 BSAB to WS05 BSAB	15810	14280	15810	15300	15810	15300	15810	15810	15300	15810	15300	15810	13199.8	11922.4	13199.8	12774	13199.8	12774	13199.8	13199.8	12774	13199.8	12774	13199.8
Transmission Link from WE08 BSOU to WS02 BSOU	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6	2666	2408	2666	2580	2666	2580	2666	2666	2580	2666	2580	2666
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	37445	33813.3	37445	36230	37445	36230	37445	37445	36230	37445	36230	37445	18810.8	16990.4	18810.8	18204	18810.8	18204	18810.8	18810.8	18204	18810.8	18204	18810.8
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	74989	67732	74989	72570	74989	72570	74989	74989	72570	74989	72570	74989	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118
Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	8072.4	7291.2	8072.4	7812	8072.4	7812	8072.4	8072.4	7812	8072.4	7812	8072.4	186	168	186	180	186	180	186	186	180	186	180	186
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	6547.2	5913.6	6547.2	6336	6547.2	6336	6547.2	6547.2	6336	6547.2	6336	6547.2
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992	7998	7224	7998	7740	7998	7740	7998	7998	7740	7998	7740	7998
Transmission Link from WE22 KANA to WS08 KFAR	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE23 OUSS to WS08 KFAR	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455	104470	94360	104470	101100	104470	101100	104470	104470	101100	104470	101100	104470
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363

Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	26764	24172	26764	25900	26764	25900	26764	26764	25900	26764	25900	26764	26771.6	24180.8	26771.6	25908	26771.6	25908	26771.6	26771.6	25908	26771.6	25908	26771.6
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	36234.7	32728	36234.7	35065.3	36234.7	35065.3	36234.7	36234.7	35065.3	36234.7	35065.3	36234.7
Transmission Link from WP 01 to IR01	0	0	0	0	104544	104561	104561	104561	104544	82500	0	0	0	0	0	0	104544	104560	104560	104560	104544	82500	0	0
Transmission Link from WX01 MECH to WS11 MECH	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824	0	0	0	0	0	0	0	0	0	0	0	0
Sum	1481692	1338284	1481692	1433879	1586236	1538439	1586252	1586252	1538423	1564192	1433879	1481692	2436104	2200352	2436104	2357520	2540648	2462080	2540665	2540665	2462064	2518604	2357520	2436104

Transmission Link Flow (Cubic Meter)
Scenario: S2 - Full coverage, All Transmission Links

Transmission Link	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	16990.9	15346.7	16990.9	16442.8	16990.9	16442.8	16990.9	16990.9	16442.8	16990.9	16442.8	16990.9
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	106314	96025.9	106314	102885	106314	102885	106314	106314	102885	106314	102885	106314
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	432931	391035	432931	418966	432931	418966	432931	432931	418966	432931	418966	432931
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	30787.4	27808.1	30787.4	29794.7	30787.4	29794.7	30787.4	30787.4	29794.7	30787.4	29794.7	30787.4
Transmission Link from RW01 RAAY to WS01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from RW04 ADEL to WS04 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from RW06 DAYC to WS06 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from SP02 ADEL to RR02 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from SP03 DAYC to RR03 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	93712	84636	93712	90680	93712	90680	93712	93712	90680	93712	90680	93712	93744	84672	93744	90720	93744	90720	93744	93744	90720	93744	90720	93744
Transmission Link from WE05 BLEI to WS09 BLEI	8816.4	7963.2	8816.4	8532	8816.4	8532	8816.4	8816.4	8532	8816.4	8532	8816.4	5795.53	5234.67	5795.53	5608.58	5795.53	5608.58	5795.53	5795.53	5608.58	5795.53	5608.58	5795.53
Transmission Link from WE06 BETC to WS07 BOUT	6333.3	5720.4	6333.3	6129	6333.3	6129	6333.3	6333.3	6129	6333.3	6129	6333.3	4164.77	3761.73	4164.77	4030.43	4164.77	4030.43	4164.77	4164.77	4030.43	4164.77	4030.43	4164.77
Transmission Link from WE07 BSAB to WS05 BSAB	15810	14280	15810	15300	15810	15300	15810	15810	15300	15810	15300	15810	10394.8	9388.89	10394.8	10059.5	10394.8	10059.5	10394.8	10394.8	10059.5	10394.8	10059.5	10394.8
Transmission Link from WE08 BSOU to WS02 BSOU	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6	2666	2408	2666	2580	2666	2580	2666	2666	2580	2666	2580	2666
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	37445	33813.3	37445	36230	37445	36230	37445	37445	36230	37445	36230	37445	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	74989	67732	74989	72570	74989	72570	74989	74989	72570	74989	72570	74989	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	37650	34006.5	37650	36435.5	37650	36435.5	37650	37650	36435.5	37650	36435.5	37650
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	8072.4	7291.2	8072.4	7812	8072.4	7812	8072.4	8072.4	7812	8072.4	7812	8072.4	186	168	186	180	186	180	186	186	180	186	180	186
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	5116.4	4621.26	5116.4	4951.35	5116.4	4951.35	5116.4	5116.4	4951.35	5116.4	4951.35	5116.4
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992	7998	7224	7998	7740	7998	7740	7998	7998	7740	7998	7740	7998
Transmission Link from WE22 KANA to WS08 KFAR	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE23 OUSS to WS08 KFAR	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455	81336.8	73465.5	81336.8	78713	81336.8	78713	81336.8	81336.8	78713	81336.8	78713	81336.8
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363

Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568	52566.6	47479.5	52566.6	50870.9	52566.6	50870.9	52566.6	52566.6	50870.9	52566.6	50870.9	52566.6
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	26764	24172	26764	25900	26764	25900	26764	26764	25900	26764	25900	26764	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	36234.7	32728	36234.7	35065.3	36234.7	35065.3	36234.7	36234.7	35065.3	36234.7	35065.3	36234.7
Transmission Link from WP 01 to IR01	0	0	0	0	104544	104561	104561	104561	104544	82500	0	0	0	0	0	0	104544	104560	104560	104560	104544	82500	0	0
Transmission Link from WX01 MECH to WS11 MECH	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824	0	0	0	0	0	0	0	0	0	0	0	0
Sum	1481692	1338284	1481692	1433879	1586236	1538439	1586252	1586252	1538423	1564192	1433879	1481692	1974011	1782977	1974011	1910333	2078555	2014893	2078571	2078571	2014877	2056511	1910333	1974011

Transmission Link Flow (Cubic Meter)
Scenario: S0CC - Climate Change, All Transmission Links

Transmission Link	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from RW01 RAAY to WS01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from RW04 ADEL to WS04 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from RW06 DAYC to WS06 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from SP02 ADEL to RR02 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from SP03 DAYC to RR03 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	93712	84636	93712	90680	93712	90680	93712	93712	90680	93712	90680	93712	93712	84636	93712	90683.6	93712	90688.3	93712	93712	90683.6	93712	90683.6	93712
Transmission Link from WE05 BLEI to WS09 BLEI	8816.4	7963.2	8816.4	8532	8816.4	8532	8816.4	8816.4	8532	8816.4	8532	8816.4	11041.1	9966.22	11041.1	10682.8	11041.1	11572	11956.8	11956.8	10682.8	11041.1	10682.8	11041.1
Transmission Link from WE06 BETC to WS07 BOUT	6333.3	5720.4	6333.3	6129	6333.3	6129	6333.3	6333.3	6129	6333.3	6129	6333.3	7934.37	7161.91	7934.37	7676.88	7934.37	8315.83	8592.38	8592.38	7676.88	7934.37	7676.88	7934.37
Transmission Link from WE07 BSAB to WS05 BSAB	15810	14280	15810	15300	15810	15300	15810	15810	15300	15810	15300	15810	19803.4	17875.4	19803.4	19160.7	19803.4	20755.4	21445.7	21445.7	19160.7	19803.4	19160.7	19803.4
Transmission Link from WE08 BSOU to WS02 BSOU	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	37445	33813.3	37445	36230	37445	36230	37445	37445	36230	37445	36230	37445	37439	33812	37439	36230	37439	36230	37439	37439	36230	37439	36230	37439
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	74989	67732	74989	72570	74989	72570	74989	74989	72570	74989	72570	74989	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118
Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	8072.4	7291.2	8072.4	7812	8072.4	7812	8072.4	8072.4	7812	8072.4	7812	8072.4	186	168	186	180	186	180	186	186	180	186	180	186
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	1886.67	1698.21	1886.67	1823.85	1886.67	2637.32	2724.42	2724.42	1823.85	1886.67	1823.85	1886.67
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	8029	7252	8029	7770	8029	7770	8029	8029	7770	8029	7770	8029
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992
Transmission Link from WE22 KANA to WS08 KFAR	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE23 OUSS to WS08 KFAR	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363

Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	26764	24172	26764	25900	26764	25900	26764	26764	25900	26764	25900	26764	26727	24156	26727	25890	26727	25890	26730.5	26730.5	25890	26727	25890	26727
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WP 01 to IR01	0	0	0	0	104544	104561	104561	104561	104544	82500	0	0	0	0	0	0	104544	104560	104560	104560	104544	82500	0	0
Transmission Link from WX01 MECH to WS11 MECH	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824
Sum	1481692	1338284	1481692	1433879	1586236	1538439	1586252	1586252	1538423	1564192	1433879	1481692	1632857	1474813	1632857	1580194	1737401	1688695	1741475	1741475	1684738	1715357	1580194	1632857

Transmission Link Flow (Cubic Meter)
Scenario: S1CC - NWSS, All Transmission Links

Transmission Link	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	22299.8	20127.2	22299.8	21575.6	22299.8	23586.1	24370.3	24370.3	21575.6	22299.8	21575.6	22299.8
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29579.5	30518.1	30518.1	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	195911	176707	195911	189510	195911	223440	230854	230854	189510	195911	189510	195911
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	563570	508673	563570	545271	563570	594743	614519	614519	545271	563570	545271	563570
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	8236.05	7353.22	8236.05	7941.78	8236.05	19821.3	20470.2	20470.2	7941.78	8236.05	7941.78	8236.05
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	48888.5	44107.9	48888.5	47295.4	48888.5	54150.2	55947.9	55947.9	47295.4	48888.5	47295.4	48888.5
Transmission Link from RW01 RAAY to WS01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from RW04 ADEL to WS04 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from RW06 DAYC to WS06 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from SP02 ADEL to RR02 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from SP03 DAYC to RR03 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	93712	84636	93712	90680	93712	90680	93712	93712	90680	93712	90680	93712	93744	84672	93744	90720	93744	90720	93744	93744	90720	93744	90720	93744
Transmission Link from WE05 BLEI to WS09 BLEI	8816.4	7963.2	8816.4	8532	8816.4	8532	8816.4	8816.4	8532	8816.4	8532	8816.4	7360.76	6644.15	7360.76	7121.89	7360.76	7714.64	7971.21	7971.21	7121.89	7360.76	7121.89	7360.76
Transmission Link from WE06 BETC to WS07 BOUT	6333.3	5720.4	6333.3	6129	6333.3	6129	6333.3	6333.3	6129	6333.3	6129	6333.3	5289.58	4774.61	5289.58	5117.92	5289.58	5543.88	5728.26	5728.26	5117.92	5289.58	5117.92	5289.58
Transmission Link from WE07 BSAB to WS05 BSAB	15810	14280	15810	15300	15810	15300	15810	15810	15300	15810	15300	15810	13202.2	11916.9	13202.2	12773.8	13202.2	13837	14297.1	14297.1	12773.8	13202.2	12773.8	13202.2
Transmission Link from WE08 BSOU to WS02 BSOU	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6	2666	2408	2666	2580	2666	2580	2666	2666	2580	2666	2580	2666
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	37445	33813.3	37445	36230	37445	36230	37445	37445	36230	37445	36230	37445	18920.2	16744.8	18920.2	18195.1	18920.2	36300	37510	37510	18195.1	18920.2	18195.1	18920.2
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	74989	67732	74989	72570	74989	72570	74989	74989	72570	74989	72570	74989	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118
Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	8072.4	7291.2	8072.4	7812	8072.4	7812	8072.4	8072.4	7812	8072.4	7812	8072.4	186	168	186	180	186	180	186	186	180	186	180	186
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	6548.44	5910.81	6548.44	6335.9	6548.44	6878.22	7106.95	7106.95	6335.9	6548.44	6335.9	6548.44
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992	7998	7224	7998	7740	7998	7740	7998	7998	7740	7998	7740	7998
Transmission Link from WE22 KANA to WS08 KFAR	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE23 OUSS to WS08 KFAR	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455	104470	94360	104470	101100	104470	101100	104470	104470	101100	104470	101100	104470
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363

Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	26764	24172	26764	25900	26764	25900	26764	26764	25900	26764	25900	26764	26753.7	24074.2	26753.7	25904.1	26753.7	25886.6	26758.3	26758.3	25904.1	26753.7	25904.1	26753.7
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	36234.7	32728	36234.7	35065.3	36234.7	35065.3	36234.7	36234.7	35065.3	36234.7	35065.3	36234.7
Transmission Link from WP 01 to IR01	0	0	0	0	104544	104561	104561	104561	104544	82500	0	0	0	0	0	0	104544	104560	104560	104560	104544	82500	0	0
Transmission Link from WX01 MECH to WS11 MECH	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824	0	0	0	0	0	0	0	0	0	0	0	0
Sum	1481692	1338284	1481692	1433879	1586236	1538439	1586252	1586252	1538423	1564192	1433879	1481692	2436440	2199450	2436440	2357487	2540984	2616487	2700073	2700073	2462031	2518940	2357487	2436440

Transmission Link Flow (Cubic Meter)
Scenario: S2CC - Full coverage, All Transmission Links

Transmission Link	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
Transmission Link from CE01 AWAL to WS02 BSOU	0	0	0	0	0	0	0	0	0	0	0	0	17015.3	15357.2	17015.3	16462.6	17015.3	18047.5	18647.5	18647.5	16462.6	17015.3	16462.6	17015.3
Transmission Link from CE01 AWAL to WS03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	106725	96203.3	106725	103218	106725	129966	134271	134271	103218	106725	103218	106725
Transmission Link from CE01 AWAL to WS06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	433530	391293	433530	419451	433530	458452	473695	473695	419451	433530	419451	433530
Transmission Link from CE01 AWAL to WS08 KFAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from CE01 AWAL to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	30870.3	27843.9	30870.3	29862	30870.3	35265.8	36435.5	36435.5	29862	30870.3	29862	30870.3
Transmission Link from RW01 RAAY to WS01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from RW04 ADEL to WS04 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from RW06 DAYC to WS06 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from RW10 DEQO to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from SP01 RAAY to RR01 RAAY	79050	71400	79050	76500	79050	76500	79050	79050	76500	79050	76500	79050	144367	130396	144367	139710	144367	139710	144367	144367	139710	144367	139710	144367
Transmission Link from SP02 ADEL to RR02 ADEL	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400	74400	67200	74400	72000	74400	72000	74400	74400	72000	74400	72000	74400
Transmission Link from SP03 DAYC to RR03 DAYC	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780	42780	38640	42780	41400	42780	41400	42780	42780	41400	42780	41400	42780
Transmission Link from SP04 DEQO to RR04 DEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE01 BAAB to WS04 ADEL	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417	6417	5796	6417	6210	6417	6210	6417	6417	6210	6417	6210	6417
Transmission Link from WE02 JAMH to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE02 JAMH to WS04 ADEL	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE03 CHA2 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE03 CHA2 to WS04 ADEL	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058	16058	14504	16058	15540	16058	15540	16058	16058	15540	16058	15540	16058
Transmission Link from WE04 CHA1 to EX04 ADEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE04 CHA1 to WS04 ADEL	93712	84636	93712	90680	93712	90680	93712	93712	90680	93712	90680	93712	93744	84672	93744	90720	93744	90720	93744	93744	90720	93744	90720	93744
Transmission Link from WE05 BLEI to WS09 BLEI	8816.4	7963.2	8816.4	8532	8816.4	8532	8816.4	8816.4	8532	8816.4	8532	8816.4	5802.7	5237.77	5802.7	5614.39	5802.7	6081.67	6283.93	6283.93	5614.39	5802.7	5614.39	5802.7
Transmission Link from WE06 BETC to WS07 BOUT	6333.3	5720.4	6333.3	6129	6333.3	6129	6333.3	6333.3	6129	6333.3	6129	6333.3	4169.92	3763.96	4169.92	4034.6	4169.92	4370.4	4515.75	4515.75	4034.6	4169.92	4034.6	4169.92
Transmission Link from WE07 BSAB to WS05 BSAB	15810	14280	15810	15300	15810	15300	15810	15810	15300	15810	15300	15810	10407.7	9394.45	10407.7	10070	10407.7	10908.1	11270.8	11270.8	10070	10407.7	10070	10407.7
Transmission Link from WE08 BSOU to WS02 BSOU	2665.6	2407.6	2665.6	2579.6	2665.6	2579.6	2665.6	2665.6	2579.6	2665.6	2579.6	2665.6	2666	2408	2666	2580	2666	2580	2666	2666	2580	2666	2580	2666
Transmission Link from WE09 ARAY to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE09 ARAY to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528
Transmission Link from WE10 KART to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE10 KART to WS03 CHWE	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539	45539	41132	45539	44070	45539	44070	45539	45539	44070	45539	44070	45539
Transmission Link from WE11 CHOU to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE11 CHOU to WS03 CHWE	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE12 HEQO to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE12 HEQO to WS03 CHWE	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726
Transmission Link from WE13 QOBB to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE13 QOBB to WS03 CHWE	37445	33813.3	37445	36230	37445	36230	37445	37445	36230	37445	36230	37445	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE14 RICH to WS03 CHWE	74989	67732	74989	72570	74989	72570	74989	74989	72570	74989	72570	74989	85715	77420	85715	82950	85715	82950	85715	85715	82950	85715	82950	85715
Transmission Link from WE15 SAA1 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE15 SAA1 to WS03 CHWE	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352	80352	72576	80352	77760	80352	77760	80352	80352	77760	80352	77760	80352
Transmission Link from WE16 SAA2 to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE16 SAA2 to WS03 CHWE	120528	108864	120528	116640	120528	116640	120528	120528	116640	120528	116640	120528	38226.7	34255.9	38226.7	36903.1	38226.7	74494.1	76939.9	76939.9	36903.1	38226.7	36903.1	38226.7
Transmission Link from WE17 ZAKK to EX03 CHWE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE17 ZAKK to WS03 CHWE	24118	21784	24118	23340	24118	23340	24118	24118	23340	24118	23340	24118	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE18 DEQ2 to WS10 DEQO	8072.4	7291.2	8072.4	7812	8072.4	7812	8072.4	8072.4	7812	8072.4	7812	8072.4	186	168	186	180	186	180	186	186	180	186	180	186
Transmission Link from WE19 DEQ3 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE19 DEQ3 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to EX10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE20 DEQ1 to WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	5122.95	4624.1	5122.95	4956.67	5122.95	5384.19	5563.24	5563.24	4956.67	5122.95	4956.67	5122.95
Transmission Link from WE21 ANTO to EX06 DAYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE21 ANTO to WS06 DAYC	7992	7218	7992	7734	7992	7734	7992	7992	7734	7992	7734	7992	7998	7224	7998	7740	7998	7740	7998	7998	7740	7998	7740	7998
Transmission Link from WE22 KANA to WS08 KFAR	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813	34813	31444	34813	33690	34813	33690	34813	34813	33690	34813	33690	34813
Transmission Link from WE23 OUSS to WS08 KFAR	104455	94346	104455	101086	104455	101086	104455	104455	101086	104455	101086	104455	81480.5	73527.6	81480.5	78829.5	81480.5	88194.5	91125	91125	78829.5	81480.5	78829.5	81480.5
Transmission Link from WE24 HOUM to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE24 HOUM to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363

Transmission Link from WE25 AAAN to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE25 AAAN to WS01 RAAY	53568	48384	53568	51840	53568	51840	53568	53568	51840	53568	51840	53568	52816.9	47587.8	52816.9	51073.8	52816.9	51840	53568	53568	51073.8	52816.9	51073.8	52816.9
Transmission Link from WE26 BDED to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE26 BDED to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	0	0	0	0	0	5190	5363	5363	0	0	0	0
Transmission Link from WE27 QMA3 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE27 QMA3 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE28 QMA1 to WS01 RAAY	5363	4844	5363	5190	5363	5190	5363	5363	5190	5363	5190	5363	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE29 QMA2 to WS01 RAAY	10726	9688	10726	10380	10726	10380	10726	10726	10380	10726	10380	10726	0	0	0	0	0	10354.7	10683.6	10683.6	0	0	0	0
Transmission Link from WE30 KAHA to EX01 RAAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE30 KAHA to WS01 RAAY	26764	24172	26764	25900	26764	25900	26764	26764	25900	26764	25900	26764	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to EX11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transmission Link from WE31 DAYC to WS11 MECH	0	0	0	0	0	0	0	0	0	0	0	0	36234.7	32728	36234.7	35065.3	36234.7	35065.3	36234.7	36234.7	35065.3	36234.7	35065.3	36234.7
Transmission Link from WP 01 to IR01	0	0	0	0	104544	104561	104561	104561	104544	82500	0	0	0	0	0	0	104544	104560	104560	104560	104544	82500	0	0
Transmission Link from WX01 MECH to WS11 MECH	36824	33260	36824	35636	36824	35636	36824	36824	35636	36824	35636	36824	0	0	0	0	0	0	0	0	0	0	0	0
Sum	1481692	1338284	1481692	1433879	1586236	1538439	1586252	1586252	1538423	1564192	1433879	1481692	1976129	1783893	1976129	1912050	2080673	2154684	2222884	2222884	2016594	2058629	1912050	1976129

Unmet Demand (Cubic Meter)
Scenario: Reference (S0), Selected Demand Sites (12/19), Annual Total

Demand Site	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744
WS01 RAAY	760871	786194	811518	836841	862165	503120	528443	553767	579091	604415	629738	655062	680386	705709	731001	756357
WS02 BSOU	160329	163289	166249	169209	172169	175129	178090	181050	184010	186970	189930	192890	195850	198811	201771	204731
WS03 CHWE	1139876	1176967	1214051	1251134	1288219	1262173	1299257	1336341	1373425	1410509	1447593	1484677	1521728	1558845	1595929	1633013
WS04 ADEL	1967158	1995485	2023932	2052349	2080726	2109144	2137541	2165920	2194334	2222731	2251129	2279526	2307922	2336319	2364716	2393097
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	4548064	4586538	4625013	4663488	4701962	4740437	4778912	4817386	4855861	4894336	4932810	4971285	5009760	5048228	5086707	5125184
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	343991	353229	362467	371705	380943	390181	399419	408658	417896	427134	436372	445610	454848	464086	473325	482563
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	454832	460161	465490	470819	476148	481477	486806	492133	497464	502793	508122	513451	518780	524109	529438	534767
Sum	9583865	9730607	9877463	10024290	10171076	9870405	10017212	10163999	10310825	10457631	10604438	10751245	10898018	11044852	11191630	11338455

Unmet Demand (Cubic Meter)
Scenario: S1 - NWSS, Selected Demand Sites (12/19), Annual Total

Demand Site	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744
WS01 RAAY	760871	786195	811519	836842	862166	503120	528443	553767	579091	604423	0	0	0	0	0	0
WS02 BSOU	160329	163289	166249	169209	172169	175129	178090	181050	184010	186970	0	0	0	0	0	0
WS03 CHWE	1139876	1176967	1214051	1251134	1288219	1262173	1299257	1336341	1373425	1410509	0	0	0	0	0	0
WS04 ADEL	1967158	1995485	2023932	2052349	2080726	2109144	2137541	2165920	2194334	2222731	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	4548064	4586538	4625013	4663488	4701962	4740437	4778912	4817386	4855861	4894336	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	343991	353229	362467	371705	380943	390181	399419	408658	417896	427134	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	454832	676947	682276	687605	692934	698263	703592	708921	714250	719579	0	0	0	0	0	0
Sum	9583865	9947394	1E+07	10241077	10387863	1E+07	10233998	10380787	10527611	10674425	208744	208744	208744	208744	208744	208744

Unmet Demand (Cubic Meter)
Scenario: S2 - Full coverage, Selected Demand Sites (12/19), Annual Total

Demand Site	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744
WS01 RAAY	760871	786195	811519	836842	862166	503120	528443	553767	579091	604423	0	0	0	0	0	0
WS02 BSOU	160329	163289	166249	169209	172169	175129	178090	181050	184010	186970	0	0	0	0	0	0
WS03 CHWE	1139876	1176967	1214051	1251134	1288219	1262173	1299257	1336341	1373425	1410509	0	0	0	0	0	0
WS04 ADEL	1967158	1995485	2023932	2052349	2080726	2109144	2137541	2165920	2194334	2222731	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	4548064	4586538	4625013	4663488	4701962	4740437	4778912	4817386	4855861	4894336	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	343991	353229	362467	371705	380943	390181	399419	408658	417896	427134	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	454832	676947	682276	687605	692934	698263	703592	708921	714250	719579	0	0	0	0	0	0
Sum	9583865	9947394	10094250	10241077	10387863	10087191	10233998	10380787	10527611	10674425	208744	208744	208744	208744	208744	208744

Unmet Demand (Cubic Meter)
Scenario: S0CC - Climate Change, Selected Demand Sites (12/19), Annual Total

Demand Site	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744
WS01 RAAY	760871	788516	816610	844777	873015	516937	545309	573790	602315	630872	659556	688292	717130	746008	774929	803991
WS02 BSOU	160329	163506	166727	169956	173194	176440	179694	182957	186228	189507	192795	196091	199396	202709	206030	209360
WS03 CHWE	1139876	1182679	1226514	1270455	1314500	1295521	1339776	1384137	1428602	1473173	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06
WS04 ADEL	1967158	1999586	2032751	2065992	2099326	2132735	2166223	2199784	2233413	2267170	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	4548064	4592465	4637944	4683532	4729230	4775036	4820951	4866975	4913108	4959350	5E+06	5E+06	5E+06	5E+06	5E+06	5E+06
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	343991	354652	365572	376518	387491	398489	409514	420565	431642	442745	453875	465030	476212	487420	498654	509914
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	454832	460982	467282	473597	479926	486271	492631	499006	505396	511802	518222	524657	531107	537573	544054	550550
Sum	9583865	9751129	9922145	10093571	10265426	9990172	10162842	10335958	10509448	10683362	1E+07	1E+07	1E+07	1E+07	1E+07	1E+07

Unmet Demand (Cubic Meter)
Scenario: S1CC - NWSS, Selected Demand Sites (12/19), Annual Total

Demand Site	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744
WS01 RAAY	760871	788517	816611	844778	873016	516937	545309	573790	602315	630872	0	7656.52	17523.7	27460.7	37487	47829.5
WS02 BSOU	160329	163506	166727	169956	173194	176440	179694	182957	186228	189507	0	0	0	0	0	0
WS03 CHWE	1139876	1182679	1226514	1270455	1314500	1295521	1339776	1384137	1428602	1473173	0	0	0	0	0	0
WS04 ADEL	1967158	1999586	2032751	2065992	2099326	2132735	2166223	2199784	2233413	2267170	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	4548064	4592465	4637944	4683532	4729230	4775036	4820951	4866975	4913108	4959350	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	343991	354652	365572	376518	387491	398489	409514	420565	431642	442745	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	454832	677768	684068	690383	696712	703057	709417	715792	722182	728588	0	0	0	0	0	0
Sum	9583865	9967916	10138932	10310358	10482213	10206958	10379628	10552744	10726234	10900148	208744	216400	226268	236205	246231	256573

Unmet Demand (Cubic Meter)
Scenario: S2CC - Full coverage, Selected Demand Sites (12/19), Annual Total

Demand Site	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744	208744
WS01 RAAY	760871	785838	811183	836527	861874	502784	528180	553557	578874	604183	0	0	0	0	0	0
WS02 BSOU	160329	163255	166217	169180	172142	175104	178066	181029	183991	186954	0	0	0	0	0	0
WS03 CHWE	1139876	1176088	1213228	1250369	1287512	1261512	1298654	1335812	1372961	1410108	0	0	0	0	0	0
WS04 ADEL	1967158	1994917	2023372	2051806	2080238	2108685	2137122	2165565	2193996	2222448	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	4548064	4585626	4624159	4662694	4701229	4739765	4778302	4816840	4855380	4893920	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	343991	353010	362262	371514	380767	390020	399273	408527	417780	427034	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	454832	676821	682158	687495	692833	698170	703508	708846	714184	719522	0	0	0	0	0	0
Sum	9583865	9944299	10091323	10238329	10385338	10084785	10231850	10378919	10525910	10672913	208744	208744	208744	208744	208744	208744

Unmet Demand (Cubic Meter)
Scenario: Reference (S0), Selected Demand Sites (12/19)

Demand Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0
WS01 RAAY	64621.8	58369	64621.8	62537.5	64621.8	62537.5	64621.8	64621.8	62537.5	64621.8	62537.5	64621.8	64243.4	58018.6	64243.4	62158.5	64243.4	62158.5	64243.4	64243.4	62158.5	64243.4	62158.5	64243.4
WS02 BSOU	13617	12299.2	13617	13177.7	13617	13177.7	13617	13617	13177.7	13617	13177.7	13617	17388.1	15705.4	17388.1	16827.2	17388.1	16827.2	17388.1	17388.1	16827.2	17388.1	16827.2	17388.1
WS03 CHWE	96809.8	87445.2	96809.8	93690.5	96809.8	93690.5	96809.8	96809.8	93690.5	96809.8	93690.5	96809.8	138694	125274	138694	134220	138694	134220	138694	138694	134220	138694	134220	138694
WS04 ADEL	167072	150907	167072	161687	167072	161687	167072	167072	161687	167072	161687	167072	203249	183581	203249	196693	203249	196693	203249	203249	196693	203249	196693	203249
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	386274	348893	386274	373814	386274	373814	386274	386274	373814	386274	373814	386274	435290	393165	435290	421248	435290	421248	435290	435290	421248	435290	421248	435290
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	29215.7	26388.6	29215.7	28273	29215.7	28273	29215.7	29215.7	28273	29215.7	28273	29215.7	40984.9	37018.8	40984.9	39662.5	40984.9	39662.5	40984.9	40984.9	39662.5	40984.9	39662.5	40984.9
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	38629.6	34891.4	38629.6	37383.5	38629.6	37383.5	38629.6	38629.6	37383.5	38629.6	37383.5	38629.6	45418.6	41023.4	45418.6	43953.5	45418.6	43953.5	45418.6	45418.6	43953.5	45418.6	43953.5	45418.6
Sum	796240	719193	796240	770563	814485	827980	853657	853657	788808	796240	770563	796240	945267	853786	945267	914764	963513	972181	1002685	1002685	933009	945267	914764	945267

Unmet Demand (Cubic Meter)
Scenario: S1 - NWSS, Selected Demand Sites (12/19)

Demand Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0
WS01 RAAY	64621.8	58369	64621.8	62537.5	64621.8	62537.5	64621.8	64621.8	62537.5	64621.8	62537.5	64621.8	0	0	0	0	0	0	0	0	0	0	0	0
WS02 BSOU	13617	12299.2	13617	13177.7	13617	13177.7	13617	13617	13177.7	13617	13177.7	13617	0	0	0	0	0	0	0	0	0	0	0	0
WS03 CHWE	96809.8	87445.2	96809.8	93690.5	96809.8	93690.5	96809.8	96809.8	93690.5	96809.8	93690.5	96809.8	0	0	0	0	0	0	0	0	0	0	0	0
WS04 ADEL	167072	150907	167072	161687	167072	161687	167072	167072	161687	167072	161687	167072	0	0	0	0	0	0	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	386274	348893	386274	373814	386274	373814	386274	386274	373814	386274	373814	386274	0	0	0	0	0	0	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	29215.7	26388.6	29215.7	28273	29215.7	28273	29215.7	29215.7	28273	29215.7	28273	29215.7	0	0	0	0	0	0	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	38629.6	34891.4	38629.6	37383.5	38629.6	37383.5	38629.6	38629.6	37383.5	38629.6	37383.5	38629.6	0	0	0	0	0	0	0	0	0	0	0	0
Sum	796240	719193	796240	770563	814485	827980	853657	853657	788808	796240	770563	796240	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0

Unmet Demand (Cubic Meter)
Scenario: S2 - Full coverage, Selected Demand Sites (12/19)

Demand Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0
WS01 RAAY	64621.8	58369	64621.8	62537.5	64621.8	62537.5	64621.8	64621.8	62537.5	64621.8	62537.5	64621.8	0	0	0	0	0	0	0	0	0	0	0	0
WS02 BSOU	13617	12299.2	13617	13177.7	13617	13177.7	13617	13617	13177.7	13617	13177.7	13617	0	0	0	0	0	0	0	0	0	0	0	0
WS03 CHWE	96809.8	87445.2	96809.8	93690.5	96809.8	93690.5	96809.8	96809.8	93690.5	96809.8	93690.5	96809.8	0	0	0	0	0	0	0	0	0	0	0	0
WS04 ADEL	167072	150907	167072	161687	167072	161687	167072	167072	161687	167072	161687	167072	0	0	0	0	0	0	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	386274	348893	386274	373814	386274	373814	386274	386274	373814	386274	373814	386274	0	0	0	0	0	0	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	29215.7	26388.6	29215.7	28273	29215.7	28273	29215.7	29215.7	28273	29215.7	28273	29215.7	0	0	0	0	0	0	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	38629.6	34891.4	38629.6	37383.5	38629.6	37383.5	38629.6	38629.6	37383.5	38629.6	37383.5	38629.6	0	0	0	0	0	0	0	0	0	0	0	0
Sum	796240	719193	796240	770563	814485	827980	853657	853657	788808	796240	770563	796240	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0

Unmet Demand (Cubic Meter)
Scenario: S0CC - Climate Change, Selected Demand Sites (12/19)

Demand Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0
WS01 RAAY	64621.8	58369	64621.8	62537.5	64621.8	62537.5	64621.8	64621.8	62537.5	64621.8	62537.5	64621.8	64279.1	57938.7	64279.1	62155.6	64279.1	77673.4	80258.4	80258.4	62155.6	64279.1	62155.6	64279.1
WS02 BSOU	13617	12299.2	13617	13177.7	13617	13177.7	13617	13617	13177.7	13617	13177.7	13617	17391.6	15697.6	17391.6	16826.9	17391.6	18334.8	18944.4	18944.4	16826.9	17391.6	16826.9	17391.6
WS03 CHWE	96809.8	87445.2	96809.8	93690.5	96809.8	93690.5	96809.8	96809.8	93690.5	96809.8	93690.5	96809.8	138776	125090	138776	134214	138776	169977	175607	175607	134214	138776	134214	138776
WS04 ADEL	167072	150907	167072	161687	167072	161687	167072	167072	161687	167072	161687	167072	203307	183452	203307	196690	203307	222136	229515	229515	196690	203307	196690	203307
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	386274	348893	386274	373814	386274	373814	386274	386274	373814	386274	373814	386274	435375	392974	435375	421241	435375	458346	473587	473587	421241	435375	421241	435375
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	29215.7	26388.6	29215.7	28273	29215.7	28273	29215.7	29215.7	28273	29215.7	28273	29215.7	41005.3	36972.9	41005.3	39660.8	41005.3	48570.5	50180.9	50180.9	39660.8	41005.3	39660.8	41005.3
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	38629.6	34891.4	38629.6	37383.5	38629.6	37383.5	38629.6	38629.6	37383.5	38629.6	37383.5	38629.6	45430.3	40996.9	45430.3	43952.5	45430.3	49093.7	50725	50725	43952.5	45430.3	43952.5	45430.3
Sum	796240	719193	796240	770563	814485	827980	853657	853657	788808	796240	770563	796240	945564	853122	945564	914741	963810	1101548	1136234	1136234	932987	945564	914741	945564

Unmet Demand (Cubic Meter)
Scenario: S1CC - NWSS, Selected Demand Sites (12/19)

Demand Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0
WS01 RAAY	64621.8	58369	64621.8	62537.5	64621.8	62537.5	64621.8	64621.8	62537.5	64621.8	62537.5	64621.8	49.0492	0	49.0492	0	49.0492	15531	16026.6	16026.6	0	49.0492	0	49.0492
WS02 BSOU	13617	12299.2	13617	13177.7	13617	13177.7	13617	13617	13177.7	13617	13177.7	13617	0	0	0	0	0	0	0	0	0	0	0	0
WS03 CHWE	96809.8	87445.2	96809.8	93690.5	96809.8	93690.5	96809.8	96809.8	93690.5	96809.8	93690.5	96809.8	0	0	0	0	0	0	0	0	0	0	0	0
WS04 ADEL	167072	150907	167072	161687	167072	161687	167072	167072	161687	167072	161687	167072	0	0	0	0	0	0	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	386274	348893	386274	373814	386274	373814	386274	386274	373814	386274	373814	386274	0	0	0	0	0	0	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	29215.7	26388.6	29215.7	28273	29215.7	28273	29215.7	29215.7	28273	29215.7	28273	29215.7	0	0	0	0	0	0	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	38629.6	34891.4	38629.6	37383.5	38629.6	37383.5	38629.6	38629.6	37383.5	38629.6	37383.5	38629.6	0	0	0	0	0	0	0	0	0	0	0	0
Sum	796240	719193	796240	770563	814485	827980	853657	853657	788808	796240	770563	796240	49.0492	0	49.0492	0	18294.7	72948.5	73444.2	73444.2	18245.7	49.0492	0	49.0492

Unmet Demand (Cubic Meter)
Scenario: S2CC - Full coverage, Selected Demand Sites (12/19)

Demand Site	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0
WS01 RAAY	64621.8	58369	64621.8	62537.5	64621.8	62537.5	64621.8	64621.8	62537.5	64621.8	62537.5	64621.8	0	0	0	0	0	0	0	0	0	0	0	0
WS02 BSOU	13617	12299.2	13617	13177.7	13617	13177.7	13617	13617	13177.7	13617	13177.7	13617	0	0	0	0	0	0	0	0	0	0	0	0
WS03 CHWE	96809.8	87445.2	96809.8	93690.5	96809.8	93690.5	96809.8	96809.8	93690.5	96809.8	93690.5	96809.8	0	0	0	0	0	0	0	0	0	0	0	0
WS04 ADEL	167072	150907	167072	161687	167072	161687	167072	167072	161687	167072	161687	167072	0	0	0	0	0	0	0	0	0	0	0	0
WS05 BSAB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS06 DAYC	386274	348893	386274	373814	386274	373814	386274	386274	373814	386274	373814	386274	0	0	0	0	0	0	0	0	0	0	0	0
WS07 BOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS08 KFAR	29215.7	26388.6	29215.7	28273	29215.7	28273	29215.7	29215.7	28273	29215.7	28273	29215.7	0	0	0	0	0	0	0	0	0	0	0	0
WS09 BLEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS10 DEQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS11 MECH	38629.6	34891.4	38629.6	37383.5	38629.6	37383.5	38629.6	38629.6	37383.5	38629.6	37383.5	38629.6	0	0	0	0	0	0	0	0	0	0	0	0
Sum	796240	719193	796240	770563	814485	827980	853657	853657	788808	796240	770563	796240	0	0	0	0	18245.7	57417.5	57417.5	57417.5	18245.7	0	0	0

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: Reference (S0), Selected Branches (12/19), Annual Total

Branch	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750
WS01 RAAY	1888601	1913925	1939249	1964572	1989896	2015220	2040544	2065867	2091191	2116514	2141838	2167162	2192486	2217809	2243133	2268457
WS02 BSOU	176021	178981	181942	184902	187862	190822	193782	196742	199702	202663	205623	208583	211543	214503	217463	220424
WS03 CHWE	4671763	4708847	4745931	4783015	4820099	4857183	4894267	4931351	4968435	5005519	5042603	5079687	5116771	5153855	5190939	5228023
WS04 ADEL	3294088	3322485	3350882	3379280	3407676	3436074	3464470	3492868	3521265	3549661	3578059	3606455	3634852	3663250	3691646	3720044
WS05 BSAB	93075	94640.9	96206.7	97772.5	99338.4	100904	102470	104036	105602	107168	108734	110299	111865	113431	114997	116563
WS06 DAYC	4846963	4885437	4923912	4962387	5000861	5039336	5077811	5116285	5154760	5193235	5231709	5270184	5308659	5347133	5385608	5424082
WS07 BOUT	37284.8	37912.6	38540.4	39168.2	39795.9	40423.8	41051.6	41679.3	42307.1	42934.9	43562.8	44190.5	44818.3	45446.2	46073.9	46701.7
WS08 KFAR	1163876	1173114	1182352	1191590	1200828	1210066	1219304	1228543	1237781	1247019	1256257	1265495	1274733	1283971	1293210	1302448
WS09 BLEI	51903	52775.4	53647.7	54520.1	55392.4	56264.7	57137.1	58009.5	58881.8	59754.1	60626.5	61498.9	62371.2	63243.6	64115.9	64988.2
WS10 DEQO	47523	48318.7	49114.4	49910.1	50705.8	51501.5	52297.2	53092.9	53888.6	54684.3	55480	56275.7	57071.4	57867.1	58662.8	59458.5
WS11 MECH	671618	676947	682276	687605	692934	698263	703592	708921	714250	719579	724908	730237	735566	740895	746224	751553
Sum	17726466	17877134	18027803	18178471	18329139	18479808	18630476	18781144	18931813	19082481	19233149	19383818	19534486	19685155	19835823	19986491

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S1 - NWSS, Selected Branches (12/19), Annual Total

Branch	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750
WS01 RAAY	1888601	1913925	1939249	1964572	1989896	2015220	2040544	2065867	2091191	2116514	2141838	2167162	2192486	2217809	2243133	2268457
WS02 BSOU	176021	178981	181942	184902	187862	190822	193782	196742	199702	202663	205623	208583	211543	214503	217463	220424
WS03 CHWE	4671763	4708847	4745931	4783015	4820099	4857183	4894267	4931351	4968435	5005519	5042603	5079687	5116771	5153855	5190939	5228023
WS04 ADEL	3294088	3322485	3350882	3379280	3407676	3436074	3464470	3492868	3521265	3549661	3578059	3606455	3634852	3663250	3691646	3720044
WS05 BSAB	93075	94640.9	96206.7	97772.5	99338.4	100904	102470	104036	105602	107168	108734	110299	111865	113431	114997	116563
WS06 DAYC	4846963	4885437	4923912	4962387	5000861	5039336	5077811	5116285	5154760	5193235	5231709	5270184	5308659	5347133	5385608	5424082
WS07 BOUT	37284.8	37912.6	38540.4	39168.2	39795.9	40423.8	41051.6	41679.3	42307.1	42934.9	43562.8	44190.5	44818.3	45446.2	46073.9	46701.7
WS08 KFAR	1163876	1173114	1182352	1191590	1200828	1210066	1219304	1228543	1237781	1247019	1256257	1265495	1274733	1283971	1293210	1302448
WS09 BLEI	51903	52775.4	53647.7	54520.1	55392.4	56264.7	57137.1	58009.5	58881.8	59754.1	60626.5	61498.9	62371.2	63243.6	64115.9	64988.2
WS10 DEQO	47523	48318.7	49114.4	49910.1	50705.8	51501.5	52297.2	53092.9	53888.6	54684.3	55480	56275.7	57071.4	57867.1	58662.8	59458.5
WS11 MECH	671618	676947	682276	687605	692934	698263	703592	708921	714250	719579	724908	730237	735566	740895	746224	751553
Sum	17726466	17877134	18027803	18178471	18329139	18479808	18630476	18781144	18931813	19082481	19233149	19383818	19534486	19685155	19835823	19986491

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S2 - Full coverage, Selected Branches (12/19), Annual Total

Branch	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750
WS01 RAAY	1888601	1913925	1939249	1964572	1989896	2015220	2040544	2065867	2091191	2116514	1686698	1706640	1726582	1746525	1766467	1786410
WS02 BSOU	176021	178981	181942	184902	187862	190822	193782	196742	199702	202663	161928	164259	166590	168921	171252	173584
WS03 CHWE	4671763	4708847	4745931	4783015	4820099	4857183	4894267	4931351	4968435	5005519	3971050	4000253	4029457	4058661	4087864	4117068
WS04 ADEL	3294088	3322485	3350882	3379280	3407676	3436074	3464470	3492868	3521265	3549661	2817721	2840084	2862446	2884809	2907172	2929534
WS05 BSAB	93075	94640.9	96206.7	97772.5	99338.4	100904	102470	104036	105602	107168	85627.6	86860.7	88093.8	89327	90560.1	91793.2
WS06 DAYC	4846963	4885437	4923912	4962387	5000861	5039336	5077811	5116285	5154760	5193235	4119971	4150270	4180569	4210867	4241166	4271465
WS07 BOUT	37284.8	37912.6	38540.4	39168.2	39795.9	40423.8	41051.6	41679.3	42307.1	42934.9	34305.7	34800.1	35294.5	35788.8	36283.2	36777.6
WS08 KFAR	1163876	1173114	1182352	1191590	1200828	1210066	1219304	1228543	1237781	1247019	989302	996577	1003852	1011128	1018403	1025678
WS09 BLEI	51903	52775.4	53647.7	54520.1	55392.4	56264.7	57137.1	58009.5	58881.8	59754.1	47743.4	48430.3	49117.3	49804.3	50491.3	51178.2
WS10 DEQO	47523	48318.7	49114.4	49910.1	50705.8	51501.5	52297.2	53092.9	53888.6	54684.3	43690.5	44317.1	44943.7	45570.3	46197	46823.6
WS11 MECH	671618	676947	682276	687605	692934	698263	703592	708921	714250	719579	570865	575062	579258	583455	587652	591848
Sum	17726466	17877134	18027803	18178471	18329139	18479808	18630476	18781144	18931813	19082481	15312652	15431303	15549955	15668606	15787257	15905909

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S0CC - Climate Change, Selected Branches (12/19), Annual Total

Branch	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750
WS01 RAAY	1888601	1916247	1944342	1972508	2000746	2029056	2057437	2085890	2114415	2143011	2171679	2200419	2229230	2258113	2287068	2316094
WS02 BSOU	176021	179199	182419	185649	188886	192132	195386	198649	201920	205200	208488	211784	215088	218401	221723	225052
WS03 CHWE	4671763	4714559	4758394	4802335	4846380	4890531	4934786	4979147	5023612	5068183	5112858	5157639	5202524	5247515	5292611	5337811
WS04 ADEL	3294088	3326516	3359683	3392930	3426257	3459665	3493153	3526721	3560370	3594100	3627909	3661800	3695770	3729821	3763953	3798164
WS05 BSAB	93075	94755.7	96459.4	98167.5	99880	101597	103318	105044	106775	108509	110248	111992	113740	115492	117249	119011
WS06 DAYC	4846963	4891364	4936843	4982431	5028129	5073935	5119850	5165874	5212007	5258249	5304600	5351059	5397628	5444306	5491093	5537988
WS07 BOUT	37284.8	37958.5	38641.6	39326.4	40012.9	40701.3	41391.4	42083.3	42777	43472.5	44169.7	44868.7	45569.5	46272	46976.4	47682.5
WS08 KFAR	1163876	1174537	1185457	1196403	1207376	1218374	1229399	1240450	1251527	1262630	1273760	1284915	1296097	1307305	1318539	1329799
WS09 BLEI	51903	52839.4	53788.6	54740.3	55694.4	56651	57610.1	58571.7	59535.7	60502.2	61471.2	62442.6	63416.5	64392.9	65371.7	66353
WS10 DEQO	47523	48377.3	49243.4	50111.7	50982.3	51855.1	52730.2	53607.5	54487.1	55368.9	56253	57139.3	58027.9	58918.7	59811.8	60707.1
WS11 MECH	671618	677768	684068	690383	696712	703057	709417	715792	722182	728588	735008	741443	747894	754359	760840	767336
Sum	17726466	17897870	18073089	18248734	18424806	18601304	18778229	18955581	19133358	19311563	19490194	19669252	19848736	20028647	20208984	20389749

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S1CC - NWSS, Selected Branches (12/19), Annual Total

Branch	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750
WS01 RAAY	1888601	1916247	1944342	1972508	2000746	2029056	2057437	2085890	2114415	2143011	2171679	2200419	2229230	2258113	2287068	2316094
WS02 BSOU	176021	179199	182419	185649	188886	192132	195386	198649	201920	205200	208488	211784	215088	218401	221723	225052
WS03 CHWE	4671763	4714559	4758394	4802335	4846380	4890531	4934786	4979147	5023612	5068183	5112858	5157639	5202524	5247515	5292611	5337811
WS04 ADEL	3294088	3326516	3359683	3392930	3426257	3459665	3493153	3526721	3560370	3594100	3627909	3661800	3695770	3729821	3763953	3798164
WS05 BSAB	93075	94755.7	96459.4	98167.5	99880	101597	103318	105044	106775	108509	110248	111992	113740	115492	117249	119011
WS06 DAYC	4846963	4891364	4936843	4982431	5028129	5073935	5119850	5165874	5212007	5258249	5304600	5351059	5397628	5444306	5491093	5537988
WS07 BOUT	37284.8	37958.5	38641.6	39326.4	40012.9	40701.3	41391.4	42083.3	42777	43472.5	44169.7	44868.7	45569.5	46272	46976.4	47682.5
WS08 KFAR	1163876	1174537	1185457	1196403	1207376	1218374	1229399	1240450	1251527	1262630	1273760	1284915	1296097	1307305	1318539	1329799
WS09 BLEI	51903	52839.4	53788.6	54740.3	55694.4	56651	57610.1	58571.7	59535.7	60502.2	61471.2	62442.6	63416.5	64392.9	65371.7	66353
WS10 DEQO	47523	48377.3	49243.4	50111.7	50982.3	51855.1	52730.2	53607.5	54487.1	55368.9	56253	57139.3	58027.9	58918.7	59811.8	60707.1
WS11 MECH	671618	677768	684068	690383	696712	703057	709417	715792	722182	728588	735008	741443	747894	754359	760840	767336
Sum	17726466	17897870	18073089	18248734	18424806	18601304	18778229	18955581	19133358	19311563	19490194	19669252	19848736	20028647	20208984	20389749

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S2CC - Full coverage, Selected Branches (12/19), Annual Total

Branch	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
IR01	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750	783750
WS01 RAAY	1888601	1913568	1938912	1964258	1989604	2014951	2040299	2065647	2090996	2116345	1723815	1744220	1764625	1785030	1805436	1825843
WS02 BSOU	176021	178948	181910	184872	187834	190797	193759	196721	199684	202646	165491	167876	170261	172645	175030	177415
WS03 CHWE	4671763	4707968	4745108	4782249	4819392	4856535	4893679	4930825	4967971	5005118	4058436	4088337	4118239	4148141	4178044	4207948
WS04 ADEL	3294088	3321865	3350302	3378739	3407177	3435615	3464055	3492495	3520936	3549378	2879728	2902621	2925515	2948410	2971305	2994201
WS05 BSAB	93075	94623.2	96190	97756.9	99323.8	100891	102458	104025	105592	107159	87511.9	88773.4	90034.8	91296.3	92557.9	93819.4
WS06 DAYC	4846963	4884525	4923058	4961593	5000128	5038664	5077201	5115740	5154279	5192819	4210635	4241657	4272680	4303704	4334728	4365754
WS07 BOUT	37284.8	37905.5	38533.7	39161.9	39790.1	40418.4	41046.6	41674.9	42303.2	42931.5	35060.6	35566.3	36072.1	36577.9	37083.7	37589.5
WS08 KFAR	1163876	1172895	1182147	1191399	1200652	1209905	1219158	1228411	1237665	1246919	1011073	1018522	1025971	1033420	1040869	1048319
WS09 BLEI	51903	52765.5	53638.4	54511.3	55384.3	56257.2	57130.2	58003.3	58876.3	59749.4	48794	49496.8	50199.5	50902.3	51605.1	52308
WS10 DEQO	47523	48309.7	49105.9	49902.1	50698.4	51494.6	52290.9	53087.2	53883.6	54679.9	44652	45293	45934	46575	47216.1	47857.2
WS11 MECH	671618	676821	682158	687495	692833	698170	703508	708846	714184	719522	583428	587724	592021	596318	600615	604913
Sum	17726466	17873943	18024814	18175688	18326566	18477448	18628335	18779225	18930119	19081017	15632374	15753836	15875301	15996770	16118241	16239716

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: Reference (S0), Selected Branches (12/22)

Branch	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0
WS01 RAAY	160402	144879	160402	155228	160402	155228	160402	160402	155228	160402	155228	160402	192663	174019	192663	186448	192663	186448	192663	192663	186448	192663	186448	192663
WS02 BSOU	14949.8	13503	14949.8	14467.5	14949.8	14467.5	14949.8	14949.8	14467.5	14949.8	14467.5	14949.8	18720.9	16909.2	18720.9	18117	18720.9	18117	18720.9	18720.9	18117	18720.9	18117	18720.9
WS03 CHWE	396780	358382	396780	383981	396780	383981	396780	396780	383981	396780	383981	396780	444024	401054	444024	429700	444024	429700	444024	444024	429700	444024	429700	444024
WS04 ADEL	279772	252697	279772	270747	279772	270747	279772	279772	270747	279772	270747	279772	315949	285373	315949	305757	315949	305757	315949	315949	305757	315949	305757	315949
WS05 BSAB	7905	7140	7905	7650	7905	7650	7905	7905	7650	7905	7650	7905	9899.85	8941.8	9899.85	9580.5	9899.85	9580.5	9899.85	9899.85	9580.5	9899.85	9580.5	9899.85
WS06 DAYC	411660	371822	411660	398381	411660	398381	411660	411660	398381	411660	398381	411660	460676	416094	460676	445815	460676	445815	460676	460676	445815	460676	445815	460676
WS07 BOUT	3166.65	2860.2	3166.65	3064.5	3166.65	3064.5	3166.65	3166.65	3064.5	3166.65	3064.5	3166.65	3966.45	3582.6	3966.45	3838.5	3966.45	3838.5	3966.45	3966.45	3838.5	3966.45	3838.5	3966.45
WS08 KFAR	98849.7	89283.6	98849.7	95661	98849.7	95661	98849.7	98849.7	95661	98849.7	95661	98849.7	110619	99913.8	110619	107050	110619	107050	110619	110619	107050	110619	107050	110619
WS09 BLEI	4408.2	3981.6	4408.2	4266	4408.2	4266	4408.2	4408.2	4266	4408.2	4266	4408.2	5519.55	4985.4	5519.55	5341.5	5519.55	5341.5	5519.55	5519.55	5341.5	5519.55	5341.5	5519.55
WS10 DEQO	4036.2	3645.6	4036.2	3906	4036.2	3906	4036.2	4036.2	3906	4036.2	3906	4036.2	5049.9	4561.2	5049.9	4887	5049.9	4887	5049.9	5049.9	4887	5049.9	4887	5049.9
WS11 MECH	57041.6	51521.4	57041.6	55201.5	57041.6	55201.5	57041.6	57041.6	55201.5	57041.6	55201.5	57041.6	63830.6	57653.4	63830.6	61771.5	63830.6	61771.5	63830.6	63830.6	61771.5	63830.6	61771.5	63830.6
Sum	1438970	1299715	1438970	1392552	1556533	1549302	1595720	1595720	1510115	1517345	1392552	1438970	1630918	1473087	1630918	1578308	1748480	1735058	1787668	1787668	1695870	1709293	1578308	1630918

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S1 - NWSS, Selected Branches (12/22)

Branch	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0
WS01 RAAY	160402	144879	160402	155228	160402	155228	160402	160402	155228	160402	155228	160402	192663	174019	192663	186448	192663	186448	192663	192663	186448	192663	186448	192663
WS02 BSOU	14949.8	13503	14949.8	14467.5	14949.8	14467.5	14949.8	14949.8	14467.5	14949.8	14467.5	14949.8	18720.9	16909.2	18720.9	18117	18720.9	18117	18720.9	18720.9	18117	18720.9	18117	18720.9
WS03 CHWE	396780	358382	396780	383981	396780	383981	396780	396780	383981	396780	383981	396780	444024	401054	444024	429700	444024	429700	444024	444024	429700	444024	429700	444024
WS04 ADEL	279772	252697	279772	270747	279772	270747	279772	279772	270747	279772	270747	279772	315949	285373	315949	305757	315949	305757	315949	315949	305757	315949	305757	315949
WS05 BSAB	7905	7140	7905	7650	7905	7650	7905	7905	7650	7905	7650	7905	9899.85	8941.8	9899.85	9580.5	9899.85	9580.5	9899.85	9899.85	9580.5	9899.85	9580.5	9899.85
WS06 DAYC	411660	371822	411660	398381	411660	398381	411660	411660	398381	411660	398381	411660	460676	416094	460676	445815	460676	445815	460676	460676	445815	460676	445815	460676
WS07 BOUT	3166.65	2860.2	3166.65	3064.5	3166.65	3064.5	3166.65	3166.65	3064.5	3166.65	3064.5	3166.65	3966.45	3582.6	3966.45	3838.5	3966.45	3838.5	3966.45	3966.45	3838.5	3966.45	3838.5	3966.45
WS08 KFAR	98849.7	89283.6	98849.7	95661	98849.7	95661	98849.7	98849.7	95661	98849.7	95661	98849.7	110619	99913.8	110619	107050	110619	107050	110619	110619	107050	110619	107050	110619
WS09 BLEI	4408.2	3981.6	4408.2	4266	4408.2	4266	4408.2	4408.2	4266	4408.2	4266	4408.2	5519.55	4985.4	5519.55	5341.5	5519.55	5341.5	5519.55	5519.55	5341.5	5519.55	5341.5	5519.55
WS10 DEQO	4036.2	3645.6	4036.2	3906	4036.2	3906	4036.2	4036.2	3906	4036.2	3906	4036.2	5049.9	4561.2	5049.9	4887	5049.9	4887	5049.9	5049.9	4887	5049.9	4887	5049.9
WS11 MECH	57041.6	51521.4	57041.6	55201.5	57041.6	55201.5	57041.6	57041.6	55201.5	57041.6	55201.5	57041.6	63830.6	57653.4	63830.6	61771.5	63830.6	61771.5	63830.6	63830.6	61771.5	63830.6	61771.5	63830.6
Sum	1438970	1299715	1438970	1392552	1556533	1549302	1595720	1595720	1510115	1517345	1392552	1438970	1630918	1473087	1630918	1578308	1748480	1735058	1787668	1787668	1695870	1709293	1578308	1630918

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S2 - Full coverage, Selected Branches (12/22)

Branch	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0
WS01 RAAY	160402	144879	160402	155228	160402	155228	160402	160402	155228	160402	155228	160402	151722	137040	151722	146828	151722	146828	151722	151722	146828	151722	146828	151722
WS02 BSOU	14949.8	13503	14949.8	14467.5	14949.8	14467.5	14949.8	14949.8	14467.5	14949.8	14467.5	14949.8	14742.7	13316	14742.7	14267.1	14742.7	14267.1	14742.7	14742.7	14267.1	14742.7	14267.1	14742.7
WS03 CHWE	396780	358382	396780	383981	396780	383981	396780	396780	383981	396780	383981	396780	349669	315830	349669	338389	349669	338389	349669	349669	338389	349669	338389	349669
WS04 ADEL	279772	252697	279772	270747	279772	270747	279772	279772	270747	279772	270747	279772	248810	224731	248810	240784	248810	240784	248810	248810	240784	248810	240784	248810
WS05 BSAB	7905	7140	7905	7650	7905	7650	7905	7905	7650	7905	7650	7905	7796.13	7041.67	7796.13	7544.64	7796.13	7544.64	7796.13	7796.13	7544.64	7796.13	7544.64	7796.13
WS06 DAYC	411660	371822	411660	398381	411660	398381	411660	411660	398381	411660	398381	411660	362782	327674	362782	351079	362782	351079	362782	362782	351079	362782	351079	362782
WS07 BOUT	3166.65	2860.2	3166.65	3064.5	3166.65	3064.5	3166.65	3166.65	3064.5	3166.65	3064.5	3166.65	3123.58	2821.3	3123.58	3022.82	3123.58	3022.82	3123.58	3123.58	3022.82	3123.58	3022.82	3123.58
WS08 KFAR	98849.7	89283.6	98849.7	95661	98849.7	95661	98849.7	98849.7	95661	98849.7	95661	98849.7	87112.3	78682.1	87112.3	84302.3	87112.3	84302.3	87112.3	87112.3	84302.3	87112.3	84302.3	87112.3
WS09 BLEI	4408.2	3981.6	4408.2	4266	4408.2	4266	4408.2	4408.2	4266	4408.2	4266	4408.2	4346.65	3926	4346.65	4206.43	4346.65	4206.43	4346.65	4346.65	4206.43	4346.65	4206.43	4346.65
WS10 DEQO	4036.2	3645.6	4036.2	3906	4036.2	3906	4036.2	4036.2	3906	4036.2	3906	4036.2	3976.8	3591.95	3976.8	3848.51	3976.8	3848.51	3976.8	3976.8	3848.51	3976.8	3848.51	3976.8
WS11 MECH	57041.6	51521.4	57041.6	55201.5	57041.6	55201.5	57041.6	57041.6	55201.5	57041.6	55201.5	57041.6	50266.6	45402.1	50266.6	48645.1	50266.6	48645.1	50266.6	50266.6	48645.1	50266.6	48645.1	50266.6
Sum	1438970	1299715	1438970	1392552	1556533	1549302	1595720	1595720	1510115	1517345	1392552	1438970	1284348	1160056	1284348	1242917	1401910	1399667	1441098	1441098	1360480	1362723	1242917	1284348

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S0CC - Climate Change, Selected Branches (12/22)

Branch	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0
WS01 RAAY	160402	144879	160402	155228	160402	155228	160402	160402	155228	160402	155228	160402	192699	173939	192699	186446	192699	201963	208680	208680	186446	192699	186446	192699
WS02 BSOU	14949.8	13503	14949.8	14467.5	14949.8	14467.5	14949.8	14949.8	14467.5	14949.8	14467.5	14949.8	18724.4	16901.4	18724.4	18116.7	18724.4	19624.6	20277.2	20277.2	18116.7	18724.4	18116.7	18724.4
WS03 CHWE	396780	358382	396780	383981	396780	383981	396780	396780	383981	396780	383981	396780	444106	400870	444106	429694	444106	465457	480937	480937	429694	444106	429694	444106
WS04 ADEL	279772	252697	279772	270747	279772	270747	279772	279772	270747	279772	270747	279772	316007	285242	316007	305752	316007	331200	342215	342215	305752	316007	305752	316007
WS05 BSAB	7905	7140	7905	7650	7905	7650	7905	7905	7650	7905	7650	7905	9901.68	8937.69	9901.68	9580.35	9901.68	10377.7	10722.9	10722.9	9580.35	9901.68	9580.35	9901.68
WS06 DAYC	411660	371822	411660	398381	411660	398381	411660	411660	398381	411660	398381	411660	460761	415903	460761	445808	460761	482913	498973	498973	445808	460761	445808	460761
WS07 BOUT	3166.65	2860.2	3166.65	3064.5	3166.65	3064.5	3166.65	3166.65	3064.5	3166.65	3064.5	3166.65	3967.18	3580.95	3967.18	3838.44	3967.18	4157.91	4296.19	4296.19	3838.44	3967.18	3838.44	3967.18
WS08 KFAR	98849.7	89283.6	98849.7	95661	98849.7	95661	98849.7	98849.7	95661	98849.7	95661	98849.7	110639	99867.9	110639	107049	110639	115958	119815	119815	107049	110639	107049	110639
WS09 BLEI	4408.2	3981.6	4408.2	4266	4408.2	4266	4408.2	4408.2	4266	4408.2	4266	4408.2	5520.57	4983.11	5520.57	5341.42	5520.57	5785.98	5978.41	5978.41	5341.42	5520.57	5341.42	5520.57
WS10 DEQO	4036.2	3645.6	4036.2	3906	4036.2	3906	4036.2	4036.2	3906	4036.2	3906	4036.2	5050.83	4559.11	5050.83	4886.92	5050.83	5293.66	5469.71	5469.71	4886.92	5050.83	4886.92	5050.83
WS11 MECH	57041.6	51521.4	57041.6	55201.5	57041.6	55201.5	57041.6	57041.6	55201.5	57041.6	55201.5	57041.6	63842.3	57626.9	63842.3	61770.5	63842.3	66911.7	69137	69137	61770.5	63842.3	61770.5	63842.3
Sum	1438970	1299715	1438970	1392552	1556533	1549302	1595720	1595720	1510115	1517345	1392552	1438970	1631219	1472411	1631219	1578283	1748782	1866393	1923251	1923251	1695845	1709594	1578283	1631219

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S1CC - NWSS, Selected Branches (12/22)

Branch	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0
WS01 RAAY	160402	144879	160402	155228	160402	155228	160402	160402	155228	160402	155228	160402	192699	173939	192699	186446	192699	201963	208680	208680	186446	192699	186446	192699
WS02 BSOU	14949.8	13503	14949.8	14467.5	14949.8	14467.5	14949.8	14949.8	14467.5	14949.8	14467.5	14949.8	18724.4	16901.4	18724.4	18116.7	18724.4	19624.6	20277.2	20277.2	18116.7	18724.4	18116.7	18724.4
WS03 CHWE	396780	358382	396780	383981	396780	383981	396780	396780	383981	396780	383981	396780	444106	400870	444106	429694	444106	465457	480937	480937	429694	444106	429694	444106
WS04 ADEL	279772	252697	279772	270747	279772	270747	279772	279772	270747	279772	270747	279772	316007	285242	316007	305752	316007	331200	342215	342215	305752	316007	305752	316007
WS05 BSAB	7905	7140	7905	7650	7905	7650	7905	7905	7650	7905	7650	7905	9901.68	8937.69	9901.68	9580.35	9901.68	10377.7	10722.9	10722.9	9580.35	9901.68	9580.35	9901.68
WS06 DAYC	411660	371822	411660	398381	411660	398381	411660	411660	398381	411660	398381	411660	460761	415903	460761	445808	460761	482913	498973	498973	445808	460761	445808	460761
WS07 BOUT	3166.65	2860.2	3166.65	3064.5	3166.65	3064.5	3166.65	3166.65	3064.5	3166.65	3064.5	3166.65	3967.18	3580.95	3967.18	3838.44	3967.18	4157.91	4296.19	4296.19	3838.44	3967.18	3838.44	3967.18
WS08 KFAR	98849.7	89283.6	98849.7	95661	98849.7	95661	98849.7	98849.7	95661	98849.7	95661	98849.7	110639	99867.9	110639	107049	110639	115958	119815	119815	107049	110639	107049	110639
WS09 BLEI	4408.2	3981.6	4408.2	4266	4408.2	4266	4408.2	4408.2	4266	4408.2	4266	4408.2	5520.57	4983.11	5520.57	5341.42	5520.57	5785.98	5978.41	5978.41	5341.42	5520.57	5341.42	5520.57
WS10 DEQO	4036.2	3645.6	4036.2	3906	4036.2	3906	4036.2	4036.2	3906	4036.2	3906	4036.2	5050.83	4559.11	5050.83	4886.92	5050.83	5293.66	5469.71	5469.71	4886.92	5050.83	4886.92	5050.83
WS11 MECH	57041.6	51521.4	57041.6	55201.5	57041.6	55201.5	57041.6	57041.6	55201.5	57041.6	55201.5	57041.6	63842.3	57626.9	63842.3	61770.5	63842.3	66911.7	69137	69137	61770.5	63842.3	61770.5	63842.3
Sum	1438970	1299715	1438970	1392552	1556533	1549302	1595720	1595720	1510115	1517345	1392552	1438970	1631219	1472411	1631219	1578283	1748782	1866393	1923251	1923251	1695845	1709594	1578283	1631219

Water Demand (not including loss, reuse and DSM) (Cubic Meter)
Scenario: S2CC - Full coverage, Selected Branches (12/22)

Branch	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35	Nov-35	Dec-35
IR01	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0	0	0	0	0	117562	156750	156750	156750	117562	78375	0	0
WS01 RAAY	160402	144879	160402	155228	160402	155228	160402	160402	155228	160402	155228	160402	151910	137121	151910	146980	151910	159214	164508	164508	146980	151910	146980	151910
WS02 BSOU	14949.8	13503	14949.8	14467.5	14949.8	14467.5	14949.8	14949.8	14467.5	14949.8	14467.5	14949.8	14760.9	13323.9	14760.9	14281.9	14760.9	15470.6	15985.1	15985.1	14281.9	14760.9	14281.9	14760.9
WS03 CHWE	396780	358382	396780	383981	396780	383981	396780	396780	383981	396780	383981	396780	350101	316017	350101	338740	350101	366933	379136	379136	338740	350101	338740	350101
WS04 ADEL	279772	252697	279772	270747	279772	270747	279772	279772	270747	279772	270747	279772	249118	224864	249118	241033	249118	261094	269778	269778	241033	249118	241033	249118
WS05 BSAB	7905	7140	7905	7650	7905	7650	7905	7905	7650	7905	7650	7905	7805.78	7045.84	7805.78	7552.46	7805.78	8181.05	8453.13	8453.13	7552.46	7805.78	7552.46	7805.78
WS06 DAYC	411660	371822	411660	398381	411660	398381	411660	411660	398381	411660	398381	411660	363231	327868	363231	351443	363231	380694	393354	393354	351443	363231	351443	363231
WS07 BOUT	3166.65	2860.2	3166.65	3064.5	3166.65	3064.5	3166.65	3166.65	3064.5	3166.65	3064.5	3166.65	3127.44	2822.97	3127.44	3025.95	3127.44	3277.8	3386.81	3386.81	3025.95	3127.44	3025.95	3127.44
WS08 KFAR	98849.7	89283.6	98849.7	95661	98849.7	95661	98849.7	98849.7	95661	98849.7	95661	98849.7	87220.1	78728.7	87220.1	84389.6	87220.1	91413.4	94453.5	94453.5	84389.6	87220.1	84389.6	87220.1
WS09 BLEI	4408.2	3981.6	4408.2	4266	4408.2	4266	4408.2	4408.2	4266	4408.2	4266	4408.2	4352.02	3928.33	4352.02	4210.79	4352.02	4561.25	4712.95	4712.95	4210.79	4352.02	4210.79	4352.02
WS10 DEQO	4036.2	3645.6	4036.2	3906	4036.2	3906	4036.2	4036.2	3906	4036.2	3906	4036.2	3981.72	3594.07	3981.72	3852.5	3981.72	4173.14	4311.93	4311.93	3852.5	3981.72	3852.5	3981.72
WS11 MECH	57041.6	51521.4	57041.6	55201.5	57041.6	55201.5	57041.6	57041.6	55201.5	57041.6	55201.5	57041.6	50328.7	45428.9	50328.7	48695.5	50328.7	52748.4	54502.6	54502.6	48695.5	50328.7	48695.5	50328.7
Sum	1438970	1299715	1438970	1392552	1556533	1549302	1595720	1595720	1510115	1517345	1392552	1438970	1285936	1160743	1285936	1244205	1403499	1504510	1549333	1549333	1361768	1364311	1244205	1285936

Net Benefit (U.S. Dollar)
Cost/Benefit Type: Benefit, All Scenarios, Annual Total

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	**Sum**
Reference (S0)	1382209	1382926	1383623	1384324	1385033	1467470	1468175	1468884	1469586	1470291	1470996	1471702	1472413	1473114	1473824	1474526	23099096
S0CC - Climate Change	1382209	1381032	1379869	1378713	1377559	1457582	1456330	1455077	1453837	1452600	1451365	1450142	1448914	1447695	1446490	1445278	22864692
S1 - NWSS	1382209	1343331	1344027	1344728	1345437	1427874	1428579	1429288	1429990	1430694	3369753	3397273	3424792	3452311	3479831	3507350	34537468
S1CC - NWSS	1382209	1341491	1340384	1339283	1338184	1418262	1417064	1415865	1414679	1413497	3369529	3395714	3421507	3447293	3473069	3498794	34426826
S2 - Full coverage	1382209	1343331	1344027	1344728	1345437	1427874	1428579	1429288	1429990	1430694	3369753	3397273	3424792	3452311	3479831	3507350	34537468
S2CC - Full coverage	1382209	1343313	1344015	1344722	1345429	1427883	1428581	1429279	1429991	1430703	3369529	3397091	3424655	3452219	3479784	3507350	34536753

Net Benefit (U.S. Dollar)
Cost/Benefit Type: Capital Cost, All Scenarios, Annual Total

Scenario	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	**Sum**
S1 - NWSS	0	0	0	0	-6637670	-6637670	-6637670	-26921000	-26921000	-27294200	-27294200	-27294200	-27294200	-27294200	-27294200	-237520000
S1CC - NWSS	0	0	-20283300	-20283300	-26921000	-26921000	-26921000	-26921000	-26921000	-27294200	-27294200	-27294200	-27294200	-27294200	-27294200	-338936000
S2 - Full coverage	0	0	0	0	-6637670	-6637670	-6637670	-27262500	-27262500	-27635700	-27635700	-27635700	-27635700	-27635700	-27635700	-240252000
S2CC - Full coverage	0	0	-20283300	-20283300	-27262500	-27262500	-27262500	-27262500	-27262500	-27635700	-27635700	-27635700	-27635700	-27635700	-27635700	-342693000

Net Benefit (U.S. Dollar)
Cost/Benefit Type: Operating Cost, All Scenarios, Annual Total

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	**Sum**
Reference (S0)	-3870710	-3872850	-3874930	-3877020	-3879140	-3915550	-3917650	-3919770	-3921860	-3923970	-3926070	-3928180	-3930300	-3932390	-3934510	-3936600	-62561500
S0CC - Climate Change	-3870710	-3872970	-3875260	-3877560	-3879850	-3916490	-3918810	-3921120	-3923460	-3925790	-3928120	-3930480	-3932810	-3935160	-3937550	-3939900	-62586000
S1 - NWSS	-3870710	-3754700	-3756780	-3758870	-3760990	-3797400	-3799510	-3801620	-3803710	-3805820	-3702580	-3726650	-3750730	-3774810	-3798890	-3822970	-60486700
S1CC - NWSS	-3870710	-3754820	-3757110	-3759410	-3761710	-3798340	-3800660	-3802970	-3805310	-3807650	-5482880	-5508370	-5527380	-5545910	-5564430	-5582860	-71130500
S2 - Full coverage	-3870710	-3754700	-3756780	-3758870	-3760990	-3797400	-3799510	-3801620	-3803710	-3805820	-3039720	-3061320	-3082930	-3104530	-3126130	-3147740	-56472500
S2CC - Full coverage	-3870710	-3754650	-3756740	-3758850	-3760960	-3797430	-3799510	-3801590	-3803720	-3805840	-4837130	-4859240	-4881360	-4903470	-4925590	-4947710	-67264500

Net Benefit (U.S. Dollar)
All Scenarios, Annual Total

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	**Sum**
Reference (S0)	-2488500	-2489920	-2491300	-2492700	-2494100	-2448080	-2449480	-2450890	-2452280	-2453680	-2455080	-2456480	-2457890	-2459280	-2460690	-2462080	-39462400
S0CC - Climate Change	-2488500	-2491930	-2495390	-2498840	-2502300	-2458910	-2462480	-2466040	-2469620	-2473190	-2476760	-2480340	-2483900	-2487470	-2491060	-2494620	-39721300
S1 - NWSS	-2488500	-2411370	-2412750	-2414140	-2415550	-9007190	-9008590	-9010000	-29294700	-29296100	-27627000	-27623600	-27620100	-27616700	-27613200	-27609800	-263469000
S1CC - NWSS	-2488500	-2413330	-2416720	-22703400	-22706800	-29301000	-29304600	-29308100	-29311600	-29315100	-29407500	-29406800	-29400100	-29392800	-29385500	-29378200	-375640000
S2 - Full coverage	-2488500	-2411370	-2412750	-2414140	-2415550	-9007190	-9008590	-9010000	-29636200	-29637600	-27305600	-27299700	-27293800	-27287900	-27282000	-27276100	-262187000
S2CC - Full coverage	-2488500	-2411340	-2412730	-22697400	-22698800	-29632000	-29633400	-29634800	-29636200	-29637600	-29103300	-29097800	-29092400	-29086900	-29081500	-29076000	-375421000

REFERENCES

Barlow P (2003) Groundwater in Freshwater-Seawater Environments of the Atlantic Coast. Technical Report, USGS, Reston

Bazzi, M. (2020). Reclaiming riparian landscapes: the case of Al-Ghadir River in southern Beirut (Doctoral dissertation).

Bear J (1999) Seawater Intrusion in Coastal Aquifers: Concepts, Methods and Practices. Kluwer Academic Publishers, Dordrecht. https://doi.org/10.1007/978-94-017-2969-7

Boyd, C. E. (2019). *Water quality: an introduction*. Springer Nature.

BTD (2016) Feasibility Study of Damour Area (Mount Lebanon) for Artificial Aquifer Recharge of Site A14: Final Report. Bureau Technique pour le Développement, Beirut, Lebanon

BTD (2022) Assessment of Seawater Intrusion into the Lebanese Coastal Hydrogeological Units. Bureau Technique pour le Développement, Beirut, Lebanon

Copernicus Sentinel-5P (processed by ESA), 2021, TROPOMI Level 2 Nitrogen Dioxide total column products. Version 02. European Space Agency. https://doi.org/10.5270/S5P-9bnp8q8

Dagher, L. A., Hassan, J., Kharroubi, S., Jaafar, H., & Kassem, I. I. (2021). Nationwide assessment of water quality in rivers across Lebanon by quantifying fecal indicators densities and profiling antibiotic resistance of Escherichia coli. Antibiotics, 10(7), 883.

Daoud A (1973) Groundwater Recharge in the Beirut Area. Thesis. American University of Beirut (AUB). Lebanon

Domenico PA, Mifflin MD (1965) Water from low-permeability sediments and land subsidence, Water Resources Research, vol. 1, no. 4., pp. 563-576

Doummar J, Hajj Chehade A, Al Sayegh G (2015) Geology and Hydrogeology of the Ghadir Surface Water Basin. Technical Study Report, Beirut and Mount Lebanon Water Authority (EBML), Beirut, Lebanon. American University of Beirut

Dubertret L (1945) Géologie Du Site De Beirut 1:20000. République Libanaise. Ministère des Travaux Publics, Beyrouth

Dubertret L (1955) Carte géologique du Liban au 1:200,000 avec notice explicative. République Libanaise. Ministère des Travaux Publics, Beyrouth, 74 p

ELARD (2012). Extension of Al Ghadir Wastewater Treatment Plant – Lebanon, Environmental and Social Impact Assessment, December 27, 2012.

Elezian H (1985) Depositional Environment of the Cenomanian Sannine Limestone Formation of the Beirut Region (Lebanon). American University of Beirut

El-Kareh (1970) Some Sedimentological Aspects of St. George's Bay and a comparison of Theoretical and Empirical evaluation of settling times in low viscosity fluids. Master of Science. Geology Department. American University of Beirut

Elias A, Tapponnier P, Singh SC, King G, Briais A, Daëron M, Carton H, Sursock A, Jacques E, Jomaa R, Klinger Y (2007) Thrusting offshore Mt Lebanon: Source of the tsunamigenic, 551 AD Beyrut-Tripoli earthquake, Geology, 35(8), 755 – 758, doi:10.1130/G23631A.1

Frem M, Saad S (2021) Spatially Distributed Groundwater Recharge Estimation through the Application of a Long-Term Regional Water Balance using Geographic Information Systems: A Case Study for Lebanon. Master of Science. Université Saint-Joseph de Beyrouth

Geara-Matta, D., Lorgeoux, C., Samrani, A., Chebbo, G., & Moilleron, R. Water uses and wastewater management in Lebanon.

Ghattas (1975) The Geology and Hydrogeology of the Western Flexure of Mount Lebanon Between Dbaiye and Jdaide. Master of Science. Geology. American University of Beirut

Griffiths, C., Klemick, H., Massey, M., Moore, C., Newbold, S., Simpson, D., & Wheeler, W. (2012). US Environmental Protection Agency valuation of surface water quality improvements. *Review of Environmental Economics and Policy*.

Hajj (1987) Foraminifera of the Ashrafiyeh Miocene Marl Unit, Beirut: Identification, Correlation and Paleo-ecology. Master of Science. Geology Department. American University of Beirut

Heath RC (1983) Basic ground-water hydrology, U.S. Geological Survey Water-Supply Paper 2220, 86p

Hespanhol, I., & Prost, A. M. E. (1994). WHO guidelines and national standards for reuse and water quality. *Water Research*, *28*(1), 119-124.

Kanaan (1966) Sedimentary Structures and Thickness and Facies Variation in the Basal Cretaceous Sandstones of Central Lebanon. Master of Science. Geology Department. American University of Beirut

Kazpard V, Saad Z, El Samrani A (2007) Tracing sources of nitrate in groundwater by using hydro-chemical and isotopic methods: Beirut region and its suburbs. Advances in Isotope Hydrology and its Role in Sustainable Water Resources Management (IHS—2007), 21, 537

Khadra WM, Stuyfzand PJ, Khadra IM (2017) Mitigation of saltwater intrusion by 'integrated fresh keeper' wells combined with high recovery reverse osmosis. Sci. Total Environ. 574, 796–805. http://dx.doi.org/10.1016/j.scitotenv.2016.09.156

Kunkel R, Wendland F (2002) The GROWA98 model for water balance analysis in large river basins–the river Elbe case study. J. Hydrol. 259, 152–162

"Labour Force and Household Living Conditions Survey 2018-2019 in Beirut", Central Administration of Statistics, 2020

Lebanon Follow-up Labour Force Survey – January 2022 – Fact Sheet

Mabee SB, Hardcastle KC (1997) Analyzing Outcrop-Scale Fracture Features to Supplement Investigations of Bedrock Aquifers. Hydrogeology Journal, vol. 5, no. 4, p. 21-36

Mayer X, Ruprecht J, Bari M (2005) Stream salinity status and trends in southwest Western Australia. Department of Environment, Salinity and land use impacts series, Report No. SLUI 38

Mcheik A, Fakih M, Bousserrhine N, Toufaily J, Garnier-Zarli E, Hamieh T (2013) Biomobilization of Heavy Metals from the Sediments Affect the Bacterial Population of Al-Ghadir River (Lebanon). Agriculture, Forestry and Fisheries. Vol. 2, No. 3, pp. 116-125.doi: 10.11648/j.aff.20130203.11

Mcheik A, Fakih M, Trabulsi H, Toufaily J, Hamieh T, Garnier-Zarli E, Bousserrhine N (2015a) Metal Pollution Assessment of Sediment and Water in Al-Ghadir River: Role of Continuously Released Organic Matter and Carbonate and Their Purification Capacity. International Journal of Environmental Monitoring and Analysis. Vol. 3, No. 3, pp. 162-172. doi: 10.11648/j.ijema.20150303.18

Mcheik A, Fakih M, Noureddine H, Trabulsi H, Toufaily J, Hamieh T, Garnier-Zarli E, Bousserrhine N (2015b) Anaerobic Sediments Decrease the Leaching of Trace Metals to Groundwater. International Journal of Environmental Monitoring and Analysis. Vol. 3, No. 3, pp. 180-190. doi: 10.11648/j.ijema.20150303.20

MoE/UNDP/GEF (2011). Lebanon's second national communication to the UNFCCC. Beirut, Lebanon.

MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon.

MoE/UNDP/GEF (2022). Lebanon's Fourth National Communication to the UNFCCC. Beirut, Lebanon.

MoEW, UNDP (2014) Assessment of Groundwater Resources of Lebanon. Ministry of Energy and Water, Lebanese Republic

Morris DA, Johnson AI (1967) Summary of hydrologic and physical properties of rock and soil materials as analyzed by the Hydrologic Laboratory of the U.S. Geological Survey, U.S. Geological Survey Water-Supply Paper 1839-D, 42p

Nader FH (2000) Petrographic and Geochemical Characterization of the Jurassic-Cretaceous Carbonate Sequence of the Nahr Ibrahim Region, Lebanon. American University of Beirut

PEDCo Environmental, Inc, United States. Environmental Research Laboratory (Cincinnati, Ohio). Energy Pollution Control Division, Environmental Research Laboratory (Athens, & Ga.). (1980). *Industrial Process Profiles for Environmental Use*. Industrial Environmental Research Laboratory, Office of Research and Development, US Environmental Protection Agency.

Peltekian A (1980) Groundwater quality of greater Beirut in relation to geological structure and The Extent of Seawater Intrusion. Master of Science. Geology. American University of Beirut

Rhoades JD, Kandiah A, Mashali AM (1992) The use of saline waters for crop production. FAO irrigation and drainage paper 48. Food and Agriculture Organization of the United Nations, RomeSaadeh M (2008) Seawater Intrusion in Greater Beirut, Lebanon. In Climatic Changes and Water Resources in the Middle East and North Africa (pp. 361-371). Berlin: Springer

Rolf L (2017) Assessing the Site Suitability of Managed Aquifer Recharge (MAR) Projects in Karst Aquifers in Lebanon-A Multi Criteria Analysis. Master's thesis. Utrecht University, The Netherlands

Saadeh M (2008) Seawater Intrusion in Greater Beirut, Lebanon. In Climatic Changes and Water Resources in the Middle East and North Africa (pp. 361-371). Berlin: Springer

Ukayli MA (1971) Hydrogeology of Beirut and Vicinity. American University of Beirut

United States. Environmental Protection Agency. Office of Water Regulations, & Standards. (2013). *Water quality standards handbook*. US Environmental Protection Agency, Office of Water Regulations and Standards.

UNDP (United Nations Development Programme) (1970) Liban Etude Des Eaux Souterraines. New York

Walley CD (1997) The Lithostratigraphy of Lebanon: A Review. Lebanese Science Bulletin, 10(1), 1–20