



Building Sustainably

WATER USE BEST PRACTICES FOR CONSTRUCTION SITES

Case Studies from FIFA World Cup Qatar 2022™ Stadiums



اللجنة العليا
للمشاريع واليرث
Supreme Committee
for Delivery & Legacy



WATER USE BEST PRACTICES FOR CONSTRUCTION SITES

Case Studies from FIFA World Cup Qatar 2022™ Stadiums

► March 2023

Developed By:

Gulf Organisation for Research & Development (GORD)

In Collaboration With:

Supreme Committee for Delivery & Legacy (SC)

COPYRIGHT © 2023 All rights reserved to Gulf Organisation for Research & Development.



TABLE OF CONTENTS

LIST OF TABLES.....	3	Best Practice 4: Using TSE for Dust Suppression	22
LIST OF FIGURES.....	4	Best Practice 5: Reusing Abstracted Water.....	23
FOREWORD - DR. YOUSEF ALHORR	5	Best Practice 6: Ensuring Low Flow of Water Tankers for Dust Suppression.....	22
FOREWORD - ENG. BODOUR AL MEER.....	6	Best Practice 7: Using Low-Flow Rate Water Fixtures	24
ACKNOWLEDGEMENTS	7	Best Practice 8: Reducing Flush Tank Capacity	25
1.0 INTRODUCTION	8	Best Practice 9: Installing Aerators on the Water Taps.....	25
1.1 FIFA Endorsement and SC Commitment	9	Best Practice 10: Paving Haul Roads with Milled Asphalt.....	26
2.0 WATER USE IN GSAS CONTEXT	10	Best Practice 11: Extending Prime Coat	27
2.1 FIFA World Cup Qatar 2022™ Stadiums	10	Best Practice 12: Covering Stockpiles with Tarpaulin or Mesh	27
2.2 Scope of Analysis	12	Best Practice 13: Using Atomizing Systems for Dust Suppression	28
2.3 Water Use Data Analysis	13	Best Practice 14: Installing Portable Dry Urinal Units.....	28
2.3.1 Distribution of Water Consumption Between Domestic and Non-Domestic Use.....	13	Best Practice 15: Using a Closed-Loop Wet Wheel Wash System.....	29
2.3.2 Distribution of Non-Domestic Water use Between Potable and Non-Potable	14	Best Practice 16: Installing Dry (Waterless) Wheel Cleaning System.....	30
2.3.3 Domestic Water Consumption Per Person Per Day (Including Both Site and Office).....	16	Best Practice 17: Reusing Water from AC Condensation for Gardening.....	31
2.3.4 Total Water Consumption Per Month.....	16	Best Practice 18: Organizing Awareness Trainings and Competitions.....	32
2.3.5 Variation of Water Consumption Through the Construction Stages	17	Best Practice 19: Providing Knowledge-Sharing Sessions.....	32
3.0 IMPLEMENTED METHODS AND MEASURES.....	18	3.2 Common Practices.....	33
3.1 Best Practices.....	18	Common Practice 1: Inspections to Detect Water Leaks from Pipelines and Repair.....	33
Best Practice 1: Adopting Principles for Effective Energy Management.....	18	Common Practice 2: Use of Chemicals for Concrete Curing	34
Best Practice 2: Monitoring Water Consumption	20	Common Practice 3: Use of Jute Fabric to Minimize the Evaporation	34
Best Practice 3: Adopting a Treatment System.....	22	Common Practice 4: Use of Chemical Toilets.....	34
		4.0 CONCLUSION.....	35
		5.0 BIBLIOGRAPHY	36

LIST OF TABLES



Table 1: GSAS-CM certification ratings achieved by all FIFA World Cup Qatar 2022™ stadium projects..... 9

Table 2: Awarded level based on the WPC value 10

Table 3: Awarded [W.1] and [W.2] levels 11

Table 4: Distribution of water consumption between domestic and non-domestic uses 14

Table 5: Distribution of non-domestic water consumption between potable and non-potable 15

Table 6: The ratio of domestic water consumption per person per day..... 16

Table 7: Water consumption per month 16

LIST OF FIGURES

Figure 1: Potable water saved is enough to fill Al Janoub Stadium.....	15	Figure 19: Dry (waterless) urinals installed on the construction site	29
Figure 2: Water consumption variation through the three construction stages...	17	Figure 20: Closed-loop wet wheel wash system.....	29
Figure 3: Workflow for Water Conservation Plan.....	19	Figure 21: Layout representation of closed-loop wet wheel wash system	30
Figure 4: GSAS-CM site audits	20	Figure 22: Dry wheel wash system	30
Figure 5: Strategy on sustainability implementation in water at Education City Stadium.....	21	Figure 23: Benefits of using a dry (waterless) wheel cleaning system on construction sites.....	30
Figure 6: Water consumption data analysis of Education City Stadium.....	21	Figure 24: Air conditioner condensate water used for gardening.....	31
Figure 7: Water meters	22	Figure 25: On-site training session	32
Figure 8: Treatment system in Lusail Stadium's workers accommodation	22	Figure 26: Knowledge-sharing session	32
Figure 9: TSE sprayed on the construction site.....	23	Figure 27: Training and awareness programs workflow.....	33
Figure 10: Dewatering water sprayed on the construction site	23	Figure 28: Use of jute fabric (Hessian cloth) for concrete curing.....	34
Figure 11: Modified tanker for low-flow rate	24	Figure 29: Use of chemical toilets on construction sites.....	34
Figure 12: Dual flush toilet installed on site.....	25		
Figure 13: Reduced flushing consumption of water closets	25		
Figure 14: Aerators installed on water taps.....	26		
Figure 15: Roads paved with milled asphalt.....	27		
Figure 16: Application of prime coat on laydown area.....	27		
Figure 17: Covering stockpiles with tarpaulin	28		
Figure 18: Mist cannons	28		

FOREWORD



Dr. Yousef Mohammed Alhorr

Founding Chairman,
Gulf Organisation for Research &
Development

Water is a finite resource, and while it makes up 71% of our earth, less than 1% of it is useable with the rest being salty, frozen or inaccessible. The World Economic Forum has warned that by 2030, the gap between water supply and demand is expected to reach 40% in the absence of tangible measures across all industries. Water scarcity hence is a global issue but it is indisputably more intense in countries like Qatar given its desert climate and hot weather conditions. According to Qatar National Climate Change Action Plan, the annual water demand in Qatar has swelled by more than 10.6%, as a result of increasing population and urban development. Against this background, Qatar National Environment and Climate Change Strategy (QNE) has recognized water among five priority areas to address climate change. Working towards Qatar National Vision 2030, public and private entities across all sectors in Qatar are calling for science-based solutions that enable water efficiency.

One of the prominent industrial consumers of water amid Qatar's rapid urbanization is the construction sector where domestic and non-domestic applications require large amounts of water. From trench excavation, concrete curing, equipment cleaning and dust suppression to meeting the drinking and cleaning needs of workers on site, water makes an inevitable part of the urban built environment which encompasses infrastructure projects such as stadiums.

Working in line with the country's national strategy to achieve water security, the Supreme Committee for Delivery & Legacy (SC) exceeded the environmental standards set for the FIFA World Cup Qatar 2022™ venues. A part of this massive undertaking was to incorporate water conservation practices throughout the construction of the stadiums. This was made possible with the use of the Global Sustainability Assessment System (GSAS) as a guiding framework and green building rating system for all new venues of the tournament.

In this report titled "Water Use Best Practices for Construction Sites: Case Studies from FIFA World Cup Qatar 2022™ Stadiums", we have consolidated the measures that best demonstrate SC's water stewardship during various stages of the stadiums' development. Covered under the scope of this comprehensive document are ways in which stadium sites across Qatar saved water in domestic and non-domestic use. By detailing water use best practices on construction sites, we hope and envisage this report to become a guiding document for projects and organizations looking to make water environmentally sustainable, socially equitable and economically beneficial.

As the developer of GSAS, the Gulf Organisation for Research & Development (GORD) is proud to have partnered with SC in meeting its unwavering climate commitment that was evident from the outset. We are honored to be part of the nation's iconic green projects which by default reflect a lasting sustainability legacy of Qatar 2022™.

FOREWORD

Sustainability formed a central part of Qatar's bid for the FIFA World Cup Qatar 2022™, helping it stand out among competitors. When we started drawing up plans for the tournament, we had a nearly blank canvas – giving us a huge advantage to ensure that sustainability sat at the heart of all our FIFA World Cup Qatar 2022™ planning and delivery, before we first broke ground on any projects.

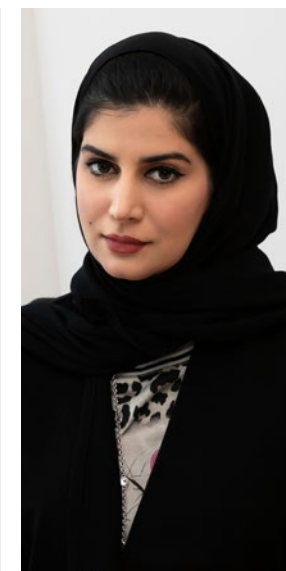
Working with our partners and stakeholders, we have delivered a number of the sustainability promises we made in our bid – the key of which is building the infrastructure required for the tournament according to the highest sustainable building and construction standards. On stadium sites, this involved Qatari entities working with international partners to achieve sustainable design and construction – of which efficient resource planning and effective waste management form crucial elements.

Our collective efforts have helped minimize the impact that the construction of tournament venues had on the environment, and contributed to upscaling environmental consciousness across the industry. Along the way, we have set new benchmarks that we hope the rest of both the construction and mega-event industries locally and internationally can benefit from.

However, despite all of the progress we have made our work is not done, and maintaining this positive momentum will be key to the legacy we are aiming for the tournament to leave after 2022.

The Gulf Organisation for Research & Development (GORD) has been a key partner in helping us achieve the immediate positive environmental impact of the FIFA World Cup Qatar 2022™, guided by the GSAS certification system. Our collaboration will continue long after 2022 as we move to deliver our long-term legacy plans aimed at ensuring that sustainable environmental development is maintained for generations to come, and reports such as this one will contribute to this.

We are pleased to share this report on sustainable construction, focused on water management best practices and case studies from stadium sites across Qatar. We are certain the report will be an invaluable tool to many in the construction industry, and look forward to continued cooperation.



Eng. Bodour Al Meer

Executive Director - Sustainability,
Supreme Committee
for Delivery & Legacy (SC)

ACKNOWLEDGEMENTS

This report has been made possible through the continued efforts and support of many dedicated individuals and entities, including the Supreme Committee for Delivery & Legacy, GSAS Certified Green Professionals working at stadiums' construction sites, and the Gulf Organisation for Research & Development's technical and administration support teams.

1.0 INTRODUCTION

The construction of mega projects can last for many years, employing thousands of people, using hundreds of machinery and equipment, and deploying a diversity of technologies. These construction sites become a long-living working place for the construction crew where water is required at all times for many purposes.

Saving and optimizing water consumption are necessary for executing any sustainable construction work. Water is required to provide a safe and comfortable environment and is required to carry out several construction-related activities on site.

In most cases, construction sites rely on tankers to fulfill their daily water requirements with limited reliance on supply from the public mains. Water-efficient practices and smart controls can reduce water consumption, thus reducing diesel consumption from tankers' transportation and the associated carbon emissions. There are many other environmental benefits to reducing water consumption, including a lesser burden on the domestic water network, lesser demand for desalination, and a lesser burden on existing natural sources allowing for sustainable replenishment of underground reserves.

The main water uses at construction sites can be divided into domestic and non-domestic use:

- Domestic water use includes water required within the temporary buildings located at the construction site such as offices, sanitary facilities, welfare facilities, canteens, prayer rooms and mess halls.
- Non-domestic water use includes water required for various site operations such as mobilization, demolition, excavation, backfilling, concrete mixing and curing, dust suppression, road sweeping, equipment and wheel washing, site cleaning, testing and commissioning, etc.

Unfortunately, construction activities in Qatar and the region face some specific challenges impacting the water consumption, such as high temperature and humidity. On the other hand, dewatering from low-lying land is often

required, where groundwater is pumped out and utilized, whenever possible, for non-structural activities such as dust suppression, site sweeping and equipment cleaning.

In Qatar, with the goals set forth in Qatar National Vision 2030 (QNV 2030) and Qatar National Development Strategy 2018-2022, significant attention has been placed on the impact of diminishing water. The environmental pillar of the FIFA World Cup Qatar 2022™ Sustainability Strategy, hence, includes objectives for green building and water conservation.

As all key stakeholders have the intention to pursue sustainability, substantial efforts have been undertaken to reduce the amount of water used during construction as a way to meet the main objectives of the respective strategies and visions.

1.0 INTRODUCTION



1.1 FIFA Endorsement and SC Commitment

For the FIFA World Cup Qatar 2022™, GSAS Design & Build (GSAS-D&B) certification with 4-Star rating was endorsed as the required green building rating system for the match venues. The Supreme Committee for Delivery & Legacy (SC) went beyond FIFA's minimum requirement by specifying GSAS Construction Management (GSAS-CM) certification for all FIFA World Cup Qatar 2022™ stadium sites. The SC also specified GSAS-CM certification to be achieved with a minimum rating of Class A for the construction sites of the stadiums. Furthermore, the SC has implemented GSAS Operations (GSAS-OP) certification for the stadiums and head office.

GSAS-CM is applied to assess the processes and practices of contractors to evaluate the sustainability impact of projects over the course of the construction phase (start to end). The FIFA World Cup Qatar 2022™ stadiums have achieved very recognizable GSAS-CM ratings as shown in Table 1.

Table 1: GSAS-CM certification ratings achieved by all FIFA World Cup Qatar 2022™ stadium projects

Stadium	GSAS-CM Rating
Ahmad Bin Ali Stadium	Class A*
Al Bayt Stadium	Class A*
Al Janoub Stadium	Class A*
Al Thumama Stadium	Class A*
Education City Stadium	Class A*
Khalifa International Stadium	Class A
Lusail Stadium	Class A*
Stadium 974	Class A*

2.0 WATER USE IN GSAS CONTEXT

The water used for construction activities is assessed in GSAS-CM v2.1 under the Water category, which is composed of two criteria “[W.1] Domestic Water Management” and “[W.2] Non-Domestic Water Management”. [W.1] criterion assesses the methods and measures undertaken to minimize the amount of water used for human consumption in the temporary buildings, while [W.2] criterion assesses the methods and measures implemented to minimize water consumption in construction activities on site.

The assessment is performance-based as the Water Calculator is used to determine the Water Performance Coefficients (WPCs) based on the total number of workers available on site, the installed water fixtures specifications, and the total water consumption compared to the business-as-usual scenario. The WPCs determine the awarded criterion level from 0 to 3 as indicated in Table 2.

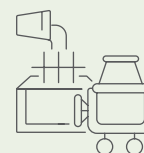
Table 2: Awarded level based on the WPC value

Level	EPC value	
	[W.1] Domestic Water Management	[W.2] Non-Domestic Water Management
0	$WPC_{\text{Domestic}} > 0.90$	$WPC_{\text{Non-domestic}} > 0.90$
1	$0.85 < WPC_{\text{Domestic}} \leq 0.90$	$0.85 < WPC_{\text{Non-domestic}} \leq 0.90$
2	$0.80 < WPC_{\text{Domestic}} \leq 0.85$	$0.80 < WPC_{\text{Non-domestic}} \leq 0.85$
3	$WPC_{\text{Domestic}} \leq 0.80$	$WPC_{\text{Non-domestic}} \leq 0.80$

A $WPC > 0.90$ means that up to 10% of water saving has been achieved compared to the reference value; therefore, a level of 0 is assigned. The greater the water saving, the greater the awarded level up to a maximum of 3.

On-site meters are necessary to be installed to monitor the water consumption for domestic and non-domestic use, hence completing the GSAS Water Calculator. In addition, the number of workers, the installed water fixtures quantities, and their respective flows are required to do the assessment. Further information related to tankered water, treated sewage effluent (TSE), and/or abstracted water, etc. is also required.

The assessment of the water use is carried out over the full construction period and audits are conducted during three construction stages which are:



STAGE 1:
Enabling and
Foundation



STAGE 2:
Substructure and
Superstructure



STAGE 3:
Finishing

2.0 WATER USE IN GSAS CONTEXT

2.1 FIFA World Cup Qatar 2022™ Stadiums

Table 3 represents the FIFA World Cup Qatar 2022™ Stadium projects' awarded levels for the Water criteria [W.1] and [W.2].

Table 3: Awarded [W.1] and [W.2] levels

Stadium Project	Stage 1		Stage 2		Stage 3	
	[W.1]	[W.2]	[W.1]	[W.2]	[W.1]	[W.2]
Ahmad Bin Ali Stadium	2	3	3	3	3	3
Al Bayt Stadium	2	2	2	3	2	3
Al Janoub Stadium	2	2	2	3	3	3
Al Thumama Stadium	2	3	3	3	3	3
Education City Stadium	2	3	2	3	3	3
Khalifa Stadium	3	3	2	2	2	3
Lusail Stadium	2	3	3	3	3	3
Stadium 974	2	3	2	3	2	3



2.0 WATER USE IN GSAS CONTEXT

2.2 Scope of Analysis

This report focuses on the water use in stadium construction sites of the FIFA World Cup Qatar 2022™ during the entire construction period. It highlights the role of GSAS-CM in optimizing water consumption. It also provides water use data on construction sites that can be used by future projects as a reference for planning their water use. However, it is crucial to indicate that the study takes into account the following considerations for a reliable comparison between projects:

1. The scope of the assessment extends to all water used on site either for human consumption or construction activities, except for the following:
 - 1.1 The water discharged from dewatering activities that was not reused on site. Dewatering was necessary at Education City Stadium and Stadium 974. These projects reused as much water as possible but not all. The excess water that could not be reused on site has been excluded from this analysis.
 - 1.2 Water consumption for sports turf irrigation was not considered in the analysis, as it is a special activity for stadiums and would lead to misleading benchmarking for future typical projects.
 - 1.3 Water consumption from on-site workers' accommodation was excluded from the analysis, as it is not common to have accommodation onsite on most construction projects.
 - 1.4 Water consumption from on-site batching plants was excluded, as it is also not a common practice to have them in-situ in most construction projects.
2. Khalifa International Stadium was refurbished and not newly constructed; therefore, it has been excluded from the analysis.
3. Al Bayt Stadium and Al Janoub Stadium construction started before the implementation of the water consumption monitoring; therefore, they have been excluded from the analysis.

2.0 WATER USE IN GSAS CONTEXT

2.3 Water Use Data Analysis

Stadium projects can be considered unique buildings as they intend to host instantly a large crowd of people for sports events. However, the construction practices can be considered similar to other typical buildings, despite the fact that some specific arrangements could impact the water consumption, such as the double shift working schedule (24/7) which was implemented in the stadiums and required extra water use for construction activities. Furthermore, due to the hot climate, higher amount of water was required for human consumption and concrete curing. Also, due to the desert's dry and windy conditions, a large quantity of water was required for dust suppression.

The collected data was analyzed, and the following ratios were calculated accordingly:

- Distribution of water consumption between domestic and non-domestic use.
- Distribution of non-domestic water use between potable (mains and tankers), and non-potable (TSE and discharge from dewatering).
- Domestic water consumption per capita in liters per person per day.
- Total water consumption per month.
- Variation of water consumption through the construction stages.
 - Domestic use
 - Non-domestic use
 - Total

2.3.1 Distribution of Water Consumption Between Domestic and Non-Domestic Use

Knowing the detailed distribution of the water consumption on site between domestic use and construction activities can be of interest to future projects when planning their site logistics. As part of the GSAS-CM requirements, the stadium projects separately monitored the amount of water used for domestic and non-domestic purposes.

Domestic water use includes water required for human consumption such as washing, sanitary and cleaning, within the temporary buildings located at the construction site such as offices, sanitary facilities, welfare facilities, canteens, prayer rooms, pantries and mess halls. Non-domestic water use includes any construction activity running on site and utilizing water. Listed here are the most typical water-consuming construction activities on construction sites:

- Demolition activities that require water.
- Concrete mixing and curing
- Backfill compaction
- Dust suppression
- Testing and commissioning of HVAC and wet utilities
- Mixing of mortar, screed and plaster
- Wheel washing
- Washing out of concrete trucks

2.0 WATER USE IN GSAS CONTEXT

All consumed water is counted for, regardless of the water source and whether it is potable or not. However, definitely, the use of non-potable water results in savings of potable water allowing projects to achieve a higher criterion level.

Table 4 shows that 21% of the total water was used for human consumption and 79% was used in construction activities.

Table 4: *Distribution of water consumption between domestic and non-domestic uses*

Stadium	Domestic water consumption percentage	Non-domestic water consumption percentage
Ahmad Bin Ali Stadium	27%	73%
Al Thumama Stadium	21%	79%
Education City Stadium	21%	79%
Lusail Stadium	21%	79%
Stadium 974	14%	86%
Average Ratio	21%	79%

The distribution of water consumption is very similar across the stadiums. It is to be noted that Stadium 974 made use of the huge amount of discharged water from dewatering activities for dust suppression. The project utilized such easily available water on site to ensure a highly effective dust control on their precinct, which is the second largest. This is the reason why this stadium's percentage of non-domestic water use is higher than the other stadiums.

2.3.2 Distribution of Non-Domestic Water use Between Potable and Non-Potable

Knowing the detailed distribution of water consumption between potable and non-potable can be of interest for future projects when planning their site logistics. For those construction activities that do not require potable water according to the Qatar Construction Standards (QCS), the stadium projects tried to use non-potable water whenever possible. This included treated sewage effluent (TSE) and water discharged from dewatering activities. This way, potable water was saved for better uses.

As part of GSAS-CM requirements, the stadium projects monitored the potable water supplied from the network and by tankers, as well as the non-potable water from on-site dewatering and TSE by tankers.

2.0 WATER USE IN GSAS CONTEXT

Table 5: *Distribution of non-domestic water consumption between potable and non-potable*

Stadium	Potable water consumption percentage	Non-potable water consumption percentage (dewatering + TSE)
Ahmad Bin Ali Stadium	33%	67%
Al Thumama Stadium	14%	86%
Education City Stadium	52%	48%
Lusail Stadium	14%	86%
Stadium 974	19%	81%
Average Ratio	27%	73%

Figure 1 shows that overall, 73% of the water used in construction activities was non-potable. This percentage is lower in the case of Education City Stadium because less water was required for dust suppression due to its smaller precinct. Al Thumama and Lusail stadiums are located close to residential areas which are considered sensitive receptors, therefore enhanced dust control measures were implemented on these sites, thereby requiring more water for dust suppression.

Furthermore, the total amount of non-domestic water used reached 1,401,874 cubic meters (m³), where almost 1.08 million m³ of potable water – enough to fill Al Janoub Stadium – was saved during approximately four years of construction, thanks to the water conservation practices.



Figure 1: *Potable water saved is enough to fill Al Janoub Stadium*

2.0 WATER USE IN GSAS CONTEXT

2.3.3 Domestic Water Consumption Per Person Per Day (Including Both Site and Office)

The expected water consumption for domestic use on site might be useful for a future project to know. This can be estimated from the expected workforce throughout the life of the project and the ratio of domestic water use per person per day that is presented here. The stadium projects monitored their water consumption for domestic use. Also, as a business-as-usual practice, the projects kept records of the total number of personnel, both within the temporary offices and on site.

These combined data have been used for calculating the ratios as shown in Table 6. The average consumption per worker per day was 19.7 liters, with little variance across all stadiums.

Table 6: *The ratio of domestic water consumption per person per day*

Stadium	Domestic water consumption per person per day (l)
Ahmad Bin Ali Stadium	18.6
Al Thumama Stadium	19.5
Education City Stadium	19.9
Lusail Stadium	20.7
Stadium 974	19.9
Average Ratio	19.7

2.3.4 Total Water Consumption Per Month

Before the commencement of the construction works, projects estimate the duration of the project; therefore, knowing the expected water consumption per month can help them to estimate the total water consumption that will be required. This can be applied on cost estimations, procurement management and logistics arrangements. Table 7 shows the stadium projects' total water consumption per month, including both domestic and non-domestic uses.

Table 7: *Water consumption per month*

Stadium	Total water consumption per month (m ³ /month)
Ahmad Bin Ali Stadium	10,526
Al Thumama Stadium	9,087
Education City Stadium	5,282
Lusail Stadium	10,185
Stadium 974	5,831

Three of the stadiums have very similar consumption of around 10,000 m³/month. However, Education City Stadium and Stadium 974 have significantly lower consumption. This is because of the different typologies of these projects. Education City Stadium's precinct is much smaller than the others and therefore required less water for dust suppression and backfill compaction. On the other hand, Stadium 974 is

2.0 WATER USE IN GSAS CONTEXT

the only one with a steel structure instead of concrete, which resulted in less water use for concrete curing. Besides, the stadium was built using shipping containers and was prefabricated offsite, which reduced the need for indoor walls and floor finishings, resulting in lower water consumption for plaster and screed mixing on site.

2.3.5 Variation of Water Consumption Through the Construction Stages

As GSAS-CM assessment is conducted three times during the entire construction period, the project's water consumption is continuously monitored during all three stages. Therefore, data is available to analyze the variation of water consumption through the construction phase. As not all the construction stages have the same duration in every stadium, the time variation of the consumption was analyzed per month. Table 8 shows the monthly average water consumption for each construction stage combined for all the stadiums.

Table 8: Monthly average water consumption per stage

Stadium Project	Monthly average water consumption (m3/month) per stage		
	Stage 1	Stage 2	Stage 3
Domestic	672	1,702	2,309
Non-Domestic	4,913	5,321	7,954
Total	5,585	7,023	10,263

Figure 2 illustrates the variation in the average water consumption per month through the three construction stages. There is a clear ascending trend in total water consumption over time.

Domestic water consumption per month increases with time due to the increase in the stadiums' labor force at the finishing stage.

Non-domestic water consumption slightly increases with time. Stage 2 consumption is higher than Stage 1, mainly due to the curing of the concrete structure. Stage 3 is even higher, driven by testing and commissioning of HVAC and wet utilities, water used for on-site plaster and screed manufacturing, and final cleaning of the site.

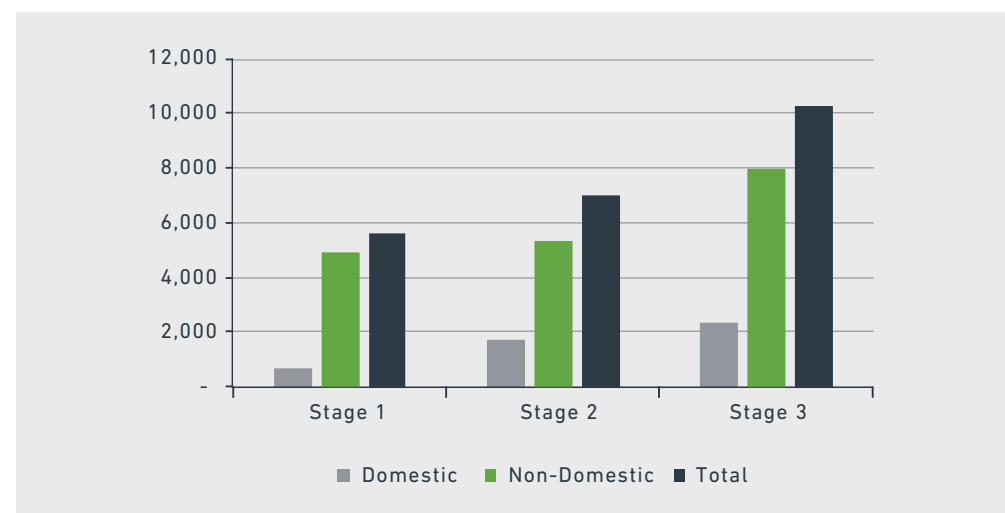


Figure 2: Water consumption variation through the three construction stages

3.0 IMPLEMENTED METHODS AND MEASURES

3.1 Best Practices

Best Practice 1: Adopting Principles for Effective Energy Management

Key decisions can be taken at the management level to promote water conservation on construction sites. Most of these decisions should be taken at the early stages of the project and involve the management teams of the client, designer and contractor.

1. The Client

The SC has considered water conservation as one of the key practices to achieve sustainability during the construction of stadiums. The SC included contractual requirements to develop and implement a Construction Environmental Management Plan (CEMP) and to achieve GSAS-CM certification, with at least Class A rating. The provisions included hiring professionals with GSAS-CM expertise by the contractor, project management and construction supervision teams.

All stadium projects reported to the SC on a weekly and monthly basis, with energy conservation evidence as part of the reporting. The SC additionally organized bimonthly knowledge-sharing meetings across all the projects and ensured dissemination of best practices reports to share lessons learned on water conservation practices.

2. The Designer

The design of a building can affect different construction activities. Some construction activities are more water-demanding than others; therefore, this is an aspect that was considered during the design of the stadiums.

For example, the initial design of Lusail Stadium had the stadium's foundations reaching the water level, which required huge dewatering during the construction process. However, considering that dewatering is a cost-intensive activity that consumes a lot of resources and results in water waste, the design of the foundations was changed and made shallower to avoid the water table and therefore the need for dewatering during the construction phase. This resulted in significant energy savings and avoided a significant amount of CO2 emissions associated with the dewatering processes.

3. The Contractor

Contractors have a leading role in the implementation of water conservation measures as they oversee the deployment of necessary resources. Success in achieving the goal requires an integrated approach from several departments within the contractor's organization. Therefore, full commitment from the project manager is paramount throughout the construction phase as shown in Figure 3.

3.0 IMPLEMENTED METHODS AND MEASURES

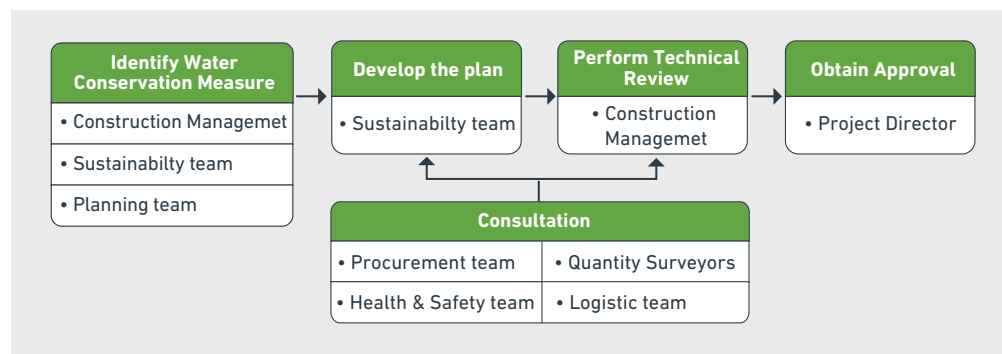


Figure 3: *Workflow for Water Conservation Plan*

► Planning

At the commencement of the construction phase, the contractor's sustainability team should take the lead in developing the plan and identifying opportunities for reducing water consumption. This plan includes:

- Renting temporary buildings with efficient water fixtures.
- Arranging a water metering system.
- Arranging the water tanks according to the expected demand.
- Exploring opportunities in the market for:
 - Sustainable alternatives like non-potable water sources including TSE.
 - Low-flow rate fixtures and flushing systems.
 - Highly water-saving plumbing fixtures.
- Training and awareness program for the staff and workers.

► Procurement and Subcontracting

The contractor must include the necessary provisions in the contracts to ensure that the subcontractors comply with GSAS-CM requirements for water management. The contractor must procure and/or rent efficient water-saving plumbing fixtures such as low-flow taps, dual-flush systems, water-saving toilets, water-saving showering products, water-saving faucets, efficient washing machines, etc.

► Construction Phase

During the construction phase, the contractor is in charge of deploying the resources to execute and supervise the implementation of water conservation practices. Key activities of the sustainability team include:

- Monitoring the water consumption.
- Training the workforce on water conservation practices.
- Supervising and auditing the implementation of sustainable measures.
- Reporting to Project Management on water consumption and implementation of sustainable measures.

3.0 IMPLEMENTED METHODS AND MEASURES

Site Audits

GSAS Trust conducts four site audits per stadium. The site audit looks into the implementation of methods and measures stipulated in GSAS-CM guidelines for all targeted criteria. One of the main subjects for each audit is water conservation measures. Audits help project teams to stay focused and perform continuous supervision of mitigation measures. The stages of the auditing system result in the improvement of best practices including water conservation throughout the project life.



Figure 4: GSAS-CM site audits

Best Practice 2: Monitoring Water Consumption

Measuring the water consumption is part of the GSAS-CM requirements; therefore, water meters were installed on the SC stadium sites.

The collected data must be entered into the GSAS-CM Water Calculator to compute the water performance coefficients (WPCs) and determine the water criteria levels. Therefore, the water monitoring system must be configured to obtain data matching the Water Calculator structure as follows:

- Temporary Buildings' consumption includes:
 - Working days per month, operating hours, the total number of occupants per day, and total measured water consumption for both employees and workers, including site offices, worker accommodation buildings, facilities, kitchens (canteen), etc.
- Flow rates and quantities of sanitary fixtures and fittings used at the employees' site offices and workers' facilities, including washrooms, pantries, canteens/kitchens, workers' toilets, workers' accommodations, washing facilities, and mess hall(s).
- Construction activities' water consumption includes:
 - Construction value (total construction cost).
 - Mains potable water consumption in cubic meters.
 - Supplied potable water by tankers in cubic meters.
 - Recycled water used on site like treated sewage effluent (TSE), etc. in cubic meters.
 - Abstracted water use in cubic meters.
 - Flow rates of non-domestic taps, guns, misting, sweepers, washing, and cleaning equipment, hydraulic spinning systems, high-pressure washers, testing and commissioning activities, etc.

3.0 IMPLEMENTED METHODS AND MEASURES

It is to be noted that the water monitoring arrangements on stadium sites were designed to cater to a monitoring system meeting GSAS-CM requirements. For example, a single water connection feeding both temporary buildings and construction activities was avoided. As construction progressed and site arrangements continued to change with time, some water tanks and meters had to be relocated along the process to allow for detailed monitoring of all systems separately.

Following the principle “You can’t manage what you can’t measure”, the project teams analyzed the collected data for decision making that led to water savings. For example, when the installed water fixtures were found to be working at a low-efficiency factor, they were replaced by more efficient fixtures, thereby saving water and avoiding CO₂ emissions that would otherwise be emitted from the excessive transport of water. Figure 5 and Figure 6 show excerpts from a water management report developed by the Education City Stadium.

Sustainability Implementation in Water

Reduction in Water Consumption

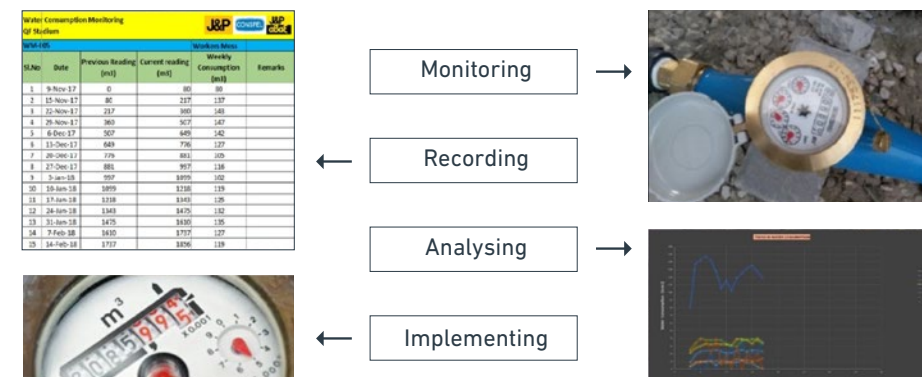


Figure 5: Strategy on sustainability implementation in water at Education City Stadium

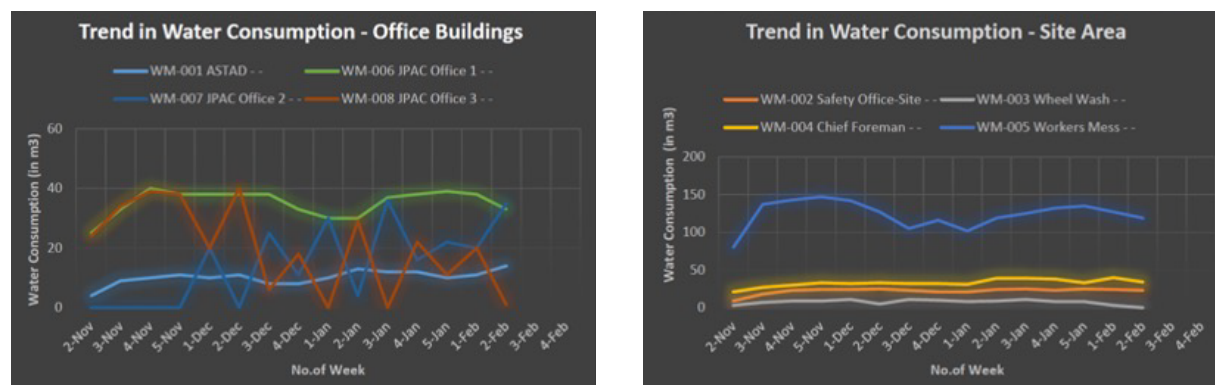


Figure 6: Water consumption data analysis of Education City Stadium

All water sources were accurately quantified through the installation of submeters on any standpipes being used. Water meters were installed in a way to ensure that domestic and non-domestic uses were separately monitored. Detailed records were documented throughout the construction period. Different water types such as potable water, fresh water, TSE, dewatering water, etc. were separately monitored.

3.0 IMPLEMENTED METHODS AND MEASURES



Figure 7: Water meters

Best Practice 3: Adopting a Treatment System

Workers' accommodation facilities were made available adjacent to the Lusail Stadium's construction site. Instead of installing the typical septic tanks, the project team set up a water treatment facility. The treated water was sprayed on haul roads, stockpiles and laydown areas on site to suppress the dust. This resulted in saving potable water and mitigating the CO₂ emissions from its transportation from off-site facilities. Figure 8 shows the treatment system installed in Lusail's workers accommodation.



Figure 8: Treatment system in Lusail Stadium's workers accommodation

Best Practice 4: Using TSE for Dust Suppression

Treated sewage effluent (TSE) was used in most stadium projects for different purposes such as dust suppression and backfilling activities. In Ahmad Bin Ali Stadium, TSE was analyzed to check that pollutant concentrations were within the allowable limits provided in Annex 3/2/1 of Annexes of the Executive By-Law No. 4 of 2005 and as per the requirements of the QCS2014 Section 5 Part 4. By maximizing the use of TSE, potable water use was minimized on site for non-sanitary functions. Figure 9 shows TSE being sprayed on the construction site. In the other stadium sites, TSE was mainly used for dust suppression.

3.0 IMPLEMENTED METHODS AND MEASURES



Figure 9: TSE sprayed on the construction site

Best Practice 5: Reusing Abstracted Water

Dewatering took place in two stadium sites resulting in huge quantities of abstracted water. As per the local regulations and environmental law, the dewatering water can only be used for non-domestic purposes after being treated and demonstrating adherence to relevant authorities' requirements. From this standpoint, Education City and 974 Stadiums managed to use the dewatering water for dust suppression over the construction site and soil stockpiles, and used it for washing vehicle tires. Similarly, Stadium 974 used dewatering water for dust suppression throughout the dewatering process. Figure 9 shows dewatering water being sprayed over the construction site.



Figure 10: Dewatering water sprayed on the construction site

Best Practice 6: Ensuring Low Flow of Water Tankers for Dust Suppression

A traditional mitigation measure for dust generated from the non-paved hauling roads and open areas on construction sites is to spray water on these areas several times a day via tankers. Effective dust suppression requires large quantities of water, which is an environmental problem. Across the SC projects, water consumption has been reduced by implementing the following measures:

3.0 IMPLEMENTED METHODS AND MEASURES

- Discharged water from dewatering was used where available (974 Stadium, Al Janoub Stadium, Al Thumama Stadium and Education City Stadium).
- Treated Sewage Effluent (TSE) was used instead of potable water in all the stadiums. TSE water was pre-treated through chlorination in the tanker and quality tests were performed regularly to ensure that the water met sanitary standards.
- Tankers' trips and routes were scheduled to improve the efficiency of the process.
- Tankers' fixtures were modified to reduce their flow rate and improve their efficiency for the wider spread of water.



Figure 11: *Modified tanker for low-flow rate*

Best Practice 7: Using Low-Flow Rate Water Fixtures

At Al Janoub Stadium project site, water-efficient fixtures such as low-flow and dual-flush toilets were used to minimize water use. Low-flow rate taps and aerators were also installed. In the facilities where aerators could not be installed, the water pressure was reduced to the minimum possible, subsequently minimizing the flow rate.

At Al Thumama Stadium project site, low-flush and low-flow water-efficient fixtures were procured and installed in all the facilities. The site office used automatic water flow shut-offs, flow controllers, regulators and low-flow urinals. The project also utilized low-flow appliances instead of conventional appliances to reduce occupant water consumption. Regular maintenance and monitoring were carried out. Also, internal weekly site audits were conducted by the contractors' teams to inspect the adequacy of the flow rate of the water fixtures.

Overall, stadium projects managed to reduce the flow and flush rates in the conventional water fixtures and toilets by 25 to 50%. For example, the taps flow rate in the ablution areas was reduced to 5 l/m compared to the conventional reference of 9.64 l/m, and the lavatories' flow rates were reduced to 1.6 l/m compared to the standard 1.9 l/m. Similarly, the flow rate in the kitchen sinks was reduced to 2.87 l/m compared to the benchmark of 6.81 l/m, while the dual-flush toilets were reduced to 4.5 per flush as explained in Section 3.1.8. Figure 12 shows an example of the dual flush toilets installed at some construction sites.

3.0 IMPLEMENTED METHODS AND MEASURES



Figure 12: *Dual flush toilet installed on site*

Best Practice 8: Reducing Flush Tank Capacity

The flushing toilet or water closet (WC) system uses the force of water to dispose of human waste (urine and feces) through a drainpipe to another location for treatment. The flushing in conventional toilets is based on a mounted water storage tank above or behind the bowl that is typically 4.5 to 6 liters of water in capacity. The improper use of such toilet systems results in excessive use of water leading to more consumption throughout the project's lifetime. Hence, reducing water consumption is crucial. One of the ideas applied at the stadium projects was to reduce water consumption in sanitary facilities through the use of a sealed two-liters plastic bottle filled with water inside the tank of the toilet. Such action results in a 30% reduction in the amount of water that fills the tank. So, if the toilet was

flushed fifty times a day, 100 liters were saved per day. Figure 13 shows the water consumption reduction technique used in water closets at the stadium projects.

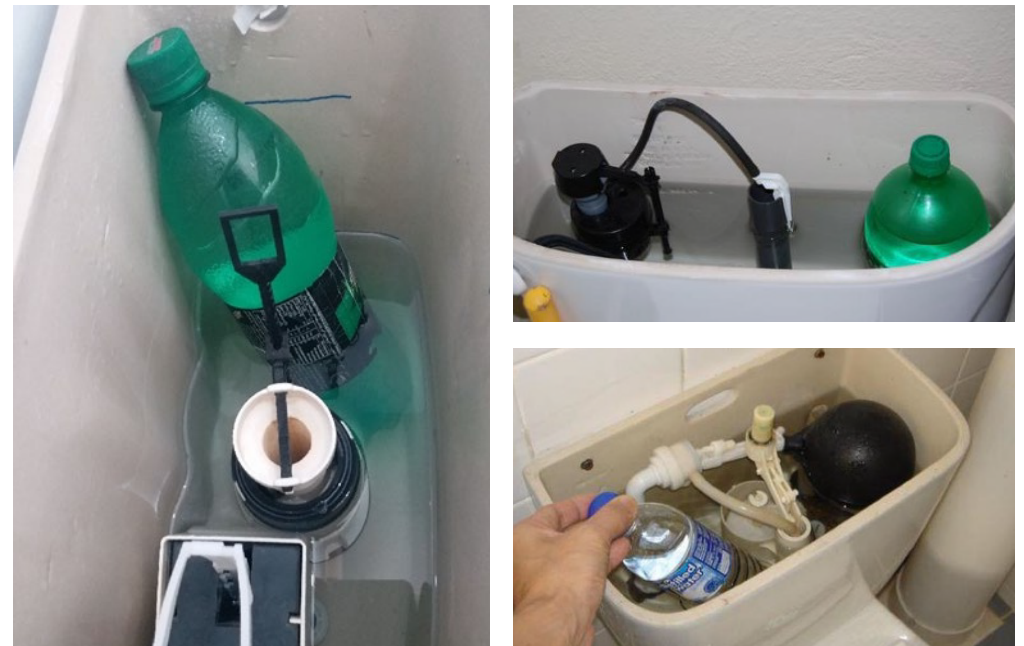


Figure 13: *Reduced flushing consumption of water closets*

Best Practice 9: Installing Aerators on the Water Taps

Types of water taps and their flow rate play a significant role in water savings. In some stadium projects, some pre-existing buildings had faucets with high flow rates. Part of the water-saving efforts deployed by

3.0 IMPLEMENTED METHODS AND MEASURES

the projects was installing aerators on the existing faucets in addition to most of the faucets in temporary buildings and welfare facilities. Aerators are simply screwed onto the faucet head, creating a non-splashing stream and delivering a mixture of water and air. They are considered an extra step to control the water flow rate towards reducing water consumption. Regular awareness sessions and weekly inspections were carried out by the sustainability team to ensure the functionality of the aerators. The selected types of aerators achieved the following new maximum rates for different types of water fixtures installed at on-site facilities:

- a. 1.9 l/m maximum for toilet taps and ablution area.
- b. 3.8 l/m maximum for pantry/custodial taps.

Figure 14 shows the different types of aerators installed on the water taps at different stadium sites.

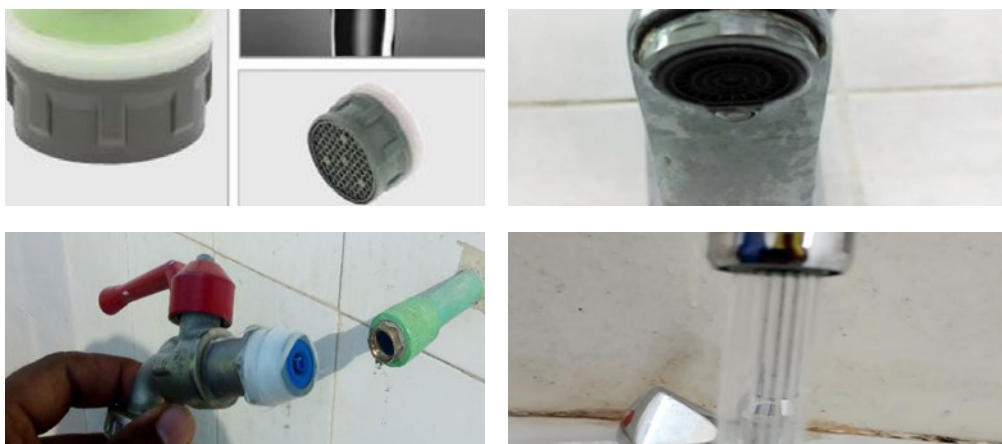


Figure 14: *Aerators installed on water taps*

Best Practice 10: Paving Haul Roads with Milled Asphalt

Hauling roads are necessary for large construction sites like stadiums. Sand and clay-based roads are considered among the main dust generators at construction sites and therefore, best practices are needed to eliminate the potential dust. Typically, water is sprayed on such roads for dust suppression. However, paving hauling roads is a more effective way of dust suppression and results in saving large quantities of water.

The construction sites of Education City and 974 Stadiums paved the hauling roads and pedestrian pathways with milled asphalt. Milled asphalt is a waste material sourced when re-paving roads. During the process, the asphalt is milled into small fragments that can be easily spread and compacted as a final layer on hauling roads. Overall, the use of milled asphalt has several benefits including the following:

- It is very effective in preventing dust generation as the aggregates are bonded with bitumen.
- It is an affordable and efficient material.
- Its use diverts waste from landfills, hence reducing the burden on the environment.
- It saves a huge quantity of water that is generally used to spray on dirt-hauling roads.
- It requires less maintenance and repair compared to dirt-hauling roads.
- It prevents mud during the rainy seasons.

3.0 IMPLEMENTED METHODS AND MEASURES



Figure 15: Roads paved with milled asphalt

Best Practice 11: Extending Prime Coat

The machinery used for moving materials in the laydown area generate dust, unless the area is paved, which is usually not the case during construction. In the case of the stadium sites, laydown areas were also utilized to assemble large façade elements, which required extra movement of materials. Hence, dust was expected to be generated during windy days from non-paved laydown areas.

As a case study, Al Janoub Stadium site considered the possibility of spreading asphaltic emulsion on the laydown area to stabilize the soil and mitigate dust generation without using water. However, this posed the problem of soil contamination as the emulsion would have to be removed after the job completion. To avoid this environmental and economic problem, the project team located the laydown area at the future parking lot location. This way, the asphaltic emulsion would serve as the prime coat for the asphalt paving works. This solution provided a paved laydown area, reducing dust generation significantly and saving water completely.



Figure 16: Application of prime coat on laydown area

Best Practice 12: Covering Stockpiles with Tarpaulin or Mesh

In SC stadium construction sites, excavated materials were stockpiled for a short and/or long term depending on the scope of work. Unprotected stockpiles of excavated material are one of the main dust sources. At Lusail Stadium, long-term stockpiles were covered with 40 feet by 40 feet tarpaulin sheets forming a thick cover for a more stable stockpile, hence reducing the need for water that was potentially planned for dust suppression (refer to Figure 17). The following advantages are found when comparing the use of tarpaulin as opposed to spraying water on the stockpiles:

- It is capable of withstanding adverse wind conditions and sunlight, making it more durable.
- It holds moisture much better, helping the stability of the stockpile.
- It helps save huge quantities of water that is needed to wet the soil.
- It requires less maintenance and therefore saves contractors money if it is used for more than a year.

3.0 IMPLEMENTED METHODS AND MEASURES

- It has a lower long-term cost. Tarpaulin needs to be replaced only once every two to three years with lower maintenance costs, while the spray of water must be applied twice a day at least, which results in the consumption of tens of cubic meters of water per day.



Figure 17: *Covering stockpiles with tarpaulin*

Best Practice 13: Using Atomizing Systems for Dust Suppression

Spraying water is a common practice on construction sites to reduce the potential dust, especially in dry areas such as Qatar. The main dust-generating activities like loading and unloading of soil and aggregates, movement of trucks on haul roads, laydown areas, excavation areas, stockpiling soil, etc. require water suppression. To perform the task, huge quantities of water are required, especially on projects that have a massive plot area. As part of the sustainable practices, some of the stadium projects spent more effort to reduce the water consumption from such activities. At 974 and Lusail Stadiums' sites, cannons were used to spray water in the loading areas rather than using the typical hose. The cannons sprayed pressurized water pumped through a series of jet nozzles. They were placed near loading areas and water was pumped out and dissipated in the air to

capture the dust instead of letting it spread. The mist cannons can also be directed to the stockpiles to pre-wet the soil. They have a lower water consumption compared to traditional spraying methods while achieving the desired dust control.



Figure 18: *Mist cannons*

Best Practice 14: Installing Portable Dry Urinal Units

On construction sites, sanitary facilities for staff and workers are commonly installed as part of the welfare arrangements. Stadium projects like any other mega project have installed facilities that comply with the local and internationally relevant standards. The arrangements differ from one stadium site to another depending on the scope of work, the plot area, the number of workers, and the types of activities. In addition to the wellbeing and social aspect, the arrangements made on stadium sites considered the environmental aspect by ensuring sustainability requirements. Part of the sustainable practices was deploying portable dry urinal units (waterless urinals) in different places around the site, which helped the project meet

3.0 IMPLEMENTED METHODS AND MEASURES

the minimum number of sanitary facilities required for the project while minimizing the temporary water lines and infrastructure needed to set up water-requiring sanitary facilities. The use of dry (waterless) urinals was preferred due to their low operating costs and their zero demand for water. They were also very easy to install, maneuver and demobilize. Figure 19 shows an example of dry (waterless) urinals installed on the construction site of Stadium 974.



Figure 19: Dry (waterless) urinals installed on the construction site

Best Practice 15: Using a Closed-Loop Wet Wheel Wash System

A closed-loop wet wheel wash system was used at Stadium 974 construction site to remove the dirt from the wheels of heavy vehicles before they would leave the site. The system reduced the quantity of water needed to wash

the tires of exiting trucks and vehicles by reusing the water for the same purpose after applying the required filtration process. The washed water was directed to a drain where an oil separator was installed to remove oils, dirt and contaminants. The same installed water tank was refilled with filtered water. Figure 20 elaborates on this cycle of water starting with filling the water tank and ending with refilling the tank with filtered water. Furthermore, Figure 21 elaborates on the structural details of the installed system.

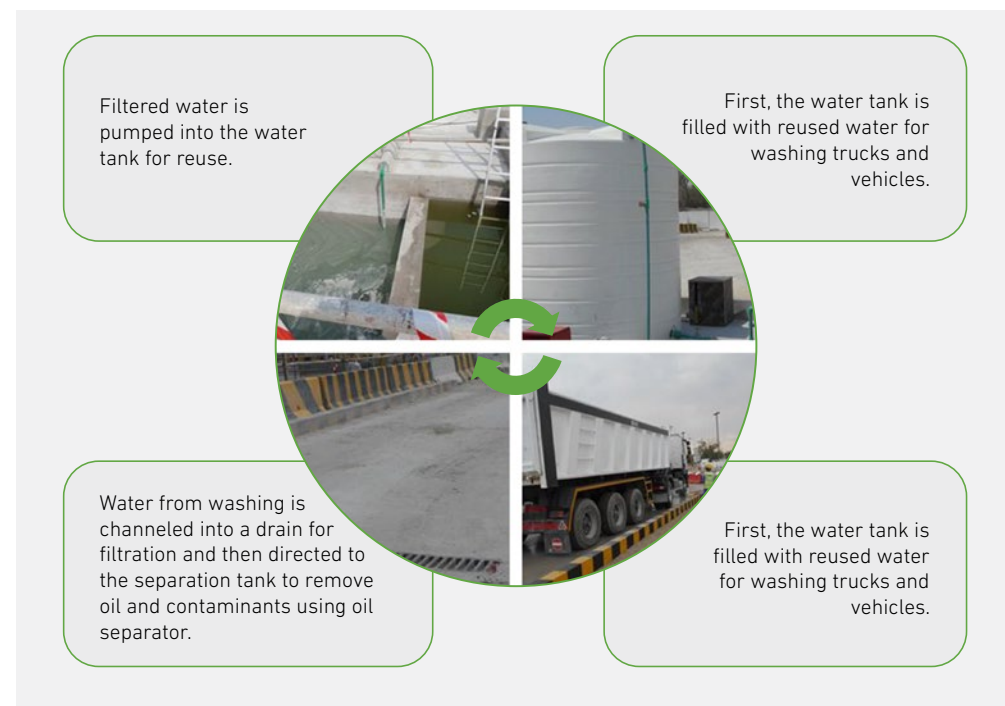


Figure 20: Closed-loop wet wheel wash system

3.0 IMPLEMENTED METHODS AND MEASURES

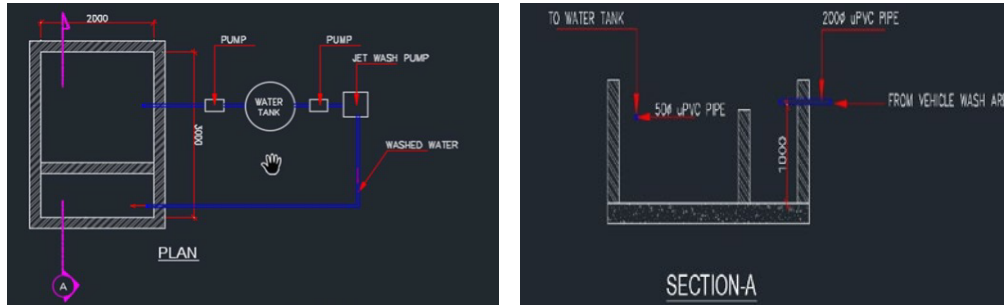


Figure 21: Layout representation of closed-loop wet wheel wash system

Best Practice 16: Installing Dry (Waterless) Wheel Cleaning System

Dry (waterless) wheel cleaning is an economic and environmentally friendly solution. The dry-wheel wash system is quick, easy to install, extremely strong and easy to maintain. It provides an economical and ecofriendly option for wheel cleaning due to its high efficiency in removing mud and debris from the wheels, tires, and undersides of trucks and vehicles exiting construction sites. As a sustainable practice in most stadium sites, trucks, earthmoving equipment, construction equipment and vehicles were always driven over the waterless system to clean their wheels and undersides and to prevent the spreading of mud and other contaminants on the nearby local roads.

As an example, in the Lusail Stadium project, a dry wheel wash on site was installed at gate 5 to reduce the water demand on the wheel washing. Figure 22 shows the installed waterless system.



Figure 22: Dry wheel wash system

In general, the benefits of using a dry (waterless) wheel cleaning system on construction sites can be summarized in Figure 23.



Figure 23: Benefits of using a dry (waterless) wheel cleaning system on construction sites

3.0 IMPLEMENTED METHODS AND MEASURES

Best Practice 17: Reusing Water from AC Condensation for Gardening

In the temporary facilities installed at construction sites, water from air conditioner condensation usually ends up in the ground without utilization. With good planning, condensate water can be used to water both indoor and outdoor plants on site. One of the good features of condensate water is that it does not contain chlorine or any other minerals that may be found in drinking water as it is pulled out from the air outside (Ambience Air, 2022). The air conditioner condensate could also be used for other applications on the construction sites such as cleaning the inside or outside of temporary buildings. In the stadium construction sites, air conditioner condensate

was directed to water gardens located in the surrounding area of the site offices and welfare facilities by adding a plastic extension tube to the metal discharge pipe of the AC systems. For ACs located away from gardens, the air conditioner condensate was collected in buckets. The collected water was carried to water the temporary gardens provided in the other parts of the site. Huge quantities of air conditioner condensate were used for gardens' watering, resulting in saving a quantifiable amount of potable water. The benefits of condensate water reuse also include reducing the risk of slipping by avoiding wet and slippery surfaces and reducing the potential for insects breeding grounds. Figure 24 shows how the system was operated on the construction sites.



Figure 24: Air conditioner condensate water used for gardening

3.0 IMPLEMENTED METHODS AND MEASURES

Best Practice 18: Organizing Awareness Trainings and Competitions

Staff and workers are the end users of the water fixtures on site. Therefore, raising awareness on water conservation can help to significantly reduce water consumption.

SC stadium projects implemented comprehensive training programs for all staff and workers on sites. Special training was provided to supervisors, foremen and workers on the efficient use of domestic and non-domestic water. Staff attention was brought to the responsible use of potable and non-potable water in the temporary buildings and construction sites.



Figure 25: On-site training session

Best Practice 19: Providing Knowledge-Sharing Sessions

Water conservation practices in construction sites are still not very common in this region. Some of the construction personnel at stadium sites were still not used to water conservation practices on site; therefore, it was crucial for them to gain knowledge on the subject and to witness implementation on other sites.

The SC organized a series of regular knowledge-sharing sessions. All the stadium project teams would meet in one stadium site where they would be briefed by the host team about the implementation of water conservation measures and challenges encountered. These sessions were particularly useful for those SC stadium projects that started construction later, as they could benefit from the lessons learned from the earlier projects.



Figure 26: Knowledge-sharing session

3.0 IMPLEMENTED METHODS AND MEASURES

Additionally, skill-based training was provided to staff carrying out duty as per the GSAS-CM guidelines. The stadium projects' contractors and subcontractors ensured the availability of needed resources for sustainability training and awareness programs accordingly. The comprehensive training program delivered on stadium projects dramatically improved the awareness and knowledge of the majority of staff and workers on site, which was directly reflected in the project's water saving. The trainings were delivered in several forms, including indoor presentations, outdoor tall-box-talks (TBTs), direct supervision, inductions, task-specific special training, day-to-day sessions, etc. All types of training programs were recorded and documented. These programs were developed at an early stage of the project and were updated on a regular basis. The training program development process was supervised by the sustainability manager and communicated to the project management team for review and approval. The project owner representatives also added their inputs to the program. The training and awareness programs provided by stadium projects are summarized in the flow chart given in Figure 27.

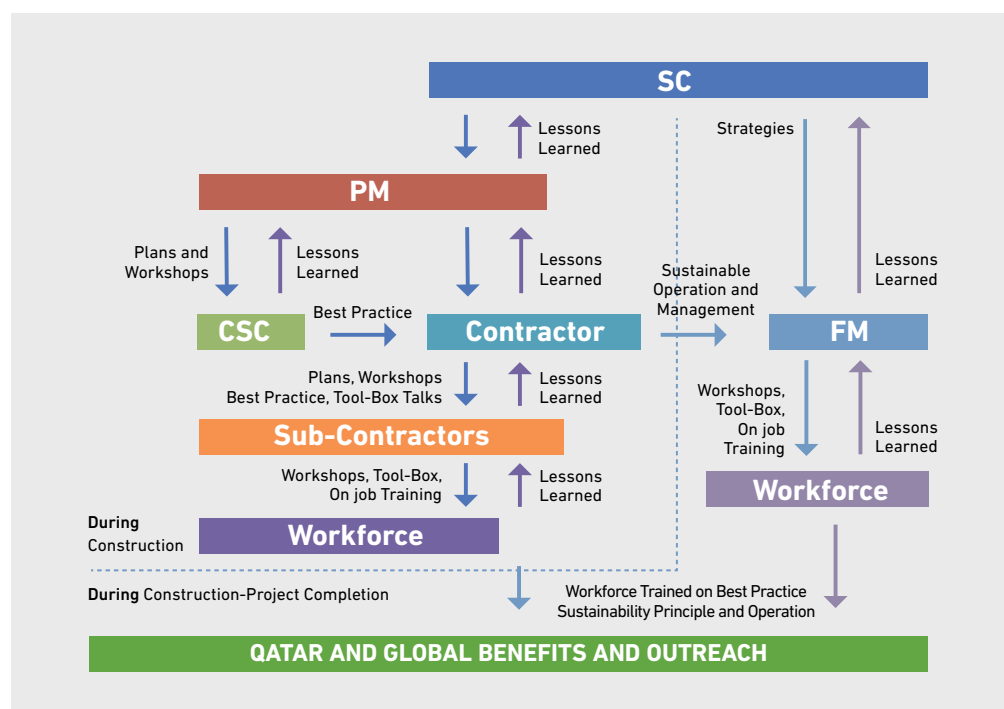


Figure 27: Training and awareness programs workflow

3.2 Common Practices

Common Practice 1: Inspections to Detect Water Leaks from Pipelines and Repair

Every drop of water is priceless. Aging infrastructure causes 30-50% of water loss due to leaks and cracks in pipes and fittings. Fortunately, at the stadiums' construction sites, most of the pipes and fittings were located at grade which enabled the project teams to easily realize the leak if any at an early stage with minimal loss. The detection of water leakage in the water infrastructure of existing buildings utilized by some projects had also been considered. Leak detection and immediate repair were among the sustainable practices implemented by the FIFA World Cup Qatar 2022™ Stadium projects. For example, in the Al Thumama Stadium project, a regular hourly inspection was conducted by the cleaners who reported to the H&S supervisors any kind of water leakage in the form of a checklist. Also, there was an internal weekly site audit conducted by the contractor to check the water fixtures' flow rate and any leakage, and to perform regular monitoring of domestic water consumption. The installed water monitoring

3.0 IMPLEMENTED METHODS AND MEASURES

meters were used to provide regular out-of-hour meter readings to detect any leaks or other unwarranted consumption. In Lusail Stadium, the site's plumbing fixtures were monitored for leakage and checked on the environmental daily checklist. On a daily basis, an inspection was conducted to record water leakages and control the wastage of water on the construction site, such as negligence of use, inefficient operation of sanitary installations, inappropriate design, leakages, flaws in domestic facilities, lack of maintenance, and the quantity of water used for cleaning.

Common Practice 2: Use of Chemicals for Concrete Curing

Curing is an essential step for concrete elements after being cast to hydrate cement and maintain moisture content and therefore for the development of the strength of concrete. A part of the durability and sustainability practices considered by stadium projects was the use of chemicals for concrete curing. This activity contributed to several desired features. In addition to achieving the desired durability of the concrete elements, huge quantities of water were saved.

Common Practice 3: Use of Jute Fabric to Minimize the Evaporation

Jute fabric (Hessian cloth) fabric is a type of textile fiber made from the jute plant. In building construction, the jute fabric is commonly used for concrete curing and cooling, especially in summer. It reduces the need to frequently spray water on the concrete elements and reduces the quantities of water applied. It ensures the cooling of the element throughout curing leading to more strong and more durable concrete elements with no cracks. At some stadium projects, the jute fabric was used to cover the cast-in-place concrete elements such as columns, beams, etc. Figure 28 shows the jute fabric (Hessian cloth) used in the Al Bayt Stadium project.

Common Practice 4: Use of Chemical Toilets

Chemical toilets are used in a variety of situations. In the construction sites, sometimes they are provided to improve the welfare service wherever the traditional water closet (WC) facility cannot be installed due to space issues or some other restrictions. Chemical toilets do not require a direct connection to a sewage network or water supply as they rely on chemicals to reduce odors. They are connected to holding tanks, which are emptied frequently. Chemical toilets compared to WCs save huge quantities of water. At the Al Thumama Stadium project, chemical toilets were distributed around the construction site, so that workers' movement from and to the WCs was eliminated resulting in a higher level of satisfaction. Chemical toilets demonstrated their efficiency and are considered among the best-known alternatives to WCs.



Figure 28: Use of jute fabric (Hessian cloth) for concrete curing



Figure 29: Use of chemical toilets on construction sites

4.0 CONCLUSION



Big construction sites require large amounts of water, not only for construction activities but to cater to the human necessities of thousands of workers. Qatar's harsh climate causes the water demand to be even higher; workers drink more to stay hydrated, more water is required for proper concrete curing and significant amounts of water are needed for dust control.

Potable water in Qatar comes from desalination, which is a carbon-intense activity that contributes to climate change. Therefore, the use of non-potable water has been maximized in the FIFA World Cup Qatar 2022™ stadiums, in order to mitigate emissions associated with potable water desalination and comply with the conservation targets considered in Qatar Vision 2030. The specific water quality standards required for construction activities like backfilling and dust suppression, were achieved through the non-potable water sources including treated sewage effluent (TSE) and water discharged from dewatering activities.

Following the principle "you can't manage what you can measure", a comprehensive water consumption monitoring program was implemented at the stadium sites. Metering helped identify leakages and opportunities for water conservation although it entailed an initial cost, like the installation of water meters for individual sources and uses throughout the site.

Data from the FIFA World Cup Qatar 2022™ stadiums' construction sites prove that good practices can have a significant impact on the overall water consumption. These practices include the installation of low-flow water fixtures and aerators, the use of abstracted water, and the implementation of alternative dust control measures to reduce water spraying for dust suppression.

This report is aimed at guiding and benefiting future projects that can use the knowledge of water conservation data and practices implemented on Qatar 2022's stadium sites. It is one of the many initiatives to pass on the sustainability legacy of the FIFA World Cup Qatar 2022™ to other projects in Qatar and the region.

5.0 BIBLIOGRAPHY

1. GSAS 2019 Construction Management Assessment Manual for Buildings & Infrastructure. Gulf Organisation for Research and Development (GORD), 2019, <https://www.gord.qa/admin/Content/GSAS-2019-Construction-Management-Assessment-Manual.pdf>
2. GSAS 2019 Construction Management Guidelines Manual for Buildings & Infrastructure. Gulf Organisation for Research and Development (GORD), 2019, <https://www.gord.qa/admin/Content/Link2611201914490.pdf>
3. GSAS Technical Guide 2019. Gulf Organisation for Research and Development (GORD), 2019, <https://www.gord.qa/admin/Content/Link2722020122828.pdf>
4. Weather Stats, Forecast, Statistics, Analysis in Doha, Qatar, <https://weather-stats.com/qatar/doha/monthly>
5. Dust Management Best Practices for Construction: Case Studies from FIFA World Cup Qatar 2022™ Stadiums. The Gulf Organisation for Research and Development (GORD) and Supreme Committee for Delivery and Legacy, 2022, <https://gsas.gord.qa/wp-content/uploads/2021/10/Dust-Management-Best-Practices-For-Construction-Sites.pdf>
6. Waste Management Best Practices for Construction: Case Studies from FIFA World Cup Qatar 2022™ Stadiums. The Gulf Organisation for Research and Development (GORD) and Supreme Committee for Delivery and Legacy, 2022, <https://gsas.gord.qa/wp-content/uploads/2021/10/GSAS-SC-Waste-Management-Report.pdf>
7. Energy Management Best Practices for Construction: Case Studies from FIFA World Cup Qatar 2022™ Stadiums. The Gulf Organisation for Research and Development (GORD) and Supreme Committee for Delivery and Legacy, 2023.



Building Sustainably