50MW Photovoltaic Power Plant
Risha, Jordan

Volume 4: Environmental and Social Impact Assessment Appendices

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ACWA Power

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1	Financial Capital
2	Social Capital
3	Natural Capital
4	Manufactured Capital
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Consultant CVs

Curriculum Vitae

Kenneth Robert Wade

Introduction

Ken is the Director for Environmental Planning and Sustainability at 5 Capitals headquarters in Dubai, overseeing major projects in the Power and Water Sectors the MENA Region and Sub-Saharan Africa including Uganda and Kenya. He has extensive national and international experience of planning and undertaking Environmental Impact Assessment (EIA) including World Bank/IFC and Equator Principles ESIA and SEA, spanning thirty-five years, in the UK, Middle East and Africa.

To date, Ken has successfully completed ESIA bankable documents for power, water and industrial projects exceeding US$50 billion from more than 20 countries worldwide. He is currently directing projects in Kenya, Uganda, Botswana and Mozambique. A number of the projects in Africa have involved detailed consultations with communities and stakeholders and the preparation of Stakeholder Engagement Pans (SEP), Resettlement Action Plans (RAP) and Land Acquisition and Livelihood Restoration Frameworks. These have been undertaken in association with local social and environmental specialists. In addition, we have prepared Biodiversity Action Plans to ensure that design measures are introduced where possible to minimise impacts on IUCN Red Data List species and vulnerable habitats.

Ken has extensive environmental and social auditing experience, having undertaken consultation and operational audits at over 10 major power projects in the GCC, North Africa and Europe. Ken is currently the Project Director responsible for overseeing the audits in Uganda at the Soroti 10MW PV project, which relate to the construction phase. As part of the project environmental and social due diligence at Nkusi (hydropower, Uganda) Ken undertook an audit of the status of the project in regard to compliance against the Ugandan standards and the lenders requirements (e.g. IFC Performance Standards and Equator Principles).

Selected Project Experience

Ken's recent project portfolio on conventional power projects includes Project Director experience on a number of major power projects including the following:

ESIA for Soroti PV Plant, Uganda

- Project Director for the ESIA prepared for NEMA and for the international lending banks including KfW. Worked closely with locally approved NEMA Registered environmental consultants based on 5 Capitals required scope. Local Consultants undertook the baseline surveys while our team worked closely with the Developer, engineers and the banks to ensure that the proposals were agreed with local communities and reports accepted by the Equator Principles Banks to WB/IFC standards.

Nkusi 10MW Run of River Hydropower Scheme

- A Gap Analysis was undertaken by 5 Capitals to determine the additional studies required to comply with international requirements (IFC). Ken directed the new studies with local Ugandan consultants and submitted a new ESIA covering all aspects of the 10MW Hydropower project. The Lenders and LTAs approved this. 5 Capitals also prepared a series of management plans including a Resettlement action Plan. The ESAP was prepared by 5 Capitals and approved by LTAs closing out all CPs prior to acceptance by Lenders KfW.

ESIAs for Power Projects in UAE, Oman, Egypt and Vietnam

- Hassyan 2,400MW Clean Coal IPP ESIA 2015/16, UAE;
- Nam Dinh 1,200MW Coal IPP ESIA 2015/16, Vietnam
- Dairut CCGT IPP ESIA 2015/16 Egypt
- Salalah 2 IPP 600MW CCGT IPP ESIA 2015, Oman

SEA for Geothermal Development Strategy, Kenya

- Project Director for the Strategic Environmental Assessment (SEA) of Olkaria and Eburru Geothermal Development fields for the Programme period 2012 to 2020. Overseen extensive stakeholder consultations and public meetings to identify environmental and social issues. The Social and environmental assessment was undertaken in accordance with requirements of National Policies, Programmes and Plans and in compliance with funders including World Bank, African Development Bank and JICA, EIB, AFD.

ESIA and EDD for Power Projects in Botswana, Mozambique and Vietnam

- Project Director for on-going ESIA projects for proposed coal-fired power plants in Africa and South East Asia. In each country, 5 Capitals is working closely with local consultants who are providing baseline surveys and consultations, which will feed, into the actions plans which may include RAPs. All the projects will have bankable documents prepared for the Equator Principles Banks in accordance with WB/IFC standards.

GIS for Industrial Cities Phase 1 Habitat Surveys, Saudi Arabia

- Technical Director responsible for Phase 1 Habitat surveys of major industrial sites (35km^2 to 200km^2) being assessed for ecology and conservation issues as part of the Master Planning for new cities being developed by MODON (Saudi Arabia). Satellite imagery reviewed using Arc GIS 10 followed by ground truthing of selected

areas to provide high quality conservation planning maps and protection of key habitats/species.

ESIA's Ouarzazate 160MW Concentrated Solar Power Plant, Morocco

- Project Director for Social and Environmental Assessment of the largest CSP (Concentrated Solar Power) plant in North Africa (Phase 1). Investors including The African Development Bank, European Investment Bank and KfW of Germany approved the environmental and social studies undertaken and reported in the SESIA. Subsequent ESIA studies for Stages II and III (NOOR) totalling 500MW have been approved by the international banks.

ESIA Reviews for Iron Ore Mining Project, Saudi Arabia

- Project Director for technical review of Iron Ore Mining project site and assessment of alternative processing plant locations in relation to social and environmental issues. The project included the identification of sensitive terrestrial and marine habitats which must be protected during proposed construction and operational work and which also play a key role in sustaining local communities.

ESIA Qurayyah IPP, Saudi Arabia

- Project Director for the Social and Environmental Assessment studies for the 4,000 MW gas-fired power plant at Qurayyah, located on the Arabian Gulf. The project is the largest and cleanest power plant on the Arabian Peninsula with the lowest greenhouse gas emissions per megawatt in the entire Region. Equator Principles lending banks, USExIm and KEXIM, approved the funding of the project.

SEA for King Abdullah Economic City, Saudi Arabia

- Project Manager for the first citywide Strategic Environmental Assessment undertaken in the Kingdom. The project has involved the management of a team of more than 60 technical experts worldwide including marine and terrestrial ecologists. Baseline studies for the marine, terrestrial and air environments, have been undertaken and predictive 3D marine and air modellng. A Planning Guidance Toolkit and models have been prepared for the client and developers.

King Abdullah Economic City Environmental Advisor, Saudi Arabia

- Project Manager to EMAAREC for the Environmental Advisory role which has included technical support at meetings and the review of EIAs prepared for major developments such as the Container Port and the proposed aluminium plant. In addition, advice has also been given on construction related environmental issues.

ESIA Power Plant ESIA at Kirikkale, Turkey

- Project Expert Advisor to Turkish/Saudi Consortium - European Bank for Reconstruction and Development funded project for a new 800 MW power plant outside Ankara, using river water for plant cooling. In addition a 50km corridor for overhead power lines was also assessed and approved by Turkish Authorities and EBRD.

ESIA for 200MW PV Project and other developments, UAE

- Project Director for the 200MW PV development to be built in Dubai UAE Metro Red Line extension, Jebel Ali Development and Um Nahad Mixed use Development (ongoing). Responsible for project direction on all aspects of EIA, mitigation and monitoring.

TDIC Staff Accommodation Projects Sir Bani Yas Island, UAE

- Project Director for 2 projects being undertaken for Arif & Bintoak Design Engineers on behalf of TDIC. Providing sustainability advice to the Project team and preparing written reports and technical notes to develop sustainability strategies in accordance with TDIC Guidelines and Estidama.

Green Building Project Plans, Dubai, UAE

- Project Director for LEED reviews, workshops, assessments and construction monitoring for >20 new build projects in Dubai, including residential towers, commercial, industrial and mixed use developments for LEED certification, silver, gold and platinum ratings.

Green Building Projects, Abu Dhabi, UAE

- Project Director for Estidama and TDIC Sustainability Reviews for Proposed TDIC Staff Accommodation on Sir Banyias Island, Abu Dhabi. The study includes detailed energy, wind and daylight modelling.

ESIA Mocha Pipeline and IWPP, Yemen

- Project Director responsible for the EIA being undertaken for a 100km water pipeline project and desalination plant for the city of Taiz. The Equator Principles compliant SEA requires the environmental assessment of the pipeline route in relation to environmental and social issues to comply with the requirements of the regulators and the international funding banks. The studies identified endemic flora including *Aloe* spp. which will be retained or translocated.

SEA Raz as Zawr IWPP, Saudi Arabia

- Project Director responsible for providing ongoing environmental technical advisory services to one of the Consortia bidding for the proposed IWPP at Raz as Zawr on the Arabian Gulf. The plant will provide 1 million m^3 of desalinated water daily and approximately 900MW of power. An Equator Principles compliant Social and Environmental Assessment included including marine and terrestrial site surveys, air monitoring and water and air modelling studies.

ESIA Burj al Baher Development, Tripoli, Libya

- Project Director responsible for providing an Equator Principles compliant Social and Environmental Assessment for a major tourism development comprising a 5 star hotel, apartments and offices in three iconic 30 storey towers on the coast, east of Tripoli. The lending banks requested the EIA study.

EIA National Recycling Park, Dubai

- Project Director undertaking an Environmental Impact Assessment for a new facility in Dubai Industrial City that will recover materials including paper, plastics and metal for recycling. In addition a closed composting facility will also recycle organic waste. Dubai Municipality has approved a scoping study and an EIA is currently in preparation. The EIA includes odour modelling to confirm the effectiveness of the state-of-the art bio-filtration systems.

ESIA Shuqaiq IWPP Environmental Auditing, Saudi Arabia

- Project Director and Lead Environmental Auditor for the construction environmental monitoring programme required by PME and the Lending Banks. This is a condition of the environmental approval and the bank loans for the US $2 billion project and will require quarterly environmental audits of the construction site for the 36-month construction programme.

ESIA Shuaibah Phase III IWPP, Saudi Arabia

- Project Manager responsible for planning, undertaking and preparing the Environmental and Social Impact Assessment report for the first Independent Water and Power Project on the sensitive Red Sea coastline of Saudi Arabia. The plant will provide 950MW power and 880,000m3 of desalinated water daily. Key environmental issues included coral reef ecology, atmospheric emissions from existing plants and disposal of fly ash. The project scope included presentations to the lending banks and advice on the pollution abatement required to protect the local environment. The final ESIA report was approved by both the Equator Principles Banks and PME meeting Financial Close in December 2005.

ESIA Shuqaiq Phase II IWPP, Saudi Arabia

- Project Manager for the second IWPP in Saudi Arabia responsible for the preparation of an Environmental Scoping Study prior to selection of the preferred consortium. Currently (November 2006) undertaking a Social and Environmental Assessment (SEA) in accordance with Equator Principles (revised July 2006) which will shortly be submitted to PME and the lending banks.

ESIA Marafiq IWPP, Saudi Arabia

- Project Director for the third IWPP in Saudi Arabia. Following completion of the Scoping Study, the project has included technical discussions with the Royal Commission for Yanbu and Jubail and advice to the Consortium related to BAT (Best Available Techniques) in accordance with RC Environmental Regulations (2004). This will be the largest of the IWPPs in Saudi Arabia, to date, providing 2,000MW of power and 1million m3 of desalinated water per day.

ESIA Hidd Phase III IWPP, Bahrain

- Project Director for the environmental studies required for the privatisation of the Hidd Power and Water Plant and extension of the Phase III Desalination facilities. The studies included an Environmental Review for the lending banks together with Environmental Due Diligence, a Construction Environmental Management Plan and an operational EMP framework.

Mesaieed IPP, Qatar

- Project Director for the scoping study for a new water and power plant at Mesaieed, latterly a power plant. The studies included consultations with SCENR and the Environmental Section of Mesaieed Industrial City. Advice was provided to the consortium regarding the outfall and intake structures required to minimise impacts on the sensitive coastal waters.

ESIA Al Ezzel Power and Desalination Plant, Bahrain

- Project Director for the EIA required by the Ministry of Finance and National Economy. The key environmental issues related to the sensitive coastal waters and ambient air quality changes due to stack emissions. Consultations were undertaken with the Regulator Environmental Affairs and a presentation of the EIA report was made to stakeholders prior to the approval for the plant.

City of Arabia, Dubai UAE

- Project Director for the City of Arabia EIA (part of Dubailand) submitted to Dubai Municipality. The assessment of the 200 hectare site included investigations into air quality, groundwater and ecology. In addition, particular attention was given to the assessment of the wastewater treatment strategy and solid waste disposal strategy.

DIFC Liberty House, Dubai UAE

- Project Director responsible for the preparation of an EIA for the Liberty House Development, part of DIFC. The EIA considered a wide range of environmental issues including transportation, water and energy saving techniques, air quality, acoustics and ground conditions.

DIFC, Emirates Financial Towers, Dubai UAE

- Project Director for the EIA for the prestigious Emirates Financial Towers project. The EIA considered a wide range of environmental issues including transportation, water and energy saving techniques, air quality, acoustics and ground conditions.

EIA Fishing Harbour EIA's, Bahrain

- Preparation of EIA's for the upgrading and refurbishment of fishing harbours at Sitra, Muharraq and Budaiya. Key EIA issues included the effects of dredging works on water quality, fisheries and marine biology. The EIA also assessed specialist hydraulic studies undertaken by HR Wallingford and the marine ecology surveys by Al-Reem. Other environmental issues included noise, air quality and environmental management. Planning permission granted by Environmental Affairs and proposed mitigation measures incorporated into contract conditions.

EIA Al Kobaisi and Kingdom Group Ready Mix Concrete Plants, Bahrain

- Preparation of EIA's for new concrete and Asphalt plants at Hidd. Key EIA issues included Air Quality and Health associated with the dust and particulate generation. In addition other key issues included the environmental management of the site to prevent future pollution or nuisance from site activities. Planning permission granted by Environmental Affairs and proposed mitigation measures incorporated into contract conditions.

EIA Ocho Rios Sewage Treatment, Jamaica

- Environment Project Manager for a major engineering scheme to construct a new sewage treatment works, sewerage, associated pumping stations and long-sea outfall in Ocho Rios, on the north coast of Jamaica. The feasibility study included the review and assessment of alternative options and the collection of new environmental data. The project involved working closely with Government Institutions and Environmental Departments to ensure that consultations were undertaken particularly at the development stage of the Project. Key factors: legislation and environmental quality standards, coastal water quality surveys, laboratory chemical and microbiological analyses, sewage treatment processes, coastal fisheries and coral reef ecology.

Macao Lake Water Quality studies, Hong Kong

- Responsible for the assessment of two man-made lakes on Macao designed to provide aesthetic amenity for new business park development. Key issues included the impact of nutrients from storm drainage and the use of reed-beds for reducing impacts. The impact from birds on migration routes to Mai Po Wetlands was also investigated.

EIA Hungerford Bridge, London

- Environmental Project Manager responsible for the preparation of an Environmental Statement for the Millennium Footbridge access at Hungerford Bridge in London (between Charring Cross and Waterloo). The project included close consultations with Westminster City Council, Transport for London and the Environment Agency in relation to the construction and operational impacts of the works. In particular there were issues relating to impact on the nature conservation value of the intertidal habitats and the local water quality in the River Thames.

EIA Aberystwyth Harbour Redevelopment

- Environmental Project Manager responsible for all aspects of coastal water quality assessment in relation to dredging, activities for a new marina and water side development. Key issues included legislation, water quality standards, engineering construction methods, prediction of future water quality, environmental impact assessment.

EIA Project Director for Motorway Widening Schemes (UK)

- including the widening of the M25 and M1 motorways, A465 and A437 trunk roads. The assessments have included the presentation of expert evidence to public enquiry on behalf of the Highways Agency.

Project Director, EIA for the Redevelopment Millbay Docks, Plymouth

- Responsible for directing the Environmental Statement for a major waterside redevelopment on brownfield land in Plymouth. Key EIA issues included air quality, noise assessment, water quality, ecology, archaeology and landscape. Ecological studies include extended Phase 1 Habitat survey, bats and intertidal macroinvertebrate survey.

Project Director, Environmental Scoping Assessment for residential development, Newport, Gwent

- Project Director for the Environmental assessment for a proposed housing development located adjacent to the River Usk. The river is designated as a SSSI and cSAC and consequently, detailed specific assessment was required for potential impacts resulting in noise and vibration, uncontrolled discharges and the mobilisation of any contamination on the site.

Rochester Riverside Urban Regeneration Project EIA UK

- Environmental Project Manager responsible for the preparation of the Environmental Statement for Rochester Riverside development on brownfield site including former gas works. Major environmental issues which have been addressed are intertidal ecology and nature conservation, site contamination and remediation strategy, air quality, noise and archaeological assessment. Co-ordination of engineering and environmental inputs from several WSP companies.

Brentford Waterside Redevelopment, London

- Environmental Project Manager responsible for water quality and biological assessment of the River Brent and Grand Union Canal at Brentford as part of the proposed major development. The study has involved detailed consultations with statutory consultees particularly the Environment Agency. This has resulted in agreement with EA on the environmental enhancement measures such as the terracing alongside the canal with marginal plants and reedbeds.

Papers, Publications & Journals

- **Wade K R and Jones A (1995)**: Conservation plans for Special Areas of conservation (SAC's) and Special Protection Areas (SPA's) in Northern Ireland in Proceedings from 5th European Coastline Conference Ed P Doody
- **Ormerod S J, Rutt G Weatherley and Wade K R. (1990)**: Detecting and managing the influence of forestry on river systems in Wales: results from surveys, experiments and models by Martin Steer. Irish Rivers: Biology and Management, publisher Royal Irish Academy
- **Ormerod S J and Wade K R (1990)**: The role of acidity in the ecology of Welsh lakes and streams in Acid Waters in Wales edited by Edwards Gee and Stoner. Kluwer Academic publisher.
- **Wade K R, Ormerod S J and Gee A S (1989)**: Classification and ordination of macroinvertebrate assemblages to predict stream acidity in upland Wales. Hydrobiologia 171, 59-78.
- **Ormerod S J, Wade K R and Gee A S (1987)**: Macrofloral assemblages in upland Welsh streams in relation to acidity and their importance to invertebrates. Freshwater Biology 18, 545-557.
- **Jenkins R A, Wade K R and Pugh E (1984)**: Macroinvertebrate - habitat relationships in the River Teifi catchment and the significance to conservation. Freshwater Biology 14, 23-24.

- **Stoner J H, Gee A S and Wade K R (1984)**: The effects of acidification on the ecology of streams in the Upper Tywi catchment in West Wales. Environmental Pollution (A) 35, 125-157.

Key Skills / Achievements

- International EIA and Biological experience over past 35 years.
- Experience as a Regulator in the UK water industry and as a Project Manager / Project Director responsible for EIA, SEA, ESIA for major development projects around the world.
- Technical Director responsible for the Equator Principles ESIA/SEA for the first three IWPP's in Saudi Arabia at Shuaibah, Shuqaiq and Marafiq (2005/2006).
- Technical Director responsible for the development of National Environmental Standards for Saudi Arabia (PME, 2012), including marine water quality to protect sensitive ecosystems in the Red Sea and Arabian Gulf.
- Advisor to Equator Principles Banks and Export Credit Agencies lending multi billion dollar funds for new power and water plants. This has led to introduction of new clean technologies compliant with World Bank/ IFC and Equator Principles II (2006) and EP III (2013) into the MENA Region.
- Expert Witness at Planning Inquiries and courts of law in the UK.
- Publication of leading edge research into the effects of acidification to lakes and rivers and advisor to European, UK and Middle East authorities on new environmental standards.
- Wide experience of environmental modelling to predict the impacts of developments and the identification of appropriate mitigation measures for sustainable development.

Personal Details

Professional Qualifications

Qual.	Subject	Institution
MSc	Applied Hydrobiology	University of London
BSc (Hons)	Microbiology	University of Surrey

Year of Birth - 1954

Employment History

5 Capitals Environmental & Management Consulting

2007 – Date Director Environmental Planning

WSP

2004 – 2006: Technical Director EIA and Sustainability Division

1996-2003 Associate Director: EIA Developments.

Acer Environmental Wallace Evans

1990 – 1996 Project Manager: EIA Developments

Welsh Water (Scientific Services)

1989 – 1990 Scientific Project Manager – Welsh Water Consulting

1984 – 1989: Area Biologist for the South Eastern Division

1978 – 1983: Assistant Biologist for the South Western Division

CURRICULUM VITAE

Steven Bater

Introduction

Steven Bater is a chartered environmental professional with over13 years' experience working across a diverse range of environmental disciplines, including 5 years as a manager leading a team of EIA professionals. Steven has proven skills in:

EIA - including the management of all environmental aspects of a project from providing initial environmental appraisals at concept design phase through to onsite supervision of construction.

EMS - including establishing, managing, and auditing an EMS accredited to ISO 14001, plus facilitating with audit close outs and responding to environmental incidents.

Environmental Management of Highways Projects - more than 8 years of experience of the environmental assessment and auditing for highways infrastructure projects and overseeing the environmental compliance of associated facilities including developing the environmental management framework for a $54 billion national road and drainage infrastructure project.

Auditing - Steven is a qualified ISO 14001 Lead auditor and has over 10 years of experience in auditing against the environmental requirements for infrastructure projects.

Employment History

January 2015 – April 2016

SENIOR ENVIRONMENTAL CONSULTANT, 5 Capitals, Dubai, UAE

Key Responsibilities:

- Take the lead on Environmental Impact Assessment for a diverse range of power projects and large scale development across the globe.
- Plan and instigate specialist environmental surveys and investigations according to internationally recognized best practice.
- Liaise with Statutory Environmental Authorities and International Lenders regarding environmental requirements.
- Audit active construction sites and live operational industrial facilities against Environmental Requirements and recognized best practice.
- Undertake environmental risk analysis to assist clients in the identification of significant risks and development of appropriate control plans and monitoring requirements.

January 2015 – April 2016

SENIOR ENVIRONMENTAL SPECIALIST, IPA, Dubai, UAE

Key Responsibilities:

- Be the lead advisor on environmental issues and requirements for ISO 14001.
- Lead the development and implementation of environmental management systems to ensure clients are able to meet regulatory and/or contractual commitments.
- Undertake sustainability reviews and assessments to identify opportunities for cost savings and improved sustainability credentials.
- Prepare audit frameworks to measure compliance with ISO 14001 and demonstrable continual improvement.
- Identify opportunities and means for improved efficiencies in energy, water and material consumption.
- Develop and implement tools as required for carbon calculation, material efficiency and life cycle analysis.
- Support communication, promote awareness and provide tailored environmental training as required according to client's requirements.

September 2013 – January 2015

SENIOR ENVIRONMENTAL SPECIALIST, Parsons Brinkerhoff, Doha, Qatar

Key Responsibilities:

- Act as an Environmental contact for over 50 billion US dollars of highway and drainage works across Qatar on behalf of the Public Works Authority (Ashghal). Included providing advice and overseeing delivery of ESIA's prepared by international consultant including AECOM, Hyder, Atkins, WSP and Parsons.
- Be a chief point of contact for the client on all matters environmental. Facilitate ongoing effective communication with the client, internal customers, statutory bodies and parent companies.
- Act as a technical reviewer for the Public Works Authority, undertaking detailed review of Environmental Impact Assessments, Scoping Reports, Permit Applications, Contaminated Land Assessments, CEMPs and environmental design input ensuring compliance with legal requirements, international standards, recognised best practice and client expectations.
- Provide technical guidance and advice on subjects including waste management, contamination risks, biodiversity, water quality, noise, air quality, landscape and cultural heritage impacts.
- Oversee contractor performance during construction, including the management of impacts on site and compliance with MoE requirements.

- Enforce and promote the contracts Environmental Management System and the implementation of the Project Management Delivery System.
- Respond to expectations and requirements from the Ministry of Environment within Qatar.

July 2012 – September 2013

ENVIRONMENTAL MANAGER, Skanska, Bristol, UK.

Key Responsibilities:

- Develop implement and maintain a suitable Environmental Management System to minimise Environmental risk, demonstrate continuous improvement and secure accreditation to ISO14001.
- Identify and undertake Environmental Impact Assessments for a diverse range of highways infrastructure projects.
- Arrange and undertake water/soil sampling and testing to ensure compliance with facility specific permits, licenses and exemptions.
- Manage a supply chain able to supply environmental services including the negotiation of competitive rates.
- Hold responsibility for the programming and cost management of all environmental works, including that undertaken by sub contractors and external consultants.
- Ensure appropriate management of over 2,000 hectares of highways soft estate according to client requirements.
- Drive a reduction in cost whilst implementing environmental management aspects.

November 2011 – July 2012

ENVIRONMENT AND SUSTAINABILITY MANAGER, Balfour Beatty Mott MacDonald JV, Bristol, UK.

Key Responsibilities:

- Be the line manager for a team of 11 multidisciplinary environmental professionals. Manage resources both internal and external and encourage the professional development of the team.
- Provide technical guidance and advice across the entire business on the environmental requirements for highways intrastate projects including waste management, contamination risks, biodiversity, water quality, noise, air quality, landscape and cultural heritage impacts.
- Develop programmes for the delivery of EIA for a diverse range of infrastructure projects.
- Agree contractual environmental deliverables with the client during the demobilisation of an 8 year contract.

- Act as the point of contact for a team of 11 staff members during a period of transition and closure of an 8 year contract.
- Propose, secure funding and co-ordinate the delivery of specific environmental studies, design and build projects.
- Ensure that the collection and collation of environmental management data is adequate.

May 2007 – November 2011

DEPUTY ENVIRONMENTAL TEAM LEADER, Balfour Beatty Mott MacDonald JV, Bristol, UK.

Key Responsibilities:

- Quality assurance of environmental assessment reports to ensure technical accuracy, practicality of mitigation techniques and opportunities for environmental enhancements.
- Provide technical guidance and advice across the entire business on the environmental requirements for highways intrastate projects including waste management, contamination risks, biodiversity, water quality, noise, air quality, landscape and cultural heritage impacts.
- Propose, secure funding and co-ordinate the delivery of specific environmental studies, design and build projects for highways projects
- Oversee site works to ensure compliance according to statutory, client and parent company requirements.
- Be the line manager for a team of 5 multidisciplinary environmental professionals. Manage resources both internal and external and encourage the professional development of the team.
- Development, management and compliance assurance of the organisations EMS to ISO14001, including the preparation of numerous environmental management plans for depots and construction sites.
- Undertaking detailed audits and inspections of depots construction sites and offices to confirm compliance with EMS and associated ISO 14001 accreditation.
- Consult with statutory stakeholders regarding EIA findings and proposals/findings from long term pollution remediation schemes.

July 2005 – May 2007

ENVIRONMENTAL COORDINATOR, Balfour Beatty Mott MacDonald JV, Bristol, UK.

Key Responsibilities

- Oversee environmental impact assessments for a diverse range of infrastructure projects.

- Undertake environmental assessments for biodiversity, water quality, contamination, landscape, cultural heritage, air quality, noise and waste.
- Prepare specifications for infrastructure works in conjunction with design teams to ensure environmental requirements are incorporated within contact conditions.
- Prepare construction environmental management plans and oversee management of environmental issues onsite.
- Undertake protected species surveys, prepare associated licenses and oversee completion of mitigation works.
- Pollution response management and associated stakeholder consultation.

July 2003 – July 2005,

ENVIRONMENTAL ENGINEER, Balfour Beatty Mott MacDonald, Gillingham, Kent,UK.

Key Responsibilities

- Undertake environmental impact assessments for a diverse range of infrastructure works.
- Undertake specific protected species surveys.
- Respond to land management queries.
- Meet with members of the public to discuss environmental concerns.

Personal Details

Professional Qualifications

Year	Qualification	Institution
2007	MSc. Ecology and Management of the Natural Environment (Part time whilst in full time employment)	University of Bristol, UK
2002	BSc. Hons. Environmental Science with Geography	University of Sussex, UK

Nationality

British

Other Skills and Qualifications

- Chartered Environmentalist with Society for the Environment
- Full Member of the Institute of Environmental Management and Assessment
- Full Member of the Chartered Institute of Ecology and Environmental Management
- Certified Lead ISO 14001:2015 Auditor

- LEED Advanced Professional (Building Design and Construction)
- ILM Certificate in Leadership and Management
- Metier certified in Applied Project Management and Control
- PADI Open Water Diver

CURRICULUM VITAE

Max Burrow

Introduction

Max is 5 Capitals Operations Manager, based in Dubai. He has experience in the management and preparation of environmental studies, plans and programmes for a variety of international projects and schemes, typically relating to multi-billion dollar industrial developments, large infrastructure projects and mixed-use applications.

Max's work at 5 Capitals has primarily been undertaken across the MENA, Sub-Saharan Africa and South East Asia regions and has had a key input for developers to attain project finance or necessary compliance approvals from an environmental and social perspective. Such work ensures project applicability to lender (e.g. Equator Principles, WB/IFC, EBRD), and local requirements.

Max has a strong environmental and social auditing background, undertaking audits on major projects and reviewing application of Environmental & Social Management Systems at both the construction and operational phases of projects, with associated determination of compliance in line with the applicable standards.

Prior to joining 5 Capitals, Max gained an Environmental Management degree from The University of Birmingham (UK) and spent several years working in the highways sector on behalf of the UK's Highways Agency and private developers.

Summary of Experience

Power & Water Sectors:

Max has had specific environmental and social input to over 30 power projects in 14 countries worldwide. The technology/fuel combinations for these power & water projects have included: Thermal (Coal, HFO, Crude, Natural Gas), Gas Turbines and Combined Cycle Projects (Crude, Diesel and Natural Gas), Renewables (Photovoltaic, Wind, Concentrated Solar Power, Geothermal) and Desalination (Reverse Osmosis and Multi-Stage Flash)

- Environmental & Social Impact Assessment – Max has managed the ESIA undertakings for a host of power and desalination projects on behalf of International Financial Institutions, National Power Generating Companies
- Auditing - Max has been the Lead Auditor undertaking quarterly and bi-annual environmental audits for the construction and operational phases of several power projects in line with the requirements of the site-specific EMMP's, national standards and international lender guidelines to monitor compliance throughout these phases. The prepared audit reports have been submitted to the national regulators or international financial institutions.
- Environmental Due Diligence – Max has undertaken Due Diligence studies on behalf of private investors for several power and water facilities in countries such as UAE, Oman, Jordan and Turkey.
- Strategic Environmental Assessment - Max has had key SEA input for a project in Kenya to investigate potential options for geothermal expansion in the Rift Valley.
- Environmental Management Plans - Max has prepared several Construction Environmental Management Plans (CEMP) and Operational Environmental Management Plans (OEMP), on behalf of lending bank consortiums and Project Companies. These have been undertaken for multiple power projects in the Middle East.
- Specialist Studies & Performance Testing - Max has prepared specific noise and wastewater performance testing procedures and has also undertaken the noise performance testing alongside, reviews and study of performance test air emissions in order to gain approval from lending banks.
- Compliance Reviews – Max has played a key role in the design, undertaking and analysis of a unique study for the world's largest national power company to assess compliance to national environmental regulation and to develop a strategy for compliance improvement into the future.
- Training – Max has written and delivered training material for/to the world's largest national power company in regard to environmental compliance with national regulation and standards.

Industrial Sector:

Besides power and water Max has experience in several other industrial sectors, where he has been involved in ESIA work or advising on environmental and social issues of projects. Such projects have included:

- Aluminum rod and conductor plant in Abu Dhabi.
- Rare Earths Mining Project in Kenya.
- Iron Ore mining project in Tabuk, Saudi Arabia.
- DRI Steel project in Saudi Arabia.

Development Projects:

- Max has project managed and prepared EIA studies for several large-scale mixed-use residential/commercial developments in Dubai. These include developments at/for: Nadd Al Hammar, Porto Island, Dubai Properties, Dubai Hills, Dubai Design District and Al Thaniya 2nd.
- Max has undertaken habitat mapping on several proposed Industrial city locations in Saudi Arabia. This included on site observation combined with the application of GIS mapping.

Infrastructure Projects:

- Max has worked on the Dubai Metro red line extension project and has had key input to the EIA.
- Max undertook the preliminary EIA work on behalf of the project developer for a fly-ash landfill site in Shuqaiq, Saudi Arabia.
- Highways Infrastructure - Max effectively coordinated and managed the environmental requirements for various highway schemes from study through to build on the Highways Agency's Area 2 network and several projects outside of this area. Such projects included works for widening, re-surfacing, drainage, structures, ecological mitigation, remediation, electronics and lighting. Max acted as the main environmental contact for these schemes and was responsible for liaising with outside agencies/regulators and advising senior project management. For such schemes, his duties consisted of: the preparation of environmental scoping reports, further environmental assessments, environmental specifications and construction environmental management plans. Additionally, Max undertook field studies/surveys on site and used GIS software to gather additional baseline data.

Personal Details

Professional Qualifications

Year	Qualification	Institution
2009	BSc (Hons) Environmental Management	University of Birmingham, UK
2010 to Present	Graduate Member	IEMA - Institute of Environmental Management and Assessment

Date of Birth

9th January 1987

Nationality

British

Employment History

5 Capitals Environmental & Management Consulting - Dubai, UAE
Operations Manager
April 2016 - Present

Consultant
January 2012 – April 2016

Balfour Beatty Mott MacDonald. – Bristol, UK
Environmental Coordinator
March 2011 – December 2011

Waterman Transport and Development. – Solihull, UK
Graduate Engineer
July 2009 - August 2010

CURRICULUM VITAE

Dima Maroun

Introduction

Dima is a Senior Environmental Consultant with 5 Capitals based in Dubai. Dima has over 10 years experience in the areas of environmental impact assessment, environmental management planning and implementation and water resource studies. She has acted as a Project Manager and Technical coordinator, and as an individual technical specialist in environmental monitoring. She has worked for both government and private sector clients.

Her principal capabilities comprise:

- Air quality monitoring, management of specialized consultants in air and noise quality monitoring, equipment calibration and maintenance scheduling, specifications of air quality surveys.
- Preparation of a wide range of environmental documentation including; EIAs, IEEs and Scoping Reports, ESMPs, Construction Environmental Management Guidelines, HSE and Policy documents.
- Detailed knowledge of regulatory and policy frameworks of international lending agencies, including the WB, IFC, OPIC, EU and MCC. Is knowledgeable in ISO 14001.
- Preparation and implementation of Environmental Management and Monitoring Plans, including a) environmental baseline surveys, b) construction and operation monitoring of terrestrial, aquatic and atmospheric environments, and c) management and co-ordination of site surveys and inspections.
- Established Report Templates, Communication Management Plans, CEMP Inspection Templates, CEMP Inspection Manual, Socio-Economic Survey Questionnaires.
- Preparation and implementation of extensive public consultation programmes compatible with Jordanian, IFC and WB standards.
- Co-ordination and liaison with key governmental ministries, local authorities and other project stakeholders internationally, as well as with international funding agencies.
- Developed training material for CEMP inspections and conducted training sessions to relevant project stakeholders.

Summary of Experience

Nov.'12 – Feb '17 Freelance Environmental Consultant

Jordan Nuclear Power Plant Proposed Site Evaluation Study: Environmental and Socio-Economic Analysis. Deputy Environmental Consultant. Tasks included:

- Liaising with lead consultant (KEPCO) on Environmental and Socio-Economic Tasks and advising on Jordanian Government Environmental Requirements,
- Co-writing the scope of work for the Ecological Baseline that was conducted by a local subconsultant.
- Writing the Scope of Work for the Archeological Baseline study that was conducted by the Jordanian Department of Antiquities. The study was conducted to meet both the Jordanian and USNRC Standards.
- Co-writing Initial Environmental Report.

Amman Development Corridor Project, Jordan. Environmental Specialist and Technical Coordinator, responsible for the implementation of the World Bank approved Environmental Management Plan. Tasks included:

- Preparation and maintenance of Environmental Quality Monitoring (EQM) Equipment for use
- Conducting Environmental Quality Monitoring for 13 Sites as required by the Amman Development Corridor (ADC) Environmental Management Plan
- Preliminary Training "Introduction of EQM Use and Purpose" , Onsite training of EQM Equipment Application and use of Use of EQM computer software conducted for Ministry of Public Works and Housing staff.
- Preparation of Final ADC Environmental Report.
- Preparation of Training Manuals for EQM Equipment Use.
- Preparation of ADC environmental works chapter for PMT Completion Report for World Bank.
- Preparation of Report on Contractor Environmental Non-Compliance and implementation of penalty system (monetary withholding) as well as time needed to remediate the items, the report is to cover the complete duration of the project for World Bank.

Oct.'06 - Oct.'12 Dar Al-Handasah Consultants (Shair & Partners), Jordan

Environmental Specialist

- **Feasibility Study of the "Mini-Project" (Rail link from Shidiya phosphate mine to Aqaba port): Environmental and Socio-Economic Analysis**. Lead Environmental and Socio-Economic Specialist, Preparation of preliminary ESIA for a 30 km narrow gauge track that will run parallel to an existing road and connect to the existing railway link, as well as the construction of a new trans-shipment terminal

in Wadi Yutum where trucks will transport phosphate via the Aqaba Back Road to the new Aqaba South Port. Tasks included gathering baseline data on Ecology, Atmosphere, Archeology and Socio-Economic (truck drivers). Data was analyzed and presented in a final report.

- **High Speed Railway Addendum for Jordan National Railway Study.** Deputy Team Leader, Preparation of the ESIA Addendum for High Speed Railway passenger, the report covers the additional 30 km of possible new alignment and the option of including a HSR component into the study. Tasks included update of Cultural Resources Plan, Noise, Air Quality and Socio-Economic Activities.
- **Amman Marka International Airport (AMIA) Masterplan Environmental Overview.** Environmental Specialist, Tasks included to provide an overview of the current situation relating to waste operations at AMIA, and the existing land uses within and in areas adjacent to AMIA. The study was submitted to the Jordan Airports Company, an entity sanctioned by the Government of Jordan to take over the operations and management of all airports in Jordan.
- **PESIA for Zarqa Governorates Water Wells Rehabilitation.** Environmental Specialist and Deputy Team Leader, Preparation of the PESIA of the rehabilitation of 99 water wells in Zarqa Governorate while complying with both the environmental requirements of the Kingdom of Jordan and the MCC. Tasks also included delegating a scoping session, liaising with both the clients and regulating authorities, producing the terms of reference for the main stage ESIA.
- **Disi-Mudawarra to Amman Water Conveyance System, Jordan.** Environmental Specialist for the implementation of the Environment and Social Management Plan (ESMP). Tasks included setting up the Environmental and Social Department for the Project Company whilst carrying out all ESMP requirements as well as training, development of ESMP processes, communication strategies, audits, revision and approval of Contractor plans and reports and reporting to the lenders.
- **National Railway Study, Jordan.** Deputy Project Manager, Preparation of an ESIA, ESMP, RAP for a project comprising of over 1000kms of rail line. Tasks included supervision of Air and Noise Quality Baseline Study for both rural and urban areas. All environmental documentation was prepared in accordance to IFC standards while meeting Jordanian Requirements. The ESIA was approved by the Jordanian Ministry of Environment.
- **Airport Highway Expansion Project, Jordan.** Environmental Coordinator for a project to rehabilitate and provide service roads for 20kms of existing highway. Tasks include Coordination between Supervising Consultants, Contractors, Project Management Team (PMT), Ministry of Environment and other stakeholders, Implementation of General Construction Environmental Management Guidelines, in accordance to Jordanian Laws and Regulations through site inspections, revision and approval of audits submitted by the Contractor (in compliance with the requirements of the local laws), Implementation of training to Contractors, Supervising Consultants and relevant stakeholder.
- **Disi Water Conveyance Project, Jordan.** Environmental Specialist and Technical Coordinator for four Project Components; Review, update and modification of existing Project ESIA, Development of a new Project ESMP in accordance with IFC

Guidelines, Design and Implementation of Public Consultation Programme and a Review of Compliance of Project ESMP with Equator Principles.

- **Amman Development Corridor Project, Jordan.** Environmental Specialist and Technical Coordinator, responsible for the implementation of the World Bank approved Environmental Management Plan. Tasks included:
  - Implementation of Environmental Quality Monitoring (SO2, NOx, CO, Lead, PM10, TSP and Noise). Planning Air Quality Studies with Specialist Consultants, conducting compliance checks on Air and Noise Standards, coordinating maintenance and calibration checks on Environmental Quality Equipment. Analyzing results in comparison to Jordanian and International Standards and reporting findings to Supervising Consultants, Contractors, Project Management Team (PMT), Ministry of Environment and other stakeholders on a quarterly basis.
  - Coordination between Supervising Consultants, Contractors, Project Management Team (PMT), Ministry of Environment, external auditors and other stakeholders.
  - Implementation of Construction Environmental Management Guidelines (CEMG) through site inspections, revision and approval of Management Plans and documents submitted by the Contractor in compliance with the requirements of the CEMG and recommend acceptance or rejection of documentation to the PMT.
  - Established Report Templates, Communication Management Plans, CEMP Inspection Templates and CEMP Inspection Manual
  - Implementation of training to Contractors, Supervising Consultants and relevant stakeholder.
  - Preparation of quarterly environmental reports for financiers (World Bank, European Investment Bank and Arab Fund for Social and Economic Development).
  - Preparation of final handing over environmental documents as well as final EQMS training to the project owner.
  - Coordinating and attending bi-annual workshops with financiers, regulators and other relevant government authorities.
  -

Jan.'06 – Oct.'06: ECO Consult Amman, Jordan – Environmental Specialist

Contributed to a variety of consultancy projects, working in various small teams and taking on differing levels of responsibility.

- **Saraya Development project in Aqaba, Jordan.** Project Manager for the Environmental Impact Assessment (EIA) of a project covering 60 dunums. Project components include high end resort hotels and residential accommodation set around a lagoon area opening out to the Gulf of Aqaba. The EIA covers both onshore and offshore activities during the construction, operation and decommissioning phases.
- **Oil Shale Extraction, Jordan.** Research environmental implications of different methods of oil shale extraction.

Jan.'05–Dec.'05: Engicon, Amman, Jordan

- **Water Data Banks- Phase IV Project.** Project Manager for this EU funded project. Tasks included:
  - Assessment of the present situation in relation to available information and studies executed in the field of water quality and more specifically, reuse of wastewater.
  - Together with the key international experts, building the project architecture with special emphasis on setting up a Steering Committee with the Ministry of Water & Irrigation and a platform for reuse of wastewater involving the different stakeholders.
  - Utilization of the Virtual Work Space developed by the Consortium and establishing a link to the EXACT website.
  - Acting as the focal point for project activities in Jordan (including supply contracts).
- **Karama Dam Tourism Project.** Responsible for the preparation of an Environmental and Socioeconomic Impact Study. The site covers 929 dunums and is located in the area (Northern Jordan).
- **Sector Assistance Review, Jordan.** Participant in a Japan International Cooperation Agency (JICA) funded project aimed to determine the sectors that in most need of assistance in Jordan.

Jan.'04 – May'04: Independent Consultancy

- **Royal Naval Base , Aqaba, Jordan.** Project Manager, EIA for the Royal Naval Base in Aqaba, Jordan. The project consisted of offshore and onshore construction. The site included the construction of jetties, berths and housing complexes. The construction methods assessed and monitored were dry and wet dredging and offshore pumping.
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June'00 – Dec.'04: Dorsch Consult, Amman, Jordan

- Northern Governorate (NG) Water Authority Support Project, Jordan. Water Quality Analyst responsible for the following tasks:
  - Water quality sampling according to WHO and Jordanian Water Quality Standards for selected water sources and wastewater effluent.
  - Project liaison with Northern Governorates Laboratory.
  - Assisting NG Laboratory in implementing water quality monitoring program for 4 governorates (Irbid, Mafraq, Ajloun, Jarash) and introducing ArcView GIS as a database/ monitoring tool.
  - Preparation of a Working Paper on water quality control and sampling.
  - Assist in Environmental Impact Analysis.
  - Preparation of maps for various functions and regional projects using ArcView GIS

Personal Details

Professional Qualifications

Year	Qualification	Institution
2000	BSc Environmental Sciences, Concentration in Policy and Management	State University of New York, College of Environmental Science and Forestry (Affiliated with Syracuse University)

Nationality

American / Jordanian

Additional Qualifications

- Environmental Auditing and Environment Management Systems Module, SOAS – 2016- 2017
- Corporate Governance and Responsibility Forum, Schema, Jordan - June 12- 15, 2011
- Energy Simulation Theory and Application, Equest, Sabeq USAID, Jordan February 13 – 17, 2011
- Corporate Social Responsibility Communication Workshop, Schema, Jordan October 17 – 18, 2010

MEMBERSHIP:

- Jordan Green Building Council – Since March 2010
- Jordanian Royal Society for the Conversation and Nature - since June 2000

KEY QUALIFICATIONS

Mr. Masri has over 6 years of professional experience in project management and conducting environmental and social assessments to include: Environmental and Social Impact Assessments, Strategic Environmental and Social Assessments, Environmental and Social Management Plans, Environmental and Social Baseline Studies, Stakeholder Engagement Plans, Stakeholder Consultation Plans, and other. Mr. Masri has been involved in extensive environmental and social studies in various sectors to include energy and renewable energy, infrastructure, tourism, water and wastewater, etc.

As a consultant, Mr. Masri has been involved in environmental and social assessments funded by international donor agencies and has undertaken such assessments in accordance with international best practices to include: International Finance Corporation's (IFC) Environmental and Social Performance Standards (PS) and Environment, Health, and Safety (EHS) Guidelines and the European Bank for Reconstruction and Development's (EBRD) Environmental and Social Policy and Environmental and Social Performance Requirement.

Mr. Ibrahim Masri has Bachelor of Science in Chemistry from the American University of Beirut (AUB) and Master of Science in Environmental Management and Science from Carnegie Mellon University. In addition, Mr. Masri is a Leadership in Energy and Environmental Design Accredited Professional (LEED-AP).

PROFESSIONAL EXPERIENCE

Sep 2011 – present **Consultant**
ECO Consult
Amman Jordan

Nov 2008 – Jul 2010 **Senior Environmental Analyst**
ECO Consult
Amman, Jordan

Responsibilities include:

- Develop technical reports such as Environmental and Social Impact Assessment, Strategic Environmental Assessment, Environmental Management Plan, Environmental Baseline Report, etc.
- Technical and financial proposal development for potential projects for the company.
- Conduct site visits, interviews, focus groups, for data collection to analyze information and develop outcomes and conclusions to be included within technical reports
- Revision of local and international (World Bank, IFC, EBRD, USAID) social and environmental quality objectives for inclusion in technical reports to ensure compliance with their requirements
- Liaise with clients, experts, government officials, financiers, NGO representatives and local communities for data collection, defining project scope and boundary, and feedback over project concerns
- Working on projects related to environment and energy as listed below:

1) **Environmental and Social Impact Assessment (ESIA) for Mass 100MW Wind Farm Project. Financier: IFC; Client: Mass Group Holding; Position: Project Manager/E&S Consultant. Tafileh – Jordan. 2016 – ongoing.**

- Managed and led ESIA team for the study.
- Conducted site visits, interviews, and data collection to analyze information and develop outcomes and conclusions to be included within technical reports.
- Undertook stakeholder consultations to understand their views, perceptions, and concerns regarding Project development.
- Liaised with experts and identify, assess and quantify the various potential impacts anticipated from the project activities and which mainly relate to shadow flicker and noise, landscape and visual, geology and hydrology, biodiversity, archeology, infrastructure and utilities, occupational health and safety, and waste management, etc.
- Compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified;
- Developed the Stakeholder Engagement Plan (SEP) which outlines a systematic approach to stakeholder engagement throughout project lifetime to build and maintain a constructive relationship with stakeholders, in particular the locally affected communities;

2) **Development and Implementation of E&S Requirements for the Rajef 82MW Wind Farm Project. Financier: EBRD, Client: Green Watts Renewable Energy; Position: Project Manager/E&S Consultant. Ma'an – Jordan. 2016 – Ongoing.**

- Develop Social plan and Corporate Social Responsibility (CSR) Program that will be implemented for the Project during the construction and operation phase;
- Provide training and capacity building program for the project's Community Liaison Officers on the Stakeholder Engagement Plan (SEP) and community grievance mechanism; and
- Develop a Land Acquisition and Compensation Framework (LACF) for the Project as per EBRD's PR 5.

3) **Environmental and Social Impact Assessment (ESIA) for the Rajef 132kV Overhead Transmission Line. Financier: EBRD; client: National Electric Power Company (NEPCO); Position: Project Manager/E&S Consultant. Ma'an – Jordan. 2016 – 2017.**

- Managed and led ESIA team for the study.
- Conducted site visits, interviews, and data collection to analyze information and develop outcomes and conclusions to be included within technical reports.
- Undertook stakeholder consultations to understand their views, perceptions, and concerns regarding Project development.
- Liaised with experts and identify, assess and quantify the various potential impacts anticipated from the project activities and which mainly relate to community health and safety, landscape and visual, geology and hydrology, biodiversity, archeology, infrastructure and utilities, occupational health and safety, and waste management, etc.
- Compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified; and
- Followed up with the Ministry of Environment on the submitted study to explain its outcomes and conclusions and obtain environmental permit for the project.

4) **Environmental, Social, Health and Safety (ESHS) Management System for Arc and Nubian 100 MW Solar PV Project. Financier: IFC; Client: Enerray S.P.A Italia; Position: Project Manager/E&S Consultant. Benban – Egypt. 2016.**

- Develop overall structure and components of the ESHS management system for the project;
- Liaise with the IFC to determine requirements of the ESHS management system for the project; and
- Develop technical plans and procedures to include but not limited to worker grievance mechanism, community grievance mechanism, chance find procedures, HSE policy, HR policy, child labor procedures, and other.

5) **ESIA for Al-Hussein 485 MW Thermal Power Plant, 2016. Financier: EBRD; Client: 5 Capitals; Position: Project Manager/E&S Consultant. Zarqa – Jordan. 2016.**

- Undertook scoping session for the project to present to stakeholders project concept and components and ESIA scope of work and methodology, to ensure project and ESIA study takes into account stakeholder requirements and concerns; and
- Reviewed scoping report/terms of reference and ESIA document prepared by 5 Capitals to ensure compliance with local ESIA regulations.

6) **ESIA for SunRise 50 MW Solar PV Project, 2016. Financier: EBRD; Client: 5 Capitals; Position: Project Manager/E&S Consultant. Mafraq – Jordan. 2016.**

- Prepared and implement stakeholder consultation plan and undertake consultations with relevant stakeholders to include but not limited to national governmental entities, non-governmental organizations, local communities, and other.
- Reviewed scoping report/terms of reference and ESIA document prepared by 5 capitals to ensure compliance with local ESIA regulations

7) **ESIA for Saudi Oger/Arabia Group 50 MW Solar PV Project. Financier: TBD; Client: Saudi Oger Ltd and Arabia Group; Position: Project Manager/E&S Consultant. Mafraq – Jordan. 2015 – 2016.**

- Managed and led a team of archeology and cultural heritage expert, biodiversity expert, geology and hydrogeology expert, etc.
- Conducted site visits, interviews, and data collection to analyze information and develop outcomes and conclusions to be included within technical reports.
- Undertook stakeholder and local community consultations to understand their views, perceptions, and concerns regarding Project development.
- Liaised with experts and identify, assess, and quantify the various potential impacts anticipated from the project activities and which mainly relate to landscape and visual, biodiversity, archeology, infrastructure and utilities, occupational health and safety, and waste management, etc.
- Developed and compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified;
- Developed the Stakeholder Engagement Plan (SEP) which outlines a systematic approach to stakeholder engagement throughout project lifetime to build and maintain a constructive relationship with stakeholders, in particular the locally affected communities;

8) **E&S Audit and Implementation of Environmental and Social Management Plan (ESMP) during Operation for the Tafileh Wind Farm Project. Financier: IFC and EIB; Client: Jordan Wind Project Company (JWPC); Position: Project Manager/E&S Consultant. Tafileh – Jordan. 2015 – Ongoing.**

- Undertake monthly environmental and social audit to ensure project compliance with Environmental and Social Management Plan (ESMP) and Environmental and Social Action Plan (ESAP), and IFC PS.
- Overall management of E&S team involved in implementation of ESMP during operation to include avi-fauna monitoring and turbine shutdown team, bat monitoring team, community liaison offer, etc.
- Overall management of E&S deliverables to client and lenders.

9) **Environmental and Social Impact Assessment (ESIA) for the Rajef 80-85 MW Wind Farm. Financier: EBRD; Client: Green Watts Renewable Energy; Position: E&S Consultant. Ma'an – Jordan, 2012- 2016**

- Liaised with various experts to collect and analyze data to map out the current environmental baseline conditions of the project area to include birds, bats, flora/fauna, archeology, land use, etc.
- Liaised with experts and identify, assess, and quantify the various potential impacts anticipated from the project activities and which mainly relate to land use, community health and safety, avi-fauna, archeology, biodiversity, etc.
- Undertook consultations with local community members as well as vulnerable groups (e.g. semi-nomadic tribes) to understand their views, perceptions, and concerns regarding Project development.
- Compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified;
- Developed the Stakeholder Engagement Plan (SEP) which outlines a systematic approach to stakeholder engagement throughout project lifetime to build and maintain a constructive relationship with stakeholders, in particular the locally affected communities;

10) **Preliminary Environmental Impact Assessment (PEIA) for the West Zarqa Wastewater Force Main. Financier: KfW Development Bank; Client: Water Authority of Jordan (WAJ)/CDM International; Position: Project Manager/Environmental Consultant. Zarqa – Jordan. 2015- 2016.**

- Managed and led a team of archeology and cultural heritage expert, biodiversity expert, traffic and transportation expert, etc.
- Conduct site visits, interviews, and data collection to analyze information and develop outcomes and conclusions to be included within technical reports.
- Liaise with experts and identify, assess and quantify the various potential impacts anticipated from the project activities and which mainly relate to land use and land acquisition, water resources, biodiversity, archeology, roads and traffic, and other.
- Developed and compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified.
- Follow up with the Ministry of Environment on the submitted study to explain its outcomes and conclusions and obtain environmental permit for the project.

11) **Environmental Baseline Study (EBS) for the Rehabilitation and Extension of the Industrial Jetty. Client: TECNICAS REUNIDAS S.A. & PHB WESERHUTTE; Position: Project Manager/Environmental Consultant. Aqaba – Jordan. 2015.**

- Managed and led a team of marine environment experts, marine water quality experts and air quality experts.

- Designed the scope of work for the environmental baseline study.
- Liaised with experts for evaluation of baseline conditions.
- Undertook an onshore site assessment to document the level of pollution and contamination onsite.
- Produced a comprehensive EBS report.

12) Environmental and Social Impact Assessment (ESIA) for Shams Ma'an 50 MW Solar Project. Financier: JBIC; Client: Shams Ma'an Power Generation Company; Position: Project Manager/E&S Consultant. Ma'an – Jordan. 2014 – 2015.

- Managed and led a team of archeology and cultural heritage expert, biodiversity expert, traffic and transportation expert, etc.
- Conducted site visits, interviews, and data collection to analyze information and develop outcomes and conclusions to be included within technical reports.
- Undertook stakeholder and local community consultations to understand their views, perceptions, and concerns regarding Project development.
- Liaised with experts and identify, assess and quantify the various potential impacts anticipated from the project activities and which mainly relate to landscape and visual, geology and hydrology, biodiversity, archeology, infrastructure and utilities, occupational health and safety, and waste management, etc.
- Compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified;
- Developed the Stakeholder Engagement Plan (SEP) which outlines a systematic approach to stakeholder engagement throughout project lifetime to build and maintain a constructive relationship with stakeholders, in particular the locally affected communities;
- Coordinated and discussed with potential financiers to the Project (mainly) to present the ESIA study, its scope, outcomes and conclusions, etc. financiers mainly included the Japan Bank for International Corporation (JBIC).
- Followed up with the Ministry of Environment on the submitted study to explain its outcomes and conclusions and obtain environmental permit for the project.

13) Environmental and Social Impact Assessment (ESIA) for Arabia One 10 MW Solar Project. Financier: IFC; Position: Project Manager/E&S Consultant; Client: Arabia One Clean Energy Investments PSC. Ma'an – Jordan. 2014

- Managed and led a team of archeology and cultural heritage expert, biodiversity expert, traffic and transportation expert, etc.
- Conducted site visits, interviews, and data collection to analyze information and develop outcomes and conclusions to be included within technical reports.
- Undertook stakeholder and local community consultations to understand their views, perceptions, and concerns regarding Project development.
- Liaise with experts and identify, assess, and quantify the various potential impacts anticipated from the project activities and which mainly relate to landscape and visual, biodiversity, archeology, infrastructure and utilities, occupational health and safety, and waste management, etc.
- Compiled the Environmental and Social Management Plan (ESMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified;

- Developed the Stakeholder Engagement Plan (SEP) which outlines a systematic approach to stakeholder engagement throughout project lifetime to build and maintain a constructive relationship with stakeholders, in particular the locally affected communities;
- Coordinated and discussed with potential financiers to the Project (mainly) to present the ESIA study, its scope, outcomes and conclusions, etc. financiers mainly included the International Finance Corporation (IFC).
- Follow up with the Ministry of Environment on the submitted study to explain its outcomes and conclusions and obtain environmental permit for the project.

14) Further Advancing the Blue Revolution Initiative (FABRI). Financier/Donor: United Stated Agency for International Development (USAID); Position: Environmental Consultant. Amman – Jordan. 2014

- Undertook preliminary environmental screenings and assessments for 13 research projects in the water and wastewater sector in Middle East and North African countries (Jordan, Morocco, Oman, Palestine, etc.).
- Liaised with various experts from academic and research institutions to collect and analyze data to develop outcomes and conclusion.

15) Preliminary Environmental Impact Assessment (PEIA) for the Demolition of the Old Passenger Terminal Building at the Queen Alia International Airport. Client: Joannou & Paraskevaides (J&P); Position: Project Manager/Environmental Consultant. Amman – Jordan. 2013.

- Reviewed and analyzed Contractor's demolition method statement to understand and identify potential environmental impacts from the demolition process.
- Identified, assessed, and quantified the various potential impacts anticipated from the demolition activities and which mainly relate to air quality, noise, aesthetics, road networks, occupational health and safety, and waste management.
- Compiled the Environmental Management Plan (EMP) that identifies mitigation measures and monitoring requirements for each of the impacts identified.
- Held regular meetings with Contractor (mainly Construction Manager) for data collection, site visits, and to update/present the outcomes of the study and its components.
- Followed up with the Ministry of Environment on the submitted study and obtain environmental permit for the project.

16) Construction Environmental Management Plan (CEMP) for the Phosphate Rock Terminal in Aqaba, Project Coordinator, Jordan Phosphate Mines Company (JPMC), Aqaba – Jordan, 2010.

- Analyzed the construction method statement of the contractor and subcontractors involved to identify potential environmental impacts from the construction process.
- Developed the CEMP for the different phases of the project (preconstruction, construction, and decommissioning) including detailed mitigation measures and monitoring requirements.
- Developed the institutional strengthening plan that identifies measures to ensure the proper implementation of the CEMP through assigning responsibilities of staff and training requirements.

17) Environmental Impact Assessment (EIA) for the Aqaba Liquefied Natural Gas Terminal, Project Coordinator, Royal HaskoningDHV, Aqaba-Jordan, 2013.

- Liaised with various experts to collected and analyze data to map out the current environmental baseline conditions of the project area mainly related to corals and marine water quality.
- Assisted in identifying, assessing, and quantifying anticipated environmental impacts from the various project components throughout the various project phases.
- Assisted in developing the Environmental Management Plan (EMP) which identifies for each impact potential mitigation measures, compensations measures, and monitoring requirements.

18) Strategic Environmental Assessment (SEA) for the Jabal Ajloun Development Area (JADA), Project Coordinator, Jordan Development Zones (JDZ), Ajloun – Jordan, 2012.

- Collected and analyzed data to map out the current environmental and social baseline conditions of the development area.
- Identified and assessed anticipated environmental and social impacts on both the strategic and development level.
- Developed stakeholder positioning based on extensive consultations that presents their concerns and attitude towards the project development.
- Developed the strategic environmental management plan that details strategic recommendations and development level mitigation measures, monitoring and institutional requirements.

19) International Finance Corporation's (IFC) Inspection Reform Project, Environmental Researcher, IFC, Amman – Jordan, 2009

- Reviewed and analyzed Jordanian legislations that govern the environmental inspection process on industries in Jordan (air and water quality, waste management, health and safety).
- Identified overlaps, contradictions, and gaps between legislations causing inefficiencies between different ministries when conducting environmental inspections.

20) Environmental Baseline Survey for the Jordan Phosphate Mining Company, Project Coordinator, Jordan Phosphate Mines Company (JPMC), Aqaba – Jordan, 2010

- Conducted data analysis on previous emission inventories and monitoring /testing reports to characterize current environment conditions within the project site.
- Developed a legal framework which governs the current environmental conditions within the project site.

EDUCATION

2011 **Master of Science in Environmental Management and Science**
Carnegie Mellon University
Pittsburgh, USA

Concentration: Green Design
Relevant courses:

- Water and Wastewater Engineering

- Environmental Life Cycle Assessment
- Industrial Ecology and Green Design
- Advanced Life Cycle Assessment
- Energy Conversion and Supply
- Managerial and Engineering Economics
- Energy Utilization and Demand
- Economics of Global Warming
- LEED and Green Design
- Introduction to Sustainable Engineering

2008 **Bachelor of Science in Chemistry**
American University of Beirut (AUB)
Beirut, Lebanon

CERTIFICATIONS: Leadership in Energy and Environmental Design Accredited Professional (LEED-AP)

TRAINING COURSES & WORKSHOPS

- 14-day training in Project Management based on Project Managements Institutes (PMI) curriculum

LANGUAGES

Language	Reading	Speaking	Writing
Arabic	1	1	1
English	1	1	1

1 = Fluent, 5 = Basic

Appendix B

Environmental Scoping Study – MoEnv Approval Letter

المملكة الأردنية الهاشمية

وزارة البيئة

الرقم: ع ا/ا/٢٨٣١
التاريخ
الموافق: ١٩/٤/٢٠١٧

السادة شركة الاتجاهات الجديدة للاستشارات

تحية طيبة وبعد ،،

إشارة لكتابكم رقم ECS-01-17/ وزارة البيئة/3/330 تاريخ 2017/4/11، ومرفقه تقرير الأسس الم جعية لدراسة مشروع الريشة لتوليد الكهرباء من الطاقة الشمسية والعائد للمعادة شركة الريشة في محافظة الم رق.

أوافق على الأسس المرجعية المقترحة للدراسة أعلاه في الدراسة وذلك استنادا إلى توصية اللجنة الفنية لمراجعة دراسات تقويم الأثر البيئي للمشاريع.

وتفضلوا بقبول فائق الإحترام ،،،

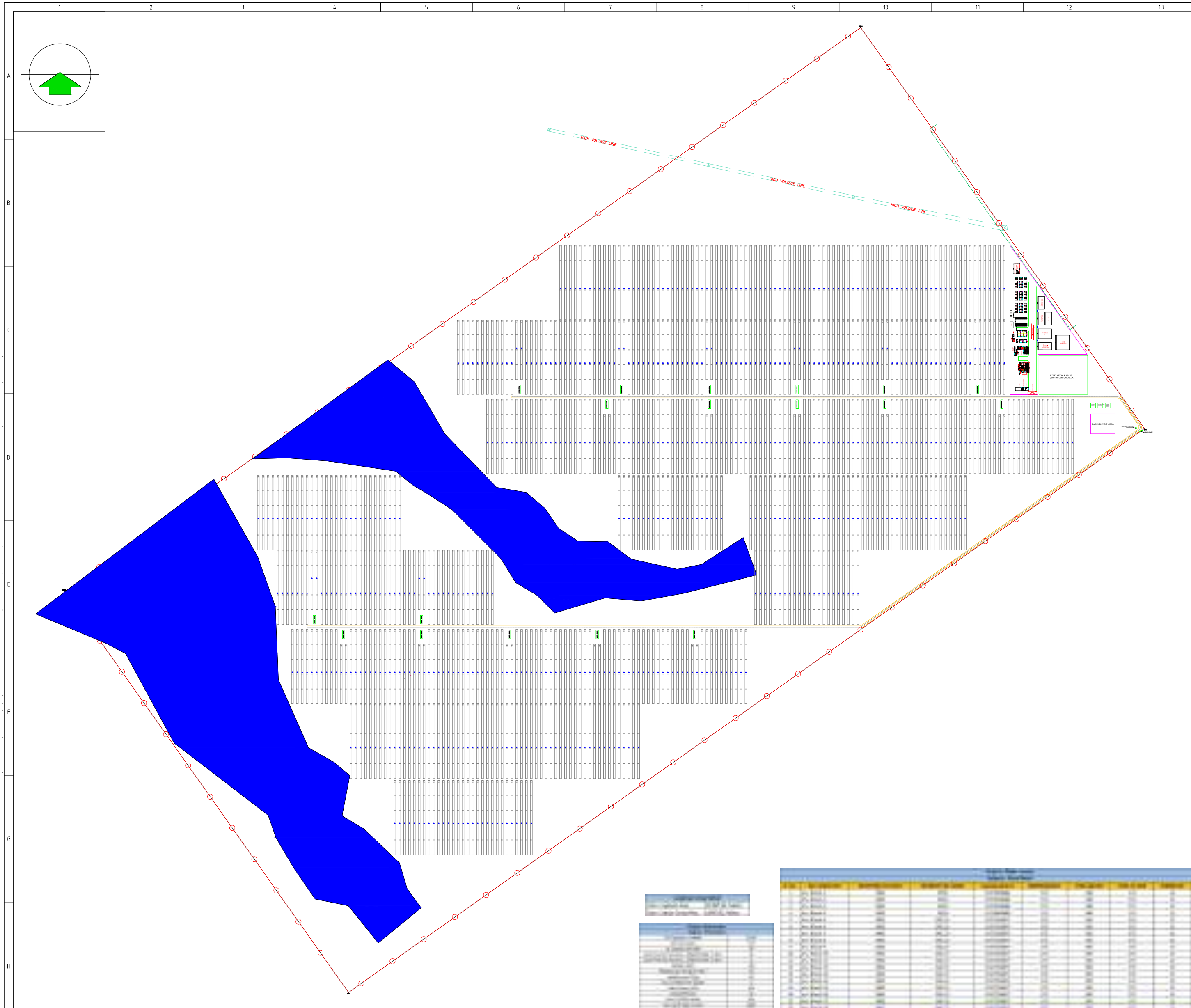
وزير البيئة

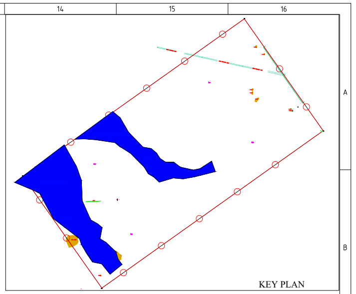
د. ياسين الخياط

المهندس أحمد القطارنه
الأمين العام

Appendix C

Project Location Layout Drawing

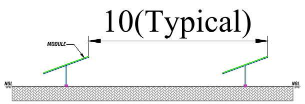




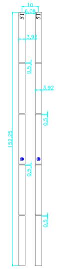
KEY PLAN

LEGEND :-

SYMBOL	DESCRIPTION
(mod. structure symbol)	MOD.STRUCTURE
(road symbol)	3.5 M WIDE ROAD
INVERTER STATION	INVERTER STATIONS
(red line)	FENCING



PITCH DETAIL



TYPICAL STRUCTURE
& PITCH DETAILS

TENDER PURPOSE ONLY

NOTE:-
PARAMETER MAY GET CHANGE DURING DETAIL ENGINEERING

No.	DATE	REMARKS	DRN	CKED
R0	20.04.2017	TENDER PURPOSE ONLY	A.K	M.S

REVISIONS

PROJECT TITLE:
DEVELOPMENT OF 50 MW (AC)
SOLAR PHOTO VOLTAIC PLANT
AT JORDAN

CLIENT:-
- - - - - - - - -

EPC CONTRACTOR :-
THE MIRA CORP. SUITES: B-1, 1ST FLOOR,
MATHURA ROAD NEW DELHI-110065
E-mail : delhi.solar@sterlingwilson.com.
Website : www.sterlingandwilson.com.

DRAWING TITLE:
PV PLANT ARRAY LAYOUT

DRAWING NO : SWD-JOR-50 MW-E-DWG-104		SCALE	NTS
DRAWN	A.K	SHEET NO	1 OF 1
CHECKED	M.S	PAPER SIZE	A0
APPROVED	R.S		
DATE	20.04.2017	REV NO.	R0

Appendix D

No Objection Letter from the Department of Antiquities

المملكة الأردنية الهاشمية

وزارة السياحة والآثار

دائرة الآثار العامة

الرقم ١١٢٣\٢١\١٥

التاريخ ٢٠١٧/٠٣/٢٧

الموافق

السادة شركة ECO CONSULT

اشاره لكتابكم رقم 17 - 01 - ECS / دائرة الاثار العامة/1/319 تاريخ 2017/3/6 و الخاص بدراسة تقييم الأثر البيئي والاجتماعي لمشروع الريشة لتوليد الكهرباء من الطاقة الشمسية في محافظة المفرق.

نرجو أن احلمكم باننا وبعد الاطلاع على الاحداثيات المرسلة بكتابكم تبين عدم وجود اية معالم او لقى اثرية على السطح ، على ان يتم التوقف عن العمل في حال العثور على اية معالم او لقى اثرية اثناء تنفيذ المشروع وابلاغ دائرة الاثار العامة بذلك.

واقبلوا الاحترام

د. منذر جمحاوي

مدير عام دائرة الآثار العامة

نسخة/مديرية آثار محافظة المفرق.

نسخة/ مديرية التنقيبات الاثرية .

ن ح

Appendix E

Hydrology Survey Report from ACES

HYDROLOGICAL SURVEY AND DRAINAGE ASSESSMENT STUDY FOR 50 MW SOLAR PV PROJECT AL-RISHA, JORDAN

Report No.	S17000003-HS
Revision No.	Rev.0
Status	Final Report
Date	February 24th, 2017

PREPARED FOR
ACWA POWER GLOBAL SERVICES LLC
DUBAI, UAE

Revision History						
Rev.0	February 24th, 2017	For Review/Approval	SD	SH	TW	NG
Revision No.	**Date**	**Description**	**Prepared**	**Checked**	**Approved**	**QA Check**

ص.ب ٥٥٠٤ ، عمان ١١١٨٣ الأردن هاتف: ٥٨١٠٧٧٧ ٦ ٩٦٢ فاكس: ٥٨١٢٧٧٧ ٦ ٩٦٢
P.O. Box 5504 Amman 11183 Jordan Tel: 962 6 5810777 Fax: 962 6 5812777
Email: acesamman@aces-int.com www.aces-int.com

Messrs.: ACWA Power Global Services LLC
Dubai, UAE

Ref.: S17000003-HS-Rev.0
Date: February 24th, 2017

Subject: HYDROLOGICAL SURVEY AND DRAINAGE ASSESSMENT STUDY FOR 50 MW SOLAR PV PROJECT
Al-Risha, Jordan

Dear Sirs,

Arab Center for Engineering Studies (ACES) is pleased to submit this HYDROLOGICAL SURVEY AND DRAINAGE ASSESSMENT STUDY FOR 50 MW SOLAR PV PROJECT to be constructed in Al-Risha, Jordan. This investigation was carried out according to ACWA Power Global Services LLC proposal request, dated November 9th, 2016, our proposal ref. no. PS16000270-Rev.0, dated November 19th, 2016 and our contact confirmation dated January 8th, 2017.

In the event that additional information or clarifications are required, please contact our office at your convenience. We would like to take this opportunity to thank you for your confidence and look forward to be of service to you in the near future.

Sincerely yours,
Arab Center for Engineering Studies (ACES)

Dr. Thaer M. Wahshat, P.E.
ACES Jordan Manager

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1.0 INTRODUCTION

This report present the results and findings of the detailed hydrological survey and drainage assessment study conducted for 50 MW Solar PV project site located at Al-Risha, Jordan.

2.0 DESCRIPTION OF THE AREA

The study area is located in the eastern region of Jordan, south of Ruweished town. Most parts of the project is located in an almost flat area. The elevations of the site and the run-on area are from about 850 m to about 880 m above the sea level (ASL). The site is surrounded mostly by plain area as shown is **Figure 1.**

The major part of the area has only very sparse natural vegetation, mostly scattered small resistant bushes with rocks or bare soil in between, and there are no agricultural lands existing nearby the project area.

3.0 SITE TOPOGRAPHY

The topography of the catchment is characterized by a considerably low to moderate slopes in the upper parts of the catchment and more gentle slopes in the lower parts.

Figure 2 presents the site topography, which is also include in our topographical survey report (S17000003-TS-Rev.1). The southwest corner of the site, which consists the lower elevation of the site is 850m above the sea level and sloping upward to the northeast with variable slope to 880m.

The site topography as shown in the **Figure2**, the lower elevation of the site as presented in **Figure 2** starts from the southwest corner with 850m above sea level and sloping upward to the northeast with variable slope to 880m.

Wadi drains are mostly located in the southwest towards the existing creak and some in the north direction towards the open areas.

The runoff producing areas are almost flat to rolling terrain in most localities. Most parts of the area consist of uncultivated areas with sandy silt transported by the wind and wadi flows.

4.0 CLIMATE

The general climatic pattern of the catchment areas is part of Mediterranean, where the rainfalls are low in the majority of the region. The average rainfall does not exceed100 millimeters per year. **Table 1**presents the summary of temperature and precipitation averages for Ruweished area and the monthly rainfall and temperature means of the region are presented in **Figure 2**.

As per the Isohyetal map included in **Figure 3** the rainfall of the region varies from less than 50 mm to about 100 mm.

Figure 1: Site Plan for 50 MW Solar PV Project

Table 1: Summary of Some Average Climate Elements in Ruweished

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
P (mm)	9	13	10	11	7	0	0	0	0	3	10	14	77
T Cº (Min)	3	5	8	13	17	20	22	22	20	15	7.3	9	13.4
T Cº (Mean)	7.5	9.5	13	18.5	23	26.5	29	28.5	26.5	21	13.65	11	19.0
T Cº (Max)	12	14	18	24	29	33	36	35	33	27	20	13	24.5

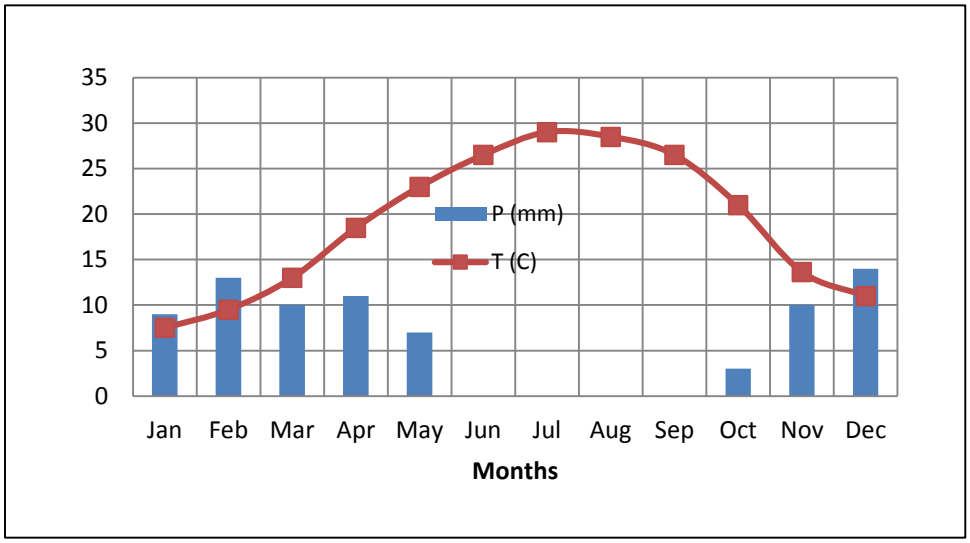

Figure 2: Long Term Average Rainfall and Temperature over the Project

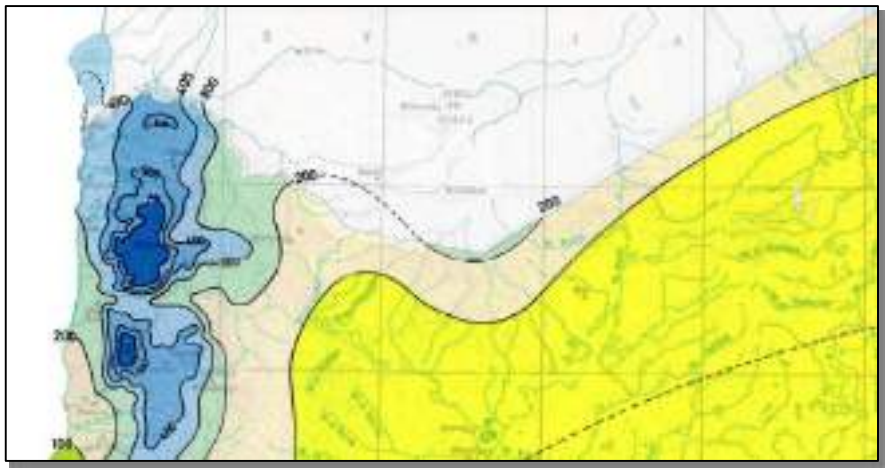

Figure 3: Isohyetal map of long-term average rainfall over Jordan

5.0 CATCHMENT CHARACTERISTICS

The catchments of the major wadis draining in the study area consist of small wadis ranging from less than 1 km^2 to about 22 km^2.

For the delineation of the catchment areas related to the drainage of the proposed hydraulic structures, digital version of the topographic maps of the largest available scale are preferable. The largest available scale for this purpose is digital version of 1:50,000 scale and those maps, covering the project area are available in Jordan. These available maps were found satisfactory to delineate the catchments.

Using AutoCAD, the areas of the catchments as presented in **Figure 4** have been measured. The characteristics of the catchments included the catchment area (A), highest elevation (H1), lowest elevation (H2), longest wadi course (L), distance between the nearest point located on the main wadi course to the centroid of the catchment and the outlet of the catchment (Lc), and the general slope (S) of the catchment itself.

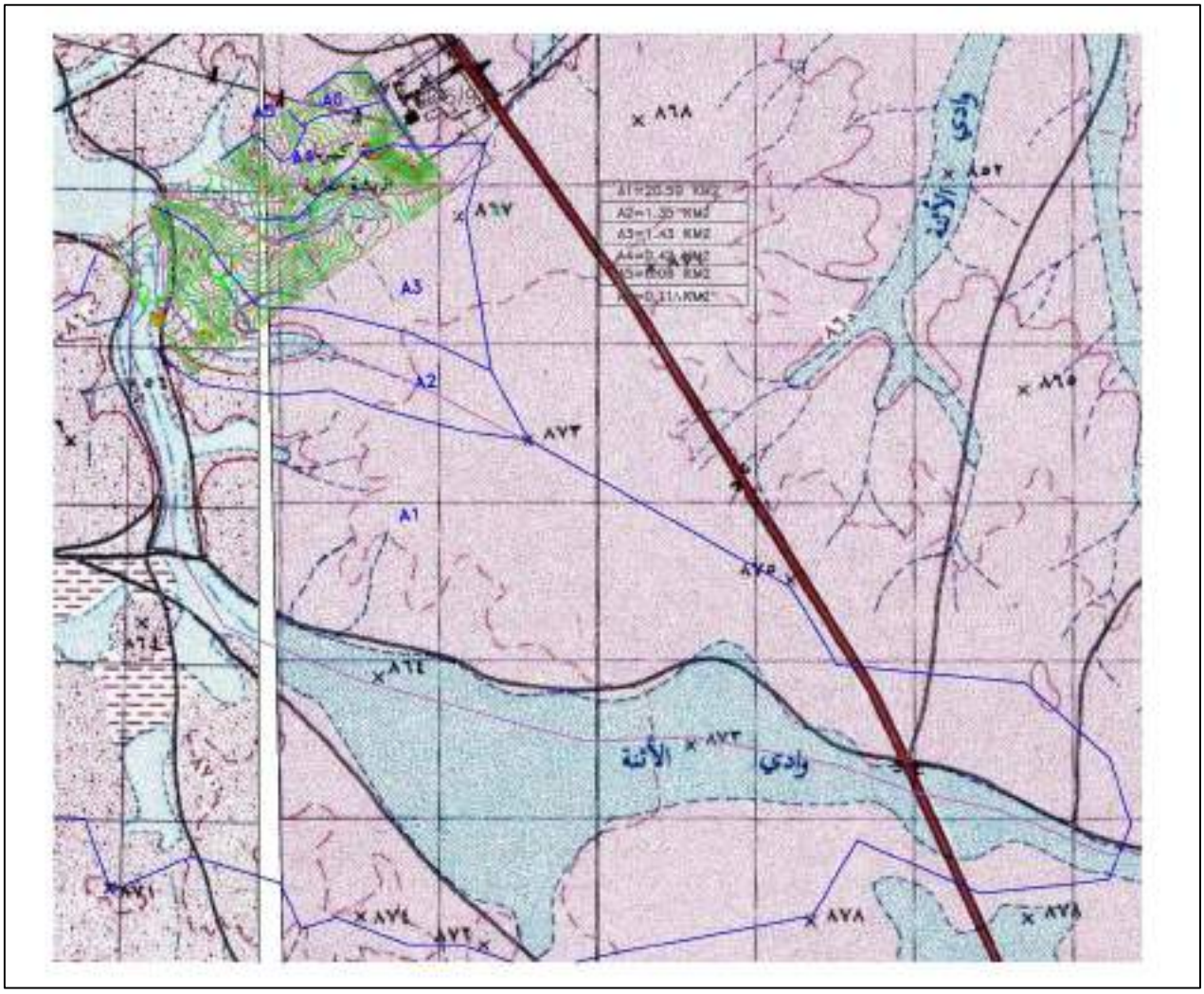

Figure 4: Map of Catchment Areas

6.0 AVAILABILITY OF HYDROLOGICAL DATA

In order to carry out the hydraulic study, the Intensity-Duration-Frequency (IDF) curves for Ruweished rainfall station have been used to calculate the rainfall intensities for 50 and 100 years frequencies.

7.0 SOIL IN THE PROJECT AREA

Since soil surveys have been mainly limited to localized projects in separate parts of the country, comparatively little is known about the soils of Jordan at a national level. The only exception is the outdated Moorman (1959) study. So far, there has been no attempt to assemble or re-evaluate all previous activities in order to establish a general soil map in current terms. However, according to our present knowledge and based on all previously published soil studies and available data, the following soil taxonomic units, according to USDA Soil Taxonomy, have been identified in Jordan (Rihani, 1983), (ACSAD, 1980) , (Bender , 1964, 1974).

A simplified nation-wide soil map has been drown (Figure 6) by that presents the dominating soil suborders of the respective areas, which we consider the most accurate, though simplified, nation-wide soil map of Jordan that is available until now. It should be noted that some of the soil names that were determined according to the 4th edition of the USDA soil taxonomy (1990) are now obsolete and should be replaced by the classifications according to the 11th edition (USDA 2010) as explained in the text. In the future, the World Reference Base for Soil Resources (WRB) could be used in Jordan too.

Comparative overview of roughly corresponding soil names used during Jordan's major soil surveys and their equivalent names in the World Reference Base for Soil Resources (WRB), and referring to our map drawn on the basis of the database of the National Soil Map and Land Use Project of Jordan (**Figure 5**). However, the table neither provides a complete summary of soils occurring in Jordan, nor can the names of the different classification systems directly be «translated» from one to another system (Source: B. Lucke).

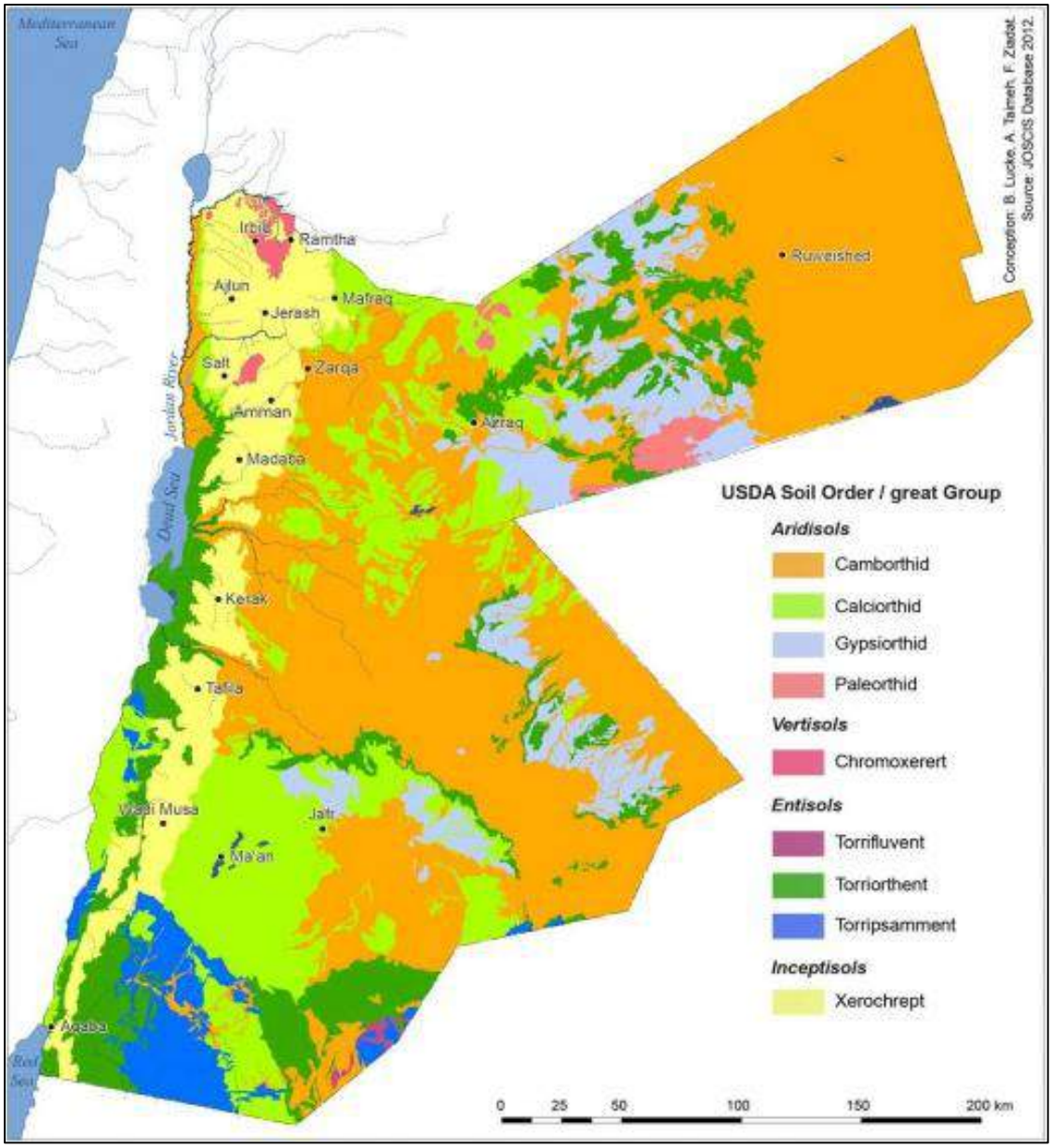

Figure 5: Soil Map for Jordan

[4]Moorman 1959, Food and Agriculture Organization (FAO) of the United Nations' Soil Terminology
[5]Rihani K. 1983, *Arid Soils in Jordan*, MSc thesis, UJ Amman
[6]https://books.google.jo/books?isbn=9401137668Determination of micronutrients in calcareous soils of the adrid zone (**ACSAD**/SS/P12/**1980**) [Ismael H El-Bagouri] on Amazon.com. -
[7]Bender F. 1964, 1974, *Geology of Jordan*, Natural Resources Authority and German Geological Mission in Jordan Hanover, Germany
[8]USDA Soil Taxonomy, 1990, 4TH edition
[9]USDA Soil Taxonomy, 2010, 11TH edition
[10]Bernhard Lucke, Feras Ziadat et Awni Taimeh, 2012, The Soil of Jordan, Presses de l'Ifpo, Contemporain publications, Atlas of Jordan.

The dominant soil subgroups in the study area are Camborthid with low content of carbonates.

1. Camborthids Group:

Camborthids are Aridisols that have an ochric epipedon and a cambic subsurface horizon. Most Camborthids are deep and found on flat or gentle darker than the topsoil. These soils have much less calcium carbonate content than the calciorthids. The extent of these soils in Jordan is very limited compared to other Aridisols, where crusting due to high silt content is one of the characteristics of these soils.

Detailed description of soil is found in the soil maps produced by the Ministry of Agriculture (MOA, 1995).

As a result, the dominant soils in the project area are Camborthid soils as presented in **Figure 5 above**.

8.0 HYDROLOGY

8.1 Rational Method

The Rational method is probably the most popular method for designing hydraulic structures. It is mostly preferable in storm design systems in urban areas. It has been applied all over the world and many refinements of the method have been produced. Although the Rational method incorporates some empirical aspects and its applications require a great judgment and experience, it has been shown that it is founded a theoretical basis and well accepted hypothesis. This made the method transferable from one country to another.

$$Q_p\,(T) = k \,.\, C \,.\, i_M\,(t_c,T) \,.\, A \,.\, F$$

Where:
Q_p (T) = the peak runoff, for a return period T, at the design point in the drainage system
C = the runoff coefficient
i_M (t_c,T) = the mean rainfall intensity, with a return period T, for a duration equal to the so-called time of concentration
A = the area of the watershed upstream of the design point
K = is a unit conversion factor depending on the units used
F = a correction factor taking into account such effects as special rainfall distribution, storage in the water course or sewage, watershed shape and slope … etc. This correction factor is not used in all formulations of the Rational method

The rational method formula looks very simple and is the reason why it remains so popular. However, it is founded on some implicit hypothesis which s limitations.

The first hypothesis assumes that Q_p is produced by the mean rainfall intensity of duration equal to the time of concentration, t_c, and so it is independent of the temporal distribution of instantaneous intensities over that duration. This means that the rainfall-runoff process is assumed a linear process. If it were non-linear, the Rational method could lead to large errors. Consequently, **the method should not be used in the following cases:**

- **Watersheds with important storage effects, such as detention basins, flood plains, storage backwater effects in flat areas or caused by submerged outlet conditions.**
- **Watersheds with strong variations in the areal distributions of land slopes or land use.**

The second hypothesis is the probabilistic one, because it assumes that the peak runoff Q_p has the same return period as the mean rainfall intensity, but this assumption is applicable in all other methods used for flood estimation from precipitation records. This means that the rainfall-runoff process is not random and the runoff coefficient C is not random variable. On the other hand, C should be a random variable in natural watersheds where the runoff coefficient depends on antecedent rainfall conditions.

Assuming the return period of i_M (t_c,T_1), as T_1 and the return period of C(T_2) as T_2, the peak discharge Q_p (T′), given by the a given by the above mentioned equation, will generally have an unknown return period T′, which can be estimated only by statistical analysis of the observed data. However, as T_1 increases, the error in T′ becomes smaller and, for saturated conditions, the above mentioned equation may lead to correct estimates. For such conditions the infiltration rates remain approximately constant, and so does the runoff coefficient. But it is not generally possible, without experimental data, to give a prior lower limit of T_1, for which the runoff process becomes deterministic. Although many modified Rational method formulae taking into account these effects have been proposed for natural watersheds (Chow, 1964), they should not be extrapolated or transposed.

As a consequence of the Rational method hypothesis, **the use of the method should be limited to small homogeneous urban watersheds and the design of simple tree-type storm sewer systems with free outfallsand no special hydraulic structures (e.g., detention basins).** In such conditions that exist in the study area, **the method gives good estimates of peak runoff as shown experimentally by comparison of the results given by the Rational method and much more complex simulation models** (Wisner, 1981). However, it is not easy to give precise limits on the method applicability, because they may depend on local drainage practices, an example of such limits are given below:

For the total watershed area, the upper limit for the applicability of the Rational method should be between 100 and 300 ha (i.e., 1 and 3 km^2). When comparing practices in various countries, it was noted that this upper limit varies widely. For example, this limit is 10-50 ha (i.e., **0.1 and 0.5 km^2**) in the **United Kingdom**, 200 ha (i.e., **2 km^2**) in **France**, and 4500 ha (i.e., **45 km^2**) in the **Soviet Union**. Such Upper limits for the Rational method applicability depends on catchment homogeneity, experimental data and analysis, and local refinements of the method.

The Rational method is generally applicable to the catchments with a minimum imperviousness of 20% to 30% (that exist in the catchment areas of the project**).** The selection of this minimum value further depends on local practices for drainage of natural pervious areas in towns (such as open spaces or private gardens), **the return periods under consideration (usually less than 10 years)**, climatic conditions, vegetation, soil characteristics, etc. [1]

The Rational formula has been used to estimate the peak discharges from areas with a relatively low time of concentration that is few minutes to 20 minutes[2].

Therefore, in small homogeneous catchments, the most commonly used method is the “Rational” formula, which is related to the area, slope, time of concentration and the runoff coefficient of the basin. However, for the determination of peak flows, the Rational formula can have the following form:

$$Q_P = \frac{C * I * A}{3.6}$$

Where:
C = Runoff Coefficient
I = Rainfall Intensity [mm/h]
A = Catchment Area [km^2]

The derived and drawn IDF representative curves will be used in knowing the rainfall intensities needed for the Rational formula, which is applicable in computing the design floods might occur in small catchment areas.

Jordan has no local regulatory practice for Storm water design, therefore, the hydrologist, in their studies follows available international standards.

[1] UNESCO, 1984, Manual on drainage Systems, prepared by the Working Group of Project A 2.9. pp 141-142.
[2] Wanielista, Martin P., University of Florida, 1990, John Willy and Sons, p 226.

The runoff coefficient for rural watersheds is given by:

$$C = C_r + C_i + C_v + C_s$$

Where:

- *C*= runoff coefficient for watershed
- C_r= component of coefficient accounting for watershed relief
- C_i= component of coefficient accounting for soil infiltration
- C_v= component of coefficient accounting for vegetal cover
- *Cs*= component of coefficient accounting for surface type The designer selects the most appropriate values for C_r, C_i, C_v, and C_s from **Table 2**.

Table 2: Runoff Coefficients for Rural Watersheds[3]

Watershed characteristic	Extreme	High	Normal	Low
Relief - C_r	0.28-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.14-0.20 Rolling, with average slopes of 5-10%	0.08-0.14 Relatively flat land, with average slopes of 0-5%
Soil infiltration - C_i	0.12-0.16 No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	0.06-0.08 Normal; well drained light or medium textured soils, sandy loams	0.04-0.06 Deep sand or other soil that takes up water readily; very light, well-drained soils
Vegetal cover - C_v	0.12-0.16 No effective plant cover, bare or very sparse cover	0.08-0.12 Poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface Storage - C_s	0.10-0.12 Negligible; surface depressions few and shallow, drainage ways steep and small, no marshes	0.08-0.10 Well-defined system of small drainage ways, no ponds or marshes	0.06-0.08 Normal; considerable surface depression, e.g., storage lakes and ponds and marshes	0.04-0.06 Much surface storage, drainage system not sharply defined; large floodplain storage, large number of ponds or marshes
Note: The total runoff coefficient based on the 4 runoff components is $C = C_r + C_i + C_v + C_s$				

In the project area the relief is gentle where the slopes are low and range between 0.004and 0.02. In this case the C_r is about 0.08, the infiltration is normal then the Cican have a value of 0.06, the vegetal cover is normal to low then the Cvcan have a value of 0.07, the surface storage is also normal to low then the Cscan have a value of 0.09. Accordingly, the runoff coefficient C is found to be 0.30.

8.2 Unit Hydrograph Method

The unit hydrograph (UH) for a catchment defines the pattern of runoff for the catchment for a unit volume of rainfall in a specified duration (e.g. 1 hour). Where recorded rainfall and river flows are available it is possible to derive the unit hydrograph directly from the data, but for this study empirical methods must be used. The SCS dimensionless UH was used, with the hydrograph peak and time to peak estimated using Snyder's method (1938).

The key parameters of the hydrograph are the unit storm duration, time lag, time to peak and the time base (total duration). Various formulae have been proposed for determining these parameters from catchment characteristics. For large catchments (i.e., between 5 and 5000 km2) Snyder's method is generally recommended, but as the Rational method is easier and in many cases, can fit catchments of less than 15 km2, the Snyder's method will be applied to larger catchments. This method can be summarized as follows:

For the lag time anf the duration of the unit rainfall (time interval) of the hydrograph, the following equations are used:

$$t_L = C*C_t * (L*L_c)^{0.3}$$

$$t_r = \frac{t_L}{5.5}$$

Where:
t_L= lag time (middle of rainfall to UH peak)
L= length of main stream
L_c= length of stream from catchment centroid to outlet
C= factor equal to 1 in English units and 0.75 In SI units
C_t= coefficient
t_r= unit rainfall duration

The value of the coefficient C_t typically lies in the range of 0.45 to 2.25, with the lower values corresponding to catchments with steep slopes. For the study area the range of coefficients, C. C_t has been found between 1.1 and 1.5 to be acceptable.

For the ease of the calculation it is usual to adjust the unit duration to a convenient or standard time interval such as 1/2 , 1, 2 or 3 hours, etc. The modified time lag is then found as follows:

$$T_{LR} = t_L + \frac{t_R - t_r}{4}$$

Where:
t_{LR}= modified lag time
t_R= modified unit rainfall duration

The time to peak and peak flow of the UH are found as follows:

$$t_p = t_{LR} + \frac{t_R}{2}$$

$$q_p = C_p * \frac{A}{t_p}$$

Where:
t_p= time to peak of unit hydrograph (hours)
q_p=peak of unit hydrograph (m^3/s)
A=catchment area ($km^{2)}$
C_p=coefficient

The value of the coefficient CP is of the range of 4 - 5 to give the runoff in m^3/s for 1 inch of effective rainfall (or between 0.16 and 0.2 for 1 mm of effective rainfall). Having in mind that, it is not easy to define the value of $C_P$precisely and it is subject to minor subsequent modification to ensure that the unit hydrograph gives the correct volume of runoff.

Various hydrograph shapes have been postulated, the simplest of which is a triangle. For this study, the more "natural" curved SCS hydrograph has been used. The ordinates of the dimensionless hydrograph are given in **Table 3** and it is illustrated in **Figure 6**; the ordinates are multiplied by q_p to give the UH for the catchment concerned for the relevant multiples of tp.

Since these values will not generally be for convenient numbers of half hours, hourly or two-hourly values (as appropriate) are interpolated. The overall volume of runoff indicated by this adjusted UH is calculated and the UH ordinates are then factored in order to achieve the exact unit runoff required.

Table 3: SCS Dimensionless Unit Hydrograph

T_p = ...		Q_p = ...		T_p = ...		Q_p = ...	
T/T_p		Q/q_p		T/T_p		Q/q_p	
0.00		0.00		1.40		0.75	
0.10		0.02		1.50		0.66	
0.20		0.08		1.60		0.56	
0.30		0.16		1.80		0.42	
0.40		0.28		2.00		0.32	
0.50		0.43		2.20		0.24	
0.60		0.60		2.40		0.18	
0.70		0.77		2.60		0.13	
0.80		0.89		2.80		0.10	
0.90		0.97		3.00		0.08	
1.00		1.00		3.50		0.04	
1.10		0.98		4.00		0.02	
1.20		0.92		4.50		0.01	
1.30		0.84		5.00		0.00	

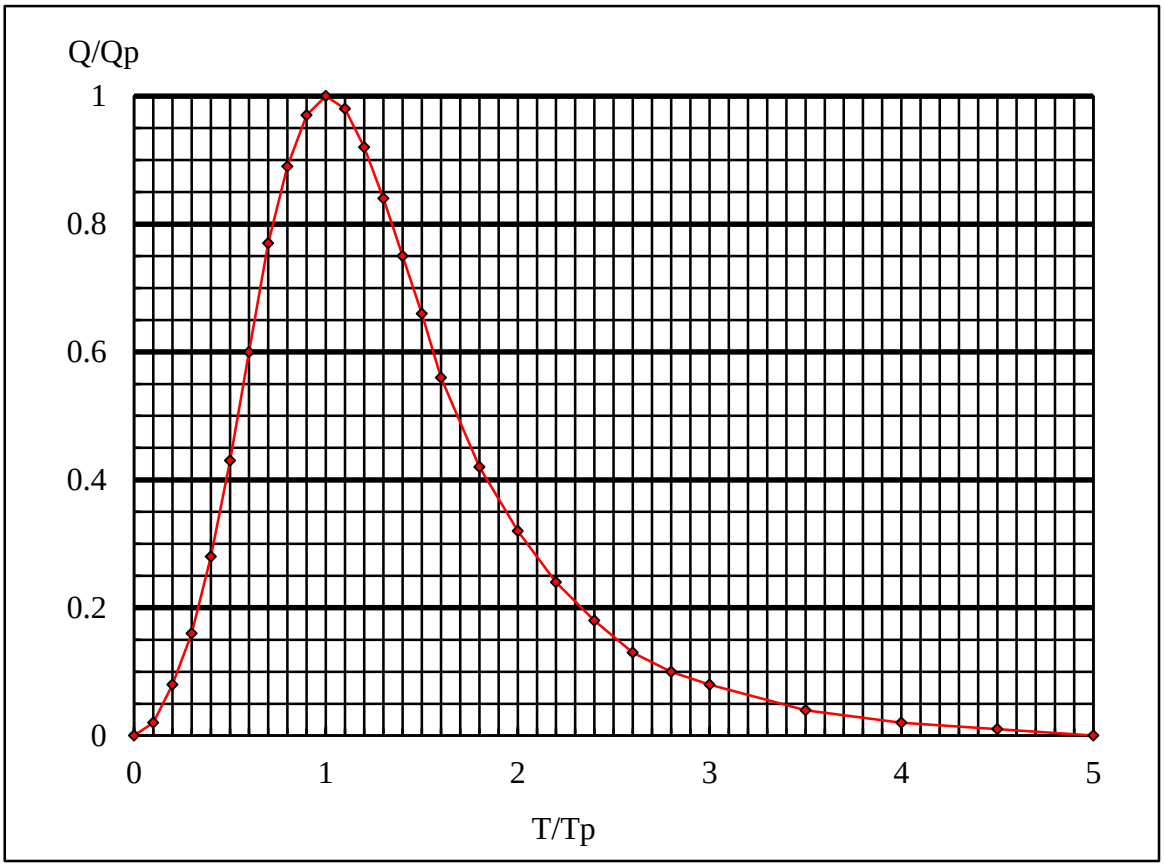

Figure 6: Dimensionless Unit Hydrograph

9.0 FLOOD DETERMINATION

In the following sections, the methodology used in the computation of the flows will be explained and the computation results will be presented.

In small homogeneous catchments or those having area less than 5 km2, the most commonly used method is the “Rational” formula, which is related to the area, slope, time of concentration and the runoff coefficient of the basin.

The derived and drawn IDF curves will be used in knowing the rainfall intensities needed for the “Rational” formula, which is applicable in computing the design floods, might occur in small catchment areas.

There are many formulae used to calculate the time of concentration (i.e., Izzard’s, Kerby’s, Kirpich’s and Kinematics formulae) and they may give different values for the same conditions, in most cases the most common formula is Kirpich’s formula, which can be used in such study which is as follows:

Time of concentration (T_c) recommended by Kirpich’s formula is as follows:

$$t_c = 0.0078\left(\frac{L^{0.77}}{S^{0.385}}\right)$$

Where:
S=Slope of the Catchment [m/m]
L=Longest Wadi(m)
T_c=Time of Concentration [min]

The annual data series of the short duration precipitation for Ruweished have been collected for the Ministry of Water and Irrigation as shown in **Table4.** The statistical analysis of these short duration annual data series of precipitation are presented in **Table 5**.

Table 4: Annual Data Series of the Short Duration Precipitation at Raweished

Annual Maximum Depths (mm)	Duration (min)								
	5	10	15	30	60	120	360	720	1440
1984	0.99	1.54	1.91	2.18	2.83	3.17	3.17	3.45	4.5
1985	3.52	4.05	5.22	5.46	5.8	7.04	13.43	16.47	21.0
1986	2.88	3.58	4.03	5.59	8.18	9.26	19.82	23.03	24.27
1987	2.24	2.93	2.93	3.13	3.57	4.28	8.49	10.83	12.8
1988	2.93	4.32	4.81	7.39	10.26	11.1	11.3	14.34	18.57
1989	5.61	7.64	8.25	15.99	17.37	17.37	17.37	17.37	28.0
1990	1.92	2.22	2.78	4.05	6.97	10.64	18.66	20.68	20.68
1991	5.07	6.47	6.52	6.52	6.52	8.96	14.81	15.55	15.55
1992	1.76	2.82	3.3	5.42	8.59	13.62	21.83	21.83	21.83
1993	1.89	2.78	3.34	4.6	6.55	9.79	11.74	13.1	13.1
1994	5.13	5.98	8.1	8.1	9.57	9.75	10.33	12.07	12.25
1995	3.52	6.67	7.33	7.33	7.33	10.21	19.88	25.04	25.23
1996	4.28	4.72	5.19	6.22	8.03	9	9	9.51	9.51
1997	5.39	5.82	6	6	7.34	8.13	11.68	14.41	14.41
1998	5.19	6.86	6.86	6.86	7.33	11.56	11.58	11.58	11.58
2000	1.56	2.48	2.73	4.49	5.41	5.71	5.71	5.71	5.71
2001	0.91	1.43	2.14	2.63	4.04	6.93	11.56	13.45	16.38
2002	4.69	6.48	7.56	7.88	7.88	7.88	13.56	14.47	14.47
2003	3.12	3.67	4.55	5.78	10.33	14.81	18.36	18.36	18.36
2004	5.28	7.9	9.28	13.32	16.12	16.12	17.87	17.87	17.87
2005	4.38	6.38	7.04	9.53	13.38	14.41	20.39	25.7	30.56

Table 5: Statistical Analysis of Short Duration Annual Precipitation Data Series of Ruweished

Water Year	Duration (min)								
	5	10	15	30	60	120	360	720	1440
Total	72.26	96.74	109.87	138.47	173.40	209.74	290.54	324.82	356.63
Count	21	21	21	21	21	21	21	21	21
Mean	3.44	4.61	5.23	6.59	8.26	9.99	13.84	15.47	16.98
S.D	1.57	2.05	2.23	3.27	3.71	3.73	5.11	5.82	6.80
Reduced Sn	1.0696	1.0696	1.0696	1.0696	1.0696	1.0696	1.0696	1.0696	1.0696
Reduced Y_n	0.5252	0.5252	0.5252	0.5252	0.5252	0.5252	0.5252	0.5252	0.5252

The Gumbel's double exponential distribution has been applied to calculate the IDF information and draw the IDF curves as in **Table 6, 7 and Figure 7**.

Table 6: Rainfall [mm], Duration [min.] & Frequency [year] at Ruweished

Year	Duration (min)								
	5	10	15	30	60	120	360	720	1440
2	3.21	4.30	4.90	6.11	7.71	9.43	13.08	14.60	15.97
3	3.99	5.33	6.02	7.75	9.57	11.30	15.64	17.52	19.38
5	4.87	6.48	7.26	9.58	11.64	13.39	18.49	20.77	23.18
10	5.97	7.92	8.83	11.87	14.24	16.00	22.08	24.85	27.94
25	7.36	9.74	10.80	14.77	17.52	19.31	26.61	30.00	33.97
50	8.39	11.09	12.27	16.93	19.96	21.76	29.97	33.83	38.44
100	9.42	12.43	13.72	19.06	22.38	24.20	33.31	37.62	42.87
200	10.44	13.76	15.17	21.19	24.79	26.62	36.64	41.40	47.29

Table 7: Rainfall [mm], Duration [min.] & Frequency [year] at Ruweished

Year	Duration (min)								
	5	10	15	30	60	120	360	720	1440
I2	38.50	25.81	19.61	12.22	7.71	4.72	2.18	1.22	0.67
I3	47.94	31.99	24.07	15.50	9.57	5.65	2.61	1.46	0.81
I5	58.45	38.86	29.05	19.15	11.64	6.69	3.08	1.73	0.97
I10	71.66	47.50	35.30	23.74	14.24	8.00	3.68	2.07	1.16
I25	88.35	58.42	43.20	29.55	17.52	9.65	4.44	2.50	1.42
I50	100.73	66.52	49.06	33.85	19.96	10.88	5.00	2.82	1.60
I100	113.02	74.56	54.88	38.12	22.38	12.10	5.55	3.14	1.79
I200	125.26	82.57	60.68	42.38	24.79	13.31	6.11	3.45	1.97

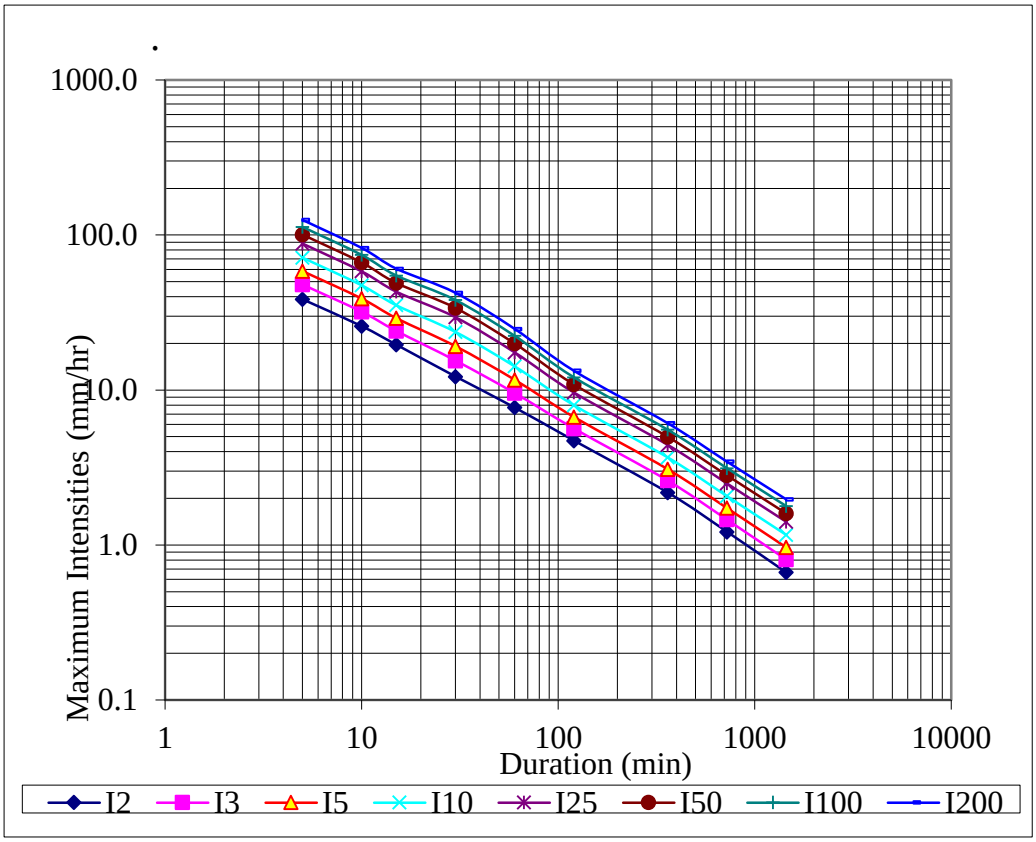

Figure 7: Rainfall IDF Curves at Ruweished

Using **Table 7 and/or Figure 7**, the best fit trend line can be drawn for the rainfall intensities and find the equation and regression coefficient as they can be used in the derivation of the rainfall intensities relevant to any time of concentration.

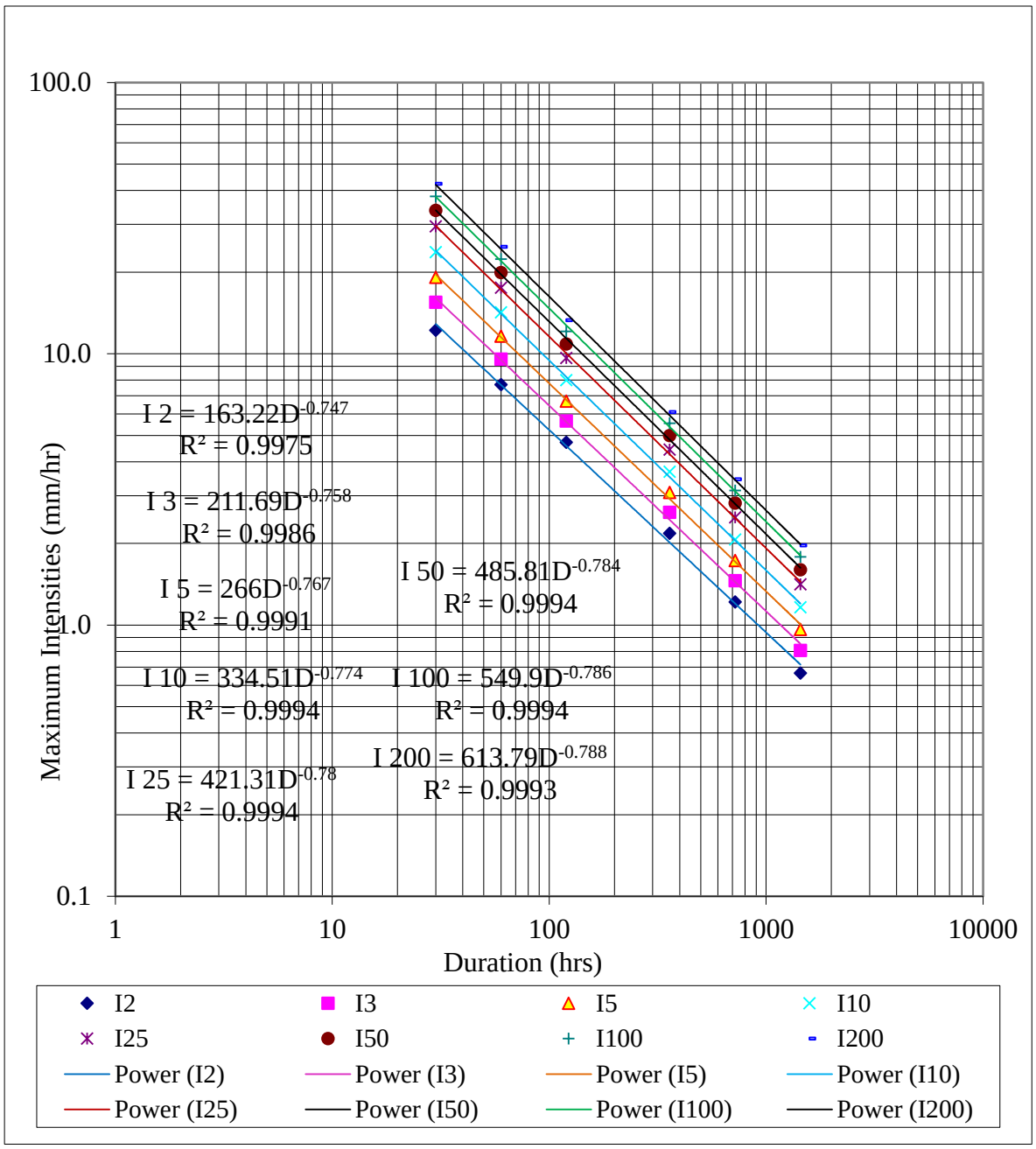

Figure 8: Best Fit Distribution (Power Trend Line) for the IDF Curves of Ruweished

The hydrological calculation for the available catchment areas within the project has been computed.

10.0 DESIGN FLOODS

The intensities and discharges for 50 and 100 year frequency have been computed for each sub catchment and presented in **Table 8**.

Table 8: Catchment Characteristics &Competed Intensities & Discharges (Rational Method)

Area No.	Area / Sq. Km	Length (m)	Elev. Diff. (m)	Slope (m/m	Time of Concent. Minutes	I mm 50-yr	I mm 100-yr	Runoff Coeff. C	Discharge (m^3/sec) (50-yr)	Discharge (m^3/sec) (100-yr)
A1[3]	22.023	8.56	35.0	0.004	Unit Hydrograph method				11	15
A2	1.173	2.57	20.5	0.008	52.86	28.99	33.82	0.3	2.833	3.305
A3	2.039	2.35	21.0	0.009	47.11	31.97	37.36	0.3	5.432	6.349
A4	0.054	0.28	5.0	0.018	10.00	119.18	142.56	0.3	0.541	0.647
A5	0.105	0.52	12.0	0.023	10.31	116.11	138.83	0.3	1.015	1.214

10.1 Unit Hydrograph Method for Design Floods of Catchment A1

The method used for determining the design floods for 50-year and 100-year return periods.

10.1.1 Unit Effective Rainfall

Only part of the rainfall will contribute directly to runoff (i.e. will be effective). The process of evaporation or percolation to groundwater will lose the rainfall remained.

The total losses from any rainfall storm are generally divided into two parts:

- Initial losses (interception by plants, filling the small depressions over the ground surface and covering the soil moisture deficit)
- Continuing loses (infiltration/percolation).

Table 9: Hourly Distribution of Rainfall Intensities Relevant to Frequencies Indicated

Hour	Minute	50-years	100-years
1	60	19.6	22.0
2	120	11.4	12.7
3	180	8.3	9.3
4	240	6.6	7.4
5	300	5.6	6.2
6	360	4.8	5.4

[3] Floods of catchmentA1 have been estimated by using Unit Hydrograph Method

Table 9 (cont'd): Hourly Distribution of Rainfall Intensities Relevant to Frequencies Indicated in Ruweished

Hour	Minute	50-years	100-years
7	420	4.3	4.8
8	480	3.8	4.3
9	540	3.5	3.9
10	600	3.2	3.6
11	660	3.0	3.3
12	720	2.8	3.1
13	780	2.6	2.9
14	840	2.5	2.8
15	900	2.3	2.6
16	960	2.2	2.5
17	1020	2.1	2.4
18	1080	2.0	2.3
19	1140	2.0	2.2
20	1200	1.9	2.1
21	1260	1.8	2.0
22	1320	1.7	1.9
23	1380	1.7	1.9
24	1440	1.6	1.8

The most common procedure for estimating initial losses is to use the SCS (US Soil Conservation Service) method. This method estimates the initial losses, based on a curve number, which depends on land use, soil type, hydrologic condition and land development (if applicable, e.g. terraced). A high curve number yields low losses and hence high effective rainfall and runoff.
For selecting the curve number, the following assumptions have been made:

Land use : Mostly bare soil with some pasture/range or vegetation.
Soil types : Groups A to B with moderate to low runoff potential
Hydrologic condition : fair

The SCS tables give a curve numbers about 73 for the above conditions for the average antecedent moisture condition (AMC class II) for the average antecedent condition indicated to be represented by rainfall of 13-28 mm in the previous 5 days.

The SCS equation (originally developed for rainfall in inches) for estimating total losses (in millimeters) using the selected curve number (CN) convenient to the relevant area is as follows:

$$S = \frac{25400}{CN} - 254$$

The loss of initial abstraction (Ia), is the total loss of the rainfall occurring before the start of the runoff (i.e., before ponding). This value covers the interception, the filling of serface depressions, the filling of soil moisture deficit and sometimes, in hot climates the evaporation may occur before the runoff. In addition to this each soil type might have a potential moisture retention (S'). Then, the total losses (S) can be given by the summation of (Ia) and (S').

$$I_a = 0.2 * S$$

Where:
S = total losses [mm]
CN = curve number (78 for the project area).
I_a = initial abstraction [mm]

For the condition of CN = 78:

$$\mathbf{S = \frac{25400}{CN} - 254}$$

$$S = 108.86 \text{ mm}$$

$$I_a, = 0.2*S = 21.77 \text{ mm}$$

The SCS method contains equations for estimating losses throughout a storm; the cumulative losses during the storm increase until they reach the estimated S total losses. This would only happen in a very severe event; thereafter all rainfall is effective. An alternative procedure for estimating the continuing losses (i.e., the infiltration) is the Φ-index, which states that the loss rate is a fixed rate in mm/hour; effective rainfall is therefore zero when the rainfall intensity drops below this rate.

This approach is generally considered preferable for the type of conditions encountered in Ruweished area. With this method, small rainfalls are automatically considered ineffective, whereas some other rainfalls would always be effective. However, it requires the estimation of the loss rate.

For the soils prevalent over most of the study area, rates of minimum infiltration of 1 mm/hour is considered appropriate for the wadi A1 in the study area. **Tables 10 and 11** show the derivation of effective rainfall over the basin as an example, for the return period of 50 and 100 years respectively, assuming this infiltration rate and by using IDF curves derived for Ruweished rainfall distribution.

Table 5: Effective Rainfall Calculation at Ruweished {50-Year} For Wadi A1 (Wadi Athanah)

Time (hours)	Rain intensity P(mm/hr)	Cumulative Rainfall (mm)	Areal Reduction Factor	Cumulative Areal Rain (mm)	P Increment (mm)	Nested Profile (mm)	Cumulative storm rain (mm)	P - Ia	Profile P - Ia	Effective** Rain (mm)
0	0									
1	19.6	19.627	0.818	16.054	16.054	0.393	0.393	0.000	0.000	0.000
2	11.4	22.797	0.867	19.775	3.721	0.426	0.819	0.000	0.000	0.000
3	8.3	24.884	0.890	22.147	2.372	0.465	1.284	0.000	0.000	0.000
4	6.6	26.479	0.903	23.922	1.775	0.513	1.797	0.000	0.000	0.000
5	5.6	27.786	0.912	25.354	1.433	0.574	2.371	0.000	0.000	0.000
6	4.8	28.902	0.919	26.564	1.209	0.655	3.026	0.000	0.000	0.000
7	4.3	29.881	0.924	27.615	1.051	0.767	3.793	0.000	0.000	0.000
8	3.8	30.755	0.928	28.547	0.933	0.933	4.726	0.000	0.000	0.000
9	3.5	31.548	0.932	29.388	0.841	1.209	5.935	0.000	0.000	0.000
10	3.2	32.274	0.934	30.155	0.767	1.775	7.710	0.000	0.000	0.000
11	3.0	32.945	0.937	30.861	0.706	3.721	11.430	0.000	0.000	0.000
12	2.8	33.570	0.939	31.516	0.655	16.054	27.484	10.551	10.551	9.551
13	2.6	34.156	0.941	32.127	0.612	2.372	29.856	12.923	2.372	1.372
14	2.5	34.707	0.942	32.701	0.574	1.433	31.289	14.356	1.433	0.433
15	2.3	35.228	0.944	33.243	0.542	1.051	32.340	15.407	1.051	0.051
16	2.2	35.723	0.945	33.756	0.513	0.841	33.181	16.247	0.841	0.000
17	2.1	36.194	0.946	34.244	0.488	0.706	33.887	16.953	0.706	0.000
18	2.0	36.643	0.947	34.709	0.465	0.612	34.498	17.565	0.612	0.000
19	2.0	37.074	0.948	35.153	0.444	0.542	35.040	18.107	0.542	0.000
20	1.9	37.487	0.949	35.579	0.426	0.488	35.528	18.594	0.488	0.000
21	1.8	37.884	0.950	35.987	0.409	0.444	35.972	19.039	0.444	0.000
22	1.7	38.266	0.951	36.381	0.393	0.409	36.381	19.447	0.409	0.000
23	1.7	38.636	0.951	36.760	0.379	0.379	36.760	19.826	0.379	0.000
24	1.6	38.992	0.952	37.126	0.366	0.000	36.760	19.826	0.000	0.000

Table 6: Effective Rainfall Calculation at Ruweished {100-Year} For Wadi A1 (Wadi Athanah)

Time (hours)	Rain intensity P(mm/hr)	Cumulative Rainfall (mm)	Areal Reduction Factor	Cumulative Areal Rain (mm)	P Increment (mm)	Nested Profile (mm)	Cumulative storm rain (mm)	P - Ia	profile P - Ia	Effective** Rain (mm)
0										
1	22.0	21.981	0.818	17.980	17.980	0.434	0.434	0.000	0.000	0.000
2	12.7	25.496	0.867	22.116	4.136	0.470	0.904	0.000	0.000	0.000
3	9.3	27.807	0.890	24.749	2.633	0.513	1.417	0.000	0.000	0.000
4	7.4	29.573	0.903	26.716	1.968	0.567	1.984	0.000	0.000	0.000
5	6.2	31.019	0.912	28.304	1.587	0.634	2.618	0.000	0.000	0.000
6	5.4	32.253	0.919	29.643	1.339	0.724	3.342	0.000	0.000	0.000
7	4.8	33.335	0.924	30.807	1.163	0.848	4.190	0.000	0.000	0.000
8	4.3	34.301	0.928	31.839	1.032	1.032	5.222	0.000	0.000	0.000
9	3.9	35.177	0.932	32.768	0.930	1.339	6.561	0.000	0.000	0.000
10	3.6	35.979	0.934	33.616	0.848	1.968	8.529	0.000	0.000	0.000
11	3.3	36.720	0.937	34.396	0.780	4.136	12.665	0.000	0.000	0.000
12	3.1	37.410	0.939	35.120	0.724	17.980	30.645	13.711	13.711	12.711
13	2.9	38.057	0.941	35.796	0.676	2.633	33.278	16.344	2.633	1.633
14	2.8	38.665	0.942	36.431	0.634	1.587	34.865	17.932	1.587	0.587
15	2.6	39.240	0.944	37.029	0.598	1.163	36.028	19.095	1.163	0.163
16	2.5	39.786	0.945	37.596	0.567	0.930	36.958	20.025	0.930	0.000
17	2.4	40.305	0.946	38.134	0.538	0.780	37.739	20.805	0.780	0.000
18	2.3	40.801	0.947	38.647	0.513	0.676	38.415	21.481	0.676	0.000
19	2.2	41.276	0.948	39.138	0.490	0.598	39.013	22.080	0.598	0.000
20	2.1	41.732	0.949	39.608	0.470	0.538	39.551	22.618	0.538	0.000
21	2.0	42.170	0.950	40.059	0.451	0.490	40.042	23.108	0.490	0.000
22	1.9	42.592	0.951	40.493	0.434	0.451	40.493	23.560	0.451	0.000
23	1.9	42.999	0.951	40.911	0.418	0.418	40.911	23.978	0.418	0.000
24	1.8	43.392	0.952	41.315	0.404	0.000	40.911	23.978	0.000	0.000

10.2 Design Floods Estimation

Table 12 shows the catchment hydrological and time parameters that will be used in deriving the unit hydrograph.

Table 12: Calculation of Snyder's Synthetic Unit Hydrograph Parameters

Wadi Name	Length L(km)	C * Ct	Lc L(km)	Lag Time t1= $C*Ct(L*Lc)^{0.3}$	Duration of Rainfall Tr (Hrs)
Wadi A 1	8.56	1.30	3.72	3.671	0.667

Lag Time t'l (Hrs)	Standard Time t'r (Hrs)	Area (Km^2)	Cp	UH Qpk (m^3/s)	UH Tpk (Hrs)
3.75	1.00	22.02	0.20	1.15	4.25

Corrected Cp	Corrected UH Qpk (m3/s)	Highest Elev. (m)	Lowest Elev. (m)	Slope (%)
0.1797	0.17974	885.00	850.00	0.41

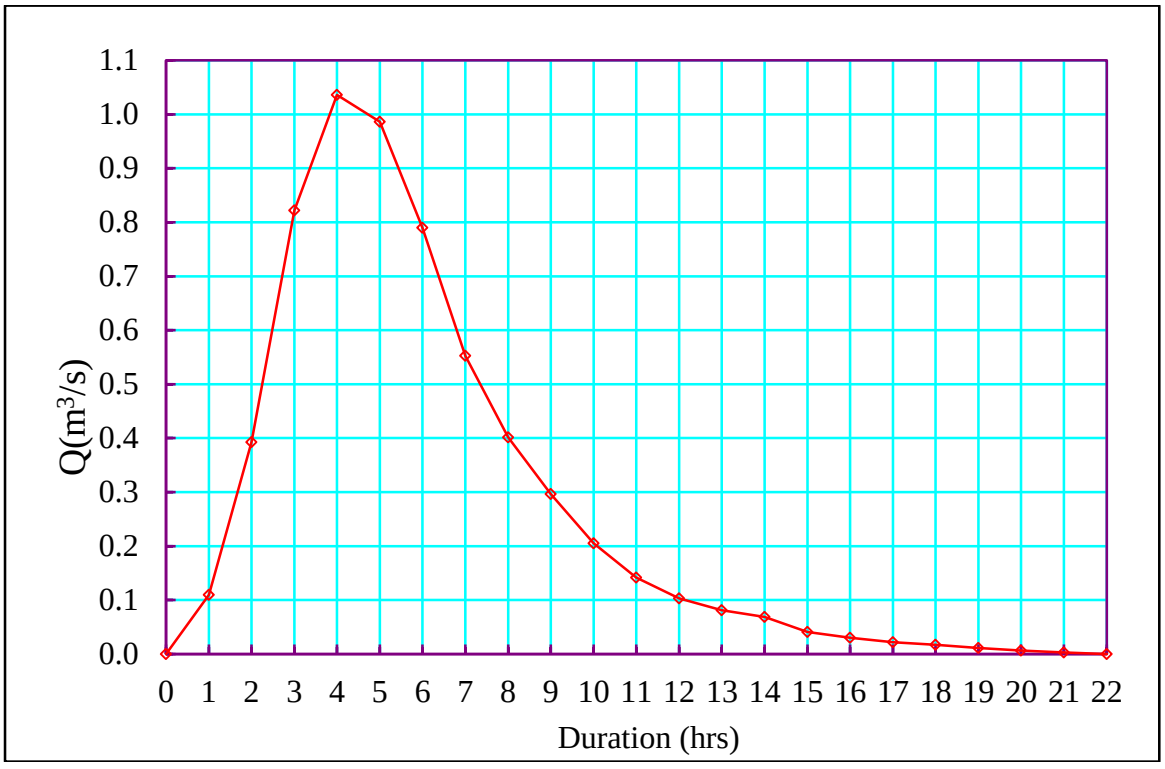

Figure 9: 1-Hourly. 1-mm Synthetic Unit Hydrograph for Wadi Athanah

By using the effective rainfalls for the 50-year and 100-yearand the derived unit hydrograph, the resulted peak floods and their hydrographs have been illustrated in **Table13** and illustrated in a combined **Figure 10.**

Table 13: Computed Design Floods for Wadi Athanah

T [Years]	Computed
	Q [m3/s]
50	11
100	15

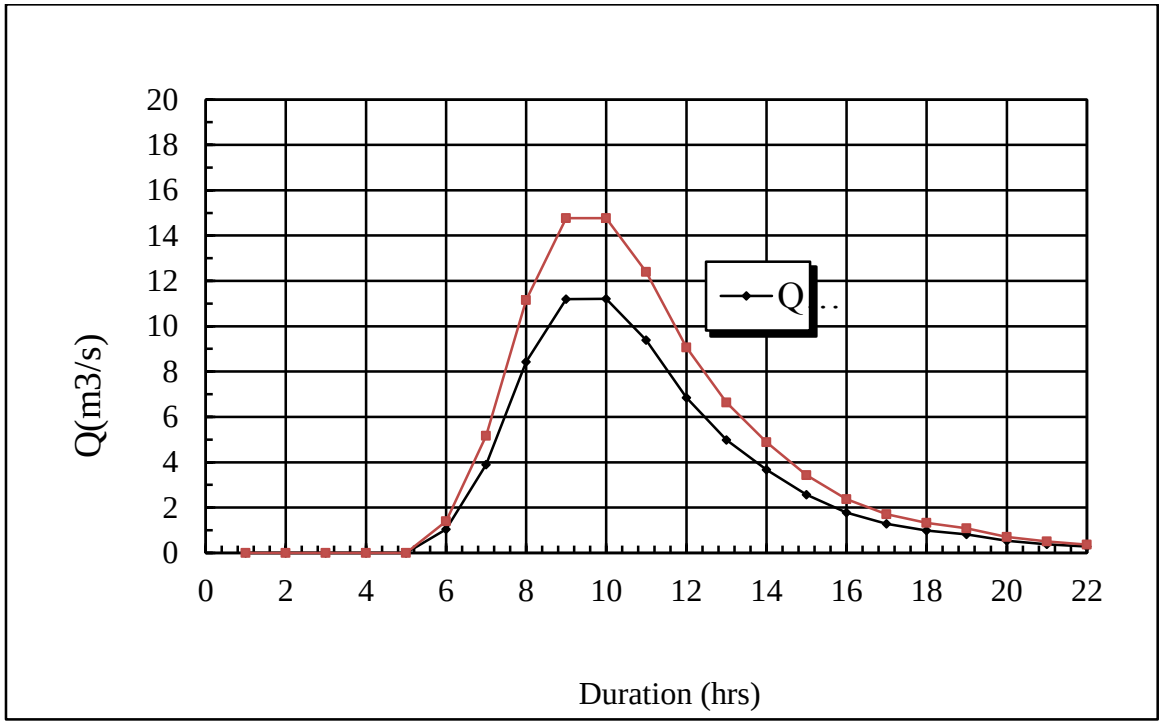

Figure 10: 50-year and 100-yead Flood Hydrographs for Wadi Athanah

11.0 DESIFG CEITERIA FOR HYDRAULIC STRUCTURES

11.1 Hydraulic Design

The hydrological study aims to provide the peak flood estimates that determine the required design discharge for the cross project drainage structures. It is necessary to estimate the flow that crosses the project in order to convey these flows safely across the project.

The selected hydraulic structure should be sufficient to transfer the floodwater from one side of the project to the other safely; proper hydraulic study was carried out to those locations. Some locations might need diversions to be added.

The hydraulic design is usually covering the sizing of the drainage structures needed for the project including:

- Channels of various sizes and types.
- Side ditches to drain small basins located near the project.
- Side protection for the project.

11.2 Hydraulic Design

For the design of diversion channels, wherever applicable, the Manning's Equation is normally used. Manning's Equation can be summarized as follows:

$$Q = \frac{A*(R)^{2/3}*S^{1/2}}{n}$$

Where:
A = cross sectional area of the water in the culvert or ditch [m^2]
R= hydraulic radius equals to the division of the cross sectional area to the wetted perimeter of the section [m]
S = slope of the culvert [m/m]
n = Manning's coefficient

The above mentioned method is being applied for the frequency of design floods of 50 and 100-year.

The following channel and diversions dikes are proposed as shown in **Figure 11.**

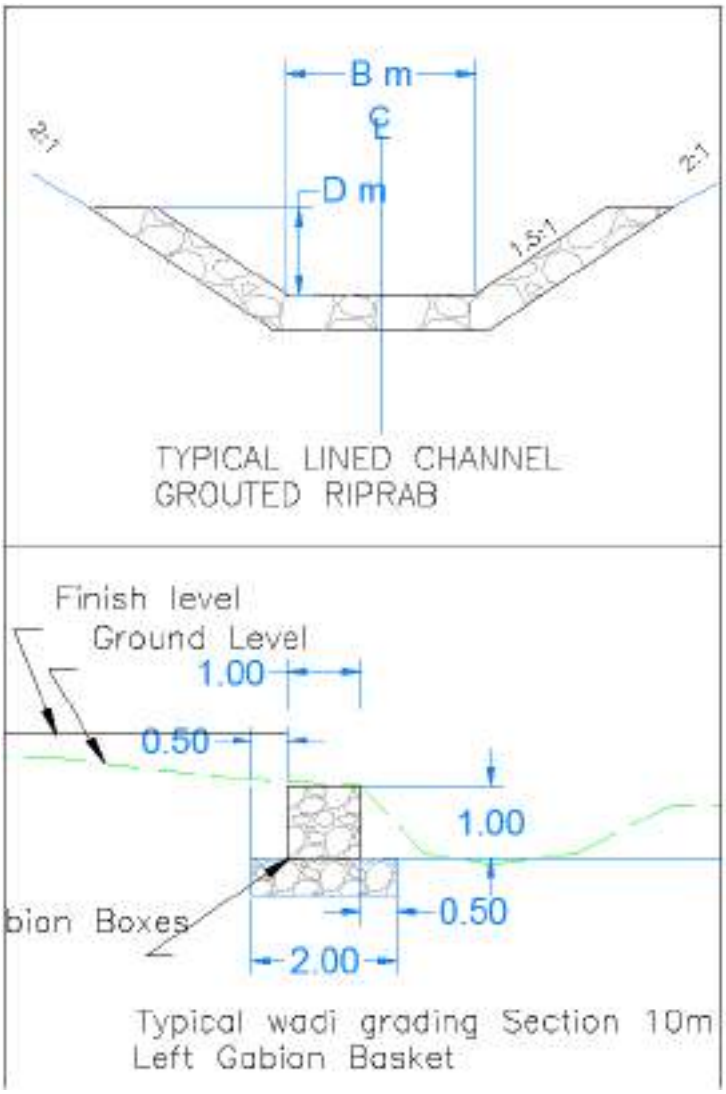

Figure 11: Typical Protection Works

12.0 SUMMARY

1. The storm water has been studied and designed based on the existing topographic condition.
2. Gentle slopes are dominant in the plot of the project area where the general catchment slopes are less than 0.6%.
3. The nearest Ruweished IDF curves have been used in the computation
4. The runoff water runs in wide streams and the maximum water depth around 20 to 30 cm and spread over wide drains in the lower parts of the site.
5. For maintenance proposes and to serve the site in all weather condition, it is recommended to define the lower parts of the wadi banks by means of creating depression within in the flooding plain in order to guide the flood to a well-defined outflow path.
6. If any road to cross the channel of the wadi or any recommended channel at any location, it should cross over culvert having cross sectional area capable of discharging the design flood from one side to the other without damaging the proposed roads.
7. The design and layout of photovoltaic arrays of the project should be protected by providing PVC sleeves at each channel crossing.

13.0 RECOMMENDATIONS

13.1 Alternative-1

1. The storm water has been transported outside the site by means of channels.
2. Two types of channels have been proposed for this site, Channels lined with grouted riprap type, and or diversion with gabion retaining structures.
3. The South west wadi (Wadi-1, Wadi-2), catchment (area A1) merges with wadi-1 generated from catchment area (A2) this location can be treated with either Grouted riprap lined channel along with the wadi course, or by creating new diversion channel at the south west border to guide the water to be diverted outside the site, this option recommend excavating 10m wide earth channel and the inner side is to be built with gabion basket as shown in **Figure 12.**
4. other wadis are drained through lined channels as shown in the following **Table 14.**

Table 14: Computed Design Floods for Wadi Athanah

Diam	WADI CROSS SECTION						
	OPTION-1 with Gabion on the inner side	OPTION-2 lined channel	Lined Channel	Lined Channel	Lined Channel	Lined Channel	Lined Channel
	A1 (WADI-1)	A1 (WADI-1)	A2	A3	A4	A5	A6
Bed Width	10	5	2	2	1	0.5	0.5
Height	1	1	0.6	0.75	0.6	0.5	0.5
Area	10	6.5	1.74	2.34	1.14	0.625	0.625
Slope	0.004	0.006	0.007	0.009	0.014	0.018	0.023
P	13	8.61	4.16	4.704	3.163	2.303	2.303
R	0.769	0.755	0.418	0.498	0.360	0.27	0.27
Capacity	15.17	17.11	3.25	5.59	2.73	1.4	1.59
Velocity	1.52	2.63	1.87	2.38	2.39	2.25	2.54

13.2 Alternative-2

The storm water runs in wide wadis and spread over wide width with maximum water depth from 20 to 30 cm above the ground and with non-erosive velocities, the distribution of photovoltaic arrays have been designed without any consideration to the water courses existence, if the **owner** finds that it is the only way to construct his project, then it is recommended to grade the wadi courses natural ground to the extent of water flood boundaries and the foundation of the photovoltaic arrays should be protected against scouring , the recommended scour protection is depending on the foundation types, (addition of reinforced concrete casing for adepth of 60 cm to 1.0m below the ground and 50 cm above the ground) as shown in **Figure 12** below.

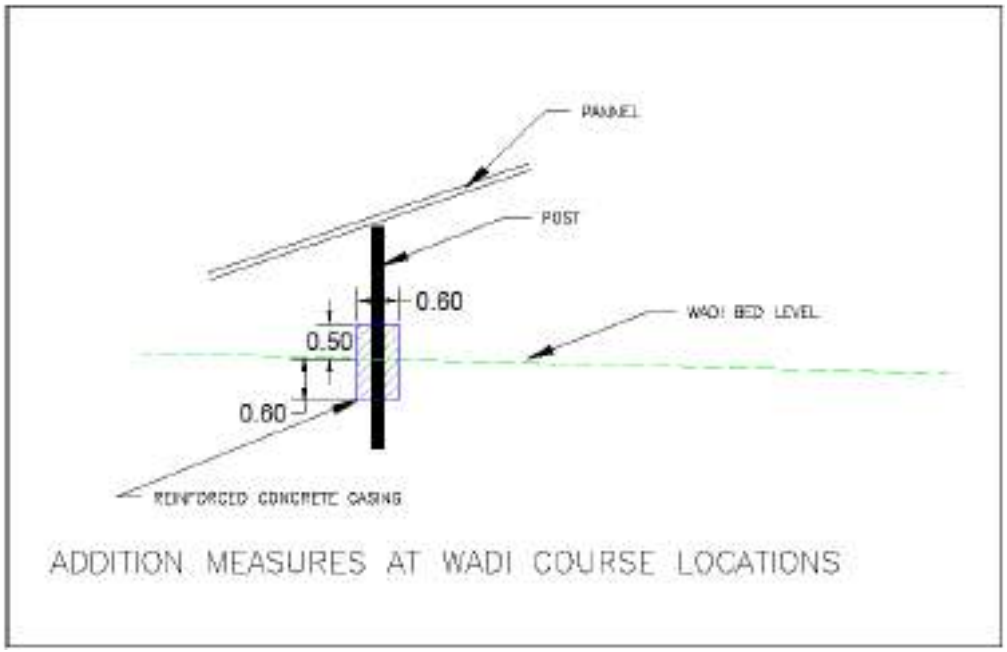

Figure 12: Scour Protection at Foundation Support

14.0 ACES CONFIDENTIALITY & PROPRIETARY RIGHTS

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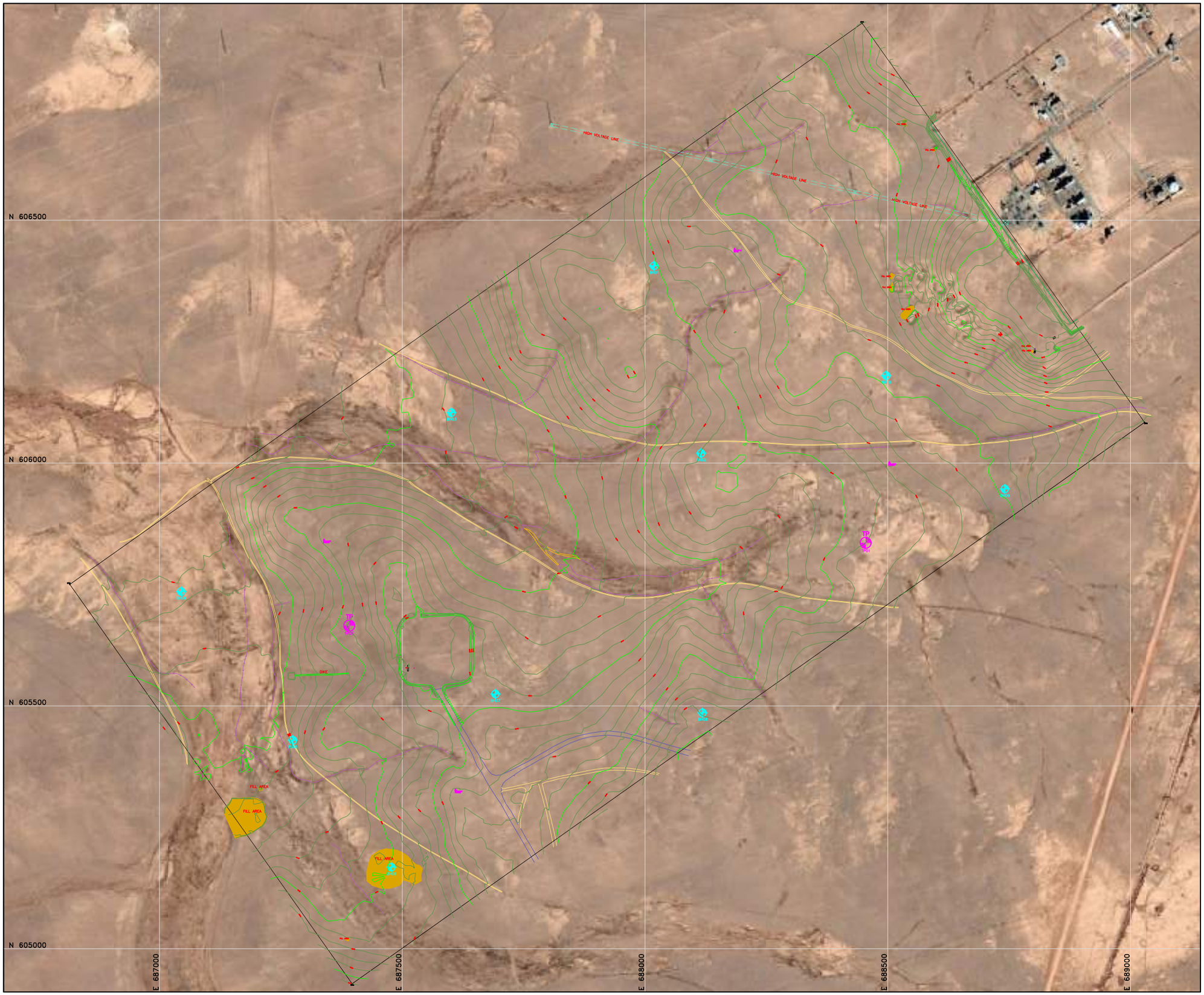
Attachments
Plans & Profiles



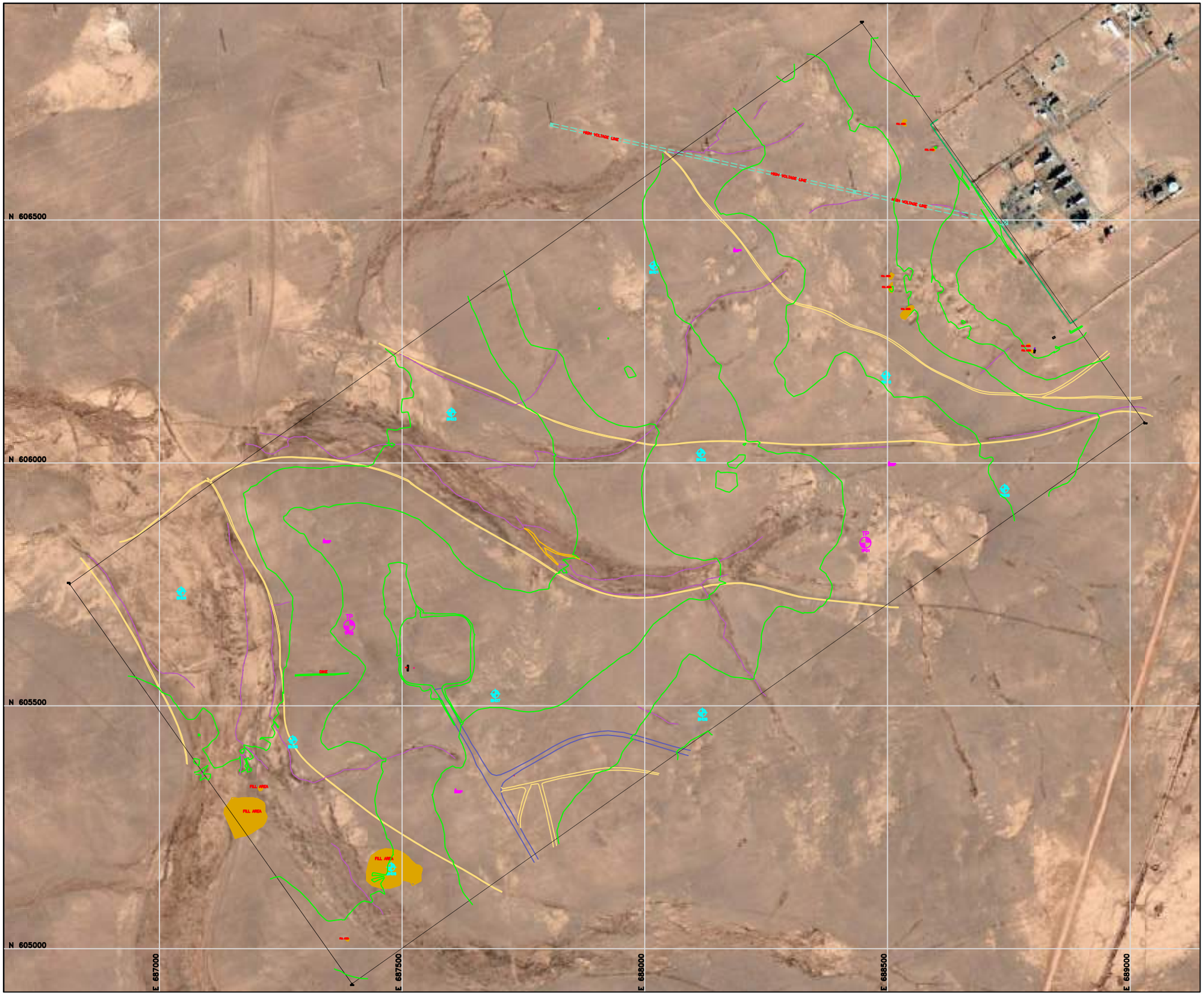
REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

TITLE:

AL RISHA SOLAR PV PLANT

SITE PLAN

DATE		SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	
DRAWN BY		DRAWING NO.	
CHECKED BY			



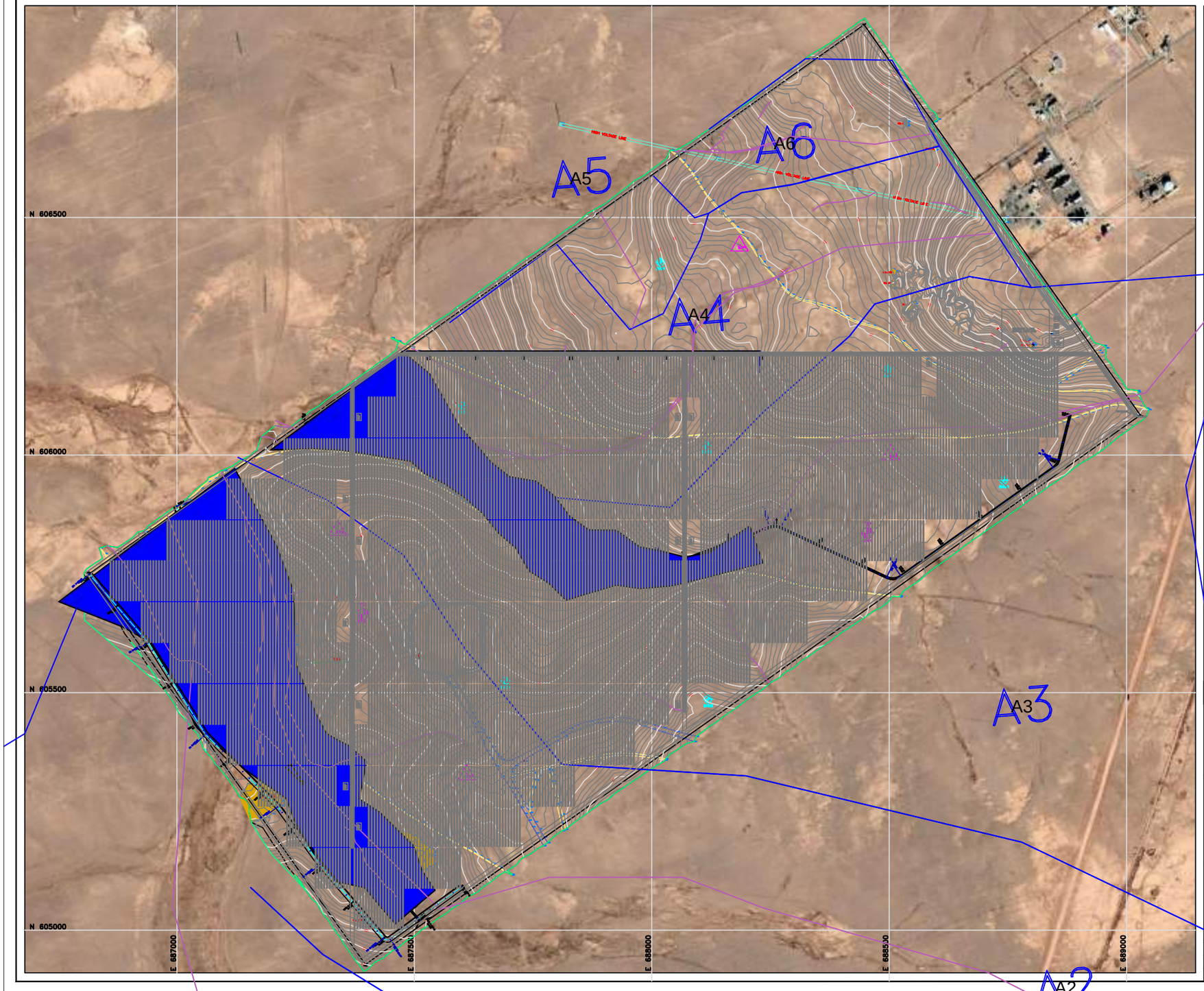
REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

ACES

TITLE:

AL RISHA SOLAR PV PLANT

DATE		SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	
DRAWN BY		DRAWING NO.	
CHECKED BY			



SYMBOLS TYPE :-

	WELL
	RESERVOIR
	RAIN MANHHOLE
	WATER MANHOLE
	FIRE HYDRANT
	SEWERAGE MANHOLE
	SEPTIC-TANK
	GATE
	HIGH VOLTAGE PYLON
	ELECTRIC POLE
	ELECTRIC BOX
	WATER VALVE
	ELECTRIC MANHOLE
	LIGHT POLE (1,2,3,4 LIGHS)
	SIGN BOARD
	TRAFFIC LIGHT
	TRAFFIC SIGN
	FLAGPOLE
	TREE
	TELPHONE BOX
	TELEPHONE MANHHOLE
	TELPHONE POLE
	REFERANCE POINT
	BUILDING ROOF EINCO
	CULVERT INFORMATION

LINE TYPE :-

	FENCE
	WATER PIPE LINE
	BUILDING
	CANAL
	WALL
	ASPHALTED ROAD
	CONT-MIN
	CONT-MAJR
	STONE WALL
	GUARD RAIL
	CURBED ROAD
	TREE LINE
	BENJERSEY

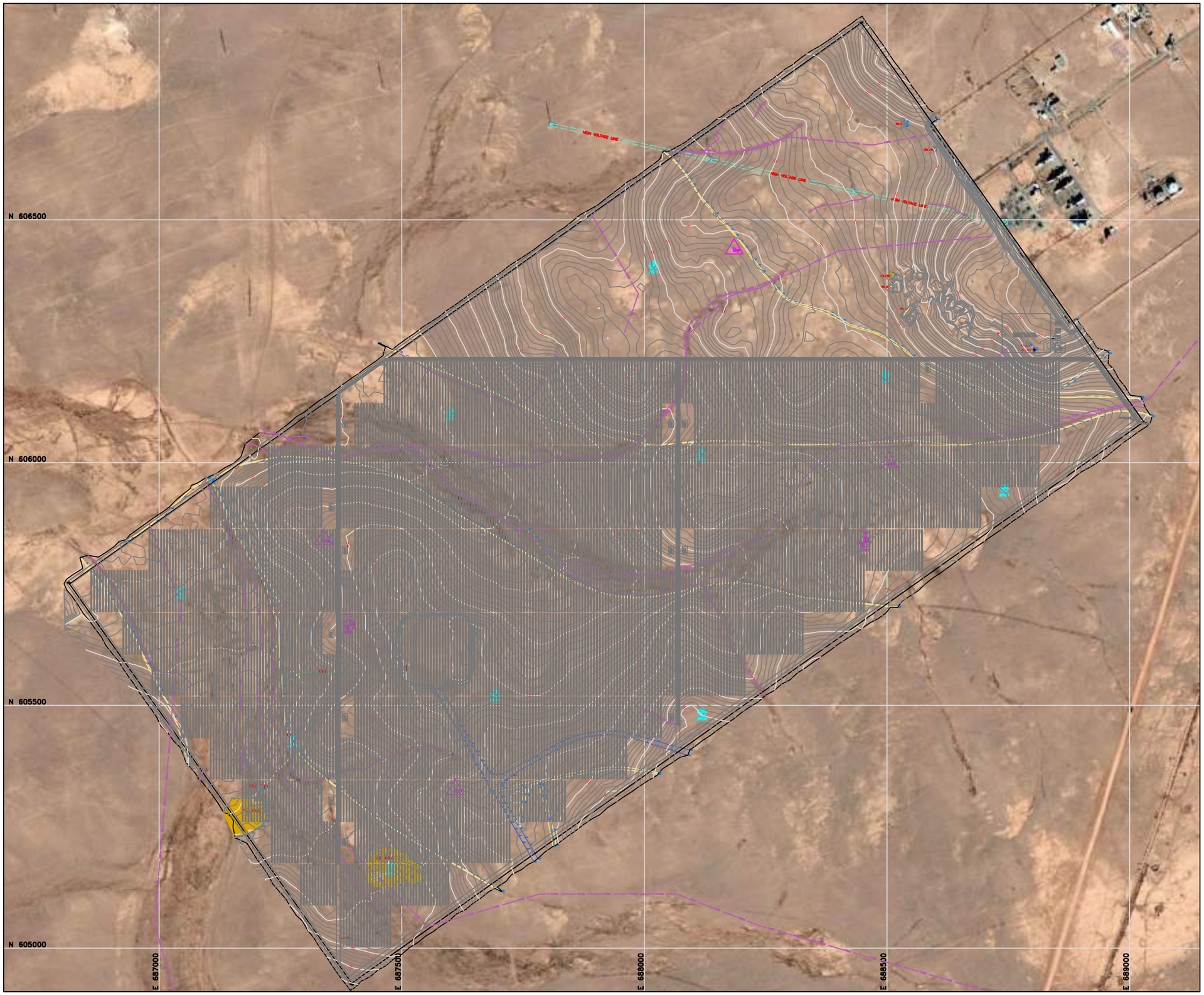
REFERANCE POINT

Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0683)	687339.150	605841.508	855.733
BM2(MA0682)	688184.835	606440.149	861.752
BM3(MA0681)	688503.511	606001.025	861.313
BM4(MA0684)	687610.200	605327.061	858.872

TITLE:

AL RISHA SOLAR PV PLANT
TOPOGRAPHIC PLAN

DATE	06/02/2017	SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	Survey Works
DRAWN BY	KHALIL N.	DRAWING NO.	1
CHECKED BY	Ahmad Al Omari		



REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT

EXISTING CONDITION

DATE	20/02/2017	SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	HYDROLOGY
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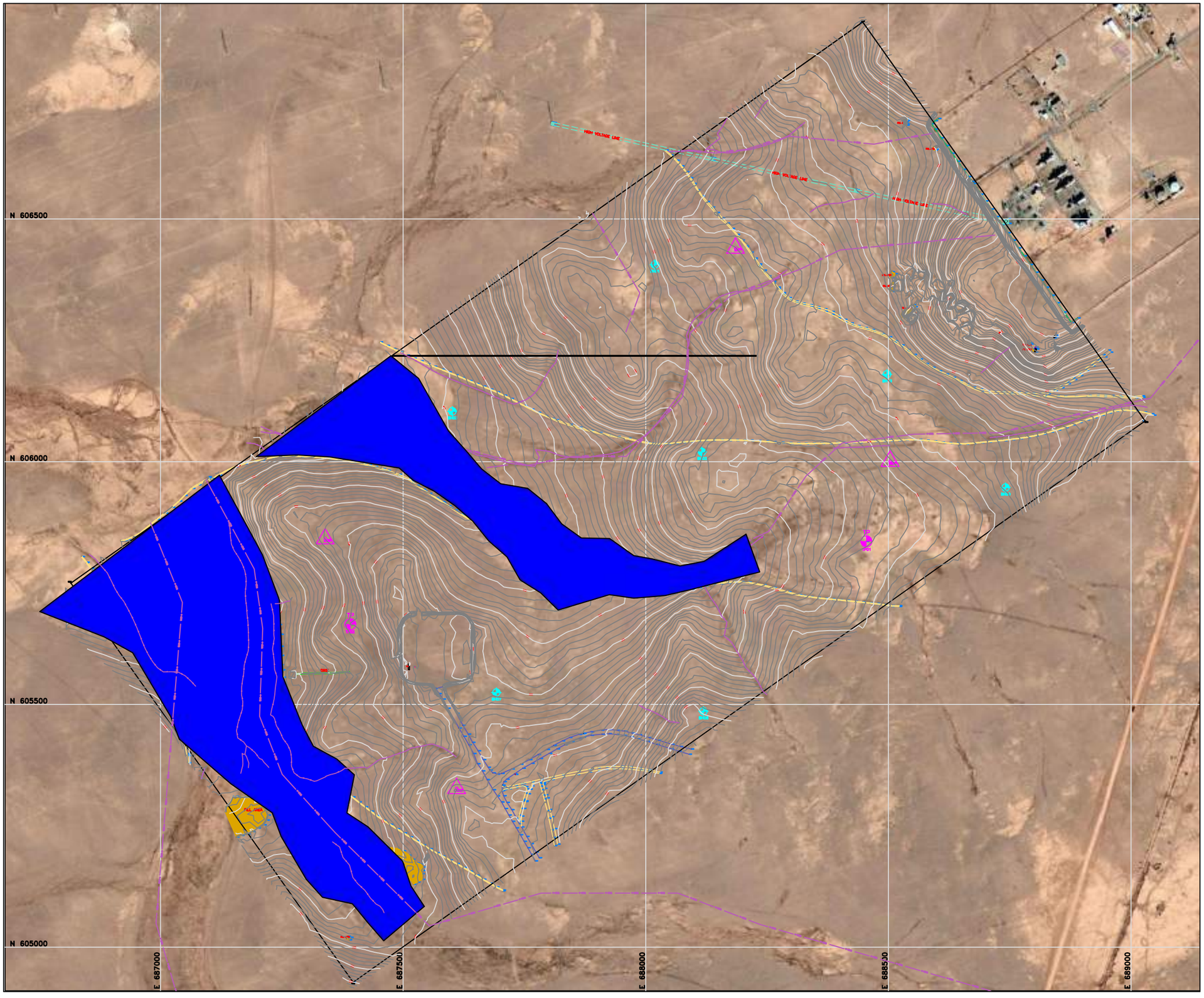
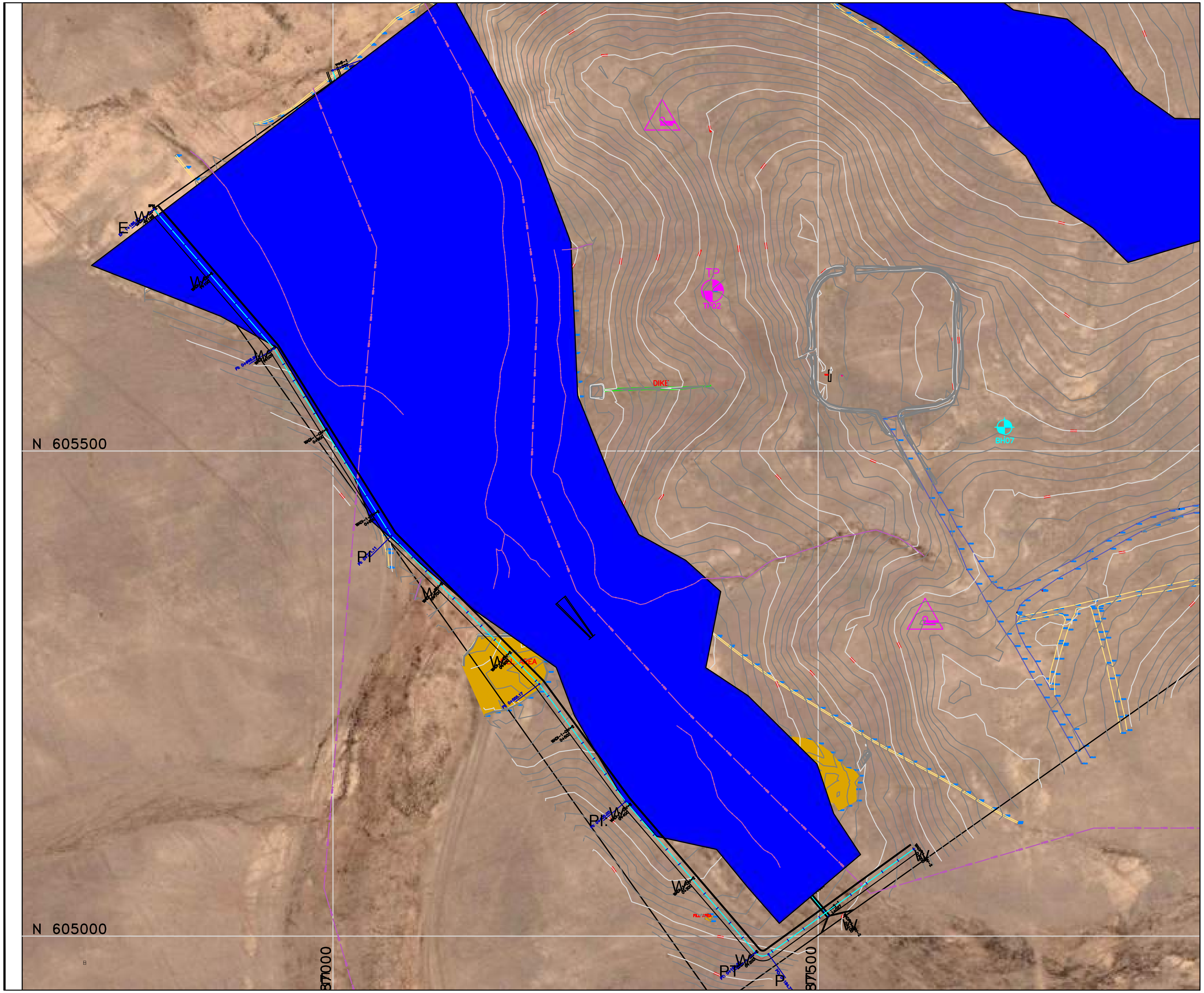
CHECKED BY	F.N		



REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT
FLOODING PLAN

DATE	20/02/2017	SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	FLOODING PLAN
DRAWN BY	F,N	DRAWING NO.	2
CHECKED BY	F,N		

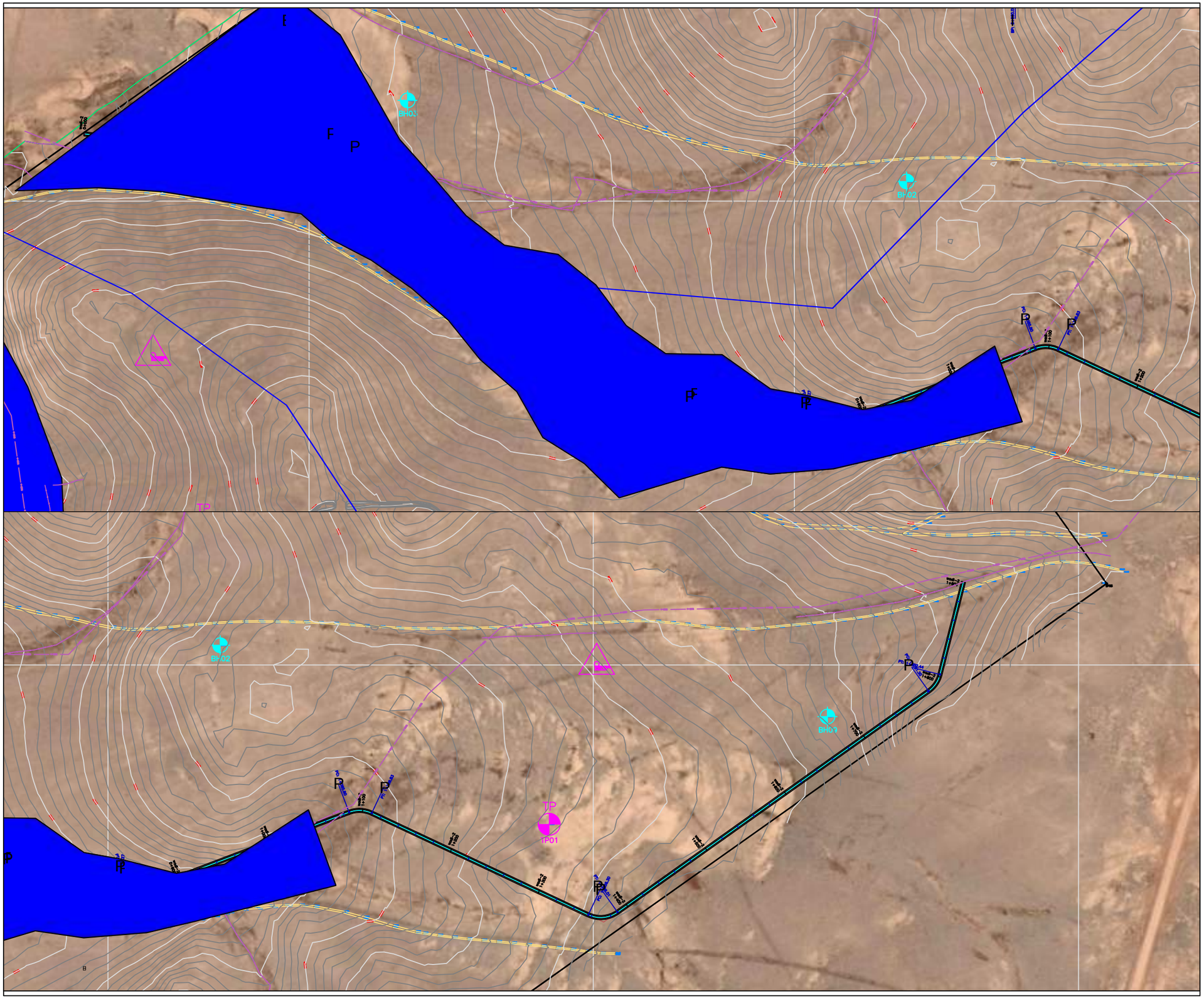


REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT

WADI–1&2 TREATMENT

DATE	20/02/2017	SCALE	1 : 500
SUBMITTAL NO.		DRAWING TITLE	CHANNELS
DRAWN BY	F.N	DRAWING NO.	3
CHECKED BY	F.N		



REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT

WADI-3 TREATEMENT

DATE	20/02/2017	SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	WADI-3
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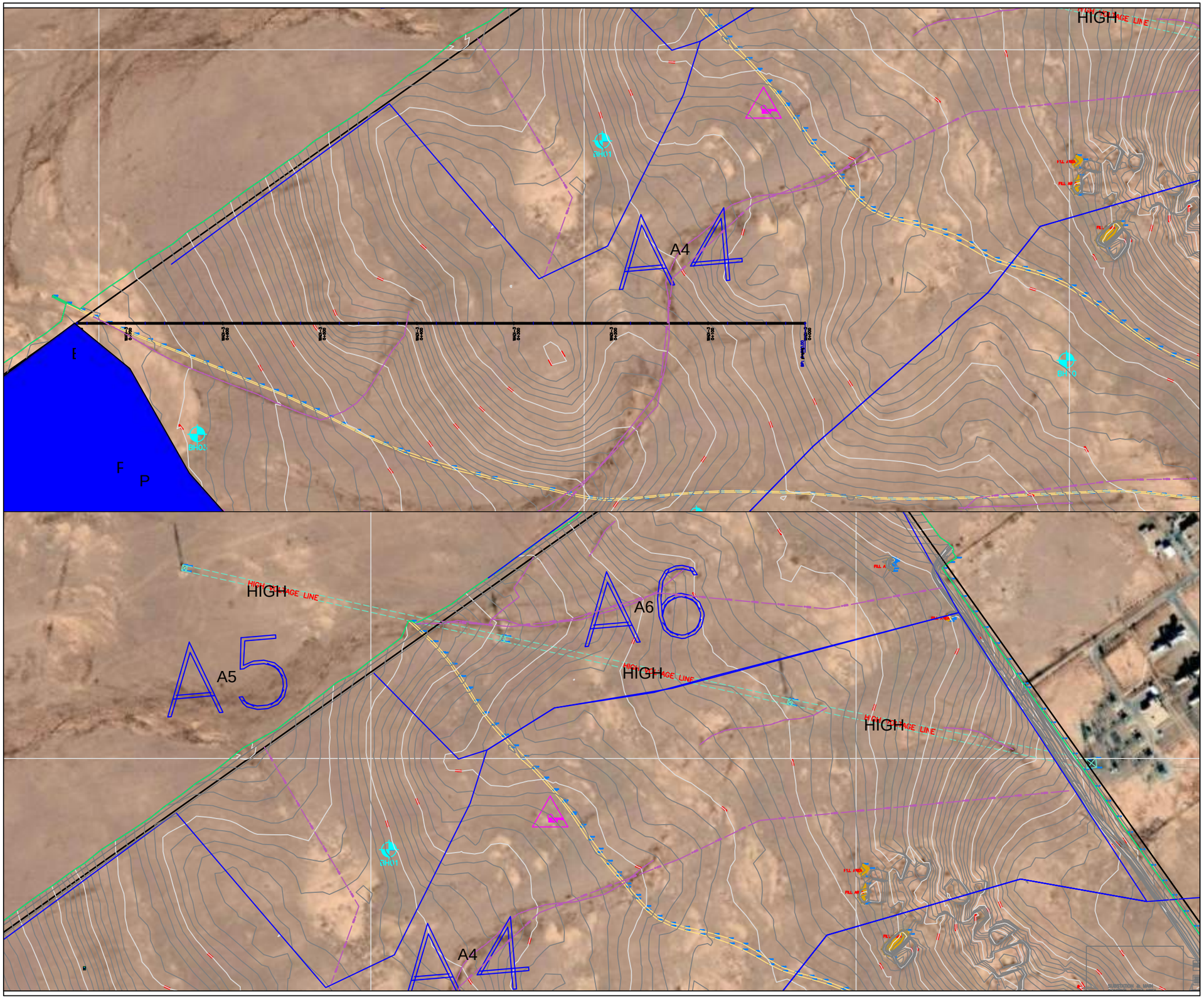
CHECKED BY	F.N		



REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT

WADI-4 TREATEMENT

DATE	20/02/2017	SCALE	1 : 500
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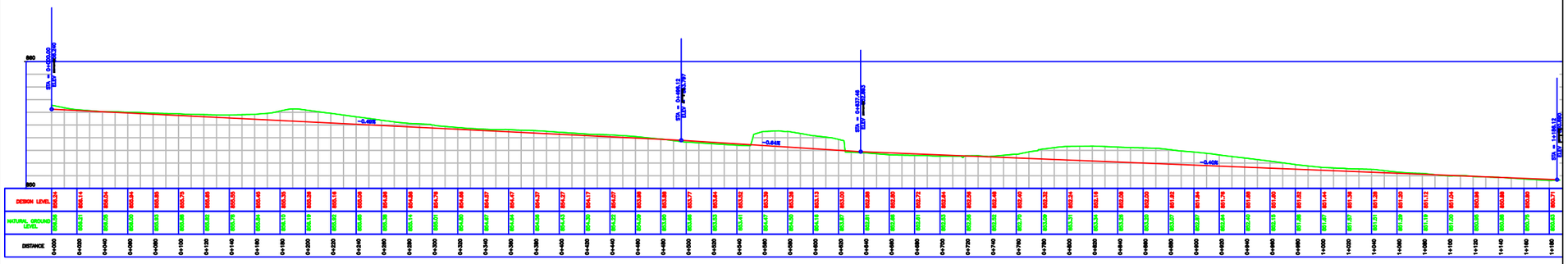
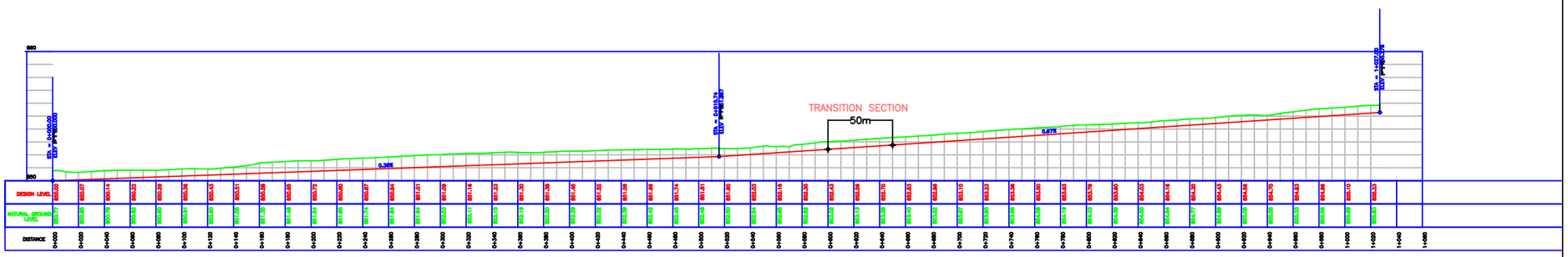
CHECKED BY	F.N		

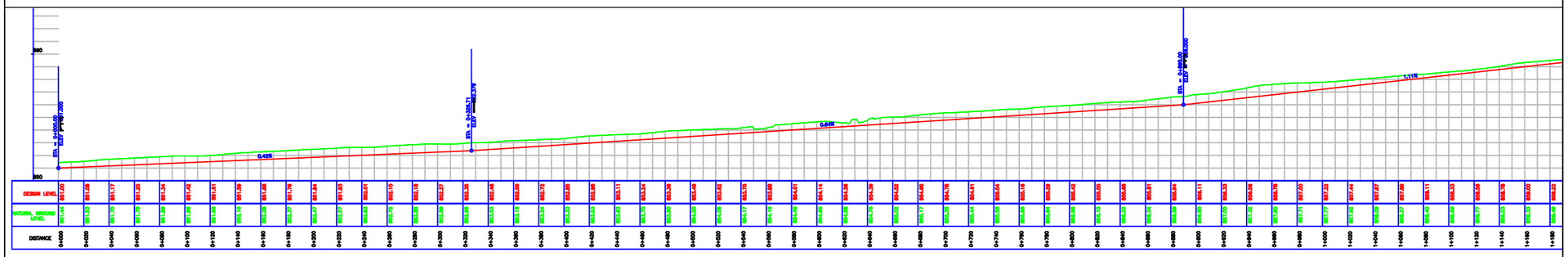


WADI–1–DIV–2 PROFILE
10.0m X1.0m

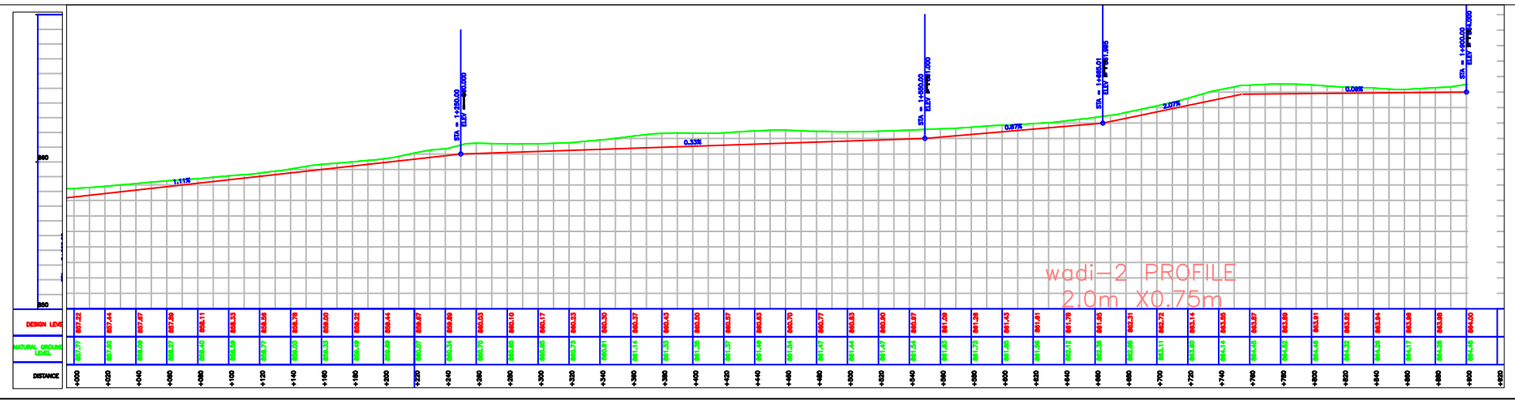


wadi–1 PROFILE
5.0m X1.0m

wadi–1 PROFILE
2.0m X0.60m



wadi–2 PROFILE
2.0m X0.75m



wadi–2 PROFILE
2.0m X0.75m

REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT
PROFILE FOR WADI–1,2,3

DATE	20/02/2017	SCALE	1 : 500
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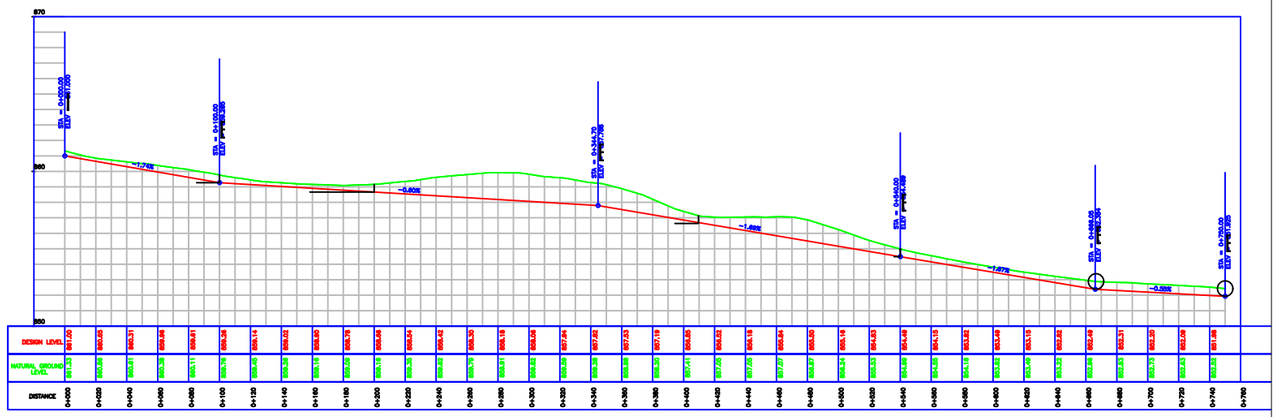
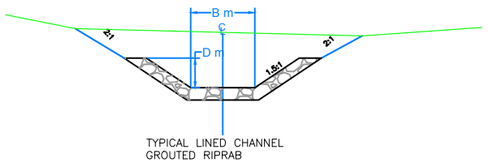
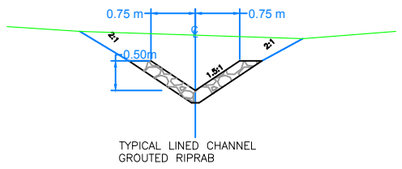
CHECKED BY	F.N		



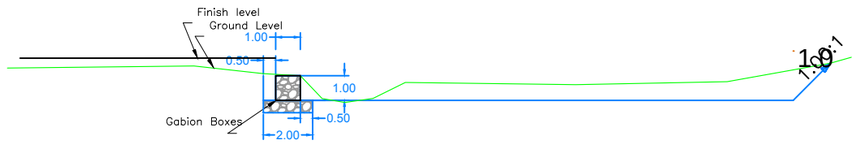
WADI–3 PROFILE
0.50m X0.50m



TYPICAL LINED CHANNEL
GROUTED RIPRAB



TYPICAL LINED CHANNEL
GROUTED RIPRAB



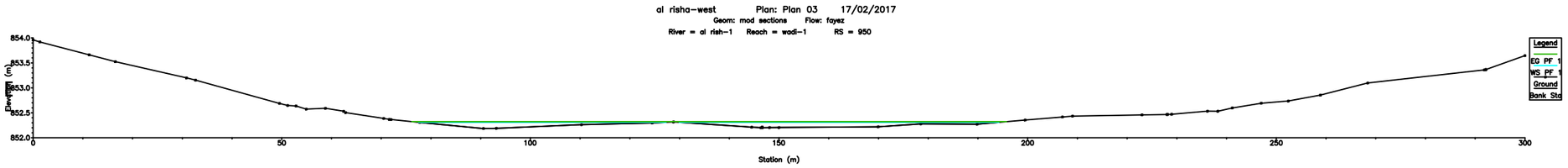
Typical wadi grading Section 10m
Left Gabion Basket

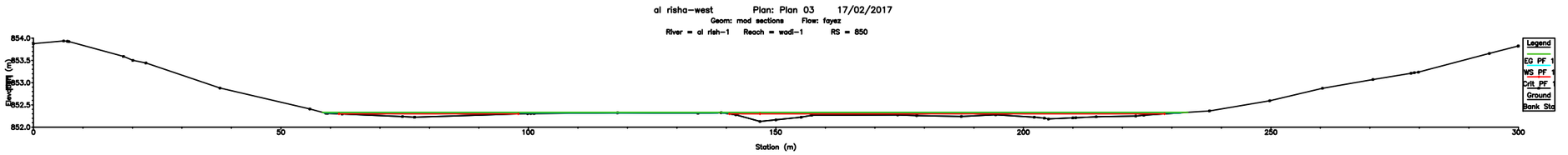
REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

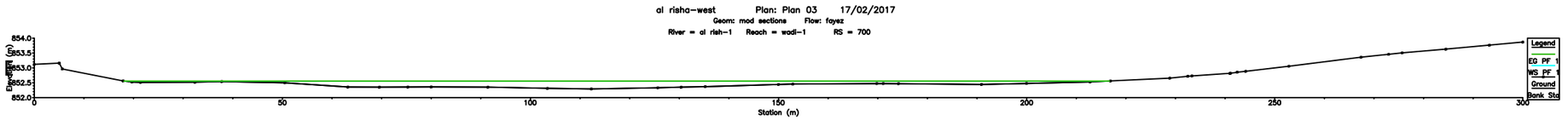
AL RISHA SOLAR PV PLANT

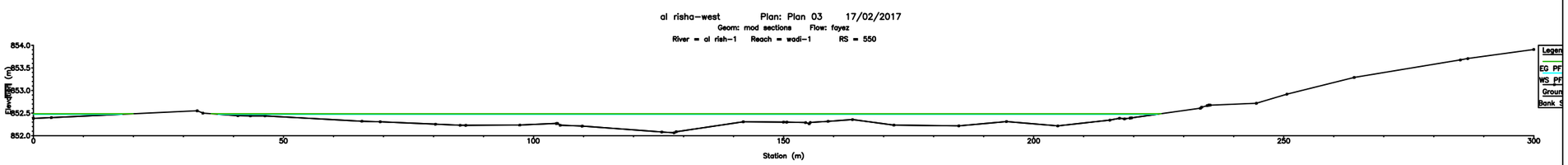
PROFILE FOR WADI–4
TREATMENTS DETAILS

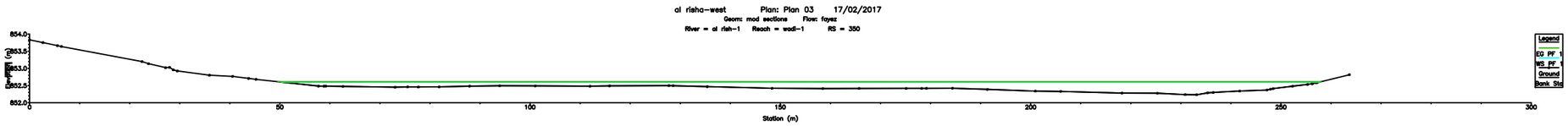
DATE	20/02/2017	SCALE	1 : 1000
SUBMITTAL NO.		DRAWING TITLE	PROFILE+DETAILS
DRAWN BY	F.N	DRAWING NO.	7
CHECKED BY	F.N		











REFERANCE POINT			
Po. No.	EASTING	NORTHING	ELEV.
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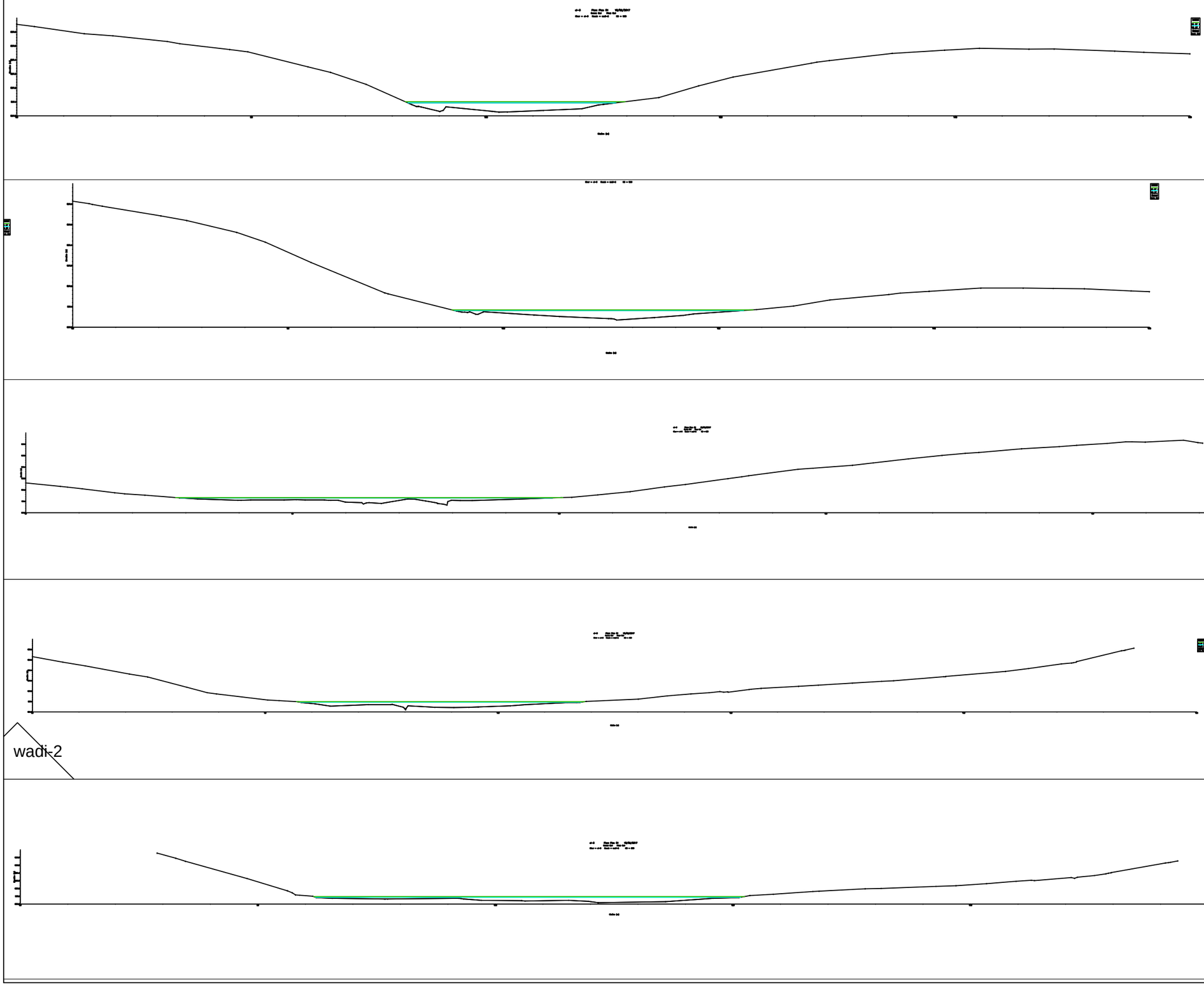
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT
CROSS SECTIONS-WADI-1,2

DATE	20/02/2017	SCALE	1 : 200
SUBMITTAL NO.		DRAWING TITLE	CROSS SECTIONS
DRAWN BY	F.N	DRAWING NO.	8
CHECKED BY	F.N		



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BM1(MA0883)	687339.150	605841.508	855.733
BM2(MA0882)	688184.835	606440.149	861.752
BM3(MA0881)	688503.511	606001.025	861.313
BM4(MA0884)	687610.200	605327.061	858.872

AL RISHA SOLAR PV PLANT

PROFILE FOR WADI-4
TREATMENTS DETAILS

DATE	06/02/2017	SCALE	1 : 200
SUBMITTAL NO.		DRAWING TITLE	CROSS SECTION
DRAWN BY	F.N	DRAWING NO.	9
CHECKED BY	F.N		