Compendium of figures
**North Surat Basin geology subcrop and MNES Springs**

**Legend:**
- **Springs**
- **Monitoring Wells – Hutton & Precipice**
- **QGC ATP 852**
- **QGC PL/ATP**
- **QCLNG EIS Tenement Boundary**
- **Gubberamunda Top Subcrop**
- **Springbok Top Subcrop**
- **Walloon Subgroup Top Subcrop**
- **Walloon Subgroup Base Subcrop**
- **Hutton Top Subcrop**
- **Precipice Top Subcrop**

**Scale:** 1:450,000 (A3)

Figure ES2 – Outcrop of shallow GAB aquifers
QCLNG Project Area Groundwater Data Baseline Periods

QCLNG Northern Gas Field production commences in October 2014

QCLNG Central Gas Field production commences in October 2013

Depressurisation commenced in 2005 for domestic gas production

QCLNG Southern Gas Field production commences in October 2013

---

**Legend**

- **Town**
- **Major Road**
- **Major River**
- **Current Production Blocks**
- **QCLNG Project Area**

**Vibrating Wire Piezometers**

- Existed, More than 1 year of data before QCLNG Production Starts
- Proposed, More than 1 year of data before QCLNG Production Starts

**Monitoring Bores**

- Existed, More than 1 year of data before QCLNG Production Starts
- Proposed, More than 1 year of data before QCLNG Production Starts
- Proposed, Less than 1 year of data before QCLNG Production Starts

**Data Availability by QGC Block**

- More than 1 year of data before QCLNG Production Starts
- Less than 1 year of data before QCLNG Production Starts
- Other QGC Blocks

**Formation to be Monitored**

- A Alluvium
- G Gubberamunda
- W Westbourne Formation
- S Springbok Sandstone
- E Eurombah Sandstone
- H Hutton Sandstone
- P Precipice Sandstone
Approx. 5 km

Mooga Formation
Orallo Formation
Gubberamunda Sandstone
Westbourne Formation
Springbok Sandstone
Walloon Subgroup
Eurombah Formation
Hutton Sandstone
Evergreen Formation
Precipice Sandstone

Figure ES12 – Great Artesian Basin detailed facies model
Produced water and treatment collection and distribution networks: Northern, Central and Southern Gas Fields

Pump
Existing ponds
Under construction or to be built
Development blocks

Figure ES13 – Produced water and treatment collection and distribution networks: Northern, Central and Southern Gas Fields
Figure 1 – The QCLNG gas field project area
**WMMP STAGES**

- CSG water monitoring and management plan
- Groundwater Monitoring Plan (GWMP)
- Regional groundwater model
- Underground Water Impact Report (UWIR)
- Bore baseline assessment
- Farm bore monitoring
- Aquifer hydraulic connectivity
- Injection feasibility and pilot trials
- Springs monitoring program
- Subsidence monitoring program

**Figure 3 – QCLNG Project water flows**
Figure 4 – GEN2 regional groundwater model boundaries
Figure 6 – QGC's aquifer characterisation strategy

**STAGE 2 WMMP**

**DATA AQUISITION**
- Drilling (coring, logging, well testing)
- Seismic
- Dynamic testing (production / injection trials)
- Monitoring

**GROUNDWATER IMPACT ASSESSMENT**
- Drawdowns estimates and hydrodynamics changes
- Impacts and risks
- Response actions
- Mitigation / make good measures

**AQUIFER INJECTION FEASIBILITY**
- Containment
- Injectivity
- Feasibility impact assessment
- Costs and risks
- Aquifer injection Conceptual FDP

**Existing data** (wells, seismic)

Geological modelling
- Geomechanical modelling
- Geochemical modelling

Geological modelling (structural, facies and property)

**GEN3 Model**

Dynamic and scenario modelling

- Potentiometric surface mapping
- Aquifer connectivity

**Groundwater level data**

**Groundwater chemistry**

**QWC regional model**

**Springs management**

'Make good' provisions

Demonstration of expanded knowledge for future modelling
Figure 7 – Maximum modelled drawdown contours in Hutton Sandstone at 2025
Figure 8 – Surat Basin NW-SE geological cross section
Note: The use of the term aquifer is used in a relative sense.

Figure 9 – Heterogeneity of Springbok Formation
Figure 10 – Stage 1 monitoring bores and core hole conversions 2011
Figure 11 – Piper diagram of groundwater quality

- Gubberamunda
- Lower Springbok
- Mid Springbok

PPY – Poppy
KEE – Kenya East
BEL – Bellevue
BWS – Berwyndale South
LRN – Lauren
Figure 12 – Water monitoring bores in the Springbok Sandstone

Water Monitoring Bores
Springbok Sandstone

- Town/City
- Registered water bores – Gubberamunda

Water bores in Springbok Sandstone
- Completed Baseline Assessments
- Registered Water Bores – DERM
- Principal Road
- QGC Field
- QGC Field 20 km Buffer

Scale 1:1,300,000 (A3)
Figure 16 – Groundwater levels in Gubberamunda and Springbok Sandstone monitoring bores in central and southern leases 2011/12
Figure 17 – Berwyndale South GW1 (Gubberamunda) groundwater depths

Data logger GW level (m bTOC)

- Pumping test
- Manual readings (m bTOC)

October 2011
December 2011
February 2012
Figure 18 – Berwyndale South GW2 (Springbok) groundwater depths

- Pumping test
- Data logger GW level (m bTOC)
- Manual readings (m bTOC)
Figure 20 – Status of bore baseline assessments
Figure 22 – Schematic of nested monitoring bores and VWPs
Figure 23 – Groundwater monitoring bores and VWPs
Figure 25 – The connectivity knowledge cycle

Knowledge cycle

- Review of strategy and approach
- Assessment of leakage rates
- Local scale modelling and analysis
- Fundamental studies and conceptual model evolution
- Baseline monitoring (including core studies and pumping tests)
- Field monitoring and measurement (including hydrochemistry)

Applications

- Regional modelling: Prediction of timing and magnitude of impacts
- Early warning (Springs): Guides response actions
- Early warning (Private bores): Guides response actions
- Strategy development: Guidance for technical / economic feasibility of mitigation strategies
- Operational planning: Informs the Field Development Plan regarding acceptable impacts

Outcomes

- Fundamental studies and conceptual model evolution
- Assessment of leakage rates
- Local scale modelling and analysis
- Baseline monitoring (including core studies and pumping tests)
- Field monitoring and measurement (including hydrochemistry)

Review of strategy and approach

- Fundamental studies and conceptual model evolution
- Assessment of leakage rates
- Local scale modelling and analysis
- Baseline monitoring (including core studies and pumping tests)
- Field monitoring and measurement (including hydrochemistry)
Figure 30 – Springs in the Northern Surat Basin

- Town / City
- Springs within 100 km of modelled drawdown
- Other springs
- Principal road
- Extent of estimated modelled drawdown (QGC GEN2 Model) in northern direction of springs
- QCLNG Project Area
- 100 km from estimated modelled drawdown

Scale 1:1,200,000 (A3)
Injun Creek Group includes the Westbourne Formation, Springbok Sandstone, WMC and the Eurombah Formations where they occur.

Figure 31 – Inferred regional groundwater flow directions and spring elevations
Figure 32 – Cockatoo Creek Springs conceptual model

- Eurombah Formation
- Hutton Sandstone
- Evergreen Formation
- Precipice Sandstone
- Torsdale Volcanics (Carboniferous)

Horizontal Scale 1:200,000
Vertical Scale 1:5,000
40 x Vertical Exaggeration

Note: Cockatoo Creek Spring complex is located 50 km North-East of QGC’s QCLNG tenements.
Figure 33 – Dawson River conceptual model

- Dawson River 8 Springs complex located 40 km North of QGC’s QCLNG tenements.
- Walloon Subgroup
- Eurombah Formation
- Hutton Sandstone
- Evergreen Formation
- Precipice Sandstone
- Torsdale Volcanics (Carboniferous)

Note: Dawson River 8 Spring Complex

Inferred fault / fractured zone
Figure 34 – Scott’s Creek Springs conceptual model

Note: Scott’s Creek Springs complex is located 45 km West/North-West of QGC’s QCLNG tenements.
Spring identification

Data collection, analysis and knowledge mapping

Spring field survey:
- Ecological
- Hydrogeological

Groundwater modelling predictions

Spring assessment

Potentially affected springs:
Springs that sit above an aquifer (regardless of connection) with predicted >0.2 m drawdown at any time over modelling period of 300 years.

Risk profiling of springs:
Predicted impact risk ranking based on consideration of source aquifer, distance from tenures, distance from source to target coal seams, conservation ranking, distance to recharge etc.

Development of springs impact management strategy

Develop monitoring strategy for highest risk-ranked springs:
Assignment of springs by QWC to particular CSG companies based on distance to tenement boundaries to include, for example, wetted area, water quality sampling, flow measurements, condition assessments, additional bore monitoring.

Develop mitigation strategy:
Tenure holders to assess and propose options to QWC, such as relocation of stock bores, market-based options (i.e. purchasing entitlements) etc.

Figure 35 – Outline of QWC’s methodology for development of the Surat CMA Springs Impact Management Strategy (SIMS)
Indicative Monitoring Lines for Ground Motion

Map Projection: GDA 94

Data Source:
Roads - StreetPro, Towns - GA

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Note: Every effort has been made to ensure this information is spatially accurate. The location of this information should not be relied on as the exact field location.

Scale: 1:900,000 (A3)

Figure 37 – Indicative monitoring lines for ground motion
Figure 38 – Aquifer injection feasibility plan

- **Phase 1**
- **IMP-Feasibility**
- **WCK GW4 Precipice Production Trial**
- **Injection Trial Preparation**
- **Infrastructure and Facilities for Injection Trial**
- **Injection Trial**

**Stage 1**
1. QGC feasibility studies
2. Production Trial
3. Injection Trial

**Stage 2**
4. WCK GW4 complete
5. WCK GW10 complete
6. EA amendment submitted
7. EA condition amended
8. Lodge Injection Trial 1 Management Plan (IMP1)
9. Groundwater extraction trial complete

**Stage 3**
10. Injection well complete
11. Approval to inject
12. Start injection trial
Figure 39 – Location of GW4 bore

NDA with major structures

Wells GP info resource
Coal Seam Gas
Conventional
Bowen Surat major structure petrosys
QGC Field
WCK GW4

QGC
A BG Group business

Figure 39 – Location of GW4 bore
Figure 42 – QGC management systems of potential CSG water extraction impacts
Response action process

Phase 1

- Exceedance observed
  - Initial advice to Minister
    - Has there been a reporting or trigger level exceedance?
      - NO: Continue with routine monitoring
      - YES: Reassess and verify exceedance
        - Is exceedance verified?
          - NO: Report to SEWPAC
          - YES: Report to SEWPAC

Phase 2

- Undertake risk assessment
  - Is risk acceptable?
    - NO: If required carry out action
      - NO: Report to SEWPAC
      - YES: Evaluation action, Is further action required?
        - NO: Report to SEWPAC
        - YES: Undertake further action
  - YES: Evaluation action, Is further action required?
    - NO: Report to SEWPAC
    - YES: Undertake further action

Phase 3

- NO
  - YES

Figure 43 – Outline of QGC generic methodology for a response action
Figure 44 – Predicted range of drawdowns in Precipice Sandstone 20 km northeast from QCLNG tenements towards Scott’s Creek Spring
Figure 45 – Predicted range of drawdowns in Hutton Sandstone 20 km northeast from QCLNG tenements towards Scott’s Creek Spring
Figure 46 – Tenement buffer, early warning bores, source aquifers and EPBC springs
Figure 47 – Example of Envelope to Groundwater Risk Management

- **95th Percentile drawdown**
- **Median drawdown**

**Exceedance Threshold**
80% of 95th percentile drawdown prediction*

**Early Warning Trigger Value**
50% of 95th percentile drawdown prediction*

*Corresponds with >0m impact at spring

- **Usual monitoring**
- **Increased monitoring**
- **Mitigating Action**

### Drawdown (m)

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<th>Year</th>
<th>Usual monitoring</th>
<th>Increased monitoring</th>
<th>Mitigating Action</th>
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<tr>
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<tr>
<td>2100</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Figure 48 – Proposed early warning monitoring bores scheme

Possible spring source aquifer

Potentiometric groundwater level (spring source aquifer)

Possible spring source aquifer

Baseline groundwater level (excluding trends)

Trigger 1: Early warning trigger – prompts further study monitoring investigation – 50% x drawdown limit

Trigger 2: Exceedence threshold – prompts mitigation actions – 80% x drawdown limit

Trigger 3: Drawdown limit – breach of Condition
Figure 49 – Hutton Sandstone drawdown contours in vicinity of EPBC listed springs
Figure 50 – Location of planned stimulation wells

- Cameron (8, 10)
- Kathleen (2, 3, 4)
- Woleebee Ck (109, 110, 121, 129)
- Jammat (5)
- Celeste (7, 135, 166, 174)
- Celeste (10, 11)
- Myrtle (9, 10)
- Clume (7, 8, 9, 10)

Scale 1:700,075 (A3)
Figure S1 – Location of QGC’s gas fields
Figure 52 – Relationship between gas fields
Figure 54 – Kenya to Chinchilla Weir pipeline
Figure 55 – Central and Southern Gas Fields collection networks

- Pump
- Existing ponds
- Under construction or to be built
- Development blocks

Note: Beneficial use from non-QCLNG CSG production only.
Figure 56 – Northern Gas Fields collection networks (proposed)
Figure 57 – Water treatment process
Figure 61 – Northern Water Treatment Plant and nearby ponds with Q100 flood extent

DATA SOURCE:
Roads, Watercourses - GA
Cadastre - DERM
Imagery - Nearmap
Map Projection: GDA 94
Scale: 1:20,000 (A3)

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20/09/2012
D
DATE:
CREATED BY:
MAP NO:
REV NO:
MAP TYPE:
Other
PLAN REF:
CHECKED BY:
LC
M_14552_01
TM
v4

Worsfold East
Worsfold West
Delga Park
Brine Pond
Clarified Water Pond
Brine Pond
Raw Water Pond
Treated Water Pond

Watercourse
Q100 Flood Extent
Existing Pond
Pond (under construction)
Proposed Pond (under construction)
Proposed Water Treatment Plant
QGC Owned Land
Property Boundary

Kilometers
Scale 1:20,000 (A3)
Figure 62 – Kenya water management and infrastructure
Figure 63 – Berwyndale South water management and infrastructure

QCLNG
Stage 2 WMMP
Berwyndale South water management infrastructure

- Existing Water Pipeline
- Watercourse
- Major Pond
- Existing Pond
- Proposed Pond
- Central Processing Plant
- Field Compression Station
- Windiibi Water Treatment Plant
- Property Boundary
- QGC Owned Land

Scale 1:30,000 (A3)
Figure 64 – Woleebee Creek water management infrastructure
Figure 65 – Linkage to Chinchilla beneficial use scheme
Figure 66 – Chinchilla Weir discharge outlet structure location
Figure 68 – Surface water quality monitoring sites (Kenya and Windibri REMP)
Figure 69 – Linkage to the Dawson Valley beneficial use scheme
Figure 70 – Northern WTP to Glebe Weir Pipeline
Concentrated Brine to Single Landfill

Figure 73 – RWF Block Flow Diagram

* Proposed on-site mechanical crystallisers at the Kenya East WTP are located outside the shown conceptual RWF layout
Proposed on-site mechanical crystalisers at the Kenya East WTP are located outside the shown conceptual RWF layout.
Salt waste
Separation geotextile
Leachate collection layer (drainage layer)
Protection geotextile
Geomembrane (2 mm)
GCL
Prepared sub-base

Figure 75 – Conceptual RWF base barrier design
Salt waste

Protection geotextile

Geomembrane (1.5 mm)

GCL reinforced

Drainage geocomposite

Geomembrane (2 mm)

GCL reinforced

Protective liner

Drainage geocomposite

Prepared sub-base

Figure 76 – Conceptual RWF wall barrier design
Figure 77 – Conceptual RWF capping design

- Topsoil
- Soil sub-base (unclassified fill)
- Soil sub-base (unclassified fill)
- Separation geotextile
- Drainage aggregate layer
- Protection geotextile
- Geomembrane (1.5 mm)
- GCL
- Earthen cover (300 mm min. thick select fill below GCL)
Figure 78 – Monocell cross section
July 12 – December 12
Preliminary design

December 12 – March 13
Finalise concept design

March 13 – September 13
FEED

September 13 – July 15
Order, install and commission Mechanical Crystallisers

March 13 – September 14
Approvals and permits

July 14 – August 15
Design, construct and commission

Figure 79 – Regulated Waste Facility Timeline
Selective Salt Recovery

Figure 81 – SSR Block Flow Diagram
Figure 82 – Selective Salt Recovery Timeline

- December 13 – December 13: Approvals
- July 11 – September 12: Pilot Plant
- July 12 – March 13: Pre-FEED
- March 13 – October 13: FEED
- October 13 – September 15: Design, construct and commission