Queensland is the focus of major developments in the resources sector, creating huge potential for sustained economic growth in many regions across the State. This paper presents an industrial land demand-forecasting model that has the potential to improve State and local government strategic land use planning across Queensland’s resource rich regions. This model is unique in that it ties industrial land demand-forecasts directly to the resources sector’s planned production levels. This approach differs from other commonly used models that are based on historic industrial land sales and/or population and employment projections; in that it is future focused and based on the cumulative commercial proposals of specific resources companies operating in a region. This model can help regional communities capitalise upon opportunities for economic growth by ensuring availability of sufficient industrial land to accommodate supply chain business related to the resources sectors.

A case study example of this model has been developed for the Surat Basin in response to the ongoing expansion of the CSG industry and the emergence of a significant coal mining industry. The case study demonstrates how the model’s projections can be applied to inform planning of industrial land release at a local and regional scale where other land forecasting techniques are either inadequate or not suitable.
1 Introduction

Queensland is the focus of major development associated with the “resources boom mark 2”, creating huge potential for sustained economic growth in many regions across the State. The ability of regional communities to capitalise upon these opportunities is closely tied to the availability of land to accommodate supply chain industry which support resource sector activity.

Planning of land supply at emerging resource frontiers can be challenging due to a lack of reliable data for land demand trends, leaving a significant information gap for planning agencies to speculate upon. Economic growth at these frontiers can be constrained if planner’s projections fail to accurately determine the magnitude of future land demand.

Industrial land demand models have been used in Queensland to forecast the industrial land supply for periods up to 20 to 30 years. These forecasts have been primarily used in the public sector for preparation of regional plans and planning schemes and by the private sector for the development and staging of industrial land releases.

Various models, particularly economic models, have been used to forecast industrial land demand. The most frequent economic models being used are based upon either:

- Employment forecasting which uses industrial employment ratios, such as jobs per hectare, as a proxy for the actual demand for industrial land;
- Historic land take up based on vacant land sales, building approvals or plumbing connections.

These employment based or historic take up models have generally operated well in urban communities where steady population growth has been the key driver of all forms of urban land demand. However, in regions where industrial land demand is based upon expansion of the resources sector rather than population growth per se, the effectiveness of these techniques has proven inadequate. Examples of where historic population projections or land sales data does not reflect the anticipated level of demand for industrial land include the Bowen Basin, the Surat Basin, and the North West Minerals Province, the North East Minerals Province and the Galilee Basin.

The Industrial Land Analysis and Planning Branch [ILAP], a department within the Office of the Coordinator-General, a part of the Department of Employment, Economic Development and Innovation [DEEDI], identified a need to develop more effective land demand forecasting technique, based upon actual industry demand rather than an employment proxy, that could be implemented in anticipation of demand from industrial supply chains supporting the expansion of the resources sector. In response, ILAP developed a unique proto-type model that ties industrial land demand-forecasts directly to the resources sector’s planned production levels in a specified geographic region.

This paper presents the first known attempt in Queensland to apply such an industrial land demand-forecasting technique, through a case study example that was developed for the Surat Basin in response to the ongoing expansion of the Coal Seam Gas [CSG] industry and the emergence of a significant coal mining industry. The case study demonstrates how the modelling technique and its projections can be applied to inform planning of industrial land release at a local and regional scale where other land forecasting techniques are either inadequate or not suitable.

It is considered that this model has the potential to improve State and local government strategic land use planning across Queensland’s resource rich regions.
2 Model Overview

This model has the potential to assist regional communities to capitalise upon opportunities for economic growth by ensuring availability of sufficient land for new industrial development supporting expansion of the resources sector.

This model is unique in that it’s forecast aligns directly with the resources sector’s planned production levels. This approach differs from other commonly used models that are based on historic industrial land sales and/or population and employment projections; in that it is future focused and based on the cumulative commercial proposals of specific resources companies operating in a region.

2.1 Model Methodology

The methodology assumes that as a resource sector’s production level increase, there will be a commensurate increase in the demand for industrial land from related supply chain industries. The industrial land demand-forecasting model [Figure 1] is based on a six step process:

1. Calculate the quantity of land occupied by existing supply chain business supporting the ‘target’ resources sector in the surrounding region.
2. Calculate the current annual production levels of the ‘target’ resources sector in the surrounding region.
3. Develop baseline ratios by cross referencing annual production levels against the amount of land occupied by supply chain business. This establishes a ratio for the quantity of industrial land occupied per unit of production by the resources sector.
4. Determine future production levels for the ‘target’ resources sector in the surrounding region within a predetermined time frame. A 20 year planning horizon is suggested to align with Strategic Frameworks under Queensland Planning Provisions [QPP] compliant planning schemes.
5. Forecast future industrial land demand for supply chain business based on future annual production levels. It is suggested that low-medium-high growth scenarios are forecast. Land demand relates to the final allotments, within a subdivided estate that accommodate an industrial activity. Land demand projections should then be offset by the amount of land already occupied by supply chain industry to come to a final ‘net’ figure.
6. Convert net industrial land demand to raw industrial land requirements. Raw industrial land requirements are assumed as double net industrial land demand. This reflects that raw broadhectare industrial zoned land supplies may include constrained areas such as steep slope, drainage lines, flood liable land, protected vegetation or unstable soils which are not suitable for development. Additionally, raw industrial land requires that roads, open space and utility infrastructure be provided to facilitate the development of industrial estates. Overall this typically results in an average net yield of about 50% of a site’s original zoned area.

Figure 1: Model methodology

1. Determine existing industrial supply chain land occupancy
2. Determine existing resource sector production levels
3. Develop baseline ratios for: Land Occupancy : Unit of production
4. Determine future production levels for the ‘target’ resource sector
5. Forecast future industrial land demand [net] for supply chain industries based on future production
6. Convert net industrial land demand to raw industrial land requirements
2.2  Model Assumption, Inputs and Data Sources

Data inputs and assumptions that form the basis of this industrial land demand-forecasting model can be gathered from a variety of government and commercial sources.

It is possible to affordably compile land supply and occupancy data where information is not available through State government’s Industrial Land Monitoring Program or other existing land audits. This data will confirm the supply of vacant land as well as land occupancy by supply chain business.

Input data for the resources sector, including historic and forecast production levels, is readily available and can be sourced from State government databases or Initial Advice Statements (IAS) and Environmental Impact Statements (EIS) that have been prepared by resources sector proponents. It is critical to gather data from as many proponents as possible to gain clear insight into the cumulative demands that will result from all resources sector proposals in a specified region.

2.3  Applying the Model Outputs through Strategic Land Use Planning

The industrial land model is a useful tool to determine the magnitude of future industrial land demand. However this data is superfluous unless it can be appropriately implemented through Regional Plans and Planning Schemes to enable future development.

To properly implement the model, strategic planners need to determine the most appropriate locations for additional land release across a region when the model demonstrates that it is needed. Site suitability assessments should be undertaken to scope out the best locations for future industrial land release based on:

- Proximity to catalysts and demand drivers, specifically the resources sector activity;
- The land supply situation. There is no tangible benefit to be had in releasing additional land where existing supply is sufficient;
- Access to transport networks. Supply chain industry will generate significant transport activity for the movement of goods and its workforce; and
- Access to a skilled workforce. Existing population centres are more attractive places for supply chain industry to establish as these offer a readymade workforce and higher amenity environment for new businesses.

Land release can be planned with more certainty once initial investigations have determined which locations most appropriately meet these general suitability criteria.
3 Case study – Surat Basin CSG and coal mining supply chain

A case study example of this model was developed for the Surat Basin in response to the booming CSG industry and the emergence of a significant coal mining industry. The case study demonstrates how the model’s projections can be applied to inform planning of industrial land release at a local and regional scale where other land forecasting techniques have proven to be either inadequate or not suitable.

A four phase methodology [Figure 2] was adopted for this case study which:

1. Separately forecast industrial land requirements for supply chains supporting the CSG and coal mining industries using the industrial land demand model;
2. Combined these separate forecasts to determine a total future industrial land demand;
3. Compared the total forecast demand against existing vacant industrial land supplies in strategically located townships across the Surat Basin in order to determine a shortfall of industrial land through to 2030; and then
4. Assessed the strategic suitability of select townships in the Surat Basin to accommodate future industrial land release to meet the emerging land supply shortfall.

Figure 2: Case study methodology

3.1 Case Study – Assumptions

The Surat Basin case study was predicated on the following assumptions:

- a land demand per unit of production ratio of:
  - 0.22ha net per 1 Petajoule [PJ] of CSG production; and
  - 3ha net per 1 Million tonnes Run of Mine [RoM] of coal mining production.
- Existing CSG supply chain business occupies 53ha of industrial land. This existing occupancy is offset against net land demand.
- Existing coal mining supply chain business occupies 9ha of industrial land. This existing occupancy is offset against net land demand.
- ‘offset’ net industrial land demands are doubled to equal raw industrial land requirements; and
- an available supply of 948ha of suitably located vacant industrial land at select locations across the Surat Basin including:
  - Roma – 316ha;
  - Miles – 61ha;
  - Wandoan – 25ha;
  - Chinchilla – 36ha;
  - Dalby – 241ha; and
  - Oakey – 269ha.
### 3.2 Case Study – Production Scenarios

A series of low-medium-high production level scenarios were prepared to help determine the likely amount of industrial land that would be required for resources sector supply chain businesses between 2010 and 2030. The three scenarios were based on possible ‘production level’ forecasts for the CSG and coal mining industries in 2030 assuming the partial or full realisation of Liquid Natural Gas (LNG) and coal mining proposals that are the key drivers leading the development of the resources sectors in the Surat Basin.

**Scenario 1 - Domestic Market Focus**
This scenario is equivalent to a slower growth economy focussed on the continued servicing of domestic markets. It would encompass:

- CSG production at 500PJ per annum (Figure 3); and
- Coal production at 26M/t RoM per annum (Figure 4).

**Scenario 2 - Small Export Focus**
This scenario is equivalent to a medium growth economy, including the elements of Scenario 1 above, plus CSG and coal mining activity oriented towards small export markets. It would encompass:

- CSG production at 1,592PJ per annum. Scenario 2 assumes a limited production at a number of proposed LNG plants in Gladstone (Figure 3); and
- Coal production at 116M/t RoM per annum. Scenario 2 assumes construction of the proposed Surat Basin Railway and limited production from a number of proposed coal mines in the Surat Basin (Figure 4).

**Scenario 3 - Large Export Focus**
This scenario is equivalent to a high growth economy, including the elements of Scenarios 1 and 2, plus CSG and coal mining industries oriented towards large export markets. It would encompass:

- CSG production at 3,636PJ per annum. Scenario 3 assumes a high level of production at all known LNG plant proposals in Gladstone (Figure 3); and
- Coal production at 201M/t RoM per annum. Scenario 3 assumes construction of the proposed Surat Basin Railway and a high level of production and export from all known coal mine proposals in the Surat Basin (Figure 4).

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSG Industry</td>
<td>500PJ</td>
<td>1,592PJ</td>
<td>3,636PJ</td>
</tr>
<tr>
<td>Coal Mining Industry</td>
<td>26M/t</td>
<td>116M/t</td>
<td>201M/t</td>
</tr>
</tbody>
</table>

Table 1: Anticipated CSG and coal mining annual production levels at 2030

![Figure 3: Forecast CSG annual production levels at 2030](image-url)
3.3 Case Study – Land demand forecasts

Net industrial land demand forecasts were prepared for the three scenarios, all of which were based on the following ‘production to land occupancy’ ratios:

- 0.22ha net per 1PJ of CSG production; and
- 3ha net per 1M/t RoM of coal mining production.

Industrial land demand projections were then offset by the amount of land already occupied by the CSG and coal mining industry supply chains equal to:

- 53ha for the CSG industry supply chain; and
- 9ha for the coal mining industry supply chain.

Each scenario then doubles the ‘offset’ net industrial land demand to equal ‘raw’ industrial land requirements. The following forecasts are additional to the amount of land already occupied by the CSG and coal mining industry supply chains.

Scenario 1 - Domestic Market Focus

Under this scenario, raw industrial land demand for:

- CSG Industry Services are forecast to equal 114ha (Table 2 and Figure 5); and
- Mining Industry Services are forecast to require only the existing 9ha already occupied by Mining Industry Service firms. Therefore no additional land would be required under this scenario (Table 2 and Figure 6).

Scenario 2 - Small Export Focus

Under this scenario, raw industrial land demand for:

- CSG Industry Services are forecast to equal 594ha (Table 2 and Figure 5); and
- Mining Industry Services are forecast to equal 678ha (Table 2 and Figure 6).

Scenario 3 - Large Export Focus

Under this scenario, raw industrial land demand for:

- CSG Industry Services are forecast to equal 1,494ha (Table 2 and Figure 5); and
- Mining Industry Services are forecast to equal 1,188ha (Table 2 and Figure 6).

Table 2: Raw land forecasts based on potential CSG and coal mining production levels.

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSG Industry</td>
<td>114ha</td>
<td>594ha</td>
<td>1,494ha</td>
</tr>
<tr>
<td>Coal Mining Industry</td>
<td>9ha</td>
<td>678ha</td>
<td>1,188ha</td>
</tr>
<tr>
<td>Total</td>
<td>123ha</td>
<td>1,272ha</td>
<td>2,682ha</td>
</tr>
</tbody>
</table>
3.4 Case Study Implications – Strategic Land Use Planning

3.4.1 Need for additional land

Forecasting exercises were undertaken to estimate the quantity of industrial land required to accommodate supply chains supporting expansion of the CSG and coal mining industries in the Surat Basin through to 2030 (Figures 5 and 6). These low-medium-high growth forecasts have been combined and compared against existing supplies of vacant industrial zoned land to help determine whether existing supplies are sufficient or additional land releases are required (Figure 7).
Scenario 1 - Domestic Market Focus
There is sufficient available vacant industrial zoned land within the Surat Basin to support the low growth scenario beyond 2030 (Figure 7).

Scenario 2 - Small Export Focus
There is only sufficient available vacant industrial zoned land at suitable locations to support this medium growth scenario until between 2020 and 2025. Over the entire period to 2030 an additional 324ha of raw industrial land release would be required to meet demand forecasts for the Mining Industry Services and CSG Industry Services sectors (Figure 7 and Table 3).

Table 3: Scenario 2: Combined raw industrial land requirements

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSG Industry</td>
<td>53ha</td>
<td>188ha</td>
<td>324ha</td>
<td>559ha</td>
<td>594ha</td>
</tr>
<tr>
<td>Mining Industry</td>
<td>9ha</td>
<td>170ha</td>
<td>339ha</td>
<td>509ha</td>
<td>678ha</td>
</tr>
<tr>
<td><strong>Total land demand</strong></td>
<td>62ha</td>
<td>358ha</td>
<td>663ha</td>
<td>967ha</td>
<td>1,272ha</td>
</tr>
<tr>
<td><em>Existing vacant land supply</em></td>
<td>948ha</td>
<td>948ha</td>
<td>948ha</td>
<td>948ha</td>
<td>948ha</td>
</tr>
<tr>
<td><strong>Supply differential</strong></td>
<td>+886ha</td>
<td>+590ha</td>
<td>+286ha</td>
<td>-19ha</td>
<td>-324ha</td>
</tr>
</tbody>
</table>

Scenario 3 - Large Export Focus
There is only a sufficient supply of available vacant industrial zoned land at suitable locations to support this high growth scenario until between 2015 and 2020. Over the entire period to 2030 an additional 1,734ha of raw industrial land release would be required to meet demand forecasts for the Mining Industry Services and CSG Industry Services sectors (Figure 7 and Table 4).

Table 4: Scenario 3: Combined raw industrial land requirements

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSG Industry</td>
<td>53ha</td>
<td>413ha</td>
<td>774ha</td>
<td>1,134ha</td>
<td>1,494ha</td>
</tr>
<tr>
<td>Mining Industry</td>
<td>9ha</td>
<td>297ha</td>
<td>594ha</td>
<td>891ha</td>
<td>1,188ha</td>
</tr>
<tr>
<td><strong>Total land demand</strong></td>
<td>62ha</td>
<td>710ha</td>
<td>1,368ha</td>
<td>2,025ha</td>
<td>2,682ha</td>
</tr>
<tr>
<td><em>Existing vacant land supply</em></td>
<td>948ha</td>
<td>948ha</td>
<td>948ha</td>
<td>948ha</td>
<td>948ha</td>
</tr>
<tr>
<td><strong>Supply differential</strong></td>
<td>+886ha</td>
<td>+238ha</td>
<td>-420ha</td>
<td>-1,077ha</td>
<td>-1,734ha</td>
</tr>
</tbody>
</table>

It should also be noted that these scenarios do not take into account competing demand for industrial zoned land that will occur from other industry sectors, including for instance the Transport, Manufacturing and Service Industry sectors. It is plausible to anticipate that the supply of vacant industrial zoned land could be more rapidly exhausted as a result of competing demand from other industry sectors. Further and more broadly scoped modelling would be required to confirm this possibility.

3.4.2 Suitable location for future land release
The industrial land demand-forecasting model identified shortfalls in the supply of appropriately located industrial zoned land within 10-15 year timeframes, triggering the need for further planning investigation for industrial land release. It is anticipated that demand for industrial zoned land will be most concentrated at localities in close proximity to CSG and coal mining industry activities around Roma, Miles, Wandoan, Dalby and Chinchilla. An assessment of select industrial precincts across the Surat Basin was undertaken to determine their general suitability as locations for future industrial land release based on a set criteria of:

- Proximity to catalysts and demand drivers;
- Land supply deficiency;
- Access to transport networks; and
- Access to a skilled workforce.

This assessment highlighted that the townships of Wandoan, Miles and Chinchilla as potential locations for additional land release (Figure 8).
Industrial Land Demand Forecasting for Supply Chain Business
Supporting Queensland’s Resource Sector

Roma

Roma is located at the centre of developed deposits of natural gas, CSG, petroleum and crude oil. While it is expected that further expansion of Roma’s well established CSG Industry Services sector will occur, it is generally considered that the 316ha of available vacant industrial zoned land in Roma is a sufficient supply.

Wandoan

Wandoan is strategically located adjacent to major coal mine proposals which are anticipated to be significant drivers of demand for mining services. Wandoan is also identified as a key node on the Surat Basin Railway. It is anticipated that the 25ha of vacant industrial zoned land at Wandoan could be rapidly exhausted if proposed coal mines adjacent to Wandoan proceed. Wandoan is therefore considered suitable for further investigation for industrial land release.

Miles

Miles is located at the centre of well developed CSG deposits and within 1 hour travel time of an emerging coal mining industry of significant proportions at Wandoan, Wandoan West and Cameby Downs. Miles is also strategically located at the junction of the Warrego Highway-Leichhardt Highway-Western Railway and in proximity to the planned Surat Basin Railway. This proximity to key demand drivers and road and rail transport networks is expected to increase demand for industrial zoned land in Miles.

It is anticipated that the 61ha of available vacant industrial zoned land in Miles could be rapidly exhausted under the medium and high growth scenarios if all planned CSG and coal mining projects were to proceed. This limited supply of vacant industrial zoned land, coupled with its locational benefits, identifies Miles as a suitable location to investigate for future industrial land release.
Chinchilla

Chinchilla is well located in relation to many productive CSG fields and exploration areas. Chinchilla has recently experienced a spike in industrial development from the CSG supply chain taking advantage of its proximity to CSG fields, Chinchilla’s well established amenities, community services and workforce. Ongoing expansion of the CSG supply chain is anticipated to rapidly take up the remaining 36ha of vacant industrial zoned land in Chinchilla as it responds to the development of nearby CSG deposits. Chinchilla is considered suitable for further investigation for future industrial land release.

Dalby

Dalby is well located at the centre of many productive CSG fields and exploration areas, coal mines and power stations. It is considered that the available 241ha of vacant industrial zoned land at Dalby is a sufficient supply.

Oakey

Oakey has a supply of 269ha of vacant ‘broad hectare’ industrial zoned land, ensuring it is well placed to accommodate additional industrial development in the medium to long term. It is considered that the available supply of vacant industrial zoned land at Oakey is sufficient.

3.4.3 Test case summary

The model demonstrated an emerging need for additional land release over a 20 year regional planning horizon. Accurate regional land supply data has enabled that a land release assessment of key locations across the entire Surat Basin be undertaken. This assessment revealed that some locations are more suitable for land release, demonstrating that sophisticated implementation of the model’s data has the potential to lead to planned development outcomes that will enable both economic and community development.
4 Verification of the model’s transferability

The 2010 Surat Basin Case Study is the first attempt to apply the model. In early 2011, an opportunity arose for the ILAP Branch, with the assistance of Foresight Partners Pty Ltd, to test some of the models parameters and assumptions with information from another Industrial Land Study that had already been undertaken at the Paget Industrial Area in Mackay in 2006. Paget is a well established concentration for coal mining supply chain services to the Bowen Basin and re-surveying the area in 2011 to measure growth of coal mining supply chain services was considered a good opportunity to verify some of the model’s parameters and assumptions, specifically the ‘production to land occupancy’ ratios for the coal mining supply chain. This process involved the re-surveying of Paget’s coal mining supply chain to determine the take up of land over the period 2006-2011. This survey captured the growth in the number of firms and land area occupied by these firms, providing the latest occupancy data that was then able to be measured against the annual production levels for the 2006 - 2011 period. This measurement enabled a comparison between the growth in both the number of mining services firms and the industrial land they occupied, compared to the growth in RoM coal production over the same 5 year period.

This investigation highlighted:

- Excess site capacity. Interviews with supply chain industry indicated that only some firms would need to move to larger industrial sites as RoM coal production increased over time. Some firms had initially established upon larger sites and were able to expand on-site as business increased. Therefore, it appears that there is some excess site capacity built into the current site occupancy of industrial land by the coal mining supply chain.
- Take up of land versus production levels. The survey in Paget determined a take up rate of 1.6ha net per additional 1M/t RoM of annual coal mining production over the 5 years, 2005/06 to 2010/2011. This is a lower figure than the ‘production to land occupancy’ ratios adopted by the Surat Basin test case, highlighting that well established supply chain firms will absorb excess site capacity ahead of expanding onto new larger sites.

The Surat Basin test case should be considered in context of these findings to better understand how the model should be applied initially, as a supply chain matures and as production levels vary over time. In relation to the Surat Basin test case it can be assumed that:

- A low level of supply chain penetration will occur until such time as coal mining production rises substantially.
- When coal mining production increases (see Scenario 2 for the Surat Basin), many new entrant supply chain firms may purchase or occupy new sites. This could be either larger sites than initially required, in the expectation that production levels will increase in the future or some firms may occupy smaller sites and expand in the future as they may need additional land. Accordingly land demand forecasts for coal mining supply chain under Scenario 2 are still considered valid.
- Recognising that some supply chain firms may establish on sites with excess capacity, it is possible that land demand forecasts under Scenario 3 may now be seen as too high, given the possibility that some firms could expand on site as production levels increase, as was the case in Paget. Accordingly, the model may need some progressive revisions to more accurately reflect eventual land requirements over a 10 to 20 year timeframe.

5 Conclusion

Queensland’s planners have challenging tasks ahead in managing the “resources boom mark 2”. This paper has presented an industrial land demand-forecasting model that is based on the resources sector’s planned production levels. The paper has demonstrated that the model has real potential to be applied in local and regional planning to support employment and economic growth.

A case study example of this model was developed for the Surat Basin in response to the booming CSG industry and emerging coal mining industry. The case study demonstrated how the model’s projections can be applied to inform industrial land release strategy at a local and regional scale. The model’s parameters have been further investigated and proven to be suitably accurate for its designed application. However further review and adjustment of this modelling technique is required, as is the case with all planning processes.

The future use of this model is encouraged where traditional population or employment based forecasting techniques are not suitable or have been proven deficient.