Australian Government | Infrastructure Australia

Supporting appendices Infrastructure Market Capacity 2023 Report

December 2023

Appendix A: Demand- side analysis methodology

Infrastructure Australia's Major Public Infrastructure Pipeline

The analysis in the 2023 *Infrastructure Market Capacity* report is based on the aggregation of project-level data to inform a portfolio view of Australia-wide infrastructure, with data current as at June 2023.

Infrastructure Australia established the 'Major Public Infrastructure Pipeline' in the 2021 *Infrastructure Market Capacity* report – this included a database of identifiable publicly funded infrastructure projects which met certain criteria for inclusion.

Projects were included in the database if the investment value was above a threshold capital cost (over $50 million for South Australia, Tasmania, the Northern Territory and the Australian Capital Territory, and over $100 million for all other Australian states). The periods covered within the portfolio were between 2014–15 and 2031–32 – that is projects were included on the basis that there was (or would be) a non-zero amount of construction activity across those ten years.

Project data gathering and collation

This report has involved an update to the public project-level information contained in the 2022 *Infrastructure Market Capacity* report, using the most recent obtainable information. The project-level data that provides the basis for analysis within this report is a product of collaboration between private sector suppliers (GlobalData, Oxford Economics Australia), Infrastructure Australia, the Jurisdictions and the Australian Department of Infrastructure, Transport, Regional Development, Communications and the Arts – the Department have provided budgeted transport infrastructure project expenditure from 2017–18 onwards. The data received from the states and territories included infrastructure projects that were allocated funding in 2022–23 budgets.

The exception to this is the energy and fuels sector. While previous editions of the Infrastructure Market Capacity report relied on Australian Energy Market Operator (AEMO) projections of the installed generation capacity of its Integrated System Plan, this report draws on actual private and public energy project data as more realistic representations of demand. With regard to transmission activity, the 2021 dataset on transmission line projects collated by the University of Technology Sydney has been retained in this report.

The inclusion of project-level data in the major public infrastructure pipeline follows the same criteria as in 2023 (i.e. threshold value cut-offs and publicly funded works). Furthermore, the collation of project-level data has expanded during the development of the 2023 Infrastructure Market Capacity report – identifiable public energy projects, as mentioned above, have also been gathered and added to the project database. While these projects are not reported in the five-year pipeline of major public infrastructure projects, the entire project database is examined in *Section 2: Understanding demand*.

For each project, the database includes information, where available, on the following fields:

- Location (including jurisdiction)
- Investment cost (or megawatts for energy projects)
- Project stage (preconstruction stages, under construction or completed)
- Project schedule
- Funding source (public, private, mixed)
- Project type (project classification)

Data classification

The National Infrastructure Project Database ingests, aggregates, and organises infrastructure project data supplied by the Australian Governments and state and territory governments (public investments), and GlobalData (private investments) – each project is assigned a 'typecast' of which there are 62 distinct areas of activity.

Each typecast lies within a corresponding 'master type' of which there are 17 different subsectors. Finally, the master types can be aggregated into the three following infrastructure 'sectors':

- **Transport**, which includes roads, railways, level crossings and other transport projects such as airport runways (noting that airport buildings are represented in the 'Building' sector)

- **Utilities**, which includes water and sewerage, energy and fuels, gas and water pipelines and telecommunications
- **Building**, which includes non-residential buildings for health, education, sport, justice, transport buildings (e.g., parking facility and warehouse), other buildings (art facilities, civic/ convention centres, and offices), limited coverage of detached and semi-detached residential buildings.

A full list of (sub)sectors is available in *Appendix D: Infrastructure typecasts*.

Projects are classified according to project stage and funding source, as follows:

Project stage classifications:

- Planning
- Procurement
- Implementation, and
- Completed (in Operations and Maintenance)

Funding source classifications:

- Public
- Private
- Public/Private.

Creating a portfolio of major project activity

The transformation of project-level data into a portfolio (i.e., a monthly timeline) follows the principles established in the 2021 *Infrastructure Market Capacity* report. For each individual project, the total investment cost is split across time using start and finish dates (estimated for projects not yet commenced and/or finalised). This distribution of costs assumed that each project undergoes three distinct phases of investment, in order of size: the construction phase (80%), planning phase (15%) and the commissioning stage (5%).

Project investment costs are allocated to the planning and commissioning phases in a linear fashion, whereas a sigmoidal function (or 'S-curve') has been applied to the proportion of investment within the construction phase.1 This method of cost distribution best reflects the general pattern of project expenditure over the construction phase: activity starts from small beginnings then accelerates over time to reach a climax before slowing to project completion.

Translating portfolio activity to resource demands

Similarly, translating the portfolio of project activity into resource demands follows the same process established in the 2021 *Infrastructure Market Capacity* report. For each individual typecast/sector, Turner & Townsend completed a detailed review of the project costing information across multiple project types and disciplines. This has allowed Turner & Townsend to develop a 'typical' project cost breakdown for each of the specific typecasts. Turner & Townsend's industry experience and knowledge was utilised to split these construction resources into more detailed cost breakdowns (per typecast – up to level four within the 'International Construction Measurement Standards'). These cost breakdowns have remained largely unchanged from the 2021 *Infrastructure Market Capacity* report although the expansion of the project database to include new typecasts has required the development of new cost breakdowns.

These cost breakdowns per typecast have been reconciled by Turner & Townsend over each resource category (plant, labour, equipment and materials) against industry accepted percentages. Finally, for each resource per typecast, a low, median and high estimate of demand was provided. This is to reflect the fact that although a 'typical' cost breakdown has been used for each typecast in this analysis, every individual infrastructure project is inherently different, even within the same sector. Consequently, the resulting individual resource demands are typically presented as occurring within a 'P90 range' (+-20% of the demand estimate generated) – that is, there is a 90% confidence that the actual demand lies in that range. For similar reasons, estimated growth in resource demands provided in this report are rounded to the nearest 5%.

The costs are as of 2021–22, with an appropriate level of escalation applied where applicable. In occurrences where there were variances within costs for certain items, an average of all costs collated was applied.

Turner & Townsend utilised the benchmarked rates for each resource per typecast to estimate the level of demand for each individual labour, plant, material and equipment construction resource based on the project expenditure per month for each individual project. The final output assigns a monthly expenditure for every cost item per project per typecast.

Resource classifications used in this analysis

The key resource categories used in the analysis remain unchanged from the 2021 *Infrastructure Market Capacity* report. However, there have been numerous additions to the resources within these categories to account for the sectoral expansion of the project database (for instance, plasterboard due to the inclusion of residential building).

The key resource categories developed for the infrastructure portfolio can be summarised by the acronym 'PLEM':

- Plant
- Labour
- Equipment
- Materials.

Plant covers individually distinct (and mostly mobile) capital items typically used in the implementation of major projects. It is further classified as either:

- Site plant: including cranes, scaffolding and scissor lifts
- Preliminaries: including site offices, lunchrooms and toilets
- Civil plant: including mobile plant such as excavators, graders, bulldozers and compactors
- Specialty plant: including items that are purpose built, modified or manufactured for a specific application/use such as tunnel boring machines, modified excavators and pile driving plant, augers, heavy transportation and low loaders amongst other items.

Labour covers workforce occupation categories and subcategories across the following major occupational groups (see *Appendix E: Resource classifications* for a complete list):

- Project Management Professionals: including occupational roles in Risk Management, Project Management, Commercial Management, Construction Management and Environmental and Occupational Health Professionals
- Engineering, Scientists and Architects: including a range of professional non-management roles including different types of Engineers, Surveyors, Architects, IT Professionals, Geologists, Maintenance Planners, Safety Officers and Procurement roles.
- Structures and Civil Trades and Labour: including Plant Operators, Concreters, Bricklayers, Carpenters and Joiners, Drillers, Rail Track Workers and Structural Steel Erectors amongst other roles.
- Finishing Trades and Labour: including Telecommunications Field Staff and Cablers, Plumbers, Electricians, Electrical Line Workers, Tilers, Glazers, Plasterers and Painters.

Equipment reflects generally non-distinct capital investment items and have been categorised as either control, electrical or mechanical equipment. Being non-distinct (and often bespoke) items, demand for equipment is expressed in dollar terms, not as units. This also applies to electrical bulk which is included in the materials category.

Materials cover the resources which are 'put in place' and include the following distinct items:

- Concrete, including aggregates, sand and cement
- Wall and frame materials, including timber, bricks, and plasterboard
- Rock and bluestone
- Steel: including structural and reinforcing steel as well as rail track
- Bitumen binders
- Asphalt
- Electrical bulk, representing mainly electrical cables, accessories and fittings, conductors, insulators, transformers, switches and other related items.

Interpreting the results

Last year's project-based view of the infrastructure market focussed almost exclusively on major public infrastructure pipeline; that is including public projects over $50 million for South Australia, Tasmania, the Northern Territory and the Australian Capital Territory, and $100 million for all other Australian states.

The market view has now been greatly expanded to include smaller value-works, achieving a truer view of public infrastructure demand. In addition, this analysis now also includes private construction demand data to increase our view of demand further. Both these factors are included in this report's findings.

Appendix B: Supply- side analysis methodology

Introduction and methodology

Methodology

Unlike labour, where relatively consistent and detailed data is collected regularly by the Australian Bureau of Statistics, there is no equivalent single source of quantitative 'truth' for the supply capacity of some critical non-labour infrastructure inputs. This includes concrete and quarry products, other construction materials or construction plant and equipment.

- In the case of quarry materials, different state jurisdictions are responsible for publishing their own state production data (although not all state production is readily available) as well as a diverse range of information about individual quarries. Critically, there is little or no data on latent capacity (or legal capacity, given restrictions on production and truck movements) of the quarrying industry to increase production to meet rising demand.
- Similarly, while data for the steel industry, through the Australian Steel Institute and Australian Bureau of Statistics trade data, can provide trends in local steel production, exports and imports, there is little quantitative data on the extent by which local production can be increased to meet rising demand, how long it would take to increase local supply or whether high quality imports can be procured to bridge the gap.
- Unpublished plant and equipment sales data may be obtainable from private databases, though the Australian Bureau of Statistics maintains detailed data on the volume of construction plant and equipment exported and imported through trade statistics.
- For other key construction inputs materials – including fuel, oil, cement, concrete, clay bricks, roofing tiles and sawn timber – the Australian Bureau of Statistics historically published local production data through its Manufacturing Production (Cat. No. 8301.0.55.001) and Production of Selected Construction Materials (Cat. No. 8301.0) surveys, but these were discontinued in 2004 and 2014 respectively.[2]

Because quantifying supply is challenging, we have combined published production and trade data with industry surveys and interviews.

Insights are gathered and assessed from various commercial participants on what they see as the looming limitations on delivering Australia's ambitious infrastructure program. In these soundings, industry had both positive and negative feedback regarding the state of the Australian infrastructure market, the outlook and opportunities for activity, the way the infrastructure program is being procured and delivered, and the greatest risks to capacity. Through this approach, key 'pinch-points' in Australia's infrastructure supply chain have been identified which are under pressure now or could come under pressure in coming years.

Industry engagement

In fleshing out capacity challenges facing the local infrastructure supply chain, a two-stage industry engagement process was adopted:

- **Detailed surveys of builders and civil contractors**. Builders and civil contractors represent the main interface with public and private sector infrastructure clients, but also have broad oversight of the industry's draw on PLEM resources and so have insights as to where supply chains are being challenged. For this report it was important to gather perspectives across a diverse industry spectrum, from very large builders and contractors to smaller and medium sized businesses. The views of the former are generally reflected in a survey conducted by Oxford Economics Australia between March and May 2023, referred to in this report as the "OEA Industry Survey", while perspectives from predominantly smaller and medium sized enterprises have been captured by a similar survey of its member base by the Civil Contractors Federation (CCF) during May 2023. [3]
- **Deeper industry interviews with the wider supply chain**. These industry soundings, conducted between April and June 2023, allowed more time and discussions for deeper probing of challenges with major infrastructure industry suppliers. These soundings helped pinpoint where capacity challenges were already apparent or at risk, their potential causes as well as possible solutions that would help mitigate capacity risk. For this report, these interviews were held with

a. Suppliers of quarry materials, cement, concrete and related products
b. Steel producers and fabricators
c. Representatives and suppliers of other input industries including bitumen and plasterboard
d. Distributors of plant and construction equipment
e. Representatives from the timber industry

Industry survey insights

To better understand the nature of supply side constraints affecting the broad spectrum of the infrastructure market, three industry surveys were undertaken focusing on builders and civil contractors. These were the 2022 Infrastructure Australia survey, the 2022 Civil Contractors Federation (Tier 3) member survey (noted below), both of which surveyed a broad spectrum of the market focusing on both large Tier 1s and smaller businesses (Tier 3s).

By undertaking data collection across the spectrum of infrastructure businesses, it was hoped that an overarching 'industry view' would not be biased towards either very small or very large organisations. There were interesting similarities in the responses to some of the questions asked, suggesting that some concerns are not isolated to just large or small companies. However, there were also critical differences, particularly in relation to industry capacity to deliver and proposed solutions to capacity challenges.

Survey questions asked

The structure of the survey was broadly as follows:

- Respondent characteristics (size, location, segment, ownership etc.)
- Recently experienced growth in activity
- Anticipated growth in activity in coming years
- Factors impacting capacity and capability
- Specific supply chain challenges by input
- Recent experience with cost escalation (labour and non-labour inputs)
- Potential solutions to mitigate capacity/capability risk
- Confidence in delivering infrastructure over next 12 months, two to four years, or beyond five years
- Confidence to proportionally scale up to meet increases in public infrastructure investment

Appendix C: Infrastructure typecasts

Project information sources and data difficulties

Project information sources

The project-level data that provides the basis for analysis within the *Infrastructure Market Capacity* report is a product of collaboration between private sector suppliers (GlobalData, Oxford Economics Australia), Infrastructure Australia, the Jurisdictions and the Australian Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA).

The Major Public Infrastructure Pipeline (major public infrastructure pipeline) utilised publicly funded project information mainly sourced from data-sharing partnerships between Infrastructure Australia, the Jurisdictions and DITRDCA. The data received from the states and territories included infrastructure projects that were allocated funding in the 2022—23 budget. The data received from DITRDCA included transport infrastructure projects that have been allocated federal funding since 2017–18.

Both these datasets contained information on projects that had commenced prior to 2020–21 (2017-18) if they were still underway. However, these datasets did not provide information on projects that had already finalised by those years. Project-level data provided by GlobalData and supplemented by Oxford Economics Australia was used to fill gaps in the project database – this included projects which had finalised before the dates above, or projects that were otherwise outside of the scope of the jurisdictional/federal lists (for instance, council projects that were valued above the

$50/$100 million cut-off).

In some instances, projects were disaggregated so that they could be appropriately categorised across different infrastructure typecasts. For instance, a rail project that involved stations, tunnelling and aboveground line works would be split into three components that would sit in three different typecasts – those being 'Station (Rail)', 'Tunnel (Rail)', and 'Main Line Works (Rail) (Greenfield)'.

The expansion of the project database to include privately funded projects and publicly funded projects beneath the threshold value cut-off was facilitated by data provided by GlobalData and Oxford Economics Australia. Furthermore, construction and maintenance market forecasts in this report were provided by Oxford Economics Australia.

Data difficulties

The gathering and collation of project-level data across the variety of sources has allowed for an enhanced view of project activity across Australia. In combination, the data sources provided more than 17,000 project entries. This was then reduced to approximately 6,300 unique entries that would constitute the Total Infrastructure Pipeline.

The substantial reduction in project entries is reflective of an intensive manual data cleaning process during the development of this report. This process was required for numerous reasons, most importantly, the project-level data provided by the different sources was not tailored to the data requirements of this report. As such, each source (including different jurisdictions) contained unique formatting that had to be collated and standardised.

Due to the above, the main difficulty was the duplication of project entries across different data sources – for instance, transport projects with split state and federal funding would be contained in two lists. Furthermore, the project-level data sourced from GlobalData and Oxford Economics Australia contained both publicly and privately funded infrastructure such that the aforementioned transport project could potentially be found across four datasets. The unique formatting (and naming conventions) of the different data sources made identifying these duplicates an intensive manual process.

The main difficulties are summarised below, with the guidelines used to deal with them:

- Duplication across data sources: in the instance where the same project was identified across numerous data sources, jurisdictional and federal project information was treated as the most accurate source.
- Projects outside of scope: despite the widening of the project database, there are still certain types of projects which were excluded in this report. This includes offshore projects, Defence projects, projects that finalised before 2014-15, projects with insufficient explanatory detail, projects that had not yet been confirmed (speculative, not relevant to jurisdictional/federal data) and projects which belonged to a typecast outside of the scope of the 2022 Infrastructure Market Capacity report (notably, mining and heavy industry).

- Programs of work: programs of work and the individual projects that constitute these programs were identified across the data sources. In the instance where the individual projects provided additional detail (compared to the program of works), then they were included in the database and the program of works was excluded to avoid a double count of expenditure. In the instance where the individual project expenditure did not sum to the total value of the program of works, then the program of works was included and assigned a capital cost equal to the difference between the total program value and the summed individual projects.

Infrastructure typecasts

The portfolio comprises 3 broad infrastructure sectors:

- Transport
- Utilities, and
- Buildings

The portfolio breaks these three sectors down across the following 17 Master Types and 62 separate typecasts as shown in Table 1 below.

Table 1: Infrastructure typecasts

SuperSector	MasterType	Typecast
Transport	Road	State Road (Highway/Freeway)
Transport	Road	Bridge (Road)
Transport	Road	Low Use Road
Transport	Road	Tunnel (Road)
Transport	Road	Routine Road Maintenance
Transport	Road	State Road (Highway/Freeway) Rehabilitation Maintenance
Transport	Road	Low Use Road Rehabilitation Maintenance
Transport	Rail	Station (Rail)
Transport	Rail	Main Line Works (Rail) (Greenfield)
Transport	Rail	Tunnel (Rail)
Transport	Rail	Bridge (Rail)
Transport	Rail	Light Rail (Greenfield)
Transport	Rail	Light Rail, Stabling, and Signalling Works (Brownfield)
Transport	Rail	Main Line Works (Rail) (Brownfield)
Transport	Road/Rail	Level Crossing
Transport	Aviation	Airport Runway

SuperSector	MasterType	Typecast
Utilities	Energy and Fuels	Gas Pipeline
Utilities	Energy and Fuels	Wind
Utilities	Energy and Fuels	Utility Solar
Utilities	Energy and Fuels	Hydro
Utilities	Energy and Fuels	Pumped Hydro
Utilities	Energy and Fuels	Transmission Line: Single Circuit
Utilities	Energy and Fuels	Transmission Line: Double Circuit
Utilities	Energy and Fuels	Transmission (other)
Utilities	Energy and Fuels	Coal
Utilities	Energy and Fuels	CCGT
Utilities	Energy and Fuels	Peaking Gas+Liquids
Utilities	Telecomm and Digital	Telecommunications

SuperSector	MasterType	Typecast
Utilities	Water and Sewerage	Water Pipeline
Utilities	Water and Sewerage	Dam
Utilities	Water and Sewerage	Water Treatment Plant
Buildings	Aviation	Airport Building
Buildings	Education	School (Greenfield)
Buildings	Education	School (Brownfield)
Buildings	Education	Higher Education (Brownfield)
Buildings	Education	Higher Education (Greenfield)
Buildings	Education	Higher Education (Addon/Brownfield)
Buildings	Health	Hospital (Greenfield)
Buildings	Health	Hospital (Addon/Brownfield)
Buildings	Health	Health Facility (Greenfield)
Buildings	Health	Health Facility (Brownfield)
Buildings	Health	Aged Care Facility (Greenfield)
Buildings	Health	Aged Care Facility (Brownfield)
Buildings	Health	Health Facility (Addon/Brownfield)

SuperSector	MasterType	Typecast
Buildings	Health	Aged Care Facility (Addon/Brownfield)
Buildings	Justice	Correctional Centre
Buildings	Justice	Courthouse
Buildings	Justice	Police Facility
Buildings	Justice	Fire and Emergency Facility
Buildings	Other Building	Civic/Convention Centre
Buildings	Other Building	Office
Buildings	Other Building	Arts Facility
Buildings	Other Building	Laboratory
Buildings	Residential	Detached Residential
Buildings	Residential	Multi Residential
Buildings	Residential	Semi-detached Residential
Buildings	Residential	Accommodation
Buildings	Retail	Retail Store
Buildings	Sports Facility	Arena/Sporting Facility
Buildings	Telecomm and Digital	Data Centre
Buildings	Transport Building	Parking Facility
Buildings	Transport Building	Warehouse

Appendix D: Resource classifications

Resource Classifications

Labour was focused on the following occupational breakdowns considered most relevant to the infrastructure market and consistent with the Australian and New Zealand Standard Classification of Occupations (ANZSCO).

Table 2: Labour occupation classification

PLEM Category	Major Subdivision	Minor Subdivision	Detailed Item
Labour	Engineering, Scientists and Architects	Architect	Architect
Labour	Engineering, Scientists and Architects	Civil Engineer Professionals	Civil Engineer
Labour	Engineering, Scientists and Architects	Civil Engineer Professionals	Geotech Engineer
Labour	Engineering, Scientists and Architects	Civil Engineer Professionals	Quantity Surveyor
Labour	Engineering, Scientists and Architects	Civil Engineer Professionals	Structural Engineer
Labour	Engineering, Scientists and Architects	Draftsperson	Draftsperson
Labour	Engineering, Scientists and Architects	Electrical Engineer	Electrical Engineer
Labour	Engineering, Scientists and Architects	Electronic Engineer	Electronic Engineer
Labour	Engineering, Scientists and Architects	Engineering Manager	Engineering Manager
Labour	Engineering, Scientists and Architects	Environmental Professionals	Environmental Professionals
Labour	Engineering, Scientists and Architects	Geologists, Geophysicists and Hydrogeologists	Geologists, Geophysicists, and Hydrogeologists
Labour	Engineering, Scientists and Architects	Industrial, Mechanical and Production Engineers	Mechanical Engineer

PLEM Category	Major Subdivision	Minor Subdivision	Detailed Item
Labour	Engineering, Scientists and Architects	IT Professionals	IT Professionals
Labour	Engineering, Scientists and Architects	Landscape Architect	Landscape Architect
Labour	Engineering, Scientists and Architects	Maintenance Planner	Maintenance Planner
Labour	Engineering, Scientists and Architects	Other Professional Engineers	Other Professional Engineers
Labour	Engineering, Scientists and Architects	Procurement	Procurement
Labour	Engineering, Scientists and Architects	Safety Officer	Safety Officer
Labour	Engineering, Scientists and Architects	Surveyor	Building Surveyor
Labour	Engineering, Scientists and Architects	Surveyor	Land Surveyor
Labour	Engineering, Scientists and Architects	Telecoms Engineer	Telecoms Engineer
Labour	Finishing Trades and Labour	Electrical Line Workers	Electrical Line Workers
Labour	Finishing Trades and Labour	Electricians	Electricians
Labour	Finishing Trades and Labour	Glazer	Glazer
Labour	Finishing Trades and Labour	Painting Trades	Painting Trades
Labour	Finishing Trades and Labour	Plasterers	Plasterers
Labour	Finishing Trades and Labour	Plumbers	Plumbers
Labour	Finishing Trades and Labour	Telecoms Cabler	Telecoms Cabler
Labour	Finishing Trades and Labour	Telecoms Field Staff	Telecoms Field Staff
Labour	Finishing Trades and Labour	Tiler	Tiler

PLEM Category	Major Subdivision	Minor Subdivision	Detailed Item
Labour	Project Management Professionals	Enviro. & Occupational Health Professionals	Enviro. & Occupational Health Professionals
Labour	Project Management Professionals	Project Management Professionals	Commercial Management
Labour	Project Management Professionals	Project Management Professionals	Construction Management
Labour	Project Management Professionals	Project Management Professionals	Project Management
Labour	Project Management Professionals	Project Management Professionals	Risk Management
Labour	Structures and Civil Trades and Labour	Bricklayer	Bricklayer
Labour	Structures and Civil Trades and Labour	Carpenters and Joiners	Carpenters and Joiners
Labour	Structures and Civil Trades and Labour	Concreter	Concreter
Labour	Structures and Civil Trades and Labour	Crane Op	Crane Op
Labour	Structures and Civil Trades and Labour	Driller (Piling/Foundations)	Driller (Piling/Foundations)
Labour	Structures and Civil Trades and Labour	General Construction Labourer	General Construction Labourer
Labour	Structures and Civil Trades and Labour	Other	Other
Labour	Structures and Civil Trades and Labour	Plant Op	Plant Op
Labour	Structures and Civil Trades and Labour	Rail Track Worker	Rail Track Worker
Labour	Structures and Civil Trades and Labour	Rigger & Dogman	Rigger & Dogman
Labour	Structures and Civil Trades and Labour	Road Based Civil Plant Op	Road Based Civil Plant Op
Labour	Structures and Civil Trades and Labour	Structural Steel Erector	Structural Steel Erector

Plant, materials and equipment was classified according to the system adopted in **Table 3**.

Table 3: Plant, material and equipment classification

PLEM Category	Major Subdivision	Minor Subdivision	Detailed Item
Material	Asphalt	Asphalt	Asphalt
Material	Bitumen Binders	Bitumen Binders	Bitumen Binders
Material	Concrete	Concrete	Aggregate
Material	Concrete	Concrete	Cement
Material	Concrete	Concrete	Sand
Material	Electrical Bulk	Electrical Bulk	Electrical Bulk
Material	Other	Linemarking & Road Furnitures	Linemarking & Road Furnitures
Material	Rock/Bluestone	Rock/Bluestone	Rock/Bluestone
Material	Steel	Girders	Girders
Material	Steel	Rail Track	Rail Track
Material	Steel	Steel – Structural Elements	Steel – Structural Elements
Material	Steel	Steel Re-inforcement	Steel Re-inforcement
Material	Walls	Bricks	Bricks

PLEM Category	Major Subdivision	Minor Subdivision	Detailed Item
Material	Walls	Plasterboard	Plasterboard
Material	Walls	Timber	Timber
Plant	Civil	Bulldozers	Bulldozers
Plant	Civil	Compactor	Compactor
Plant	Civil	Excavator	Excavator
Plant	Civil	Graders	Graders
Plant	Prelims	Site Offices, Lunchrooms	Site Offices, Lunchrooms
Plant	Prelims	WC	WC
Plant	Site	Mobile Cranes	Mobile Cranes
Plant	Site	Scaffold (tubular)	Scaffold (tubular)
Plant	Site	Scissor Lifts	Scissor Lifts
Plant	Site	Street Sweeper	Street Sweeper
Plant	Site	Tower Cranes	Tower Cranes
Plant	Speciality Plant	Speciality Plant	Speciality Plant
Equipment	Control Equipment	Control Equipment	Control Equipment
Equipment	Electrical Equipment	Electrical Equipment	Electrical Equipment
Equipment	Mechanical	Mechanical	Mechanical

Appendix E: Workforce and skills methodology

Definitions

Demand

- **Major public infrastructure pipeline (MPIP) demand** refers to the estimated workforce resources (that is, the sum of full-time equivalents in occupations as defined by Infrastructure Australia) required to undertake major public building and engineering construction. Major projects are those with a value above either $100 million (in NSW, Vic, Qld or WA) or $50 million (in SA, Tas, ACT or NT), as well as all energy projects regardless of total value.
- **Total public infrastructure pipeline (TPIP) demand** refers to the workforce required to undertake total public infrastructure building and engineering construction. This includes all of MPIP, as well as publicly funded projects below the MPIP threshold, all roads maintenance, and privately funded public infrastructure.
- **Non-major public infrastructure pipeline demand** refers to those public infrastructure projects not otherwise captured by MPIP.
- **Privately funded public infrastructure** is any building or engineering construction that is privately built, but is for public use, regardless of ultimate ownership or operation. All transport and utilities projects are considered public infrastructure, as are a subset of non-residential buildings. For example, hospitals may be privately funded, owned, and operated, but are considered public infrastructure.
- **Private demand** refers to the workforce required to complete all other private engineering construction and building, which is anything that is privately funded and not otherwise captured by the definitions above. This comprises mostly residential building, but it includes a portion of private non-residential building and private engineering construction for private use.
- **Building and engineering construction** for the definitions above refer to projects relating respectively to fixed structures with a roof, and anything without a roof (e.g., roads, rail, pipelines). 'Building' and 'construction' may be used interchangeably elsewhere in the report. The 'construction industry/sector' (as defined in the ANZSIC standard) captures work on both buildings and engineering construction.

Occupational groups

The public infrastructure workforce consists of four main occupational groups, each consisting of discrete occupations.

- **Project management professionals** plan, organise, direct, control and coordinate the construction process. They are typically responsible for the physical and human resources engaged across the construction lifecycle.
- **Engineers, scientists and architects** design, plan, organise and manage the detailed specifications of the construction and maintenance. They are engaged throughout the construction process and include many subspecialists.
- **Structures and civil trades and labour** do construction and the preparation for construction. They include those who support these tasks, such as truck drivers and crane operators.
- **Finishing trades and labourers** move infrastructure projects from construction to completion. They fit out construction projects and ensure they are operational and can be used for their particular purpose.

Occupations and roles

Occupations were defined using the Australian and New Zealand Standard Classification of Occupations (ANZSCO), through consultation with Infrastructure Australia's industry experts and additional key stakeholders.

Roles were defined using job advertisement data from Lightcast and consultation with industry stakeholders. Roles provide a greater specificity on the workforce needed to support the current and future infrastructure pipeline that would otherwise be masked by occupational analysis.

Lightcast aggregates job advertisements to create insight into the supply and demand for talent. The data set includes millions of job advertisements covering every occupation and industry in Australia.

Skills

Skills were defined using the Lightcast skills taxonomy. Lightcast developed this taxonomy using proprietary algorithms that defined and referenced

over 1,500 general and technical skills identified by employers as important for new hires. This can be used to understand trends in skill demand, including skill needs for specific occupations.

Workforces

The engaged workforce is made up of those workers engaged on public infrastructure construction work. The adjacent workforce is made up of those in the rest of the construction industry, who would take zero to six months to train. The trainable workforce is made up of those working outside the construction industry who have a high level of overlapping skills, who would take approximately six to 12 months to train. The distant workforce is made up of those working outside the construction industry who have only some overlaps in skills, who would take one to three years to train.

The trainable and distant workforces work in industries such as professional, scientific, and technical services; transport, postal and warehousing; public administration and safety; and mining.

Occupational shortage assessment

The table below shows how the overall assessment of occupational shortages was produced. **Overall assessment** reflects whether occupations were likely in shortage (fulfilled three or more criteria), potentially in shortage (fulfilled two criteria) or unlikely to be in shortage (fulfilled less than two criteria).

There are four criteria:

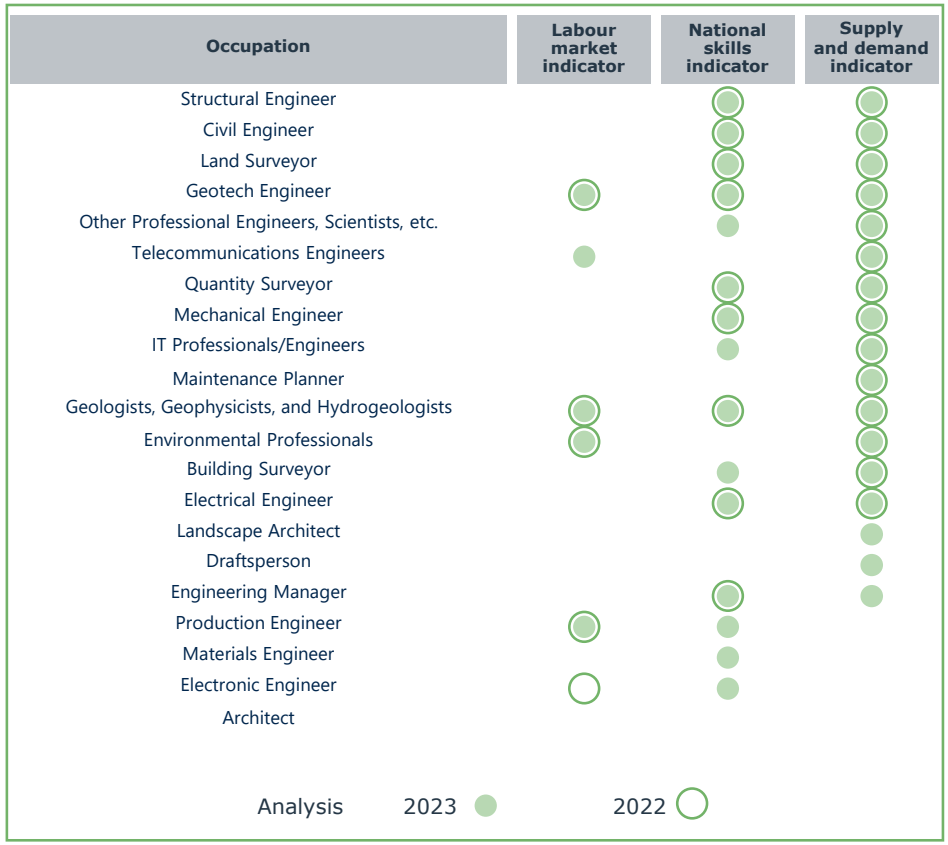
- **NSC Skill Priority List** – This indicates whether occupations are in shortage on the Skills Priority List (SPL) from the National Skills Commission (now Jobs and Skills Australia).
- **Existing worker shortage in public infrastructure** – is the demand for an occupation in public infrastructure exceeding the supply for an occupation in our modelling? Assessed as at June 2023.
- **Labour market Indicators** – is an occupation in shortage according to the following criteria: change in advertised salary; change in share of job advertisements; and share of advertisements posted for more than 30 days?

Table 4: Assessment of shortage and the relevant indicators for each occupation by occupational group

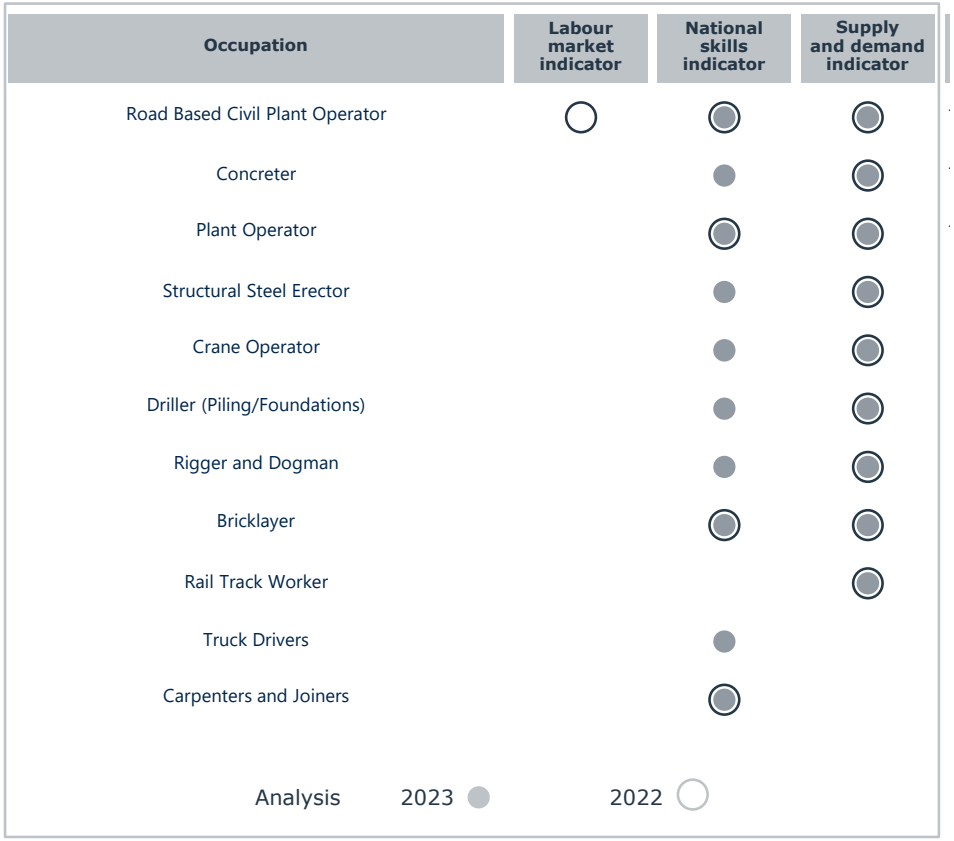
Project management professionals

Occupation	Labour market indicator	National skills indicator	Supply and demand indicator
Project Management		●	◉
Procurement			◉
Commercial Management			◉
Environmental and Occupational Health Professionals			◉
Risk Management		◉	◉
Construction Management		◉	
Architect			
Analysis	2023 ●	2022 ○	

Engineers, scientists and architects



Structural and civil trades and labour



Finishing trades and labourers

Occupation	Labour market indicator	National skills indicator	Supply and demand indicator
General Construction Labourer		●	◉
Safety Officer	◉		◉
Painting Trades		◉	◉
Electrical Line Workers		◉	◉
Telecoms Field Staff			◉
Telecoms Cabler		◉	◉
Glazier		◉	◉
Plasterers	○	◉	◉
Tiler	◉	◉	◉
Plumbers		◉	
Mechanical Engineering Trades Workers		◉	
Electricians		◉	
Electrical or telecommunications Trades Assistant	○		

Analysis 2023 ● 2022 ○

Modelling methodology

Introduction

The fundamental question addressed by this report is to what extent the current and projected supply of labour can support Australia's proposed investment in public infrastructure. To understand this, it was necessary to clearly define the occupations and skills that underpin this workforce and to estimate the numbers of workers available at different points in time, including projections for the future. The broad approach was:

- To estimate numbers of workers in or near the infrastructure workforce as determined by official statistics and our own forecasts or modelling based on those statistics
- To confront these estimates with additional data (such as job advertisements) that provides extra information on variables (such as skills) not covered by the official statistics, and extra granularity (such as estimates down to the level of 'roles', below existing ANZSCO unit groups) on variables which required further detail than official statistics provided.

The analytical work has two elements: developing classifications and making estimates. The two elements overlap, as we used data-based estimates to define our classifications, but it is useful to understand the steps separately.

Two key classifications were developed for this work and are used throughout the report. These classifications build on the standard classifications used for occupation and industry: the Australian and New Zealand Standard Classification of Occupations (ANZSCO) and the Australia and New Zealand Standard Industrial Classification (ANZSIC). Using data to categorise, combine (and in some cases add) our final occupational classifications added additional granularity to the standard measures. The two classifications are:

6. Which occupations and roles are relevant to public infrastructure?
7. Which parts of the workforce in relevant occupations are engaged in, adjacent to, trainable for or distant from public infrastructure?

These classifications were developed to capture the full range of occupations that contribute to public infrastructure in a single streamlined taxonomy. They also support a more nuanced view of the labour force that recognises the portability

of skills across and between sectors. Finally, the addition of roles provides a level of granularity which is not present in ANZSCO but which is critical to understanding skill needs.

There were six key pieces of data analysis that built on those classifications, seeking to estimate:

1. Historical and current labour supply
2. Anticipated workforce attrition
3. Future labour supply
4. Workforce shortages
5. Skill profiles
6. Demographics.

The methods used for these two classifications and six pieces of analysis are outlined in more detail below.

The most important data sources across the project were the 2016 Census and the ongoing Labour Force Survey, to quantify where supply matched demand until 2036; and job advertisement data from Burning Glass as an indicator of demand. Each of these data sources has its own strengths and weaknesses, which limits the conclusions that can be drawn:

- The Census is comprehensive but infrequent; it is self-completed and depends on respondents identifying their own occupation and industry.
- The Labour Force Survey is carefully calibrated to definitive population totals and has higher quality consistent use of classifications, but it is based on a sample.
- The job advertisements are also a sample, but of a varying and unknown proportion of the full quantum of demand – varying not just over time but also by occupation and industry.
- The classification of job advertisements to industry and occupation is done by a statistical / machine learning algorithm based on analysis of the original text, introducing its own statistical noise.

Key limitations of the analysis can be understood in several categories:

- measurement noise – such as Census respondents misclassifying their industry or occupation in a way different to any misclassification that takes place in the Labour Force Survey
- processing noise – such as the Lightcast machine learning algorithm misclassifying the occupation of a job advertisement
- analytical assumptions – such as assuming that the proportions of detailed job titles within an ANZSCO unit group in the workforce reflect the proportion of those titles appearing in job adverts for that ANZSCO unit group; or that the proportion of people in each industry working in each occupation at the time of the Census (the best source at that level of granularity) has not changed materially since.

Every effort has been made to control for these problems, as outlined in the detail below, but significant uncertainty and limitations are inevitable.

Defining public infrastructure relevant occupations and roles

Methodology

An occupational and role taxonomy was previously developed by Nous in partnership with Infrastructure Australia (IA) and their other consulting partners.

This comprises a four-tier taxonomy, going from group at the highest level, down to classification, sub-classification, and role. The first three levels were defined by IA, then mapped to ANZSCOs to enable alignment with key data sources; roles were defined through job advertisement data from Lightcast.

As in previous years, a share of non-project-management occupations are apportioned into project management occupations, to reflect that many project management roles on public infrastructure projects are undertaken by individuals captured under other occupations. This was done using job advertisement data to assess cosine similarity of skills for roles. Any ANZSCOs that contained less than one per cent of project management professional roles in its job advertisements were excluded from further analysis.

Assumptions

The following assumptions were adopted in defining infrastructure-relevant occupations:

1. Job advertisements are matched appropriately to ANZSCO unit groups in the Lightcast data set.
1. All individuals covered by a mapped ANZCO unit group have skills relevant to public infrastructure.

Limitations of analysis

1. Potential limitations identified in completing our analysis include:

2. The workforce engaged in public infrastructure is diverse. Several occupations involved in pre-planning stages have been omitted from the analysis, such as construction lawyers, transport economists and policy analysts.
3. Infrastructure-relevant occupations are limited to those identified as working in the sector. Individuals outside defined occupations may share a sufficient base of skills to be relevant for public infrastructure. This is most likely true for labouring occupations such as general construction labour, riggers or operators of basic plant.

Defining the engaged, adjacent, trainable and distance share of the workforce

Methodology

Individuals were allocated to ANZSIC (industry) group segments by ANZSCO (occupation) based on 2021 census data. ANZSIC groups were then classified based on those directly linked to the construction of public infrastructure and those that were not. ANZSIC groups identified as directly linked included ANZSIC E, 692, 942 and 529. These formed the basis of engaged and adjacent estimates, with trainable and distant drawn from the remaining ANZSICs.

Weightings were developed to apportion the share of workers engaged and adjacent to public infrastructure. Workforce-to-spend ratios provided by Infrastructure Australia were used to calculate public-private split estimates based on labour, rather than for the total value of projects by state and type of project. Occupational profiles by ANZSIC groups were then used to estimate which occupations were most likely to be working on public and private projects, allowing us to map the monetary public-private split data to the actual supply of labour for engaged and adjacent individuals.

For each ANZSIC group not identified as directly linked, a skills profile was developed using Lightcast job advertisement data. This was compared to the profile for the same occupation in directly linked ANZSICs using cosine similarity analysis. Based on similarity score the ANZSCO-ANZSIC segment was allocated to either the trainable or distant category.

Assumptions

The following assumptions were adopted in defining the engaged, adjacent, trainable and distant shares of the public infrastructure related workforce:

1. ABS data collections capture the full extent of government investment in public infrastructure.
2. ANZSIC E, 692, 942 and 529 account for most of the building and engineering construction activity.
3. Ratios provided by Infrastructure Australia to translate value to employment are consistent with industry practice.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Our definition includes work funded by all tiers of government (Australian Government, state and territory governments and local councils). We are unable to differentiate based on funder.
2. The ABS expenditure data does not present any split within the private sector that can be used to estimate work done on private projects destined for private ownership but meant for public use, some of which are included in demand estimates.

Estimating historical and current labour supply for public infrastructure

Methodology

Nous maintains bespoke estimates of workforce supply by ANZSCO unit and ANZSIC group, using iterative proportional fitting to combine latest-available census data with more up-to-date Labour Force Survey data; these were drawn on for IA-relevant occupations.

The resulting estimate for total workforce in infrastructure-relevant roles was then apportioned based on weightings developed in the previous step to determine the number of engaged, adjacent, trainable or distant workers from 2016 to 2023.

Assumptions

The following assumptions were adopted to estimate the historical and current labour supply for public infrastructure:

1. The distribution of job advertisements by ANZSCO unit group is a reasonable approximation of the workforce under each ANZSCO minor group.
2. Individuals are classified in the same way under census, labour force survey and Lightcast data.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Small variations in estimates may occur at sub-jurisdictional level from official statistics due to the approach adopted to overcome limitations in census microdata.

Estimating anticipated future workforce attrition

Methodology

Estimates of workforce attrition are based on changes to the age profile of the current infrastructure workforce between two consecutive census surveys.

Age profiles of individuals in the current workforce were approximated using 2021 ABS Census demographic data on individuals working in construction-related industries, split by five-year age groups. The attrition rate was calculated based on movement between the 2016 Census and 2021 Census of consecutive five-year age groups for individuals older than 45 years old under the construction ANZSIC. The change between the two Census surveys and consecutive age groups captures mortality, retirement and career changes.

Due to exceptional circumstances surround the 2021 census – namely the COVID-19 pandemic and the associated economic disruption – it was estimated that the attrition rates produced would be an underestimate over the projection period: in particular due to people delaying retirements and even re-entering the workforce, higher attrition is expected than the shift between the censuses would suggest. An adjustment factor was applied to account for this.

Nous then iteratively shifted the age distribution of the current workforce every five years, and applied attrition estimates to the respective five-year age groups. This produced attrition estimates by occupation and age to 2036.

Assumptions

The following assumptions were adopted in projecting workforce attrition:

1. The age distribution of the current infrastructure workforce is well-approximated by the age profile of individuals working in construction related industries.
2. The change in workforce between the two Census surveys mostly captures mortality and retirement.
3. The change in workforce at an ANZSCO 6-digit level is well approximated by changes at the ANZSCO 4-digit level.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Estimated attrition ranges may vary within the ANZSCO 6-digit level compared to the ANZSCO 4-digit level.
2. We are unable to differentiate attrition by mortality, retirement or career changes.

Estimating future labour supply for public infrastructure

Workforce supply forecasts from 2023 to 2036 were developed by integrating current supply with education and migration inflows modelled after 2023. Inflows were modelled at an ANZSCO occupation level; neither education nor migration were modelled directly at the workforce (i.e., engaged/adjacent/trainable/distant) level. To estimate this breakdown, the current and historical supply were used to derive an average engaged/adjacent/trainable/distant workforce composition, and these proportions were applied to inflows.

Education inflow

New entrants via education were estimated based on the number of workforce-ready graduates across higher education and vocational education and training (including apprenticeships and traineeships, qualifications, and individual units of competency) in each year and mapped to infrastructure-related ANZSCOs. This was done in three steps:

Forecast population to 2036 by five-year age groups

Population projections derived by the Australian Institute of Health and Welfare (AIHW) were used to model population in five-year age groups at the Statistical Area Level 2 granularity up until 2032. Population projections between 2032 and 2036 were interpolated using the compound annual growth rate (CAGR) from 2027 to 2032.

Projecting the number of workforce-ready graduates (all pathways)

Domestic bachelor (higher education) commencements were calculated each year using the Tertiary Collection of Student Information data (TCSI) from the Department of Education, formerly called the Higher Education Information Management System (HEIMS). This was done by age group and translated to a ratio of commencements in each region, per age group, by its population. The commencement ratio was then combined with population forecasts to 2036 to obtain commencements into 2036. Commencements

were then overlayed with estimated completion rates from the Department of Education project graduations. Estimates were then adjusted to account for students who may delay workforce entry to pursue further study.

Vocational education and training graduates were calculated in three parts – apprenticeships and traineeships, qualification completers, and part-completers (people that may only undertake a few units of competency for occupational or high-risk licencing purposes). Apprentice and trainee completions were calculated with a similar approach used for domestic bachelor graduates, with completion rates based on prior Nous work. Our approach for non-apprenticeships or traineeship was adjusted to accommodate individuals who did not complete their full training but had completed all intended training to obtain the job they needed.

The completion rates for non-apprenticeships and non-completers who had completed all intended training draw on data from the National Centre for Vocational Education Research (NCVER). To avoid double counting of individuals already in the labour market, both apprenticeships and non-apprenticeship graduates were filtered to only include individuals studying to get a job or to transition careers.

The workforce-ready graduates were mapped to IA groups and IA subclasses using Nous' proprietary concordances that link education to occupation.

Migration inflow

Migration inflows were projected using data supplied by the Department of Home Affairs. Data was broken down by visa subclass at an ANZSCO unit group level. Four visa subclasses were modelled that relate to permanent labour increases: 186 Employer Nomination Scheme; 187 Regional Sponsored Migration Scheme; 189 Skilled – Independent; and 190 Skilled – Nominated. Temporary visas were excluded to avoid double counting of the workforce. Migration figures were apportioned to regions based on existing distributions.

Assumptions

The following assumptions were adopted to estimate future labour supply for public infrastructure:

1. New supply is estimated on an annual basis and distributed evenly across the calendar year.
2. Population forecasts from 2032 to 2036 follow the compound annual growth rate of the AIHW's 2027-2032 population forecast.
3. The current rates of people commencing vocational and higher education are maintained to 2036.
4. The current rates of people completing (and where relevant, partly completing) vocational and higher education are maintained to 2036.
5. The relationship between fields of education and/or qualification, and ANZSCO career outcomes, are maintained.
6. VET students have been segmented into different categories based on reason of study. 'Skillers' and 'starters' (as identified through the student outcomes survey) are students who represent a net addition to the workforce. The ongoing proportion of 'skillers' and 'starters' maintains the same ratio as per student survey outcomes.
7. The visa classes of interest are: 186 employer nomination scheme; 187 regional sponsored migration scheme; 189 skilled independent; and 190 skilled nominated. These permanent visa classes represent a net workforce migration to Australia.
8. Current rates of migration the above subclasses is assumed to be maintained to 2036.
9. Perturbed data instances in the migration data which have a value of "<5" have been assumed to take on a value of three.
10. The distribution of migration to different states is assumed to follow the current distribution of infrastructure workers.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Education completion rates could vary due to factors including age, region, and field of study. This has not been individually estimated in this study.
2. Population estimates have not been updated since 2019; growth projections and geographical projections may have shifted somewhat, particularly due to impacts of the COVID-19 pandemic.
3. Distribution of migrants to states could vary depending on external market factors. This has not been individually estimated in this study.

Identifying shortages based on modelled supply and demand

Methodology

Demand estimates provide by Infrastructure Australia were matched to Nous supply forecasts by sub-classification to estimate potential shortage or surplus at Infrastructure Australia group, classification, sub-classification, and when relevant, geographical region.

Assumptions

1. The following assumptions were adopted to estimate future labour supply for public infrastructure:
2. Occupational definitions are consistent for demand- and supply-side estimates.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Demand estimates are based on known infrastructure investment at 30 June 2022.
2. Demand estimates do not incorporate demand from individual councils for public infrastructure.
3. Demand estimates are very limited outside of public infrastructure, so limited inferences can be made about private infrastructure and private non-infrastructure construction.
4. Not all demand data can be appropriately assigned to geographical regions; while this has no impact on any aggregate analysis, regional analysis may underestimate some shortages and overestimate others. This varies by jurisdiction, depending on the quality of data provided.

Identifying shortages based on labour market indicators

Method for occupational indicators of shortage

Each occupation has been assessed for signs of shortages using four independent methods which answer the following questions respectively:

1. Is the occupation in shortage on the National Skills Commission's Skills Priority List?
2. Does our supply and demand analysis of public infrastructure show a shortage?
3. Do the number and kind of job advertisements indicate a shortage?

An occupation is classified under 'Likely Shortage' if three or more of these assessments showed a shortage, 'Potential Shortage' if two showed a shortage and two did not or were unclear, and 'Unlikely Shortage' if only one or none of the assessments showed a shortage.

Assumptions

The following assumptions were adopted to identify shortages based on labour market indicators:

1. Movement in indicators reflects difficulties by employers in sourcing labour.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. A range of factors may contribute to movement in identified indicators. Consequently, indicators should be viewed in conjunction with other assessments of shortage to provide a fuller picture.
2. Stakeholder engagement was not undertaken as part of the project in 2023; accordingly, the indicator for views from key industry bodies and participants was dropped.

Developing skills profiles for identified occupations

Methodology

Lightcast job advertisements were used to develop skills profiles by occupation and roles based on the Lightcast skills taxonomy and text analytics algorithm.

Nous assessed each skill identified by whether they were general, or specialist as defined by Lightcast and the distinctiveness of the skill – how likely a skill is requested in a job advertisement from a particular industry compared to the entire labour market. These combined to create the three categories – general, technical and specialist – used in analysis.

Nous also assessed the degree of change in mentions of particular skill. Two periods, 2017 to 2019 and 2020 to 2022 (selected for full years of data), were compared to identify skills with increasing, declining or stable demand.

Assumptions

The following assumptions were adopted to develop skills profiles for relevant occupations:

1. Mentions of skills in job advertisements are representative of an employer's skills needs for a given occupation.

Limitations of analysis

Potential limitations identified in completing our analysis include:

1. Sample sizes can be small for some occupations. To ensure sufficient samples all job advertisements were used for a given occupation, rather than restricting to those industries directly linked to public infrastructure.

Demographic analysis

Methodology

Detailed tables from the 2021 census provided employment data by gender, age, Statistical Area Level 3 (SA3) of residence, and ANZSCO.

The figures were used to summarise age and gender distribution across occupations in scope for this report. The geographic indicators were used to explore the distribution of the infrastructure labour force across Australia.

The data used for these analyses required no modeling or estimation, just summary of data available through the ABS' TableBuilder.

Assumptions

1. Gender, age, and geographic distributions within infrastructure-specific occupations are consistent with broader industry trends and population estimates over relevant periods.
2. Gender and age distributions for common job titles within the infrastructure industry do not differ significantly from distributions in other industries.

Limitations of analysis

1. Demographic information could not be explored by ANZSIC industry classifications because of (1) table size restrictions imposed by the ABS and (2) individual categories with small numbers, which the ABS is unable to provide to protect individual privacy.
2. A key implication for analysis was the inability to accurately explore different segments of the infrastructure workforce (such as engaged, adjacent, trainable, and distant) by demographic breakdown. Only broader aggregations were possible.

Professional pathways methodology

Definitions

Term	Definition
Profile	Data about one person and their career path.
Infrastructure Profiles	All profiles that have, at some point, had an occupation within the list of infrastructure-related occupations. Note that for these profiles, their pathway will include occupations that are not in the IA subclasses list.
Occupation	An occupation spans a number of specific job titles (i.e. “roles”), regardless of employer or industry. This is equivalent to the occupational subclass per the taxonomy previously created in collaboration with Infrastructure Australia. For non-infrastructure occupations, alternative taxonomies are used as provided by Lightcast in the Social Profiles data, selecting the most comparable.
Pathway	The full sequence of a person’s occupations, ordered by when the person began them. We include education as a special case of occupation when considering pathways. Pathways can be measured either with: • **Events** – when something changes • **Time** – sampling e.g. once per year, whether something changes or not In either case, we may refer to different starting points, and refer to relative sequencing. For example: • Aligning profiles at the first instance of an infrastructure occupation • Use “t minus 1, 2, 3…” to refer to steps in the pathway beforehand Use “t plus 1, 2, 3…” to refer to steps in the pathway afterwards
Simplified Pathway	A pathway where all stages are simplified to either “Job” or “Education”. This is useful for getting a sense of the highest-level pathways that may be common in infrastructure.

Term	Definition
Transition	A change within a particular person/profile from one 'bucket' to another, at a given level of the occupation taxonomy. Specific transitions are outlined below, from most granular to most broad. These transitions are combined to form a sequence for each profile, resulting in a pathway. Concurrency will be "ignored" as it can't always be determined and poses methodological challenges that are not a high priority. A transition can include/ not include **education** and will be specified whenever transitions are discussed. Due to the issue of concurrency, if there is a transition from *employment to education* or *education to employment*, this could mean that an individual has: • left a job and started education, • stayed in a job and started education, or • started a job during their education.
Job Transition	A change from either one **job title/ employer** to another. These transitions will include a separate job title entry for a change in employer, even if the job title remains the same.
Role Transition	A change from one job title to another.
Occupation Transition	A change from one occupation (subclass) to another. Note that this includes education. This would treat multiple **roles** within the same **occupation** as the same, i.e. if someone changed roles (Project Officer Project Sponsor) it would not trigger an **occupation transition**.
Occupational Group Transition	Similar to the above, but to/from one occupation **group** to another, or to/from a non-infrastructure equivalent
Industry transition	A change to/from an infrastructure-relevant industry (construction) to/from education or a non-infrastructure industry (non-construction).
First *position*	The first job/role/occupation etc. in a pathway.
Transition From X	For a given transition (at any point in a pathway), the job/role/occupation etc. someone is moving ***from***.
Transition Through X	For a given profile, i.e. an entire pathway, a job/role/occupation that someone lands in ***at some point*** (or at a given point).

Introduction

To inform strategies to address shortages among professional roles in the infrastructure industry, Nous conducted additional analysis to determine significant flows between occupations within and surrounding the infrastructure industry. This analysis leveraged Lightcast's Social Profiles data for Australia, which scrapes professional experience from social media. It comprises anonymised real-world career profiles that include information on educational background and the specific jobs held by individuals throughout their careers.

To do this it was necessary to define the set of career profiles that are relevant to public infrastructure and to distinct occupational groups. This allows us to estimate the proportion of individuals that experience key events of interest, and accordingly, to make inferences about problems facing infrastructure professionals and likely interventions. The primary objectives of this analysis were as follows:

- **Origins and Transitions:** Determine the sources and destinations of individuals involved in infrastructure occupations, shedding light on their career mobility patterns.
- **Tenure and Retention:** Ascertain the duration of individuals' engagement in relevant occupations and evaluate the extent to which the workforce is retained within the industry over time.
- **Professional Pathways:** Identify the crucial occupational trajectories that serve as major conduits for individuals pursuing a career in the infrastructure sector.
- **Lead Time and Components:** Analyse the time required to progress to specific occupations, considering factors such as relevant occupations, unrelated occupations, and educational pursuits.

Overall limitations of this analysis include:

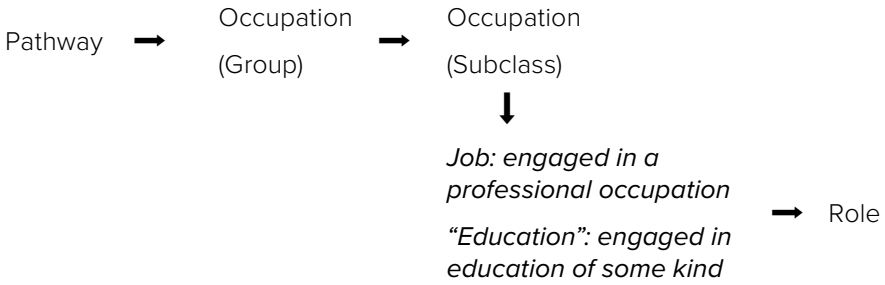
1. Sample size varies by occupation, and very noticeably by occupational group. Different individuals are more or less likely to fill out and/or maintain their professional social media, and there are different incentives to do so across occupations. The analysis assumes that this does not bias within-occupation results.
2. Similarly, not all key fields of interest can be populated; in particular, the industry of a role and the ANZSCO it maps to cannot always be ascertained. Again, the analysis assumes that this does not bias within-occupation results

Defining elements of professional pathways

Methodology

Each entry in the Social Profiles data represents either a job (also referred to as a professional "role") or time spent in education, which, ordered chronologically, make up a person's professional pathway. A simplified pathway is a pathway where all stages are simplified to either "Job" or "Education" and is useful for getting a sense of the highest-level pathways that may be common in infrastructure.

The taxonomy is therefore:



When examining these pathways, it is essential to consider the following defining elements:

- Profile – Data about one person and their career path.
- Infrastructure Profiles – All profiles that have, at some point, had an occupation within the list of infrastructure-related occupations.

There are also two key dimensions to each occupation:

- Industry – The same occupation can be found in different industries. As with the workforce modelling, infrastructure is best identified as relevant occupations engaged in the Construction industry.
- Employer – The same person can undertake the same occupation with different employers.

A pathway can be measured either by:

- "Events" – a change in employment, such as a role change within the same occupation, a move to a different employer with the same or a different role, or a change of occupation altogether.

- "Time" – sampling a pathway at some interval over time (primarily once per year).

Most profile entries can be linked to an infrastructure-relevant occupation through an ANZSCO code provided in the Social Profiles data, and aggregating specific occupations (at the 'subclass' level), occupational 'groups', and industries will create a "stock-flow" model of professional pathways over time.

A change within a profile from one grouping to another, at any given level of the occupation taxonomy (e.g. from one occupational group to another, or from one occupational subclass to another), is referred to as a "transition".

Specific transitions of interest are outlined below, from most granular to most broad:

- Job transition – A change from either one job title / employer to another. These transitions will include a separate job title entry for a change in employer, even if the job title remains the same.
- Role transition – A change from one job title to another.
- Occupation transition – A change from one occupation (subclass) to another. The analysis includes education at this level and treats multiple roles within the same occupation as non-transitions.
- Occupation Group transition – A change from one occupational group to another, or from/to a non-infrastructure equivalent.
- Industry transition – A change to/from an infrastructure-relevant industry (construction) to/from education or a non-infrastructure industry (non-construction).

Concurrency will be "ignored" in pathways as it cannot be reliably and consistently determined. If there is a transition from *employment to education* or *education to employment* this could mean that an individual has:

- Left a job and started education,
- Stayed in a job and started education, or
- Started a job during their education.

Assumptions

The following assumptions were adopted in defining elements of professional pathways:

1. All occupations relevant to the public infrastructure workforce are determined by their ANZSCO6 code's presence in the IA classification mapping.
2. Start and end dates are accurate and will determine the sequence of events in a person's professional pathway.

Limitations of analysis

Potential limitations identified in defining these elements include:

1. Occupation ANZSCO6 codes can map to multiple IA subclasses, the most likely mapping is selected and matched. Geotech engineers and Structural engineers are not mapped as a result.

Identifying and analysing relevant profiles and pathways

Methodology

The Social Profiles data is categorised at the 'role' level and mapped to the 'occupation' level using ANZSCO6 codes provided by the Lightcast taxonomy. The dataset is filtered to include only profiles with relevant ANZSCO6 codes that can be mapped to a subclass occupation. Additionally, the data is filtered to profiles that have worked in infrastructure-relevant industries (i.e., construction industry) at least once in their professional pathway. This ensures that the analysis focuses on career profiles that have worked in an infrastructure-relevant occupation at least once.

For roles that fall outside of the infrastructure-relevant occupations list but are part of the relevant profiles, other occupation and 'cluster family' descriptions are pulled from the dataset. These descriptions provide a similar level of detail as the subclass and group occupation levels, respectively.

Entries are collated based on an individual's anonymised identifier and sequenced by start date to create events-based professional pathways for analysis. These pathways are expanded to create yearly versions using the start and end dates for each event, resulting in time-based professional pathways.

In cases where career profiles have overlapping entries during the same calendar year (e.g., working and studying simultaneously), each case is addressed as follows:

- Lead time – Entries are kept in parallel, and the elapsed time from the first entry in their professional pathway to the start of working in an occupation is used.

- Event based pathways – Each event can represent only one path per individual; therefore, overlapping entries are included sequentially based on start date.
- Time based pathways – The most recent event identified by start date within that year is represented.
- Years in occupation, education, or industry – Overlapping entries are considered separately to calculate aggregated metrics for individual profiles.

A person's career pathway can span many years and events, with an infrastructure-relevant occupation occurring at any stage. Aggregated pathways are therefore anchored at the first instance of an individual entering an infrastructure-relevant occupation, group, or industry within construction; this is referred to as 't0' or 'e0' for time and events, with preceding and subsequent years or events referred to as 't-1', 't+1' etc.

Assumptions

The following assumptions were adopted in analysing elements of professional pathways:

1. An experienced professional is an occupation within the project management professionals or engineering, scientists, and architects occupation groups with at least 5 years in any occupation (excluding education).
2. An entry-level professional is an occupation within the project management professionals or engineering, scientists, and architects occupation groups with the immediate previous transition being education and/or with less than 5 years in any occupation (excluding education).
3. Any role in a person's pathway without an end date is assumed to end at the start of the next event in the profile and assumed to be current if at the end of the pathway.
4. Any education without a start date is assumed to have occurred prior to work, and if without an end date assumed to last a maximum of 2 years.

Limitations of analysis

Potential limitations identified in analysing these elements include:

1. Sample sizes of career profiles are highly reliant on individual's need to upload an online work profile. This results in substantially smaller sample sizes for structures and civil trades and labour and finishing trades and labour, compared to project management professionals and engineering, scientists, and architects.
2. Most granular level of analysis is done at the occupation level rather than role level due to substantial sample sizes being limited at the role level.
3. There is limited ability to identify industry of occupation in the dataset due to missing data, but this is required for filtering to IA relevant industries in addition to ANZSCO6 occupation mapping. This results in much of the dataset being discarded.

Analysing features of profiles

Methodology

Nous created a set of features to better understand career journeys and identify archetypical pathways. These were:

- **Length of time in occupation**: measured in years, calculates the total length of time a person spends in a specific occupation, based on starting and end dates. Occupations for a single profile that are not sequential are aggregated. Aggregated mean and median values can be calculated for this feature.
- **"Lead time" to occupation**: measured in years, calculates elapsed total time leading up to an occupation from the first entry in a person's pathway. Lead time is completely prior to starting the occupation of interest and does not include the time spent in that occupation. Aggregated mean and median values can be calculated for this feature.
- **Number of occupations transitioned out of/ into 80% of workforce**: considers immediate occupation transitions before and after a given occupation. Education is excluded as we are only interested in range of occupations. This counts the smallest number of distinct source and destination occupations which cover 80% of people making transitions into or out of an occupation respectively.

To compare features, two extra aggregated features were created:

- **Ratio length of time in occupation/lead time to occupation** – calculates the ratio of each person's length of time in occupation to their lead time. All profiles are aggregated and categorised between a ratio of less than 1, and greater than or equal to 1. A higher ratio here suggests a person generally spends a longer time working in an occupation compared to their lead time to the same occupation.

- **Ratio number of occupations transitioned out of/into 80% of workforce** – the ratio of occupations a given occupation could come from, to the occupations it could lead into. A higher ratio here suggests an occupation leads to more options than there are options that lead to it; for example, it requires certain skills to enter the occupation, but provides experience that is in demand elsewhere.

Assumptions

The following assumptions were adopted in calculating features of professional pathways:

1. Length of time in occupation does not include profiles entries that are implied to be currently employed occupations or most recent occupations (those with no end date), as this will skew the data.
2. Lead time to occupation does not double count overlapping employment/education years that occur in parallel with each other.

Limitations of analysis

Potential limitations identified in calculating these features include:

1. Ratio of length of time in occupation/lead time to occupation cannot be calculated accurately for instances of those who have no lead time to an occupation.
2. The reliability of the feature analysis of each occupation is dependent on the sample size of profiles available for the occupation of interest.

Analysing fields of education whose graduates join the infrastructure workforce

Methodology

To augment the experience-driven analysis of how professionals progress through careers, TCSI data was combined with the proprietary concordance developed for the workforce modelling to analyse pathways from the other direction. The analysis focused on enrolments and estimated graduations to identify the following:

- **Key fields of education and courses**: Aimed to identify specific fields of education and the courses within them that exhibit a high rate of subsequent employment in key infrastructure-relevant occupations. This information helps determine the share of a field of education within a particular occupation.
- **Infrastructure occupations as destinations for graduates**: Explored how infrastructure occupations are positioned as potential destinations for graduates from different fields of education. This provides insights into the occupation's share within a specific field.

To further enhance the analysis, the findings were connected to the Quality Indicators for Learning and Teaching (QILT) Graduate Outcome Surveys for the years 2021 and 2022.

Assumptions

1. Key steps of the workforce modelling, namely the concordance of education to occupation and the estimation of flows from higher education, produce reasonable estimates.
2. Current statistics and patterns for enrolments, graduations, and employment remain comparable over the near- to mid-term.

Limitations of analysis

The fields of education provided as part of the QILT GOS results could not be directly connected to the fields of education used elsewhere in the modelling; accordingly, the actual employment and participation rates relevant to the field of education analysis would be slightly different

Trades pathways

Definitions

Term	Definition
A/T	Apprentices & Trainees. This refers to the individuals who are undertaking apprenticeships and traineeships.
Contract	A particular training contract. A contract is signed under a given employer and training provider. One A/T may sign multiple contracts over the course of their journey due to events outlined below.
Status	The current state at which an apprentice or trainee is in during a given contract
Event	A change in the status of training within or between contracts.
Pathway	The sequence of events between an A/T signing their first contract and terminating their final contract. Depending on the training in question, some A/Ts may be able to terminate the training early to take up work, so there are multiple terminal contract statuses that may be of interest (particularly: completed, withdrawn, cancelled).
Intended Occupation Transition	When a particular A/T changes training contracts to one with a different intended occupation.
Program Transition	When a particular A/T changes training contracts to start a different program, but this program does not have a different intended occupation.
Employer Transition	When a particular A/T changes training contracts, but only to change employers (noting that an Intended Occupation Transition or Program Transition would generally also incur a change of employer).
Infrastructure-relevant contract	A contract which has a target occupation in the infrastructure occupations list.

Term	Definition
A/T Cohort	A group of A/Ts, most likely defined by the date of first (observed) contract signing. This will be a relevant dimension for analysis to ensure like-for-like comparisons: for example, A/Ts that started in 2022 have had less time to produce events, and would skew aggregate results towards shorter pathways.
Potential Workforce	The pool of A/Ts at a 'point in time' (either time per se or a point in a sequence of events) that could be employed. This would include those that have completed an infrastructure-relevant contract and no further events have been observed, and those that have dropped out of an infrastructure-relevant contract but are employable, if these can be identified. This 'stock' could then flow into actual employment, which we will most likely not be able to determine, or back into training (infrastructure-relevant or not). By taking this more explicit stock-and-flows approach, we will be able to identify key points and types of attrition.

Introduction

To help address shortages in trades and labouring roles, this analysis seeks to identify where apprentices and trainees (A/T) are dropping out and the most effective interventions to address these points.

In doing so, it was necessary to define the students that are relevant to public infrastructure, and events of interest. This enables estimation of the number of students that have commenced, cancelled, completed, or are continuing their studies at points in time. The training someone commences only explains part of a student's journey into the workforce, so further analysis was undertaken to estimate where apprentices and trainees go when cancelling or completing courses.

To understand this, the proportions of each subset who would then go on to further study or transition into the workforce was estimated. The broad approach was:

- to map student pathways throughout their studies by each year from commencement, and then estimate the stock of those who have completed and cancelled at each point in time.
- to estimate the proportions of students who go on to pursue other studies after dropping out of their apprenticeship or traineeship.
- to estimate the proportions of students that transition into a given occupation after completing their apprenticeship or traineeship.

This analysis combines four datasets provided by the NCVER. To map student pathways, the Apprentices & Trainees data is used in isolation. To understand what students are doing after dropping out, a combination of enrolments data (i.e. the Total Vet Activity data) and completions data (i.e. the Program Completions data) is used to identify if students commence another course. Of those who complete a course, the Student Outcomes Survey data is used to estimate what occupations students transition into after an apprenticeship or traineeship.

While these data sources have clear strengths in tracking the movements of students during and after studies, there are limitations when combining them:

- Studies often take 2-4 years to complete, so there is insufficient data to analyse the pathways for the cohorts of students commencing after 2019.
- The NCVER does not enable or permit cross-linking of all of these data sets at the individual student level, in part due to privacy concerns. This means that only proportions of non-completers that go on to further study in the Apprentices & Trainees data can be approximated, rather than detailed journeys.
- The Student Outcomes Data is self-completed and is a sample of students. This is itself only an approximation of where completers go after study.

Defining elements of trades pathways

Methodology

The NCVER Apprentices & Trainees dataset contains data on all students employed under a training "contract". A contract is signed under a given employer and training provider where one A/T may sign multiple contracts over the course of their journey due to events outlined below. "Infrastructure-relevant contracts" are those with a target occupation in the infrastructure occupations list. The dataset observes the current state at which an A/T is in during a given contract (the "status") and details of students' training contracts or study over time. An "event" is a change to one of those data points – which includes when they start a contract, recommence one (for example, with a different employer) or cancel it. Details are also available for a given contract's associated qualification and the qualification's intended occupation (by ANZSCO 6-digit code).

The dataset is used to map each student's "pathway", or sequence of events between a student signing their first contract and terminating their final (observed) contract. Between commencing and terminating their final contract, students can transition through to different programs or recommence with a different employer/provider – all of which would incur a change in contract. Events identified as being of interest were:

- "Started" – when a training contract has been commenced in a given period.
- "Continuing" – when a training contract that was started in a previous period is ongoing in the current period.
- "Recommenced" – when a training contract has been cancelled and a new one has been commenced as the continuation of an existing apprenticeship/traineeship under the same qualification
- "Cancelled" – when a training contract has been terminated prior to successful completion in a given period. This includes any contracts which have been transferred due to a change in employer, suspended in a different calendar year than recommencement, expired or withdrawn from.
- "Completed" – when all of the prescribed requirements of a training contract have been met in a given period.

The variations of transitions that come from the movement of these events are:

- Intended Occupation Transitions – When a particular A/T changes training contracts to one with a different intended occupation.
- Program Transitions – When a particular A/T changes training contracts to start a different program, ***but*** this program does not have a different intended occupation.
- Employer Transitions – When a particular A/T changes training contracts, but ***only*** to change employers (noting that an Intended Occupation Transition or Program Transition would generally also incur a change of employer).

The pool of A/Ts at a 'point in time' (either time per se or a point in a sequence of events) that could be employed will identify the "potential workforce". This would include:

- Those that have completed an infrastructure-relevant contract and no further events have been observed.
- Those that have dropped out of an infrastructure-relevant contract but are employable, *if these can be identified***.**

This 'stock' could then flow into actual employment or back into training (infrastructure-relevant or not). By taking this more explicit stock-and-flows approach, we will be able to identify key points and types of attrition.

Assumptions

The following assumptions were adopted in defining elements of trades pathways:

1. All relevant student pathways are determined by their program's ANZSCO6 code and its presence in the IA classification mapping.
2. Each program's intended occupation accurately reflects the occupation the training equips a student to undertake.
3. A student is continuing their course if no event is observed in a given calendar year since commencement and they have neither completed nor cancelled their contract yet.
4. If a student has suspended their course and has not recommenced within the same calendar year, they have "Cancelled" their contract.
5. Any "Cancelled" statuses that precede a "Completed" status is actually a "Recommenced" event.
6. The A/T cohort is the group of A/Ts, most likely defined by the date of first (observed) contract signing. This will be a relevant dimension for analysis to ensure like-for-like comparisons: for example, A/Ts that started in 2022 have had less time to produce events and would skew aggregate results towards shorter pathways.

Limitations of analysis

Potential limitations identified in defining these elements include:

1. Cancellations may be slightly overestimated, as a "Recommenced" implicitly captures any "Cancelled" statuses that occurred within the same calendar year but not if it occurs in a previous calendar year.
2. Consecutive "Cancelled" statuses have been collapsed into single "Cancelled" statuses, which means that complexity in some pathways (1.8%) is understated.

Analysis of trades pathways

Methodology

The NCVER Apprentices & Trainees dataset was filtered for individuals that at some point were undertaking a program with an intended occupation within the IA taxonomy developed as part of the workforce modelling. The filtering ensures that all apprentices and traineeships considered were, at some point, undertaking training that should lead to an occupation relevant to public infrastructure. The dataset was filtered further for distinct student-program combinations that were commenced between 2015-18 to allow adequate time from commencement and ensure that full pathways are captured. Courses that have been superseded over the period have been taken into account, and apprenticeships are distinguished from traineeships at the course level.

Contract statuses were renamed to enable consistent analysis across pathways. "Cancelled" is expanded to capture all of the "Withdrawn", "Suspended" and "Expired" statuses as defined by the NCVER. In addition, "Recommenced" is redefined as outlined in the section above.

The dataset is then sampled per year and student-program combination for at least four years after commencement. This creates a stock-flow analysis in which the stock of completed and cancelled apprentices and trainees can be observed over time relative to commencement (e.g. 't+0', 't+1').

For all years that a student-program combination is not observed in the original dataset, status is imputed. After a student-program combination has "Started" or "Recommenced", a "Continuing" status is imputed for each year afterwards until they are "Completed" or "Cancelled". Once they have "Completed" or "Cancelled", they remain in that status until the end of the observation period.

However, apprentices and trainees can sometimes take longer than four years to complete. For these student-program combinations, we take their terminal status (which will either be to complete or drop out) and abridge anything from their 'fifth' year from commencement to this point. If a student-program combination transitions in to their 'fifth' year from commencement, their status would be capturing any terminal status that occurred after their fourth. This essentially creates a catch-all year for anything that happens after a student-program combination's fourth year from commencement, 'summarising' the complexity of a small number of pathways.

Assumptions

The following assumptions were adopted in analysing trades pathways:

1. Most apprenticeship and traineeship pathways should be and are completed within four years.

Limitations of analysis

Potential limitations identified throughout the analysis include:

1. Pathways analyses may not be reflective of the current trends in VET pathways as they only cover commencements between 2015 and 2018.
2. Variations in estimations may occur between the pathways and at the overall student level, as the pathways have been simplified to a student-program level.
3. Variations in estimations may occur between the aggregated data and apprentices or trainee data only, due to some programs being classified as both.
4. Inferences made from changes in status after a student-program combination's fourth year from commencement have lower precision.

Analysis of students who cancel

Methodology

To further understand where students who cancel go, NCVER data on enrolments and completions, which can be linked, are used.

The NCVER Total VET Activity dataset (TVA) contains data on all students that commence a VET subject. The dataset includes this information at the program level, the relevance of which can be inferred by the program's intended occupation (by ANZSCO6). This enables the analysis to distinguish between students who commenced relevant and non-relevant programs.

The NCVER completions data covers students that complete a VET qualification. The dataset also includes this information at the program level that has an attached ANZSCO6 code. Because student identifiers are consistent, the completion of the relevant and non-relevant programs they commenced (in the TVA) can be determined.

The distinct programs present in the filtered Apprentices and Trainees data are then searched for within the TVA at the student level to identify those who started an apprenticeship or traineeship. If those student-program combinations are found within the completions dataset, then they are taken out of the analysis. This leaves the pool of people who started an apprenticeship or traineeship but did not complete it – that is, those who dropped out.

Of those, the students who started a relevant program are distinguished from those who started a irrelevant one via the program's intended ANZSCO. Each subset of people is then searched for within the completions data.

The commencement and completion rates of those programs are then extrapolated to those who "Cancel" in the Apprentices and Trainees data. This allows for an approximation of how many students are commencing other VET courses upon cancellation, and how many of those programs are relevant to public infrastructure.

Assumptions

The following assumptions were adopted in analysing students who cancel:

1. Students who do not complete an apprenticeship or traineeship, and do not appear again in the TVA, have fully dropped out.
2. The students who start an apprenticeship or traineeship in the TVA are the same students in the Apprentices and Trainees data.
3. The proportion of students who "Cancel" in the Apprenticeships and Trainees data going into relevant and non-relevant courses is well-approximated by the student movements captured by the TVA and Program Completions data.

Limitations of analysis

Potential limitations identified throughout the analysis include:

1. The Apprentices and Trainees data and the two other datasets used are not linked in the analysis at the individual student level. This is relevant because the TVA includes students undertaking

qualifications but not as an apprentice or trainee; accordingly, proportions applied to those who "Cancel" in the Apprentices and Trainees data are an estimate. Actual proportions for only apprentices and trainees would likely vary.

2. Small variations in estimations may occur between the aggregate and jurisdictional levels as a subset of students either could not have a state imputed or are "Overseas".

Analysis of students who complete

Methodology

To further understand student movements upon completion of studies, a subset of the NCVER Student Outcomes Survey dataset is used. This subset only includes the outcomes of students who completed their specified program.

The dataset contains information on which qualification each student completed, and the occupation they transitioned into. The qualification is included at the program level, and their destination occupation is indicated by an ANZSCO4 code. The qualification's intended occupation can be identified by the program's associated ANZSCO6 code. On the other hand, ANZSCO4 codes can be associated with many occupations, and so is insufficient to map to one destination occupation in some cases. Therefore, the student's 'destination' has been apportioned out based on the occupation's prevalence across the dataset and existing workforce.

The dataset is filtered for only programs that exist within the pathways analysis of the Apprentices and Trainees dataset. Students are then summed over intended occupations and occupational groups to obtain the proportions of those students that go into actual occupations and occupational groups. These proportions determine the percentages of students that intend to enter a given occupation (by program they commenced) and transition to a given occupation.

Assumptions

The following assumptions were adopted in analysing students who complete:

1. The sample used in the Student Outcomes Survey is a good representation of the population in the Apprentices and Trainees data.
2. Destination occupations for students are well approximated by the apportioning based on occupational prevalence across the dataset and existing workforce.

Limitations of analysis

Potential limitations identified throughout the analysis:

1. The students within the Student Outcomes Survey data are not the same as those in the Apprentices & Trainees data. Proportions of those going into destination occupations are only indicative of all completers.
2. A subset of students within the Student Outcomes Survey data have an "Unknown" destination occupation, which could either be in public infrastructure or not. They have been removed, which could skew proportions.
3. The dataset only captures student outcomes between 2015-2021, which may not be reflective of current trends in student transitions.

The subset used only includes the outcomes of students who completed their specified program. Data on part-completers is available but could not be incorporated in the analysis in a timely fashion.

Data sources and usage

A range of data sources have been used to support analysis for this report. These are outlined in Table 1.

Table 1: Data sources used and their purpose

Data source	Definition of occupations	Definition of public infrastructure	Estimation of current and historical supply	Estimation of future workforce attrition	Estimation of future workforce supply	Modelled supply and demand shortages	Labour market indicators of shortage	Development of skills profiles	Demographic analysis	Professional pathways analysis	A&T pathway analysis
Lightcast labour market data	✓	✓	✓			✓	✓	✓			
ABS Census 2016 and 2021[1]		✓	✓	✓	✓	✓			✓		
ABS Engineering Construction Activity[2]			✓		✓						
ABS Building Construction Activity[3]			✓		✓						
ABS Payroll Jobs and Wages[4]			✓								
Australian Institute of Health and Welfare[5]					✓	✓					
Department of Home Affairs migration data[6]					✓	✓					
Higher education completion rates[7]					✓	✓			✓		

Data source	Definition of occupations	Definition of public infrastructure	Estimation of current and historical supply	Estimation of future workforce attrition	Estimation of future workforce supply	Modelled supply and demand shortages	Labour market indicators of shortage	Development of skills profiles	Demographic analysis	Professional pathways analysis	A&T pathway analysis
Higher education graduates[8]					✓	✓			✓		
VET completion rates[9]					✓	✓					
VET student outcomes survey data[10]					✓	✓					✓
TCSI enrolment data[11]					✓	✓				✓	
QILT Graduate Outcome Survey[12]										✓	
NCVER Total VET Activity data[13]					✓	✓					✓
Infrastructure demand data[14]						✓					
Lightcast Social Profiles data										✓	
NCVER Apprentices & Trainees data[12]											✓
NCVER Program Completions data[12]											✓

References

1 A sigmoid function is a mathematical function having a characteristic “S”-shaped curve or sigmoid curve. Cumulative construction activity on projects, when mapped against time, typically follow an ‘S-curve’ pattern.

2 The collection history of the Manufacturing Survey is reported by the ABS here: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DSSbyCollectionid/87E111C47BE15BB2CA256BD000 26FB74?opendocument Reasons for discontinuing data collection range from a lack of interest from industry clients following substantial price increases when moving to a user funding model, unwillingness to fund from the Federal Government, industry closures and consequent consent problems.

3 While CCF National was approached to undertake this survey of its members for this Report, they also publish the results of the survey at https://www.civilcontractors.com/communication/surveys/

Endnotes

1 Australian Bureau of Statistics (2016 and 2021), Various products on TableBuilder, ABS Website, accessed 1 May 2023.

2 Australian Bureau of Statistics (December 2022), Engineering Construction Activity, Australia, ABS Website, accessed 1 May 2023.

3 Australian Bureau of Statistics (March 2022), Building Activity, ABS Website, accessed 1 May 2023.

4 Australian Bureau of Statistics (15 April 2023), Weekly Payroll Jobs and Wages in Australia, ABS Website, accessed 31 May 2023.

5 Australian Institute of Health and Welfare, Population Projections, 2012-2027.

6 Data obtained via information request to the Department of Home Affairs.

7 Department of Education, Completion Rates of Higher Education Students

8 Department of Education, Student Data

9 National Centre for Vocational Education Research, Latest VET statistics

10 National Centre for Vocational Education Research, VET student outcomes

11 Tertiary Collection of Student Information (formerly Higher Education Information Management System) data

12 Quality Indicators for Learning and Teaching (QILT), Graduate Outcome Survey (GOS) 2021 and 2022

13 National Centre for Vocational Education Research data

14 Projected infrastructure demand data supplied by Infrastructure Australia