Preliminary design of a gravitational water channel from Northern Queensland to the Murray Darling Basin

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Summary: A Bradfield Scheme is defined as any scheme for long distance conveyance of large volumes of water from across the Great Dividing Range. This note describes a staged, gravitational surface channel scheme (with preliminary costing) for an environmentally beneficial water supply scheme for the central Queensland areas of the Mitchell Grass Downs, pipeline to new mine developments in the Galilee Basis, and potentially to St George, Bourke and the rivers of the Murray-Darling Basin.

Despite the considerable benefits, there are a number of open issues to be addressed such as environment, crop selection, aqueduct design, and others. These issues are highlighted in text boxes following each chapter.

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Issue Boxes

1. Existing Infrastructure
2. Environmental Concerns
3. Potential Crops
1. The first fully gravitational surface routes to the Murray Darling Basin from Northern Queensland.

Illustration 1: Viable routes for a fully gravitational surface aqueduct to the Murray Darling Basin from Northern Queensland.

The routes shown above allow construction of a channel with a continuous flow of water from the upper Tully River, to the Burdekin River, crossing the Great Dividing Range at Lake Buchanan or Lake Galilee, and through to Blackall. There are a number of potential routes from Blackall down the Bulloo Valley to St George in the MDB in Queensland, or Bourke in the MDB in NSW.

This is the first publication of a fully gravitational surface route for watering the entire inland of Queensland and New South Wales with an inland river of flood waters.

While a number of so-called ‘drought-breaking’ schemes have been touted recently including raising dam walls, the following problems with these approaches are solved by long distance water conveyance.

1. **Limitations of local dams.** A single dam can provide limited storage. In drought, it is depleted rapidly by demand, and in flood most goes over the spillway. Drought-busting requires water to be conveyed long distances from high rainfall to low rainfall areas, to smooth out rainfall variations due to seasons or random variation in rainfall.

2. **Large dams at low elevations.** Lower catchment dams generally require irrigation water pipelines and pumping and do not make use of the free gravitational force for moving water around. Viable irrigation schemes require water to be delivered at the lowest cost possible that gravitational channels can provide.

3. **Tunnels and pipelines.** These cannot be tapped on route and require expensive pumping infrastructure. A long surface aqueduct may include in-line water reservoirs that both
harvest water en route and enable local irrigation schemes all along the route.

The routes marked on the image are potential gravitational aqueducts with different start and end points. Together they would compromise a new ‘inland river’ that follows the contours, perpendicular to the flow of natural surface waters. I propose calling it the Bradfield Channel. It that would open vast areas of the outback to new irrigation schemes, provide reliable water to townships, safe water to mines of the Galilee Basin, insure against Climate Change and supplement the dwindling supply of water to the Murray Darling Basin.

**Issue 1. Existing infrastructure.** While much of the aqueduct route is over sparsely populated areas with no existing linear infrastructure, the route does cross existing roads and railway lines at a couple of points. In particular, the Flinders Highway, the Capricorn Highway, the Landsborough Highway, and the Mitchell Highway. Usually bridges or culverts will be constructed to convey the water across linear infrastructure unimpeded. Moreover, due to relatively flat Australian terrain, the route may be diverted into existing watercourses to reduce the construction costs. Pipes would be avoided due to cost, as it is often said that if water has to be piped, then farmers cant afford it.

Points of conveyance across linear infrastructure may also be suited to installation of hydro power plants due to proximity of existing power lines. In that case, a drop of 5-10m might be expected. A detailed options analysis would be required to evaluate these considerations.
2. A lower cost alternative for the Burdekin River Region Irrigation Area

Low water delivery costs are critical to the potential return on investment for government and private sector investors. The fully pumped irrigation schemes would only be viable in circumstances of high prices or high-value products.

The Hells Gates Dam Feasibility Study by the Snowy Mountains Engineering Company (SMEC) is examining a $5.35 billion irrigated agricultural and power project on the upper Burdekin River. However, is it the best design? Here I have annotated their current plan with what I think is a sustainable improvement, and also could be stage one of a larger Bradfield Scheme.

Water is released from the Hells Gates Dam (purple) into the Burdekin River (green) and captured in low on-river weirs adjacent to the agricultural zones (yellow). Pumps raise the water to temporary storages at the top of the bank (SMEC).

Instead of pumping water up to the hill from weirs in the river, irrigation zones could be fed from an aqueduct (light blue) at about the 350m contour. Irrigation channels (blue) could then follow an approximate downhill path within the existing terrain to use gravity as the driver for water delivery, thereby avoiding pumping costs.

Finally, additional storages (red) associated with the aqueduct could capture flows from the Basalt and Hann Rivers providing extra flood storage or water capture.
The economic and environmental benefits of a gravity fed aqueduct are many:

1. Locating the dam lower on the Burdekin (red) at the Mt Foxton site would avoid inundation of the Gregory Development Road bridge over the Clarke River avoiding road relocation works.

2. The lower location is below the confluence with the Running River, providing additional stream capture.

3. The cost of water would be considerably lower.

4. The weir pools at each zone of the SMEC design would potentially impede migrating fish. The alternative plan would not interfere with the natural Burdekin River downstream of the main dam wall.

5. Run-of-river power stations may potentially be installed along the aqueduct depending at fall locations. Power generation would likely take place over most of the year.

6. The aqueduct could continue on past Charters Towers and the Flinders Highway, providing water to mines of the Galilee Basin including Adani, town water and irrigation to the Mitchell Grass Downs, and even further to Blackall, St George and the Murray Darling Basin.

7. Constructed stage by stage, the scheme would establish revenue centers at each stage and require lower startup financing.

Another significant difference between this and the current SMEC design is the location of the dam lower on the Burdekin at the Mt Foxton Site (height 375m AHD) versus Hells Gate site (height 392m AHD). The relative costs/benefits of these two sites have been tabulated in the study Table 1: Dam Location Options Analysis. The Hells Gate was thought to have fewer environmental and cultural heritage concerns but had a more significant potential impact on the road infrastructure. An aqueduct delivery system may influence the optimal dam/weir location.

Alternatively, the aqueduct could originate from an upper Hells Dam site instead of Mt Foxton, at a higher location, and follow a contour above 350m. The dam wall may also be raised to the maximum height, creating a mega-dam as proposed by Sir Leo Heischler and Leon Ashby.

Frequently, environmental and cultural heritage concerns are overblown, as there are well-established mechanisms for dealing with them, including offsets and agreements. Particularly in the case of projects of national significance, these would not present insurmountable impediments to projects.

In summary, the first financially viable stage of a Bradfield Scheme may be the development of a weir and aqueduct in the upper Burdekin supporting 50,000 ha of irrigated horticulture, including fruit, vegetables, pulses/legumes, and broad-scale agriculture of both perennial and annual crops. Various factors increase the cost and the environmental impact of the SMEC proposal that are not present in this proposal – the impact to downstream water flows, the Gregory Development Road inundation, and the cost of weirs and pumping that are mitigated by delivering water in a gravity-fed aqueduct.
3. **Schematic Overview of Initial Stage**

Illustration 3: Schematic diagram of a gravity-fed mini-Bradfield Scheme transporting water from the coastal rivers via a levy/pipeline combination (blue) to the storage and distribution lakes on the Great Dividing Range (green).

Above is the schematic diagram of a gravity-fed mini-Bradfield Scheme transporting water from the coastal rivers via a levy/pipeline combination (blue) to the storage and distribution lakes on the Great Dividing Range (green).

The levy would source water from the Burdekin River at Hell's Gate or Mt Foxton (note a dam may not be needed) and acquire the additional water en route at the Basalt, Campaspe and Cape Rivers (purple). These are headwater collections and so would not impact the regular flows significantly, and help to mitigate flood flows downstream.

The storage lakes of Lake Buchanan and Lake Galilee are currently dry salt lakes whose capacity
would be significantly expanded by dams at a few strategic locations. The lakes are uniquely positioned at intermediate elevations on the Great Dividing Range allowing stored water to be gravity fed to the destinations.

From the storage lakes, channels or pipelines would distribute the water where and when needed – to industrial uses east of the Divide such as the Adani Mine, and new irrigation areas west of the Divide around Muttaburra, Aramac, Barcaldine, and Longreach.

**Issue 2. Environmental Concerns.** A number of issues would be expected to be investigated during the concept stage of the development. The location of the proposed route does not impact any known environmental or cultural heritage sites. Due to the generally flat terrain, the route may be shifted to avoid sensitive areas. The potential for passage of invasive or undesirable species between watersheds may be mitigated by fish barriers consisting of long rubble sections installed at strategic watershed crossings. Reduction in flood flows may impact bird breeding and vegetation. However, as the water harvesting occurs on the aqueduct route high in the catchments, flood flows will be reduced, but not eliminated. There may be environmental benefits due to the mitigation of high flood flows. For example, the Great Barrier Reef is know to be affected by the high contaminant and silt loads in flood flows, and so may benefit from their moderation. These are matters for more detailed assessments. A detailed environmental assessment would be required to address these issues.
4. A safer alternative to the Adani Mine Groundwater Plan

Illustration 4: A Galilee pipeline could be constructed to pipe water from storages and so mitigate the environmental impact of these mines on ground and surface waters.

Ongoing concerns with the groundwater plan have delayed the approval of the massive Adani (Carmichael Coal) Mine. What if the mine did not have to use groundwater at all, but drew water from large storages created nearby at Lake Buchanan and Lake Galilee? The salt lakes perched on the Great Dividing Range could be filled with flood water from an aqueduct to Hells Gate Dam on the headwaters of the Burdekin River.

Low-cost gravitational flow is viable, as it is downhill from the headwaters of the Burdekin,
providing the weir is built to a sufficient height.

Not only Adani, but 5 mines have been approved for the Galilee Coal Basin (see image). Are they going to run into the same water sourcing problems too? A Galilee pipeline should be constructed to pipe water east from one the two storages and so mitigate the environmental impact of these mines on ground and surface waters.

The mines in the Bowen Basin draw water from the Burdekin Falls Dam via a pipeline—why not build the same river saving infrastructure for the Galilee Basin?

Also, the storage could also be used for town water supply and irrigation of the fertile Mitchell Grass Downs to the west of the Great Dividing Range. Use a renewable amount of flood waters and leave the limited groundwater source alone.

Renewable hydropower generation is also possible at and between Lake Buchanan and Lake Galilee, as well as locations along the aqueduct route. The power generated could be sold to the mines, generating carbon-free revenue.

**Issue 3. Potential crops.** In general, the more reliable water supply in irrigation schemes supports high value crops such as tree crops like almonds, and also grapes. Australia is one of the most efficient cotton producers in the world. Due to the proximity of the aqueduct to existing cotton gins in Emerald, the cotton growers may find the Mitchell Downs a viable option for production. A detailed business plan would be required to determine the crop selection to maximise returns from the scheme.
5. Preliminary estimates of the cost of stages and returns of the New Bradfield Scheme

The internal rate of return for the scheme including the supply of North Queensland flood water to the Murray-Darling Basin is between 5-10%, based on capital expenditure of $12.75 billion, and annual agricultural revenue between $2 and $4 billion. Supply of water for mines and towns and hydropower generation would provide additional income.

The stages of the plan are 1 (red), 2 (orange), 3 (yellow) and 4 (green). The figures below are very approximate and may change over time as estimates become more precise (Note 1).

Illustration 5: The stages of the plan are shown as stage 1 (red), 2 (orange), 3 (yellow) and 4 (green). The figures below are very approximate and may change over time as estimates become more precise (Note 1).

The internal rate of return for the scheme including the supply of North Queensland flood water to the Murray-Darling Basin is between 5-10%, based on capital expenditure of $12.75 billion, and annual agricultural revenue between $2 and $4 billion. Supply of water for mines and towns and hydropower generation would provide additional income.

The stages of the plan are 1 (red), 2 (orange), 3 (yellow) and 4 (green). The figures below are very approximate and may change over time as estimates become more precise (Note 1). The cost of the main stages are as follows (Note 2):

1. Burdekin River Irrigation Area. Mt Foxton to the Flinders Hwy. This stage captures flood flows and provides gravity-feed irrigation to 50,000ha north of Charters Towers. 125km of 5m aqueduct ($1.25B), 75m weir ($0.5B) TOTAL $1.75B (Note 3)

2. Lake Galilee Basin Supply. Flinders Hwy to Lake Galilee. This stage transfers flood flows to Lake Galilee Storage on the Great Dividing Range and supplies the Galilee pipeline to 5 mines in the Galilee Basin. 250km of 5m aqueduct ($2.5B), 20m storage ($0.5B) TOTAL $3B

3. Aramac/Muttaburra/Longreach Irrigation Area. Lake Galilee to Longreach. This stage is one arm of western Mitchell Grass Downs distributor providing 50,000ha of new gravity-fed irrigation area. 200km of 5m HDPE lined aqueduct and local storage ($2B)

4. Murray Darling Basin. Lake Galilee to St George. This stage conveys water from the Lake Galilee Storage to the cotton growing regions around St George. 600km of 5m HDPE lined aqueduct and short pumped pipeline ($6B)

These first four stages could provide the water for the three new irrigation areas of approximately 50,000ha each – 150,000ha and five new coal mines in the Galilee Basin. Based on efficiencies of 10ML per hectare of the irrigated crop, plus an additional 500GL for mine and other usage, losses,
and environmental flows, 2000GL of water would be required per annum. Based on stream monitoring records a weir at the Mt Foxton site could provide over 3000GL per annum, enough for the scheme and additional regular stream flow (Note 4).

With an expected return on the crops of between $6,000 and $25,000 per ha, this would produce a total output of between $1B and $4B per annum. As the water is gravity fed the operational costs are meager (Note 5). At a water cost of 10% of production, the water purchases would be $100M to $400M pa covering operational expenses. The economic modeling done for the Burdekin River Irrigation Scheme is scaled up x3.

CONSTRUCTION OUTPUT (4 stages)

• $12.75 billion.
• $8.1 billion contributions to GRP
• $2.4 billion in household income
• 25,000 FTE jobs

AGRICULTURAL OUTPUT (3 stages)

• $1-5 billion in total output
• $2.4 billion in contributions to GRP
• $0.75 billion in household income
• 15,000 FTE jobs

IRR between 5% and 10%

Notes

1. Each stage produces additional revenue so that the costs of the scheme are not entirely front-loaded but could progress in a self-funded manner.

2. The cost of the aqueduct would depend on the height - assumed at $1 million per km. Prices for dams are guesses only. Resumption costs included.

3. The estimate is half of the similar Upper Burdekin River Irrigation Scheme proposed by SMEC due to the absence of hydropower, lower weir, and relocation of road infrastructure on Gregory Development Road (~$0.69B). The water would be gravity-fed from the aqueduct delivering water at a considerably lower cost.

4. Additional stages of the scheme could supply an additional 2000GL of water from the Herbert and Tully Rivers into the Mt Foxton weir.

5. The generation of hydropower, mine, and town water usage and forestry would provide additional revenue.