Analysis II: Identification of Copper Mine Impacts for Bingham Canyon, Prominent Hill, Intag, and Solwara 1

◀ Chimney sampling
Image credit: Nautilus

Analysis II provides a description of the ecosystem goods and services expected to be impacted by the Solwara 1 project, compared with impacts at Bingham Canyon, Prominent Hill, and the proposed Intag mine.

Analysis II provides a description of the ecosystem goods and services expected to be impacted by the Solwara 1 project while providing a parallel description of the ecosystem goods and services of the currently operating Bingham Canyon and Prominent Hill mines and the proposed Intag mine. The section first presents a brief description of each mine, then the specific ecosystem services are identified and evaluated in regards to each of the sites. A comprehensive comparison of the impacts for each ecosystem good or service is provided.

Proposed Solwara 1 Copper Mine, Bismarck Sea, Papua New Guinea

7%
CONCENTRATION

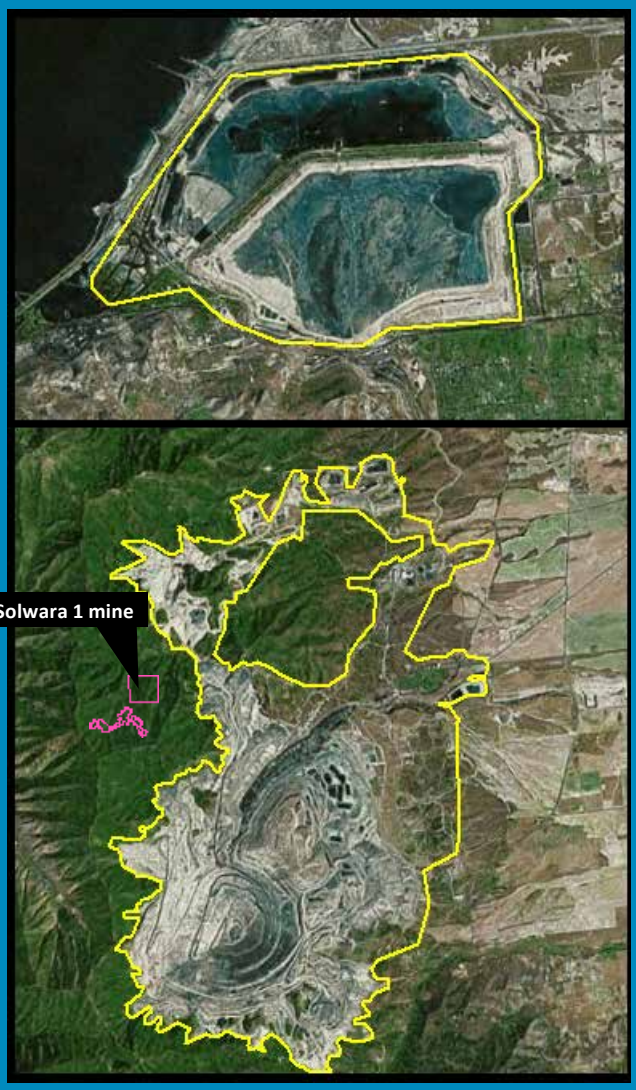
OF COPPER IN THE MINERALIZED MATERIAL AT SOLWARA 1 IS CONSIDERED REMARKABLY HIGH BY TERRESTRIAL MINING STANDARDS

The Solwara 1 deposit and the seafloor production system that Nautilus proposes to deploy at the Solwara 1 site are well described in the Nautilus documents. The mineralized material has a remarkably high concentration of copper (average over 7%[45]) as well as accompanying valuable elements such as gold and silver. Copper is present almost exclusively as chalcopyrite, with pyrite also present. The total area of mining is projected to be no greater than 11 ha (0.11km2).

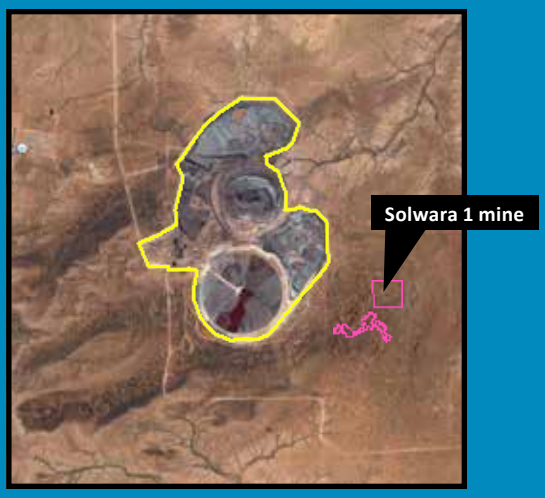
For the purposes of this study, it is assumed that the proposed Solwara 1 mine will produce approximately 1,957,000 metric tons of mineralized material over three years[46] at an average grade of approximately 7% copper.[47] Nautilus has not completed a preliminary economic assessment, pre-feasibility study, feasibility study or any other similar economic analysis of the proposed development of the Solwara 1 project.[48]

Solwara 1 may also have an added 3 ha (0.03km2) area of impact due to disposal of sediment overburden, as well as a larger area which will be impacted to a lesser extent by sedimentation from the mine-derived plume. For the calculation of natural capital impacts, this report uses a total projected maximum mine site and sediment disposal area of 14 ha (0.14km2).[49] This area does not include the zone that will be impacted by the mine-associated sediment plume. Although this zone will be subject to increased sedimentation during the mining period, it is also already subject to naturally high sedimentation as a result of the activity of the nearby North Su volcano.

Figure 6.
GIS maps of relative sizes of mine sites

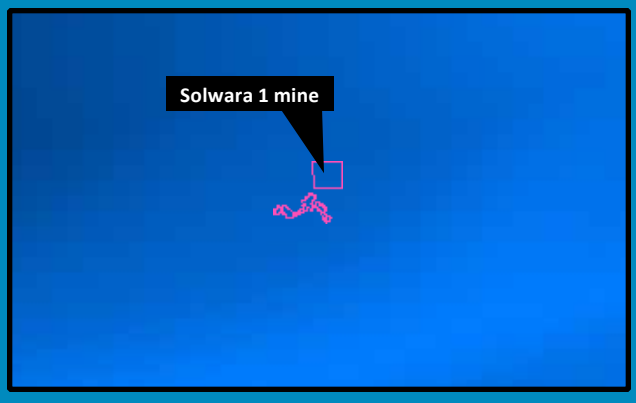


▲ Bingham Canyon: Tailings Pond (above) and Mine (below)



▲ Prominent Hill Mine

▲ Proposed Intag Mine*



▲ Solwara 1 Mine Site, with Tongling Refinery area* (square)

▲ JFK Airport, New York City
(for size comparison)

N

0 2 4 Kilometers

*This shape is not indicative of the overall footprint, as the design is not publically available

The proposed mining operations will impact dense forests in a region of Ecuador that spans two of the world's 34 most biologically important regions

Proposed Intag Copper Mine, Intag Province, Ecuador

Intag is a proposed open-pit copper mine on the western slope of the Andes within the Intag region in Ecuador. The Intag mining proposal aims to exploit sulphide deposits with a concentration of 0.7% copper,[50] (although notably, this grade is 10 times lower than the grade of the Solwara 1 deposit), a percentage that is considered feasible by current terrestrial mining standards. A report carried out by the Japanese International Co-operation Agency (JICA) estimates that Intag might have as much as 1.3 billion metric tons of low-grade copper ore.

The proposed mining operations will impact dense forests in a region of Ecuador that spans two of the world's 34 most biologically important regions, the Tropical Andes biological hotspot and the Tumbes-Chocó-Magdalena biological hotspot.[51] Additionally, the potential mine will be located high in the Andes Mountains where steep slopes and high annual rainfall averages abound. The downstream area and parts of the proposed mine area already have established farming communities and adjoin the headwaters of the Esmeraldas River.

Over the last decade, the communities of Intag have worked to develop and implement a prosperous approach to the region's economy which does not include mining. This proposal has resulted in very significant opposition to the mine. A lengthier project description of the Intag copper mining proposal and a regional ecosystem service analysis is available in a 2011 Earth Economics report on the Intag copper mine proposal.[52]

19 MILLION
TONS OF COPPER

HAVE BEEN PRODUCED BY BINGHAM CANYON SINCE 1905

Bingham Canyon Mine, Utah, USA

The Bingham Canyon mine is an open-pit copper mining operation located in Utah, USA, that is owned by Rio Tinto Group and managed by Kennecott Utah Copper Corporation. At approximately 1 km deep and 4 km wide, the mine is one of the deepest open-pit mines in the world.[53] Since the mine's opening in 1905, the mine has produced over 19 million tons of copper, 715 tons of gold, 5,900 tons of silver, and 386,000 tons of molybdenum.[54] In 2013 alone, the mine produced approximately 194,000 tons of copper, accounting for 25% of all U.S. copper production,[55] and it employed approximately 2,800 people.[56] Although Bingham Canyon has proved to be one of the most valuable mines in the world, it has also generated significant negative impacts

for the surrounding landscape and communities. As an example, at least 28 reportable spills were recorded between 1998 and 2011. These spills resulted in millions of gallons of process water (reportedly containing arsenic), copper tailings, and sulphuric acid being released into the environment.[57] It is estimated that a 72-square-mile plume of groundwater is now likely contaminated due to multiple spills over the years.[58] The release of a number of toxic substances including selenium, copper, arsenic, zinc, lead and cadmium may have also resulted in significant impacts to fish, bird and wildlife habitats.[59]

1.1%

THE CONCENTRATION OF COPPER IN ORE AT PROMINENT HILL, CONSIDERED ABOVE AVERAGE BY CURRENT TERRESTRIAL MINING STANDARDS

Prominent Hill Mine, South Australia, Australia

Prominent Hill mine is a copper mine located approximately 650 km north-northwest of Adelaide in the state of South Australia, Australia. Employing approximately 1,400 staff and contractors, the mine consists of the "Malu" open pit mine and the "Ankata" underground mine. Production at Prominent Hill began in 2009, and by 2013, the mine produced approximately 73,362 metric tons of copper and 3.6 metric tons of gold. As of 2014, it was estimated that the overall mineral resource base at Prominent Hill amounted to 178 million tons of ore containing 1.1% copper, or roughly 1.9 million tons of copper.[60] Prominent Hill is located within the Woomera Prohibited Area, a restricted-access weapons-testing site in a desert region, with relatively few adjacent landholders and downstream users compared to the other terrestrial mines.

Table 3 provides a listing of land cover or seabed classifications found at the four mine sites as well as a listing of the potentially associated categories of natural capital goods and services. A white box indicates that a good or service is not present in the land cover or seabed natural capital classification. For example, there is no food harvesting at the Solwara 1 site, and the high levels of heavy metals present in the seafloor organisms is likely to prevent them from ever becoming a viable food source.[61] Pollination and fresh water provisioning are not present and have no possibility of being present at the Solwara 1 site. A orange box indicates the presence or possible presence of a good or service, and an "X" in the orange box indicates that market transactions or peer reviewed academic journal valuation studies exist which can be used to help establish dollar values for the natural capital goods and services present.

Table 3. ▶
Ecosystem Services Present and Monetized for Solwara 1 and Comparison Mines

Key	
	Ecosystem Service Not Present
	Ecosystem Service Present but No Valuation
x	Ecosystem Service Present with Valuation Studies

Ecosystem Service	Solwara 1	Prominent Hill	Bingham Canyon	Intag
Provisioning Services				
Food			x	x
Medicinal Resources				
Ornamental Resources				
Energy & Raw Materials			x	x
Water Supply				x
Regulating Services				
Biological Control	x			x
Climate Stability		x		x
Air Quality			x	
Moderation of Extreme Events			x	
Pollination				x
Soil Formation				x
Soil Retention			x	x
Waste Treatment			x	x
Water Regulation			x	x
Supporting Services				
Habitat & Nursery	x	x	x	x
Nutrient Cycling				x
Genetic Resources	x			x
Cultural Services				
Natural Beauty			x	
Cultural and Artistic Information				
Recreation and Tourism			x	x
Science and Education				
Spiritual and Historic				

Table 3 clearly shows fewer potential impacts for Solwara 1 than for the other mine sites. In the deep seabed environment, up to 11 ecosystem services are produced, while the other terrestrial environments each contain at least 19 ecosystem services. While the deep sea environment may also contribute to the regulating services associated with water regulation and moderation of extreme events, these services are unlikely to be significant for a footprint the size of the Solwara 1 Project. There are limited historic market transactions or valuation studies of the ecosystem services of deep sea environments in the academic or grey literature, so the value of these impacts is difficult to quantify. However, significant ecosystem services that are typically strongly impacted by mining, such as freshwater supply and quality or soil formation and erosion control, are not present at the proposed Solwara 1 mine site.

Table 4 below shows the estimated level of impact on each ecosystem service across Solwara 1 and the three comparison mines. The level of impact estimates for Solwara 1 was based on a 2008 Environmental Impact Statement.[62] The Prominent Hill mine level of impact estimates were based on documents published by Prominent Hill mine owner OZ Minerals.[63] The level of impact estimates for the Bingham Canyon mine were based on sources from mine owner Rio Tinto[64] and the EPA.[65] The level of impact estimates for the proposed Intag mine are based on a Japan International Cooperation Agency mine assessment[66] and an Earth Economics analysis of the Intag Region and mining proposal.[67]

2

ECOSYSTEM SERVICE VALUATION STUDIES

HAVE BEEN PUBLISHED ON THE DEEP SEA BED TO DATE

Though there is a dearth of information about the value of ecosystem goods and services provided at the seabed, the issue of valuing goods and services can be bounded within a framework and methodology that takes a highly conservative approach by using the highest terrestrial dollar values where no deep seabed estimates exist. For example, waste treatment is present at the Solwara 1 site. It is, however, unquestionably less valuable than a wetland in processing wastes for an adjacent community because it is remote from any human habitation and the physical throughput is far lower. Valuing the loss of waste treatment at Solwara 1 as if it were equal in value to a terrestrial wetland would clearly overestimate the damage of waste treatment loss at Solwara 1.

Table 4.
Level of Ecosystem Service Impact by Mine

Key
Low impact
Moderate impact
Significant impact
High impact

Ecosystem Service	Level of Impact (0 = lowest, 3 = highest)			
	Solwara 1	Prominent Hill	Bingham Canyon	Intag
Provisioning Services				
Food	0	1	3	3
Medicinal Resources	0	1	1	3
Ornamental Resources	0	0	0	1
Energy & Raw Materials	3	3	3	3
Water Supply	0	1	3	3
Regulating Services				
Biological Control	1	3	2	2
Climate Stability	1	1	2	3
Air Quality	1	0	1	1
Moderation of Extreme Events	0	1	3	3
Pollination	0	1	1	3
Soil Formation	0	3	3	3
Soil Retention	0	3	3	3
Waste Treatment	1	2	3	3
Water Regulation	0	1	3	3
Supporting Services				
Habitat & Nursery	2	2	3	3
Nutrient Cycling	1	2	3	2
Genetic Resources	1	3	3	3
Cultural Services				
Natural Beauty	1	1	3	2
Cultural and Artistic Information	0	1	2	3
Recreation and Tourism	0	0	3	3
Science and Education	1	3	1	2
Spiritual and Historic	0	3	1	3

The deep sea is one of the least studied land cover/seascapes types in terms of ecosystem services. The first article discussing the ecosystem functions and services of the deep sea was published by Thurber et al on July 14, 2014, in Biogeosciences.[68] This article provided a structure for examining ecosystem functions and services provided by deep marine environments where built capital structures or uses are either non-existent, present or abundant. A table from that article has been modified below simply to show presence or potential presence and marked to show overlap with the Solwara 1 site.

Table 5.
Built and Natural Capital Goods and Services Present in Deep Sea Ecosystem Types
Source: Derived from Thurber et al., 2014, Table 1.

Key	
	Ecosystem Service Not Present
	Ecosystem Service Present but No Valuation
X	Ecosystem Service Present with Valuation Studies

Built and Natural Capital Goods/ Services Present	Deep Sea Ecosystem Types								
	Abyssal Plains	Biogenic Habitats	Canyons	Deep Pelagic	Margins	Mid-ocean Ridges	Sea-mounts	Trenches	Vents and Seeps
Alternative energy									X
Bio prospecting (Genetic & Medicinal Resources)									X
Carbon capture and disposal									
Communication cables									
Fisheries									
Metal-rich sediments									
Methane harvesting									
Military									
Oil and gas extraction									
Phosphate mining									
Polymetallic crusts									X
Polymetallic nodules									
Rare Earth elements									
Seafloor massive sulphides									X
Waste disposal									

Four boxes (those with an "X") in Table 5 show that the site, within the Thurber et al. classification, could provide metals, alternative energy and bio prospecting values. These categories are fully contained within the Earth Economics modified TEEB framework provided above, which includes additional natural capital benefits such as scientific knowledge.