DEVELOPMENT OF MEGA CUTTER SUCTION AND TRAILER SUCTION HOPPER DREDGERS & RELATED PROJECTS IN CANADA

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ABSTRACT

This paper reviews the development of mega Cutter Suction Dredgers (CSD) & Trailer Suction Hopper Dredgers (TSHD) starting with look at the market drivers and consolidation of the European dredging contractors that allowed the investment in such large vessels to happen.

The historical development of dredgers is reviewed with comparisons of production rates on large projects from the mid 1800's to today. The design improvements of modern dredgers are presented. The two largest TSHDs in the world both have a capacity of 46,000 m^3 and can dredge to a depth of 155m, these vessels have been working since 2009 & 2010. The largest CSD is currently under construction and will be launched in 2017 with a total power of 41 Mega Watts capable of dredging rock to depths of 45m and pumping dredged material up to 8 kilometres.

Reference and overview is made to two projects carried out in Canada with mega TSHDs using their deep dredging capability working in stiff boulder clay for the Husky 'Glory Holes'. The first project was in 2003 when the TSHD *Vasco Da Gama* was modified to be able to dredge at 128m water depth. The second project in 2012 was carried out by the TSHD *Cristóbal Colón* at a similar water depth.

A separate reference and overview is made to the use of a CSD to create an access channel and to remove a rock filled bund for the release of the Hebron concrete gravity base production structure from a dry dock in Mosquito Cove, Bull Arm, Newfound Land.

Keywords: history, consolidation, technology, performance, deep water dredging, Suez Canal, Hebron, White Rose

INTRODUCTION

The last 20 years has been a period of significant growth in the number and size of dredgers, using the volume of the hopper of a Trailer Suction Hopper Dredger (TSHD) as a measure the size has increased from 5,000m^3 in 1965; 17,000m^3 in 1994; 33,000m^3 in 2000 and 46,000m^3 in 2009. A similar growth rate is recorded for Cutter Suction Dredgers (CSD) in this case measured by their installed power.

A review of the overall available capacity of TSHD and CSD over the last ten years shows an increase in TSHD capacity of 74% to 2.4 million m^3 and CSD capacity of 41% to 2.1GW. Regionally the largest increase in average capacity of both TSHD and CDS's is by the Chinese dredging companies.

This paper reviews the background for this increase in capacity, an overview of the technology to design and deliver these vessels and takes a look at the use of mega CSD and TSHD's in Canadian waters.

MARKET DRIVERS

The development of the dredging industry is directly linked to global population growth and the movement of rural populations to coastal cities. From a population of around 1 billion people in the mid 1800's industrialisation started an ever increasing growth to an estimated 7.4 billion in 2016, currently the population is increasing by 1 billion every 12 years (or 1.1%) and is expected to continue to increase to the middle of the 21st century after which models estimate a tailing off to a medium of 11 billion by 2100.

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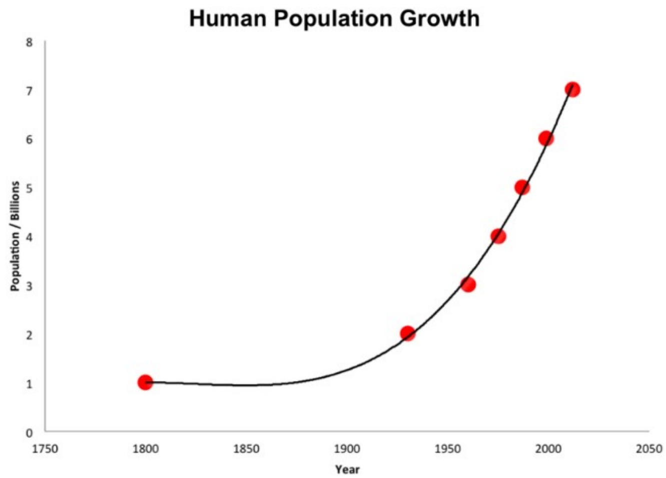
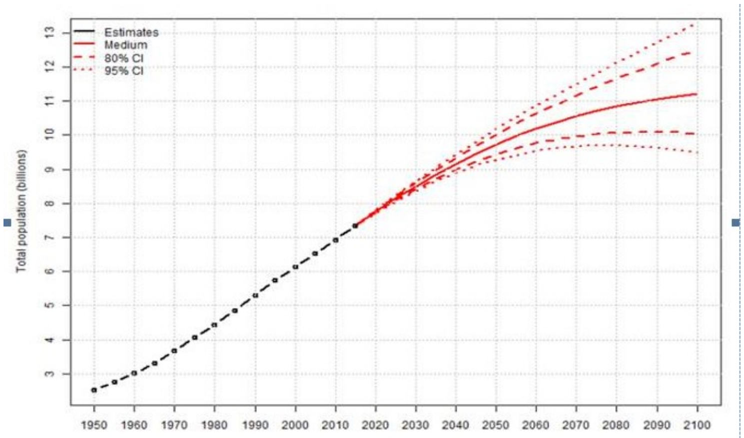




Source: United Nations, Department of Economic and Social Affairs, Population Division (2015), World Population Prospects: The 2015 Revision, New York: United Nations

Figure 1. World Population Growth 1800 to 2040 (wikipedia) and medium-variant projection 2015 to 2100

There are various independent reports that detail the connection between population growth and movement and the increase in the need for dredging however the key drivers can be summarised as: -

- Increase in seaborne trade growth of 3.2% per year between 1977 and 2014, requiring increased maintenance & capital dredging for new and existing ports and canals as the size of ships increases. Examples include the Panama and Suez canals and a worldwide port construction program to be ready for the post panamax vessels with drafts of up to 15m.

- The reclamation of new land adjacent to the sea to provide accommodation for the increasing population who are moving from rural, typically inland areas to urban areas in cities often near the sea.

- In parallel to this there is a need to protect existing land at centres of population adjacent to the sea as a result of natural erosion but increasingly due to the effects of climate change i.e. rises in water level and increased frequency and intensity of weather systems.

- Rise of the global consumption of energy and metals: the exploration of oil & gas is often in remote areas, requiring the construction of new ports and other infrastructure. Energy consumption is estimated to rise by 1.0% annually between 2013 and 2040. Example projects include LNG transportation were ports are required to export the gas: Australia, Russia, Middle East and USA-Canada for shale gas and, at the other end of the journey, ports are required to unload the gas: Japan, Europe and Asia. In separate energy market the renewable sector is also generating work for the dredging companies.

- Growth of global tourism: construction of new airports, cruise liner facilities, beaches etc.

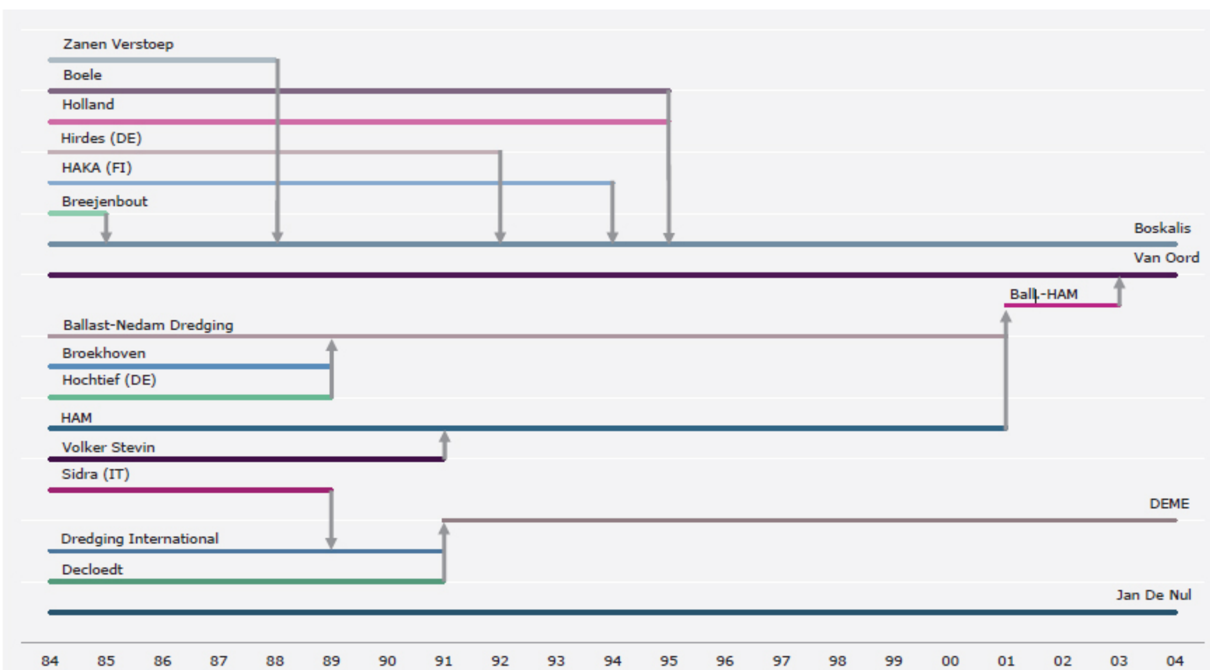
It is the combination of the different market drivers plus a world wide spread of the projects that smooths out the variance of any individual market or regional downturn.

Growth of Global Projects from 1975 to Present Day

In the period 1975 to 1985 there was a requirement for new ports in the Middle East and the European dredging companies and GLDD from the USA were ready to expand and open these foreign markets. These Middle Eastern ports (Damman, Jeddah, Jubail, Yanbu, Dubai & Abu Dhabi) often involved rock dredging and this accelerated the need for powerful CSD’s. The next period of international activity started in the mid 1990’s and included airports, new ports and land reclamation in Asian countries including Hong Kong, Japan and Singapore. This global demand has continued to this day encompassing South and Central America (development of modern ports and the expanded Panama Canal), Australia (general trade, export of minerals, coal and LNG), Africa (ports related to general trade and energy), Russia (energy export) and back to Europe for large infrastructure projects such as the planned Fehmarn tunnel between Denmark and Germany, further coastal protection schemes along the Belgium and Netherlands coasts and the development of new deep water ports for post-panamax cargo ships (London Gateway, Liverpool 2). North America has its own market including coastal protection, the upgrading of ports for trade and energy exports, including the proposed Roberts Bank T2 in Vancouver and the Prince Rupert LNG export terminals.

CONSOLIDATION OF EUROPEAN DREDGING COMPANIES

To be able to invest in mega dredgers it was first necessary to have mega companies and this process took place for the European players from the 1980’s to the early 2000’s (Figure 2). Prior to this consolidation there where a number of smaller companies typically working regionally in their country of origin with a significant number coming from the Netherlands and Belgium were the protection of the low lands and the need to create new land was important especially after a series of flooding events in the 1900’s with the notable event of 1953. In the USA GLDD and Weeks Marine followed a similar path of growth by acquisition.



Source: Company websites

Figure 2. Consolidation of European Dredging Companies

Main Players Today

Since the last major merger of HAM into Van Oord in 2003 the four European dredging companies have seen continued growth each with a dredging related annual turnover of around Euro 1.3 to 1.7 billion, (Refer to Figure 3). Alongside these European dredging companies the growth of the Chinese dredging company CCCC (CHEC) is equally impressive with a total turnover of Euro 4.8 billion, this is by far the largest value in the world with Euro 0.9 billion coming from outside China and the remaining Euro 3.7 billion from the closed internal market. GLDD leads the American market with a contribution of turnover from international projects.

Rank (2015)	Company	Country based	Working area	Total sales (EUR m)	Dredging sales (EUR m)
1.	CCCC (CHEC)	China	China (mainly)	57,863	4,805
2.	Boskalis	Netherlands	Global	3,240	1,727
3.	Van Oord	Netherlands	Global	2,579	1,622
4.	Jan De Nul	Belgium	Global	2,245	1,610
5.	DEME	Belgium	Global	2,286	1,349
6.	Great Lakes Dredge & Dock	USA	USA (mainly)	772	614
7.	National Marine Dredging Company	UAE	UAE/ME	469	469
8.	Penta Ocean	Japan	Asia/ME	3,709	160
9.	Toa Corporation	Japan	Asia	1,511	130
10.	Rohde Nielsen	Denmark	Europe	130	130

Source: Company websites – table originally prepared by Rabobank for the Dredging in Figures report of 2015

Figure 3. Top Ten Dredging Companies - 2015

DEVELOPMENT OF MEGA CSD'S & TSHD'S

In this section the development of the mega dredgers is reviewed with reference to the size of the projects and the production capacity of dredgers.

Mega Projects Past & Present

To put the development of dredging vessels into historical context we can refer to one of the first ever mega projects, the 163 km long Suez Canal that was constructed over fifteen years from 1854 to 1869. For the first 10 years the excavation of 15 million m^3 was carried out by hand (in dry conditions) using hundreds of thousands of men, camels and donkeys. For the last 5 years steam-powered bucket dredgers were employed to load hopper barges (Scow's to use the American term) for disposal at sea. At peak production the combined fleet of these steam dredgers achieved 180,000 m^3 per month and in total would remove 60 million m^3 over the 5 years.

140 years later in the late 1990's and early 2000's the dredging fleets working on the mega projects of Hong Kong and Singapore achieved productions of 5 million m^3 per month.

Another comparison to showcase the advance of mega project dredging production figures is to return to the Suez Canal for the expansion that took place in 2014/15. Over a 9 month period 259 million m^3 were dredged with a fleet of 22 vessels mainly CSD's. In a single day one dredger (*Ibn Battuta*) achieved 230,000 m^3 (although this was in perfect conditions and is far above a typical production rate) and the highest daily output of the combined fleet was 1.73 million m^3.

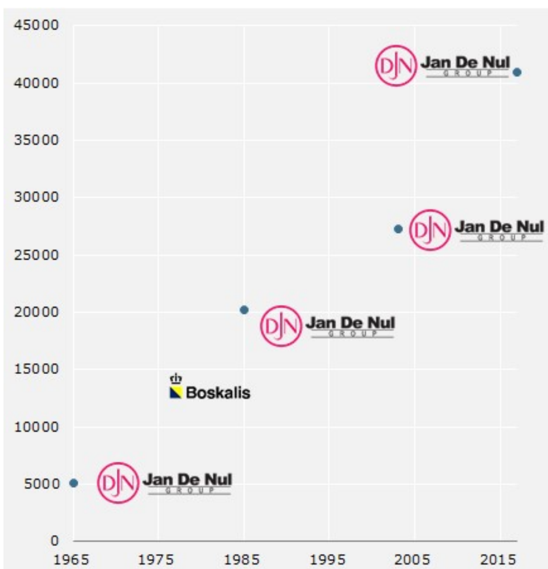
Dredging Technology

Historically the key steps in the development of dredging can be summarised as the transition from manual/horse labour to using steam power in 1800's as illustrated on the Suez Canal project. This was followed in 1860's by the development of the centrifugal pump to allow the suction of dredged materials. By the end of the 19th century these advances in technology allowed the development of various types of dredgers that are familiar today: initially bucket dredgers, followed by suction hopper dredgers then CSD dredgers with rotating cutter heads combined with suction. The 20th century saw the introduction of diesel power, serious upscaling and more recently the use of electronics has brought precise control of the equipment, vessel positioning and surveying changing the whole process from an art to a science.

Backhoe Dredgers are not included in this paper as their productivity does to typically match them to mega projects, however the same upscaling and use of modern control systems applies equally to their development.

Mega Cutter Suction Dredgers

As previously mentioned it was the rock dredging for the ports in the Middle East in the 1970's that required more powerful CSD's and Figure 4 charts the increase in total power from 5 kW vessels in 1965 to the present day including the 41MW CSD currently being constructed in Pula Croatia for delivery in 2017 with further plans for a 44MW LNG powered CSD slated for 2019. Both of these new dredgers will be able to extend the current maximum dredging depth from 35m to 45m. Table 1 presents an approximate definition of CSD types from 'small' to 'mega' based on installed pumping power and the length of the vessel.



Source: Company websites

Figure 4. Increasing total power of CSD's in kW 1965 to 2017

Table 1: Approximate Definition of CSD Type

Type	Length [m]	Pumping power [kW]		
		Inboard	uwp	total
Small	62	2,000	750	2,750
Medium	95	5,500	1,350	6,850
Large	115	7,500	2,350	9,850
Mega	130	12,000	3,400	15,400
New 2017	150	17,000	8,500	25,500

Technical Developments of Mega Cutter Suction Dredgers

New CSD's with increased power allow dredging of harder soils, at greater depths, discharging the dredged material over longer distances, and operation in more onerous environmental conditions. At the same time the vessels operate more efficiently, with less downtime, and with lowered emissions. Figure 5 illustrates a typical modern dredger with 23.5MW of power, note the massive cutter ladder with a weight of 1,100 t. It seemed oversized in relation to the 2m diameter cutting head, but this is what it takes to dredge strong rock.

The technical developments that have improved the performance of a modern CSD from the 1970's include: -

- Self-propelled design combining both functions of sailing and dredging in an efficient way.
- Diesel-electric drive systems enable more efficient operation of the different drives (cutter-head, dredge pumps, winches), and more optimal power generation.
- Automation of systems: increasing performance with better control and monitoring of more parameters.
- Improved dredge pump design results in higher efficiency, and reduced downtime with better wear resistance and less blockage.
- Development of improved cutter-head teeth systems.
- Water-lubricated composite bearings instead of grease-lubricated bronze bearings.
- Double walled wear-resistant dredge pipes.
- Barge loading systems with larger self-propelled split hopper barges with better fendering and mooring systems alongside the CSD.
- On board accommodation to a high standard for 40 to 60 persons
- Advances in survey including multi-beam systems providing detailed 3D data, fast visualisation of the results and the ability to transmit the survey drawings directly to the dredge operator.
- Training of operators and project staff on simulators and with dedicated dredging courses.
- Logistics with fast efficient transport of spare parts combined with computer controlled maintenance programmes for all on board systems.

With the upscaling to CSD vessels to over 27 MW of power the more recent technical developments for mega CSD's includes: -

- Dynamically controlled flexible spud-carrier giving active control of longitudinal movement, the roll angle and the pitch leading to being able to work in higher sea states.
- Flexible suspension of the cutter-ladder absorbing the shock loads and vibrations during rock dredging.
- Emissions limitation and/or LNG fuel options

The result of all these improvements is summarised in Figure 6 with a comparison of the previous largest CSD from 2003 with the latest being built in 2017.

Figure 5. Typical Modern CSD with 23.5 MW of Total installed Power

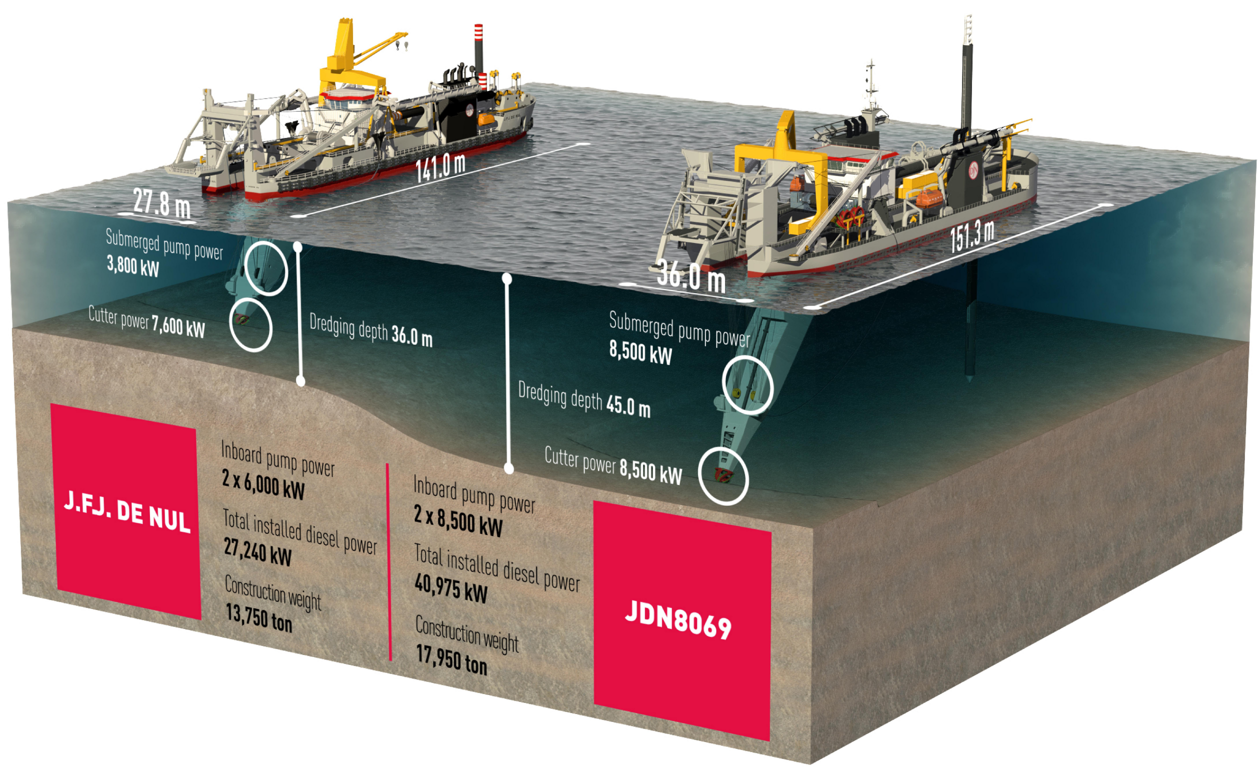


Figure 6. Comparison of Existing largest CSD (launched 2003) with Latest CSD (to be launched 2017)

Performance of Mega Cutter Suction Dredgers

A CSD is inherently capable of dredging all types of material from soft soils to hard rock. The cutter head can be configured with rock pick point. Coupled with the ability to remove material from the seabed is the ability to pump the dredged material long distances. All modern CSD's can also directly load barges typically with a capacity in the range of 2,000 to 4,000 m^3.

Rock Dredging

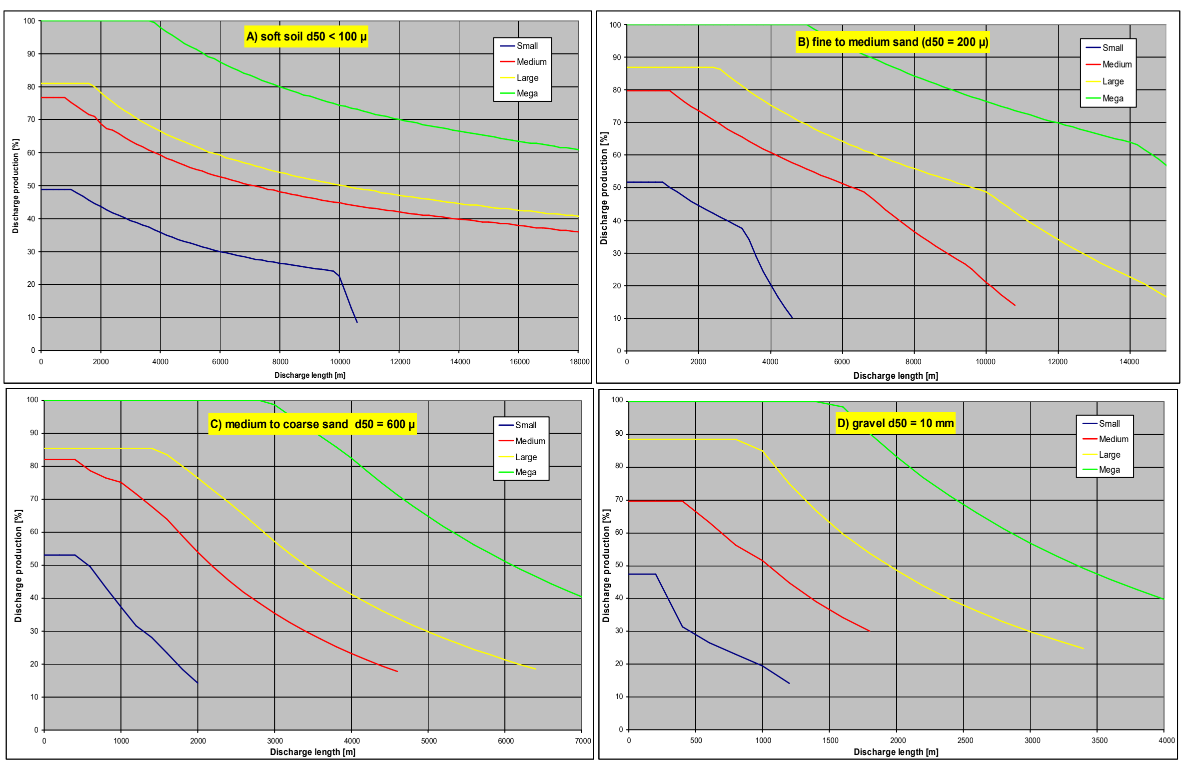
In the right circumstances a mega CSD can dredge rock with a strength of 100Mpa or higher, however this would typically require layering of the high strength rock with weaker rock strata. The tensile strength can also become more important at these high values. Generally for homogenous hard rock drilling & blasting becomes a much cheaper option. The process of dredging rock requires the cutter pick points to break the rock into sizes less than the pump intake of around 400mm, this produces a gravel/cobble mixture with a median particle size of 250mm.

Pumping Distances

Referring to Figures 7 below gives the typical pumping ranges possible for various types of CSD. For a modern CSD fine sand pumping distances of over 10 km can easily be achieved, note the effect of the grain size on the achievable pumping distance. Rock pumping distances are similar to gravel although wear and tear on the pumping system including the pipes in significantly increased.

Production Rates

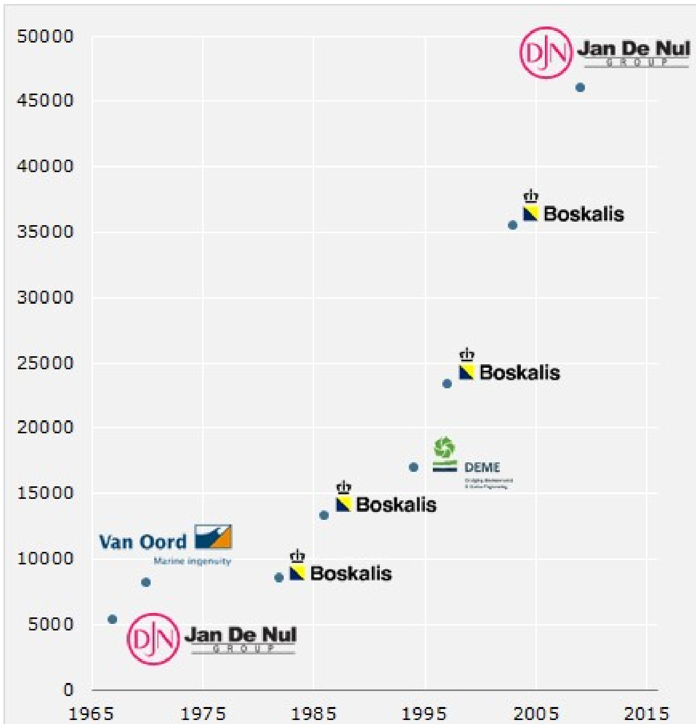
CSD production rates vary due to soil types, sea conditions pumping distances or barge loading disposal distances and environmental constraints so each case needs to be considered in isolation. A range of 5,000 m^3 per day in rock to 40,000 m^3 per day in good conditions could be used as a rough guide for a modern mega CSD.



Figures 7. Typical Pumping Ranges for Various Types of CSD for Various types of Material

Mega Trailer Suction Hopper Dredgers

The increase in the size of TSHD's was driven by the land reclamation projects in Asia that commenced in the mid 1990's as illustrated in Figure 8. The continued demand to dredge and place sand for worldwide reclamation projects over the last 20 years has continued to drive up the size of vessels to the current largest vessels at 46,000 m3 hopper capacity. Table 2 presents an approximate definition of TSHD types from small to mega based primarily on hopper size, the installed power is also important as this enables longer pumping distances: -



Source: Company websites

Figure 8. Increasing Volume in m^3 of TSHD from 1965 to 2017

Table 2 Definition of TSHD Type

Type	Hopper size [m³]	Inboard pump power [kW]
Small	700	350
Medium	4,500	2,500
Large	10,000	5,500
Jumbo	23,000	10,500
Mega	35,000	16,000

(*) Source "Dredgers of the world 2009/2010"

Technical Developments of Mega Trail Suction Hopper Dredgers

With the increase of hopper size and installed pump power these modern vessels are designed to recover and transport large quantities of sand and many of the technical developments referred to above for CSD's are equally applicable to TSHD's and are not repeated here.

The increase in hull length allowed longer dredge pipes with a corresponding ability to dredge in deep waters, currently in standard configuration a dredge depth of 155m with a 46,000 m^3 hopper size is achievable and this could be extended if required. The length of the dredge pipes can be seen in Figure 9.

In parallel with the development of CSD cutter heads the drag head of TSHD’s have also undergone technical advancement allowing active dredging of harder, compacted material. This has been achieved by jetting systems, pick points fixed to the drag head and rotating teeth to cut seabed soils. This has enabled dredging to take place at depths beyond the current 35m limit of CSD’s (45m from 2017) although with much reduced productions from a TSHD dredging sand or silts.

Figure 9. Mega TSHD with a Hopper Capacity of 46,000 m^3 Capable of Dredging to 155m

Production Rates of Mega Trailer Suction Hopper Dredgers

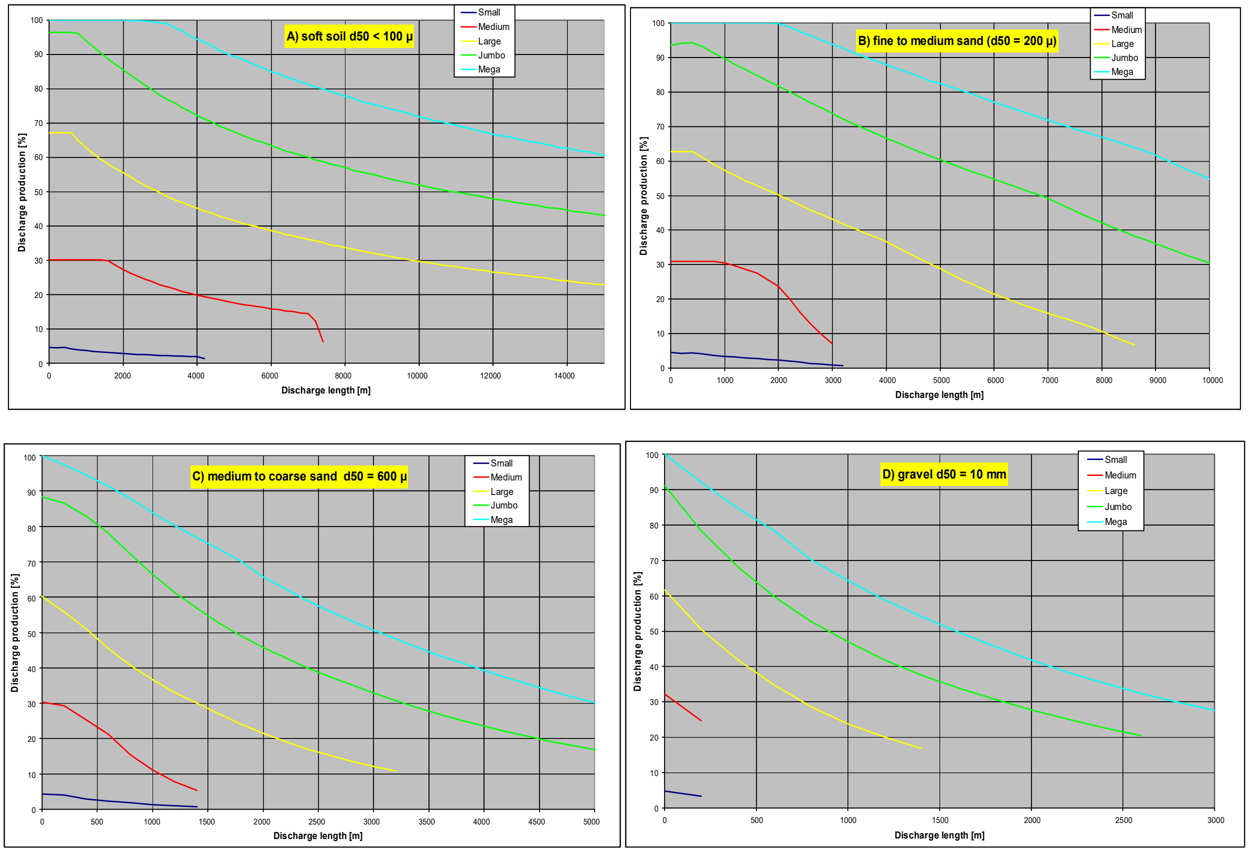
TSHD production rates like CSD’s vary due to soil types, sea conditions, pumping distances and environmental constraints so each case needs to be considered separately. As an example a recent reclamation project in Nigeria employed simultaneously three TSHD’s, two with a hopper capacity of 46,000 m^3 and one with a hopper capacity of 18,000 m^3 and achieved the following: -

- A total of 51.2 million m^3 was discharged
- Longest discharge distance 9,740m (no booster pumps required)
- Material: ranging between coarse shells and gravel to medium sand.
- Discharge productions ranging up to 15,000m^3/hr on the shortest pipeline length, dredge productions up to 26,000m^3/hr

This project highlighted the importance of the design and operation of the discharge system with the challenge of pumping ashore on long discharge lengths with three vessels simultaneously.

Pumping Distances

Referring to Figures 10 below gives the typical pumping ranges possible for various types of TSHD. The same comments given for pumping material from a CSD apply to pumping from a TSHD.



Figures 10. Typical Pumping Ranges for Various Types of TSHD for Various types of Material

Emissions Control

The dredging industry is acknowledging the need to curb engine emissions and new build dredging vessels are being constructed with various devices to limit diesel engine emissions, these include: -

- SCR (Selective Catalytic Reduction): reduction of NOx by injection of Urea ('AdBlue').
- DPF (Diesel Particle Filter): reduction of CO and Hydrocarbons, and particulate matter.

Or alternatively:

- Power generation by means of 'dual fuel' diesel engines which allow LNG to be used.

The aim is to be compliant with or better the IMO Tier III requirements.

USE OF MEGA DREDGERS IN CANADIAN WATERS

Reference is made to two projects carried out in Canada with mega TSHDs using their deep dredging capability working in stiff boulder clay for the Husky 'Glory Holes'.

A second reference is made to the use of a CSD to create a trench and remove an earth filled bund for the release of the Hebron concrete gravity base production structure from a dry dock in Mosquito Cove, Bull Arm, Newfoundland.

Mega TSHD's - Husky White Rose Glory Holes

Husky Oil Operations White Rose field is located on the Grand Banks offshore the east coast of Canada, 200 nautical miles south east of Newfoundland. As part of the development this project required the excavation of a 'Glory Hole' of sufficient dimensions to protect subsea wells, templates, manifolds and other equipment from damage due to iceberg scour, Figure 11.

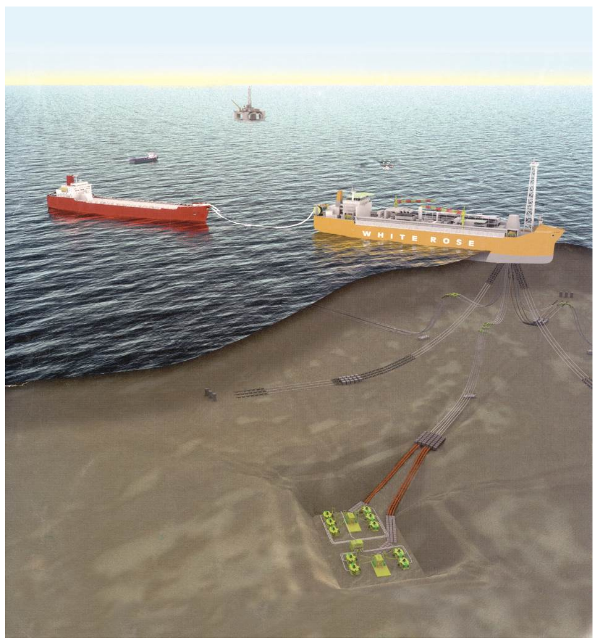


Figure 11. Illustration of Glory Hole

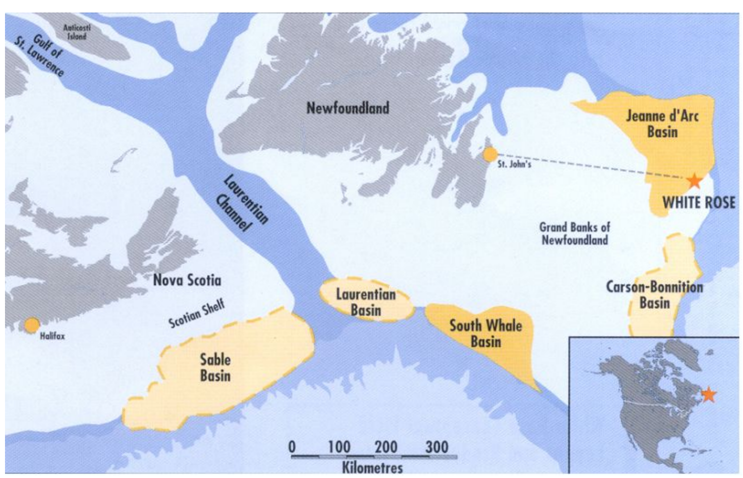


Figure 12. White Rose Location

The first project was in 2003 when the TSHD *Vasco Da Gama,* was modified specifically for this project to be able to dredge at 128m water depth, Figure 13. A second project in 2012 was carried out by the TSHD *Cristóbal Colón* at a similar water depth using the vessel's standard dredging configuration. Previous to the use of TSHD's this type of work was carried out by grab buckets with much slower production and it was difficult to get the base of the Glory Hole dredged to tolerance.

Figure 13 – The 33,000 m3 TSHD *Vasco Da Gama Alongside in St Johns Newfoundland*

Sea State Conditions

The work was planned before the winter weather conditions started in October. Sea state conditions in these offshore ocean locations were at best limited to calm local conditions with long period swell passing the site. The TSHD's dredge pipe is suspended from winches with active heave compensation to maintain the drag head a constant distance off the seabed. The heave compensator has a vertical range of around 8 m and allowed the vessels to work in waves with a significant height (Hs) of 2.5 m and a period (Tm) of around 8 to 10 seconds. Over the one month execution time around 6 days (20%) were lost due to weather.

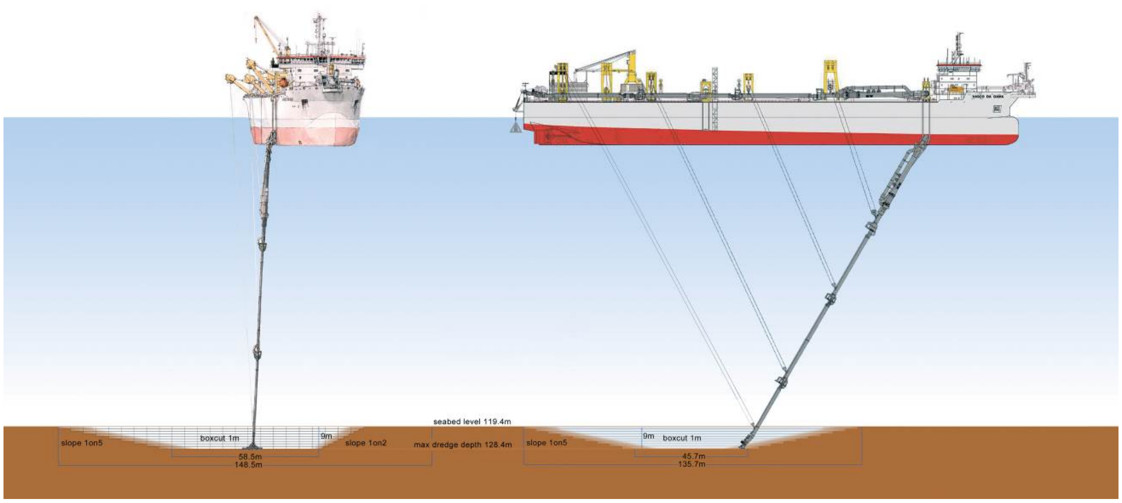


Figure 14 – Dredging of the 9m Deep Glory Hole at 120m Seabed Depth

Dragheads for Boulder Clays

For both projects the seabed consisted of sands and stiff to very stiff clays ranging in strengths from 250kPa to in excess of 450kPa containing boulders up to 1.8 m in diameter. To dredge these soils a ripper head consisting of a non-active drag head with several removable ripper teeth was used with a high pressure jetting system. The total volume dredged was in the order of 100,000 m^3 and this was achieved over a period of approximately one month. Dredged material was dumped from the hopper at a designated disposal site a short distance from the dredging site.

Figure 15 – Draghead with Pick-Points and Large Boulders

Survey & Dredge Tolerances

The survey system consisted of a multibeam with fibre optic motion sensor and sound velocity / draught sensor located on the moonpool carriage and a fibre optic motion sensor / gyro compass on deck. The dredged seabed vertical tolerance varied within the Gloy Hole with a typical value of 0.5 m. The biggest contributor to the inaccuracy of the survey was the large and variable thermocline in the watercolumn

Hebron Field - GBS Bund Removal by Mega CSD

The Hebron Field was developed by Exxon Mobil using a stand-alone, concrete GBS production platform to be installed in approximately 95 meters water depth on the Grand Banks offshore Newfoundland, Canada approximately 180 nautical miles east-southeast of St. John’s. The GBS was partially constructed by Kiewit-Kvaerner Contractors (KKC) in a dry dock in Mosquito Cove, Bull Arm, Newfoundland. On completion the dry dock was flooded, the bund wall excavated and the GBS was floated out to a deep water Site location for completion of construction activities, see figure 16. The removal of the bund wall and an access channel to float out the GBS was dredged by the 20MW CSD *Leonardo da Vinci* in 2014. A floating pipeline was used to dispose of the dredged material and this was mobilised from Broad Cove, see Figure 16 for site locations.

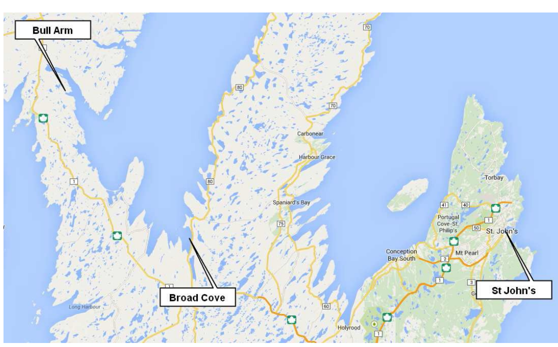


Figure 16. Site Map

Figure 17. The construction of the GBS in dry dock

Scope of Works

The site was used in the 90’s to build the Hibernia GBS, and was chosen again to construct the Hebron GBS. For the Hibernia GBS, a similar setup was used, although at that time the tow out channel was narrower and the bund wall was removed by means of a cable crane with grab. For the Hebron GBS dry dock aggregates used for constructing the cofferdam were sourced from the west coast of Newfoundland and hauled by ship to Bull Arm prior to start of construction. The bund wall was constructed through the use of articulated trucks and D-6 dozers. The trucks deposited their load at the end of the embankment and the dozer then pushed the material out and downward, forcing the aggregates into the ocean. Afterwards, an 800mm thick slag-cement and bentonite slurry wall was excavated via clamshell in order to reduce water infiltration into the dry dock. The Scope of Works required the removal of the bund wall and the dredging of the surround area to give an access channel with a depth of -16.0m, see Figure 17.

Execution of the Works

The CSD *Leonardo da Vinci* was mobilised from Dakar, Senegal and arrived in St. Johns on 18th June and started dredging on 25th June, the dredging was completed 18 days later on 13th July.

The project required 1100m of floating hose to allow the dredged material to be pumped to the disposal area. The individual pipes were transported by freighter and unloaded at Broad Cove where they were assembled. To avoid delays the floating pipeline was mobilisied in early May and its assembly was completed on 13th June using local vessels and workers.

In total around 250,000 m^3 was dredged including the limestone bund wall, an area of pre-blasted rock and natural glacial till, Figure 21 shows a multi-beam survey towards the end of the dredge. The CSD pumps and the floating pipeline were able to handle rock boulders up to 450mm in size.

Turbidity was an environmental concern and modelling of the dredge plume was carried out in advance of the work. Fishing seines were installed on the north and south side of the disposal area to prevent fines from being transported out of the cove. During dredging operations, there was almost no plume visible at the disposal site, due to the gravelly material being dredged.

Figure 18. Arrival of CSD *Leonardo da Vinci*

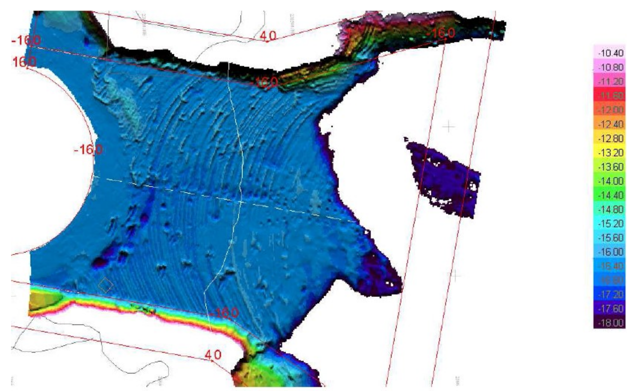


Figure 19. Multibeam Survey completion of dredging

The use of the powerful CSD to complete the dredge in 18 days ensured the overall project schedule was maintained.

Working in Canadian Waters

It is necessary for the foreign flagged vessels to comply with the Coasting Trade Act to obtain a Coastal License, to allow the vessel to operate in Canadian waters. Details need to be submitted to Transport Canada, describing the vessel specifications, the scope of work to be performed, schedule, etc. This application is sent to local contractors, in order to verify if local alternative vessels exist. Foreign staff and specialist crew also required a visa to permit them to work in Canada, local crew were employed for non-specialist positions such as deck hands, welders etc.

The recently agreed Canadian European Trade Agreement (CETA) will potentially ease the process of bringing foreign vessels to work in Canada. In practice the use of large specialist dredging vessels from non-Canadian companies combined with the use of Canadian vessels has proven to be a successful way of delivering these one-off marine projects.

CONCLUSIONS

The long term investment in dredging fleets of the world is expected to continue based on the principal driver of population growth and all the needs this brings including ports for trade, land to live on, protection of land from climate change and supply of energy. This statement takes the long view and acknowledges a current cooling in world trade. The dredging fleets built up from the 1970's will also need to be replaced with modern vessels.

Currently the most interesting investment is building of larger mega CSD vessels. With an increase of more than 50% in total onboard power these offer a step change in capability to extend the boundaries of what can be achieved in terms of efficiency, production, depth of dredging, type of material that can be dredged and being able to work at remote and exposed locations.

For TSHD's the current approach is for more efficient vessels with hoppers in the range from 3,500 to 11,000 m^3, designed to limit impact on the environment with alternative fuels and emission suppression systems. In the USA GLDD have recently launched the 11,500 m^3 TSHD *Ellis Island* and Weeks Marine the 6,500 m^3 TSHD *Magdalen*.

In the past ten years the country with the largest investment has been China, other developing countries have also been investing in dredging fleets (India, Malaysia Middle East).

Mega TSHD's principally are designed for moving large quantities of material but they also offer the ability to work in deep waters and dredge harder materials as the Glory Holes on the Bank Banks of East coast Canada demonstrated. In the case of the Hebron bund wall the production rate of a powerful mega CSD offers a reliable and fast method of removing and disposing a variety of materials including rock in shallow water.

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