CLAIMS

1. An explosive delivery system comprising:

a vehicle;

a first reservoir configured to store an explosive mounted to the vehicle;

a delivery hose reel mounted to the vehicle;

a delivery hose having a central bore that extends a length of the delivery hose from a proximal end to a distal end of the delivery hose and an outlet disposed at the distal end, wherein the delivery hose is configured to deliver the explosive out of the outlet of the delivery hose, wherein the delivery hose is stored on the delivery hose reel; and

a plurality of level sensors disposed on an outer surface of the delivery hose and that are dispersed along the delivery hose,

wherein each of the level sensors is configured to determine if the sensor is disposed in water, air, or explosive.

2. The explosive delivery system of claim 1, further comprising a second reservoir configured to store a sensitizing agent mounted to the vehicle,

wherein the explosive in the first reservoir is an emulsion.

3. The explosive delivery system of any one of claims 1–2, further comprising a third reservoir and a fourth reservoir mounted to the vehicle,

wherein the third reservoir is configured to store ammonium nitrate prill and the fourth reservoir is configured to store diesel fuel.

4. The explosive delivery system of any one of claims 1–3, wherein the plurality of level sensors are capacitance and conductance sensors that are configured to detect a capacitance and a conductance of a predetermined surrounding area of each capacitance and conductance sensor.

5. The explosive delivery system of claim 4, wherein each of the plurality of capacitance and conductance sensors comprises a pair of metal plates that are disposed on the outer surface of the delivery hose.

6. The explosive delivery system of any one of claims 1–5, further comprising a communication medium that is configured to communicate with the plurality of level sensors.

7. The explosive delivery system of claim 6, wherein the communication medium communicates with the plurality of level sensors over a wireless network.

8. The explosive delivery system of claim 6, wherein the communication medium is hard wired to the plurality of level sensors.

9. The explosive delivery system of claim 6, wherein the communication medium is disposed within a sidewall of the delivery hose.

10. The explosive delivery system of any one of claims 1–9, wherein the plurality of level sensors are equally or variably spaced from each other along the delivery hose.

11. The explosive delivery system of any one of claims 1–10, wherein the plurality of level sensors comprise a plurality of subsets of level sensors, wherein a first subset of level sensors is disposed at the distal end of the delivery hose that is configured to be inserted into a blasthole, wherein the level sensors are spaced apart from each other a first predetermined distance along the delivery hose.

12. The explosive delivery system of claim 11, wherein the plurality of level sensors comprise a second subset of level sensors that is disposed farther away from the distal end of the delivery hose than the first subset of level sensors, wherein the level sensors in the second subset of level sensors are spaced apart from each other a second predetermined distance along the delivery hose, wherein the first predetermined distance is different from the second predetermined distance.

13. The explosive delivery system of claim 12, wherein the first predetermined distance is less than the second predetermined distance.

14. The explosive delivery system of any one of claims 1–13, further comprising a baiting sensor that is configured to detect a presence of a detonator in a blasthole.

15. The explosive delivery system of claim 14, wherein the baiting sensor is a wireless reader that is configured to detect a presence of a wireless readable tag disposed on the detonator in the blasthole.

16. The explosive delivery system of claim 1, further comprising processor circuitry to:

receive or determine the dimensions of a blasthole;

control unwinding of the delivery hose from the delivery hose reel and control an insertion rate of the delivery hose into the blasthole; and

determine a distance of the distal end of the delivery hose from the delivery hose reel.

17. The explosive delivery system of claim 16, wherein the processor circuitry is configured to:

determine a height of water in the blasthole based on capacitance and conductance determined by each of the plurality of level sensors and the distance of the distal end of the delivery hose from the delivery hose reel before delivering the explosive into the blasthole.

18. The explosive delivery system of claim 16, wherein the processor circuitry is configured to:

control a flow rate of the explosive into the blasthole; and

retract the delivery hose from the blasthole and wind the delivery hose on the delivery hose reel as the explosive is delivered into the blasthole at a predetermined rate.

19. The explosive delivery system of claim 18, wherein the processor circuitry is configured to:

determine a height and volume of the explosive in the blasthole based on capacitance and conductance determined by each of the plurality of level sensors, the distance of the distal end of the delivery hose from the delivery hose reel, and the dimensions of the blasthole; and

determine if the explosive is filling the blasthole at a rate consistent with the flow rate of the explosive.

20. The explosive delivery system of claim 18, wherein the processor circuitry is configured to:

retract the delivery hose from the blasthole at a rate that maintains a height of the explosive between adjacent level sensors of the plurality of level sensors.

21. The explosive delivery system of any one of claims 1–20, wherein the vehicle is autonomous.

22. The explosive delivery system of any one of claims 1–21, wherein the vehicle is controlled by an operator.

23. The explosive delivery system of claim 22, wherein the operator controls the vehicle remotely.

24. A sensor system for detecting a presence of water or explosives in a blasthole comprising:

an extension member that is configured to be inserted into a blasthole; and

a plurality of level sensors that are dispersed along the extension member,

wherein each of the level sensors is configured to detect a capacitance and a conductance of a predetermined surrounding area of each level sensor to determine if the level sensor is disposed in water, air, or explosive.

~~25. The sensor system of claim 24, wherein the extension member is a cable.~~

~~26. The sensor system of claim 25, wherein the cable comprises a weight at a distal end of the cable that is inserted into the blasthole.~~

~~27. The sensor system of any one of claims 24–26, wherein the extension member is a delivery hose that is configured to deliver an emulsion to the blasthole, and~~

~~wherein the plurality of level sensors are disposed along an external surface of the delivery hose.~~

~~28. The sensor system of any one of claims 24–27, wherein the plurality of level sensors are one or more of capacitance sensors and conductance sensors, and combo sensors.~~

~~29. The sensor system of any one of claims 24–27, wherein the plurality of level sensors are combo sensors that detect a capacitance and a conductance of the predetermined surrounding area of each level sensor.~~

~~30. The sensor system of claim 29, wherein each of the plurality of combo sensors comprises a pair of metal plates that are disposed on an outer surface of the extension member.~~

~~31. The sensor system of any one of claims 24–30, further comprising a communication medium that is configured to communicate with the plurality of level sensors.~~

~~32. The sensor system of claim 31, wherein the communication medium communicates with the level sensors over a wireless network.~~

~~33. The sensor system of claim 32, wherein each of the plurality of level sensors comprises a transmitter to wirelessly transmit a detected capacitance and conductance to the communication medium over a period of time.~~

~~34. The sensor system of claim 31, wherein the communication medium is hard wired to the plurality of level sensors.~~

~~35. The sensor system of any one of claims 32–34, wherein the communication medium is disposed within the extension member.~~

~~36. The sensor system of any one of claims 24–35, wherein the plurality of level sensors are spaced from each other along the extension member.~~

~~37. The sensor system of claim 24, wherein the plurality of level sensors comprise a plurality of subsets of level sensors, wherein a first subset of level sensors is disposed at a distal end of the extension member that is configured to be inserted into the blasthole, wherein the level sensors are spaced apart from each other a first predetermined distance along the extension member.~~

~~38. The sensor system of claim 37, wherein the plurality of level sensors comprise a second subset of level sensors that are disposed farther away from the distal end of the extension member than the first subset of level sensors, wherein the level sensors in the second subset of level sensors are spaced apart from each other a second predetermined distance along the extension member, wherein the first predetermined distance is different from the second predetermined distance.~~

~~39. The sensor system of claim 38, wherein the first predetermined distance is less than the second predetermined distance.~~

~~40. The sensor system of any one of claims 24–39, further comprising a baiting sensor that is configured to detect a presence of a detonator in the blasthole.~~

~~41. The sensor system of claim 40, wherein the baiting sensor is a wireless reader that is configured to detect a presence of a wireless tag disposed on the detonator in the blasthole.~~

~~42. The sensor system of any one of claims 24–41, further comprising processor circuity to:~~

~~determine a height of water in the blasthole based on capacitance and conductance determined by each of the plurality of level sensors.~~

~~43~~25. An explosive delivery apparatus comprising:

a sidewall;

a central bore that extends a length of the explosive delivery apparatus from a proximal end to a distal end of the explosive delivery apparatus;

an outlet disposed at the distal end of the explosive delivery apparatus,

a plurality of level sensors disposed on an outer surface of the explosive delivery apparatus and that are dispersed along the explosive delivery apparatus, wherein each of the level sensors is configured to determine if the sensor is disposed in water, air, or explosive; and

a communication medium coupled to the explosive delivery apparatus,

wherein the communication medium is configured to communicate with the plurality of level sensors.

~~44. The explosive delivery apparatus of claim 43, wherein the communication medium is disposed within a sidewall of the explosive delivery apparatus.~~

~~45. The explosive delivery apparatus of claim 44, further comprising a conduit disposed in the sidewall of the explosive delivery apparatus and configured to deliver a sensitizing agent to the central bore of the explosive delivery apparatus.~~

~~46. The explosive delivery apparatus of any one of claims 43-45, further comprising a hose head disposed at the distal end of the explosive delivery apparatus.~~

~~47. The explosive delivery apparatus of any one of claims 43-46, wherein the plurality of level sensors include capacitance and conductance sensors that are configured to detect a capacitance and a conductance of a predetermined surrounding area of each capacitance and conductance sensor.~~

~~48. The explosive delivery apparatus of claim 47, wherein each of the plurality of capacitance and conductance sensors comprises a pair of metal plates that are disposed on an outer surface of the explosive delivery apparatus.~~

~~49. The explosive delivery apparatus of any one of claims 43–48, wherein the communication medium communicates with the plurality of level sensors over a wireless network.~~

~~50. The explosive delivery apparatus of claim 43–49, wherein the communication medium is hard wired to the plurality of level sensors.~~

~~51. The explosive delivery apparatus of any one of claims 43–50, wherein the plurality of level sensors are spaced from each other along the explosive delivery apparatus.~~

~~52. The explosive delivery apparatus of any one of claims 43–51, wherein the plurality of level sensors comprise a plurality of subsets of level sensors, wherein a first subset of level sensors is disposed at a distal end of the explosive delivery apparatus that is configured to inserted into a blasthole, wherein the level sensors are spaced apart from each other a first predetermined distance along the explosive delivery apparatus.~~

~~53. The explosive delivery apparatus of claim 52, wherein the plurality of level sensors comprise a second subset of level sensors that are disposed farther away from the distal end of the explosive delivery apparatus than the first subset of level sensors, wherein the level sensors in the second subset of level sensors are spaced apart from each other a second predetermined distance along the explosive delivery apparatus,~~

~~wherein the first predetermined distance is different from the second predetermined distance.~~

~~54. The explosive delivery apparatus of claim 53, wherein the first predetermined distance is less than the second predetermined distance.~~

~~55. The explosive delivery apparatus of any one of claims 43-54, further comprising a baiting sensor that is configured to detect a presence of a detonator in a blasthole.~~

~~56. The explosive delivery apparatus of claim 55, wherein the baiting sensor is a wireless reader that is configured to detect a presence of a wireless tag disposed on a detonator in a blasthole.~~

~~57~~26. A method of dipping, baiting, and loading a blasthole comprising:

placing a first vehicle in a vicinity a blasthole, the first vehicle comprising:

unwinding a delivery hose stored on a delivery hose reel from the delivery hose reel, wherein the delivery hose reel is mounted to the vehicle;

inserting the delivery hose into the blasthole without performing a separate dipping step to determine a level of any water in the blasthole;

determining a level of any water in the blasthole by a plurality of sensors that are disposed along an outer surface of the delivery hose; and

loading an explosive into the blasthole through the delivery hose.

~~58~~27. The method of claim ~~57~~26, wherein the vehicle comprises:

a first reservoir configured to store an emulsion mounted to the vehicle;

a second reservoir configured to store a sensitizing agent mounted to the vehicle;

a third reservoir configured to store ammonium nitrate prill; and

a fourth reservoir configured to store diesel fuel;

wherein the vehicle is configured to mix the explosive that is either a mixture of the emulsion and the sensitizing agent or a mixture of the ammonium nitrate prill and the diesel fuel, and

wherein the delivery hose is configured to deliver the explosive through a central bore of the delivery hose and out of an outlet of the delivery hose.

~~59~~28. The method of claim ~~58~~27, further comprising:

modifying a type of the explosive delivered into the blasthole if water is detected in the blasthole.

~~60~~29. The method of claim ~~59~~28, wherein the emulsion sensitized with the sensitizing agent is delivered into the blasthole if water is detected in the blasthole.

~~61~~30. The method of claim ~~58~~27, wherein the ammonium nitrate prill and the diesel fuel are delivered into the blasthole if water is not detected in the blasthole.

~~62~~31. The method of any one of claims ~~57–61~~26-30, further comprising:

placing a second vehicle at the blasthole when the first vehicle is not within the vicinity of the blasthole;

loading a detonator into the blasthole with a baiting assembly without performing a separate dipping step to determine a level of any water in the blasthole; and

determining a level of any water in the blasthole by a plurality of sensors that are disposed along an outer surface of the baiting assembly.

~~63~~32. The method of claim ~~62~~31, wherein the loading of the detonator into the blasthole by the second vehicle and leaving the vicinity of the blasthole occurs before the placing of the first vehicle in the vicinity of the blasthole.

~~64~~33. The method of claim ~~62~~31, wherein the loading of the detonator into the blasthole by the second vehicle and leaving the vicinity of the blasthole occurs after the placing of the first vehicle in the vicinity of the blasthole.

~~65~~34. The method of any one of claims ~~57–64~~26-33, further comprising:

determining if a detonator is correctly positioned in the blasthole by detecting a presence of the detonator by a baiting sensor disposed near a distal end of the delivery hose.

~~66~~35. The method of any one of claims ~~57–65~~26-34, wherein the baiting sensor is a wireless reader that detects a presence of a wireless tag disposed on the detonator in the blasthole.

~~67~~36. The method of any one of claims ~~57–66~~26-35, further comprising:

determining a distance of a distal end of the delivery hose from the delivery hose reel.

~~68~~37. The method of claim ~~67~~36, wherein the delivery hose comprises a plurality of level sensors disposed on the outer surface of the delivery hose and that are dispersed along the delivery hose.

~~69~~38. The method of claim ~~68~~37, further comprising:

determining a height of water in the blasthole based on capacitance and conductance determined by each of the plurality of level sensors and the distance of the distal end of the delivery hose from the delivery hose reel before loading the explosive into the blasthole.

~~70~~39. The method of claim ~~68~~37, further comprising:

determining a height and volume of the explosive in the blasthole based on capacitance and conductance determined by each of the plurality of level sensors, the distance of the distal end of the delivery hose from the delivery hose reel, and the dimensions of the blasthole; and

determining if the explosive is filling the blasthole at a rate consistent with a flow rate of the explosive.

~~71~~40. The method of any one of claims ~~57–70~~26-39, further comprising:

retracting the delivery hose from the blasthole and winding the delivery hose on the delivery hose reel as the explosive is loaded into the blasthole at a predetermined rate.

~~72~~41. The method of any one of claims ~~57–71~~26-40, further comprising:

retracting the delivery hose from the blasthole at a rate that maintains a height of the explosive between adjacent level sensors of the plurality of level sensors.

~~73~~42. The method of any one of claims ~~57–72~~26-41, wherein the vehicle is autonomous.

~~74~~43. The method of any one of claims ~~57–73~~26-42, wherein the vehicle is controlled by an operator.

~~75~~44. The method of claim ~~74~~43, wherein the operator controls the vehicle remotely.

~~76~~45. A system for delivering an explosive into a blasthole, comprising: a delivery apparatus configured to deliver the explosive;

a nozzle disposed at a distal end of the delivery apparatus;

one or more sensors that collects data for one or more parameters in a blasthole;

a processing circuitry that controls loading of the explosive into the blasthole, wherein the processing circuitry varies one or more parameters of the explosive based on the data collected from the one or more sensors.

~~77. The system of claim 76, wherein one of the parameters is pH.~~

~~78. The system of claim 76, wherein one of the parameters is temperature.~~

~~79. The system of claim 76, wherein one of the parameters is density of the explosive.~~

~~80. The system of claim 76, wherein the one or more sensors include a plurality of level sensors that are axially spaced apart along the delivery apparatus,~~

~~wherein each of the level sensors is configured to determine if the sensor is disposed in water, air, or explosive.~~

~~81. The system of claim 76, wherein the one or more sensors are disposed on the nozzle.~~

~~82~~46. A method of loading explosive into a blasthole comprising:

inserting a delivery hose into the blasthole without performing a separate dipping step to determine a level of any water in the blasthole;

determining a level of any water in the blasthole by a first plurality of level sensors that are disposed along a portion of the delivery hose;

loading an explosive into the blasthole through the delivery hose; and collecting data regarding one or more parameters in the blasthole via one or more parameter sensors disposed at the distal end of the delivery hose.

~~83. The method of claim 82, wherein the one or more parameters in the blasthole comprises pH.~~

~~84. The method of claim 82, wherein the one or more parameters in the blasthole comprises temperature.~~

~~85. The method of claim 82, wherein the one or more parameters in the blasthole comprises a density of the explosive.~~

~~86. The method of claim 82, further comprising varying one or more parameters of the explosive based on the data collected from the one or more parameter sensors.~~

~~87. The method of claim 86, wherein a density of the explosive is adjusted based on the data collected from the one or more parameter sensors.~~

~~88. The method of claim 82, wherein the one or more parameter sensors are disposed on a nozzle of the delivery hose.~~

~~89~~47. A method of loading explosive into a blasthole comprising:

inserting a delivery hose into the blasthole, wherein the delivery hose comprises one or more sensors disposed at a distal end of the delivery hose;

sensing one or more parameters in the blasthole with the one or more parameter sensors;

adjusting a parameter of the explosive in response to the one or more parameters sensed by the one or more parameter sensors.

~~90. The method of claim 89, wherein the one or more parameters in the blasthole comprises pH.~~

~~91. The method of claim 89, wherein the one or more parameters in the blasthole comprises temperature.~~

~~92. The method of claim 89, wherein the one or more parameters in the blasthole comprises a density of the explosive.~~